UNDER THE AUSPICES OF THE MINISTRY OF AGRICULTURE AND FISHERIES MOROCCO

Ministère de l'Agriculture et de la Pêche Maritime

2016 International Conference on PULSES

FOR HEALTH, NUTRITION AND SUSTAINABLE AGRICULTURE IN DRYLANDS

Marrakesh, Morocco, 18-20 April, 2016

CONFERENCE PROGRAM & ABSTRACT BOOK

ICARDA
Science for Better Livelihoods in Dry Areas

المعهد الوطني للبحث الزراعي
Institut National de la Recherche Agronomique

FONDATION OCP

IFAD
Investing in rural people

Food and Agriculture Organization of the United Nations

CGIAR
RESEARCH PROGRAM ON Grain Legumes

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AGENDA

Date/Time	Activity	Speaker
April 17, 2016		
17:00-19:00	*Evening registration*	
April 18, 2016		
08:00-08:50	*Registration*	
08:50-10:00	***Conference Opening Ceremony***	
08:50-09:30	*Welcome addresses*	- *Ministry of Agriculture and Fisheries, Morocco* - *FAO* - *Fondation OCP* - *IFAD* - *CRP-GL* - *BOT-ICARDA* - *ICARDA*
09:30-10:00	***KN01:*** *Soil Health and Environmental Management for Sustainable Agricultural Production Systems*	*Rattan Lal, The Ohio State University, USA*
10:00-10:30	***Coffee Break***	
10:30-12:00	***Session 1, Plenary: Global Pulses Scenario – Production, Consumption and Trade*** ***Chair: Périn Saint Ange, Associate Vice-President, IFAD*** ***Co-Chair: Andrew Jacobs, Director of AGT Foods, GPC***	
10:30-11:00	***KN02:*** *Global pulses consumption, production and trade scenario: Trends and Outlook*	*Pramod K Joshi, IFPRI*
11:00-11:30	***KN03:*** *Opportunities for enhancing pulses production to bridge demand-supply gap*	*Mahmoud Solh, ICARDA*
11:30-12:00	***KN04:*** *Status and prospects of pulses in Morocco*	*Nabil Chaouki, Ministry of Agriculture, Morocco*
12:00-13:30	***Panel discussion: Opportunities for bridging demand-supply gap in pulses***	*Representatives from Government, FAO, IFAD, CRP-GL, ICARDA, NARS leaders, private sector(GPC), farmers*
13:30-14:30	***Lunch***	
	CONCURRENT SESSIONS 2 & 3	
14:30 – 16:00	***Session 2: Pulses – Global Health, Nutrition and Gender*** ***Chair: Riccardo Del Castello, Communication for Development officer, FAO*** ***Co-Chair: Nawfel Roudies, Director, ADP, Fondation OCP***	
14:30-15:00	***KN05:*** *Potential of pulses in the context of global health challenges*	*Dilrukhi Thavarajah, Clemson University, USA*
15:00-15:15	***OP01:*** *Alleviating micronutrient deficiency through iron fortification of lentil dal*	*Rajib Podder, University of Saskatchewan , Canada*
15:15-15:30	***OP02:*** *Lupins – a protein crop able to perform in drylands*	*Federico Andreotti, Wageningen University Netherlands*
15:30-15:45	***OP03:*** *Lentil - A dietary solution to Arsenic poisoning in Bangladesh*	*Judit E.G. Smits, University of Calgary, Canada*
15:45-16:00	***OP04:*** *The role of women and the youth in pulses value chains*	*Esther Mwihaki Njuguna, CRP-GL, Kenya*

14:30-16:00	***Session 3: Innovations in Pulses Genomics*** ***Chair: Fred Muehlbauer, Research Geneticist, WSU*** ***Co-Chair: Michael Baum, Director, BIGM, ICARDA***	
14:30-15:00	***KN06:*** *Pulse genomics comes of age*	*Rajeev K Varshney, ICRISAT*
15:00-15:15	***OP05:*** *A role for genetics in the era of vast sequence datasets*	*Noel Ellis, New Zealand*
15:15-15:30	***OP06:*** *The lentil genome – from the sequencer to the field*	*Kirstin Bett, University of Saskatchewan, Canada*
15:30-15:45	***OP07:*** *Genome-wide SNP identification, linkage map construction and QTL mapping of mineral nutrients in pea*	*Rebecca McGee, USDA, USA*
15:45-16:00	***OP08:*** *Deploying genome sequence information for pigeonpea improvement*	*Rachit K Saxena, ICRISAT*
16:00-16:30	***Coffee break and Poster Session***	
	CONCURRENT SESSIONS 4 & 5	
16:30-18:00	***Session 4: Pulses and Natural Resource Management*** ***Chair: Andrew Noble, Deputy Director General (Research), ICARDA*** ***Co-Chair: Abdallah Aboudrar, ENA-Meknes***	
16:30-17:00	***KN07:*** *The next step to increase legume nitrogen fixation: Host plant improvement*	*Thomas R Sinclair, NCSU, USA*
17:00-17:15	***OP09:*** *A plus for pulses: symbiotic nitrogen fixation for sustainable intensification in the drylands*	*Rachid Serraj, CGIAR-ISPC, Italy*
17:15-17:30	***OP10:*** *Soil health, the missing link in sustainable pulses production*	*Ashok K Patra, ICAR-IISS, India*
17:30-17:45	***OP11:*** *Interaction of nitrogen fixation and water use efficiency in chickpeas*	*Carola Blessing, University of Sydney, Australia*
17:45-18:00	***OP12:*** *Phenotypic and genotypic diversity for tolerance to environmental stresses in Rhizobia nodulating lentil and chickpea in Morocco*	*Imane Thami-Alami, INRA, Morocco*
16:30-18:00	***Session 5: Pulses Genetic Resources: Conservation and Utilization*** ***Chair: Shoba Sivasankar, Director, CRP Grain Legumes*** ***Co-Chair: Janny van Beem, GCDT***	
16:30-17:00	***KN08****: Plant genetic resources for climate resilient crop cultivars for food and nutrition*	*Hari D Upadhyaya, ICRISAT*
17:00-17:15	***OP13****: Approaches for efficient conservation and mining of temperate pulses genetic resources*	*Ahmed Amri, ICARDA*
17:15-17:30	***OP14****: Walking on the wild side – expanding genetic diversity for future lentil breeding*	*Bert Vandenberg, University of Saskatchewan, Canada*
17:30-17:45	***OP15****: Mining natural genetic variation from old and new germplasm collections for chickpea breeding*	*R Varma Penmetsa, UC-Davis, USA*
17:45-18:00	***OP16****: Molecular approach for studying genetic diversity and population genetic structure of Asiatic Vigna accessions*	*Aditya Pratap, IIPR, India*
20:00-22:30	***Gala dinner***	

April 19, 2016		
08:30-11:00	***Side Event: Practical Issues in Pulses Production and Marketing in Morocco Organizer: Moroccan Society of Agronomy and Horticulture (SMAHo)***	
08:30-11:00	***Session 6, Plenary: Opportunities for Enhancing Pulses Production Chair: Mahmoud Solh, Director General, ICARDA Co-Chair: Rachid Dahan, Secretary General, INRA***	
08:30-09:00	***KN09:*** *Opportunities and limitations of multidimensional crop improvement in grain legumes to support increased productivity in mixed crop livestock systems*	*Michael Blummel, ILRI*
09:00-09:15	***OP17:*** *Rice fallow – an opportunity for horizontal expansion of pulses*	*Masood Ali, ICAR, India*
09:15-09:30	***OP18:*** *Varietal and seed use of faba bean in Ethiopia: implication for the national seed system*	*Dawit Alemu, EIAR, Ethiopia*
09:30-09:45	***OP19:*** *Increased adoption of modern technologies and competiveness of legumes value chain players through the Private Public Partnership*	*Mphatso Dakamau, AICC, Malawi*
09:45-10:00	***OP20****: Plant-pollinator inter-play in pulses in the context of ecosystem health*	*María José Suso, CSIC, Spain*
10:00-10:15	***OP21****: Ensuring seed security and production of rainfed pulses in semi-arid tropics*	*Ch Ravinder Reddy, MSSRF, India*
10:15-10:30	***OP22****: Pulses suitability assessment for sustainable productivity of drylands of Morocco*	*Rachid Moussadek, INRA, Morocco*
10:30-10:45	***OP23****: Adoption and impact of improved legume varieties in rotation on cereal yield, household income and food self-sufficiency in the Ethiopian highlands*	*Solomon Tiruneh, AARI, Ethiopia*
10:45-11:00	***OP24:*** *Spatial big data analytics for intensification of pulses*	*Chandrasekhar Biradar, ICARDA*
10:30-11:00	***Linking FAO event on Soils & Pulses (Rome) and ICARDA/IFAD event on Pulses (Marrakesh)***	***Eleonora Lago (IFAD) & Mahmoud Solh (ICARDA)***
11:00-11:30	***Coffee break***	
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11:30-13:00	***Session 7: Innovation in Pulses Breeding Chair: Bert Vandenberg, Professor, University of Saskatchewan Co-Chair: Clare Coyne, Research Geneticist, USDA***	
11:30-12:00	***KN10:*** *Enhancing genetic gains through innovations in breeding approaches*	*William Erskine, University of Western Australia, Australia*
12:00-12:15	***OP25****: Transgenics – a way forward for managing key stresses in pulses*	*NP Singh, IIPR, India*
12:15-12:30	***OP26:*** *Exploitation of heterosis for a major breakthrough in pulses*	*CV Sameer Kumar, ICRISAT*
Á12:30-12:45	***OP27:*** *Breeding pulses for nutritional quality with emphasis on bio-fortification*	*Ashutosh Sarker, ICARDA*
12:45-13:00	***OP28:*** *Association mapping for flowering time in lentil*	*Jitendra Kumar, IIPR, India*

11:30-13:00	***Session 8: Innovation in Productivity Management*** ***Chair: Mohamed Badraoui, Director General, INRA*** ***Co-Chair: Masood Ali, Formerly Director, IIPR***	
11:30-12:00	***KN11:*** *Innovations in productivity management of pulses*	*KHM Siddique, University of Western Australia, Australia*
12:00-12:15	***OP29****: Exploring management options to increase pulses production by using simulation models*	*Hélène Marrou, SupAgro, France*
12:15-12:30	***OP30****: Integration of pulses for a more productive cereal systems with lower environmental footprints*	*Yashpal Singh Saharawat, ICARDA*
12:30-12:45	***OP31****: Innovation platform approach and agricultural food legumes value-chain improvement in Morocco*	*El Houssine El Mzouri, INRA-Morocco*
12:45-13:00	***OP32****: Innovative techniques for pulses improvement and adoption of newer technologies with reference to climate change*	*Om Gupta, JNKVV, India*
13:00-14:00	***Lunch time***	
	CONCURRENT SESSIONS 9 & 10	
14:00-15:30	***Session 9: Innovation in Abiotic Stress Management*** ***Chair: Prof. KHM Siddique, Director, Institute of Agriculture, UWA*** ***Co-Chair: Prof. Ahmed Bamouh, Professor, IAV-Hassan II***	
14:00-14:30	***KN12:*** *Impact of high temperature stress on pulses*	*PV Vara Prasad, KSU, USA*
14:30-14:45	***OP33****: Dissecting water saving traits in pulses: efforts and future trends*	*Michel Ghanem, ICARDA*
14:45-15:00	***OP34****: Faba bean improvement towards drought stress through the exploitation of genetic diversity*	*Lamiae Ghaouti, IAV Hassan II*
15:00-15:15	***OP35****: Combined effect of drought and heat stresses is more profound than their standalone effects in chickpea*	*Srinivasan Samineni, ICRISAT*
15:15-15:30	***OP36:*** *Pigeon pea success story in Eastern and Southern Africa: achievements and prospects*	*Ganga Rao NVPR, Kenya*
14:00-15:30	***Session 10: Innovation in Biotic Stress Management*** ***Chair: Rebecca McGee, Research Geneticist, USDA, USA*** ***Co-Chair: Seid K Ahmad, Legumes Pathologist, ICARDA***	
14:00-14:30	***KN13:*** *Integrated management of parasitic weeds to reclaim pulses area in Mediterranean region*	*Diego Rubiales, CSIC, Spain*
14:30-14:45	***OP37****: Management of soil-borne diseases for sustainable pulses production*	*Weidong Chen, USDA, USA*
14:45-15:00	***OP38****: Integrated pest management of food legume insect pests in North Africa, West and Central Asia*	*Mustapha El-Bouhssini, ICARDA*
15:00-15:15	***OP39****: Foliar diseases in food and forage legumes*	*Eva Madrid, Max Planck Institute, Germany*
15:15-15:30	***OP40****: Combating wilt susceptibility in chickpea – a success story and challenges ahead*	*Deep Ratna Saxena, RVSKVV, India*
15:30-16:00	***Coffee break and Poster session***	

16:00-19:00	***FAO Side Event: International Year of Pulses, Regional Dialogue for Africa*** ***Riccardo Del Castello, FAO Contd….. on April 20, 2016***	
16:00-18:00	***Panel Discussion: ICARDA Research Strategy***	***Kamel Shideed, ICARDA***
20:00-22:00	***Dinner***	
April 20, 2016		
08:30-13:00	***Session 11: Toward Sustainable Food Production Systems in Drylands*** ***Chair: Kamel Shideed, Assistant Director General (IC), ICARDA*** ***Co-chair: Mohamed El Gharous, PM6P***	
08.30-8.40	*Introduction*	*Kamel Shideed, ICARDA*
08:40-10:00	***A: Knowledge Sharing – Country Successes, Lessons Learnt & Challenges Ahead*** *(7 minute lightening presentations by country NARS and project leads)*	
08:40-09:25	*India-Morocco Food Legumes Initiative*	*SA Patil, Advisor, Fondation OCP, India*
	Morocco	*Dahan Rachid, INRA*
	India	*Ch Ravinder Reddy, MSSRF*
	Bangladesh	*Mohd Omar Ali, BARI*
	Nepal	*Yam Pandey, NARC*
09:25-10 :00	*Strengthening Wheat-Legumes Systems in West Asia & North Africa*	
	Egypt	*Mohamed Solomon, FCRI*
	Sudan	*Gamal Elkheir Khalifa Ismaeel, ARC*
	Tunisia	*Mohamed Salah Gharbi, INRAT*
	Morocco	*Hamida Hilali, INRA*
	Ethiopia	*Asnake Fikre, EIAR*
10:00-10:30	***Coffee break***	
10:30-12:00	***B. Achieving Diversification & Sustainable Intensification of Cereal Based Systems with Pulses***	
10:30-11:30	*Thematic Roundtables: Facilitated by Andrea Gros and Rajita Majumdar, ICARDA*	
11:30-11:50	*Presentation on roundtable outcomes*	
12:00-13:00	***Joining Hands on a Practical Path Forward: Science, Policy, Institutions & Markets*** ***Chair: Philippe Ellul, CGIAR Consortium***	
12:00-12:20	*Call for votes and recommendations*	
12:20-12:30	*Concluding Remarks*	*Philippe Ellul, CGIAR Consortium*
12:30-13:00	*Media Q&A/Open floor*	
	Vote of Thanks	
13:00-14:00	***Lunch***	


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KEYNOTE PRESENTATIONS

KN#	Session	Author(s)	Title
1	Inaugural	Rattan Lal	KN01: Soil health and environmental management for sustainable agricultural production systems
2	Session 1	Pramod K Joshi* and P Parthasarathy Rao	KN02: Global pulses consumption, production and trade scenario: Trends and outlook
3	Session 1	Mahmoud Solh	KN03: Opportunities for enhancing pulses production to bridge demand-supply gap
4	Session 1	Nabil Chaouki	KN04: Status and prospects of pulses in Morocco
5	Session 2	Dilrukhi Thavarajah	KN05: Potential of pulses in the context of global health challenges
6	Session 3	Rajeev K Varshney	KN06: Pulse genomics comes of age
7	Session 4	Thomas R Sinclair	KN07: The next step to increase legume nitrogen fixation: Host plant improvement
8	Session 5	Hari D Upadhyaya	KN08: Plant genetic resources for climate resilient crop cultivars for food and nutrition
9	Session 6	Michael Blümmel, Jane Wamatu, Barbara Rischkowsky and Siboniso Moyo	KN09: Opportunities and limitations of multidimensional crop improvement in grain legumes to support increased productivity in mixed crop livestock systems
10	Session 7	William Erskine*, Wallace Cowling and Janine Croser	KN10: Enhancing genetic gains through innovations in breeding approaches
11	Session 8	Kadambot HM Siddique	KN11: Innovations in productivity management of pulses
12	Session 9	PV Vara Prasad, Harsh Nayyar and Kadambot HM Siddique	KN12: Impact of high temperature stress on pulses
13	Session 10	Diego Rubiales	KN13: Integrated management of parasitic weeds to reclaim pulses area in Mediterranean region


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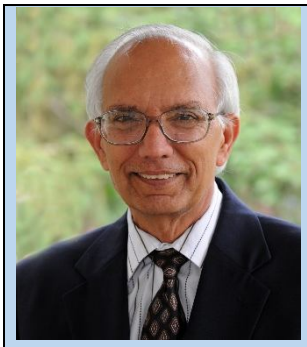
KN01: Soil health and environmental management for sustainable agricultural production systems

Rattan Lal

Carbon Management and Sequestration Center, The Ohio State University, Columbus, Ohio. *(lal.1@osu.edu)



Rattan Lal is a distinguished university professor of Soil Science at the Ohio State University in Columbus, Ohio, USA. Previously, he was Senior Research Fellow at the University of Sydney, Australia (1968-69) and a Soil Physicist at IITA in Ibadan, Nigeria (1969-87). His research focus is on climate-resilient agriculture, soil carbon sequestration, sustainable intensification, enhancing efficient use of agro-ecosystems, and sustainable management of soils of the tropics. He was included in the Thomas Reuters 2014 and 2015 list of World's Most Influential Scientific Minds. He is a recipient of honorary degrees from Punjab Agricultural University in Ludhiana, India, the Norwegian University of Life Sciences in Aas, Norway, Alecu Russo University of Moldova, and Technical University of Dresden, Germany.

Formerly, he was the president of the Soil Science Society of America (2005-2007), and is currently the President Elect of the International Union of Soil Sciences in Vienna, Austria since 2014. He is also the Chair of the Advisory Committee to UNU-FLORES in Dresden, Germany since 2014. He has mentored 105 graduate students, 54 postdoctoral researchers, and 145 visiting scholars. He has authored or co-authored more than 1,976 research publications, including 783 referenced journal articles, 427 book chapters, plus he has written 16 books and edited or co-edited 61 books.

Pulses-based diversified cropping systems, practiced in conjunction with conservation agriculture, can provide numerous ecosystem services because of improvements in soil health and functionality. Soil health refers to capacity of a soil as a living system to perform several functions including nutrient cycling, water conservation, soil structure and tilth, and adaptation and mitigation of climate change. Specific improvements in soil functions with pulse-based cropping systems include: (1) improvement in soil fertility especially availability of nitrogen (N), (2) enhancement of sol organic carbon pool because of the input of a high quality (low C:N ratio) biomass, (3) increase in soil aggregation and structure because of improvement in soil organic carbon (SOC), glomalin, and polysaccharides, (4) effective soil and water conservation and erosion protection, (5) reduced leaching and effective long-term storage of nutrients by increase in cation exchange capacity and tightening of the nutrient loop, and (6) increase in microbial biomass carbon (MBC) because of the improvement in active fraction of the SOC pool. Similar to leguminous cover crops, pulse-based cropping systems may also aggravate N_2O emissions by affecting the nitrification/denitrification processes. However, reduced input of agricultural chemicals can avoid emissions by 1.25 kg Ce/kg of nitrogenous fertilizers and 5-6 kg Ce/kg of the active ingredients of pesticides. Biological nitrogen fixation can supply 50 to 80% of N uptake by pulses, and also contribute some residual N to the following cereal crop. Thus, agronomic productivity and use efficiency of input is improved for pulse-based rather than continuous cereal based systems. Furthermore, food and nutritional demands of the growing population (9.7 billion people by 2050) necessitate enhanced production of protein-rich pulses. The hidden hunger, caused by deficiency of protein and micronutrients, already affecting more than 2 billion people compared with 795 million affected by hunger (low calorie intake). Integrated and diversified cropping systems, involving pulses, can also strengthen resilience of agro-ecosystem to changing and uncertain climate. Increase in SOC sequestration by pulses is in accord with the "4 per Thousand" initiative presented at COP21 in Paris and to be followed-up at COP22 in Morocco, and also with the Sustainable Development Goals of the UN.

KN02: Global pulses consumption, production and trade scenario: Trends and outlook

Pramod K Joshi[1]* and P Parthasarathy Rao[2]

International Food Policy Research Institute (IFPRI), New Delhi; [2]International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India. *(p.joshi@cgiar.org)

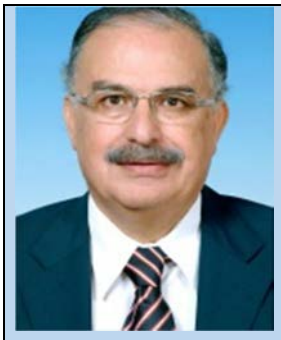
Pramod K Joshi is the director for IFPRI South Asia. Previous to this, he held the positions of the director at National Academy of Agricultural Research Management, and National Centre for Agricultural Economics and Policy Research, India. Earlier, Dr. Joshi was South Asia Coordinator at the IFPRI and Senior Economist at ICRISAT. His areas of research include technology policy, market, and institutional economics. Dr. Joshi has received the Dr. MS Randhawa Memorial Award of the National Academy of Agricultural Sciences (2009–11), Prof RC Agarwal Lifetime Achievement and DK Desai Awards of the Indian Society of Agricultural Economics (ISAE), and RT Doshi Foundation Award of the Agricultural Economics Research Association for outstanding contribution in social science and agricultural economics research. He is Fellow of the National Academy of Agricultural Sciences, and ISAE. He was president of ISAE (2014) and Indian Society of Agricultural Marketing (2014). Dr. Joshi has also served as the chairman of the SAARC Agricultural Centre's governing board in Dhaka, Bangladesh (2006–08); chairman of the UN-CAPSA governing board in Bogor (2007); and member of the intergovernmental panel on the World Bank's International Assessment of Agricultural Science and Technology for Development (2007–08). He served as a member of the International Steering Committee for the Climate Change, Agriculture, and Food Security Challenge Program, led by the ESSP Science Community and the CGIAR (2009–11). He was also a member of the core group of the Indian government's "Right to Food" National Human Rights Commission and the secretary-general of the Fourth World Congress on Conservation Agriculture.

Pulse-based food is an important source of dietary protein and essential minerals. On an average at the global level, pulses share 5% of the total protein consumption but their contribution in several developing countries range from 10 to 40%. The World Food Programme for instance includes 60 grams of pulses in its typical food basket, alongside cereals, oils, sugar and salt. However, the global per capita availability of pulses declined from 9.5 kg in the sixties to around 6 kg in mid-2000 and marginally increased since then. To meet the growing demand and raise their per capita availability, countries made efforts to increase production and explore trade opportunities. Between 1980 and 2013, global pulses production grew at an annual rate of 1.3% in two phases. While there was almost a period of stagnation in production during the nineties, it increased sharply since 2005. The major increase came from developing countries where both area and yield growth from a low base contributed to the production. For developed countries, the centre of production shifted from Europe to North America and Oceania prominently Canada and Australia. For developing countries too, new centers of production emerged in East and West Africa, and Southeast Asia (especially Myanmar). There have also been dynamic changes in the composition of pulse types with the share of cowpeas, chickpea, pigeonpea and lentil increasing and that of peas dry, beans dry and broad beans declined. To meet the excess demand, trade in pulses increased from 7% of their production in the 80s to 19% in 2011. In absolute term, a 4-fold increase in pulse trade is observed compared to 1.5 times in cereals. Developed countries (Canada, Australia and USA) emerged as the main exporters and developing countries the main importers. The exceptions were Myanmar and East African countries that emerged as important exporters. The value of pulse exports in 2011 was US$ 7.7 billion with developed countries accounting for about 52%. Developing countries account for bulk of the imports led by South Asia that accounted for about 40% of the total imports. Globally, the top four traded pulses are peas dry, beans dry, lentils and chickpeas. Projections indicate that demand for pulses will continue to grow in the short to medium term in developing counties due to growing population, rising per capita incomes among the lower income groups and increasing demand for snack/processed food due to growing urbanization. To meet the future demand for pulses, supply side constraints, like low yields in developing countries, small scale production, poor access to improved seed, week institutional arrangements, low research priorities and lack of government support like for cereals, are the major obstacles the pulse sector is facing. Besides addressing the above issues, the role of private sector is critical in ensuring pulse-based food and snacks to the urban population. It will require an enabling policy environment and efficient marketing and processing arrangements.

KN03: Opportunities for enhancing pulses production to bridge demand-supply gap

Mahmoud Solh

International Center for Agriculture Research in the Dry Areas (ICARDA), Beirut, Lebanon. *(m.solh@cgiar.org)



Mahmoud Solh holds a PhD in Genetics from the University of California, Davis, USA, and has an impressive record of scientific publications. He has more than 30 years' experience international agriculture research and development in developing countries particularly in dry areas. He started his professional career in the Ford Foundation starting in 1972, ICARDA, then the American University of Beirut, FAO and now as Director General of ICARDA since May 2006. He has in-depth knowledge of needs and aspirations of the national agricultural research and development systems in non-tropical dry Areas particularly in West, Central and South Asia and North and Easter Africa regions. He also has rich experience in donor relations and fund raising. Throughout his career his activities have focused on contributing to food security, alleviating poverty, and developing sustainable agricultural research systems; planning, implementation, and evaluation of agricultural research projects for research and development; institutional and human resource capacity development; and promoting north-south and south-south cooperation. Dr. El Solh is the author of more than 120 publications/papers and articles including books and chapters of books. His contribution to agricultural research and development has been recognized through several prestigious awards and honors, last of which could be listed: a) Award of Distinction, 2011, University of California, Davis, USA; b) Honorary Doctors degree by the Swedish University of Agricultural Sciences (SLU), 2012, Uppsala, Sweden,; c) Life Time Achievement Award" from the International Commission of Dryland Development (IDDC), March 2013; d) Innovation Prize, Gregor Mendel Foundation, 2015; and f) FAO Live Time Achievement Medal, FAO, 2016.

Dry areas which cover 41% of the earth's surface are home to over 1.7 billion people – and majority of them are poor. About 16% of the population lives in chronic poverty, particularly in marginal rainfed areas. With climate change and depleting natural resources, we need to focus on those climate smart crops which require not only less inputs but also contribute positively to soil health and environments. Pulses contribute greatly to the sustainability of the prevailing cropping systems; and they need to be mainstream in cereal-based production systems where ground water depletion is fast and soil health is becoming a serious issue. Cultivation of pulses requires ten times less water than producing the same quantity of animal meat. Pulses not only fix atmospheric nitrogen to the extent of 70-210 kg /ha but also lower carbon footprint because of low carbon emission and higher carbon sequestration. Global production of pulses has increased from 42 million tons in 70s to 72 million tons at present, thanks to both area increase from 63 to 80 million ha and productivity enhancement from 670 kg/ha to the present level of 905 kg/ha which is still low considering the potential of these crops. However, the production growth has occurred mainly in developed countries which have emerged as major exporter to Asia and North Africa where pulses are the main source of protein and micro-nutrients. In spite of the growth in pulses production, Asia and North Africa remain major importers of pulses, about 6-7 million tons at present which is forecasted to go up to 15 million tons by 2050. The demand – supply gap in pulses remains a challenge because production growth of pulses could not keep pace with population increase and therefore, are in short supply, resulting in sharp fall in consumption. In order to enhance pulses production, there are many opportunities in the form of closing the existing yield gaps, making new genetic gains, besides of course gaining ground in new areas through diversification and sustainable intensification of cereal-based systems and new niches like rice fallow replacement in South Asia. Post-harvest losses in pulses are also enormous sometimes up to 15% which need to be plugged-in besides strengthening the whole pulse value chain. To enhance economic competitiveness and stability in pulses production, an enabling policy environment and upfront investment in R4D activities are need of the hour. This presentation highlights successes of the past investment in collaboration with NARS partners and outlines opportunities and strategies to bridge the demand-supply gap in pulses.

KN05: Potential of pulses in the context of global health challenges

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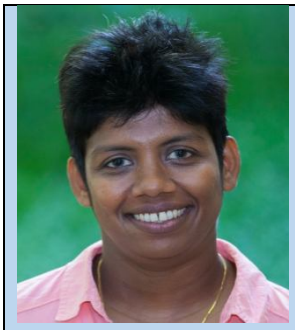

Dilrukhi Thavarajah is a Sri Lanka born Canadian. She completed her BSc degree from University of Peradeniya, Sri Lanka, then moved to University of Saskatchewan, Canada to complete her masters (Soil Science), and doctorate degrees (Plant Physiology). As a postdoctoral fellow, Dil established the first discoveries of lentil selenium research using syncrotron techniques. Then, she joined the world largest lentil breeding program in Crop Development Centre, Saskatchewan, Canada where she initiated Canadian lentil biofortification program. In 2010, Dil moved to North Dakota State University, Fargo, ND, and established nations first Pulse Quality and Nutrition Laboratory. Since 2014, Dil is an Assistant Professor at Clemson University, SC leading Specially Crop Research program (Pulse/Vegetable Quality and Nutrition), and studying food systems linking to human health. Her current teaching responsibilities are Vegetable Crops (HORT 4560/4561), Food Systems Linking to Human Health (PES 8060), Sustainable Food Systems towards Food Security (PES 4960/4979-006), and Creative Inquiry (Tiger Gardens).

Millions of global populations are suffering from food caused health issues. Approximately 40% of the world's population is facing hidden hunger due to lack of essential micronutrients in commonly eaten staple foods. In addition, chronic, non-communicable diseases associated with obesity result in 36 million deaths globally each year, more than all other causes combined. Obesity has been a severally neglected global public health concern for decades. Today, "globesity"—the global epidemic of overweight and obesity—is taking over in many parts of the world. In fact, the global population continues to increase, with more than 90 million people to feed each year; global food demands are expected to double by 2050. With limited arable lands, decreasing soil fertility, climate change, and declining water resources, the present food systems are already challenged with respect to providing sufficient nutrients rich foods to most global populations. Dependence on animal products is not an option for most populations in the developing world and is becoming more difficult in most developed countries. Therefore, to combat global micronutrient and calorie malnutrition, novel ways to produce nutritious foods are required. To this end, traditional food crops including pulses have potentials to provide sustainable food solutions to improve human health.

KN06: Pulse genomics comes of age

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Rajeev K. Varshney is a Global Research Program Director, Genetic Gains that encompasses different disciplines including Genebank, Pre-Breeding, Genomics & Trait Discovery, Cell & Molecular Biology and Genetic Engineering, Forward and Integrated Breeding, and Seed Systems at ICRISAT. He is also Winthrop Research Professor at The University of Western Australia. In his dual appointment, he also served CGIAR Generation Challenge Program as Theme Leader for six years. Before joining ICRISAT, he worked at IPK-Gatersleben, Germany for five years. Rajeev has recently won the Shanti Swarup Bhatnagar Award – Biological Sciences, the most coveted and prestigious award from the Government of India. He is internationally recognized for his contribution in genome sequencing of pigeonpea, chickpea, peanut, pearl millet, sesame, mungbean and adzuki bean and development of molecular breeding products in chickpea, pigeonpea and peanut. Rajeev, a Highly Cited Researcher as per Thomson Reuters, has published >300 publications including in Nature, Nature Biotech, Nature Commun, PNAS, etc. Rajeev is a Fellow of the Crop Science Society of America (CSSA), Indian National Science Academy (INSA), The National Academy of Sciences, India (NASI), National Academy of Agricultural Sciences, India (NAAS), AP Academy of Sciences (APAS) and Telangana State Academy of Sciences (TSAS), India. He is also the recipient of Young Scientist awards from many of above mentioned academies. Rajeev has also received several prestigious awards including Research Excellence India Citation Award 2015 by Thomson Reuters, Highly Cited Researcher by Thomson Reuters in 2014 and 2015; The Illumina Agricultural Greater Good Initiative Award by Illumina Inc. USA, NASI-Scopus Young Scientist Award, Plaque/Certificate of Appreciation from Department of Agriculture– Bureau of Agricultural Research (DA-BAR)-The Philippines, Nepal Agricultural Research Council, Vietnam Academy of Agricultural Sciences. Rajeev has been a frequent invited speaker in several conferences e.g. G-8 Conference on "Open Data for Agriculture", FAO conference on "Agricultural Biotechnologies", brainstorming session on digital agriculture chaired by Mr Bill Gates and Nature Genetics conference. He provides leadership to several organizations by serving member/chair for committees, editorial boards, funding organizations and advisory boards.

Pulses play an important role in providing nutritional food security. Average productivity of pulses like chickpea and pigeonpea is less compared to its potential as these crops are grown in semi-arid regions and exposed to a number of biotic and abiotic stresses. Breeding efforts for enhancing productivity could not meet the desired target that are critical to feed the vastly growing global population. Modern approaches using genomics enabled breeding has the potential to increase the productivity by accelerating the rate of genetic gains. Huge germplasm wealth is stored in the global genebanks that has not yet been exploited to its full potential. For instance, ICRISAT genebank has ~35,000 accessions of chickpea and pigeonpea. With an objective to understand the mechanism or genetic basis for functional characterization of genes, draft genomes of chickpea and pigeonpea were assembled. After assembling draft genome sequences, large scale re-sequencing efforts have been initiated in both crops for identifying new sources of genetic variation and allelic variants of candidate gene(s) associated with beneficial traits. In the case of chickpea more than 500 lines including reference set, elite lines, parents of several mapping populations were re-sequenced using whole genome resequencing (WGRS) approach. Similarly in pigeonpea more than 500 lines including reference set, hybrid parental lines, wild species accessions and parents of mapping populations were re-sequenced using WGRS approach. Millions of variants were identified by aligning the re-sequencing data to their respective draft genomes. Detailed analyses provided comprehensive data on diversity features, gene loss, domestication and selection sweep. Multi-location phenotyping data for high priority traits for breeding along with SNPs was used for genome-wide association studies and identified several marker trait associations for trait of interest. Considering the potential of WGRS for exploiting the germplasm for identifying the novel superior alleles, ICRISAT has launched "The 3000 Chickpea Genome Sequencing Initiative" involving 3000 lines from the genebank of ICRISAT and ICARDA. These 3000 lines are also being phenotyped at 6 locations in India for yield and yield related traits. In summary, ICRISAT, together with its partners such as ICARDA is ushering in the era of translational genomics for agriculture for enhancing pulse productivity to benefit small-holder farmers in developing countries.

KN07: The next step to increase legume nitrogen fixation: Host plant improvement

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Thomas R Sinclair is an Adjunct Professor, Crop Science Department, North Carolina State University, Raleigh, NC. He was raised on a farm in Indiana. He received his BS and MS from Purdue University, PhD from Cornell University, and a Laurea Honoris Causa degree from University of Padova, Italy. His research interests have been to understand the interactions of plant physiology processes and environment as they impact crop yield. He synthesized many of his finding into the family of Simple Simulation Models (SSM) for simulating crop growth and yield. Currently, Dr. Sinclair is investigating specific plant traits to increase crop yields under drought conditions. He has undertaken research in Argentina, Australia, Israel, Italy, Japan, The Netherlands, and New Zealand. He also received a Ballard Fellowship to do research at Harvard University. Dr. Sinclair co-authored the books Principles of Ecology in Plant Production and Modeling Physiology & Crop Development, Growth and Yield. Also, he and his wife, Carol Janas Sinclair, have written a popular book titled Bread, Beer & the Seeds of Change

The energy crisis in the 1970s triggered a large interest in curtailing the substantial amount of fossil fuel required to manufacture nitrogen fertilizer used in crop production. Hence, considerable research investment was made to increase symbiotic nitrogen fixation rates of legumes. Nearly all of the investment was focused on ""improved"" bacteria. Unfortunately, little increase in nitrogen fixation activity or crop yields resulted from this approach except on lands where symbiotic bacteria did not previously exist. Recent research of the bacteria-plant symbiosis has shown that regulation of nitrogen fixation rates is, in most cases, almost totally under the control of the host plant. The flux of nitrogenous compounds (amides and ureides) and water from the host plant to nodules via the phloem have large influences on nodule activity. Accumulation of nitrogenous compounds in nodules as a result of feedback from the host plant, or a failure to rapidly remove these compounds from the nodules via the xylem results in feedback inhibition of nitrogen fixation rate. Conversely, rapid removal of nitrogenous compounds from the nodules and their metabolism into plant materials in the shoot allow for sustained, and even enhanced nitrogen fixation rates. Therefore, plant selection for vigorous plant growth that results in ready removal of nitrogenous compounds from circulation in the plant appears to offer an important opportunity for enhanced nitrogen fixation activity by legumes. The feedback limitation on nitrogen fixation of nitrogenous compounds also offers insight in understanding the negative impact of high soil nitrogen fertility, water deficits, and low phosphorus availability on symbiotic nitrogen fixation activity by legumes.

KN08: Plant genetic resources for climate resilient crop cultivars for food and nutrition

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Hari D Upadhyaya is the director of ICRISAT genebank. He is a well-known genetic resources specialist and groundnut breeder. He is recipient of several prestigious awards, with most recent one 'Harbhajan Singh Memorial Award'. He has received international recognition, including Crop Science Society of America awards, fellow of the American Society of Agronomy and Crop Science Society of America, the winner of Frank N Meyer Medal award for Plant Genetic Resources, Crop Science Research Award and International Service in Crop Science Award. Hari was elected Honorary Fellow of Indian Society of Plant Genetic Resources. He has published over 750 research papers including Nature Biotechnology, Proceedings of National Academy of Sciences (USA), Nature Scientific Reports, Journal of Experimental Botany, and Science Advances. His work on conceptualizing and developing mini core collection and utilizing this resource for identifying new sources of variations for climate resilient traits has brought a paradigm shift among germplasm curators/crop breeders about the germplasm utilization. The concept and process of developing mini core collection has been recognized in CGIAR systems as an 'International Public Good'. He has developed early-maturing, drought tolerant, high oil containing, and aflatoxin resistant high yielding breeding lines, of which 31 have been released as 44 cultivars in 22 countries. He has also registered 23 advanced lines as elite genetic stocks with improved characteristics in Crop Science. His work on genetics of wilt resistance, bringing together the two recessive genes which individually delay the wilting result in complete resistance, has laid sound breeding program for wilt resistance in chickpea.

Global agriculture, the foundation of nutrition and health, is vulnerable to the depletion of natural resources and climate change. Feeding the global population, projected at 9 billion by 2050, safe and nutritionally-enriched food is the greatest challenge to the humanity. Crop adaptation is another challenge to scientific community. Plant genetic resources are important resource for future progress and an insurance against unforeseen threats to production. ICRISAT genebank has the largest collection of chickpea (20,602 accessions, 59 countries) and pigeonpea (13,771 accessions, 74 countries) germplasm. These germplasm contain traits that plant breeders need for developing climate resilient cultivars. Representative subsets in the form of core (10% of entire collection) and mini-core (10% of core) collections are the most cost-effective strategy to identify agronomically-beneficial germplasm for use in crop improvement programs. Core and mini-core collections have been developed in chickpea and pigeonpea. The core collection in chickpea consists of 1,956 accessions, and 1,290 accessions in pigeonpea. The chickpea and pigeonpea mini-core collections consist of 211 and 146 accessions. Eighty-nine sets of these subsets have been distributed to NARS partners in 16 countries. Identifying genetically diverse and agronomically beneficial germplasm offers breeders opportunities to develop breeding and genetic mapping populations combining multiple resistances into desirable agronomic background. Using these resources, trait-specific genetically diverse germplasm possessing agronomically desirable traits have been identified in both the crops, and made available to researchers globally. There has been increased use of germplasm in breeding programs at ICRISAT since formation of mini-core collections. Some germplasm lines were also released as cultivars, 22 chickpea and 11 pigeonpea germplasm, respectively released as 37 and 14 cultivars in 23 and 7 countries. ICP 7035 is a promising vegetable type pigeonpea landrace cultivated in China, Fiji, India, and Philippines. Chickpea and pigeonpea have abundant genomic resources, including high throughput DNA markers, high-density genetic linkage maps, and sequenced reference genomes. The chickpea germplasm and breeding lines with unique traits are being sequenced, and comparison of sequence information with reference genome will enable us associate sequence variation with agronomically beneficial traits. Crop wild relatives harbor genes for resistance to pest and diseases, and for agronomic and nutritional traits. Crosses involving *Cajanus cajan* × *C. scarabaeoides* resulted into a line, ICPL 87162, with high seed protein (32%). Further research on systematic characterization of wild relatives for seed nutritional traits is in progress to identify nutritionally dense types for use in breeding. Increased use of agrobiodiversity together with modern genomics tools is crucial to coping with new challenges to agricultural production.

KN09: Opportunities and limitations of multidimensional crop improvement in grain legumes to support increased productivity in mixed crop livestock systems

Michael Blümmel, Jane Wamatu, Barbara Rischkowsky and Siboniso Moyo

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Michael Blümmel is Animal nutritionist with a Dr. Sc. (1994) and a Habilitation (2004) degree of the University of Hohenheim in Germany and with more than 25 years of experience in teaching, development, research and research management in Europe, US, Africa and Asia. Currently team leader of the feed research of the International Livestock Research Institute. Major research interests are feeding and feed resourcing at the interface of positive and negative effects from livestock, multi-dimensional crop improvement and crop-livestock interactions and small and medium scale enterprises around feed. About 300 scientific publications, about half peer reviewed.

While rising demand for animal sourced food (ASF) in emerging and developing countries increases feed demand, shrinking natural resource base particularly arable land and water limit feed production. Consequently crop residues as feed have become important and their monetary values relative to grains are increasing, and, in case of leguminous haulms, sometime exceeds that of the grain. Crop improvement and livestock nutrition have taken note of these emerging trends and collaboratively explored opportunities and limitations for improving crop residue quantity and quality through multidimensional crop improvement. This keynote presents findings on crop species and crop cultivar variations in grain and haulm yield, haulm fodder quality and possible trade-offs between traits in groundnut, cowpea, chickpea, lentil, and faba bean. With regard to fodder quality, groundnut and cowpea haulm rank highest, followed by lentil, chickpea and faba bean. We reports on cultivar variations that already exist which can be exploited by phenotyping for fodder quality traits during crop improvement and new cultivar release procedures as well as on further genetic enhancement towards dual-purpose traits. It also highlights trait relationships across the crops that can inform and guide further crop improvement. Significant cultivar variations have been observed for protein, neutral (NDF) and acid (ADF) detergent fiber, acid (ADL) detergent lignin, *in vitro* organic matter digestibility (IVOMD) and metabolizable energy (ME). Protein, IVOMD, and ME are positive fodder quality traits while NDF, ADF and ADL are negative ones. Trade-offs between haulm traits and grain traits were either absent or manageable. Our results suggest that grain yields are insufficient predictors of haulm yields and the latter should be recorded in contemporary legume improvement. Haulm protein content tended to be inversely related to grain yield but the trade-offs were moderate and many cultivars deviated from overall relationships. In all legume haulms investigated, cultivar-dependent protein contents ranges were proportionally far larger than ranges in IVOMD, ME, NDF, ADF and ADL. These findings are very relevant where legume haulms serve as supplement to lower quality cereal straws and stover. Haulm IVOMD, ME, NDF, ADF and ADL were mostly unrelated to grain yields. Except for haulms protein, positive haulm fodder quality traits were positively associated with haulm yield in groundnut, cowpea, chickpea and lentils. High heritability (h^2) for haulm fodder quality traits indicate for future improvement toward dual purpose traits for groundnut and cowpea. Water stress generally enforced trade relationships – positive as well as negative ones. However, water stress affected grain and haulm yields much stronger than haulm composition. The laboratory results on nutritional quality were further validated through fodder market surveys and livestock productivity trials. In sheep fed exclusively on groundnut and cowpea haulms, weight gains varied –cultivar dependent - by more than 100% (65-136 g/day). In fodder marketing, cowpea and groundnut haulm fetched prices close to that of concentrate feeds. Indeed legumes haulms can provide feed resources of very high quality that often out-perform alternative rations believed to be superior like planted forages. Clearly the choice of legume cultivars with superior feed traits will have immense implication for the overall productivity of mixed crop livestock systems. There exists anecdotal evidence that cultivars superior in grain yield and haulm yield and haulm fodder quality create higher farmer demand and have higher adoption rates than cultivars improved solely for grain yield.

KN10: Enhancing genetic gains through innovations in breeding approaches

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William Erskine is Director of the Centre for Plant Genetics and Breeding (PGB) at The University of Western Australia. He currently leads the major 'Seeds of Life' project in Timor Leste funded by the Australian Centre for International Agriculture Research (ACIAR) and DFAT, and an ACIAR project on legume intensification in rice systems in Bangladesh. He is also involved in a Meat and Livestock Australia (MLA) project on the pre-breeding of the pasture subterranean clover, which includes its recent sequencing. He was at the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria as Assistant Director General (Research) from 2001-2007, Leader of the Germplasm Improvement Program (1998-2001), and Lentil Breeder from 1980 for 18 years. Scottish born, William completed a BA (University of Cambridge) in 1973, a MAg in 1976 in Papua New Guinea, and a PhD from Cambridge in 1979.

This paper addresses two innovations to improve genetic gains in pulse breeding: the use of the animal model to improve long-term genetic gain in self-pollinating crops such as field pea, and accelerated generation cycling. The 'animal model' has been exploited to great advantage in animal and perennial tree breeding where progenies are heterozygous. Traditionally the breeding of selfing plants involves crossing *after* the selection of pure lines. In contrast, the 'animal model' exploits information from relatives to estimate breeding values of each measured individual in the pedigree and, in self-pollinating crops, this involves crossing among selected heterozygous progeny *before* selfing to homozygosity. An adaptation of the animal model was tested in field pea and involved F1 (S0) recurrent selection cycles in which selection occurred on S0 plants and crossing occurred among selected S0-derived S1 individuals (i.e. *before* the selection of pure lines). Resistance to ascochyta blight (*Didymella pinodes* complex) – a model quantitative trait - in segregating S0 cross progeny was assessed by best linear unbiased prediction (BLUP) over two cycles of selection. Genotypic concurrence across cycles was provided by pure-line ancestors. From Cycle 1, 102/959 S0 plants were selected, and their S1 self-progeny were intercrossed and selfed to produce 430 S0 and 575 S2 individuals, that were evaluated in Cycle 2. The analysis was improved by including all genetic relationships (with crossing and selfing in the pedigree), additive and non-additive genetic covariances between cycles, fixed effects (cycles and spatial linear trends), and other random effects. Narrow-sense heritability for ascochyta blight resistance was 0.305 and 0.352 in Cycles 1 and 2, respectively, calculated from variance components in the full model. The fitted correlation of predicted breeding values across cycles was 0.82. The forecasted response to selection was 11.2% in Cycle 2 with 20% S0 selection proportion. This is the first application of the animal model to cyclic selection in heterozygous populations of selfing plants. The method can be used in genomic selection, and for traits measured on S0-derived bulks such as grain yield, with rapid cycles of one or two years. The method provides a steady stream of partially selfed S2-derived selections, available for selfing and selection of new varieties. The second innovation in pulse breeding is rapid generation cycling. Single Seed Descent (SSD) is a widely-used system in self-pollinating crops to swiftly advance segregating populations toward homozygosity following crossing. We aimed to shorten the generation cycle within a SSD system by reducing the time to flower and also cutting the seed fill period. This accelerated single seed descent (aSSD) system has four components: Rapid floral initiation; miniaturisation; precocious germination; and integrated abiotic screening. The approach has resulted, for example, in a lentil protocol for *in vivo* rapid generation with a total generation cycle of between 45 – 52 days. For confirmation we have progressed a recombinant inbred line population of lentils from F_2 to F_6 generation in 225 days (7.5 months). Leveraging on the aSSD advance we are adding abiotic screening in segregating generations and the integration of marker-assisted selection (MAS). In summary, accelerated-SSD (aSSD) technology enables 6-8 generations/yr in the cool-season legumes – halving the time to homozygosity. ASSD technology will provide a platform to integrate screening (including MAS) and deliver a step-change to the rate of achievement of homozygosity in pulses. These innovations are complementary and have the potential to increase the rate of genetic gains in pulse improvement.

KN11: Innovations in productivity management of pulses

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Prof. Kadambot Siddique is currently the Hackett Professor and Director of the University of Western Australia's Institute of Agriculture. He has 30 years' experience in agricultural research, teaching and management in both Australia and overseas. He has developed a national and international reputation in agricultural science especially in the fields of crop physiology, production agronomy, farming systems, genetic resources, breeding research. Professor Siddique has published >300 scientific papers and book chapters. He has conducted research on adaptation of crops to water deficits and the phenological, morphological, physiological, biochemical and genetic traits that enable crops to cope with various abiotic stresses. His pioneering research on chickpea has contributed enormously to the Australian chickpea industry which is currently valued at more than $500 million per annum. He has trained numerous Honours, MSc and PhD students. He is a visiting Professor in a number of overseas universities. Professor Siddique was elected as the International Fellow of the Indian Society of Plant Physiology and the Foreign Fellow of the Indian National Academy of Agricultural Sciences (FNAAS). He is winner of the Western Australian Year of the Award 2014 (Professions Category) for his contribution to agricultural science and farming community. Professor Siddique was honored with a prestigious Dunhunag Award by China's Gansu Provincial Government for his outstanding contribution to research and leadership within Gansu Province and also elected as a Fellow of the Australian Agricultural Institute (FAAI) in 2013. In 2012 Professor Siddique was awarded the prestigious Hackett Professor of Agriculture Chair at The University of Western Australia. In 2011 Professor Siddique was made Member of the Order of Australia (AM) in Queen's Birthday Honors List. In 2005 he was elected as a Fellow of the Australian Academy of Technological Sciences and Engineering (FTSE). In 2009 he received a gold medal and citation from the former President of India, Dr A.P.J. Abdul Kalam, for his international contribution to agricultural science and education. In 2001, Professor Siddique received the prestigious "Urrbrae Memorial Award" for his contribution to Australian agricultural science and the industry.

Grain legumes (pulses) could make a greater contribution to sustainable food production by their highly nutritious seed products and also because of their ability to fix symbiotic nitrogen which provides nitrogen to the legume crop as well as for subsequent crops. In addition to their sustainable and environmental benefits, consumption of grain legumes offers health benefits to humans and livestock. However adoption of improved production technologies for pulse crops is not proceeding at the same pace as for cereal crops. The area planted to pulses has gradually increased over the past 50 years, but it is still only a quarter of that planted to cereals. Moreover, while increases in cereal production during the past 50 years have been predominantly due to increases in yield—through changes in agronomic practices and new varieties—increases in grain legume production are mostly due to increases in the land area planted. This is particularly the case for smallholder farming in developing countries, where production trends have mostly been static or declined over the past decade. Conservation agriculture (CA), involving minimum tillage, legume rotations, improved soil characteristics and increased nutrient and water use efficiency, has contributed to sustainable cropping system production in large-scale commercial farming systems in the Americas, Europe, Australia and Turkey. Adoption of CA is only just beginning for smallholder farming in Asia and Africa, with increasing availability of herbicides and development of implements suitable for minimum tillage. Decision regarding choice of cultivar, sowing date, plant population or seed rate, fertilizer rates and application strategies, weed and pest control methods are fundamental to enhance pulse production. Their contributions to yield improvement have changed and evolved over time in relation to changes in varieties. However, technology transfer to resource-poor farming situations, where most pulses are produced, remains a major bottleneck to meeting global demand. Methods of enhancing this process, by focusing on major constraints within the value addition chain, will be discussed.

KN12: Impact of high temperature stress on pulses

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Pulses play a significant role in food and nutritional security in dry, warm and cool regions. High temperature (heat) stress is one of the major environmental factors limiting productivity of food grain crops including pulses. The impact of heat stress on two important pulse crops (warm season pulse mung bean and cool season pulse chickpea) will be reviewed. The impact of heat stress depends on the timing, intensity and duration of stress. In most food grain crops reproductive stages of development are relatively more sensitive to heat stress compared to vegetative stages. Our research in controlled environment with exposure to short episodes (2 days) of heat stress (mean daily temperature 33°C) showed that the most sensitive periods (with maximum decreases in percent seed-set) in mung bean were 6 days before anthesis and at anthesis. These periods generally coincide with gametogenesis and fertilization. Mean daily temperature >31°C imposed for a duration of 10 days starting from floral bud development linearly decreased seed-set with mean ceiling temperature of 39°C (where seed-set was 0). Increasing the duration of heat stress from 0 to 30 days (at 5 d intervals) during floral bud development decreased seed-set by up to 76 % in mung bean. Field studies on mung bean and chickpea under late planting (heat stress) conditions showed significant decreases in numbers of pods, seeds per plant and seed yields when compared with normal planting (no heat stress). Primary causes for lower seed-set and decreased seed numbers in both controlled environment and field conditions were loss of viability of gametes and failure of fertilization. Decreased seed-set was associated with loss of pollen germination, decreased pollen load, poor stigma receptivity, impaired pollen tube growth, and failure of fertilization, ultimately leading to lower seed numbers and seed yield. Detailed biochemical analysis revealed that decrease sucrose concentrations in anthers along with lower activities of sucrose synthesizing enzymes and hydrolyzing enzymes as possible cause of reproductive function in both of these pulse crops (mung bean and chickpea). There is a need to develop high throughput phenotyping techniques and/or physiological, biochemical or genetic markers that determines reproductive function. Future research should focus on screening germplasm collections to quantify genetic variability and identify heat tolerant genotypes for use in breeding programs.

KN13: Integrated management of parasitic weeds to reclaim pulses area in Mediterranean region

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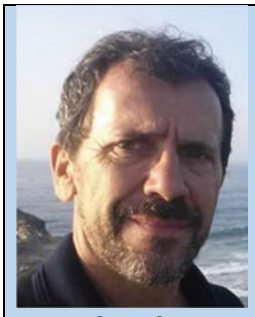

Diego Rubiales is a currently a professor at the Institute for Sustainable Agriculture, CSIC. He is also the President of the International Legume Society and was formerly the President of the European Grain Legume Association and a member of the Executive Committee of the International Parasitic Plant Society.
Rubiales has co-authored a total of 268 articles in journals with IF on various aspects of disease resistance and management during his career, with a special focus on disease resistance. He has directed 25 successful PhD and 6 Masters theses. In addition to these research activities, Rubiales has lead pea and faba bean breeding programs, resulting in two faba bean and three pea cultivar registered. He has an H index of 36.
Rubiales has extensive experience in participation and coordination of research both at the EU and Mediterranean level. Previously, he has been the coordinator of a FP5 EU project (EUFABA), FP7-ARIMNet (MEDILEG), COST action (COST849), FP7-PEOPLE-2009-IOF, and a WP leader in a FP6 EU Integrated Project (GLIP), FP6-ERANet (LEGRESIST), in two F7 projects (ABSTRESS and LEGATO), and in one Australian GRDC project. He has lead 16 Spanish research projects and 13 projects for bilateral projects with North African countries; he is currently participating in two Canadian projects.

Legume crops can be damaged by a number of parasitic weeds, being *Orobanche crenata* the most widely distributed in the Mediterranean basin and Middle East. *O. foetida* and *O. aegyptiaca* can also be of local importance. Dodders, particularly *Cuscuta campestris* can be damaging in some crops. Other parasitic weeds such as *Striga gesnerioides* and *Alectra vogelii* might be of importance on legume crops throughout semi-arid areas of sub-Saharan Africa. The only effective way to cope with parasitic weeds is through an integrated approach. Preventing the movement of parasitic weed seeds into un-infested areas is a crucial component of control. Seedbank demise can be achieved by fumigation or solarization, however, this is not economically feasible in low-value and low input legume crops. A number of cultural practices, from delayed sowing, hand weeding, no-tillage, nitrogen fertilization, intercropping or rotations can contribute to seed bank demise. Other strategies such as suicidal germination, activation of systemic acquired resistance, biocontrol or target site herbicide resistance are being explored, but are not yet ready for direct application. The only methods currently available to farmers are the used of resistant cultivars and chemical control, although both have their limitations. The most economical and environmentally friendly control option is the use of resistant cultivars, however, breeding for resistance is a difficult task considering the scarce and complex nature of resistance in most crops. As a result, only cultivars with moderate levels of resistance are available to farmers. Available sources of resistance and their undelaying mechanisms and genetic basis on the various legume crops will be reviewed and compared with those available in other crops. Implications in resistance breeding will be critically discussed.

ORAL PRESENTATIONS

OP#	Session#	Author(s)	Title
1	Session 2	R Podder*, B Tar'an, RT Tyler, CJ Henry, P Shand and A Vandenberg	OP01: Alleviating micronutrient deficiency through iron fortification of lentil dal
2	Session 2	Federico Andreotti*, Ivan Baldassarri and Anna Zepetella Del Sesto	OP02: Lupins: a protein crop able to perform in drylands
3	Session 2	Judit EG Smits*, Regina Krohn, Rubhana Raquib, and Albert Vandenberg	OP03: Lentil - A dietary solution to Arsenic poisoning in Bangladesh
4	Session 2	Esther Mwihaki Njuguna	OP04: The role of women and the youth in pulses value chains
5	Session 3	Noel Ellis	OP05: A role for genetics in the era of vast sequence datasets
6	Session 3	Kirstin Bett*, Larissa Ramsay, Crystal Chan, Andrew G Sharpe, Douglas R Cook , R Varma Penmetsa, Peter Chang, Clare Coyne, Rebecca McGee, Dorrie Main6, Jaroslav Doleze, David Edwards, Sukhjiwan Kaur, Shiv Kumar, Sripada Udupa, and Albert Vandenberg	OP06: The Lentil Genome – from the sequencer to the field
7	Session 3	Yu Ma, William Holdswroth, Michael Grusak, Peng Cheng, Michael Mazourek, Clarice Coyne, Dorrie Main, and Rebecca McGee*	OP07: Genome-wide SNP identification, linkage map construction and QTL mapping of mineral nutrients in pea
8	Session 3	Rachit K Saxena*, Aamir Khan, Obarley Yu, Vinay Kumar, Abhishek Rathore, Changhoon Kim, HD Upadhyaya, Kishan Patel, Kuldeep Tyagi, Vikas Singh, Shaun An, Dong Seon, MS Kuruvinashetti, Jihun Kim, Vanika Garg, Bellbull Kim, Wei Zhang, CV Sameerkumar, G Anuradha, S Muniswamy, Anup Karwa and Rajeev K Varshney	OP08: Deploying genome sequence information for pigeonpea improvement
9	Session 4	Rachid Serraj	OP09: A plus for pulses: Symbiotic nitrogen fixation for sustainable intensification in the drylands
10	Session 4	Ashok K Patra*, MC Manna, Sanjay Srivastava and K Ramesh	OP10: Soil health, the missing link in sustainable pulse production
11	Session 4	Carola Blessing*, Claudia Keitel, Richard Trethowan, Mark Adams and Brent Kaiser	OP11: Interaction of nitrogen fixation and water use efficiency in chickpeas
12	Session 4	I Benjeloun, I Thami Alami*, M El-Khadir, A Douira and SM Udupa	OP12: Phenotypic and genotypic diversity for tolerance to environmental stresses in rhizobia nodulating lentil and chickpea in Morocco

13	Session 5	Ahmed Amri*, Nigel Maxted, Mustapha El-Bouhssini, Aladdin Hamwieh, Abdallah Bari, Mohamed Fawzy Nawar and Shiv Kumar	OP13: Approaches for efficient conservation and mining of temperate pulses genetic resources
14	Session 5	Albert Vandenberg*, Richard Frantini, Behiye Tuba Bicer, Beybin Hacikamiloglu, Shiv Kumar, Sripada Udupa, Seid Ahmed Kemal, Omar Ali, Larissa Ramsay, Carolyn Caron, Lacey Sanderson, Doug Cook, R Varma Penmetsa, Jim Weller, Eric von Wettberg, Diego Rubiales Olmedo, Marcelino Pérez de la Vega, and Kirstin Bett	OP14: Walking on the wild side - expanding genetic diversity for future lentil breeding
15	Session 5	R Varma Penmetsa	OP15: Mining natural genetic variation from old and new germplasm collections for chickpea breeding
16	Session 5	Aditya Pratap*, Nupur Malviya, Rakhi Tomar and Ramanuj Maurya	OP16: Molecular approach for studying genetic diversity and population genetic structure of Asiatic *Vigna* accessions
17	Session 6	Masood Ali, SS Singh, Ashutosh Sarker and Shiv Kumar	OP17: Rice fallows - An opportunity for horizontal expansion of pulses
18	Session 6	Dawit Alemu* and Zewdie Bishaw	OP18: Varietal and seed use of faba bean in Ethiopia: Implication for the national seed system
19	Session 6	Mphatso Dakamau*, Felix Lombe and Tadala Rambiki	OP19: Increased adoption of modern technologies and competiveness of legumes value chain players through the Private Public Partnership
20	Session 6	María José Suso	OP20: Plant-pollinator inter-play in pulses in the context of ecosystem health
21	Session 6	Ch Ravinder Reddy*, RS Shanthakumar Hopper, CV Sameer Kumar, GV Ranga Rao, Vilas Tonapi and Rajendra Prasad	OP21: Ensuring seed security and production of rainfed pulses in semi-arid tropics
22	Session 6	R Mrabet and R Moussadek*	OP22: Pulses suitability assessment for sustainable productivity of drylands of Morocco
23	Session 6	Solomon Tiruneh, Yigezu A Yigezu*, Aden Aw-Hassan and Chilot Yirga	OP23: Adoption and impact of improved legume varieties in rotation on cereal yield, household income and food self-sufficiency in the Ethiopian highlands
24	Session 6	C Biradar*, Z Geli, X Xiao, A Sarker, J Dong, S Kumar, M Singh, R Singh, J Omari, L Atassi, and A Noble	OP24: Spatial BigData Analytics for intensification of pulses
25	Session 7	NP Singh* and Alok Das	OP25: Transgenic - A way forward for managing key stresses in pulses
26	Session 7	CV Sameer Kumar*, MV Nagesh Kumar, KN Yamini, R Vijay Kumar, A Hingane, R Saxena and Rajeev K Varshney	OP26: Exploitation of heterosis for major yield breakthrough in pulses: Pigeonpea - a case study
27	Session 7	Ashutosh Sarker*, Shiv Kumar, Jitendra Kumar, HK Dikshit, J Alam and N Ghimire	OP27: Breeding pulses for nutritional quality with emphasis on bio-fortification

28	Session 7	Jitendra Kumar*, Sunanda Gupta, Syed Mohd Quatadah, Revanappa Biradar1, Shiv Kumar and NP Singh	OP28: Association mapping for flowering time in lentil
29	Session 8	Hélène Marrou*, Michel E Ghanem, Afshin Soltani and Tom R Sinclair	OP29: Exploring management options to increase pulses production by using simulation models: An application to dryland systems
30	Session 8	Yashpal Singh Saharawat	OP30: Integration of pulses for a more productive cereal systems with lower environmental footprints
31	Session 8	El Houssine El Mzouri*, Rachid Dahan, Marouane Jbilou, Rachid Moussadek, Khalid Daoui, Basma Okbi and Mohamed El Mourid	OP31: Innovation platform approach and agricultural food legumes value-chain improvement in Morocco: IMFLI project case study
32	Session 8	Om Gupta*	OP32: Innovative techniques for pulses improvement and adoption of newer technologies with reference to climate change
33	Session 9	Michel E Ghanem*, Hélène Marrou, Shiv Kumar, Vincent Vadez and Thomas R Sinclair	OP33: Dissecting water saving traits in pulses: efforts and future trends
34	Session 9	Lamiae Ghaouti	OP34: Faba bean improvement towards drought stress through the exploitation of genetic diversity
35	Session 9	Srinivasan Samineni*, Sobhan B Sajja, Muneendra K Singh, Sudharshan R Peddi, and Pooran M Gaur	OP35: Combined effect of drought and heat stresses is more profound than their standalone effects in chickpea
36	Session 9	NVPR Ganga Rao*, Moses Siambi, Said Silim, Stephen Lyimo, Rose Ubwe, Meshack Makenge, Kananji GAD, Esnart Yohane, Manuel Amane, Yuventino Obong, Paul Kimurto, Emmanuel Monyo, CV Sameer Kumar, Omari Mponda, Robert Kileo, Kennedy Kanenga, Odeny Damaris, Patrick Okori, Chris Ojiewo, HD Upadhyaya, Rebbie Harawa, Rachit Saxena, and Rajeev Varshney	OP36: Pigeonpea success story in Eastern and Southern Africa: Achievements and prospects
37	Session 10	Weidong Chen	OP37: Management of soil-borne diseases for sustainable pulses production
38	Session 10	Mustapha El Bouhssini*, RS Malhotra, L Ali, M Imtiaz, A Hamwieh, K Street, A Bari, S Lhaloui, K El Fakhouri and A Sabraoui	OP38: Integrated pest management of food legume insect pests in North Africa, West and Central Asia
39	Session 10	Eva Madrid	OP39: Foliar diseases in food and forage legumes
40	Session 10	Deep Ratna Saxena	OP40: Combating wilt susceptibility in chickpea: A success story and challenges ahead
41		Fouad Maalouf*, Somanagouda B Patil, Karthika Rajendra, Aladdin Hamwieh, Aakash Goyal, and Shiv Kumar3	OP41: Breeding for post-emergence herbicide tolerance in cool-season food legumes


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IN DRYLANDS

OP01: Alleviating micronutrient deficiency through iron fortification of lentil dal

R Podder[1]*, B Tar'an[1], RT Tyler[2], CJ Henry[3], P Shand[2] and A Vandenberg[1]

[1]Department of Plant Sciences, University of Saskatchewan (U of S), Canada; [2]Food and Bioproduct Sciences, U of S, Canada: [3]College of Pharmacy and Nutrition, U of S, Canada. *(rap039@mail.usask.ca)

Rajib Podder is a PhD student at the University of Saskatchewan, Canada. Before coming to Canada, Rajib worked at the Bangladesh Agricultural Research Institute as a pulse breeder between 2005 and 2010. Rajib completed his M.Sc. in lentil breeding focusing on stemphylium blight resistance at the University of Saskatchewan. In 2014 Rajib began his PhD studies aiming to improve iron levels in lentil seeds through plant breeding (biofortification) and post-harvest processing (fortification), under the supervision of Dr. Albert Vandenberg.

Iron (Fe) deficiency is one of the most prevalent health concerns worldwide, especially in developing countries where diets are Fe deficient. Lentil (*Lens culinaris* Medik.) is an important staple grain legume that provides proteins and micronutrients for human diets. It is a potential crop candidate for Fe fortification with suitable approved Fe fortificants. Research has been initiated at Crop Development Center of University of Saskatchewan to increase Fe concentration and bioavailability in staple pulse crops using both biofortification and fortification techniques. The goal is to increase both concentration and bioavailability of Fe. In fortification approach, lentils were enriched with extra bioavailable Fe. Initial research was focused on identifying the appropriate form of Fe solution to fortify lentils. Known approved Fe fortificants such as ferrous sulphate hepta-hydrate, NaFeEDTA (Ethylenediaminetetraacetic acid iron (III) sodium salt), and ferrous sulphate mono-hydrate were used to fortify lentil dal. This was followed by measurement of Fe concentration, sensory evaluation and estimation of bioavailability in the fortified dal. Selection of the most suitable product type of lentil dal for fortification was followed by identification of appropriate methods for adding fortificants to lentil dal. This was followed by assessment of the optimum dose to provide a major part of the Recommended Dietary Allowance (RDA) of Fe for humans. Sensory evaluation was conducted at the panelist and consumer level to determine the acceptability of organoleptic properties of Fe-fortified lentil dal. Bioavailability of Fe for fortified lentil with three different Fe salts was estimated for fortified lentil dal. We conclude that among the three fortificants NaFeEDTA was the most suitable iron fortificant for de-hulled lentils based on ease of fortification, consumer acceptability and bioavailability. Fifty gram of lentil dal fortified with NaFeEDTA can provide approximately 10.5 mg of Fe which could meet the major portion of the RDA for average populations. This series of experiments concluded that fortification of lentil dal is a potential and effective technology that could provide significant health benefits to vulnerable populations with Fe deficiency.

OP02: Lupins: a protein crop able to perform in drylands

Federico Andreotti*, Ivan Baldassarri and Anna Zepetella Del Sesto

Wageningen University Netherlands; University Statale of Milan Italy; Slow Food. *(federico.andreotti@wur.nl)

Federico Andreotti is a Master student in Plant Sciences, Natural Resource Management, at Wageningen University (Netherlands) with focus on agroecology as driven force to develop sustainable agricultural practices and community building. He works as environmental agronomy consultant at DAVO Agricultural District of Olona Valley, Milan (Italy) to plan ecological corridors to improve ecosystem services through a better network and management of blue and green infrastructure. He worked as researcher at CIIMAR institute, Porto (Portugal) studying relations between plant and soil microbial ecology in polluted environment. He is collaborating with University of Milan (Italy) and Slow Food Movement to develop a multidisciplinary approach on pulses with a main focus on Lupins. The aim of this collaboration is to understand how pulses can be the leitmotiv to enhance soil fertility, be an interesting protein crops and be a profitable products in the market. He is Member of Boerengroep at Wageningen University association that wants to connect universities (research, education) with the reality and challenges of farmers and peasants in the Netherlands and worldwide.

Lupins is a very ancient legume, from the family of Fabaceae, used as food since 3000 years in the Mediterranean region (Uauy et al. 1995). Lupins is a legume with an old story, promoted by Slow Food, able to be efficient in drylands and with a very interesting nutritional connotations. This legume is well known as a fundamental plant in crop rotation in order to fix nitrogen and improve the quality of the soil, thanks to its root system. Enhanced water use efficiency is possible by using appropriate plant species, and Lupins is a promising legume able to adapt in drylands (Izaurralde et al. 2011). For instance, in the Mediterranean environments it was proven how Lupins can increase the availability of Nitrogen in the soil if introduced in rotation with wheat (Espinoza et al 2015. Another issue related to drylands is the acidification of the soil. Lupins permits to stop the increase of the acidity of the soil and avoid external inputs as limestone (Conyers et al 1996). The beneficial effects of Lupins on our health are different. Lupin is a very important element in a balanced diet due to its high content of essential amino-acids, the large contribution of fibers (INRAN 2016), the low glycaemic index and the fact of being gluten free. It is well known how fiber helps the intestinal transit and selected probiotic microorganisms in the human intestine. Studies proved that bread made with lupin have a reduction effect on post-prandiale glycaemia, compared to the white bread (Keogh et al. 2011). In addition to that, the lupin bread is indeed a complete amino acidic food thanks to the interactions between cereals and pulses.

In Italy, for instance, this pulse found his local and historic variety promoted by Slow Food as the Giant Lupin of Vairano. It is needed to conduct more research on Lupins, in order to provide a new interesting possibility for farmers in the drylands and provide a legume able to improve the quality of soil and as a rich source of nutrients.

OP03: Lentil - A dietary solution to Arsenic poisoning in Bangladesh

Judit EG Smits*, Regina Krohn, Rubhana Raquib, and Albert Vandenberg

Faculty of Veterinary Medicine, University of Calgary, Alberta, Canada. *(judit.smits@ucalgary.ca)

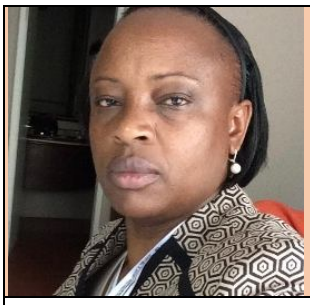
Judit Smits is a Professor of Ecosystem & Public Health in Faculty of Veterinary Medicine, University of Calgary, Canada and Adjunct Professor in School of Environment & Sustainability, University of Saskatchewan, Canada. She received Doctor of Veterinary Medicine from University of Guelph (1982) and Master in Veterinary Science (1989) and PhD in Veterinary & Environmental Toxicology (1996) from University of Saskatchewan. Her research interests are Ecosystem Health, Mammalian and Environmental Toxicology. She inspired by colleagues at the University of Saskatchewan who were growing high selenium lentils, she began with studying animal models to prove the concept of reducing arsenic levels in the body, and reversing health problems from chronic arsenic poisoning through dietary means. Smits identified a strong local partner in Bangladesh, to help design and carry out the first clinical trial based on a staple dietary item – lentil dahl. Her research is greatly enriched through interdisciplinary collaborations.

Millions of people worldwide are at risk of chronic arsenic (As) poisoning from naturally occurring As in their drinking water and food supply. Bangladesh alone, has millions of household wells with As concentrations greater than the Bangladeshi limit of 50 ppb. Selenium (Se), an essential element in human nutrition, antagonizes As in the body. This means that if sufficient Se is in the diet, As poisoning is expected to decrease. Currently we are studying whether dietary Se naturally found in lentils grown on the prairies of North America can successfully reduce As in the body and reverse damage from chronic As exposure. In Shahrasti, Chandpur district of Bangladesh we tested As in tube wells of 102 households. Over 90% had As >100 ppb. From these households, 400 individuals (approx. 100 families), are randomly assigned to one of two treatment groups. In this double-blind study, one group eats high-selenium lentils, the other, very low-Se lentils, with participants eating 65g of lentils every day (similar to normal dhal consumption) for 6 months. At time 0, after 3 months, and end of the trial, blood, urine, stool, and hair samples are collected to determine As levels. At the same time, a health examination assesses lung inflammation, body weight and condition, and blood pressure. A health questionnaire is conducted every 2 weeks throughout the trial. After 6 months on the diet, we will be able to determine the health benefits of high Se lentils. We will discuss interim results of the study at the conference.

OP04: The role of women and the youth in pulses value chains

Esther Mwihaki Njuguna

Gender Research Coordinator, CRP on Grain Legumes, Kenya. *(e.njuguna@cgiar.org)



Esther Njuguna-Mungai, is currently the gender research coordinator in the CGIAR Research Program on Grain legumes, based at ICRISAT in Nairobi. She is a graduate of Wageningen University and Research Centre (MSc in Development Economics) and University of Nairobi (PhD in Agricultural Development and Economics). She worked at the Social Economics and Applied Statistics Division of the Kenya Agricultural Research Institute in different capacities for 15 years. Most recently she coordinated Research, leading the gender and participatory market research streams, in a joint project implemented by KARI and McGill University – Innovating for Resilient Farming Systems in Eastern Kenya.

The presentation will focus on two distinct areas of presentation: the 'role of the youth in the dryland pulse value chains' and 'the role of women in the dryland pulses value chains'. The presentation will start by outlining the CGIAR focus on the women and youth IDO on 'equity and inclusion'. The trends in women population in the dryland populations will be explored. It will investigate the social and cultural context within which they participate in pulses value chains; the roles attributed to women in the drylands communities and how this impacts their capacities to participate in pulses value chains. The opportunities for enhancing women's gainful engagement in pulses value chains will be explored. The recent trends in the youth populations in dryland communities and the implications for the future will also be outlined. The challenges of interesting the youth in participating in pulses value chains, while their main interests are 'away from agriculture' and the opportunities will also be presented. The presentation will finalize with a call affirmative action, in the design and implementation of programs to focus more on the youth. Unique case studies of youth engagement will be presented.

OP05: A role for genetics in the era of vast sequence datasets

Noel Ellis

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Research interests of **Noel Ellis** have focused on the genetic basis of the inter- and intra-specific evolution and diversification of legumes at both genomic and phenotypic levels. A core activity has been to develop approaches for the isolation of genes identified by their phenotype. Dr. Ellis established and coordinated an EU FP6 integrated project 'Grain Legumes' (2004-2008 involving 80 labs in 25 countries) which ranged from life cycle analysis of economic and environmental impact to genome sequencing as research networks are needed in science, for economies and to combine disparate disciplines. His pioneering work in genetics particularly in pea has been well recognized. He was Director of CGIAR Research Program on Grain Legumes and coordinated its activities involving four CG centers and 10 NARS and ARI partners (2013 - 2015).

Genetics and genomics are very different disciplines that provide different types of information. Genomics can provide tools that help genetic analysis to generate the knowledge and understanding of biological processes that underpin interesting, or useful, characteristics of living things. I will take the opportunity of celebrating the 150th anniversary of Mendel's paper 'Experiments on Plant Hybrids' to show that genetics remains a powerful analytical tool. Genetics identifies discrete and causative differences that can be manipulated in breeding programmes or that are the basis of evolutionary change. The connection between evolutionary change and intraspecific variation was recognized by Vavilov in the 1920s in his law of homologous series in variation, which has become known as comparative genetics. Comparative genetics unites the understanding of the biology of closely related species and allows the transfer of knowledge from one to another, which is a clear economy of effort. I will illustrate these points with some examples from pea, one of the two pulse species that Mendel used in his experiments.

OP06: The Lentil Genome – from the sequencer to the field

Kirstin Bett[1]*, Larissa Ramsay[1], Crystal Chan[1], Andrew G Sharpe[2], Douglas R Cook[3] , R Varma Penmetsa[3], Peter Chang[4], Clare Coyne[5], Rebecca McGee[6], Dorrie Main[6], Jaroslav Dolezel[7], David Edwards[8], Sukhjiwan Kaur[9], Shiv Kumar[10], Sripada Udupa[10], and Albert Vandenberg[1]

[1]University of Saskatchewan, Saskatoon, SK, Canada; [2]National Research Council Canada / Global Institute for Food Security (U of S), Saskatoon, SK, Canada; [3]University of California at Davis, Davis, CA; [4]University of Southern California, Los Angeles, CA; [5]USDA ARS, Pullman, WA, [6]Washington State University, Pullman, WA; [7]Institute of Experimental Botany, Czech Republic; [8]University of Western Australia; [9]Victoria Department of Primary Industry and the Environment, Australia; [10]ICARDA, Rabat, Morocco. *(k.bett@usask.ca)

Kirstin Bett is Professor of Plant Breeding and Genetics in the Department of Plant Sciences, University of Saskatchewan in Canada. She is an experienced pulse breeder and currently responsible for the common bean breeding program at the University. CDC WM-1, developed by Dr. Bett, was the first slow darkening pinto bean variety in commercial production in Canada and second in the world after the Mexican variety Pinto Saltillo. Dr. Bett leads the pulse crop genomics and bioinformatics program where she uses both classical and molecular techniques to better understand the traits that lead to the development of superior pulse crop cultivars. This has included work in seed quality, disease resistance and cold tolerance and has extended to the use of wild species as a source of useful variability. Dr. Bett is a project lead of an $8.5-million Genome Canada project to investigate the genetics of domestication and adaptation in lentil. She led the international effort to sequence the lentil genome and released the assembly to the international research community in early 2016.

Lentil (*Lens culinaris* ssp. *culinaris*; genome size 4.3 Gb) plays a significant role in supporting sustainable agriculture worldwide. Its nutrition value has also been recognized as part of the solution to combat global food and nutritional security. The lentil genome assembly v1.0, based on the Canadian variety CDC Redberry, was released in January 2016. The assembly consists of 7 pseudomolecules anchored through the use of 6 high-density genetic linkage maps, with the total assembled bases representing approximately half of the 4.3 Gb lentil genome. It was assembled from genomic and RNA sequencing results carried out by several institutions across the world using different technologies. The assembly, with putative genes identified, can be visualized on a genome browser (JBrowse) and queried using BLAST via the Knowpulse web portal (http://knowpulse.usask.ca). Having the full genome sequence of lentil has provided tools that facilitate in-depth genetic studies. Markers and candidate genes that control several agronomic and quality traits have been identified and we have implemented marker-assisted selection for several traits of importance to the breeding program at the University of Saskatchewan. To assess the breadth of genetic potential present within the *L. culinaris* gene pool, a lentil diversity panel (~ 400 accessions from several lentil germplasm collections) has been re-sequenced using a restriction site associated DNA (RAD) genotyping-by-sequencing (GBS) approach. Sequencing results suggest 4 populations based on adaptation to specific growing environments and altitude. The distinctness of the temperate and South Asian populations is striking and demonstrates the lack of intermating that is occurring between germplasm from these distinct regions. To fully understand the genetic basis of adaptation characteristics in lentils, we plan to conduct field phenotyping of the diversity panel in different lentil growing regions. We will then develop molecular markers and other breeder-friendly resources that will allow the breeders to better use exotic germplasm while reducing the negative impacts usually associated with maladaptation to the local environment. This will enable breeders to develop better lentil varieties through systematic use of diverse cultivated germplasm.

OP07: Genome-wide SNP identification, linkage map construction and QTL mapping of mineral nutrients in pea

Yu Ma, William Holdswroth, Michael Grusak, Peng Cheng, Michael Mazourek, Clarice Coyne, Dorrie Main, and **Rebecca McGee***

USDA-Agricultural Research Service, Pullman, WA. *(rjmcgee@wsu.edu)

Rebecca McGee is a USDA-ARS Research Geneticist located at WSU in Pullman, Washington. She received a BS from the University of Washington, an MS from the University of Alaska and a PhD from Oregon State University. Prior to joining the ARS, she was a Principal Scientist at General Mills, Inc. and directed the vegetable legume breeding programs. Currently, her research focuses on breeding cool season food legumes, primarily spring- and autumn-sown peas and lentils. The priorities of her breeding program include breeding for resistance to biotic and abiotic stresses and mineral biofortification. During her career in both the private and public sectors, she has contributed to the release of more than 35 varieties of peas and lentils. She is a member of the Executive Committee of the North American Pulse Improvement Association, the Chair of the Pisum Crop Germplasm Committee, and serves on the editorial board of the Journal of Plant Registrations.

Marker-assisted selection (MAS) is now routinely used in major crops to facilitate more efficient cultivar improvement. MAS has been significantly enabled by the use of next-generation sequencing technology to identify loci and markers associated with traits of interest. Although rich in a variety of nutritional components, pea (*Pisum sativum* L.) remains behind many other crops in the availability of genomic and genetic resources. To further improve mineral nutrient levels in pea requires the development of genome-wide tools. The objectives of this research are to develop these tools by: identifying genome-wide single nucleotide polymorphisms (SNPs) using genotyping by sequencing (GBS); constructing a high-density linkage map and comparative maps with other legumes, and identifying quantitative trait loci (QTL) for boron, calcium, iron, potassium, magnesium, manganese, molybdenum, phosphorous, sulfur, zinc. In this study, 1609 high quality SNPs were found to be polymorphic between two parents of the RIL population. Mapping 1,683 markers including 75 previously published markers and 1,608 SNPs developed from this study generated a linkage map of size 1310.1 cM. Using these SNPs and the linkage map, QTL analysis of the RIL population across two locations revealed 51 QTL for seed mineral nutrient concentrations. The QTL explained from 2% to 43.3% of the phenotypic variance. Co-localizations of QTLs were detected at both locations. Interestingly B, Ca, Fe, K, Mg, Mn, Mo, P, S, Zn QTL on LGV (29.6-52.4 cM) co-localized with each other. In this region, one Mg QTL and one K QTL explained up to 43% of phenotypic variation. The locus may possibly be a major-effect region associated with improvement of multi-mineral nutrient concentrations.

OP08: Deploying genome sequence information for pigeonpea improvement

Rachit K Saxena*, Aamir Khan, Obarley Yu, Vinay Kumar, Abhishek Rathore, Changhoon Kim, HD Upadhyaya, Kishan Patel, Kuldeep Tyagi, Vikas Singh, Shaun An, Dong Seon, MS Kuruvinashetti, Jihun Kim, Vanika Garg, Bellbull Kim, Wei Zhang, CV Sameerkumar, G Anuradha, S Muniswamy, Anup Karwa and Rajeev K Varshney

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Rachit K Saxena is a Genomics Scientist at ICRISAT. Rachit has basic background in molecular genetics and possess more than 11 years research experience in international agriculture. The primary contribution of Rachit includes development and deployment of genomics and genetics resources in pigeonpea improvement, genome sequencing of pigeonpea and chickpea, and first generation map in pigeonpea. He is also leading re-sequencing genome initiatives and first generation molecular breeding in pigeonpea. In recognition of his research contributions, he has won number of awards in research circuit, most significantly he has been awarded INSA Medal for Young Scientist (2012) - by Indian National Science Academy and Promising Young Scientist Award (2013) - by International Crops Research Institute for the Semi-Arid Tropics.

Ample information has been generated through decoding pigeonpea genome. This information has been used to undertake a number of initiatives for pigeonpea improvement. For instance, whole genome re-sequencing (WGRS) has been used in specialized genetic stocks i.e. parental lines of mapping populations (20), parental lines of hybrids (104) and reference set (292). Around 3 Tb data have been generated across 416 lines with the coverage ranging from 5X to 12X. The three different datasets have provided millions sequence variations (SNPs and INDELs) and structural variations (CNVs and PAVs). Variants discovered from re-sequencing of 20 parental lines of mapping populations offer information on sampled loci across the pigeonpea genome harboring high diversity and unique accession signatures. In the case of parental lines of hybrids sequence variations have been analyzed to define heterotic groups. Further reference set data have been analyzed to understand targets of domestication and human selection associated genetic sweeps, centre of origin and genome-wide association. Study using these sequence variations reveals associations between genomic regions with agronomic important traits including days to 50% flowering, days to 75% maturity, seeds per pod and 100 seed weight etc.

OP09: A plus for pulses: Symbiotic nitrogen fixation for sustainable intensification in the drylands

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Rachid Serraj is Senior Agricultural Research Officer. He joined the ISPC Secretariat in December 2012, coming from ICARDA where he served as director of the research program on diversification and sustainable intensification of production systems (DSIPS) in Central and West Asia and North Africa. He is a crop scientist with a broad production systems background, having worked for more than 25 years with national and international research organizations. He holds a PhD in Agronomy and Crop Science from the University of Montpellier, and has published more than 200 scientific publications on a wide range of topics. Before ICARDA, he worked as professor at the University of Marrakech, as visiting research associate with USDA and University of Florida, as principal crop physiologist at ICRISAT (India), Technical Officer with the joint FAO-IAEA Division in Vienna (Austria), and at IRRI (Philippines) as leader of the rice drought frontiers research. He has trained dozens of graduate students and postdocs, and serves on several international scientific panels and editorial boards. His research interests include crop adaptation to abiotic stresses and climate change, and sustainable natural resource management in unfavorable environments.

Legume intensification and Symbiotic Nitrogen Fixation (SNF) are essential to improve productivity and soil fertility, particularly for the smallholder farmers who cannot afford inorganic fertilizers for staple crops. In the current global scenario of an N resource plateau and growing concern over adverse environmental effects of chemical fertilizers, as well as their cost for small-scale farmers in developing countries, it is essential to expand the use of SNF technologies, as a key element of an integrated soil fertility management strategy. The inclusion of a legume in a cropping system does not always ensure the attainment of optimal levels of symbiotic N_2 fixation in the field, as numerous environmental factors including drought, salinity, temperature, and soil mineral nutrient status are known to dramatically affect the process at molecular/physiological level and thus play a part in limiting the actual amount of N fixed in the field. In line with agro-ecological approaches, future R&D on legumes and SNF should be positioned in an 'innovation systems' analytical framework, which analyses the relationship between agricultural research innovations, natural resource management (NRM), and market policies and development. To meet development needs and opportunities, and to ensure the economic and ecological sustainability of agriculture, approaches to SNF/legumes systems must be integrated, dynamic and innovative. Important opportunities exist in the short, medium and long term for enhancing the global role of legumes in cropping systems. This paper intends to discuss some of these opportunities and niches for targeted introduction of N_2-fixing legumes within agroecosystems, and particularly resource-poor systems in developing countries. A framework is presented for agro-physiological contributions that can help overcome SNF limitations by environmental constraints, for improving legumes productivity and strengthening their role in cropping systems. Such framework should harness the holistic approaches to legume intensification based on the synergistic integration of research — in socioeconomic analysis, NRM, genomics and breeding — to farmers' fields and to the value chains.

OP10: Soil health, the missing link in sustainable pulse production

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Ashok Kumar Patra is a Director at ICAR-Indian Institute of Soil Science, Bhopal. He served as a Scientist at Indian Grassland and Fodder Research Institute, Jhansi, Senior Scientist at Central Institute of Fisheries Education, Mumbai and Principal Scientist at Indian Agricultural Research Institute, New Delhi. He received B.Sc. in 1983, M.Sc. in 1985 and Ph.D. in 1989. He was Post-Doctoral Fellow at Institute of Grassland & Environmental Research, UK, Ecologie Microbienne (CNRS-Universite' Lyon 1), France, University of Notre Dame, USA. ICRISAT Post-Doctoral Fellowship 1991-1993; INRA Post-Doctoral Fellowship (France) 2001-2003.
Ashok honoured British Council TCT Award (1996), DBT Overseas Associateship Award (2008), FAI Dhiru Morarji Memorial Award (2011), Bharat Jyoti Award (2012), Rajiv Gandhi Excellence Award (2012), Dr. G.S. Sekhon Memorial Lecture Award of ISSS (2012), Hooker Award (2013) and Bioved Agri-innovation Award (2015). He has been editor and associate editor for many journals. He is a Fellow of Range Management Society of India, Indian Society of Soil Science and National Academy of Agricultural Sciences. His research areas are Nitrogen cycling, soil biodiversity, carbon sequestration, and nanoparticles.

In India, pulses are cultivated on marginal lands under rainfed conditions and only 15% of the area under pulses has assured irrigation. Although these crops are nutrient rich, they are cultivated under nutrient-starved low soil fertility environments, and the average yield of most pulse crops in India is low (< 1 Mg ha^{-1}). Therefore, to meet the demand, the country is forced to import 2-5 million tons of pulses annually. To reverse this trend, pulse production in the country has to be increased by integrated management of crop, soil, water, fertilizers and other inputs. The application of nutrients to these crops is far below their removal indicating a net negative nutrient balance, thus impairing the soil health. Imbalanced fertilization coupled with low usage of organic source of nutrients has severely deteriorated soil health in pulses growing soils. The carbon content of the soils under pulse has to be improved to support a healthy balance of nutrients, minerals and soil microbial diversity and improving soil fertility. In addition to lack of application of major nutrients like N, P and K, deficiency of micro nutrients (S, Mo, Zn and Fe) is a major cause of concern to augment pulse production in the country. Climatic aberration is another cause of pulse yield reduction/stagnation as reported by many researchers in India. The regular use of biofertilizers in semi-arid regions of India with best bet management by farmers is rarely practiced. Concerted efforts are therefore needed to manage the soil in pulse growing regions for the maintenance of soil health and improving the productivity in marginal and dryland environments. Soil Health Cards given to those cultivating pulses should be designed to address the specific nutritional needs of these crops. The soil health monitoring and advisory service, which could be equipped to render specific advice, to pulse crop cultivators on the nutrients needed, based on soil testing must be strengthened for a sustainable production system and bridge the huge gaps in potential area and productivity of pulses.

OP11: Interaction of nitrogen fixation and water use efficiency in chickpeas

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Carola Blessing is a postdoc in the Faculty of Agriculture and Environment at the University of Sydney since May 2015. Her research focuses on plant physiological processes in response to environmental stress with the aim to identify traits and mechanisms relevant for drought tolerance in chickpea.
Carola studied geoecology at the Karlsruher Institute of Technology (KIT) in Germany. During her diploma thesis at the Institute for Meteorology and Climate Research (Garmisch-Partenkirchen, Germany) she studied the oxygen isotope exchange between carbon dioxide and leaf water. Carola did her PhD in the Grassland Group at ETH Zurich in Switzerland on carbon allocation in beech saplings under environmental stress focusing on the transport velocity of recently fixed carbon from the canopy to the soil/root system and the coupling of aboveground and belowground carbon fluxes.

Changing climate conditions e.g. drought and an increasing demand for food enhance the pressure on agricultural production. Introducing legumes into crop rotation helps to limit costs for fertilizers as nitrogen is often the limiting element. Legumes supply carbon to nitrogen fixing rhizobia, thus rhizobia compete for carbon with seeds, especially under drought when carbon uptake is limited. Therefore, the interaction between nitrogen fixation and carbon uptake per water loss i.e. water use efficiency (WUE) is crucial. We compare nitrogen fixation and water use efficiency of two contrasting chickpea genotypes in terms of their response to drought grown in Narrabri, Australia. The fractional contribution of N2 fixation to plant nitrogen uptake (Ndfa) is assessed using the 15N natural abundance method, based on genotype specific B values (nitrogen isotope composition of plants grown without nitrogen supply). WUE is approximated via carbon isotope discrimination and yield per received water. Therefore, nitrogen and carbon content as well as nitrogen and carbon isotope composition are measured at two sampling dates (during flowering- before irrigation- and during pod development- after establishing a drought and irrigation treatment) for each tissue separately. While the drought tolerant genotype only shows a reduction in yield of 10% under rain-fed conditions compared to irrigation, the drought susceptible genotype lost 22% in yield due to drought. First results of the sampling at well-watered conditions during flowering show lower Ndfa for the drought tolerant genotype. Significantly lower δ13C values for the drought tolerant genotype suggest higher stomatal conductance, which is usually a trait that is related to low WUE. It will be interesting to see if the drought tolerant genotype maintains low Ndfa and the lavish use of water under drought stress. The difference between shoot and nodule nitrogen isotope composition correlates well (R2 = 0.61) with Ndfa. The study can potentially be extended to further chickpea genotypes grown on the same field using the difference in the nitrogen isotope composition of leaves and nodules to determine Ndfa without measuring the genotype specific B value. Therefore, nitrogen and carbon isotope measurements are a promising tool to screen multiple genotypes for their interaction of Ndfa and WUE.

OP12: Phenotypic and genotypic diversity for tolerance to environmental stresses in rhizobia nodulating lentil and chickpea in Morocco

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Growth and productivity of lentil and chickpea in most of the growing areas is usually affected by different environmental stresses such as drought, extreme temperatures, soil pH, salinity and heavy metals in soils. These environmental stresses also affect biological nitrogen fixing ability of the nodulating rhizobia, thereby affecting growth and productivity of the legume crops. Here, we isolated 206 and 207 rhizobia nodulating lentil and chickpea respectively from 27 sites representing different soil types in Morocco, examined their phenotypic diversity for tolerance to the above environmental stresses, performed molecular diversity analysis using rep-PCR and showed that there is a substantial phenotypic and genotypic diversity exists in the rhizobia population. Phenotypic characterization of 206 lentil rhizobia and 207 chickpea rhizobia for tolerance to environmental stresses revealed identification of strains tolerant to heavy metals, antibiotics, high temperature, salinity and water stress. Rep-PCR analysis showed the presence of substantial diversity among the rhizobia of lentil and chickpea. Two strains of lentil and chickpea rhizobia tolerant to multiple stresses were selected for inoculation of the respective hosts in the field experiments conducted at Marchouch and Ain Sbit sites in Morocco. The results clearly demonstrated the better performance of the inoculated host with respect to nodulation, chlorophyll concentration, dry matter and nitrogen content and yield compared to un-inoculated hosts

OP13: Approaches for efficient conservation and mining of temperate pulses genetic resources

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Ahmed Amri has PhD in Genetic and Plant Breeding from Kansas State University (1989), He worked at INRA-Morocco for 20 years as cereal breeder and release of 17 barley varieties, 5 triticale and 7 bread wheat and durum varieties resistant to Hessian fly.
He worked at ICARDA since 1999 as regional coordinator for a GEF West Asia Dryland Agrobiodiversity project (1999-2005), ICARDA Regional Coordinator for West Asia (2001-2008), Coordinator Iran-ICARDA office (2005-2009) and since 2008, appointed as the Head of Genetic Resources Unit and Deputy Director of the Biodiversity and Integrated Gene Management Program. He has a total of 132 publications including 72 in the refereed journals and advised 27 PhD and MSc students.

Genetic resources, especially landraces and wild relative species are key to ensure continued genetic gains to overcome the effects of major biotic and abiotic stresses. ICARDA plays a crucial role in promoting the conservation of genetic resources and breeding of chickpea, faba bean, grass pea, lentil and pea. Its genebank holds in-trust unique pulses collections totaling more than 48,000 accessions (10029 of faba bean, 15316 of chickpea, 12463 of lentil, 4183 of *Lathyrus* and 6173 of pea). However, more collecting missions are needed mainly to target adaptive traits, fill the gaps and have more wild relative species. ICARDA with its partners have collated passport information from GENESYS, GBIF and other genebanks datasets and used DIVA-GIS program to undertake the gap analysis to guide future collecting missions and to recommend hot biodiversity spots for *in situ* conservation efforts. Patterns of specific richness and complementary analysis showed priority areas for collecting around the Mediterranean basin and priority hotspot for *in situ* conservation in the border between Syria and Lebanon. Conservation of genetic resources should be tightly linked with their use in breeding new varieties able to overcome the challenges imposed by climate change and to respond to the needs of users. ICARDA and its partners have developed the Focused Identification of Germplasm Strategy (FIGS) as an alternative and efficient approach to select best-bet and manageable subsets for sought traits based on relationships between environmental conditions of the collecting site and the trait. This approach is routinely used to respond to the seed requests and the available evaluation information showed the relevance of the approach in identifying novel diversity and efficient sources of resistance/tolerance to diseases, insects and drought. This contribution will present the results of gap analysis and FIGS approach and highlights the needs for developing strong pre-breeding activities to introgress useful genes from landraces and wild species in different genepools.

OP14: Walking on the wild side - expanding genetic diversity for future lentil breeding

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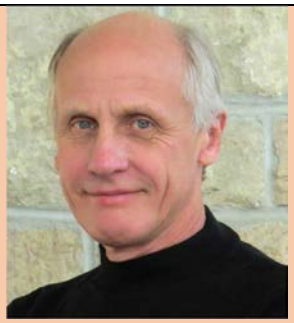

Albert Vandenberg is a professor and NSERC Industrial Research Chair on Lentil Genetic Improvement at the University of Saskatchewan. He has been actively conducting research on genetics and breeding of lentils since 1983. During his tenure, Canada has expanded its lentil production from 24,000 acres in the 1980s to 3 million acres in 2014, with more 90% of the production coming from Saskatchewan. Canada has become the world's largest producer and exporter of lentils, a crop that is expanding in per capita consumption around the world. Dr. Vandenberg is a leading influence in the Canadian pulse industry and has been instrumental in the development and commercialization of varieties of many pulse market classes. Dr. Vandenberg is engaged in many aspects of pulse crop research, including genomics, agronomy, processing and utilization, and human nutrition. In 2013 he received the Global Pulse Industry Award for Excellence from Confédération Internationale du Commerce et des Industries des Légumes Secs - International Pulse Trade and Industries Confederation (CICILS-IPTIC), the peak body for the world's pulse crop industry.

Systematic use of genetic variability through judicious use of diverse germplasm maximizes genetic gain per generation, and therefore, maximizes economic value of the crop. Sometime, however, the required genetic variation is simply not to be found in the cultivated germplasm. Under these circumstances, breeders may consider the use of wild relatives. The genus Lens consists of the cultivated *L. culinaris* plus six wild species. Wild relatives of lentil represent a rich source of resistance to both biotic and abiotic stresses, yet very little is known about them. The lentil research and breeding group at the University of Saskatchewan has been studying cultivated lentil and its wild relatives for the past two decades and has generated a wealth of cultivated x wild genetic resources, some of which have already shown utility in the breeding program. In the past few years we have worked with several international partners (Spain, Turkey, Morocco, Bangladesh, and Ethiopia) to phenotype promising individuals from three inter-specific populations (two *L. culinaris* x *L. ervodies* and one *L. culinaris* x *L. orientalis*) under several biotic and abiotic stresses. Over the next few years we plan to phenotypically and genotypically characterize the genetic variability available within the primary and secondary gene pools of genus Lens to determine the genetic basis of domestication and adaptation characteristics. Tools will also be generated for tracking introgressions from wild genomes into the cultivated one. The goal is to develop breeder-friendly resources for tracking key domestication genes, response to photoperiod, temperature and light quality, and generate resources and tools to allow breeders to better use exotic germplasm and wild relatives while reducing any negative impacts. It is anticipated that results of our work will contribute to lentil genetic improvement, conservation of biodiversity, and global food security.

OP15: Mining natural genetic variation from old and new germplasm collections for chickpea breeding

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R Varma Penmetsa is a legume biologist and molecular geneticist at the University of California-Davis. His academic background spans both applied and basic plant sciences, from a Bachelor degree in Agricultural Science (GB Pant University, India), and graduate degrees in Crop Science (MS, Virginia Tech), and Genetics (PhD, Texas A&M University). He has a longstanding engagement in legume biology that began with the molecular genetics of symbiotic development in the model legume *Medicago truncatula*. Subsequently, he was involved in comparative genetics and genomics of food crop legumes with the goal of improving molecular genomic resources in legume crops, particularly those of relevance to the developing regions of the world. This later work was conducted in collaboration with an international network of partners. Recent and current research is aimed at defining the genetic architecture of legume crop domestication and diversification, the molecular cloning and use of agronomically-relevant traits in food crop legumes, principally chickpea.

Phenotypic and genetic variation underpins the study of biological phenomena and as the building blocks for crop improvement. The global network of plant germplasm repositories are a crucial, long-term repository of such variation. Results from work on cultivated and wild chickpea germplasm, spanning both use previously collected germplasm in repositories and recently prospected material from extant wild populations of chickpea's progenitor *Cicer reticulatum* and its sister species *Cicer echinospermum* from the secondary gene pool will be presented. Lessons learnt from this first-hand account may be informative to the collection, distribution, characterization and use of germplasm resources.

OP16: Molecular approach for studying genetic diversity and population genetic structure of Asiatic *Vigna* accessions

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Aditya Pratap, born on October 18, 1976 has an illustrious career in crop improvement research. His research interests include distant hybridization, doubled haploidy breeding, plant tissue culture, and molecular breeding. Since about twelve years he has been working on genetic improvement of mungbean, chickpea and rapeseed-mustard and contributed in development of 7 popular varieties including 3 of mungbean (IPM 410-3, IPM 02-14, IPM 02-3), 3 of rapeseed-mustard (RSPT2, RSPR03, RSPN 25) and 1 of facultative winter wheat (Him Pratham). He has also developed 2 extra early mungbean genotypes (IPM 205-7 and IPM 409-4) maturing in <52 days and identified 2 photo- and thermo insensitive *Vigna* accessions. He has accomplished morphological and molecular characterization of *Vigna* species, marker assisted introgression of resistance to Fusarium wilt in chickpea, mapping and tagging of MYMIV resistance gene in blackgram, and development of haploidy breeding protocol in triticale through wheat x Imperata cylindrica system. Besides undertaking prebreeding and distant hybridization in mungbean, he has also established population structure in wild and cultivated *Vigna* besides cross-transferring a number of markers to them. To his credit he has 5 books and >130 articles including 45 research publications in high impact journals and 40 book chapters. He is a recipient of prestigious ICAR-Lal Bahadur Shashtri Outstanding Young Scientist Award-2014 and the Norman E. Borlaug International Agricultural Science and Technology Fellowship in 2011 besides several other awards.

For genetic improvement of mungbean (*Vigna radiata* L.), a short duration grain legume, mostly cultivated germplasm and exotic lines have been used so far for making crosses. However, their wild relatives offer plethora of genes conferring resistance/tolerance to biotic and abiotic stresses and quality traits besides resilience to changing climate. Their successful utilization in introgression breeding requires basic information about their population structure, genetic diversity, species relationships and distribution of variation in the gene pools. This study estimated the level of genetic diversity and population genetic structure of 53 representative accessions of cultivated and wild Asiatic *Vigna* belonging to 13 species collected from diversity rich endemic areas of India using microsatellite markers and morphological descriptors. Among these accessions 539 alleles were detected at all loci with an average of 10.16 alleles per locus. The major allele frequency varied from 0.16 to 0.65 (mean=0.30) while polymorphism information content of markers ranged from 0.47 to 0.89 (mean=0.79). The UPGMA revealed five major clusters accommodating ~96% of accessions. The largest cluster accommodated 19 (36%) while the smallest had only two accessions. The model-based population structure analysis also grouped 53 accessions into five genetically distinct sub-populations (K=5) based on maximum ΔK values. Duncan's multiple range test (DMRT) with 22 morphological descriptors also revealed significant difference among five genetic and one admixture group. Analysis of variance for morphological data revealed significant difference in 12 qualitative and quantitative traits indicating their significance in distinguishing population groups. The above information on wild and cultivated accessions of Asiatic *Vigna* will be tremendously useful in expediting their use in trait improvement through introgression breeding.

OP17: Rice fallows - An opportunity for horizontal expansion of pulses

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Masood Ali is a renowned pulse agronomist. He served as Director of the Indian Institute of Pulses Research, Kanpur during 1999-2009 and Technical Adviser (Pulses) under National Seeds Corporation of India (2011-12). Presently, he is a member of the Executive Committee of the National Food Security Mission, Govt. of India. Dr. Ali has a long (38 years) and rich experience in food legume research and management. Dr. Ali has published over 335 research/scientific papers, and edited/authored 14 books and 14 research bulletins. In recognition of his outstanding contribution in pulses research and development, dryland crop management practices and cropping system research, he has been honoured with several national and international prestigious awards. He served as President of the Indian Society of Pulses Research and Development for 7 years. He is fellow of several academies/societies including the National Academy of Agricultural Sciences.

In recent years, the value of pulses as a "Health Food", is far more recognized globally. In the dry areas, they serve as a backbone for sustainable production and livelihood security of resource-poor farmers. Global efforts are underway to increase pulse production through two-pronged strategies i.e., improving productivity and area expansion. So far, the productivity gain has been small and therefore, area expansion through intensification, diversification and introduction in new niches like rice fallows assumes great significance. Rice fallows basically imply to those lowland summer (July-September) sown rice areas which remain un-cropped during winter due to various reasons such as lack of irrigation, early withdrawal of monsoon, excessive moisture in November/December, lack of appropriate varieties for late planting, cultivation of long duration rice varieties in mono-cropping system, and socio-economic problems like stray cattle, blue bulls etc. Rice fallows are widely spread in South Asia (15 m ha), however, major area (11.65 m ha) lies in India. In India, rice fallows are spread in eastern (6.03 m ha), central (5.09 m ha) as well as in southern (0.51 m ha) regions, each having distinct bio-physical, climatic and socio-economic features, and rice-ecology. Productivity in rice fallows is quite low due to moisture stress during crop season, terminal drought, poor plant stand, lack of quality seeds, weed menace, poor crop management, and biotic stresses. Pulses are the most potential crop for introduction in rice fallows due to their short duration and low input requirements. In India, lathyrus, lentil, urdbean, mungbean and peas occupy about 1 m ha area in rice fallows and have prospects for further expansion (3-4 m ha), with technological back-up, aggressive R&D efforts, institutional support and appropriate policies. Similar changes may also happen in Nepal and Bangladesh. Considering the vast potential of rice fallows for expansion of pulses, special projects have been implemented under the National Food Security Mission in India. The major emphasis in these projects has been on introduction of high-yielding short duration varieties, seed production, capacity building and public awareness. ICARDA has also launched OFID sponsored project in Nepal and Bangladesh on "Enhancing pulse production through intensification of rice fallows with pulse as a second crop for food and nutritional security" in 2013. Technological back-up is being provided by the All India Coordinated Research Project on Mungbean, Urdbean, Lentil, Lathyrus, Rajmash and Peas. Recently, a network project on "Mitigating abiotic stresses and enhancing resource-use efficiency in pulses in rice fallows through innovative resource conservation practices" has been launched as a flagship project of ICAR at five centres. Some of the technological options are: popularization of the identified varieties and their seed production, seed priming, enhanced seed rate, seed inoculation with Rhizobium culture and PSB with 2% foliar spray of urea at flowering-pod initiation stage, retaining 20-30 cm rice stubbles and spraying Quizalofop-p-ethyl @ 100 g/ha to check stubble regeneration, mulching with paddy straw, application of post-emergence herbicide (Imazethapyr @ 1 kg/ha) and use of Zero-till seed-cum- fertilizer drill. Some of the R&D issues like disaggregated mapping of rice fallows, consolidation of past outcomes, initiating pilot projects with holistic approach, mechanization and policy issues such as creation of community water reservoirs and quality seed bank, rural credit, marketing infrastructure and containing menace of stray cattle need to be adequately addressed.

OP18: Varietal and seed use of faba bean in Ethiopia: Implication for the national seed system

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Dawit Alemu is the director of Agricultural Economics, Extension and Gender Research Directorate, Ethiopian Institute of Agricultural Research (EIAR). He Associated with EIAR since 1999 as a senior research. Dawit obtained PhD in agricultural economics. Dawit research is focusing on agricultural marketing with due emphasis to agricultural inputs.
Dawit has published 34 peer-reviewed journal articles, 8 chapters in books, 27 serial publications and 20 publications in proceedings.

The paper presents the varietal and seed use of faba bean using primary data collected from 370 faba bean producing farmers covering 19 districts in 13 major faba bean growing zones of Amhara, Oromia, SNNPR and Tigray regions in Ethiopia. The results indicated that the participation of the formal seed system in faba bean is limited though there are more than 30 improved varieties released so far in Ethiopia. The adoption rate at household level indicated that 25.9% of the farmers are full adopters, 1.6% partial adopters and the rest 72.4% were non-adopters estimated based on plot level use of improved varieties. This has partly resulted in the productivity gaps between research estimated at 3.6 ton/ha, adopters (3.2 ton/ha) and national level (1.5 ton/ha). Moreover, only 6.3% of farmers purchased certified seeds whereas 19.5% purchased or exchanged seed from local sources and 74.2% used own saved seeds. The current status calls for the need to strengthen the promotion of available improved varieties and for the formal sector to be engaged in faba bean seed delivery to ensure better adoption.

OP19: Increased adoption of modern technologies and competiveness of legumes value chain players through the Private Public Partnership

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Mphatso Dakamau has experience and skills in Agriculture Value Chains Management, Project Management, and Agricultural Finance. He is currently working as the Program Manager responsible for Legumes Development Trust and the Malawi Agricultural Partnership Program. His main responsibility is to strengthen and improve the legumes value chains through collaboration and knowledge sharing so that it is vibrant and viable. Throughout his progressive profession in the past seven years, Mphatso has participated in institutional and market reforms such as the Minimum price policy, development of Export Development Fund of Malawi, and establishment of the AHL Commodity Exchange, among others. Mphatso has also served in different National platforms/Working groups such as the Agriculture SWAp technical working groups; Trade SWAp technical Working groups; Malawi Agriculture Forum for Advisory Services; National Taskforce for the Farm Input Subsidy Program; National Conservation Agriculture Task Force; and Horticulture Development National Task Force.

For a long time Tobacco and Maize dominated agricultural sector investments and policy in Malawi. But through the diversification program, the legumes sub-sector is now considered as one of the key sub-sectors due to its potential to increase incomes of rural farmers and its spill over benefits to other sectors such as the health in terms of nutrition. The government of Malawi has identified and is promoting the intensification of legume crops as potential replacement for Tobacco as the key export crop and major forex earner, as outlined in the National Export Strategy (NES), Malawi Growth and Development Strategy (MGDS) and the Agriculture Sector-wide Approach (ASWAP). Despite the growing interest and promotion of legume crops and pulses, the sub-sector faces supply and demand constraints that limit its potential in Malawi. Some of the challenges include poor access to improved technologies for enhancing yields and quality, low soil fertility – farmers hardly use fertilizers, lack of collective activity and support among smallholder farmers, uncoordinated interventions and efforts by the public and private sectors as well as low profitability for the farmers. In order to resolve the challenges, stakeholders who form the value chains of various legume crops especially groundnut, soybean, common bean and pigeon pea formed the Legumes Development Trust (LDT) in 2013. The LDT uses the value chain approach so as to engage all players which include input suppliers, farmers, farmer organizations, traders, processors, donor partners and government departments in a Public-Private Partnership (PPP). Therefore the LDT coordinates and facilitates the formation of linkages of the stakeholders in order to promote and stimulate investments in the legumes subsector which will directly and indirectly resolve the challenges faced at all levels. This paper reviewed three of the initiatives in the legumes subsector which include the Malawi Multi-stakeholder partnership program, The Malawi Seed Alliance Program and the Malawi Oil Seed Transformation program. The review considered the progress reports, historical data, key informant interviews and field data verification exercises. It also used the authors' knowledge and experience in managing some of the programs under review. The results show that through the promotion of public private partnership in Malawi there is increased adoption of modern technologies hence increased competitiveness along the value chains in general. There are 7 notable impacts which have been achieved through the public partnerships as stated in the project above. They include: release of (more than 6) new seed varieties which are high yielding and more disease and drought tolerant, increased use/adoption of new production technologies by stakeholders in Malawi i.e. inoculants and agricultural chemicals, increased production and productivity of legume crops, more investments in the legumes sub-sector as it becomes more coordinated, increase exports of legume crops compared to the previous season, and Improved collaboration and coordination among stakeholders in the legumes value chains.

OP20: Plant-pollinator inter-play in pulses in the context of ecosystem health

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María José Suso is a Research Scientist at the Department of Plant Breeding in the Institute of Sustainable Agriculture (IAS) of the Spanish National Council of Research (CSIC). She has been working in the field of legume crop improvement and pollination for pollinator-friendly cultivar development, genetic resources germplasm conservation and management and local adaptation for low-input and organic agriculture. In the last five years she has worked as Spanish Project Leader of two EU-funded collaborative projects, Strategies for organic and low–input integrated breeding and management (SOLIBAM) and Embedding crop diversity and networking for local high quality food systems. During this time she has been nominated by the UN Environment Programme as "Expert Reviewer of the First and Second Order Draft, Deliverable 3(a) report - Thematic assessment of pollinators, pollination and food production" for the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (2015). She has been nominated by the European Commission as expert for the European Innovation Partnerships - Focus Group (EIP-FG) on Genetic Resources- Cooperation Models. She is MC Substitute at the Food and Agriculture COST Action FA1307, Sustainable pollination in Europe: joint research on bees and other pollinators (SUPER-B) (2014-2018). She is Member of the Spanish National Commission for the Evaluation and Registration of Forage and Grain Legumes Varieties. (2012-2015). She has assisted the European Commission in tasks/external evaluator related to its research programme. She lead and co-author of several peer-reviewed international high impact journals, book chapters and other publications

Pulses are pollinated by several apoid species. However, the plant pollinator inter-play does not get much attention as a useful tool in breeding planning. The attention that should be given to the understanding of the interplay plant-pollinator in pulses is the consequence of the combined importance of the pollination for the production service and breeding strategies, plus the increasing urgency, in mitigating bee-pollinators decline by the development / implementation of conservation measures. Faced with an increasingly uncertain climate and a global decline on biodiversity, the ability to incorporate the potential benefits of insect pollinators will become increasingly important to protect yields. Further, it is important to highlight that pollination and pollinators are very significant for the production of local pulse crops that are important for local communities. However, it is highly likely that bee-pollinated pulses grown today are suboptimal in terms of their floral traits for attracting and sustaining their pollinator populations. Pulses breeding for sustainable agriculture, in the face of climate change, demands the development of non-food services. Foraging places for bees are some of the ecological services provided for pulses. Declines in bee populations have increased the interest in this particular ecological service of pulses. Moreover, pulses have a great potential to be served by bee pollinators. Pollinators, as agents of crossing are natural breeders of highest importance for the development of hybrids and/or heterotic high yielding and resilient open-pollinated populations. Farmers should use pollinator-friendly crops to increase the occurrence, health and visitation of pollinators. Designing the right crop, appropriate and effective in a particular site, is where management of pollination becomes key. It is necessary the construction of a conceptual framework and an analytical tool to develop approaches in pulse production, based on understanding and sustainable use of pollinators. The view point is that plant-pollinator interplay understanding may inform breeding approaches for a sustainable agriculture to meet both goals: 1) optimal productivity (food production service), based on an efficient use of pollinators, and 2) biodiversity conservation (ecological service). To implement this approach, the methodology proposed is to support native pollinators for insect-mediated outcrossing by designing a crop with appropriate functional flower traits: Crop Design System (CDS). In the CDS approach, breeders and farmers incorporate the potential benefits of pollen vectors into practices to increase the efficiency of hybrid seed technology and, in parallel, increase the occurrence, health and visitation of pollinators, whether these are wild or managed, by developing pollinator-friendly crops. The topic is timely because initiatives, at world level (the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), on the assessment of pollination and pollinators associated with food production confirmed that the management of pollinators is an issue of paramount importance to our food supply system and food security.

OP21: Ensuring seed security and production of rainfed pulses in semi-arid tropics

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Ch Ravinder Reddy has been the Scientist at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India. Dr Ravinder, born in 1955, hails from a farming family from Madipally village in Warangal district of Andhra Pradesh, India. He had his primary and secondary education at Hyderabad and completed his B.Sc. (Agri) from Acharya NG Ranga Agricultural University, Hyderabad in 1977 and received his MSc (Agri) in 1980 and PhD (Agri) in plant pathology from Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu in 1988.

Dr Ravinder Reddy has a blend of experience from both private and public sectors as a researcher and administrator. He has been associated with different national and international developmental projects at ICRISAT where he has been advocating the farming communities for grey to green revolution in the rainfed areas. His vision and services have been towards enhancing the livelihoods of small and marginal scale farming households in Asia through various innovative interventions and through a coalition and consortium approach of different resource institutions for the benefit of the farmers. Dr. Reddy specialized interest in developing seed systems models for rainfed crops in SAT regions of Asia achieved good recognition. Dr. Reddy has published more than 40 research articles and 12 books and bulletins. Dr Ravinder honored with 12 awards and Certificate of Appreciation from various National and International Institutions for his meritorious and outstanding contribution in the field of agricultural research and development.

The debate on seed security systems has broadened from a traditional focus on direct interventions targeting one or more dimensions of seed security (availability, access and quality) to newer approaches aimed at linking formal and informal systems and the development of resilient seed systems. Some of the key factors responsible for poor crop yields is poor quality seeds, degenerated cultivars, lack of access to the availability of quality seed by the farmers and nonexistence of policy mechanism to strengthen seed systems of pulses to supply high yielding adaptable varieties and hybrids in different eco regions. Private seed companies are not showing much interest in seed production and distribution of seeds of pulse crop varieties as profit margins are lower than in case of hybrid cultivars of commercial crops. Existing government seed systems are not able to meet the demand of millions of small farm holders in addition to the normal problems associated with the government seed delivery system. We have developed, piloted and demonstrated the decentralized seed systems for rainfed self as well as cross pollinated crops involving the Farmer Producer Companies which is a business institution of men and women small farm holders recognized and supported by the Federal Government. Thus a Seed system development through strategic integration of formal and informal systems is implemented ensuring seed system resilience. This alternate seed delivery system has good potential to ensure quality seed supply to small farm holders, not only help the farmers to have access to improved varieties, quality seeds at reasonable costs in their own villages but also provide Income and livelihood security through establishment of village based seed enterprise by the small -scale farmers.

OP22: Pulses suitability assessment for sustainable productivity of drylands of Morocco

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In Morocco, pulses are essential constituents in the food system and also vital sources of protein, fiber and carbohydrates. Before 1992, Morocco was pulse exporter to Europe but from 2008 to 2013, government has spent US$ 122 million on importing about 150,000 tons of chickpea, lentil and faba bean. In order to reduce the import dependency by increasing local pulses production, decision makers have to encourage farmers to adopt pulses as rotation with cereals. Land suitability is a function of crop requirement and soil characteristics. Its analysis is a prerequisite to realize optimum utilization of the available land resources for sustainable agricultural production. Hence, deep understanding of the soil and climate constraints to pulse production is likely to increase adoption and extent of pulses in Morocco. Suitability for chickpea, faba bean and lentil was derived through a process of rating land qualities against physiological requirements of each crop. The ratings are based primarily on agronomic criteria's obtained through several research trials. Overall, ten land qualities were rated, some examples of these are pH, texture, waterlogging, and rooting depth. This land evaluation is based on crop length growth period as climate to indicate areas suitable for crop growth during wet or dry years. This identification and delineation of suitable areas for growing pulse crops has become imperative so that future research and extension programs can be developed in a realistic manner. From this study, generated land capability maps concluded that pulses have good prospects for expansion in Morocco.

OP23: Adoption and impact of improved legume varieties in rotation on cereal yield, household income and food self-sufficiency in the Ethiopian highlands

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Solomon Tiruneh had been working as an Agricultural Economics researcher in Amhara Agricultural Research Institute (Ethiopia) from Oct, 2006 to June, 2015. Currently, he has been working as socioeconomics researcher in Water and Land Resource Center (WLRC) which established by bilateral agreement between the Government of Ethiopia and Swiss Development Cooperation (SDC) with University of Bern. The center has mandated to generate evidence-based information and knowledge for policy and practices about sustainable water and land management in Ethiopia and Eastern Nile sub-region at large. In his career, he led and participated in many research activities in adoption and impact evaluations, value chain, baseline studies and policy analysis. Moreover, he had a chance of working with many NGOs and CGIAR centers (ICARDA, ICRISAT, IWMI).

Poor soils and low adoption of improved crop varieties are the main reasons for low productivity and malnutrition in Ethiopian highlands. Food legumes play a cardinal role in nutrient cycling and nutrient enrichment and are considered as engines of sustainable farming. Therefore, the adoption of high yielding legume varieties and cereal-legume rotation could help in increasing not only legume yields and hence consumption but also the yields of subsequent cereals. Using the Propensity Score Matching and Instrumental Variables approaches, this paper finds that at a current average adoption level of 16.37%, improved legume varieties lead to yield and farm income gains of 21% and 23% respectively. Currently, legume-cereal rotation is practiced by 29% and 62% of barley and wheat farmers thereby leading to yield increases of 22% and 27% and income gains of 55% and 79% respectively. Rotation and adoption of improved legume varieties have also a combined impact of reducing number of people relying on food aid and food-for-work during critical periods by 45% and 89% respectively. Model results show that access to seed, availability of family labour and soil characteristics are among the major determinants of the adoption of legume-cereal rotations. These results point to the need for increased emphasis by government and other stakeholders to enhance wider adoption of improved legume varieties through better access to seeds, promotion of labor saving soil management practices and improving extension services to better inform farmers on the benefits of improved legume technologies and legume-cereal rotations.

OP24: Spatial BigData Analytics for intensification of pulses

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His current research focus is on developing digital agriculture, bigdata analytics, resilient agro-ecosystems, sustainable intensification, enhancing input use efficiency for delivering better interventions and package of practices to reach out to smallholding farmers to improve food security and livelihood in the dry areas. He has been recognized with number of international awards and honors such as the Young Scientist of the Year, Outstanding Young Scientist, Best Team Initiative, Outstanding Team Member, Board Member, Steering Committee Member, and Panel Member of Geoinformatics for Agriculture, Working Group on high resolution remote sensing, advisory member of WMO/GWP's Integrated Drought management Program (IDMP), recently received Outstanding Young Scientist Award from the Association of Agricultural Scientists of Indian Origin affiliated with the American Society of Agronomy.

Supply-demand gap of agricultural commodities continues to rise while total arable land area is not expected to increase significantly. Future increases in agricultural production, particularly pulses, will be contingent upon agricultural intensification. One such intensification opportunity lies in the potential use of pulses in crop-fallows (e.g., rice fallows, accounts ~12 million ha in India alone) and other cropping g systems in different countries. Along with other constraints in the use of fallows, lack of updated and timely information is one of the major constraints in understanding the spatio-temporal dynamics of crop production- its spatial distribution, pattern, extent, intensity, duration, rotation and feasibility. Cropping systems dynamics varies across agro-ecosystems, mostly driven by climate, markets, and agronomic/cultural practices. Consequently, there is a need to establish a digital decision system which provides accurate and timely information that would facilitate the development of appropriate intervention packages that consist of improved- crop varieties, inputs use efficiency, nutrient balance, and agronomic practices. An important input into these analytics is the Earth Observation Systems and big-data analytics to assist in the identification and prioritize extrapolation domains for pulses across the spatio-temporal scales. Near-real-time satellite remote sensing along with climate and in-situ observations (meteorological stations and cell phones) will accelerate interventions and decision making by capitalizing upon input use efficiency; invests in sustainable land, water, crop and management practices; that will promote sustainable resource use and enhance livelihoods. The overarching focus is the development of an interactive digital-agriculture platform (e.g., http://geoagro.icarda.org/india/) that contributes to the emergence of sustainable intensification of pulses and allied crops.

OP25: Transgenic - A way forward for managing key stresses in pulses

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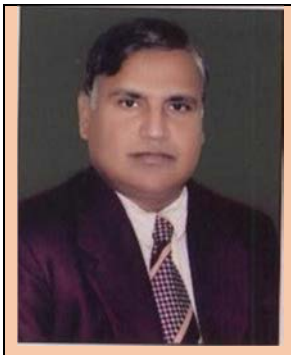

Narendra Pratap Singh is an eminent pulse geneticist currently working as the Director of ICAR-Indian Institute of Pulses Research, Kanpur. Previously, Dr. Singh was coordinating and guiding national chickpea research programme as Project Coordinator (Chickpea). He obtained his Ph.D. in Genetics from Indian Agricultural Research Institute, New Delhi. Dr. Singh acquired advanced training in early days of his career in the area of molecular biology and genetic transformation from leading biotechnology laboratories in India and abroad. He also served as visiting scientist at WA Biotechnology Centre, Murdoch University, Perth, Australia, and at the Plant Biotechnology Institute, NRC, Saskatoon, Canada. He has been instrumental in development of a number of improved varieties of pulses. Dr. Singh has published more than 200 research/conference papers in national and international journals of repute. He has served as a member of many important committees *viz.*, RCGM sub-committee on grain legumes, advisor/consultant for establishing PG Diploma courses in Biotechnology in UP Polytechnics, international Coordinator (Translational Research), International Chickpea Genetics and Genomics Consortium (ICGGC), etc. He has guided several Ph.D. and M.Sc. students in the area of genetics and biotechnology. He was instrumental in creating world class state of art facilities of biotechnology at IIPR, Kanpur, and is pioneer in application tools of biotechnology in pulse improvement in India. Dr. Singh is presently president of Indian Society of Pulses Research and Development and has also served earlier as the Editor-in Chief of Journal of Food Legumes besides being in the editorial board of several Indian and International Journals. He is a recipient of several coveted Awards including the prestigious Bioved Merit Award.

Grain legumes or pulses are key component to food security owing to its capacity for symbiotic nitrogen fixation and primary source of human dietary protein. The sustainability of the pulses production is threatened by several biotic and abiotic stresses. Genetic manipulation of the grain legume is potential approach for obviating such stresses thus addressing sustainability and increase in production. Pulses (chickpea and pigeonpea) are recalcitrant to transformation because of very low regeneration potential that can be amenable to genetic transformation. We have developed transformation-amenable regeneration system based on direct organogenesis from meristematic tissues of chickpea and pigeonpea seeds and *in vitro* grafting system to establish mature fertile plants. Insect resistance trait governed by *Bt* gene (gene derived from gram positive soil bacterium *Bacillus thuringiensis*) was used to develop transgenic chickpea and pigeonpea lines that exhibit *in-built* resistance to gram pod borer (*Helicoverpa armigera* H.). Such resistant lines can be used as potential donor for insect resistance breeding programme in pulses, and eventually curtail loss incurred in the pulses to the tune of 25-30%. Similarly, we have also developed transgenic chickpea lines (*At*DREB1a derived from *Arabidopsis*) that exhibit better physiological adaptation to drought (water limiting stress). Identification of key genes related to other biotic stress (fungus, bacteria, virus etc) climate resilient stress are required, in order to expand the repertoire of traits that can be incorporated in future. Novel strategies like marker free transgenics, stacked/pyramided traits with regulatory elements for *spatio*-temporal expression (like pod specific promoter) are required in the future for managing key stresses effectively.

OP26: Exploitation of heterosis for major yield breakthrough in pulses: Pigeonpea - a case study

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Pigeonpea is an often cross pollinated crop of grain legumes and unique jewel in rainfed cropping systems of Asia and Eastern and Southern Africa. It is mainly cultivated as rainfed crop with cereals, pulses, millets and oilseeds in various cropping systems and offers a sustenance to the soil and assured income to the farming community as an insurance during abnormal weather conditions like drought. More than 100 varieties are being released across the globe for various agro ecologies with a wide range of maturity groups; early (120 days); medium (150 days) and long duration (180 days). The cultivation is expanded to nearly 6 Million Hectares by 2015 but the productivity is very low (around 750 kg/ha) for the past 6 decades. Cytoplasmic and genetic male sterility based hybrids in field crops led to tremendous increase in productivity by exploiting the genetic principles of heterosis. The phenomenon of hybrid vigor was successfully exploited in pigeon pea by identifying sources of male sterility from the wild relatives. It took three decades of research efforts to develop stable maintainers, complete restorers and heterotic hybrid combinations. The hybrids ICPH 2671, ICPH 2740 and ICPH 3762 were released for general cultivation by the farmers in different agro ecoregions of India and a number of other hybrids are in the pipeline. Yield advantage of 30 to 40% (rainfed) and 50 to 60% (irrigated) was realized in farmers' fields over the local varieties. Seed production technology was also standardized by exploiting male sterility and entomophily thereby appreciable amounts of hybrid seeds were harvested from the seed parent. Conventional and genomic approaches are underway to identify candidate genes responsible for fertility restoration, elite parents with resistance to Fusarium wilt and sterility mosaic disease and heterotic gene pools to breed adaptive hybrids for different niches across the globe. Efforts are also underway to develop hybrids in different maturity group's vij. Super early, early, medium and long duration to recommend adaptive hybrids for different niches.

OP27: Breeding pulses for nutritional quality with emphasis on bio-fortification

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Pulses are important dietary source of nutrients for human health either directly, as a component of diet, or indirectly, being used to feed livestock. Pulse-based diets provide an exceptional variety of essential nutrients including good quality carbohydrate, protein, fiber, macro- and micronutrients and vitamins to support human health; nevertheless they also contain anti-nutritional compounds. Pulses significantly contribute to nutritional requirements of low-income consumers, who cannot afford costly animal products. They are essential components of traditional dish in Asia and Africa. Research efforts are underway to enhance some of these nutrients in seeds of major pulse crops to increase their availability in daily diet. Over 2 billion people in the developing countries suffer from micronutrient malnutrition. Of them, iron and zinc deficiencies are the major public health concerns with women and children particularly affected. Bio-fortification through conventional breeding is one of the means to address this issue, and major research thrust is put forward in lentil, chickpea, common bean and mung bean to increase iron and zinc contents in their seeds. Considerable genetic variation exists among germplasm for these elements, thus providing scope for genetic enhancement. The International Center for Agricultural Research in the Dry Areas (ICARDA) under CRP-A4NH (HarvestPlus) is engaged in enhancing iron and zinc contents in lentil seeds. Analyzing >1700 germplasm and breeding lines, it has been observed that iron content varies from 43 to 132 ppm and zinc content ranges from 22 to 95 ppm. Parents with high Fe (>70 ppm) and Zn (>55 ppm) have been identified and used in national and international breeding programs and primary, secondary and final products have been developed. A wild accession of *Lens orientalis*, ILWL118 having 150 ppm Fe is being extensively used in pre-breeding program. Genetically fixed lines and segregating populations are shared with national programs under LIEN-MN international nursery. Promising lentil lines with good agronomic performance, disease resistance and high micronutrient content have been selected in Nepal, Ethiopia and Bangladesh (RL-12 (Fe 109 ppm), RL-6 (Fe 103 ppm), RL-9 (102 ppm), FLIP 96-54L, ILL 7715 (Fe 94 ppm) and 95S167(Fe 86 ppm & Zn 63 ppm). Lentil varieties with high Fe (71-102 ppm) and Zn (51-64 ppm) are under cultivation in Bangladesh, Ethiopia, Nepal, Morocco, Turkey, Syria, Lesotho and Portugal. Bangladesh is producing >186,000 tons of micronutrient-dense varieties: Barimasur-4 (Fe 86 ppm & Zn 51 ppm), Barimasur-5 (Fe 86 ppm & Zn 59 ppm), Barimasur-6 (Fe 86 ppm & Zn 63 ppm), Barimasur-7 (Fe 81 ppm & Zn 61 ppm) and Barimasur-8 (Fe 75 ppm & Zn 62 ppm). Similarly, Alemaya with 82 ppm Fe and 62 ppm Zn is extensively grown by Ethiopian farmers. Findings from quality enhancement research in pulses revealed enough scope to improve nutritional quality, most particularly iron and zinc content. An integrated approach including nutritional component should be taken into consideration along with other economic traits from the initial stage of breeding programs to provide abundance in pulses seeds, and role in nutrition and health.

OP28: Association mapping for flowering time in lentil

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Lentil is mostly grown as cool season crop under residual soil moisture conditions. Therefore, it invariably encounters terminal moisture and heat stresses during the growth and development. As a result, it leads to forced maturity and lower yield. Possibilities of forced maturity can further increase in coming years by rising global temperature due to climate change and also due to delayed sowing after late harvesting of rice. These situations leave a window of 100-110 days for growing lentil in several countries including India. Therefore, it is required to develop early maturing cultivars to fit within this short window in order to harvest the highest yield potential within this period. In this context, knowledge of genetics of flowering time is important for developing early flowering genotypes. In the present study, a diverse panel of lentil germplasm comprising of 57 accessions was used (i) to phenotype flowering time over locations and years, (ii) to analyze genetic diversity using molecular markers and (iii) to identify molecular markers association with flowering time through association mapping. The results showed significant differences in flowering time over years and locations among genotypes due to differences in temperature and photoperiod. Genotype-Environment interaction was also highly significant. Flowering time showed high broad sense heritability estimate (h^2=0.99). Molecular diversity analysis with 16 polymorphic SSR markers resulted in amplification 26 loci ranging 1-3 loci per marker. Model-based cluster analysis led to the determination of three distinct subpopulations. All three subpopulations had shared genotypes of other subpopulations. Fourteen accessions grouped in the first sub-population had 71% accessions with more than 80 days to flower. In the second subpopulation, 10 (>44%) accessions flowered in less than 60 days and 8 accessions (39%) flowered in more than 80 days. In the third subpopulation, 12 out of 20 accessions (60%) flowered in less than 60 days and 4 accessions each (20%) flowered in 60-80 days and >80 days. The association mapping analysis showed significant association ($p < 0.05$) of a SSR marker ALD 70 with flowering time following GLM, which explained 0.56% of phenotypic variation. This marker has been identified among the elite lines and can have a high probability to have tight linkage with flowering time. Therefore, it can be useful in breeding program in development of early maturing genotypes.

OP29: Exploring management options to increase pulses production by using simulation models: An application to dryland systems

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Hélène Marrou holds a PhD in Agronomy from Montpellier Supagro (France) where she is now an assistant professor. Her teaching focuses on modeling and crop physiology while she conducts her research on Mediterranean cropping systems within the SYSTEM group (http://umr-system.cirad.fr). She developed knowledge on conceptual modeling, bioclimatology and crop physiology while conducting the first agronomic assessment of innovative mixed systems combining crops and solar panels (so called "agrivoltaïc systems"). She acquired proficiency on numerical crop models with Pr. T. R. Sinclair at North Carolina State University. She is currently developing research actions on cereal legume rotations for the Mediterranean region, using modeling approaches to explore options to optimize resource (water and nitrogen) availability and resource use efficiency across scales, from field to farm.

In the Mediterranean drylands, erratic and deficient rainfall as well as limited access to fertilizers are primary constraints to crop production. Insertion of pulses in crop sequences can alleviate the demand for N fertilizer, provided N fixation is supported by adequate water management. Solutions to improve water use efficiency can be looked for at different scales: either at field scale - optimize irrigation amount, timing and frequencies, or at farm scale – share irrigation water adequately amongst the crops grown simultaneously on the farm. Inducing deep changes in crop management and farm structure can be costly and highly risky in areas where subsistence agriculture prevails and should be supported by ex-ante analyses. We show here how a simple mechanistic crop model can be helpful for ex-ante assessment of agricultural innovation at field and farm scale and contribute to designing more water use efficient pulse-based system for the Mediterranean region through two examples. A Simple Simulation Model (SSM) developed by Soltani & Sinclair (2012) has shown to be robust in simulating various legume species. In a first study, SSM was used to simulate on common bean field in the area of Castelnaudary in the South of France. In the second study, we encapsulated the SSM model into a summary farm model in order to simulate different strategies for sharing irrigation water on a 5h ha farm growing durum wheat and chickpea with limited total water resource (2500m3 per year). At field lavel, a threshold of 0.35 or 0.5 allowed to achieve the same yields as with farmer's practices. However, cumulated irrigation was reduced by 30% with 0.35 threshold, resulting in greatly improved irrigation water efficiency. Analysis of soil water dynamics showed a mismatch between crop requirement and water supply by farmers. At farm scale, Food production and irrigation water efficiency was hardly affected by irrigation strategy, but N fertilizer requirements were drastically reduced when irrigating legumes (Lw). In addition, Lw strategy resulted into improved irrigation water efficiency on wheat cycle: saving all the water for wheat (Lrf) may allow greater water limited potential yield for wheat. However, low amount of organic N restituted from rainfed legume residues may not allow water limited yield to be achieved (B) and result into lower irrigation water use than the Lw strategy (C). Room for manoeuvre to design water efficient systems have been evidenced. Farm scale study also highlights the importance of considering N and water studies simultaneously.

OP30: Integration of pulses for a more productive cereal systems with lower environmental footprints

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Global food demand will be at least 60% higher by 2050 compared to 2010 with South Asian countries having to double their production with fewer resources while minimizing the environmental problems created by current agricultural practices and climate change. In the era of climate change and dwindling resources, cereal cultivation in South Asian countries faces the challenge of decelerated growth, declining total factor productivity and negative environmental footprints. The holistic management approaches and technology solutions will be required in the major grain-producing areas that provide the basis for future food, soil health and nutrition security. The novel production scale technology assessment platforms for basic and strategic research, and capacity development are required to bridge knowledge gaps, generate scientific information and wider delivery of established technologies in different agro-ecologies. Our platform research across different agro-ecologies of South Asia provides strong experimental evidence that, with best agronomic management practices (BMPs), including conservation agriculture practices (CA) and crop diversification, and intensification through introduction of pulses, the productivity of rice and wheat-based cropping systems of South Asia can be increased substantially while also achieving positive economic returns and less use of water, labor, nitrogen, and fossil fuel energy per unit food produced. In comparison to conventional rice- and wheat-based production technologies, the cropping system diversification to maize-wheat with components of BMPs, intensification by pulses and CA were implemented, achieved 54% higher grain energy yield, with a 103.9% increase in economic returns, 34.7% lower total water input, and a 42.9% lower global warming potential intensity. Conservation agriculture practices were most suitable for intensifying through pulses as well as diversifying wheat-rice rotations, but less so for rice-rice systems. This finding highlights the need for characterizing areas suitable for CA and subsequent technology targeting. A comprehensive baseline dataset generated will allow the prediction of extending benefits to a larger scale.

OP31: Innovation platform approach and agricultural food legumes value-chain improvement in Morocco: IMFLI project case study

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Sustainable agricultural development is one of the priorities of the National Agricultural Plan (Green Morocco Plan) to face the main challenges such as: food security, climate change impacts, sustainable efficient-use of natural resources. Morocco has been experiencing during the last decade innovating approaches to improve its agricultural productivity while adopting an ascending territorial and value-chain development approaches. Among the multi-actors approaches, that are undergoing the adoption process to reach this purpose in a limited scale, is the Innovation Platform (IP) approach which is being tested on the value-chain of "Food Legumes" that are undergoing a rehabilitation initiative at the national level in the main production areas. The objectives of this work are: to present briefly this experience and to examine its possible impact on governance and sustainable use of different resources. This IP is a coalition of stakeholders/actors who meet to share their experiences, knowledge, skills, resources and ideas for the purpose of solving problems and seize opportunities of common interest. It includes collaborators from various social and economic actors and institutions that govern their behavior, all working toward a common goal. They serve as a mechanism to improve communication, coordination and the sharing of knowledge between the key players on the India-Morocco Food Legume Initiative (IMFLI) project sites. This IP is serving also as a tool for dialog between the different actors of the value-chain to identify collectively the challenges and find opportunities to improve the food legumes production and marketing by the adoption of better technologies and innovations. The platform has adopted innovation as a systemic and dynamic process of institutional learning and recognizes that innovation can emerge from several sources, of complex interactions and knowledge flows. In our IP case the innovation consists of 3 main traits: the technology could be a commodity, a crop type, a variety, a race or integrated management of crops, water or soil packages; organizational in terms to organize and disseminate the knowledge of new ways; and institutional in terms of rules, cultures, values, norms, behavior, policy and laws. This concept of innovation systems embraces not only the providers of science but the totality and the interactions of the actors involved in innovation to achieve a common goal.

OP32: Innovative techniques for pulses improvement and adoption of newer technologies with reference to climate change

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Om Gupta is the Dean of College of Agriculture, Jabalpur since 2015. She has a long experience working on diseases of pulses with special reference to chickpea. She has been honoured with the Best Presentation Award by Indian Society of Pulses Research and Development (ISPRD), Indian Phyto Pathological Society and ISPRD Recognition Award. JNKVV Jabalpur was achiever of CGIAR'S King Baudonin Award (2002) and ICRISAT Doreen Mashler Award (2002), Best Centre Performance Award 2006 (ICAR) and Millennium ICRISAT Science Award (2008) in chickpea research due to outstanding contribution of the team under her leadership. She was associated with the development of several varieties of desi and Kabuli chickpea and mungbean. She is a Fellow of Indian phyto pathological Society, Society of Mycology and Plant Pathology, and ISPRD. She was nominated Zonal Councilor (CZ) of Indian Phyto pathological Society and Society of Mycology and Plant pathology. Gupta has published over 75 research papers in national and international journals apart from Technical bulletins, Manuals, Book chapters and several Review papers. Gupta has guided 45 MSc (Ag) and 6 PhD students as Major advisor/Co-advisor/Member of advisory committee.

Pulses are major sources of protein in vegetarian diet of Indian population. It can be grown on a range of soil and climatic conditions and play important role in crop rotation, mixed and inter-cropping, maintaining soil fertility through nitrogen fixation, release of soil-bound phosphorus, and thus contribute significantly to sustainability of the farming systems. India is the largest producer and consumer of pulses in the world. The expansion of irrigated agriculture in northern India has led to displacement of pulses by wheat, rice, and maize in large area. There has been a major shift in chickpea area (~3 million ha) from northern India to southern India during the past four decades. The short-duration varieties developed through ICRISAT and Indian NARS partnership have played a key role in expanding area and productivity of chickpeas in central and southern India. Production of major pulses is constrained by biotic and abiotic stresses. Wilt, root rots, ascochyta blight, botrytis gray mold, powdery mildew, Phytophthora, rust, stemphylium blight, and sterility mosaic are major diseases of pulses. Under climate change scenario, many of the conventional practices and strategies may no longer be relevant. Therefore, there is a need to recommend technologies to the farmers which respond well to climate change effects and give greater resilience against such shocks. Growing short duration promising varieties, utilization of rice fallow land for cultivation of lentil, grasspea and chickpea, photo-insensitive cultivars with optimal root traits and tolerant to abiotic and biotic stresses, mulching with crop residues, planting more seedling per hill for heat stress, better soil nutrient and water management, moisture conservation for late onset of monsoon and life-saving irrigation with stored rainwater for mid-season drought to harvest, positive effects of the increased CO_2 level are some recommended strategies to cope with the effects of climate change and variability on dryland agriculture. Despite the technological advances such as improved crop varieties and irrigation systems, weather and climate are still key factors in pulse productivity. Generally, higher temperatures are associated with higher radiation and higher water use. The effect of climate change on plant disease management may be less important than changes in land-use patterns, transgenic technologies, and availability of chemical pesticides. The direct effects of climate change on individual plants and plant communities may occur in the absence of pathogens, but may also bring about changes in plants that will affect their interactions with pathogens. Innovative methods may have to be adopted to develop adaptation strategies to overcome the impacts due to climate change and climate variability. There is a need for a greater understanding of the effect of climate change on the efficacy of synthetic fungicides, their persistence in the environment, and development of resistance in pathogens populations to the fungicides. Organic agriculture by avoidance of synthetic chemicals, toxic pesticides – insecticides, fungicides, herbicides, fertilizers etc. is preferred. There are various components of organic agriculture; their knowledge will increase the horizon of the agricultural scientists.

OP33: Dissecting water saving traits in pulses: efforts and future trends

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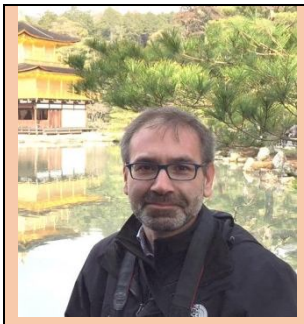

Michel Edmond Ghanem (Belgium) is a crop physiologist and agronomist working at the International Center for Agricultural Research in the Dry Areas (ICARDA) as Crop Physiologist where he leads the Crop Physiology laboratory. His research focuses on deciphering plant traits that contribute to abiotic stresses (drought, heat, salinity) and adaptation.

He holds an Agronomy Engineering degree and a Ph.D. in Plant Biology from the University of Louvain (Université catholique de Louvain, UCL, Belgium) as well as a B.Sc in Geography. Prior to joining ICARDA, he taught Plant Biology and Plant Physiology at the UCL (Belgium) and was an Associate Professor of Plant Physiology at the University of Namur (Belgium). He also worked as a Research Fellow at the CEBAS-CSIC (Murcia, Spain) where he was actively involved in the conception and the coordination of a EU-funded FP7 project in the field of root-science research (Rootopower).

Dr. Ghanem is also expert at the Biosafety Advisory Council (BAC) of Belgium on transgenic plants and serves on the Research Management Committee of the CRP Grain Legumes as Product Line coordinator on heat and drought. He is also member of the Executive Board of the Experts Working Group on Wheat phenotyping within the Wheat Initiative. His research expertise covers plant abiotic stress physiology, plant modeling, root biotechnology, and plant phenotyping.

Water limitation is a central problem in the 21st century agriculture. Optimizing plant water use together with maximizing water capture is important in addressing drought. This can be done by identifying traits that will ensure crop growth while keeping sufficient water for the grain filling period, controlling water losses, and optimizing leaf canopy development. The key is in understanding the pattern of crop water use through the season and making adjustments that allow an advantageous temporal pattern of water use. In many environments, it is highly advantageous to limit water use early in the growing season so that more soil water is available to sustain physiological activity associated with grain growth and yield later in the season when severe drought may develop. Limited transpiration by restricting transpiration rate under elevated vapor pressure deficit (VPD) and progressive exposure to soil drying translated by the fraction of transpirable soil water (FTSW) are two water saving mechanisms. Simulation studies have shown the advantage of these traits in increasing yields in some pulses. Slow plant development and early onset of reproductive development are additional approaches to modify the pattern of water use and allow water use for seed growth before the soil water store of water is exhausted. In that sense, altering plant phenology could be an opportunity for improving the pattern of water use. In addition, several management options exist for minimizing water demand and need to be explored within the context of each environment and species.

OP34: Faba bean improvement towards drought stress through the exploitation of genetic diversity

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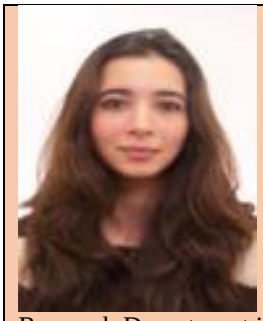

Lamiae Ghaouti is Lecturer and researcher in the Unit of Crop Genetics, Breeding and Biotechnology. Her field of expertise is breeding research and applied genetics with a focus on faba bean (*Vicia faba* L). She is currently leading in Morocco MEDILEG project which is an ARIMNET project that involves several countries from South Europe and North Africa. She received her PhD degree in 2007 from the University of Göttingen in Germany in the field of plant genetics. Awarded with Kurt von Rümker Prize in Quedlinburg, Germany.
Before joining IAV Hassan II, she had a professional experience as an assistant to research at the Department of Crop Science, Georg-August University, Göttignen in Germany. Dr. Ghaouti occupied as well the position of a legume plant breeder and member of the Research Department in the plant breeding company NPZ, KG in Hohenlieth, Germany.

Drought is becoming increasingly a structural feature of the Moroccan climate. It is the most important abiotic stress responsible for the instability of production and low yields in faba bean. The effect of drought could be partially buffered by the adoption of both the appropriate crop management strategies and the use of drought tolerant varieties. The aim of the current study is the evaluation of both improved varieties and local populations of faba bean for their tolerance to drought stress. A total of 25 varieties of faba bean originated from different countries and 60 Moroccan local populations, were tested under field conditions in different locations and for several seasons. All trials were laid out using a split-plot design with two treatments (rainfed and irrigated). The results showed that the treatments, the genotypes and their interaction showed highly significant effects for the agro-morphological traits scored. The variance among the local populations was higher than the variance among the cultivars for most measured traits. The local populations exhibited a large genetic diversity at both the intra and the inter population levels. Stress susceptibility index and mean productivity based on yield trait, were used to select genotypes combining both high drought tolerance and high productivity. The variance among the local populations was higher than the variance among the cultivars for both traits. The elite material PG2, Bachar, Nubaria 3 and a local population POP32 proved to be the most tolerant and productive. These genotypes could be used to identify the genes involved in the drought tolerance using molecular association tools and as sources of drought tolerance in the breeding programs.

OP35: Combined effect of drought and heat stresses is more profound than their standalone effects in chickpea

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Srinivasan joined ICRISAT as a Scientist in November 2013. Prior to this he has worked with ICRISAT in chickpea breeding as a Visiting scientist and Special Project Scientist from 2011-13. He was awarded top Australian scholarships in his Postgraduate studies and Outstanding partnership award-Asia in 2015. He has more than 30 research publications, book chapters and monographs to his credit. His main research interests include development of climate resilient varieties, varieties suitable for mechanical harvesting and enhancement of genetic diversity through integrated breeding and genomics approaches in chickpea.

Chickpea is a cool season legume traditionally grown under rainfed conditions globally. The crop is exposed to both drought and heat stresses simultaneously due to recent changes in climate conditions. A study was conducted, to understand the response of chickpea to individual and combination of stresses, with drought tolerant (ICC 14778, ICCV 10), drought sensitive (ICC 3776, ICC 7184), heat tolerant (ICC 1205, ICC 15614) and heat sensitive (ICC 4567, ICC 10685) genotypes. These were evaluated in four different growing environments: no stress (irrigated crop in post-rainy season of 2014-15); drought stress (rainfed crop of post-rainy season of 2014-15); heat stress (irrigated crop in summer 2015) and drought x heat stress (partially irrigated crop in summer 2015). Among the genotypes, flowering time was reduced by 4-16 days, while the maturity was reduced by 19-33 days. Under drought stress, the reduction in seed yield was less in drought tolerant ICCV 10 (11%) and more in drought sensitive ICC 3776 (43%). Under heat stress alone, the reduction in seed yield was less in the heat tolerant genotypes ICC 1205 (24%), ICC 15614 (26%) and more (85 – 87%) in heat sensitive genotypes. Under both drought and heat stresses, the heat sensitive genotypes recorded the maximum reduction (90%) in seed yield followed by drought sensitive genotypes ICC 7184 (85%) and ICC 3776 (70%). Drought tolerant and heat tolerant showed similar response in yield reduction (44 – 51%). 100-seed weight and seed number were severely reduced under drought + heat conditions. This indicated that the cumulative effect of drought and heat is more profound than standalone stresses.

OP36: Pigeonpea success story in Eastern and Southern Africa: Achievements and prospects

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Ganga Rao NVPR is presently working as Senior Legumes Breeder for pigeonpea and chickpea targeting Eastern and Southern Africa (ESA). Before that he worked with ICAR for about 10 years as a wheat and oilseeds breeder. He associated in release of 3 wheat, 14 pigeonpea and 17 chickpea varieties. He registered 10 wheat genetic stocks that are having high protein and extra bold seeds. In pigeonpea, he developed large seeded and insect tolerant pigeonpea elite genotypes. He promoted pigeonpea in target countries and area, production, productivity enhanced by about 96%, 175% and 40%, respectively in ESA. He received Srinivasa Ramanujam Memorial Award for outstanding research in Plant Genetics. He is Fellow of Indian Society of Genetics and Plant breeding. Co-recipient of ICRISAT's outstanding partnership awards in ESA along with national programs in Tanzania, Malawi and Mozambique for effective implementation of on-going chickpea and pigeonpea R&D projects. He is life member several professional societies and he has published 48 research papers.

Pigeonpea is the crop of about 6 million smallholder subsistence farmers in Eastern and Southern Africa (ESA). Pigeonpea production in ESA is steadily increasing over the last 15 years and attained about 1,047,300 t (FAO Stat 2014) with Malawi, Kenya, Tanzania, Mozambique, and Uganda being the major pigeonpea producers. Pigeonpea has huge regional and international export potential and India alone imports about 500,000 t annually. However, import demand from India is expected to increase further in coming years due to increasing gap between production and consumption. At present, ESA countries export about 200,000 t of grain/year worth of $140 million. Pigeonpea plays a major role in food and nutritional security, feed and fuel wood supply and income generation. ESA is the secondary centre of diversity with large amount of native and useful genetic diversity and recent germplasm collections in Kenya, Mozambique, Uganda and Tanzania assisted in capturing this. At present ICRISAT genebank is holding about 1200 unique germplasm accessions collected from the ESA region. Pigeonpea improvement in ESA started in 1992 by mostly relying on native germplasm and through this 33 high yielding varieties that are belonging to short (8), medium (13) and long (12) maturity groups were released. A strong region specific genetic enhancement program is in operation with major breeding thrust on high grain yield, inter-cropping compatibility, photo-period insensitivity, grain quality, resistance and/or tolerance to Fusarium wilt and Helicoverpa pod borer and resilience to climate change. Formal and informal seed systems are being strengthened, by production and delivery of 4250 t of seed during last 8 years which could cover about 0.5 million ha. Sustainable intensification options through P-micro dosing, intercropping with cereals and double up legumes had increased yields of both pigeonpea and associated crops. This led to productivity gains in the region up to 917 kg/ha and in Malawi it has reached about 1309 kg/ha. Tremendous yield gains have been recorded with new varieties, integrated crop management, effective seed systems, export demand and policy support. However, a huge gap exists between realizable and actual yields with present management options. In order to develop strong breeding pipe-line, genetic enhancement using diverse genepools and trait specific/multiple trait donors will be used in pre-breeding program. More emphasis will be given to develop medium duration varieties with high ratoonability. ICRISAT-India is effectively utilizing CMS based hybrid technology, genomic and genetic resources. Efforts are underway to use them in ESA breeding program to further elevate yield potentials. Dissemination of new varieties, SI including double-up legumes and continue supporting effective seed system models to seed production and delivery will be tried. A strategy is being outlined to bridge this gap by using all the research and development options available including inclusive market oriented development through greater engagement with market players. Value addition and utilization at house hold, community and village level will be taken up to improve the food and nutritional security.

OP37: Management of soil-borne diseases for sustainable pulses production

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Soil borne diseases pose serious threat to stability and sustainability of pulse crop production. Important soil borne diseases include *Aphanomyces* root rot, *Fusarium* wilts, *Sclerotinia* stem rot, *Sclerotium* collar rot, Pythium seed rot and damping-off, root rot caused by *Fusarium*, *Rhizoctonia* and *Phytophthora* species, and a number of nematode diseases. Management of soil borne diseases is challenging not only because several diseases may occur at the same time, but also because soil is an opaque matrix that has unique complexities encompassing physical, chemical and biological components. Interactions of these components further complicate management of soil borne diseases. Fungicide applications for controlling soil borne diseases are generally ineffective or uneconomical, underscoring the importance of employing resistance and cultural practices. Some soil borne diseases, such as Fusarium wilts, are host genotype-specific and resistance genes are available and employed in disease management. Such vertical resistance may be broken down in short duration due to pathogen population shift in race structure. *Sclerotinia* species have propagules reside in soil, but cause disease on above ground tissues and have wide host range. Many of the soil borne pathogens cause similar root rot symptoms making disease diagnosis difficulty, and specific disease management strategies are often lacking or not practical. For many of soil borne diseases, resistance is either unavailable or undefined, making developing resistance cultivars difficult. In general, management of soil borne diseases should be well-planned ahead of planting and should focus on soil management practices that promote soil health increasing soil capacity to function as a vital living system to support biological activity and enhance plant health and productivity. Cultural practices such as crop rotation, minimum tillage, cover crop, green manure, and organic amendments should be encouraged and further investigated to improve soil health (including plant growth promoting microorganisms) to suppress soil borne diseases. Additionally, modern biotechnologies in next generation sequencing should be exploited to investigate effect of cultivar and cultural practices on soil microbiome composition in relation to soil health and suppression of soil borne diseases, in order to support stable and sustainable pulse crop production.

OP38: Integrated pest management of food legume insect pests in North Africa, West and Central Asia

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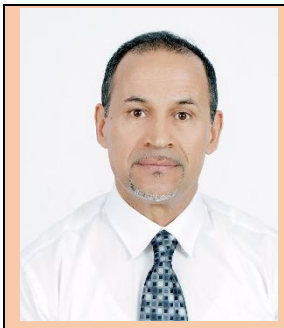

Mustapha El Bouhssini earned his Ph.D (1992) from Kansas State University. In 1996 he joined the International Center for Agricultural Research in the Dry Areas (ICARDA) in Aleppo. His research has been on integrated pest management of cereals and legume crops in North Africa, West and Central Asia. Recently the scope of his IPM program expanded to include insect pests of date palm. More than two decades of dedicated work has yielded significant contributions to the development of IPM options that are now being increasingly used in CWANA. He has published 100 refereed papers, proceedings (27), newsletters and extension publications (12), books (5) and book chapters (6), and voluntary and invited presentations (150 +) at international and regional meetings worldwide. Mustapha has also been heavily involved in human resources development in CWANA, including giving short-term training courses, mentoring individual trainees and supervising graduate students. Based on his scientific achievements in the area of entomology, Mustapha was recognized by a number of awards including the Distinguished Scientist Award from the International Branch of the Entomological Society of America, 2014; Distinguished Alumnus Award from the Entomology Department, Kansas State University, 2014; the International Plant Protection Award of Distinction from the International Association for the Plant Protection Sciences (2007) and the ICARDA Scientist of the Year (1998).

Food legumes (chickpea, lentil, faba bean) are important crops in North Africa, West and Central Asia (CWANA). However, their production is adversely affected by a number of insect pests such as chickpea Leaf miner and Pod borer, Sitona and aphids. ICARDA, in collaboration with its partners, has been developing integrated pest management options for these pests. The management strategies include host plant resistance, cultural practices and biological control. Several sources of resistance to Sitona of lentil and chickpea Leaf miner have been identified in the ICARDA genebank. The Focused Identification of Germplasm Strategy (FIGS) has been used to select sub-sets from the genebank to screen for the different pests. Germplasm carrying resistance to chickpea Leaf miner has been developed and shared with partners. Also, QTLs associated with resistance to chickpea Leaf miner have been identified. Early planting of chickpea in winter has been shown to be less damaged by the Leaf miner compared to the spring-sown crop. A number of essential oils and plant extracts from several plant species have showed good insecticidal activities against chickpea Pod borer and Leaf miner. In a recent study conducted in 2014 and 2015, a liquid formulation of the seed dressing insecticide Celest ®Top (a.i. Difenoconazole + Fludioxonil+ Thiamethoxam) has been found effective in reducing damage caused by Sitona and Stem borer on faba bean and Pea aphid on lentil. Several natural enemies have been shown to be associated with food legume pests and their potential role in regulating food legume pest populations will be discussed.

OP39: Foliar diseases in food and forage legumes

Eva Madrid

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Eva Madrid is a postdoc researcher at MPIPZ in Cologne, Germany. She has >10 years of experience in legume molecular genetics. Her main research interests are classical and marker-assisted breeding, QTL analysis for disease resistance with the aim of using molecular markers to tag genes of interest, genetic map development, development of new tools to improve breeding for disease resistance in legumes, particularly fusarium wilt and ascochyta blight of chickpea and utilization of next generation sequencing technologies for the identification of genes controlling traits of interest. Currently she is interested in studying perennialism vs. Annualism by developing a series of introgression lines (ILs) from a backcross between *Arabis montbretiana* and *Arabis alpina*. She is still collaborating with her previous group, supervising master degree and PhD students as well as collaborating in teaching plant biotechnology in Master´s degree at the University of Cordoba (UCO). Her research was focused primarily on the identification of gene(s) and QTLs controlling resistance to ascochyta blight, Fusarium wilt and rust. As well, she was involved in the transcriptome assembly of faba bean for the identification of genes related with blight resistance.

Grain legumes play an important role in dry areas worldwide. However, their yield is relatively low and variable due to a range of environmental conditions, and susceptibility to insect pests, diseases and parasitic weeds. Foliar diseases on pulses are often noticed too late to implement management with consequent devastating effects on production and in some cases on quality. Depending on the crop and/or pathogen, the yield losses due to diseases are between 10-100%. Foliar diseases caused by biotrophic pathogens, such as mildews and rusts, are major limiting factors in all legume growing areas. Downy mildew is caused by *Peronospora viciae*, including f,s. *pisi* and *fabae*, affecting pea and faba bean. Downy mildews are widespread diseases, but are more frequent and severe in cool, maritime climates. Powdery mildews are caused by *Erysiphe* sp. The most important are *E. pisi*, for which ff.spp. *pisi*, *medicaginis* and *vicia-sativa* have been described infecting pea, alfalfa and vetches, respectively. *Uromyces viciae-fabae* causes faba bean rust but also causes rusts of other legumes such as lentil, and pea. *U. appendiculatus* infects common bean worldwide, but it is most prevalent in humid tropical and subtropical areas. *U. ciceris-arietini* infects chickpea causing significant losses if infection occurs early in the growing season in few countries. On the other hand, the major foliar necrotrophic fungal diseases in legumes are ascochyta blights, chocolate spot, Botrytis gray mold, Stemphylium blight and anthracnose. Ascochyta blights is caused by different pathogens depending on the legume host, as *Didymella rabiei* in chickpea, *D. fabae* in faba bean and *D. lentis* in lentil. Botrytis gray mold incited by *Botrytis cinerea* caused serious damages on chickpea and lentil under pre- and post-harvest conditions. In faba bean, chocolate spot caused by *B. fabae* and *B. fabiopsis* is an important disease under propitious climatic conditions. Anthracnoses, caused by *Colletotrichum lupini* in lupin, *C. truncatum* in lentil and *C. trifolii* in alfalfa, are also severe diseases occurring in all countries with warm humid climates. Stemphylium blight (*Stemphylium botryosum*) is an emerging disease affecting lentil in South Asia, Canada and the USA. The main emphasis in research and development to combat diseases is on host resistance and integrated management supported with pesticide applications. Of the different control methods available, breeding for resistance is the most efficient, economical and environment friendly. Tremendous advances in DNA marker technologies and map development have been achieved for most pulses, allowing for the identification of markers close to the gene/QTL controlling disease resistance. Nevertheless, applicability of marker assisted selection is still at the beginning for common bean, cowpea, and pea. For chickpea, a set of markers was developed to select for blight resistance, and are currently used in different breeding programs. A successful integrated foliar disease management strategy is one under which grain legumes have been protected from the yield-reducing effects of the pathogen rendering the later to economic insignificance. Disease management practices, combining host plant resistance, agronomic practices, use of fungicides and decision support system could be applied together in farmers' field to provide maximum economic returns and minimize pathogen population changes due to gene flow, selection pressure and sexual reproduction. However, persistent need exists for refinement, validation, transfer and adoption of integrated disease management.

OP40: Combating wilt susceptibility in chickpea: A success story and challenges ahead

Deep Ratna Saxena

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Deep Ratna Saxena is Plant Pathologist started his career from studies on wilt complex of lentil in 1986 and continued his research endeavor on diseases of various pulses crops. He has been awarded Senior Research Fellowship of ICAR for Doctoral Research and completed his research work under the guidance of eminent pulse pathologist Dr. M.N. Khare. He contributed significantly in maintaining good wilt sick plots of chickpea and lentil and identified sources of wilt resistance, which helped in developing several wilt resistant varieties of chickpea. He has published research papers in reputed journals on mechanism of resistance and on epidemiological aspects. Presently, he is collaborating research with international organizations like ICRISAT, ICARDA and Japanese International Cooperation Agency Japan. He is also leading chickpea pathology research of India through All India Coordinated Research Project on Chickpea.

Wilt caused by *Fusarium oxysporum* f. sp. *ciceri* (Padwick) Snyder & Hans., has remained a major threat to chickpea (*Cicer arietinum* L.) cultivation worldwide. India, being a major contributor of chickpea in the globe has faced a major challenge due to wilt in 1970s. The same is true with Madhya Pradesh state, which contributes about 50 per cent in the national pool. Chickpea varieties JG 62, JG 1, JG 5 and JG 221 were badly affected due to wilt. Consequently, the emphasis was diverted in 1980s towards identification of sources for wilt resistance and their utilization. The outcome was the release of JG 315 and JG 74 varieties, the former is now global wilt donor. Early maturing wilt resistant variety JG 11 from Sehore has revolutionized chickpea cultivation in southern India. In recent past number of wilt resistant varieties JG 16, JG 130, JAKI 9218, JG 6, RVG 201, RVG 202 and RVG 203 have been developed. New donors for wilt resistance JSC 35 and JSC 40 have been identified. Challenges exist for wilt resistance in extra bold Kabuli chickpea popular in western M.P. Changing scenario of races in wilt pathogen has been discussed in the presentation. Increasing root rot incidence in rain-fed chickpea and collar rot is another concern. Chickpea cultivar JSC 37 posses' resistance to root rot, however, no substantial resistance is available for collar rot. These issues are highlighted in the presentations.

OP41: Breeding for post-emergence herbicide tolerance in cool-season food legumes

Fouad Maalouf[1]*, Somanagouda B Patil[3], Karthika Rajendra[3], Aladdin Hamwieh[2], Aakash Goyal[3], and Shiv Kumar[3]

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Fouad Maalouf is a Senior Faba bean Breeder working at ICARDA since 2007. He holds Master, PhD and Post-doc on faba bean breeding at Cordoba University-Spain. He developed the model of developing synthetic varieties in faba bean under the leadership of Drs. Jose Ignacio Cubero and Maria Jose Suso. He worked as consultant in wheat breeding program at LARI Lebanon and coordinated Lebanese component of IDUWUE, EU funded project on "Durum wheat water use efficiency". He also worked as a Teacher on plant botany and genetics in Saint Joseph University from 1997 to 2007 and in Lebanese University from 2003 to 2007. His current research focus is on breeding faba bean for major biotic and abiotic stresses and on the development of herbicide tolerance faba bean. He has supervised 15 students, including 3 PhD, 8 Master and 4 undergraduate students on different aspects of faba bean breeding. He has authored or co-authored more than 35 research publications, including 31 referenced journal articles, 4 book chapters. He contributed to the release of 11 faba bean varieties with NARS partners.

Cool-season food legumes (faba bean, chickpea and lentils) are mostly grown in rainfed dryland systems, because of many virtues such as high protein content, atmospheric nitrogen fixation, and low carbon and water foot prints. When grown in rotation with cereals, these crops also act as a break in disease cycles. However, annual and parasitic weeds are the major production constraints in this group of crops because of slow initial growth and being poor competitor to weeds. Manual weeding is laborious and time consuming. Pre-emergence herbicide application is effective but application of post-emergence herbicides is not safe due to crop sensitivity. In addition food legumes are heavily infested by *Orobanche crenata* in North and East Africa. Faba bean cultivars with resistance to orobanche have been developed in Egypt, Ethiopia and Tunisia, but the resistance is partial and consequently there is a need to develop integrated management with herbicide tolerance such as low dosage of Glyphosate. Sources for resistance to different herbicides in faba bean, chickpea and lentils were identified. At ICARDA, 289 mutant lines of faba bean were screened against high dosage of Glyphosate, resulting in identification of two lines Mu38 and Mu418 as tolerant to 1600 g a.i./ha. Similarly, 300 faba bean lines were screened against various post-emergence herbicides with different modes of action like Metribuzin, Imazethapyr and Oxyflourfen and 10 lines were found highly tolerant to Imazethapyr, and 8 to Metribuzin. In lentil, 353 genotypes were screened for tolerance to Metribuzin and Imazethapyr. Highly tolerant genotypes identified included ILL8112, ILL5988, ILL8009 and ILL4994 for Imazethapyr and ILL1005, ILL0462, ILL5531, ILL6434, ILL0195, GCP10 and 06S 53110-02 for Metribuzin. Similarly, in chickpea, screening of 49 genotypes, including germplasm accessions and advanced breeding lines, against Imazethapyr and Metribuzin and resulting in identification of 10 genotypes tolerance to Imazethapyr and two for Metribuzin. These sources are used in breeding program to transfer genes for resistance to cultivars grown in different agro ecological zones.


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POSTER PRESENTATIONS

PP#	Theme#	Author(s)	Title
1	Theme 1	Aymen Frija*, Shinan Kassam1, Dhehibi Boubaker and Aden Aw-Hassan	Understanding trends and patterns of production, consumption and trade of pulses within Middle East-North Africa (MENA): implications for Research, Development and policy within the region
2	Theme 1	Homayoun Kanouni	Winter chickpea in Iran, current status and future prospects
3	Theme 1	Badraoui Ismail, Saikouk Tarik, Benmoussa Fatima-Zohra and Aw-Hassan Aden	Food legumes consumption in Morocco: Understanding Moroccan consumers' behavior
4	Theme 1	Badraoui Ismail, Saikouk Tarik, Benmoussa Fatima-Zohra and Aw-Hassan Aden	Food legumes production in Morocco: Improving local products competitiveness through regional valorization centers
5	Theme 2	A Ouji*, R Sayar, M Mouelhi, M Amri4, M Bouhadida, N Omri, Z Abbes, H Ben Salah, MH Halila, S Kumar, A Sarker A and M Kharrat	Advances in lentil (Lens culinaris L.) breeding in Tunisia
6	Theme 2	Nora Aqtbouz*, Lamiae Ghaouti, Loubna Belqadi and Wolfgang	Analysis of genetic diversity of Moroccan landraces of faba bean (*Vicia faba* L.) based on Amplified Fragment Length Polymorphism
7	Theme 2	Priya Chugh, Jagmeet Kaur*, Satvir Kaur, Sarvjeet Singh and Shiv Kumar	Anti-oxidative defense system in lentil (*Lens culinaris* Medik.) genotypes under high temperature stress at reproductive stage
8	Theme 2	Joseph Mbasani Mansi*,, Zineb El Bouinani, Mohamad Bouseber, Fatima Zahra Briache, Fatima Gaboun, Nadia Benbrahim, Zine El Abidine Triqui and Rachid Mentag	Assessment of tolerance level of Moroccan lentil genotypes against *Orobanche crenata*
9	Theme 2	Kedar Nath Adhikari* and Usman Ijaz	At least three rust (*Uromyces viciae-fabae*) resistant genes detected for faba bean in Australia
10	Theme 2	S Muniswamy*, R Lokesha, Rachit Saxena, PS Dharmaraj, B Fakrudin , Kishan Patel, Yamanura and Rajeev K Varshney	Biometrical and molecular dissection of genetic diversity in minicore collection of pigeon-pea (*Cajanus cajan* (L.) Millsp.) for fusarium wilt, SMD and yield
11	Theme 2	Fikru Mekonnen	Performance of Kabuli chickpea (Cicer arietinum L) genotypes under drought prone environment and their nutritional status in the eastern Amhara, Ethiopia
12	Theme 2	Pronob J Paul, Srinivasan Samineni, M Thudi, Sobhan B Sajja, Abhishek Rathore, Roma Das, Amir W Khan, SK Chaturvedi , GR Lavanya , Rajeev K Varshney and Pooran M Gaur*	Mapping QTLs and identification of putative candidate genes for heat tolerance in chickpea
13	Theme 2	Kifah Gharzeddin, Fouad Maalouf* and Boulous Khoury	Choice of breeding method for improving yield and yield stability in faba bean

14	Theme 2	Jodi Humann, Sook Jung, Ping Zheng, Chun-Huai Cheng, Taein Lee, Morgan Frank, Deah McGaughey, Kristin Scott, Jing Yu, Stephen Ficklin, Marwa Sanad, Heidi Hough, Clare Coyne, Rebecca McGee* and Dorrie Main	Cool Season Food Legume genome database: enabling genetics, genomics and breeding research in pea, lentil, faba bean and chickpea
15	Theme 2	Wahiba Amri-Tiliouine*, Meriem Laouar-Abdelguerfi and Aissa Abdelguerfi	Determination of gamma radiation lethal dose in two cultivars of Kabuli chickpea (*Cicer arietinum* L.)
16	Theme 2	Sukhpreet Kaur Sidhu, Jagmeet Kaur*, Sarvjeet Singh and Inderjit Singh	Differential response of pigeonpea genotypes for phosphorus acquisition
17	Theme 2	Veena Khanna*, Suman Kumari and Palika Sharma	Elicitation of induced resistance against Rhizoctonia solani in mungbean by rhizobacterial isolates
18	Theme 2	Chafika Houasli	Evaluation of improved chickpea lines for their adaptation to Moroccan environments
19	Theme 2	Lynn Abou Khater* and Fouad Maalouf	Evaluation of faba bean accessions for earliness and heat tolerance
20	Theme 2	Fatima Anaya*, Rachid Fghire, Said Wahbi and Kenza Loutfi	Exogenous salicylic acid affects plant growth and the antioxidant system in faba bean (*Vicia faba* L.)
21	Theme 2	Behailu Mulugeta, Kassahun Tesfaye, Gemechu Keneni, Seid Ahmed and Kifle Dagne	Genetic diversity in Ethiopian faba bean (*Vicia faba* L.) varieties based on phenotypic traits and ISSR markers
22	Theme 2	F Maalouf*, M Hammoud and L Chalak	Evaluation of faba bean accessions under heat prone conditions
23	Theme 2	P Jagan Mohan Rao, K Balakrishna, Y Hari*, V Thirumala Rao, A Vijaya Bhaskar, P Raghu Rami Reddy, K Bhavani and M Mahesh	Genetic diversity analysis among Yellow Mosaic Virus (YMV) resistant and susceptible varieties in mungbean using SSR markers
24	Theme 2	Chahira Achir, Meriem Laouar, Imène Djedid and Aissa Abdelguerfi	Genetic diversity of local populations of grass pea in Algeria under semi-arid environment
25	Theme 2	Djihad Bellemou*, Meriem Laouar and Aissa Abdelguerfi	Genetic erosion of Algerian chickpea
26	Theme 2	Pavel Hanáček*, Lenka Procházková and Petr Smýkal	Genetic principle of pod dehiscence in pea
27	Theme 2	Surendra Barpete*, Aakash Goyal, Aladdin Hamwieh, Vivek Singh Tomar, VS Gautam, Murari Singh, and Ashutosh Sarker	Genetic variability and heritability of agronomic traits of selected chickpea genotypes in India
28	Theme 2	Karthika Rajendran, Ping Zheng, Shiv Kumar, Dorrie Main, Clarice Coyne*, Gopesh Saha, Nurul Amin, Kirstin Bett, Rebecca McGee	Genome wide association study using the ICARDA lentil reference set and agronomic parameter
29	Theme 2	Abdelkader Ghalem, Chaker-Haddadj Assia, Sihem Tellah, Naima Ghalmi and Sidi Mohamed Ounane	Genotypic difference in salinity tolerance during early vegetative growth and yield of cowpea (*Vigna unguiculata* L. Walp.) from different regions of Algeria
30	Theme 2	Mounia Ennami, Fatima Zahra Briache, Fatima Gaboun, Rabha Abdelwahd, Lamiae Ghaouti, Loubna Belqadi, Jim Westwood and Rachid Mentag	Host differentiation and variability of *Orobanche crenata* populations from legume species in Morocco as revealed by cross infestation and molecular analysis
31	Theme 2	L Chen, A Tullu, R Podder, S Kundu, A Vandenberg and Kirstin E Bett*	How crop-wild introgressions may affect several important agronomic traits in lentil

32	Theme 2	CV Sameer Kumar*, MV Nagesh Kumar, KN Yamini, R Vijay kumar, A Hingane, R Saxena and RK Varshney	Hybrid pigeonpea: Innovative intervention to enhance productivity
33	Theme 2	Rind Balech*, Murari Singh and Fouad Maalouf	Identification of faba bean lines tolerant to high dosage of Glyphosate
34	Theme 2	Mounia Ennami*, Lamyae Jait, Fatima Zahra Briache, Fatima Gaboun, Rabha Abdelwahd, Lamiae Ghaouti, Loubna Belqadi, Rachid Benkirane and Rachid Mentag	*In vitro* culture of *Orobanche crenata*
35	Theme 2	Anwar Tamsa", *, Karthika Rajendran, Shiv Kumar, Rachid Mentag, Nadia Benbrahim and Nour-Eddine Es-Safi	*In vitro* screening of lentil (*Lens culinaris* ssp. *culinaris*) genotypes to high temperatures
36	Theme 2	Dahbia Tabti*, Meriem Laouar, Shiv Kumar, Karthika Rajendran, Aissa Abdelguerfi	Mutation induction in lentil
37	Theme 2	Kailash C Bansal, Mohar Singh, Swarup K Parida, Jai C Rana and Akhilesh K Tyagi	Unlocking genetic potential of wild native species to diversify the cultivated legume genepool
38	Theme 2	Kaoutar Taha*, Jamal Aurag, Gilles Bena and El Bekkay Berraho	Lentil in Morocco: Genetic diversity of symbiotic rhizobia and selection of effective bacterial biofertilizers
39	Theme 2	Debjyoti Sen Gupta·*, Kevin McPhee and Shiv Kumar	Development of molecular markers for iron metabolism related genes and their expression analysis under excess iron
40	Theme 2	Fikru Mekonnen, Firew Mekbib, Shiv Kumar, Seid Ahmed and TR Sharma	Molecular diversity and population structure of the Ethiopian lentil (*Lens culinaris* Medikus) genotype assessment using SSR markers
41	Theme 2	Fikru Mekonnen*, Shiv Kumar, Seid Ahmed, RK Chahota, TR Sharma, Sarvjeet Singh, RK Gill and Ashok Kumar	Identification of molecular markers associated with rust resistance genes in lentil (*Lens culinaris* sub sp. *culinaris*)
42	Theme 2	Fikru Mekonnen, Shiv Kumar, Seid Ahmed and TR Sharma	Phenotypic variability and characteristics of lentil (*Lens culinaris* Medik.) germplasm of Ethiopia by multivariate analysis
43	Theme 2	Sheetal Raj Sharma, Sarvjeet Singh*, Navneet Aggarwal, Jagmeet Kaur, RK Gill, Somanagouda B Patil and Shiv Kumar	Effect of post-emergence herbicide metribuzin application on morpho-physiological traits, yield and yield components in lentil (*Lens culinaris* Medik.)
44	Theme 2	Moez Amri*, Zouhaier Abbes, Mariem Bouhadida, Imen Halila, Asma Najar, Safaa Kumari, Noura Omri, Ali Ouji, Warda Jendoubi, Feten Srarfi Ben Ayed, Imen Trabelsi, Rhouma Sayar, Bouaziz Sifi, Hamadi Ben Saleh, Aladdin Hamwieh, Mohamed Imtiaz, Mohamed Habib Halila and Mohamed Kharrat	Achievements of the national chickpea (*Cicer arietinum* L.) breeding program in Tunisia
45	Theme 2	Moez Amri*, Zouhaier Abbes, Imen Trabelsi, Noura Omri, Mohamed Bechir Allagui, Asma Najar, Safaa Kumari, Houcine Selmi, Jouda Mediouni, Hamadi Ben Saleh, Fouad	Achievements of the national faba bean (*Vicia faba* L.) breeding program in Tunisia

		Maalouf, Mohamed Habib Halila and Mohamed Kharrat	
46	Theme 2	Akanksha Singh, VK Sharma, HK Dikshit*, D Singh, M Aski, Shiv Kumar and A Sarker	Microsatellite marker-based genetic diversity analysis of elite lentil lines differing in grain iron and zinc concentration
47	Theme 2	Aziza M Hassanine, Sabah M Attia*, Rehab Abd El-rahman and MAM Ibrahim	*Orobanche crenata* effect on some faba bean genotypes and the genetic variation between three Orobanche isolates
48	Theme 2	Ehab AD Sarhan and Marwa AM Atwa	Phylogenetic relationships among *Phytophthora sojae*, isolated from damped-off soybean seedlings in Egypt
49	Theme 2	Ahmed Douaik	Importance of experimental design in pulse improvement
50	Theme 2	Zain El Abidine Fatemi*, Khalid Daoui, Sripada M Udupa, Ghita Soudi, Hassan Ouabbou, Lahsen El Ghadraoui, Rkia Moutiq and Sanae Benani	Recent status of Moroccan faba bean landraces: collection, characterization and utilization
51	Theme 2	Rifai Mohammed[,*], Somanagouda B Patil, Shiv Kumar, Nadia Benbrahim, Nour-Eddine Es-Safi and Rachid Mentag	Screening of lentil germplasm to identify the sources of resistance against *Orobanche crenata*
52	Theme 2	Ashutosh Kushwah*, Jaspreet Kaur, Jagmeet Kaur, Inderjit Singh and Sarvjeet Singh	Screening of chickpea genotypes for salinity tolerance during early stage of seedling growth
53	Theme 2	A Vijaya Bhaskar*, P Jagan Mohan Rao, P Raghu Rami Reddy, Y Hari and V Thirumalrao	Screening of pigeonpea germplasm against wilt and sterility mosaic diseases in central Telangana
54	Theme 2	Fatima Zahra Briache*, Mounia Ennami, Fatima Gaboun, Rabha Abdelwahd, Zain El Abidine Fatemi, Walid El-Rodeny, Zine El Abidine Triqui and Rachid Mentag	Screening of faba bean genotypes for resistance to *Orobanche crenata* under field and controlled conditions
55	Theme 2	Noureddine El-Haddad[,*], Karthika Rajendran, Shiv Kumar, Rachid Mentag, Nadia Benbrahim, Nour-Eddine Es-safi and Abdallah Bari	Screening FIGS set of lentil (*Lens culinaris* ssp *culinaris*) germplasm for tolerance to terminal heat and drought stresses
56	Theme 2	Dalila Boukecha*, Meriem Laouar and Leila Mekliche-Hanifi	Study of drought tolerance in some populations of *Lathyrus sativus* L.
57	Theme 2	R Varma Penmetsa[*], Jana Kholova, Reyazul Rouf Mir, Gul Sani, Kassaye Negash, Mohammed Rezaei, Srikanth Mallayee, Irshad Ahmed, Noelia Carrasquilla-Garcia, Peter Chang, M Matilde Cordeiro , Eric vonWettberg, Bunyamin Ta'ran,Vincent Vadez and Douglas Cook	The potential of green chickpea, aided by genetics, for an under-utilized market and value chain for small-holder farms
58	Theme 2	KN Yamini[*], G Anuradha, G Rajani, SNCV L Puspavalli , R Rajeshwar, T Revathi, J Shourabh, CV Sameer Kumar, M Sharma, RK Saxena, D Vijaya Sagar Reddy, Y Vijay , R Rajeshwari , M Suresh , EA Siddiq and RK Varshney	Towards development of high yielding pigeonpea lines with resistance to wilt and SMD, suitable to Telangana and Andhra Pradesh

59	Theme 2	Sanae Krimi Bencheqroun*, Safae Zouine, Afaf El Fadil, Seid Ahmed, Aladdin Hamwieh, and Sripada M Udupa	Virulence and molecular diversity within *Ascochyta rabiei* in Moroccan population and evaluation of genotypic stability on chickpea
60	Theme 2	Fouad Maalouf, Aline Abou Naoum, Khaled El Shamaa, and Somanagouda B Patil	Wide range of genetic variability for herbicide tolerance in Faba bean
61	Theme 2	Zeleke Ashango and Sentayehu Alamerew	Yield stability and genotype × environment interaction in common bean (*Phaseolus vulgaris* L.) varieties in Dawro Zone, Southwest Ethiopia
62	Theme 2	MSM Soliman* and Rehab AM Abd-Elrahman	Faba bean integrated pest/disease management in demonstration platform in Egypt
63	Theme 2	R Boulamtat, M El-Bouhssini, S El-Haloui, A Sabraoui, K El-Fakhouri and A Mesfioui	Management of chickpea pod borer *Helicoverpa armigera* (Hübner): use of bio-pesticides
64	Theme 2	Liangsheng Xu, Meichun Xiang, David White and Weidong Chen*	The white mold pathogen *Sclerotinia sclerotiorum* depends on low pH for pathogenicity and sclerotial development, independent of
65	Theme 2	Hassan El Harrad*, Zain El Abidine Fatemi and Abdelghani Nabloussi	Study of the effect of absence of entomophilous pollination on the productivity of faba bean
66	Theme 2	Farshid Mahmodi	Rapid detection and identification of *Colletotrichum dematium* causing anthracnose on cowpea using PCR-based techniques
67	Theme 2	Tarik Atraoui*, Mustapha Arbaoui, Loubna Belqadi, Brahim Ezzahiri, Paola De Santis, and Devra Jarvis	Genetic diversity to control disease and pest incidence: The case of faba bean
68	Theme 2	Hari D Upadhyaya*, SM Udupa, Sangam L Dwivedi, Ahmed Amri, Aladdin Hamwieh and Shiv Kumar	ICRISAT-ICARDA collaboration in enhancing use of genetic resources in chickpea improvement
69	Theme 2	Ibrahim Elkhalil Benzohra*, Boubekeur Seddik Bendahmane and Mokhtar Youcef Benkada	Evaluation of wild *Cicer* accessions for resistance to *A*scochyta blight in Algeria
70	Theme 2	Safaa G Kumari* and Joop AG van Leur	Virus disease management in pulses
71	Theme 2	Gemechu Keneni, Endashaw Bekele, Fassil Assefa, Muhammad Imtiaz, Tolessa Debele, Kifle Dagne and Emana Getu	Phenotypic diversity of Ethiopian chickpea germplasm accessions for phosphorus uptake and use efficiency
72	Theme 2	PY Kamannavar*, SB Revanappa, AG Vijaykumar, Suma Mogali, Ganajaxi Math and Vanishree	Development of high yielding and bold seed size cultivar of Mungbean: DGGV 2
73	Theme 2	DM Mannur *, RK Varshney , M Thudi , M Mahiboobsa , SB Yeri and PM Gaur	Accelerated transfer of Fusarium wilt resistance (*foc* race 4) to elite cultivar Annegeri-1 through marker assisted backcrossing in chickpea L.)
74	Theme 2	Jay Lal Mahto	Characterization of urdbean varieties and their application for distinctiveness, uniformity and stability testing in alfisol of Jharkhand drylands
75	Theme 2	Teklay Abebe*, Yemane Nega, Muez Mehari, Adhiena Mesele, Assefa Workineh, Hadas Beyene	Genotype by environment interaction of some faba bean genotypes under diverse broomrape environments of Tigray, Ethiopia
76	Theme 2	Omar Idrissi*, Sripada M Udupa, Ellen De Keyser, Patrick Van Damme and Jan de Riek	Molecular diversity and mapping towards enhanced valorization of lentil genetic resources and marker-assisted selection for efficient cultivar development
77	Theme 2	Guram Aleksidze	Pulse crops in Georgia

78	Theme 2	Aladdin Hamwieh, Murari Singh, Chandrashekar Biradar, Muhammad Imtiaz, Rajinder Singh	Responsiveness of chickpea to climate change
79	Theme 2	Alok Das, Alok Shukla, Jamal Ansari, Anamika Diwedi, Shallu Thakur, Arvind, GK Sujayanand, SK Chaturvedi, and NP Singh	Insect resistant transgenic chickpea (*Cicer arietinum* L.) for sustainable agriculture
80	Theme 2	Maryame A Al-Achtar[*], Mina G Girgis, Khalid AF EL-Dougdoug, Aladdin Hamwieh*, Ismail M Ismail and Ahmed ElFatih ElDoliefy	Molecular identification of *Rhizobium* isolates from Chickpea in Egypt
81	Theme 2	Shaimaa Mahmoud, Mohamed Mubarak and Aladdin Hamwieh	Screening of chickpea FIGS subset for Salt tolerance using field and hydroponic conditions in Egypt
82	Theme 2	Priyanka Gupta, Surendra Barpete and Shiv Kumar	Concentration and distribution of β-N-oxalyl-L-α, β-diaminopropionic acid (ODAP) in different plant parts at various growth stages in grass pea
83	Theme 3	R Moussadek[*], R Dahan, R Mrabet, and M El Mourid	Roles of legumes in conservation agriculture system under Mediterranean climate
84	Theme 3	Ganajaxi Math, AG Vijayakumar, Suma Mogali and Yamanura	Use of herbicides in chickpea (*Cicer arietinum)* production for sustainable agriculture
85	Theme 3	I El Attar*, B Diouf, I Thami Alami and J Aurag	Common bean co-inoculation with selected plant growth promoting rhizobacteria and rhizobia: impact on nodulation and growth under greenhouse
86	Theme 3	Latheef Pasha Md*, M Malla Reddy, M Venkat ramana and P Raghu Rami Reddy	Diversification of rice ecosystems through pulses in semi-arid region of Southern Deccan Plateau of India
87	Theme 3	Sanae Benani*, Khalid Daoui, Zain El Abidine Fatemi and Aziz Bouchelta	Effect of sowing date and plant population on the yield of *Vicia faba* landraces collected from different region of Morocco
88	Theme 3	Benejar Naoual*, Krimi Bencheqroun Sanae, Jouraiphy Abdelmajid and Kholtei Sanae	Effect of compost amendments on chickpea growth
89	Theme 3	Loubna Benidire*, Majida Lahrouni, Khalid Oufdou and Michael Göttfert	Effect of pre-incubation of rhizobium with hesperetin on *Vicia faba* growth and nodulation under salt stress conditions
90	Theme 3	Parvaze A Sofi*, ZA Baba, MA Bhat, N Rahul and Chandrashekhar	Effect of rhizobium inoculation on drought response in common bean (*Phaseolus vulgaris* L.)
91	Theme 3	Mouna Mechri*, Wafa Saidi, Rim Hajri, Neziha Haloui, Tarek Jarrahi, Salah Rezgui, Azaiez Gharbi, and Naceur Jedidi	Effects of tillage, preceding crop and nitrogen fertilization on the qualitative and quantitative parameters of fenugreek
92	Theme 3	Abdelaziz Mimouni*, Rachid Mrabet, Fouad Msanda, and Rachid Bouharroud	Effect of vetch and fodder pea mixed cropped with barley and corn on soil characteristics in the Southwest of Morocco
93	Theme 3	Tasnime Maghraoui*, Sanâa Wahbi, Khalid Oufdou , Hervé Sanguin, Mohamed Hafidi, Prin Yves, Duponnois Robin, and Galiana Antoine	Enhanced transfer of biologically fixed N from faba bean to intercropped wheat through rhizobial symbiosis under P deficit conditions
94	Theme 3	Malika Srour, Ilham Azizi, and Ahmed Bamouh*	Evaluation of pre-emergence herbicides for the control of weeds in lentil in Zaer region of Morocco
95	Theme 3	Wondafrash Mulugeta*,Seid Ahmed, Kindie Tesfaye and Amsalu Nebiyu	Faba bean (*Vicia faba* L.) yield potential and gap under supplementary irrigation in Ethiopia

96	Theme 3	I Thami-Alami*, C Porqueddu, C Melis, A Souihka, L Pecetti and P Annicchiarico	Agronomic and farmer-participatory comparison of legume-based crops for livestock systems of different Mediterranean regions
97	Theme 3	Zahir Ahmad Zahir*, Muhammad Usman Jamshaid, Muhammad Yahya Khan, Hafiz Naeem Asghar, Muhammad Naveed, and Javed Akhter M	Improving production of pulses through inoculation with rhizobia and rhizobacteria containing ACC-deaminase activity
98	Theme 3	Sourour Ayed*, Afef Othmani and Mongi Ben Younes	Increased yield of faba bean/durum wheat rotations under drought conditions
99	Theme 3	Baldev Ram* and SS Punia	Effect of weed management practices on weed dynamics, yield and economics of lentil (*Lens culinaris* Medik subsp. *culinaris*) under vertisols
100	Theme 3	Md. Omar Ali*, Ashutosh Sarker and Shiv Kumar	Management of irrigation water on lentil and pea cultivation under drought environment areas of Bangladesh
101	Theme 3	Wafa Saidi*, Mongi Melki and Mouna Mechri	Nitrogen fertilization of bean crop in the semi-arid Tunisian conditions
102	Theme 3	Hanane Ouhemi, Abdelali Mouaaid and Ahmed Bamouh*	Potential of foliar potassium and phosphorus fertilization on lentil and chickpea in Zaer region, Morocco
103	Theme 3	K Daoui *, Z Fatemi and R Razouk	Productivity and potential of legume crops in an agroforestry system basis on olive tree
104	Theme 3	P Raghu Rami Reddy and G Veeranna	Pulse based cropping systems as alternative to Bt cotton under rainfed vertisols
105	Theme 3	AM Rehab*, Abd-Elrahman and MSM Soliman	Response of faba bean to organic amendments in calcareous soil
106	Theme 3	Amsalu Nebiyu*, Jan Diels and Pascal Boeckx	Role of faba bean in cropping systems via its biological nitrogen fixation and improved soil balance
107	Theme 3	Julie Grossman*, Sarah Seehaver, Thanwalee Sooksa-nguan, and Sharon Perrone	Role of rhizobia inoculation in promoting effective nitrogen fixation in legume green manures in the United States
108	Theme 3	K El Fakhouri, M El Bouhssini, A Sabraoui and S Lhaloui	Effect of sowing date and seed treatment on food legume insects
109	Theme 3	A Hamal, S Ahmed, M El Bouhssini, A Ramdani, S El Haloui, K Daoui and M Karrou	Test of post-emergence herbicide for the control of weeds in food legumes in Sais region, Morocco
110	Theme 3	Basma Okbi, Kamal Alahiane, El Houssine El Mzouri* and Jamila Amzil	The effect of residual nitrogen, mulch and zero tillage on lentil (*Lens culinaris* Medik.) in rainfed agriculture of Abda, Morocco
111	Theme 3	Abdelaziz Mimouni*, Rachid Mrabet and Fouad Msanda	The introduction of vetch and pea feed: an alternative for a sustainable improvement of the productivity of subsequent corn
112	Theme 3	Fabio Montero, Guido Ramírez Caceres*, and Alejandro Rossi	The power of novel inoculant formulations on the nodulation of pea
113	Theme 3	A Kabbaj, S Qetrani, E Bahafid, B Makoudi, M Mouradi, N Pauly, P Frendo and C Ghoulam*	How does water deficit affect legume-rhizobia symbiosis performance and its contribution for agrosystems sustainability?
114	Theme 3	K Alahiane, BOkbi, E El Mzouri*, J Amzil and Y Koulali	The effect of anti-drought chemical agents application on the performance of lentil crops under dryland farming system of Abda
115	Theme 3	Sunil Kumar NM, Jadhav RL and Ravi C Deshmukh	Special technology demonstration for harnessing black gram productivity through Frontline Demonstrations in Bidar region of Hyderabad Karnataka

116	Theme 3	NM Sunil Kumar, RL Jadhav and SA Kulkarni	Special technology demonstration for harnessing pigeonpea, *Cajanus cajan* productivity through Frontline Demonstrations in Bidar district
117	Theme 3	NM Sunil Kumar, RL Jadhav and K Bhavani	Evaluation of Frontline Demonstrations of chickpea in Bidar district of Northern Karnataka
118	Theme 3	Lhaloui Saadia, Mohamed Boutfirass, and Rachid Dahan	Rehabilitating and promoting food legumes through crop rotations with cereals: Enhancing Food Security in Arab countries
119	Theme 3	NM Sunil Kumar, BV Patil, SA Kulkarni and RC Deshmukh	Increasing production of pigeonpea through intensive application of Integrated Pest Management
120	Theme 3	NM Sunil Kumar, BV Patil, OP Sharma and Ravi C Deshmukh	Increasing production of chickpea through intensive application of Integrated Pest Management
121	Theme 3	Nour Alhouda Abed*, Bedj Mimi,Wahid Slimani, Mourad Atif, Abdelhakim Ouzzane, Hocine Irekti, Zineb-Faiza Boukhatem-Benhamadi, and Abdelkader Bekki	Effect of *rhizobium* inoculation on growth and yieldof common bean and maize
122	Theme 3	Ashok N Tikle*, Pooran Gaur, and Bhojraj Singh Parmar	Yield enhancement of food legumes for sustainable productivity in rainfed areas of Madhya Pradesh
123	Theme 3	A Nurbekov*, Z Ziyadullayev, D Sydyk, N Asoev, B Yatimov and A Kholmatov	Effect of tillage methods on productivity of double cropped mungbean in the irrigated areas of Central Asia
124	Theme 3	Abbès Tanji*, Oussama El Gharras and Mohammed El Mourid	On-farm weed dynamics in rainfed no-till food legumes in Central Morocco
125	Theme 3	R Zouani, H Maaroufi, T Jarrahi and M Kharrat	On-farm evaluation of new faba bean varieties under sub-humid climate conditions of Northern Tunisia
126	Theme 3	Md. Omar Ali*, Ashutosh Sarker and Shiv Kumar	Relay cropping of lentil in the rice field: An approach for intensification of production in the medium high to medium low lands of Bangladesh
127	Theme 3	Raju GTeggelli*, B Zaheer Ahamed, SM Suresh, MC Patil and A Jagadhish	Yield and economics impacts of transplanted pigeonpea (BSMR-763) under irrigated condition
128	Theme 3	SK Meti *, Raju G.Teggelli, B Zaheer Ahamed, SM Suresh and A Siddray	Farmer participatory approaches for improved production technologies in chickpea grown in Kalaburgi district of Karnataka through frontline demonstrations
129	Theme 3	Raju G Teggelli*, B Zaheer Ahamed, SM Suresh, MC Patil and A Jagadhish	Increasing the yield and economics of pigeonpea through Frontline Demonstration in Kalaburagi district, Northern Region of Karnataka
130	Theme 3	B Zaheer Ahamed *, Raju G Teggelli, SM Suresh and MC Patil	Maximization of productivity of Pigeonpea through improved production technology in Kalaburagi district of Karnataka
131	Theme 3	SK Meti, Raju G Teggelli*, B Zaheer Ahamed, SM Suresh and MC Patil	Maximization of yield of Black gram through improved production technology in farmer's fields in Karnataka
132	Theme 3	DW Rajasekhar* and ND Sunitha	Success story of transplanting technique in pigeonpea – A changing in the cropping pattern of the Vijayapura district of Karnataka, India
133	Theme 3	B Zaheer Ahamed *, Raju G.Teggelli, SM Suresh, MC Patil and A Jagadhish	Yield and Economics of pigeonpea as influenced by improved production technology in farmer's fields of Kalaburagi district of Karnataka state
134	Theme 3	M Bandara*, A Kruger, R Howard, M Harding and T Harms	Effect of three plant growth regulators on crop growth and productivity of Kabuli chickpea cultivars CDC Frontier and CDC Orion

135		M Labhilili*, R Moussadek, KH Hachhouch, B Bourkhiss, M Abderabihi, R Kallida, FM Bentata1	Use of the biological control in food legumes as alternative to ensure sustainable diversification of agriculture
136	Theme 4	Ch Ravinder Reddy*, H Sudini, GV Ranga Rao, CV Sameer Kumar and RS Shanthakumar Hopper	On-farm seed storage is critical in strengthening pulses seed systems in India
137	Theme 4	Brij Nandan, BC Sharma, BS Jamwal, Rakesh Kumar, Irfan A Shah and Kapilashiv Bazgalia	Reconstructing quality seed production system of pulses through FPA in Jammu region of North-Western Himalayas for livelihood security
138	Theme 4	Rakesh C Mathad*, G Lokesh and Y Basavegowda	Development of molecular seed genetic purity test for pigeonpea
139	Theme 4	Zalmai Alokozai, Wazir Gul Rasoli, Naveen Safi, Abdul Rahman Manan, Javed Rizvi, Srinivas Tavva*, Murari Singh, and Yashpal Singh Saharawat	Participatory on-farm demonstration of food legumes in Afghanistan: Role in enhancing food and nutrition security
140	Theme 5	Wassim Saadaoui*, Khaoula Mokrani, Anis Zorgati, and Neji Tarchoun	Accumulation ability of three heavy metals in two legumes (bean and faba bean) in vegetative stage at different concentrations
141	Theme 5	S Barpete*, KM Khawar, SF Özcan, C Sancak and S Özcan	Evaluation of toxicity levels of micronutrient and macronutrient strengths on regeneration of grasspea under in-vitro condition
142	Theme 5	George Vandemark*, Rebecca McGee, and Mike Grusak	Genotype and environment effects on seed mineral concentrations of chickpea and lentil grown in the USA Pacific Northwest
143	Theme 5	N Karmakar*, S Mukhopadhyay, A Chakravarty, PK Bandopadhyay, and R Sadhukhan	Biochemical and morpho-physiological changes associated with heavy metal toxicity in chickpea
144	Theme 5	Rim Hajri*, Mariem Boulaares, Yves Beckers, Mokhtar Mahouachi, Mouna Mechri, Houda Kourda and M Ben Younes	Comparative study of chemical composition of three local forage legumes from semi-arid region of Tunisia
145	Theme 5	Nadia Benbrahim*, Sanae Es-Saouabi, Nour Eddine Es-Safi, SaidGmouh, and Rachid Mentag	Nutritional value and perspectives for sustainable uses of Moroccan lentil
146	Theme 5	Chafika Houasli*, Ismail Oubdir, and Karima Samir	Physicochemical and nutritional characterization of advanced Kabuli chickpea lines in Moroccan chickpea varieties
147	Theme 5	HK Dikshit*, A Singh, P Prakash, M Aski and D Singh	Screening of elite lentil lines for phenols, flavonoids and antioxidants
148	Theme 5	B Okbi, E El Mzouri*, K Alahiane and J Amzil	The effect of micronutrients application on lentil (*Lens culinaris* Medik.) grown under semi-arid area of Abda, Morocco
149	Theme 5	Jose C Jimenez-Lopez	*Lupinus angustifolius* seed proteins as food ingredient: human health benefits and cross-allergenicity implications
150	Theme 5	Jane Wamatu*, Asemahegn Mersha, Ashraf Alkhtib, Million Eshete, Seid Ahmed Kemal, Adugna Tolera, Mohammed Beyan, and Barbara Rischkowsky	Cultivar-dependent variation in lentil (*Lens culinaris* L.) and implications for selecting food-feed varieties
151	Theme 5	Ashraf Alkhtib*, Jane Wamatu, Teklu Wegi, and Barbara Rischkowsky	Variation in the straw traits of morphological fractions of faba bean and implications for selecting for food-feed varieties
152	Theme 5	Renuka Shrestha*, Shiv Kumar, Albert Vandenberg, Ashutosh Sarker,	Lentil seed quality as influenced by environmental factors

		Rajendra Darai and Dhan Bahadur Gharti	
153	Theme 5	Aqeel Hasan Rizvi*, Ashutosh Sarker, Rajib Nath, S Mondal, AK Chowdhury, M Datta , D Burman and S Banerjee	Addressing household nutritional security through improved pulse technologies
154	Theme 5	Mamoni Das and Daisy Kameng Baruah*	Nutritional evaluation of Ricebean (*Vigna umbellata)* based Food Multi Mix.
155	Theme 5	OP Yadav	Arid legumes for improved nutrition and livelihood: the way forward
156	Theme 5	AKMM Rahman, Ahmed Khairul Hasan, Ashutosh Sarker and M. Jahiruddin	Iron, Zinc and Selenium biofortification of lentil in Bangladesh: Farmers' field survey
157	Theme 6	Elazhari Mohamed and Abdelali Laamari*	Food legume value-chain study in Morocco: Supply analyses
158	Theme 6	Omyma Elmahi Mohamed[1]* and Seid Ahmed	Distribution and importance of chickpea fusarium wilt disease (*Fusarium oxysporum* f sp *ciceris*) in the Sudan
159	Theme 6	Girma T Kassie*, Seid Ahmed, Aden Aw-Hassan, Said Silim, Mulugeta Yitayih, Solomon Tiruneh and Mekonen Misganaw	Economic impact of broomrape (*Orobanche crenata*) on pulse crop production in northeastern Ethiopia
160	Theme 6	Ilham Azizi, Malika Srour, Ahmed Bamouh*, and Rachid Moussadek	Evaluation of productivity, profitability and farmer's adoption potential of direct seeding of lentils in Zaer region (Morocco)
161	Theme 6	A Bouaziz*, M Baccar, P Dugué and PY Le Gal	*Vicia faba* cultivation as seen by farmers: diversity of practices in two Moroccan regions
162	Theme 6	Asnakech Tekalign Beyene, John Derera, Julia Sibiya and Asnake Fikre	Farmers' desired traits, selection criteria for faba bean (*Vicia faba* L.) varieties, perceptions on faba bean diseases and implications
163	Theme 6	Girma T Kassie*, Aden Aw-Hassan, Seid Ahmed, Luleseged Desta, Peter Thorne and Mulugeta Yitayih	Impact of improved legume varieties on technical efficiency of crop production in Ethiopia: Application of doubly-robust treatment effects model
164	Theme 6	Yigezu A Yigezu*, Tamer El-Shater, Mohamed Boughlala, Zewdie Bishaw, Abdul-Aziz Niane, and Aden Aw-Hassan	Income and nutrition impacts of rotation and adoption of improved faba bean varieties: A Moroccan case
165	Theme 6	RK Neupane*, A Sharma,D Aryal, A Sapkota, and R Darai	Technology validation and value chain interventions for commercial promotion of lentil in rice fallows in Terai of Nepal
166	Theme 6	MA Monayem Miah*, QM Shafiqul Islam and Md. Matiur Rahman	Socio-economic impacts of introducing short duration lentil and mungbean into rice-based cropping system
167	Theme 6	Swamikannu Nedumaran* and Jyosthnaa Padmanaban	Plausible futures of pulses in different socio-economic and climate change scenarios and its implication on food security
168	Theme 6	Stefanie Christmann* and MaríaJosé Suso	Participatory approaches to maximize pollination successes in cross-pollinated pulses
169	Theme 6	Sanae Krimi Bencheqroun, Afaf El Fadil, Adbellah El Aissaoui, Saadia Lhaloui, and Fouad Abbad El Andaloussi	Occurrence of major seed-borne fungi associated to chickpea seeds in post-harvest in some regions in Morocco
170	Theme 6	El Miziani*, Lhaloui, R Dahan, and M El Bouhssini	Estimates of quantitative and qualitative losses due to Bruchids damage in stored food legumes in Morocco

171	Theme 6	Ahmed Ben Khalifa and Houcine Djeder*	Adaptation to climate change in the dry areas: Case study of Jeffara Tunisia using integrated analysis modelling
172	Theme 6	A Fadlaoui, R Arrach, A Al Balghitti and R Dahan	Agricultural policy and pulses sector in Morocco
173	Theme 6	Abderrahim Bentaibi	Analysis of social and organizational aspects of food legumes chain
174	Theme 7	Asmae Amassaghrou*, Ahmed Bouaziz, Rachid Razouk, Mohamed Karrou, Karim Barkaoui, and Khalid Daoui	Agroforestry systems in Morocco, grain legumes and olive trees in Saïs region: Moulay Driss Zerhoun case study
175	Theme 7	Ashraf Alkhtib*, Jane Wamatu, Girma Kassie and Barbara Rischkowsky	Determinants of farmers' decision on utilizing cereal and legume residue as feed and soil mulch in the Ethiopian highlands
176	Theme 7	Gaad Djouher	Food legume crop in Algeria, situation and prospect: A case of lentil
177	Theme 7	Lhaloui, El Aissaoui, Bencheqroun, Boughlala, Houasli, Dahan, El Bouhssini, and El Miziani	Innovation platforms: A novel tool for improving food legume productivity and farmer's livelihood, and enhancing food security in Morocco
178	Theme 7	RS Shantha kumar Hopper*, SV Ramana, P Nandeesa and K Thachinamurthy	"Pulse Panchayats" - Innovative approach in promoting South – South collaboration, closing the supply and demand gap of pulses
179	Theme 7	A Sabraoui*,M El Bouhssini, S Lhaloui, A Boucheltta,and K El Fakhouri	Chickpea yield losses due to Leaf miner (*Liriomyza cicerina. R*) in Morocco
180	Theme 7	Ma. Teresa B Lirag	Knowledge promotion on pigeonpea (*Cajanus cajan*): Leveraging sustainability of farm family incomes


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Theme 1
Global pulses scenarios – production, consumption and trade

PP01: Understanding trends and patterns of production, consumption and trade of pulses within Middle East-North Africa (MENA): implications for Research, Development and policy within the region

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The research community continues to express the concern over a decline in the production of food legumes within the Middle East-North Africa (MENA) region, despite the growth in average consumption. The underpinnings for the declination however, is not entirely clear. The unequal government support to food legumes vs. cereal crops remains a common statement in most of the developing countries. Some evidence suggests that market incentives (including prices and marketing channels) for production are low; while in other cases, issues of biophysical constraints have been blamed. We argue that these are specific instances or periods within which the incentives for food legume production may have waned; yet they are not convincing on their own in understanding long term trends in the decline of legume production within the region. This paper sheds light on production areas, volumes, yields, price, trade, and consumption patterns within the MENA region over the past three decades. We estimate the compound growth rate, instability index and annual fluctuation for key legume crops (lentil, faba bean, and chickpea) across six MENA countries, in order to better understand levels of stability (and instability) in key parameters . Our analysis will be of importance for research and developmental organizations engaged in enhancing broad uptake of legumes through a better understanding of both macro and micro economic factors which are likely to influence production decisions and national policies.

PP02: Winter chickpea in Iran, current status and future prospects

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Chickpea is an ancient food legume crop in Iran and cold is among the most important factors limiting its productivity in the dry highlands of the country. In the cold highlands, winter planted chickpea damages are mainly extreme cold weather, Ascochyta blight and weed infestation. As a result, chickpea growers opt for traditional spring planting. Although spring planting resulted weak plant vigor and low seed yield, it gains an ensured average yield instead of total crop failure. In order to grow a successful winter planted chickpea crop, farmers require high yielding cultivars with considerable tolerance to extreme cold and to Ascochyta blight. Winter planted chickpea has many advantages over spring sowing e.g. better plant establishment and nodulation, less damage from birds and insect pests and the possibility of extending the crop into drier regions. Winter planted chickpea promises yield stability, economic advantage, help the farmers to achieve the food and nutritional security as well as increases in their basic household incomes. Adoption of winter planted chickpea will increase water productivity, soil health and help farmers to achieve sustainable agriculture production in rainfed areas. This paper, tried to describe the status and prospects of winter chickpea in Iran, after the release of the new cold tolerant chickpea variety "Saral" as a game changer.

PP03: Food legumes consumption in Morocco: Understanding Moroccan consumers' behavior

Badraoui Ismail[1, 2], Saikouk Tarik[1], Benmoussa Fatima-Zohra[3] and Aw-Hassan Aden[4]

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When addressing the issue of food security, among the most important crops mentioned worldwide are food legumes. Food legumes have always played an important role on different aspects in Morocco such as food security and nutrition, agriculture and socio-economy. Indeed, in addition to insuring the equilibrium of human and animal diet, food legumes highly contribute in improving soil fertility and ensuring sustainability of cereal production systems. On the economic and social sides, food legumes are grown by smallholder farmers and generate revenues for rural families. Despite their importance and the existing opportunities, such as high market demand and important research and development results, local production of food legumes has shown decline in the past two decades. The observed decrease has been triggered by, among others, a shift in the Moroccan consumers' demand for food legumes from local to imported products. Therefore, an empirical study on food legume value chain, namely the processors, distributors, and consumer's stages was conducted to explore perceptions and clarify consumers' preferences and expectations. Using semi-conducted interviews with processors and retailers, we gathered data on used products origin, the main transformation phases and sales trends. This part allowed us to identify consumption trends and formulate hypotheses on consumers' behavior to test. Second, we tested the formulated hypotheses through analyzing data on consumers' preferences gathered by conducting surveys at different sales points.

PP04: Food legumes production in Morocco: Improving local products competitiveness through regional valorization centers

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Food legumes are considered as major crops when addressing the issue of food security concerns around the world. In Morocco, this crop does not only contribute to food security, it also play key roles in soil fertility improvement and generates working days for smallholder farmers. Although food legumes play an important role in ensuring human food and animal feed, as well as on environmental and socio-economic levels, local production has drastically declined during the last two decades, leaving a high market share for imported products. One of the main triggers of local production decrease has been the shift of local consumption of food legumes from locally produced products to imported ones. A prior investigation has shown that this shift is mainly due to the higher quality of imported product (e.g. cleanness, regularity of caliber) compared to the local production. One of its main recommendations is the creation of region valorization center in order to enhance the quality of locally produced food legumes. Regional valorization center, which can take the form of an industrial cooperative, is a federative actor allowing the integration and better management of value chain flows. This flows management mode allows the creation of quality products adapted to the needs of downstream actors. Therefore, the objective of this paper was to highlight the potential benefits that regional valorization centers would have on local production of food legumes and how they are organized. In order to reach this objective, we first conducted a literature review on similar existing experiences in order to identify the different roles the center plays and the organization forms it can take. Second, we adopted the Delphi method where several experts on the subject were interviewed to evaluate the feasibly of the suggested solution.

Theme 2
Innovative techniques for pulses improvement and adaptation

PP05: Advances in lentil (*Lens culinaris* L.) breeding in Tunisia

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Lentil (*Lens culinaris* Medik.) provides valuable and well balanced nutritional components for human diet such as protein, potassium, phosphorus, iron, zinc, fiber, β-carotene and some vitamins. Its straw has also high value for animal feeding. In Tunisia, lentil is mainly grown in the South-East arid and the North-West semi-arid regions. As a rainfed crop cultivated in relatively moisture-deficient soils, lentil is less exposed to biotic stresses than other legumes. Area, production and yield fluctuate considerably from year to year and it depends on the rainfall received in the southern regions of the country. Lentil cultivated area in the country has increased from 1,335 ha for the period (1987-1991) to 2,649 ha for the period 2007-2011. This increase in the cultivated area does not result in significant changes in the production (9.8 tons in 1987-1991 and 8.9 tons in 2007-2011). The long term average yield is low (0.6 ton/ha). The National lentil breeding program at INRAT in collaboration with ICARDA is currently focusing on the development of better performing genetic material using classical breeding approaches. Grain yield, drought tolerance, earliness and crop growth type facilitating mechanical harvesting with grain quality are the main criteria for variety selection in Tunisia. The national breeding program selected and registered in the Tunisian plant varieties catalogue six high-yielding varieties (Nsir, Nefza, Siliana, Kef, Boulifa and Ebba) originated from ICARDA supplied germplasm. Three of these varieties are large seeded lentil (Nsir, Siliana and Ebba). Only Boulifa has red cotyledon. The variety 'Ebba' (FLIP2007-34L) registered in 2015 produced in average over four growing seasons at Kef 33% more grain yield than cv. Siliana released in 2003. Furthermore, this variety has resistance to powdery mildew. However, the variety Boulifa (FLIP05-19L) registered in 2013 produced 6.3% higher grain yield in average of six cropping seasons than cv. Kef released in 2003. All the released varieties by the national program in collaboration with ICARDA are recommended for cultivation in northern area of the country. In the future, special attention will be given for selection of very early and high yielding varieties suitable for cultivation in the southern area of the country.

PP06: Analysis of genetic diversity of Moroccan landraces of faba bean (*Vicia faba* L.) based on Amplified Fragment Length Polymorphism

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Faba bean (*Vicia faba* L.) is the most important grain legume being grown in Morocco. This crop is mainly produced based on locally maintained varieties and seeds (about 98%). These landraces are characterized by a large genetic diversity and are well adapted to the traditional agroecosystem. Assessment of the extent and structure of the genetic diversity between and within these landraces is a crucial step for an efficient exploitation of this diversity in faba bean breeding programs. The objective of the present study was to describe the genetic diversity of a representative collection of 60 Moroccan

faba bean landraces originated from Taounate, using the AFLP markers. In addition, two checks were added: Tatoo, a German spring bean line and Côte d'Or/1, a French winter bean. Four AFLP primer combinations were used on three individuals of each faba bean landrace and the two checks. Analysis of molecular variance revealed high and significant level of within population variance (82%). The UPGMA dendrogram constructed based on Jaccard's similarity showed no conspicuous grouping of populations. All landraces were displayed in one main cluster, divided in groups, showing some degree of similarity. In conclusion, there was a large diversity within the local populations compared to the diversity between the local populations. Consequently, additionally to the inter populations genetic diversity, intra population genetic diversity should be exploited in faba bean breeding programs.

PP07: Anti-oxidative defense system in lentil (*Lens culinaris* Medik.) genotypes under high temperature stress at reproductive stage

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Lentil is an important pulse crop often affected by high temperature during its reproductive phase. The effect of high temperature stress was studied on tolerant (LL1372, LL1361, LL1396) and sensitive (EC78390, LL1380, LL1390) genotypes of lentil selected on the basis of physiological and yield attributes. These genotypes were raised under timely (TS) and late (LS) sown conditions. Biochemical analysis showed that high activities of catalase (CAT), superoxide dismutase (SOD) and higher percentage of free radical scavenging activity along with lower content of malondialdehyde (MDA) in leaves and pod wall of late sown tolerant genotypes (LL1372, LL1361, LL1396) helps to mitigate the high temperature induced oxidative stress by scavenging free radical species and protecting them from membrane injuries. These genotypes also showed high proline content useful in stabilizing the membranes under stress condition. Sensitive genotypes (EC78390, LL1380, LL1390) had lower activity of catalase (CAT), superoxide dismutase (SOD) and lower free radical scavenging activity and proline content along with higher content of malondialdehyde (MDA) and hydrogen peroxide (H_2O_2) alleviates the higher temperature induced stress in them, and adversely affecting reproductive development.

PP08: Assessment of tolerance level of Moroccan lentil genotypes against *Orobanche crenata*

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Lentil (*Lens culinaris* Medikus) is an important pulse crop grown worldwide. This legume plays a significant role in human nutrition and in maintenance and improvement of soil fertility. Despite its importance, lentil production is affected by several constraints. *Orobanche crenata* remains one of the major biotic limiting factors in Middle East, Northern Africa and East Africa. *O. crenata*, a holoparasite, can cause crop losses ranging from 5 to 100%. In absence of an efficient control strategy, development of resistant cultivars remains the most effective way to reduce damage on lentil. Thus, screening lentil genotypes for tolerance to *O. crenata* represents the first step towards the development of resistant cultivars. In this perspective, our study focused on assessing the tolerance level of 17 Moroccan lentil genotypes (varieties and landraces). For this purpose, pot and petri dishes experiments were conducted. Infestation parameters expressed in terms of number of orobanche infestation events (OIE) were assessed. Different infestation levels were observed among evaluated genotypes. In pot assay, Taza, Hamria and Zaaria showed the highest infestation and Oulad Lhaj, Abda and L5 the lowest. Petri dishes

revealed that Bakria, Tetouan, and L5 genotypes were the most tolerant, unlike Zaaria and Abda. Based on the results of both experiments, L5 genotype was found to be the most tolerant. This genotype could be integrated into a lentil improvement program for tolerance to *O. crenata*.

PP09: At least three rust (*Uromyces viciae-fabae*) resistance genes detected for faba bean in Australia

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Faba bean rust (*Uromyces viciae-fabae*) is one of the major fungal diseases in most of the faba bean growing regions in the world. It is a major disease in the northern grain growing region of Australia where farmers need to spray fungicides 2-3 time in a season to protect the crop from rust. The development of rust resistant varieties can reduce the need for fungicide spraying. Breeding resistant cultivars relies on the ability to detect the resistant genes and understanding the genetic bases of their resistance. Diallel crosses without reciprocals were made among three resistant (AC1227#14908, AC 1655 and Doza#12034) and one susceptible (Fiord) genotypes and their segregating populations from F_2 to F_3 were analysed as seedlings. Seedling tests of F_2 and F_3 progenies showed three distinct responses; highly resistant, moderately resistant and susceptible. However, no homozygous family with a moderate response was found in the F_3 progeny test, hence, this infection type could not be attributed to independent gene(s). The segregation ratio in both F_2 and F_3 population derived from Doza#12034 and a central European line Ac1655 indicated a single dominant gene was responsible for conferring resistance in each of these lines. An allelism test revealed that each of the above resistant parents carried a single and independent gene for resistance. The other parent AC1227#14908 gave near susceptible reaction at seedling stage, but it was moderately resistant at adult plant stage indicating adult plant resistance. When it was crossed with the susceptible parent Fiord, all its progenies were susceptible in F_3 indicating it had no seedling resistant gene. However, when it was crossed with resistant parents Doza#12034 and AC1655, the F_2 progenies segregated in 9 resistant: 7 susceptible ratio indicating complementary epistasis. It appeared that AC1227#14908 carries a complementary gene which cannot be expressed on its own, but when crossed with another resistant parent it gives a resistant reaction. These results clearly showed availability of at least three rust resistant genes for breeders to choose or pyramid for improving faba bean rust resistance in Australia with further indication of adult plant resistant gene.

PP10: Biometrical and molecular dissection of genetic diversity in minicore collection of pigeon-pea (*Cajanus cajan* (L.) Millsp.) for fusarium wilt, SMD and yield

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An investigation was carried out using 191 accessions of mini core collection of pigeon-pea with 5 check varieties to know the genetic diversity and ascertain the reaction of genotypes to Fusarium wilt (FW) and Sterility Mosaic Disease (SMD), validate DNA markers linked to wilt and SMD, morphological characterization and identify stable genotypes for environments. High phenotypic co-efficient of variability (PCV), genotypic co-efficient of variability (GCV), heritability and per cent genetic advance was observed for number of branches per plant, pod bearing length, number of pods per plant and seed yield per plant. High rate (0.30 to 0.99) of positive direct effect on yield was observed by means of days to 50% flowering, number of pods/plant and 100-seed weight at genotypic and phenotypic levels.

Grouping 196 genotypes showed positively skewed distribution with 13 clusters. Cluster I was the largest comprising 80 genotypes followed by cluster III (51 genotypes). Six clusters had solitary entries (IPPFC-43, GRG-281-1, ICP-3576, ICP-14116, ICP-13673 and ICPB2043. Two years of field screening for Fusarium wilt yielded 11 resistant genotypes of which, ICP-8949, GRG-2009, ICP-11320, GRG-811 and GRG-333 were wilt resistant and high yielding. A total of 69 genotypes showed moderate resistant to wilt. The genotypes viz., Bahar, ICP-7035, ICP-11910 and RAJA were resistant for SMD. Molecular diversity using 18 polymorphic Simple Sequence Repeat (SSR) markers divided genotypes into 15 clusters, of which ICP-11059 and AK-101 were solitary. Validation of two Sequence Characterized Amplified Region (SCAR) markers *viz.*, SCAR-704 (FW) and SCAR-N-18, (SMD) revealed significant association of SCAR-N-18 with SMD. Stability parameters for seed yield indicated that ASHA (ch) was stable and desirable, followed by RVK-275 and GRG-811. Morphological characterization differentiated ICP-7148 and GC-11-39 from the rest of genotypes for determinate growth habits.

PP11: Performance of Kabuli chickpea (*Cicer arietinum L*) genotypes under drought prone environment and their nutritional status in the eastern Amhara, Ethiopia

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Eight promising Kabuli chickpea genotypes with two checks (cvs. Shasho and Arerti) were evaluated for yield and quality parameters and adaptability to drought in Eastern Amhara, Ethiopia. The experiment was conducted at three locations (Sirinka, Chefa and Kobo) using randomized complete block design with three replications on farmers' fields. A workshop was prepared on food preparation, nutritional and utilization aspects of the genotypes and a panel of male and female farmers were involved in the evaluations. A combined analysis of variance over years and locations showed that significant differences among chickpea genotypes for days to flowering and maturity, pods per plant, 100-seed weight and seed yield. Genotype ICCV-14808 was found superior. These genotypes were evaluated, verified and presented for release by the National Variety Releasing Committee for the region. ICCV-14808 genotypes have a 45% of yield advantage over Shasho. These candidate varieties are bold seeded (35gm) that fulfilled the required standard for export. Besides, these varieties were drought tolerant. Based on the evaluation and assessment of the national variety-releasing committees, the genotype ICCV-14808 (named Yelbe) is released for Sirinka, Chefa, Kobo and similar agro-ecology. Based on farmer's assessment for agronomic and other criteria, this variety was highly preferred as compared to the standards checks. The *cv*. ICCV-14808 had 28.2% of protein and 54% of carbohydrate. Acceptability and utility for easiness, flour yield, easiness for chewing, flavor attractiveness, boiling time at 92°C, roasting rate (degree of non-sucker), roasting ability, shiro quality and color were evaluated by recipe farmers and preferred in those quality assessments.

PP12: Mapping QTLs and identification of putative candidate genes for heat tolerance in chickpea

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Chickpea (*Cicer arietinum* L.), a cool-season legume, is increasingly affected by heat stress at reproductive stage due to climate change and late sowing. Identifying quantitative trait loci (QTLs) for heat tolerance may facilitate breeding for improving heat tolerance. The present study was aimed at

identifying QTLs associated with heat tolerance in chickpea using 292 F_8-F_9 recombinant inbred lines (RILs) of the cross ICC 4567 (heat sensitive) × ICC 15614 (heat tolerant). Phenotyping of RILs was done for two heat stress (late sown) and one no-stress (normal sown) environments. Genotyping was performed with genotyping-by-sequencing (GBS) based 271 single nucleotide polymorphisms (SNPs) covering the whole genome of chickpea. Using composite interval mapping (CIM) analysis, two consistent genomic regions harbouring eight QTLs on CaLG05 and CaLG06 were identified. Several other QTLs for different traits were also found on different other linkage groups. Four major QTLs for number of filled pods, number of seeds, grain yield and % pod set, located in the CaLG05 genomic region, were found to have cumulative phenotypic variation of above 50%. Nineteen pairs of epistatic QTLs were found with significant epistatic effects, but there was no QTL × environment interaction effect except for harvest index and biomass. The candidate gene mining from the chickpea whole draft genome sequence revealed 25 putative candidate genes for heat stress lying in the two genomic regions CaLG05 and CaLG06. This is the first report on QTLs for heat stress response in chickpea. The markers linked to four major QTLs can facilitate marker-assisted breeding for heat tolerance in chickpea.

PP13: Choice of breeding method for improving yield and yield stability in faba bean

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Faba bean (*Vicia faba* L.) is partially allogamous crop with outcrossing rate varied from 0.3 to 0.83 with an average of 0.5. Breeding methods applied to this crop depends on the levels of outcrossing and the genetic basis of the varieties, and varied from location to location depending on pollinator activities. Different breeding methods were applied to improve productivity such as pedigree method, recurrent selection and development of synthetics. The purpose of this research is to evaluate the efficiency of different breeding methods. These methods were applied to six different crosses to develop 24 F_7 lines by pedigree, 30 F_7 lines by recurrent selection during five successive seasons and nine Syn1 lines using top cross from 2013 to 2015. The lines were evaluated in two cropping seasons (2014/2015 winter and 2015 summer) in alpha lattice design with two replications. Days to flowering (DFLR), days to maturity (DMAT), number of branches per plant (BRPT), pods per plant (PPNT), number of seeds per pod (SPO), number of seeds per plant (SPL), hundred Seed Weight (SW100), single-plant yield (SPY), grain yield per ha (GY) were recorded. Analysis of variance showed that genotypes, breeding methods (BM) and G X BM were found significant for DFLR, DMAT, SPP and GY. Average grain yield developed by recurrent method in both seasons were superior than the average yield of lines developed by pedigree methods and by synthetics Syn1. Stability analysis indicated that the lines developed by recurrent and synthetic methods were higher yielding and high stable than those developed by pedigree methods.

PP14: Cool Season Food Legume genome database: enabling genetics, genomics and breeding research in pea, lentil, faba bean and chickpea

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The Cool Season Food Legume Genome Database (CSFL, www.coolseasonfoodlegume.org) is an integrated and up-to-date genomics, genetics, and breeding database which facilitates basic, translational and applied research in cool season food legumes. Currently, it contains over 100 genetic maps; 90,500

molecular markers; and 1,500 QTLs in total for pea, lentil, chickpea, and faba bean with new genetic data being added as it is published. The data from the Kabuli- and desi-type chickpea genomes and a link for community annotation curation of these genomes using GenSAS (Genome Sequence Annotation Server) are also available. Designed with easy-to-use interfaces, CSFL allows users to quickly search and retrieve data from the database and access tools such as BLAST for searches with current genome sequences and transcripts, view genomes in the JBrowse genome browser, compare maps with CMap, and view metabolic MetaCyc pathways. The database also contains the CSFL RefTrans for each of the crops. The RefTrans is a reference transcriptome that was assembled using EST and published RNA-Seq datasets. The functionally annotated RefTrans sequences can be searched and downloaded along with the corresponding homology analysis data from SwissProt and TrEMBL. In the future, CSFL will also have an integrated Breeding Information Management System (BIMS) that will allow breeders to manage their datasets under a private account on the website as well as to use breeding decision tools. The BIMS tool will also allow for phenotypic data upload directly from the Field Book Android app. Breeders will be able to not only view their private data, but also view their data along with the publically available data on CSFL. CSFL is a one-stop website with a plethora of resources and data for breeders and researchers who work on faba bean, chickpea, lentil, and pea. This project is supported by USDA NRSP10, the USA Dry Pea and Lentil Council, Northern Pulse Growers Association, USDA-ARS and Washington State University.

PP15: Determination of gamma radiation lethal dose in two cultivars of Kabuli chickpea (*Cicer arietinum* L.)

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Determination of appropriate radiation doses for each cultivar is important in mutation breeding. In order to increase genetic variability for chickpea improvement, two Kabuli genotypes (GP10 and Ghab 4) were treated with six different doses of gamma rays (150, 200, 250, 300, 350 and 400 Gy) using Cobalt-60. Data on emergence rate, fresh and dry weight of root and shoot and survival rate were recorded. The prediction of dose effects was calculated from the linear regression equation. Lethal dose (LD50) based on survival rate (at maturity) was determined on the M_1 generation. The results showed a significant effect of radiation on two genotypes for all traits. Higher the dose, the lesser the number of survival plants and seedlings vigor were. The results showed differential sensitivity between GP10 and Ghab4, the effect was more important on Ghab 4 genotype. The LD50 values based on the survival rate were 360 Gy for the GP 10 and 258 Gy for Ghab 4 genotypes.

PP16: Differential response of pigeonpea genotypes for phosphorus acquisition

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The variation of phosphorus (P) occurrence in the soil, leads to variable response for P uptake by plants. Phosphorus is the second most essential element for all life forms. It plays a crucial role in physiological and metabolic process of plants. Pigeonpea genotypes have the potential to acquire more P with increased activity of acid phosphatase under P deficient conditions. Phosphorus solubilizing enzymes hydrolyze the fixed soil P which is unavailable to plant. The increased accumulation of P due to higher P uptake efficiency can be related to better root characters like high root surface area, root biomass, root length,

root volume and altered plant metabolism. P use efficient genotypes have ability to take immobile P from P deficient conditions by modifying root architecture. The present study was carried out at Punjab Agricultural University, Ludhiana, in 43 genotypes, acquired from various sources to determine the extent of genetic variation of pigeonpea germplasm on the basis of phosphorus acquisition. The experiment was conducted in factorial complete randomized design with eight replications in pots. Significant variation was found for root traits among the genotypes. High P uptake was observed in genotypes with high root dry weight and root area. Activity of acid phosphatase in roots under P deficient conditions increased in almost all genotypes. There was a direct relationship between P uptake, root dry weight and root area. Genotypes with higher root area showed better P uptake under P deficient condition. Genotypes ICPL 88039, ICPL 20330 and ICPL 20340 were identified as P use efficient genotypes under P deficient condition. Selected genotypes can be used in the breeding program as donors.

PP17: Elicitation of induced resistance against *Rhizoctonia solani* in mungbean by rhizobacterial isolates

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Mungbean (*Vigna radiata* (L.) Wilczek) is an important pulse crop next to chickpea and pigeonpea in India. The, root rot caused by *Rhizoctonia solani* is one of the major diseases affecting its yield. Although a number of control measures are available, inducing defense mechanism in plants seems to be a relatively novel, cheaper and appropriate method of control. Plant growth promoting rhizobacteria (PGPR) are reported to induce production of defense related proteins against fungal pathogens. This study reports the potential of five native rhizobacterial antagonists (B19a, B1b, P32a, P38a, P44b) against *R. solani* to boost the defense enzymes in the root tissues of mungbean varieties (ML-818 and PAU-911) against *R. solani* under glass house conditions. Seed bacterization with P32a and P44b induced significant protection against the pathogen and reduced the rotting incidence as compared to control. Observations revealed maximum accumulation of phenolics in plants treated with isolate P44b (47.66 µg/gfw, followed by P38a (44.02 µg/gfw) and were found significantly higher than captan (24.69 µg/gfw) and control (7.99 µg/gfw) in PAU-911. However, maximum phenol accumulation was recorded in B19a (45.12 µg/gfw) followed by P32a (40.39 µg/gfw), which was found to be at par to the fungicide (40.82 µg/gfw) treatment in ML-818. Peroxidase (PO) activity was recorded maximum with isolate P44b in PAU 911 (0.839 nm min-1 mg) and in ML818 (0.611 nm min-1 mg) compared to captan (0.648 nm min-1 mg, 0.430 nm min-1 mg) respectively. Isolate P44b also induced highest Polyphenol oxidase (PPO) activity (0.911 nm min-1 mg and 0.4793 nm min-1 mg) which was much higher than control 0.0259 nm min-1 mg and 0.1388 nm min-1 mg in PAU911 and ML818 respectively. PR proteins play important role in disease resistance and also help the plant to adapt to the environmental stress. This study showed the importance of PGPR, not only stimulating plant growth but also help in the crop to escape root rots by inducing various defense mechanisms of plants.

PP18: Evaluation of improved chickpea lines for their adaptation to Moroccan environments

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Chickpea (*Cicer arietinum* L.) is the second major food legume in Morocco. With faba bean and lentil, this crop plays an important agronomic role in the wheat-legume based farming systems thanks to its contribution in soil fertility through nitrogen fixation. Sustainable chickpea production requires identification and cultivation of stable cultivars and stability analysis plays an important role in estimating the suitability of genotypes to specific environments. In stability models, Additive main effects and multiplicative interactions (AMMI) model has been found to be efficient because it captures

a large portion of the GxE sum of squares and austerely separates main and interaction effects. The present study was conducted to determine seed yield stability of 17 elite lines of chickpea and analyze the GxE interaction at three locations (KHZ= Khmiss Zmamra, JSH= Jemâat Shaim and MCH= Merchouch) during three cropping seasons. These locations are representative areas for potential chickpea growing environments in Morocco. In each of the nine environments the trials were laid out in randomized complete blocks design with 3 replications. AMMI analysis revealed that the major contributions to total variation sum of squares were environments (95.8%), followed by genotypes (2.5%) and GxE (1.7%), indicating that the environments were diverse and caused most of the variation in grain yield. Genotypes were also different, At Khmiss Zmamra, Jemaat Shaim and Marchouch stations, the best performing genotype were Genotypes G3, G13 and G6 respectively. The first two principal components explained 48% and 23.1% of the total sum of squares, respectively; they were used to create GGE biplot diagrams. Finally, it was concluded that genotypes G2, G6 and G17 showed high yield stability as compared to other genotypes and are, therefore, recommended for release.

PP19: Evaluation of faba bean accessions for earliness and heat tolerance

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Faba bean (*Vicia faba* L.) is an important cool season food legume grown worldwide. Heat is a major abiotic stress that reduces faba bean productivity. Heat stress is increasing in terms of intensity and frequency due to the climatic change and variability. This study aimed to evaluate faba bean accessions under heat prone conditions. A set of 176 accessions from 21 countries were tested in alpha lattice design with two replications at ICARDA Terbol, Lebanon during the summer 2015. The maximum air temperature varied from 32°C to 40.5 °C during the flowering time. The heat tolerance score varied from 2 to 5. Days to flowering, plant height and seeds per plant varied significantly among genotypes. DFLR varied from 35 to 120 days. About 36 accessions flowered at 35 days after sowing (DAS) and 75 at 45 DAS. Plant height varied from 37 to 79 cm, and Seeds per pod ranged from 0 to 129. Lines with 20 seeds per plant were considered heat tolerant. Twenty two accessions originating from Egypt, Iran, Iraq, Turkey, Sudan, and Spain and 14 ICARDA improved lines were identified as extra early lines while three accessions originating from Sudan and Egypt and 5 improved lines were considered as heat tolerant.

PP20: Exogenous salicylic acid affects plant growth and the antioxidant system in faba bean (*Vicia faba* L.)

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Salinity stress is considered as one of the major abiotic stresses which strongly reduced crop productivity. In order to assess the effect of salinity constraint on some agro-physiological and biochemical traits in broad bean (*Vicia faba* L.), two cultivars (Khamassi and Sbai), originated from Morocco, were tested. The experiment was arranged as a split–plot with a randomized complete block design. In this study, the physiological response of salt stresses (0 and 120 mM NaCl) on *V. faba* L. and the effect of exogenous salicylic acid (0 and 0.5 mM SA) were investigated. The irrigation with salt water (120 mM of NaCl) was applied 15 days after sowing and lasted for 21days. Thereafter, some agro-physiological and biochemical parameters related to salt tolerance, as plant biomass, plant height, root and shoot dry weights, water content, membrane permeability, chlorophyll, and protein, were measured. Results

showed that Irrigation with saline water significantly reduced all plant growth parameters in comparison to the respective control. However the protein and chlorophyll content showed an increasing trend with salt stress. Alleviation of growth arrest was observed with exogenous applications of salicylic acid (SA) under salt stress conditions. Overall, the positive effect of SA towards resistance to the salinity of faba bean will provide some practical basis for cultivation.

PP21: Genetic diversity in Ethiopian faba bean (*Vicia faba* L.) varieties based on phenotypic traits and ISSR markers

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Faba bean (*Vicia faba* L.) is one of the earliest food legumes of Ethiopia used as source of high protein for human and animal consumptions. Many cultivars are released from local and exotic sources targeting different agro-ecologies. The study was designed to determine the genetic diversity of 32 faba bean varieties using phenotypic traits and ISSR markers. The experiment was conducted at three locations: Sinana, Agarfa and Selka for agro-morphological performance and at Addis Ababa University; Plant Genetics Research Laboratory for ISSR fingerprinting during 2014/2015. Genomic DNA extraction was done based on modified CTAB method from young leaf sample. The combined analysis of variance over three locations showed highly significant ($P<0.01$) variations among the varieties for the majority of traits recorded in the study. The combined estimate of all variance components and coefficient of variability indicated the presence of high variability among faba bean varieties. Seed yield showed strong positive phenotypic association with seed production efficiency ($r=0.9437$); seed filling rate ($r=0.9608$) and seed yield per day ($r=0.9862$). The cultivars were grouped into seven major clusters where the first three PCA accounted 65.2% of the total variation. Eleven ISSR primers amplified 120 bands, of which 107 loci were polymorphic ranged from 60% to 100% per primer. The highest gene diversity (0.38) and Shannon index (0.56) were recorded by primer 860, whereas least gene diversity (0.18) was obtained from primers 848 and 857. The genotypic analyses showed three major clusters based on Jaccard's similarity coefficient ranging from 0.29 to 0.77. The highest genetic similarity value was observed between Mesay and Bulga-70 (0.77) and distant genetic similarity between Obse and Didea (0.29). Hence, phenotypic and ISSR markers are helpful to assess the extent and pattern of genetic diversity among faba bean cultivars helping breeders for further crossing and other improvement efforts.

PP22: Evaluation of faba bean accessions under heat prone conditions

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Faba bean (*Vicia faba* L.) is one of the most important grain legumes grown world-wide for food and feed. Heat is the major abiotic stress along with drought and affecting faba bean productivity in heat prone areas. In this study we assessed the performance of 140 faba bean accessions representing the GCP reference set under heat prone conditions at ICARDA, Terbol station in Lebanon during 2015 summer season. The accessions were planted, using alpha lattice design with two replications with two checks. Data on days to flowering, growing degree days, number of pods per plant, number of mature pods per plant, number of seed per plant, number of mature seeds per plant, number of mature seeds per pod, hundred seed weight and plant height were collected. Pollen samples were collected at 30 and 35°C and tested for their germination. Principle Component Analysis showed that at 35°C degrees, yield component and pollen viability explained 58% of the total variation. Based on these results, seven heat

tolerant accessions were selected for further analysis like association mapping and consequently identifications of QTL associated with heat tolerance.

PP23: Genetic diversity analysis among Yellow Mosaic Virus (YMV) resistant and susceptible varieties in mungbean using SSR markers

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Green gram (*Vigna radiata* L Wilczek), is a self-pollinated diploid (2n = 22) pulse crop, with a genome size of 515 Mb/1C, popularly known as mungbean and is Native to the Indian subcontinent. Green gram is an excellent source of proteins (19-28%), mineral (0.18-0.21%) and vitamins which complements the staple rice diet in Asia and particularly in India. Among the various diseases limiting the mungbean productivity, Yellow Mosaic Virus YMV or Yellow Mosaic Disease (YMD) transmitted through the white fly, *Bemisia tabaci* Genn, is wide spread. In the present investigation, an attempt was made to study the genetic diversity among 17 varieties of mungbean, collected from different geographical regions of India using Simple Sequence Repeat (SSR) markers. Genetic similarity among varieties was estimated using Jaccords Coefficient of similarity. Dendrogram was performed using the Unweighted Pair Group Method with an Arithmetic mean (UPGMA) algorithm and the NTSYS software. Molecular polymorphism was 58.8% with 29 SSR primers indicating the low level of genetic variation among the varieties. The mungbean variety WGG-2 is appeared to be more divergent with 42.1% similarity, while high similarity of 81.7% was recorded between two susceptible varieties KM 14-34 and Km 14- 61 and between resistant, ESM 14-1413 and susceptible KM 14-57 variety. In one cluster all the resistant varieties (ESM 14-1312, KM14-43 and KM 14-62) and all the susceptible varieties (KM 14-34, Km-14-61 and MGG-295) grouped based on their phenotypic disease reaction for YMV, except resistant variety WGG-42 is grouped with susceptible varieties. The study indicated that SSR marker profiles were best-suitable for assessing genetic relationships among YMV resistant and susceptible varieties.

PP24: Genetic diversity of local populations of grass pea in Algeria under semi-arid environment

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The ability of *Lathyrus sativus* L. (grass pea) to provide an economic yield with low input under water stress conditions, drought and water logging, has made it a popular crop in subsistence farming in many developing countries. In Algeria, under low rainfall conditions, (250-300 mm) there is tendency to increase monoculture of cereals such as wheat, the integration of grass pea in the rotation can make the production system more sustainable by improving soil fertility and producing feed for livestock. Our main objective is to study the behavior of different populations of this species in high plains of Setif in order to determine the most adapted genotypes for semi-arid conditions. Ten local populations were collected in different regions of Algeria and evaluated under field condition using RCBD experimental design. The traits evaluated were phenologic (date of the beginning and the end of flowering, date of formation of pods and date of complete maturity, biometric (number of lost plants, plant height, number of seeds per pod and per plant, weight of 1000 seeds, and number of pods per plant) and morphologic (flower color, seed color, seed size, pod shape, seed shape, plant growth habit, leaflet shape. Variance analysis was used to estimate differences among populations. Despite severe climate (drought and late spring frosts) all populations grew and produced seeds. The analyses showed significant differences between populations for most traits. However, two groups of populations were distinguished, those with

dark seeds and others with light seeds. Our results showed that the populations with dark seeds produced more pods and seeds.

PP25: Genetic erosion of Algerian chickpea

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Chickpea (*Cicer arietinum* L.) is an important food legume crop with high nutritional value and ecological importance. In Algeria, this crop have various constraints, the most important one is the absence of varieties adapted to prevailing conditions. It is the fifth largest importer of chickpea in the world. In the sixties Algeria had more than thirty local varieties and four botanical varieties of chickpea. Unfortunately, these varieties disappeared. Currently, only eight new varieties are cultivated and do not respond to the need of agriculture. Almost all lines selected by ICARDA in 1988 as better performant and resistant to diseases are not as such in 2016 because the environment and pathogens changes. In order to highlight genetic variability, forty-six local and foreign genotypes of chickpea were characterized using agronomic and molecular traits. These genotypes showed significant differences and represent a basic genetic material to the Algerian breeders for on the genetic improvement of chickpea.

PP26: Genetic principle of pod dehiscence in pea

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The transformation of wild plants into domesticated crops is the central process of early agriculture and one of key milestone in human history. Domestication can be viewed as an accelerated evolution, the result of human and natural selection. It triggered changes representing adaptations to cultivation and harvesting named domestication syndrome. In pea these changes include loss of germination inhibition and increase of seed size, linked to successful early growth of planted seeds as well as loss of pod dehiscence. Though genetic principles of pod dehiscence was explain in several pulses (bean, soya-bean), but in case of pea they are still more information is required. The main objective of the study was to identify genetic and structural pod dehiscence of pea by comparative analysis of wild and domesticated pea genotypes. We used 136 F5 RILs of JI64 *Pisum elatius* and JI92 landrace (primitive domesticate) for genetic mapping. Based on previously published position of Dehiscence pod (Dpo1) loci we re-mapped respective region. In addition we generated candidate genes for pod dehiscence based on massive analysis of cDNA ends (MACE) results for parental lines and two bulks of dehiscent and indehiscent lines. This analysis resulted in identification of 77 differentially expressed genes (4 up-regulated and 73 down-regulated) which were selected for further analysis by qRT-PCR. Of these the expression of 20 genes were studied at two developmental stages of dorsal and ventral pod suture tissue in parental genotypes (JI64, JI92).

PP27: Genetic variability and heritability of agronomic traits of chickpea genotypes in India

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Chickpea (*Cicer arietinum* L.) is an important food legume crop for human food and nutrition in many countries. Identification of superior genotypes will play a crucial role in developing a strategy to enhance

the breeding efficiency of the crop that depends mainly on the existence of genetic variability and high heritability of desired traits. A set of 3102 chickpea lines representing the core collection were planted in an augmented design at India Research Platform, Amlaha, Madhya Pradesh, India. Both qualitative and quantitative, traits were evaluated to determine genetic diversity and identify superior lines. The quantitative characters were: days to flower, plant height, basal primary branches, basal secondary branches, days to maturity and plant stand and quantitative characters; pods per plant, yield per plant, seed yield per plots and 100-seed weight. Results showed significant variation among genotypes for duration of vegetative and reproductive phase and agronomic characters (days to maturity, yield per plant and 100-seed weights). Broad leaf genotypes showed late maturity in comparison to narrow leaf plants. Some of the genotypes were erect types, suitable for mechanical harvesting. The 100-seed weight, maturity and yield per plot ranged from 5-72g; 103-160 days and 9-597g respectively. The highest seed yield was recorded for JG11 while ICC2514 was the lowest. Broad sense heritability (h^2) was highest (64%) for 100- seed weight, 59% for plant height, 39% for days to maturity and 28% for yield and lowest for basal primary branches per plants. The substantial genetic variability presented in the genetic resources evaluated leads to select parents of interest for different breeding strategies.

PP28: Genome wide association using the ICARDA lentil reference set and agronomic parameter

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Lentil (*Lens culinaris* Medik.) is the world's fifth most important pulse crop. It is self-pollinated diploid (2n=14) and has a relatively large genome size of approximately 4 Gb. Next generation sequencing (NGS) technology was used to genotype the ICARDA Lentil Reference set using the two-enzyme (PstI, MspI) genotyping-by-sequencing (GBS) method described by Poland. This method has been shown to be capable of discovering and genotyping thousands of markers across the lentil genome. We genotyped 192 accessions from the lentil reference collection plus stress responsive lines derived from the diverse lentil collection held by ICARDA. The software package "Stacks" and in-house scripts were used to call 10,050 high quality single nucleotide polymorphisms (SNPs). GWAS with the collection was tested using historic agronomic data. Associated markers will be reported and the potential of expanding the population and phenotypic experiments to improve association precision will be discussed.

PP29: Genotypic difference in salinity tolerance during early vegetative growth and yield of cowpea (*Vigna unguiculata* L. Walp.) from different regions of Algeria

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The effects of salinity on the growth and yield responses of five cowpea (*Vigna unguiculata* (L.) Walp.) populations from different regions of Algeria P1 (El Kala), P7 (Tizi Ouzou), P13 (In Salah), P17 (Adrar) and P23 (Bechar) were investigated. The experiment was carried out under greenhouse conditions. Plants were irrigated using four saline solutions (1.93, 3.8, 4.7 and 6.0. dS m-1) 20 days after the start of the experiment for two months. The results showed that the increase of salinity reduced significantly growth (height, number of leaves and leaf area). At maturity, the components of yield (number of pods/plant, length of pods/plant, weight of 100 seeds and number of seeds/pod) were significantly affected by salt. The most affected parameter is the number of pods/plant. However, the effects vary depending on the

level of salt and the population concerned. On the basis of growth and yield, P1, P7 and P23 were more tolerant than P13 and P17. Nevertheless P13 and P17 have most abundant foliage that makes them valuable as fodder for livestock. This genetic variability can be used for success in selection programs.

PP30: Host differentiation and variability of *Orobanche crenata* populations from legume species in Morocco as revealed by cross infestation and molecular analysis

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Legumes are vitally important in Moroccan agriculture. They play a strategic role in improving soil fertility and structure. However, during the last decades, legume production had decreased due to several biotic and abiotic stresses. *Orobanche crenata* represents a major biotic constraint. In Morocco, this parasitic weed is particularly problematic in faba bean and lentil fields. For the first time, natural *O. crenata* seed populations produced on different hosts were quantified for their host specificity to *Vicia faba* and *Lens culinaris*. The virulence of Orobanche populations was investigated through field trials, pot and Petri dishes assays. Genetic diversity of these weed populations were also assessed through molecular analyses. Evaluation under controlled conditions showed a greater affinity between host species and "their own" Orobanche populations. The two host legume species showed distinct patterns of infestation. In fact, faba bean was more sensitive to both *O. crenata* populations. While, the specificity of lentil and its own *O. crenata* population appeared at a final stage of the parasite's biological cycle (emergence stage) as shown by Correspondence factorial analyses. Our results showed that prevalence of *O. crenata* seeds from faba bean fields in Morocco and its adaptation is becoming serious problem for other legume species. Analysis of Molecular Variance was used to evaluate diversity structure between *O. crenata* populations. Considerable internal variation within Orobanche populations growing on both legume species was observed (81%). Furthermore, significant divergence (19%; Ø= 0.189; p=0.010) among the two populations was also perceived, revealing a beginning of differentiation between the two *O. crenata* populations infecting faba bean and lentil.

PP31: How crop-wild introgressions may affect several important agronomic traits in lentil

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Like other ancient self-pollinating crops, the gene pool of lentil (*Lens culinaris* Medik. subsp. *culinaris*) has become very narrow following domestication and adaptation to specific regions of the world. This has limited the genetic variability available to lentil breeders. To increase genetic variation, wild relatives become important, and crop-wild introgression breeding is being used in some crops for this purpose. The genus *Lens* consists of the cultivated *L. culinaris* plus six wild species. At least one of them, *L. ervoides*, represents a rich source of genetic variability for lentil improvement. Previous research has shown that this species exhibits resistance to multiple diseases (Tullu et al. 2006; Fiala et al. 2009; Vail and Vandenberg 2010), and the resistance has been successfully transferred into an inter-specific *L. culinaris* x *L. ervoides* RIL population, LR-26 (Vail S., 2010; Vail et al., 2011). Introgression from wild relatives is not without its risks, however. Phenotyping and genotyping of this inter-specific population is providing insights into the impact of introgression on lentil breeding. In this study, we looked into several other traits that were segregating among individuals of LR-26, such as days to days to emerge, vegetative period, reproductive period and plant height as well as seed quality traits such as thousand seed weight and the content of important seed storage carbohydrates, including sucrose and total raffinose

family oligosaccharide. Analysis of variation and estimates of heritability of these traits were based on a three-year multi-environment field trial. Genotyping has been done using genotyping-by-sequencing. The phenotypic results will be combined with genotyping results. This will allow us to identify regions of the wild genome that have been introgressed and tag genetic regions associated with control of these traits of interest.

PP32: Hybrid pigeonpea: Innovative intervention to enhance productivity

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Pigeonpea is an often cross-pollinated crop of grain legumes and unique jewel in rainfed cropping systems of Asia and Eastern and Southern Africa. It is mainly cultivated as rainfed crop with cereals, pulses, millets and oilseeds in various cropping systems. It offers a sustenance to the soil and assured income to the farming community as an insurance during abnormal weather conditions like drought. More than 100 varieties are being released in the crop across the globe for various agro ecologies with a wide range of maturity duration in early (120 days), medium (150 days) and long duration (180 days) groups. The cultivation is expanded to nearly 6 Million hectares by 2015 but the productivity is unacceptably low around 750 kg/ha for the past six decades. Cytoplasmic and genetic male sterility based hybrids in field crops led to tremendous increase in productivity by exploiting the genetic principles of heterosis. The phenomenon of hybrid vigor was successfully exploited in pigeonpea crop by identifying sources of male sterility from the wild relatives. It took three decades of research efforts to develop stable maintainers, complete restorers and heterotic hybrid combinations. The hybrids ICPH 2671, ICPH 2740 and ICPH 3762 were released for general cultivation by the farmers in different agro ecoregions of India and a number of other hybrids are in the pipeline. Yield advantage of 30 to 40% (rainfed) and 50 to 60% (irrigated) was realized in farmers' fields over the local varieties. Seed production technology was also standardized by exploiting male sterility and entomophily thereby appreciable amounts of hybrid seeds were harvested from the seed parent. Conventional and genomic approaches are underway to identify candidate genes responsible for fertility restoration, elite parents with resistance to fusarium wilt and sterility mosaic disease and heterotic gene pools to breed adaptive hybrids for different niches across the globe. Efforts are also underway to develop hybrids in different maturity group's *viz*. super early, early, medium and long duration to recommend adaptive hybrids for different niches.

PP33: Identification of faba bean lines tolerant to high dosage of Glyphosate

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Orobanche crenata Forsk is a parasitic weed that invades faba bean (*Vicia faba* L.) in the North Africa, East Africa and the Middle East. Several control methods including chemical, mechanical, cultural and even induction of resistance in faba beans have been developed. Presently, an integration approach involving chemical control by glyphosate [N-(phosphonomethyl) glycine] and varietal resistance is the most effective technique. However, phytotoxicity symptoms accompanied by significant yield losses have been reported on faba beans at the recommended dose (200 g a.i./ha). In this study, we evaluated tolerance of 290 mutagenized faba bean lines against three glyphosate treatments; T1: 800 g a.i./ha; T2: 1200 g a.i./ha; T3: 1600 g a.i./ha; under field conditions at the flowering stage. The experimental design used was augmented design with three replicate checks every 9 lines. Observations were recorded on

chlorosis, rolling of apical leaves, reduced growth, lower number of pods and mortality. Some of the mutant lines showed very high tolerance against tested doses of glyphosate; 66 mutant lines against 800 g a.i./ha, 22 against 1200 g a.i./ha and 21 at 1600 g a.i./ha of glyphosate. Two mutant lines, Mu-38 and Mu-418 showed tolerance at the three tested doses of glyphosate in terms of growth and seed yield.

PP34: *In vitro* culture of *Orobanche crenata*

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Orobanche crenata is an obligate root parasite that affects legume species. It represents a major agricultural problem in Morocco and other Mediterranean countries. Yield losses are considerable and can reach 100% depending on the areas and host plant. Development of resistant genotypes is considered the most economic and ecologic control strategy for Orobanche. For that, the host-parasite interaction requires both a good biological knowledge of the target species (host and parasite) and mechanisms underlying resistance/tolerance to these constraints. In addition, the confrontation of the host plant with the parasite weed must be done in an environment controlled away from any other interaction. In *vitro culture* techniques respond to these needs. *In vitro* culture of faba bean has been already reported, however a very few studies on *in vitro* culture of Orobanche are available. This study describes the influence of different plant growth media in association with plant growth regulators on germination and *in vitro* development of calli from *O. crenata* seeds. Callus type and kinetics of development were highly influenced by media composition and gibberellic acid concentration. Among the four media used for culture, B5 medium generated a significantly higher differentiation rate of callus and protuberance formation. No *O. crenata* callus was observed on TB medium.

PP35: *In vitro* screening of lentil (*Lens culinaris* ssp. *culinaris*) genotypes to high temperatures

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Lentil (*Lens culinaris* subsp. *culinaris* Medikus) is an important cool-season food legume crop commonly grown under rainfed conditions in South Asia, North America, West Asia and North Africa (WANA). Occurrence of drought and heat stress during the reproductive stage in most of these environments, causing substantial reduction in crop yield. Lentil reproduction is sensitive to temperatures higher than 32/20^{o}C (day/night). The high temperature stress affects pollen viability, fertilization, pod set and seed development leading to abscission of flowers and pods. The lentil breeding program at the International Centre for Agricultural Research in the Dry Areas (ICARDA) aims to improve the yield potential and stability of lentil crop by incorporating genes for drought and heat tolerance and resistance to key diseases. Two studies were conducted to determine the temperature effects on lentil pollen germination, tube growth and cell membrane thermostability at ICARDA, Rabat, Morocco during 2015 cropping season. A total of 14 lentil genotypes were subjected to in vitro temperature treatments from 15°C to 40°C at every 5°C intervals. Significant genotypic differences were found among genotypes for per cent pollen germination and tube length (<0.01 level). The optimum temperature for ILL4605, ILL7815, ILL6238, ILL2507, ILL7264, ILL6063, ILL6001, ILL4258, ILL4401, ILL10712 and ILL7303 was found at 15 °C, but it was at 20 °C for ILL1734, ILL4400 and ILL3973 genotypes. Overall, high temperature stress caused reduction in pollen germination percentage and tube growth. The accessions

including ILL1734 and ILL4258 had demonstrated pollen germination percentage and pollen tube length at high temperatures (35°C & 40°C) treatment. On the other hand, the results of cell membrane thermostability studies identified highest cell membrane thermostability in ILL3973 (53.52%) and ILL7264 (45.98%), There was no relationship found between pollen germination and cell membrane thermostability at high temperature stress condition. The identified high temperature tolerant genotypes could be used as a potential donor for future use in lentil breeding program.

PP36: Mutation induction in lentil

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Lentil (*Lens culinaris* Medik.) is one of the most important cool season food legume crops cultivated worldwide in semi-arid regions, particularly in the Indian sub-continent and in the dry areas of the Middle East, Canada, southern Europe, and eastern and northern Africa. To cope with low productivity of lentil, the breeding is one of the solutions. The genetic diversity, which can be natural or induced, is key to improve the productivity of crops. Induced mutation has been extensively used for creating new genetic variation in crops such as lentil. Many useful genetic changes were induced by a mutagenic treatment including higher yield, disease resistance and early maturity in many crops. Induced mutation has been employed successfully in lentil. Gamma rays were the most used mutagen to change gene(s) in lentil due to their easy application. About 13 lentil mutant varieties were created and the most cultivated are S-256 (Ranjan), Rajendra Masoor 1, Mutant 17 MM, PL 77-2 and RH44. Currently, the Targeting-Induced Local Lesion in Genomes (TILLING) is a technique that used in a plant mutant and considered as reverse genetics strategy and the principle is to identify a mutation in the specific gene and relate this mutation to the phenotypic change in the mutated plant. At ICARDA, mutagenic lentil populations have been recently developed in order to identify any point and knock-out mutations for tendril formation and other traits such as pod shattering, herbicide tolerance and Orobanche tolerance. In Algeria, radiation mutagenesis on lentil variety Idlib-3 was carried out to create variability and select mutants using gamma rays as mutagen. The results obtained in M2 showed the existence of variability between 140 families for 10 agronomic traits. 13 families showed superiority to the original variety. We determined the lethal dose LD50 that was equal to 100 Gy. DNA extraction of M2 mutants was done for the use in low-cost Tilling technique developed by AIEA.

PP37: Unlocking genetic potential of wild native species to diversify the cultivated legume genepool

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Chickpea and lentil are among the prominent legume crops in South Asia including India. Both crops, however, have intrinsically narrow genetic base limiting further the increase in productivity. The genetic diversity existing in the indigenous germplasm has been exploited by breeders to develop improved varieties. However, to attain further breakthrough in enhancing yield and improving stability in future cultivars, new sources of genes/alleles need to be identified in the unadapted wild crop species and incorporated into the background of cultivated varieties. The wild species of chickpea and lentil, both from compatible and incompatible gene sources, have contributed traits of interest for the genetic improvement of the cultivated varieties. More recently, wild *Cicer* species have contributed to cold and fungal disease resistance including genes for high yield. These agronomic characters were mainly introgressed from *C. reticulatum* and *C. echinospermum* into the cultivated genotypes. However, use of genetically incompatible wild *Cicer* species for the improvement of cultivated chickpea varieties is still

a challenge. Global level efforts are underway to develop techniques for gene transfer from such distant species. In the recent past, NBPGR (ICAR) took initiative for diversification of the cultivated gene pool of both chickpea and lentil crops in collaboration with ICARDA. All the available global wild annual *Cicer* and *Lens* genetic resources were introduced from ICARDA. The introduced germplasm was then characterized, evaluated and the selected accessions are used to introgress genes of interest into the cultivated genetic backgrounds. Important agro-morphological traits, *viz.*, high biomass, high number of pods/plant, earliness, and multiple resistance against *Botrytis* gray mold, *Ascochyta* blight and root knot nematode are well documented in the wild *Cicer*. Likewise, in wild annual *Lens*, useful gene sources were identified for important agronomic traits *viz*, short internode, high number of pods/plant, multiple resistance against wilt, rust and powdery mildew. Inter-specific crosses were attempted in chickpea to transfer the target traits like earliness, shorter internode, high pods/plant and resistance against *Ascochyta* blight and *Botrytis* gray mold. The inter-cross mapping populations developed from *C. reticulatum* have also been used to scan the major genomic region (s) underlying QTL(s) governing seed weight and pod number using NGS (next generation sequencing)-based QTL region-specific association and multiple QTL-seq strategies. These integrated NGS-based genomic strategies have profound efficacy in rapid genome-wide scanning of potential candidate gene(s) for genomic-assisted breeding and genetic enhancement of chickpea. Further, genome-wide characterization of wild *Cicer* species for understanding the genetic structure, domestication and linkage disequilibrium (LD) pattern by large-scale genotyping of informative microsatellite and single nucleotide polymorphism (SNP) markers was conducted to facilitate chickpea improvement. The integrated reference genome- and *de novo*-based GBS (genotyping-by-sequencing) assays identified 82489 high-quality genome-wide SNPs from 93 wild and cultivated *Cicer* accessions. High intra- and inter-specific polymorphic potential (66–85%) and broader natural allelic diversity (6–64%) detected by genome-wide SNPs among accessions signify their efficacy for monitoring introgression and transferring target trait regulating genomic (gene) regions/allelic variants from wild to cultivated *Cicer* gene pools for further genetic improvement.

PP38: Lentil in Morocco: Genetic diversity of symbiotic rhizobia and selection of effective bacterial biofertilizers

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Lentil (*Lens culinaris* Medik) is a food legume rich in protein, vitamins and minerals and also known for its ability to fix N2 in root nodules. In Morocco, cultivated area of lentil is ranked in third position among food legumes, but yield is very low. To improve the production of this crop, it is necessary to identify the best bacterial symbiotic strains to be used as inoculum. To achieve this objective, 269 rhizobial strains were isolated from nodules of lentil plants from four Moroccan main producing areas (Zemmour-Zaer, Chaouia-Ouardigha, Azilal and the Eastern region). Isolates were characterized by sequencing housekeeping genes (16S rRNA, recA and gln II) and the nodulation nodC gene. The analysis based on the 16S rRNA gene sequencing showed that all isolates belong to the genus *Rhizobium*, with a genetic similarity with *R. leguminosarum* ranging from 97 to 99% over 980 bp. Phylogenetic analyses based on recA and glnII genes resulted 26 distinct multilocus haplotypes. Most of them clustering with isolates of *R. leguminosarun* bv. *viciae* and strongly rooted to *R. laguerreae* isolated from *Vicia faba* in Tunisia and *R. leguminosarum* bv *viciae* isolated from *Lens culinaris* in Germany, Turkey, Syria and in Eastern and Central Europe. The nodC gene analysis also revealed a rather large diversity with 26 different haplotypes. Forty one percent of the isolates are close to strains previously identified in Mediterranean countries, the remaining isolates were related to strains isolated from various part of the world. Based on this genetic diversity, 35 strains representing the collection have been characterized for their symbiotic effectiveness and their physiological activities have been also investigated. This analysis allowed us to identify the best strains with the high capacity to solubilize inorganic phosphate and to fix effectively

atmospheric nitrogen. Other studies are in progress in order to select the most important strains to be used as inoculums in Moroccan soils.

PP39: Development of molecular markers for iron metabolism related genes and their expression analysis under excess iron

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Multiple genes and transcription factors are involved in the uptake and translocation of iron in plants from soil. The sequence information about iron uptake and the translocation related genes are largely unkown in lentil (*Lens culinaris* Medik). This study was designed to develop iron metabolism related molecular markers for *Ferritin-1*, *BHLH-1* (Basic helix loop helix) or FER-like transcription factor protein and *IRT-1* (Iron related transporter) genes using genome synteny with barrel medic (*Medicago truncatula*). The second objective of this study was to analyze differential gene expression under excess iron conditions over time (2h, 8h, 24h). Specific molecular markers were developed for iron metabolism related genes (*Ferritin-1, BHLH-1, IRT-1*) and validated in lentil. Gene specific markers for *Ferritin-1* and *IRT-1* were used for quantitative PCR (qPCR) studies based on their amplification efficiency. Significant differential expression of *Ferritin-1* and *IRT-1* was observed under excess iron conditions through qPCR based gene expression analysis. Regulation of iron uptake and translocation in lentil needs further characterization. Greater emphasis should be given to development of conditions simulating field conditions under external iron supply and considering adult plant physiology.

PP40: Molecular diversity and population structure of the Ethiopian lentil (*Lens culinaris* Medikus) genotype assessment using SSR markers

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Knowledge of genetic diversity is essential for formulating effective germplasm collection, conservation and utilization strategies in crop improvement programs. It also provides an opportunity to take corrective steps infusing new genes to avoid risks associated with a narrow genetic base. Here, we analysed the genetic diversity of 119 lentil genotypes, including 83 germplasm accessions from Ethiopia and 36 exotic accessions from International Center for Agricultural Research in the Dry Areas, using 27 simple sequence repeat (SSR) markers. Analysis Molecular of Variance estimated the variations of 82% within and 18% among the populations. The degree of polymorphism observed among the populations was 100%. A total of 122 alleles were detected, which ranged from 2 to 7 alleles per locus, with a mean of 4.52 alleles per locus. The estimated gene diversity for 27 loci was 0.64. The average Shannon's information index value of 1.19, showed the existence of high genetic variation within the genotypes. The genetic similarity indices ranged from 0.21 to 1.00. The SSR markers showed an average polymorphic information content (PIC) value of 0.58. Cluster analysis grouped the genotypes into five major clusters as distinct genetic populations. This molecular diversity information provides a basis for future germplasm collection, utilization, and conservation strategies in gene banks and introducing exotic germplasm to widen the genetic base of the current lentil breeding populations.

PP41: Identification of molecular markers associated with rust resistance genes in lentil (*Lens culinaris* sub sp. *culinaris*)

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Lentil rust caused by *Uromyces vicia- fabae* (Pers.) J. Schroet is the most widespread and economically important disease in Ethiopia, Bangladesh, India, Nepal, and Morocco. The objective of this study was to determine the genetics of rust resistance in lentil and to locate map position of gene(s) associated with resistance to rust and to identify molecular markers that can be used in marker-assisted selection. We report here the mapping of rust resistance gene using lentil specific SSR markers. For this purpose, a recombinant inbred line (RILs) population comprising of 133 lines, derived from the cross of a rust resistant line (FLIP-2004-7L) as male parent, and a rust susceptible line (L-9-12) as female parent was used. Phenotyping of the RIL population was carried out at rust hot spots in Chefe Donsa, Sinana and Sirinka (Ethiopia) during summers of 2011 and 2012 and at Gurdaspur, India during 2011/12 cropping season. The mapping population segregated in 1:1 ratio (χ^2= 0.008), indicating that lentil rust resistance is controlled by a single gene. Linkage analysis for rust resistance gene showed that the SSR marker GLLC106 was located at a distance of 10cM from resistance gene. All resistant RILs had bands at 200bp region. This co-segregating marker can be used for marker-assisted selection in a lentil breeding program aimed at developing lentil cultivars resistant to rust disease. However, future research should be aimed at developing additional markers closer to the resistance gene so that the region is saturated.

PP42: Phenotypic variability and characteristics of lentil (*Lens culinaris* Medik.) germplasm of Ethiopia by multivariate analysis

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Lentil (*Lens culinaris* Medik) is an important crop in Ethiopian highlands. Its productivity is very low due to low yielding landraces and other factors. The objectives of this study were to classify groups of genotypes based on morphological diversity, identification of the major traits contributing to the diversity and identify superior genotypes for breeding. Eleven variables analyzed by Mahalanobis's generalized distances (D^2), Principal Components Analysis (PCA), and a cluster analysis following the method of the Unweight Pair Group Method using Arithmetic Averages (UPGMA). The result showed the existence of considerable genetic diversity among lentil genotypes, for yield and yield components indicating the scope and guarantee for use in the breeding programmes. The most important traits that contributed to genetic divergence were above ground biomass, seed yield, number of seeds per plant, days to maturity and number of pods per plant. The lentil accessions were grouped into 6 major and 15 sub clusters characterized by distinct morphological feature irrespective of their origin.

PP43: Effect of post-emergence herbicide metribuzin application on morpho-physiological traits, yield and yield components in lentil (*Lens culinaris* Medik.)

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Lentil (*Lens culinaris* Medik.) is an important cool season grain legume cultivated extensively in India, Canada, Turkey, Bangladesh, Iran, China, Nepal and Syria. It is the second most important cool season food legume crop next only to chickpea in India, and is grown on about 1.42 million hectares with a production of 1.13 million tonnes. It is a poor weed competitor and most annual grasses and broadleaf weeds compete with it throughout the growing season for nutrients, water, and light, and thus reducing crop yields (20-80%) and grain quality and also harbour insect-pests and diseases. At presently there is no suitable post-emergence herbicide for weed control as the lentil is sensitive. Thus, a set of 180 diverse lentil genotypes was screened against post-emergence herbicide metribuzin applied @ 250 g ha^{-1} at 50 days after sowing to identify tolerant genotypes. Based on preliminary screening, 30 lines including tolerant, moderately tolerant, sensitive and highly sensitive lines were selected for further evaluation on larger plot using same herbicide dose to see the effect of herbicide on morpho-physiological traits, yield and yield components. Herbicide metribuzin application showed adverse effect on most of the traits including yield of lentil genotypes. In herbicide treated plots, 50% flowering and pod initiation was delayed, while plant height, biomass accumulation, leaf area index, specific leaf weight, crop growth rate and chlorophyll content were reduced as compared to untreated plots. The 100-seed weight, pods $plant^{-1}$ and seed yield were also reduced in herbicide treated plots. Overall, six genotypes namely LL699, LL931, LL1383, LL1384, LL1385 and LL1367 showed less reduction (<19%) for seed yield and for other traits, while two genotypes LL1365 and LL1393 showed more reduction for seed yield and other traits as compared to untreated plots.

PP44: Achievements of the national chickpea (*Cicer arietinum* L.) breeding program in Tunisia

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Chickpea (*Cicer arietinum* L.) is the second major food legume cultivated in Tunisia. With faba bean and peas, it plays an important role in sustainable cropping systems and especially in the wheat based cropping systems due to their ability to fix atmospheric nitrogen. They are, also, the main source of protein in human diet particularly for the low-income populations. In Tunisia, chickpea crop undergoes several constraints mainly biotic stresses. Ascochyta blight (AB) caused by *Ascochyta rabiei* (Pass.) Labr. and Fusarium wilt (FW) caused by *Fusarium oxysporum* f. sp. *ciceris* are the main serious and damaging diseases. Recently, for winter sown chickpea, root-rot complex diseases have emerged as an important limiting factor for chickpea cultivation particularly in the favorable rainfed regions. Moreover, chickpea stunt [caused by Beet western yellows virus (BWYV) and Chickpea chlorotic stunt virus (CpCSV)] as well as the parasitic plants *Orobanche foetida* and *Cuscuta* are increasingly becoming a serious threat in some regions of the country. Considerable efforts were deployed by the Tunisian chickpea breeding program that was focused on the selection of new varieties tolerant/resistant to major biotic constraints. As a result of these efforts, eight chickpea varieties including seven winter chickpea varieties were released. These varieties stem mainly from finished ICARDA germplasm tested under different Tunisian environments. Recently, three new large seed size varieties were developed; cv. Nour

and cv. Rebha were registered in the Official catalogue respectively in 2011 and 2015 while cv. Joud have been proposed for registration in 2015. These new high yielding varieties are carrying dual resistance to AB and FW and characterized by large seed size seeds with 100 seeds weight of 44-45 g for both cv. Nour and cv. Rebha and 46-47 g for cv. Joud. Both cultivars Rebha and Joud are also carrying good resistance level to chickpea stunt caused by BWYV and CpCSV. The newly developed varieties, along with the previously released varieties such as cv. Beja 1, which is the most cultivated variety, will contribute increasingly to the development of winter chickpea cropping in Tunisia and will contribute efficiently to the improvement of chickpea seed yield which increased from 0.5 t/ha to 0.9 t/ha respectively for the periods 1961-1989 and 2001-2014. The National Chickpea Breeding Program in Tunisia is currently quite active in the development of even better performing genetic material. Classical breeding approaches as well as modern molecular tools through the development and use of molecular markers tightly linked to genes/QTLs involved in the resistance to main biotic stresses are being used.

PP45: Achievements of the national faba bean (*Vicia faba* L.) breeding program in Tunisia

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Faba bean (*Vicia faba* L.) is the most important grain legume cultivated in Tunisia. In the northern favorable regions of the country, it play an important role in the wheat based cropping systems due to its ability to fix atmospheric nitrogen. It is used for human consumption in many traditional dishes, as well as for animal feed. Faba bean planted area is estimated to 55,000 hectares representing more than 75% of the total food legume planted area in the country. In Tunisia, the development of this crop especially in the favorable regions is facing many biotic constraints that seriously reducing the grain yield. Major foliar diseases (Ascochyta blight, chocolate spot and rust) and parasitic plants *Orobanche foetida* and *Orobanche crenata* are the most damaging constraints limiting faba bean production in the main cropping regions of the country. During the last decade, considerable progress have been made resulting in the development of several high yielding varieties that contributed significantly in the improvement of grain production and increased cultivated area especially small seeded faba bean. Seven varieties including two large seeded varieties and five small seeded varieties were registered in the national plant variety catalogue. Recently, three new small/medium seeded varieties, cv. Najeh, cv. Chourok and cv. Chams, were developed from crosses made in Tunisia. Both varieties Najeh and Chourouk were registered in the national catalogue respectively in 2009 and 2014 medium seed size (74-76 g/100 seeds) was proposed for registration in 2015. These new varieties are resistant/tolerant to major foliar diseases and carrying a good resistance level for both *O. foetida* and *O. crenata*. The National Faba bean Breeding Program in Tunisia is currently quite active in the development of even better performing genetic material through classical breeding approaches as well as modern molecular tools.

PP46: Microsatellite marker-based genetic diversity analysis of elite lentil lines differing in grain iron and zinc concentration

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A total of 50 lentil elite genotypes were evaluated at three locations in India during year 2013-14 for grain Fe and Zn concentration to analyze G x E interactions using the additive main effect and

multiplication interaction model (AMMI).The AMMI analysis of variance for both grain Fe and Zn detected significant effects for genotype, environment and genotype by environment interaction. Based on AMMI model, the genotypes which are characterized by means greater than grand mean and the IPCA score nearly zero are considered as generally adaptable to all environments. For Fe content genotypes P13143, P 13135, ILL 2581, P 2130, LL 147, PL 101 and Globe mutant and for Zn content genotypes P 2205, P 13143, P 13122, P 2239, P 3204 and L 11-245 were found stable. The diversity analysis using 20 genomic and 54 EST-SSR markers indicated that the studied genotypes were diverse. The genomic SSRs exhibited higher polymorphism in comparison to EST- SSRs. The genotypes were grouped in two major clusters with 37% similarity. Local genotypes were grouped in cluster I and all exotic accessions were grouped in cluster II indicating the role of geographic origin in diversity. Based on multi-location evaluation for grain Fe and Zn concentration and molecular characterization crosses are proposed for development of grain Fe and Zn rich varieties (P 3220 x L 4649 and VL 103 x P 2130) and development of mapping populations (P13122 x L 11-287 and LL 931x P3220) for study of genetics and mapping of QTLs/gene(s).

PP47: *Orobanche crenata* effect on some faba bean genotypes and the genetic variation between three Orobanche isolates

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The present study was carried out at Giza Research Station under the naturally Orobanche infested fields during 2013/14 and 2014/15 seasons, to study the effect of Orobanche infestation on seed yield and yield components of four tolerant faba bean genotypes (Giza 843, Misr1, pop. 10, X-2054 and the susceptible genotype Giza 2. The genetic diversity of Orobanche isolates from both tolerant and susceptible cultivar was also studied. Highly significant differences were observed in plant height, number of branches/plant, number of pods/plant, seed yield and 100-seed weight. For Orobanche dry weight (g)/m2 X-2054 and population 10 had the lowest Orobanche dry weight. Giza 2 recorded the highest Orobanche dry weight (g)/m2. Results showed the superiority of X-2054 population 10 and Misr 1 in Orobanche infested fields and therefore these genotypes are recommended for breeding to tolerate Orobanche. The genetic diversity among three isolates of *Orobanche crenata* were analyzed using ten RAPD primers. A total of 68 bands were recorded 47.1% of them were polymorphic and 11 unique markers which identify the three Orobanche isolates. The highest number of unique markers was observed in isolate 3 (Orobanche isolated from the susceptible cultivar Giza 2) which scored 8 unique markers, two unique markers characterized isolate 1 (Orobanche isolated from the tolerant cultivar Giza 843) and one unique marker identified for isolate 2 (Orobanche isolated from the tolerant cultivar Misr 1). The three Orobanche isolated were grouped into two clusters. Where, isolate 3 separated alone. While, isolate 1 and isolate 2 (were in the second cluster. The highest similarity was 88% between isolate 1 and isolate 2. Hand weeding is not economical. Further, if the pulled shoots are kept in the field they are able to produce seeds, so the weed problem persists. If the practice of harvesting young shoots for human consumption were to spread, this would not only help to reduce the damage to the host plant and to reduce the broomrape seed-bank in the soil, but also provide an additional source of incomes to small holders. This approach would not only provide a sustainable means of control but also contribute towards economic sustainability. The success of such an approach would depend on the acceptance of these products by the markets. To meet that demand in Egypt, we need to show and spread the benefits of using broomrape and to develop the technology for broomrape production, collection and distribution at a reasonable price. Many requirements to meet, but the prospect is certainly food for thought.

PP48: Phylogenetic relationships among *Phytophthora sojae*, isolated from damped-off soybean seedlings in Egypt

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The phylogenetic relationships among 15 *Phytophthora sojae* isolates came from damped-off soybean seedlings in Egypt using The internal transcribed spacer (ITS) region (ITS1, ITS2 and 5.8S rDNA) of the nuclear ribosomal DNA (nrDNA) were examined. The isolates were morphologically identical and grew at temperatures between 20°C and 35°C, and the optimum temperature was 30°C, with a radial growth rate of 25 mm/24 h. The results showed that there is a difference between the bp-sequences of ITS1 and ITS2 among the fifteen isolates. These 15 isolates were classified into two groups and the grouping depends on collection sites.

PP49: Importance of experimental design in pulse improvement

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There are three main stages in any breeding program of pulses: generation of genetic variability, selection, and test of experimental cultivars. The first stage includes making crosses, inducing mutation and introducing new germplasm. The second stage uses the variability created in the first stage and includes different breeding methods that will narrow the genetic variability. The last stage compares the existing cultivars with the germplasm generated in the second stage. During each of the stages in pulse breeding program, the control of the hypotheses is done through experimentation using trials. An experiment should be subject to a strict planning by developing an experimental protocol. Its basic elements are: definition of aims and conditions of experiment; definition of factors to study their influence (treatments); definition of experimental units to be observed; definition of observations that will be performed; and how different combinations of modalities of factors will be assigned to various experimental units. The experimental error is defined as the variation between plots treated alike and it is due to plant, climatic, and soil variability. Any experimental design should provide a valid measure of experimental error and reduce it as much as possible in order to increase the heritability and the response to selection. This is why design of experiments is based on three principles: randomization, replication, and local control of heterogeneity. In the early stage, plant breeding trials often include a large number of treatments (genotypes). Assessment is done using small plots with some of them replicated (checks) while most of them (hundreds of new genotypes) are unreplicated due to limited seeds, for example. In later stages, replicated yield trials with checks and tens of genotypes are used to measure progress. Consequently, each stage requires specific experimental designs due to the particular aim and conditions of the experiment. In this research work, the main components of an experimental protocol will be shortly described and the focus will be on the conditions of an experiment (on-station and on-farm; preliminary, main, and confirmation experiments). Then, the main experimental designs (augmented, row-column, alpha-lattice, incomplete block, randomized complete block, etc.) will be presented with their principles, at which stage of the breeding program they can be used, their advantages and their limitation.

PP50: Recent status of Moroccan faba bean landraces: collection, characterization and utilization

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Faba bean (*Vicia faba* L.) is an important food and feed legume crop in Morocco with a multitude of uses. Morocco is known to be an important center for diversity for faba bean. However, the erosion of faba bean genetic resources remains one of the principal threat for this crop. Therefore, *V. faba* genetic

resources need to be collected, characterized, evaluated and conserved in genebank before being proposed to be integrated in faba bean improvement program. A total of 117 local populations were collected from 2012 to 14 from the faba bean growing region of Morocco. These populations were morphologically characterized using ICARDA/IPGRI descriptors, and evaluated for major agronomical traits. Large genetic variability has been identified in terms of leaflet characteristics (size, shape and number), plant height, pod characteristics (angle at maturity, shape, surface reflectance, distribution on the stem, length and number of seeds per pod). Moderate variability was observed for leaflet size and shape, flower color. No variability was observed for growth habit, branching from higher nodes, wing petal color, pod color at maturity and hilum color. Based on morphological traits, principal component analysis led to grouping of these landraces into nine clusters. These Moroccan landraces were also screened for biotic stresses and identified landraces tolerant to chocolate spot. Concerning drought, the tested landraces showed large variability in tolerance to drought and performed well in both environments. Molecular analysis using microsatellite markers indicated substantial diversity among the local landraces. The identified useful variability is being deployed in conventional breeding for the genetic improvement of faba bean in national breeding program.

PP51: Screening of lentil germplasm to identify the sources of resistance against *Orobanche crenata*

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The root parasite, broomrape (*Orobanche crenata*) poses a serious threat to lentil production in Mediterranean and West Asian countries. Identification of resistant sources in the germplasm collections and the development of new tolerant varieties could be helpful to address the issue. However, resistance breeding is hampered by the scarcity of genetic resources and the lack of a reliable and practical screening procedure to identify existing sources of resistance in the germplasm. Resistance to Orobanche is a multi-component event. There are a battery of escape factors or resistance mechanisms acting at different levels of the infection process. Better understanding of these mechanisms would help to detect the genetic diversity in the germplasm collections. A total of 216 accessions including resistance sources identified from the previous study and a new set of ICARDA collections were screened under naturally Orobanche infested field condition. A wide variation of responses was observed against *Orobanche crenata* between the accessions. Among them, 46 accessions have showed no infestation by Orobanche in the field trial. Particularly, GCP9, GCP10 showed high levels of tolerance when compared to other tested accessions. In order to validate the field tolerance/resistance, a set of 21 lentil accessions of this collections were tested on both pot and petri dishes assays. During these screening essays, no accessions presented total resistance against *Orobanche crenata*. However, ILL10952 accession presented high tolerance rate in both pots and petri dishes assays, while ILL8068 seems to be very sensitive. In this study, we selected some promising genotypes that could be integrated in to the breeding program. Also, we found that this study has shown the importance of in vitro screening methods, which can give very interesting results that can complement to field screening and selection of genotypes for resistance and/or tolerance to Orobanche.

PP52: Screening of chickpea genotypes for salinity tolerance during early stage of seedling growth

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Salinity is one of the major stresses which severely limit crop production. It impairs seed germination, reduces nodule formation, retards plant development and reduces crop yield. Salinity affects germination

and physiology of crops due to osmotic potential which prevents water uptake and by toxic effect of ions on embryo viability. Salinity is an ever-increasing problem in agriculture worldwide, especially in South Asia (India, Pakistan) and Australia. Chickpea is an important legume crop and sensitive to salinity. Thus, identification of salt tolerant genotypes and enhancement of salinity tolerance is a primary need to sustain the production of chickpea. Therefore, a set of 60 genotypes, including 36 wild *Cicer* accessions and 24 cultivated lines, was screened at 80mM NaCl concentration of salinity in pots using three replications for their response to germination and seedling growth. In each replication six healthy seeds were sown. Most of the genotypes did not germinate and those which germinated showed varying effect of salinity on germination and seedling growth. In general the germination percentage, seedling length and root length were decreased considerably as compared to control. It was noticed that cultivated germplasm lines showed higher tolerance to salinity than the wild *Cicer* accessions of different species. The cultivated germplasm lines namely GL 28296, PBG 166, Phule G- 94- 259, L 556, PDG 3 and CSG 8962 showed higher germination percentage and better seedling growth. Among the wild accessions, ILWC 36, ILWC-292 of *C. reticulatum*, ILWC 0 and ILWC 29 of *C. pinnatifidum* were found moderately tolerant. Some of these germplasm lines can be used in breeding program for developing salinity tolerant cultivars.

PP53: Screening of pigeonpea germplasm against wilt and sterility mosaic diseases in central Telangana

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The productivity of pigeonpea is very low which is mainly due to losses caused by several biotic stresses. Among the biotic stresses, Fusarium Wilt (FW) and Sterility Mosaic Disease (SMD) are the most serious diseases on this crop with an estimated yield loss of 100% under severe conditions. In this context, screening of pigeonpea germplasm/genotypes were evaluated to identify the sources of resistance to Fusarium wilt and Sterility mosaic disease. Screening was done at the FW and SMD sick plot at RARS, Warangal, Telangana State, India. Seventy-eight genotypes supplied under All-India Coordinated Research Project Pigeonpea along with a check and thirty Warangal pigeonpea advanced lines, were screened against wilt disease during Kharif-2014 at Regional Agricultural Research Station, Warangal. A total of 42 All India Coordinated Research Project Pigeonpea entries including a check and thirty Warangal pigeonpea advanced lines were tested against SMD. Out of 78 entries, only three entries ICPL-87119, IPA-8F and BSMR-2 were resistant to FW disease. Out of 42 entries, nine (*viz.*, IPA-8F, IPA-15F, KPL-43, BSMR-846, IPA-204, ICPL-2376, WRG-256, BAHAR and ICP-9174) were found to be resistant to SMD. Only one entry (IPA-8F) was found resistant to wilt and SMD, while two entries (KPL-44 and IPAC-68) were found moderately resistant and remaining entries were susceptible to both diseases.

PP54: Screening of faba bean genotypes for resistance to *Orobanche crenata* under field and controlled conditions

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Orobanche crenata is a parasitic weed which constitutes a serious threat to legumes grown in the Mediterranean and western Asia. In Morocco, heavy infestations of faba bean fields by *O. crenata* were

reported. The identification of tolerant/resistant faba bean genotypes remains a national priority. In this perspective, a collection of 6 Moroccan and international genotypes was tested on field, pots and Petri dishes essays. The tests were conducted during two years and results showed a wide range of tolerance but no complete resistance was detected. Thus, L5, L6 and L7 genotypes showed good tolerance level compared to susceptible genotypes (Lobab and Aguadulce). Screening in pot and petri dishes are fast and efficient methods for selection of tolerance against *Orobanche*. Root exudates and their implication on tolerance/susceptibility to *O. crenata* were also investigated on these faba bean genotypes. Result showed that in absence of *O. crenata* seeds, tolerant genotypes had a capacity to produce exudates and induce germination of a higher number of *O. crenata* seeds compared to susceptible genotypes. However, this capacity reduced remarkably when root system was in direct contact with *O. crenata* seeds. Based on these studies, we conclude that tolerance of faba bean genotypes to *O. crenata* could occur through i) developing lower host root density, ii) lower induction of Orobanche seed germination, iii) reduced attachment of *O. crenata* on host root, and iv) limited development of tubercles on host root. Selected tolerant genotypes will be integrated in faba bean breeding program for development of resistant varieties to *O. crenata*.

PP55: Screening FIGS set of lentil (*Lens culinaris* ssp *culinaris*) germplasm for tolerance to terminal heat and drought stresses

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Lentil (*Lens culinaris* Medikus) is one of the most important cool-season food legume crops. It constitutes good source of seed protein, carbohydrates and minerals particularly to the people living in the developing countries. Terminal drought and heat stress are important factors affecting lentil production especially in the dry and semi-arid regions such as Morocco. We evaluated a FIGS set of 200 lentil accessions in alpha design with two replications at Marchouch experimental station in Morocco at three different temperature regimes: normal planting, late planting with irrigation; late planting without irrigation. Observations were recorded on plant height, days to 50 % flowering, days to 95 % maturity, number of primary branches, number of secondary branches, number of tertiary branches, total number of filled and unfilled pods, biomass, grain yield and hundred seed weight. Results indicated that heat and drought stress at reproductive stage adversely affected plant height, number of primary, secondary and tertiary branches, total number of pods and seed yield. Based on heat tolerance index and drought tolerance index, we have identified heat tolerant lines (ILL4902, ILL7833, ILL729 and ILL6338) and drought tolerant lines (ILL880, ILL7295, ILL1706 and ILL1861). Two lines, ILL7835 from Nepal and ILL6075 from Pakistan have demonstrated tolerance to both heat and drought stresses.

PP56: Study of drought tolerance in some populations of *Lathyrus sativus* L.

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In Algeria, the genus *Lathyrus* is cultivated mainly for seed production (food) and also used as fodder (animal feed). *Lathyrus sativus* L. or grass pea has a good resistance to drought, salinity and flooding. However, its place is still very limited compared to that of other pulse crops. The objectives of the present are to evaluate of four Algerian populations and two varieties of *Lathyrus sativus* under drought stress applied during the flowering stage. Phenological, morphological and agronomic traits were noted.

ANOVA analysis showed that water stress at flowering stage had a significant genotype effect for most of the characters and significant interaction of stress by genotype for flowering date, width of pods, number of pods, pods weight, number of seeds per pod, 1000 grain weight and yield grain per plant traits.

PP57: The potential of green chickpea, aided by genetics, for an under-utilized market and value chain for small-holder farms

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A rare morpho-form of chickpea has green cotyledons and seed coats. Mature, dry seed of such green-seeded chickpea have been shown to have elevated beta-carotene, to levels that are similar to the first generation of golden rice. In ongoing work, developing immature, fresh vegetable form of the green-seeded type were also found to have elevated nutrient levels compared to regular tan color chickpea. Of a total of 30 green-seeded lines available in genebanks, most also exhibit a delayed-age senescence phenotype wherein many plant organs including leaves and pods exhibit delayed de-greening, reminiscent of 'stay-green' mutants characterized in a range of other crops. Using a candidate gene approach we identified molecular variation in the chickpea ortholog of the staygreen protein, we designate as CaStGR1, in 25 of 27 green-seeded lines. Sequence variation comprised of changes that are predicted to result in loss-of-function of CaStGR1 in the green-seeded germplasm. Exhaustive PCR amplification tests in one allelic class are strongly suggestive of the absence (deletion) of the entire CaStGR1 gene that was subsequently flanked by low-pass whole genome sequencing to obtain gene-spanning amplicons. A molecular lesion in this candidate gene co-segregates with the seed color phenotype in an F2 population, and allelism tests among the four alleles have been initiated. A representative subgroup of germplasm lines for the four StGR1 alleles is being evaluated for physiological traits. In parallel, marker-assisted backcross selection into cultivars of Ethiopia, India and Pakistan has been initiated to allow for rigorous examination of effects of the staygreen gene's loss-of-function on phenotypes, physiology, and agronomic traits in common genetic backgrounds, and to advance introgression of this potentially useful trait into farmer-preferred cultivars of chickpea. Efforts to ascertain market demand for fresh market chickpea per se, and with StGR1 introgressions are being explored, as the parallel and necessary prelude to deployment and uptake of this promising genetic technology for biofortification. The delayed de-greening of pods of the green-seeded genotypes, and the higher nutrient levels of this morpho-form suggest a novel niche market for an improved fresh market chickpea. Lengthening the shelf-life of vegetable chickpea from incorporating the 'stay green' trait would benefit a range of value chain participants, including small-scale farmers, local processors, and retailers that typify the fresh market chickpea production value chain, particularly in the developing world. Greater access to a fresh chickpea type would broaden options for consumers and could encourage consumption of a more sustainable plant-based protein diet.

PP58: Towards development of high yielding pigeonpea lines with resistance to wilt and SMD, suitable to Telangana and Andhra Pradesh

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Pigeonpea (*Cajanus cajanus* L.) is an important legume crop cultivated mainly for its protein-enriched seed. The productivity of pigeonpea, is hovering around 750 kg/ha for the past six decades in the world

owing to a number of constraints. Among the biotic stresses, Fusarium Wilt (FW) and Sterility Mosaic Disease (SMD) cause severe yield losses in India particularly due to endemic prevalence in Telangana and Andhra Pradesh states of the country Conventional breeding approaches though led to development of resistant varieties and hybrids for the two diseases, but in recent past break down of the resistance is an issue of major concern in crop improvement. Recent deciphering of genome sequence of pigeonpea in the year 2012 opened an avenue to utilize molecular breeding approaches to tag the genomic regions governing resistance for wilt and SMD diseases. ICRISAT along with other partners is involved in identification of the genomic regions governing resistance as well as important phenotypic traits. As a part of these efforts, two Recombinant Inbred Line populations (RIL P) (188 lines each) derived from the crosses ICP8863 × ICPL20097 (RIL PI) (segregating for SMD alone) and ICPL332 × ICPL20096 (RIL PII) (segregating for SMD and FW), were evaluated at the PJTS Agricultural University, for disease resistance as well as phenotypic traits during wet season 2012-13 and 2013-14. The best lines (18 lines from RIL PI and 22 lines from RIL PII) were further evaluated during 2015-16. Also 149 Introgression lines (ILs) derived from the cross ICPL 87119 × ICPW 12 (*Cajanus acutifolius*) were evaluated for yield traits during 2013-14 and 2014-15. Twenty five ILs were again screened for wilt resistance during 2015-16. Among RILs, four lines showed both FW and SMD resistance, 11 lines had only FW resistance and 17 lines only SMD resistance whereas majority of ILs showed resistance to wilt. The yield parameters for the RILs are currently being recorded. The outcome of this study would be the identification of high yielding disease resistant lines which would be further evaluated in multi-location trials and promising lines would be promoted as varieties suitable to these two states as well as other parts of India.

PP59: Virulence and molecular diversity within *Ascochyta rabiei* in Moroccan population and evaluation of genotypic stability on chickpea

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Ascochyta blight (*Ascochyta rabiei* Lab.) is an economically important fungal disease on chickpea in Morocco, and in other parts of the world. Significant progress has been made in breeding chickpea for Ascochyta blight resistance in Morocco, but the plant resistance is typically overcome by the evolution of virulent pathotypes of the pathogen. In this study pathogenic variability among a population of *A. rabiei* isolates, collected from four different chickpea growing regions in Morocco (Doukkala-Abda, Chaouia, Gharb and Saiss), was assessed by screening over a set of chickpea differential genotypes. On the basis of the pathogenicity test, the isolates were classified into three pathotypes groups. The most aggressive pathotype (PIII) was present in the majority of surveyed regions, however the weak aggressive pathotypes (PI and PII) were the most widespread. Genetic analysis with SSR fingerprinting of these isolates distinguished high variability within and among identified pathotype groups of *A. rabiei*, indicating low correlation between their virulence and the genetic pattern. The characterization of disease reaction of 6 Moroccan varieties and 18 selected chickpea genotypes against isolates from these three pathotypes groups revealed a high variability. None of them were resistant to PIII and only one variety and one genotype were resistant to PII and PI together. Results of this study will be useful in breeding for Ascochyta blight-resistant chickpea cultivars and development of efficient screening strategies in Morocco.

PP60: Wide range of genetic variability for herbicide tolerance in Faba bean

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Weeds have emerged as major constraint to faba bean productivity. A study was carried out to evaluate faba bean lines to post-emergence herbicides with 210 g a.i./ha Metribuzin (photosynthesis inhibitor, PI),

82 g a.i./ha Oxyfluorfen and 75 g a.i./ha Imazethapyr (amino acid synthesis inhibitor). A set of 140 accessions were planted in augmented design with three repetitive checks (ILB1814, BPL710 and Elizar) at Marchouch station, Morocco and the same accessions along with 28 advanced lines were evaluated in alpha design with two replications at Terbol station, Lebanon. In both locations, each plot was divided in three sub-plots for herbicide treatments (T1 for Metribuzin, T2 for Oxyfluorfen, T3 Imazethapyr) and a control (water spray, C). Herbicide tolerance score, HTS (1-5 scale) was recorded at 3- and 5-weeks after herbicide treatment, where 1 = highly tolerant (similar appearance as C), 3 = moderately tolerant (clear difference on plant appearance comparing with C, with necrosis in lower leaves and less than 25% death of the plants), 4 = sensitive (no further development of new leaves with severe burning of leaves with more death between 25% and 75% of the plants), and 5 = highly sensitive (complete burning of leaves leading to more than 75% mortality of the plants). Plant height and seed weight were recorded for the treated sub-plots and the controls. Data were analyzed for each location separately and the results indicated significant differences among genotypes and treatments for plant height and seed weight in both locations. In both locations plant height was lower in treated plots than the control. Chlorosis, rolling of apical leaves, reduced growth, and lower number of pods and mortality were sighted on the genotypes for the three herbicides. Oxyfluorfen affected the growth of most of faba bean genotypes at early stage, but after three weeks tolerant lines showed recovery of vegetative growth and showed no significant difference for seed weight between treated and non-treated plots. Among the tested lines 62 were considered tolerant to Metribuzin, 72 were tolerant to Oxyfluorfen and 46 were tolerant to Imazethapyr.

PP61: Yield stability and genotype × environment interaction in common bean (*Phaseolus vulgaris* L.) varieties in Dawro Zone, Southwest Ethiopia

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Stable yield performance of genotypes is very important in countries like Ethiopia where means to modify environments are limited. But, occurrence of significant GEI complicates selection of stable genotypes. In Ethiopia, the yield potential of common bean varieties is underutilized due to poor addressing of all potential areas and mismatch between selection and production environments. Thus, 14 common bean varieties were evaluated at seven locations for seed yield performance using Randomized complete block design with three replications in the 2010 main cropping season to estimate the magnitude of GLI effects and identify broadly or specifically adapted varieties. Combined ANOVA, AMMI and GGE biplot models were used to analyse data. Both main and interaction effects were highly significant ($P<0.01$) and location, variety, and GLI explained 50.3%, 28.8% and 20.9% of variation in treatment structure and indicated greater influence of location and importance of simultaneous consideration of mean performance and stability. PC1 and PC2 were highly significant ($p < 0.01$) and together contributed more than 79% variation in the GLI sum of squares. Varieties, Zebra-90, Goberasha, Roba-1 and Awash-melka were selected as broadly adapted cultivars. GGE biplot analysis suggested presence of two mega-locations and enabled identification of specifically adapted varieties.

PP62: Faba bean integrated pest/disease management in demonstration platform in Egypt

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Faba bean (*Vicia faba* L.) is the most important food legume crop in Egypt as a good source of quality protein in the common diet, besides being a good source of protein for animal feed. Increasing faba bean production and improving yield quality was thus crucial to meet the demand of the increasing Egyptian

population. Five high-potential faba bean cultivars were tested along with integrated pest/disease management options for key diseases, insect pests and Orobanche at five locations of Delta region for three seasons (2012-13 to 2014-15). Results showed that Dakahlia ranked first in the three seasons recording 5.6, 5.2 and 4. 6 t ha^{-1}, respectively. Orobanche control package on faba bean yield in- and out-demonstration fields in Orobanche-infested soil at Dakahlia, Sharkia and Assiut indicated that the two tolerant cultivars (Giza 843 and Misr 3) exceeded farmers' varieties ranging from 11.1 to 35.7%. The mean seed yield increase percentage of demonstration fields over neighboring fields were 22.5, 22.5 and 28.8%, respectively in the three seasons. Average seed yield increase of the tolerant cultivar Giza 843 in the three seasons compared to neighboring fields ranged from 0.83 to 1.48 t ha^{-1} at Assiut and Dakahlia, respectively, whereas the increase for Misr 3 ranged from 0.37 to 1.07 t ha^{-1} at Sharkia and Assiut, respectively. The average increase of seed yield of the demonstration fields over the neighboring fields over the three seasons ranged from 0.29 t ha-1 at Nubaria to 1.24 t ha^{-1} at Sharkia and from 0.50 t ha-1 at Nubaria to 1.06 t ha^{-1} at Sharkia, also from 0.49 t ha^{-1} at Nubaria to 1.04 t ha^{-1} at Sharkia, 2013-14 and 2014-15, respectively. Chocolate spot and rust diseases were also investigated through conducting demonstration fields of resistant cultivars, e.g. Sakha 1 and Sakha 4 as well as the drought tolerant cultivars Nubaria 2 and Nubaria 3.

PP63: Management of chickpea pod borer *Helicoverpa armigera* (Hübner): use of bio-pesticides

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Helicoverpa armigera (Hübner) is one of the most important insect pests worldwide. The larva feeds on various important crops such as Tobacco (*Nicotiana tabacum*), tomato (*Solanum lycopersicum.* L), chickpea (*Cicer arietinum*) & cotton (*Gossypium hirsutum*), causing important damages. In the last decades, synthetic chemicals were frequently used to manage this insect throughout the world. The intense application of pesticides has led to major problems in term of insect resistance, environment pollution, in addition to their high cost. Research on bio-pesticides has been gaining increased attention and many plant extracts and essential oils have shown promising activities in insect control. In this context, biological activity of 12 essential oils and four plant extracts were studied using third instar larva of pod borer *Helicoverpa armigera.* The aim of this study was to identify efficient botanical pesticide to control of this pest under laboratory conditions using three types of tests: direct contact (Topical method), systemic effect and fumigation. Results showed that essential oils were more promising than the plant extracts in term of larval toxicity on the pod borer.

PP64: The white mold pathogen *Sclerotinia sclerotiorum* depends on low pH for pathogenicity and sclerotial development, independent of

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White mold disease devastates pulse crops and many other crops under conducive environment conditions worldwide. The pathogen *Sclerotinia sclerotiorum* produces melanized resting structure sclerotia that can survive in soil for many years and produce copious amount of oxalic acid in culture and in planta. For over a quarter century, the oxalic acid produced by *S. sclerotiorum* has been claimed as the pathogenicity determinant. The claim was based on UV-induced mutants that concomitantly lost oxalic acid production and pathogenicity. The evidence so far supporting such a claim has not fulfilled the molecular Koch's postulates because the UV mutants are genetically undefined and harbor a developmental defect in sclerotial production. The inability to develop sclerotia is a developmental

defect, which alone could explain lack of pathogenicity. In this study, using two independent mutagenesis techniques, we generated mutants of *S. sclerotiorum* that completely lost oxalic acid production, and tested the resulting mutants for growth at different pHs and for pathogenicity on four host plants (faba bean, pea, green bean and soybean). The oxalate-minus mutants accumulated fumaric acid, produced functional sclerotia and reduced ability to acidify the environment. The oxalate-minus mutants retained pathogenicity on plants, but their virulence varied depending on the pH and buffering capacity of host tissue. Acidifying the host tissue enhanced virulence of the oxalate-minus mutants, whereas supplementing with oxalate did not. These results suggested that it is low pH, not oxalic acid per se, that establishes the optimum conditions for growth, reproduction, pathogenicity and virulence expression of *S. sclerotiorum*. Exonerating oxalic acid as the primary pathogenicity determinant will stimulate research into identifying additional candidates as pathogenicity factors towards better understanding and managing Sclerotinia diseases.

PP65: Study of the effect of absence of entomophilous pollination on the productivity of faba bean

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Several crops benefits from the presence of pollinating insects and therefore a decline or disappearance of these insects could compromise agricultural production, essentially that of cross-pollinated and partially cross-pollinated crops. A study on the effect of entomophilous pollination on some parameters of faba bean was studied through a field experiment carried out on plots placed under insect-proof cage to simulate the absence of pollinating bees (self-pollination) and other plots placed outside the cage to ensure the presence of bees (open-pollination). Field trial was conducted in 2013/14 at the e INRA experimental station of Douyet, Morocco with completely randomized blocks design, with two replications. Effect of the absence of entomophilous pollination was evaluated on morphological, phenological and agronomic parameters, such as plant height, flowering duration, number of fruits per plant, number of seeds per fruit and seed yield. As a result, the absence of entomophilous pollination reduced drastically the number of pods per plant by 28.2% and seed yield per plant by 20.8%. However, no significant difference was observed between with and without pollinators on average seeds number per pod, which was respectively of 2.9 and 2.7. Protection of pollinating bee populations is a necessity, not only for the maintenance of plant and animal biodiversity, but also for preserving the economic activities related to a sustainable agriculture and beekeeping.

PP66: Rapid detection and identification of *Colletotrichum dematium* causing anthracnose on cowpea using PCR-based techniques

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The genus *Colletotrichum* is among the most important groups of plant pathogenic fungi worldwide. The ability to accurately and rapidly diagnose species is vital for the implementation of effective disease control and quarantine measures. This study developed a species-specific PCR assay for the rapid and accurate detection of *C. dematium*. The PCR primers were designed based on sequence data of the rDNA region consisting of the 5.8S gene and internal transcribed spacer (ITS) 1 and 2 of *C. dematium* isolates, *Colletotrichum* species and the other fungal species of plant pathogens were used and evaluated for their specificity. The specificity of the species-specific primer pair CdF/CdR was verified by amplifying a 404bp specific band from the genomic DNA template of representative isolates of *C. dematium*, but not from representative isolates of other *Colletotrichum* species or heterogeneous fungi. The optimum concentration of template DNA needed for detection of *C. dematium* isolates found 10 ng/µl. The sensitivity of designed primer at minimum concentration of 100 fg/µl was successful. PCR products from specific-primer were detectable at an annealing temperature range from 52 to 60 oC; although, the

optimum annealing temperature was calculated as 54^0C. These assays will provide Plant Pathologists a valuable tool to refine anthracnose management on cowpea.

PP67: Genetic diversity to control disease and pest incidence: The case of faba bean

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This work is a part of an international project to develop and valorize the use of crop genetic diversity of major food staples to manage insect pest and diseases on farm. Faba bean (*Vicia faba* L.) is the main grain legume in Morocco (50% of the total acreage of food legumes). Its productivity is limited by several biotic stresses, especially in low inputs farming systems. This study was conducted in the province of Taounate and at our research station in Rabat to investigate the potential role of traditional variety associations in reducing the incidence and severity of chocolate spot, Ascochyta blight and rust and insect pests (weevils) affecting faba bean. The experimental trial was conducted in two locations (Taounate & Rabat). Each trial had nine repeated treatments: four pure stands (monocultures) varieties and five mixture combinations containing three and four varieties. The differences between pure and mixtures stands were identified by comparing means for disease and pest incidence and grain yield. The results showed positive contribution of the mixture of four varieties on reducing disease (+ 20%) and pest (+ 8%) incidences and on increasing yield (+ 10%). This experiment showed the positive effect of mixtures on reducing the incidence of various diseases and on increasing yield.

PP68: ICRISAT-ICARDA collaboration in enhancing use of genetic resources in chickpea improvement

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Plant genetic resources (PGR) are the basic raw materials for future genetic progress and an insurance against unforeseen threats to agricultural production. ICRISAT and ICARDA together hold the largest collection of chickpea germplasm. An extensive characterization of PGR provides an opportunity to dissect structure, mine allelic variations, and identify diverse accessions for crop improvement. The Generation Challenge Program (http://www.generationcp.org) conceptualized the development of "composite collections" and extraction of "reference sets" for more efficient tapping of global crop-related genetic resources. A two-way approach was followed to sample the variability representing diversity in chickpea germplasm, represented in both genebanks. We first developed a global composite collection of 3,000 accessions, which included the 1,956 accessions of the ICRISAT core collection, 709 unique accessions from ICARDA genebank, 39 advanced breeding lines and cultivars, 35 distinct morphological variants, 20 wild species (*Cicer echinospermum* and *C. reticulatum*), and 241 accessions carrying specific traits such as tolerance/resistance to abiotic and biotic stress or possessing important agronomic traits (early maturity, multi-seeded pods, doubled podded, large seed size, high seed protein, nodulation and responsiveness to high input environments). This composite collection represents enormous diversity –biologically, 80% landraces, 9% advanced breeding lines, 2% cultivars, 1% wild species, and 8% accessions of unknown identity, while geographically, 39% from South and Southeast Asia, 25% from West Asia, 22% from Mediterranean, and 5% each from Africa and America. This global composite collection was genotyped using SSRs (48) and high throughput assay to dissect its structure and diversity and to sample allelic richness to form genotype-based reference set. The global composite collection contains 1,683 alleles in 2,915 accessions, of which, 935 were rare, 720 common and 28 most

frequent, while genotype-based reference set (300 accessions) captured 1,315 (78%) of the 1,683 composite collection alleles of which 463 were rare, 826 common, and 26 the most frequent alleles. The reference set consists of the chickpea mini core collection developed at ICRISAT. Chickpea is largely cultivated on residual soil moisture in the arid and semiarid regions of the world. Terminal drought stress is one of the major causes of yield loss in these environments. Deep root system has been recognized as one of the most important traits for enhancing drought adaptability. When assessed for root traits at 35 d after sowing using polyvinyl chloride cylinder culture system for two post-rainy seasons, this reference set showed abundant variation and moderate heritability for root and shoot weight, root length density, and for root/total-plant dry-weight ratio. Twenty-three new accessions with diversity in root traits, several in adapted genetic backgrounds, were identified. Accessions with best root-length densities along with root and shoot dry weight were those from the Mediterranean region and western Asia. Advanced breeding lines in JG 11 genetic background containing a major QTL for drought tolerance from ICC 4958 showed greater yield over control under terminal drought stressed environments at Patancheru, India. Researchers have undertaken a major drive to introgress this QTL region into locally adapted cultivars in South Asia and in Africa. We thus find reference set an ideal resource to use in breeding and genomics to broaden the genetic base of chickpea and to improve its adaptation to stressed environments.

PP69: Evaluation of wild *Cicer* accessions for resistance to *A*scochyta blight in Algeria

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Twenty-five accessions of wild *Cicer* species (*Cicer judaicum, C. bijugum, C. cuneatum, C. echinospermum* et *C. reticulatum*) were screened for resistance to three Algerian Pathotypes (Pathotype-I, Pathotype-II and Pathotype-III) of *Ascochyta rabiei*, by artificially inoculating the accessions under glasshouse at temperature of 20±2 °c and relative humidity maintained above 80% by sprinkling fresh water. Highly significant effect ($P<0.01$) was observed on the reactions of the accession to three pathotypes. All the five accessions from *judaicum*, two accessions from *C. echinospermum* (ILWC0 and ILWC246) and three accessions each from from *C. reticulatum* (ILWC81, ILWC104 and ILWC247), *C. cuneatum* (ILWC37, ILWC40 and ILWC232) and *C. bijugum* (ILWC195, ILWC285 and ILWC286).

PP70: Virus disease management in pulses

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Cool-season food legumes (faba bean, lentil and chickpea) are the most important and widely cultivated crops in West Asia and North Africa (WANA), and are the main source of carbohydrates and protein for a large majority of the population. These crops are naturally infected by more than 70 different viruses worldwide, and the number continues to increase. Surveys conducted over the last two decades suggest that the viruses of major economic importance on food legumes in WANA are: *Faba bean necrotic yellows virus* (FBNYV), *Bean leafroll virus* (BLRV), *Beet western yellows* (BWYV), *Soybean dwarf virus* (SbDV), *Chickpea chlorotic stunt virus* (CpCSV), *Chickpea chlorotic dwarf virus* (CpCDV) and *Bean yellow mosaic virus* (BYMV). Yield loss as a result of virus attack varies greatly from almost no loss as in the case of *Vicia cryptic virus* to complete crop failure as in the case of FBNYV or luteoviruses (e.g. CpCSV, BLRV), when the conditions permit wide virus spread early in the growing season. In recent years, virus epidemics were reported in some countries of WANA (Egypt, Tunisia, Syria, Sudan), sometimes causing considerable yield reduction. Epidemic spread of these diseases was always associated with high aphid vector populations and activity. Although virus disease management can be

achieved through the combined effect of several approaches, development of resistant genotypes is undoubtedly one of the most promising control components. The development of a sensitive, rapid, economical and simple technique to identify resistant genotypes is attractive to breeders, especially when a large number of genotypes needs to be evaluated. Over the last decade faba bean genotypes resistant to BLRV, BYMV and FBNYV, lentil genotypes resistant to BLRV, SbDV and FBNYV, and chickpea genotypes resistant to BWYV and CpCSV have been successful identified. In addition, a relatively quick and simple plastic house technique was developed to identify resistant genotypes on the basis of relative virus movement and multiplication using Tissue blot immunoassay (TBIA). Moreover, progress was made in disease management of some of these viruses using a combination of management options. Many field experiments were conducted at different locations in the region to investigate the effects of a number of management components, such as planting date, plant density, seed dressing, and foliar spray with insecticide and mineral oil. Experience gathered over the last few decades clearly showed that no single method of virus disease control suffices to reduce yield losses in food legume crops. Combining two or more control components often resulted in satisfactory disease management level.

PP71: Phenotypic diversity of Ethiopian chickpea germplasm accessions for phosphorus uptake and use efficiency

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Ethiopia is known as the secondary center of diversity for chickpea (*Cicer arietinum* L.). Plant breeders primarily interested in utilizing the available germplasm for improving phosphorus uptake and use efficiency have no background information on the genetic diversity for this attribute. A field study involving 155 chickpea genotypes was undertaken at Ambo and Ginchi, Ethiopia, in 2009/2010 to characterize the genotypes. Cluster analysis grouped the genotypes into five clusters in the absence and six clusters in the presence of phosphorus. The higher number of clusters when the crop was grown with phosphorus may be a manifestation of more genetic diversity due to the application of phosphorus. The Mahalanobis's D^2 statistics mostly showed significant genetic distances between clusters constituted of local landraces on the one hand and introduced genotypes on the other. This indicated that there were distinct multivariate differences between landraces and introduced genotypes. No clear interrelationship was observed between the origins of the landraces within Ethiopia and the pattern of genetic diversity. Different characters had different contribution to the total differentiation of the populations in all the cases. The result of this study suggests existence of adequate genetic diversity for attributes of phosphorus uptake and use efficiency in these chickpea genotypes, which should be exploited in future breeding.

PP72: Development of high yielding and bold seed size cultivar of Mungbean: DGGV 2

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Mungbean *(Vigna radiata* (L.) Wilczek) is also known as greengram is one of the important pulse crop rich in easily digestible protein and it is grown in a wide range of agro-climatic conditions of the country. Due to short duration of the crop it is suitable for different cropping systems. However, in India its productivity is very low. Lack of suitable plant types and varieties with adaptation to local climatic conditions is one of the major factors which affect its production and productivity. Improvement of

mungbean is limited by low genetic variability for the components of seed yield particularly number of pods, length of pod and seed mass. Recombination breeding followed by pedigree selection offers a viable option for the improvement of mungbean. High yielding, bold seed size culture of mungbean-DGGV-2, was derived from a cross between Chinamung × TM-98-50 at All India Co-ordinated Research on MULLaRP, University of Agricultural Sciences, Dharwad. It has been evaluated at different locations (Agro climatic zones of Karnataka state) for yield and other important component traits during the years 2009-2012. It has recorded an average yield of 1280 kg/ha with a yield increase of 21.3 percent over the best check variety Chinamung. In state farm trials and farmers field, it recorded an average yield of 800 Kg/ha and 1050 Kg/ha respectively, with a yield increase of 12 percent over the check variety. Apart from high yielding potential, it has shining and bold seed size with a mean 100 seed weight of 4.82 grams and moderately tolerant to pod shattering. It also exhibited moderately tolerant to apion beetles and moderately susceptible to cercospora leaf spot and powdery mildew diseases. It has higher grain protein content of 25.41 percent and revealed good cooking quality attributes. It bears important morphological traits such as erect growth habit, determinate plant type and synchronized early maturity made it suitable for mechanical harvesting of the crop. This variety of mungbean-DGGV-2 was recently released for cultivation during *kharif* season for northern-transition agro-climatic zone-8 of Karnataka State in India.

PP73: Accelerated transfer of Fusarium wilt resistance (*foc* race 4) to elite cultivar Annegeri-1 through marker assisted backcrossing in chickpea L.)

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Chickpea is an important food legume cultivated and consumed across the Indian subcontinent. Fusarium wilt is the major constraint of its production in Northern-Karnataka region. The wilt race confined to Northern-Karnataka region is caused by soil borne fungus *Fusarium oxysporum* f. sp. *ciceris* (*Foc race* 4). Thus marker assisted backcrossing (MABC) was attempted to introgress the *foc 4* loci from WR-315 (wilt resistant) to elite cultivar Annegeri-1(A-1: wilt susceptible) (A-1 × WR-315). For MABC three markers TA96, TA27-F and TR19-V conferring the *foc 4* loci were used in foreground selection. Background selection was employed using 40 SSR markers selected from 87 polymorphic markers that were evenly distributed on to all the 8 LG of chickpea genome. After two backcrosses and two rounds of selfing, 67 families were found to be resistant to wilt under wilt sick field and possessed good background genome recovery (78.85 – 94.83 %). Of the 67 BC_2F_3 families top ten elite families with recurrent parent genome recovery of 91.07 – 94.83 % were selected. The selected lines were homozygous and stable. Stringent phenotypic evaluation of advanced lines of BC_2F_3 families in wilt sick garden could confirm resistance to *Foc* race-4. These elite lines are being evaluated for yield and yield attributing traits in multi-location trials to identify the best possible line as compared to local check for release and general cultivation in Northern-Karnataka region. The present investigation was accomplished with speedy development of elite A-1 cultivar resistant to Fusarium wilt that was otherwise susceptible, as early as in two backcrosses and selfing.

PP74: Characterization of urdbean varieties and their application for distinctiveness, uniformity and stability testing in alfisol of Jharkhand drylands

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Urdbean (*Vigna mungo* (L.) Hepper) is the third most important pulse after arhar and gram crops of Jharkhand, India. Urdbean is grown primarily as intercrop with jowar, bajra, pigeonpea, *etc*., during *kharif* and also as sole crop during of spring seasons. A total of fifty four urdbean cultivars were evaluated

during 2008, 2009, 2010 and 2011 *kharif* seasons, at Birsa Agricultural University research plot, in a Completely Randomized Block Design with three replications. Each plot consisted of four rows of 5 m length, spaced 45 cm apart with interplant distance of 15 cm. Varieties were evaluated for 21 characters. These descriptors were recorded as per IBPGR (IBPGR, 1992). This is essential for their protection under Plant Variety Protection legislation, because varietal testing for Distinctness, Uniformity and Stability are the basis for granting protection of new variety under PPV&FR Act, 2001. All the varieties showed similar expression for each character over the years depicting the stability of varieties. None of the attribute showed intra-varietal variation. On the basis of 21 descriptors, varieties were grouped into different categories for each character and may be used as reference varieties. All the varieties of determinate type *viz*., Birsa Urid 1, G 338, Pant U 19, Pant U 30, Pant U 31, T 9, UG 218 and Uttara were also erect in growth habit. Varieties like Birsa Urid 1, CO 5, LBG 17, LBG 20, LBG 402, LBG 611, LBG 623, LBG 645, LBG 648, LBG 685, Mash 1, Mash 2, Mash 414, Naveen, Pragaya, Sekhar U3 and Uttara were of ovate leaflet (terminal) shape types.

PP75: Genotype by environment interaction of some faba bean genotypes under diverse broomrape environments of Tigray, Ethiopia

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Advanced breeding lines with acceptable resistance and tolerance levels to broomrape is an important way of decreasing yield losses to small holder farmers. The objective of this research was to assess the yield stability of faba bean genotypes under diverse broomrape (*Orobanche crenata*) prone production environments. Six faba bean genotypes (ICARDA source) were tested across six environments. The AMMI analysis showed significant (P<0.01) genotype, environment and genotype by environment interaction and the environment explained higher sum of square for the response variable grain yield. The AMMI one gives the best model fitness for the grain yield and broomrape number. Using the AMMI 1 biplot, polygon view of the GGE biplot and comparison of genotypes based on ideal genotype**,** the genotype ILB4358 (cv. HASHENGE released in 2015) gave high yield (>3.5 t ha^{-1}) and stable with low Orobanche number followed by the genotype Sel.F5/3382/2003-4. Using the AMMI biplot analysis E3 (Adigolo, 2011) and E4 (Adigolo, 2012) were unfavorable environments, while, E1 (Awliegara, 2011), E2 (Awliegara,), E5 (Kolatsihidi, 2011) and E6 (Kolatsihidi, 2012) were favorable testing environments.

PP76: Molecular diversity and mapping towards enhanced valorization of lentil genetic resources and marker-assisted selection for efficient cultivar development

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Lentil (*Lens culinaris* Medik.) is an important crop for sustainable farming thanks to its ability to fix the atmospheric nitrogen enhancing soil fertility and allowing substantial reduction in fertilizer use. Recently, DNA markers have been deployed in Moroccan lentil breeding program aiming molecular diversity analysis of local landraces, molecular tagging of agronomic traits and towards marker-assisted breeding. For instance, 19 Simple Sequence Repeats (SSR) and seven primer combinations of Amplified Fragment Length Polymorphism (AFLP) markers were successfully used to characterize Moroccan

landraces of lentil. Genetic differentiation according to agro-environmental origins (dry areas, highlands and favourable areas) was demonstrated allowing oriented selection of genotypes to be included in breeding programs. Landraces from dry areas especially those originating from Jemaat Shaim would result in greater genetic gain for drought tolerance, while landraces from highlands (middle Atlas mountains) would result in greater genetic gain for cold tolerance. Furthermore, genetic evidence for the differentiation of 'lentils of Ain Sbit' as a local product quality mark (*produit de terroir*) were obtained, thus offering efficient tools for enhanced valorization and for the protection of this landrace for the benefits of local farmers. Also, a number of SSR and AFLP alleles that were identified to be linked with drought tolerance could differentiate landraces according to their response to drought stress. These alleles could be used in marker-trait association studies. On the other hand, important molecular markers including Single Nucleotide Polymorphism (SNP) were identified to be associated with quantitative trait loci related to root and shoot traits conferring drought tolerance in a recombinant inbred line population. Also the previously developed genetic linkage map related to this population was enhanced using a combination of co-dominant and dominant markers. The use of the identified DNA markers in the lentil breeding program would result in a more efficient cultivar development and enhanced valorization of genetic resources.

PP77: Pulse crops in Georgia

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The article discusses the study and practical application issues of pulse crops in Georgia. It is highlighted that pulse crops, such as, bean, soybean, chickpea, lentil, faba bean and others play an important role in providing the population with food supply. Also the pulse crops significantly improve the yield of agricultural crops by accumulating nitrogen in the soil. The following issues are dealt in the article: genetic resources of pulse crops in Georgia, the spread of the most important crops in the country, its agricultural importance, pests and diseases, and the measures to control them.

PP78: Responsiveness of chickpea to climate change

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Appropriate changes in the genetic options are needed to cope up with the changing climate and farming system to ensure food security and sustainable cereal production for the ever growing populations in developing world. Among the food legumes, chickpea is one of the key commodity for nutritious food-basics with high protein contents and is consumed by large population of across the Mediterranean and South Asia regions in various forms. Knowledge of the association of chickpea yield with the climatic factors is important in identifying and modifying the climate resilient traits of chickpea. Using systematic research data collected from 1996-97 to 2013-14 at Tel Hadya, Syria and Terbol, Lebanon on grain yield, potential yield estimated from the response of highest yielding genotype, and yield from the local checks, correlations were made and the result showed that the average May maximum daily temperature was the most influential factor on the average yield productivity as well as the potential productivity chickpea genotypes. An additional variable which improved the prediction model was number of frost days during March for average yield and average minimum temperature during April for the potential yield.

PP79: Insect resistant transgenic chickpea (*Cicer arietinum* L.) for sustainable agriculture

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Chickpea (*Cicer arietinum* L.) is an important grain legume and it offers important source of protein for human nutrition. Insect pests are major threat to chickpea production worldwide. The prominent insect pest in Indian sub-continent is the gram pod borer, *Helicoverpa armigera*, causing major yield loss of 40-60% annually. Transgenic technology offers immense potential for alleviating the loss due to insect attack by employing insecticidal genes from *Bacillus thuringiensis* (Bt). Moreover, no resistant sources has been reported in the chickpea gene pool. Here we report, development of transgenic *desi* chickpea (cv. DCP92-3) with the synthetic insecticidal crystal protein, cry1Ac, derived from *Bacillus thuringiensis*, using *Agrobacterium tumefaciens* mediated genetic transformation strategy. Average transformation frequency of 0.1% was realised and the transgenicity was confirmed using southern and western blot analysis in the derived progenies. Transgenic lines expressing higher protein (>20 ng/mg TSP) exhibit high larval mortality (80-90%) as compared to control, based on no-choice detached leaf bio-assay. Transgenic chickpea lines exhibiting higher larval mortality can be used in resistance breeding program. Insect resistance transgenic chickpea shall go a long way in sustainable chickpea production.

PP80: Molecular identification of *Rhizobium* isolates from chickpea in Egypt

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The economic importance of symbiosis in agriculture is to cultivate green safe crops, reduce chemical fertilizers, and protect environments. In the present study, the phylogenic and genetic diversity of local rhizobia, with ability to produce nodules in chickpea genotypes were studied. One hundred and twenty seven rhizobia isolates were collected from three different locations in Egypt (Seds, Nobarya and Shoubra ElKhiema). All isolates were collected from nodule-formed roots of chickpea and bacteriologically evaluated. Six isolates were chosen for further analysis using molecular techniques (PCR and DNA sequencing). The results showed that four (isolate3, 8, 9, and 10) assigned to the genus *Mesorhizobium* based on the 16S rDNA sequence analysis. The BLAST method showed identity ranging from 85.5 to 100%. The highest score of identity coverage was matching the *M. ciceri* biovar *biserrulae* strain WSM1271. The phylogenetic tree showed the genetic kinship for the Egyptian isolates in a separate clade, which may suggest an evolutionary new lineages within the genus *Mesorhizobium*. Given that, the mega-alignment conducted at the DNA sequence level showed the Egyptian isolates with some indel, SNP, and unique motifs that characterize its entity. The prospective research on these new Egyptian isolates is to assess its biological ability to fix N_2 in chickpea.

PP81: Screening of chickpea FIGS subset for Salt tolerance using field and hydroponic conditions in Egypt

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Chickpea (*Cicer arietinum* L.) is an important grain legume that plays a significant role in the nutrition of poor people in the developing world. Salt stress is one of the major abiotic stresses after drought which

affects crop productivity in many parts of the world. Despite the relative sensitivity of chickpea to salt stress, tolerant lines are reported that can be used in chickpea breeding program for salt tolerance in high yield background. A total of 138 genotypes were screened in the field (Arish) and in the greenhouse using hydroponic method. The experiment was laid out in alpha lattice design with two replications. A dose of 100 mM NaCl was used for screening in hydroponics where the salt concentration was found as 0.43 mM in the first 30 cm depth, 1.13 mM in the depth from 30 to 60 cm, and 1.06 mM in the depth more than 60 cm in the field. No significant difference observed between the two methods. Significant differences were observed among genotypes. Seven genotypes (ILs70275, 70249, 70351, 70782, 8447, 70330, 9434 and 70309) were selected as tolerant in the two screening methods.

PP82: Concentration and distribution of β-N-oxalyl-L-α, β-diaminopropionic acid (ODAP) in different plant parts at various growth stages in grass pea

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Grasspea (*Lathyrus sativus* L.) is considered as one of the hardiest crops for adaptation to climate change because of its demonstrated ability to survive drought as well as intense precipitation events, elevated temperatures and edaphic stresses. However, the presence of β-ODAP (3-N-oxalyl-L-2,3-diaminopropionic acid, or β-N-oxalyl-L-α, β-diaminopropionic acid) in grasspea seeds causes neurolathyrism, a neurological disease causing paralysis of lower limbs in man as well as animals. The present study was undertaken to study the variation in ODAP content at different growth stages in grasspea involving five representative genotypes (B222, 387, 390, Bio520 and 587) and its distribution in various plant parts at maturity. The results suggest that the ODAP content varied with plant growth and development stage and, on an average, declined gradually from 1.28 mg/g plant weight at 42-day stage to 0.19 in dried seeds at maturity. Higher ODAP accumulated in early growth stages had gradually decreased with plant age across the genotypes. The lowest ODAP was observed at maturity. The result indicated that even low ODAP genotypes contained high ODAP in green fodder. The genotypes used in the study differed significantly in ODAP content at early seedling (1.13 to 1.47 with mean 1.28 mg/g) and maturity (0.13 to 0.22 with mean 0.19 mg/g) stages. At maturity, the ODAP content was higher in dried leaves (0.69 mg/g) followed by dried stems (0.37 mg/g), pod cover (0.28 mg/g), cotyledons (0.27 mg/g), and lowest in seed coat (0.26 mg/g). Genotypes differed in ODAP content in different parts of the plants.


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Theme 3

Diversification & sustainable intensification of agri-food systems through pulses

PP83: Roles of legumes in conservation agriculture system under Mediterranean climate

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In Mediterranean countries cereal-pulse system is one of the most ancient rotations practiced under conventional agriculture. However, this system as well as others did not show a considerable improvement in productivity essentially due to natural resources degradation and dry climatic conditions. During the last decade, the research conducted under INRA-ICARDA projects (INRM and IMFLI) in Moroccan semi-arid zones, showed the necessity to shift to conservation agriculture in order to stabilize annual legume and wheat production and to enhance soil quality. The objectives of the joint projects were to (i) examine the opportunity of using legume (lentil, chickpea and vetch) as rotation crops under conservation agriculture, (ii) to assess the effect of grain legumes to increase nutrient cycling and (iii) to discuss the effect of cereal- on soil quality within no-till cropping system. These positive changes of the soil fertility under direct seeding are translated to increased production and farmers' incomes even in years of low rainfall under semi-arid climate.

PP84: Use of herbicides in chickpea (*Cicer arietinum)* production for sustainable agriculture

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In India, weeds are the major problem in achieving self-sufficiency in pulse production as they cause up to 50 per cent reduction in yield causing a shortage in pulses for the human consumption and imports of around 3 M tones every year. Due to scarcity of labor and high costs of hand weeding, herbicides are getting importance in short duration pulse like chickpea. Hence, there is a need to study the effect of post-emergent and pre-emergent herbicides on growth and yield of chickpea. A field experiment was conducted on weed management using herbicides in chickpea during winter seasons of 2012 and 2013 at the main agricultural research station, UAS, Dharwad. The experimental site was clay in nature and having available N, P_2O_5 and K_2O of 211, 13.6 and 340.6 kg/ha, respectively. Organic carbon (%) and pH of the soil were respectively 0.52% and 7.2.The experiment was laid out in a randomized block design with three replications. The treatments were: Pendimethalin@1kg/ha as pre-emergent herbicide, Quizalofop-ethyl @ 50g/ha (POE), Imazethapyr @ 50g/ha (POE), Imazethapyr@ 80g/ha (POE), Pendimethalin @1 kg/ha *fb* Imazethapyr @ 50 g/ha, Pendimethalin @1 kg/ha *fb* Quizalofop-ethyl @ 50 g/ha, Pendimethalin @1 kg/ha *fb* Imazethapyr @80 g/ha (POE), Weedy check, Weed free, and Two Inter-cultivations with one hand weeding (Farmers' practice). Pooled data of two seasons indicated that weed free (2290 kg/ha) plots were similar with farmers' practice (2128 kg/ha) and pre-emergent herbicide Pendimethalin @ 1 kg/ha (1922 kg/ha) and post-emergent herbicides Quizalofop ethyl @ 50 g/ ha (1973 kg/ha) and Imazethapyr @ 50 g a.i./ha (1812 kg/ha) were not significant. Herbicides were compared with two farmers' practice of two inter-cultivations with one hand weeding treatment were not significantly different for number of pods/plant, yield /plant, net returns, weed dry weight, weed control efficiency and weed index value. Among different herbicides, Imazethapyr @ 80 g/ha was toxic to chickpea and reduced the yield considerably (1473 kg/ha) as compared to other herbicides (1812 to 2290 kg/ha).

Residual effect study of these herbicides on germination of succeeding crops indicated that even though Imazethapyr was toxic on wheat and sorghum when sown immediately after harvesting chickpea. Hence it can be concluded that under labor scarcity situation, pre-emergent herbicide Pendimethalin 30 EC @ 1 kg/ha and post-emergent herbicide Quizalofop @ 50 g/ha are cost-effective and profitable measures for weed management in chickpea.

PP85: Common bean co-inoculation with selected plant growth promoting rhizobacteria and rhizobia: impact on nodulation and growth under greenhouse

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Modern agriculture is mainly based on the use of chemical fertilizers, which are necessary for insuring high levels of crop production, but are highly criticized for their harmful effects on the environment and health. Therefore, our main goal was to find some sustainable alternatives to chemical fertilization of common bean (*Phaseolus vulgaris* L.). Common bean seedlings were grown under greenhouse conditions and inoculated with different bacterial combinations containing one of the three common bean rhizobial strains MS 2.T9, MS 3.1 and MS 4.11 selected for their N_2 fixation potential and one of the four rhizobateria T1P21, M131, P4S9 and P1S6 selected for their high inorganic phosphate solubilization capacity. In addition three phosphate treatments were included (40 and 80 units of soluble phosphate and 200 ppm of insoluble phosphate (rock phosphate). The results showed that certain bacterial combinations were very effective and helped increasing the number of nodules as well as plants shoots dry mass. This enhancement depended on the type of phosphate applied. Under optimum P fertilization (80 units), the combination MS 2.T9/T1P21 improved nodulation and shoot and root dry weights, while mixed rhizobial strain stimulated only nodulation. Rock phosphate fertilization was the most promising combinations with rhizobial strain MS 4.11 to be further evaluated under field conditions.

PP86: Diversification of rice ecosystems through pulses in semi-arid region of Southern Deccan Plateau of India

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Rice-Rice is the pre dominant cropping system both under canals and bore wells in Telangana State of India. Changing climatic conditions, decreasing water table and ever increasing demand for electricity seriously threatening rice cultivation during rabi (dry season). Further, the post-green revolution period, the incessant cereal-cereal crop rotation has undoubtedly made the India surplus in cereal production but has marginalized pulses. This has raised serious concern about sustainability of the production system. The area under pulses is decreased. Development of short duration, disease resistant and high yielding varieties in the recent past made pulses a viable alternative to low yielding coarse cereals under rainfed conditions and also provided an opportunity for expansion in rice fallows and in double cropping systems. Recognizing the importance of pulses for meeting dietary requirements of vast vegetarian population on one hand and their role in improving soil health and conserving natural resources on the other, it is the need of the hour for fitting of pulses in cereal based cropping system. In India 85% farm house holds falls in small and marginal category with average land holding size of 1.16 ha and they are most vulnerable to climate related risks too. So there is need to diversify the existing crop, livestock and product to attain sustainability. The present study conducted in 24 farm fields spread in six villages of

Warangal district, Telangana, India situated in North Telangana Plateau. The study consists of 5 cropping systems *viz.*, Rice-Rice, Rice-maize, Rice-sun hemp, Rice-black gram/cowpea and Rice-green gram evaluated in randomized block design during 2012-13 and 2013-14. Each village was considered as one replication. During 2012-13, among five cropping systems, Rice-maize system recorded significantly higher Rice equivalent yield (10011 kg ha^{-1}) than other systems. Rice-sun hemp performed better after rice-rice. Among pulses, rice - green gram system significantly recorded higher Rice equivalent yield (7432 kg ha^{-1}) than the Rice-black gram system (7007 kg ha^{-1}). Rice-sun hemp witnessed higher per day net returns (Rs 301) than other systems. Where as in 2013-14, even though rice-rice recorded significant higher REY, rice-cowpea registered higher per day net returns (Rs 239) than other systems except rice-rice and recorded comparable REY with that of Rice-maize. Water requirement of rice in Telangana state is >1400 mm compared to < 500 mm of pulses. If land is not constraint, there is scope for the farmer to increase the area under cultivation, thus over all higher returns and employment. The study indicated ample scope of diversifying rice ecosystems through pulses in Southern Deccan Plateau of India.

PP87: Effect of sowing date and plant population on the yield of *Vicia faba* landraces collected from different region of Morocco

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In Morocco, faba bean (*Vicia faba*) is considered as the most important legume crop. It constituted an important nutritious food because of its richness in protein. However, grain yields are low and variable due to many biotic and abiotic stresses (drought, parasitic weeds, diseases, insect pest). This study aims to evaluate the performance of different faba bean (minor and major) collected from different part of Morocco under two sowing dates. The trial was conducted during 2014 and 2015 seasons at the Douyet station. The experimental design was a split plot with date of sowing as main plot and populations in sub plot with three replications. The analysis of variance showed a significant difference for number of shoots/plant, number of pods/shoot number of grain/plant, biomass yields, grain yield, and seed weight. However, harvest index didn't show any significant effect and no significant interaction was observed between population and sowing date for most yield component except seed weight. Early sowing date out-yielded (22%) the second sowing date. The faba bean landraces showed high variability for grain yield ranging from 15.4 to 41.3 q/ha for the early sowing date, while it ranged from 9.0 to 29.6 q/ha for the late sowing date. For the first sowing date, the landrace 44 gave the highest yield (41.3 q/ha), but for the second sowing date, the highest yield was recorded from landrace 66 (29.6 q/ha). It can be concluded that faba bean yield can be increased by early planting to avoid moisture stress.

PP88: Effect of compost amendments on chickpea growth

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Compost was a source of organic matter containing macro and micro nutrients, which enhanced productivity with respect to nutrient availability and uptake, consequently resulted in higher growth and yield. The aim of the present study was to evaluate the growth benefit of chickpea (morphological and nutrient uptake) by application of four composts (poultry manure, (FV), cattle manure (FB) mixed with wheat straw and two commercials composts). Chemical fertilizer (FC) and non-fertilized (NF) pots were used as controls. Physico-chemical parameters of these composts were carried out to assess maturity for

a predictive phytotoxicity. The treatments were arranged in a randomized complete block design potting mix greenhouse experiment with three replications. A preliminary results showed a significant effect on number of branch and on fresh weight plant of FV and FV+FC respectively.

PP89: Effect of pre-incubation of rhizobium with hesperetin on *Vicia faba* growth and nodulation under salt stress conditions

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Flavonoids are a diverse group of phenolic compounds, ubiquitously found in plants that serve a variety of ecological and physiological functions. Various types of flavonoids were identified in Fabaceae root exudates. However a limited number of them are involved in rhizobia legume symbiosis. Indeed, in this symbiosis interaction flavonoids act as chemo-attractants, inducers of nodulation by activation of the expression of nodD gene and determinants of host specificity. Naringenin and hesperetin are among the major signal compound, which stimulate nod gene activities of *Rhizobium leguminosarum* bv.*viceae*. It has been shown that inoculation of pea and lentil plant with rhizobia strains pre-induced by hesperetin leads to an improvement of nodulation and growth of these plants under greenhouse conditions. In this investigation we tested the effect of inoculation with pre-induced rhizobia by hesperetin on *V. faba* plant growth and nodulation under salt stress conditions. Three rhizobia strains (RhOF4, RhOF6 and RhOF53) with different tolerance to salinity were used to inoculate faba bean plants. The experiment was undertaken under a controlled environment conditions, the plants were inoculated separately with rhizobial strains, perenducted with 10 µM of hesperetin, at different levels of salt stress (0, 70 mM). The rhizobia strains grown without signal molecules were used as control inoculums. The result showed that salinity affected negatively plant nodulation and dry matter accumulation. In control plants, plant inoculated with RhOF53, salt tolerant strain, exhibited the highest root dry weight. While, plant inoculated with non-preinduced RhOF6 strains had the lowest values of root dry weight (RDW). However, inoculation of faba bean with a salt sensitive strain (RhOF6) preinduced by hesperetin increase significantly root biomass. Addition of 70 mM NaCl to the nutrient solution reduced significantly RDW in all plants except those inoculated with RhOF53+H (RhOF53 preincubated with Hesperetin). While hesperetin pretreatment of RhOF6 and RhOF4 had no effect on root dry weight under salt stress compared to plants receiving untreated rhizobia. The obtained results of shoot dry weight (SDW) showed that pretreatment of RhOF53 with hesperetin improved growth of the host plant in comparison with the control with or without salt. Relatively highest values of SDW were obtained in the symbiotic combination faba bean-RhOF53+H in all culture conditions. Hesperetin treatment did not significantly affect this parameter in plants inoculated with RhOF6 and RhOF4. However, plants receiving salt sensitive strain (RhOF6) seemed to be most affected by salinity in comparison with those infected by tolerant rhizobia. A comparison between rhizobia strains showed that faba bean plant exhibited almost double the nodule number when inoculated with RhOF53 or RhOF6 compared with those plants inoculated with RhOF4. The salinity treatment did not significantly affect this parameter except for the faba bean-RhOF6 combination which showed a significant reduction of their nodules number (NN). Furthermore, preincubation of rhizobia strains in hesperetin solution had no effect on NN in all plants under different salt stress conditions.

PP90: Effect of rhizobium inoculation on drought response in common bean (*Phaseolus vulgaris* L.)

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There is growing evidence about the role of microorganisms in enhancing stress resilience in crops through promotion of growth under stress. Rhizobia share symbiotic relationship with common bean and there are substantial reports about modulation of drought stress response in common bean by rhizobial strains through enhanced synthesis of trehalose that helps cells retain moisture. The present study was undertaken to assess the effect of rhizobial inoculation on drought response in six common bean genotypes under controlled greenhouse conditions with ambient temperature and humidity conditions. The experimental set up was factorial Completely Randomized Design with six genotypes, two water regimes (drought and irrigated) and rhizobia (with and without rhizobial inoculation). Invariably under both irrigated and drought conditions, the values of parameters studied viz., root depth, root biomass, root volume, plant height and shoot biomass was higher under rhizobial treatment as compared to control. WB-185 and WB-216 exhibited better root traits such as root biomass, rooting depth and root volume under drought. The analysis of variance revealed significant mean squares in respect of genotypes for root traits but non-significant for shoot traits. The first and second order interactions were also significant for root traits only indicating thereby that root traits exhibit variability under diverse environments to modulate plant response to drought. The plants exhibit immediate response to water shortage by changing allocations to root systems and genotypic differences for root traits become more obvious under stress. The genotypes showed significant variation between drought and irrigated as well as rhizobia inoculated and control treatments, indicating potential role for use of microorganisms for enhancing drought resilience in crops. Common bean shares symbiotic relationship with rhizobia and as such rhizobia can be effectively used to improve drought resilience in common bean.

PP91: Effects of tillage, preceding crop and nitrogen fertilization on the qualitative and quantitative parameters of fenugreek

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This study assessed the effects of tillages (conventional tillage and no-till), of the pre-crop and N fertilization (0, 20, or 40 kg N ha^{-1}) on quantitative and qualitative parameters of fenugreek.Soil samples were collected at depth (0–20 cm) in September 2013 from of Tunisian semi-arid region of an experimental rotation (faba bean) /oat and faba bean/durum wheat). Collected soil samples were filled in pots and fenugreek was planted and the trial was arranged in randomized complete block design. Data on days of flowering, biomass, nodules by plant number and the biomass protein concentration, yield parameters, and grain protein concentration were determined. The highest grain yield was registered in pots filled with soil of no till after durum wheat crop fertilized by 40 kg of N, and the lower were registered at the treatment of conventional tillage after an oat crop not fertilized. The biomass protein content was more concentrated at plants cultivated in a no till soil fertilized by 20 kg of N and the conventional tillage soil fertilized by 40 kg of N while the lower protein content was recorded at plants cultivated in a conventional tillage soil not fertilized or fertilized by 20 kg of N. Nodules number was highest in the roots of plants cultivated in a no-till soil, fertilized by 20 kg of N, no fertilization decreased significantly the number of nodules for both soil tillage. Biomass and nodules number were influenced by the interaction of the pre-crop and the fertilization, the pre-crop oat with a fertilization of 40 kg of N

allows to give the highest biomass, the absence of the nitrogen fertilization decreased the biomass for both pre-crop. The interaction of the tillage and the preceding crop also has a significant effect on the biomass, the combination no-till and oat gave the highest biomass.

PP92: Effect of vetch and fodder pea mixed cropped with barley and corn on soil characteristics in the Southwest of Morocco

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The aim of this work was to study the inclusion of vetch and fodder pea in pure stands and mixed with barley in the cropping systems and evaluates the effects of crop rotations on the chemical, physical and biological soil characteristics in the Southwest of Morocco. The experiment was conducted at two experimental stations during 2009-2010, 2010-2011 and 2011-2012 growing seasons. The experimental design was a complete block design and four replication and six treatments. Results showed that soil pH was alkalinized for barley-corn rotation and corn monoculture and acidified for vetch-corn, fodder pea-corn, vetch/barley-corn and fodder pea/barley-corn rotations. Vetch-corn, fodder pea-corn, vetch/barley-corn and fodder pea/barley-corn rotations improve significantly organic matter and total nitrogen while barley-corn and corn monoculture make less. Soil physical and biological characteristics were affected positively by vetch-corn, fodder pea-corn, vetch/barley-corn and fodder pea/barley-Corn rotations and negatively by barley-corn and corn monoculture.

PP93: Enhanced transfer of biologically fixed N from faba bean to intercropped wheat through rhizobial symbiosis under P deficit conditions

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Intercropping is the simultaneous production of more than one crop species in the same field. One of the most commonly used intercropping mixtures is the legume / non legume (usually cereals) combination. This cultural practice has often been shown to have advantages in comparison with sole crops. High grain protein content in the cereal at harvest has also generally been observed. Yield and grain quality enhancements are assumed to be linked to the complementary use, in time and space, of N sources by the different components of the intercrop. However the ability of rhizobia associated with the legume to transfer a proportion of the fixed N to wheat in mixed cultures and its effects on the cereal growth have been poorly studied. Pot experiments were carried out to analyze the impact of rhizobia inoculation on nitrogen fixation and transfer of fixed nitrogen from faba bean to wheat in mixed cultures of both species in P-deficient soils collected from the Haouz valley near Marrakech (Morocco). Plants of the two species were grown in pots for six weeks as pure or mixed cultures under greenhouse conditions. Each culture type being submitted to two different rhizobia inoculation treatments including a non-inoculated control one (Rh0) and two rhizobial strains: RhOF147 and RhOF19 that were selected based on their high and low P-solubilizing ability respectively. The 15N isotope dilution method was used to assess the amount of nitrogen fixed by faba bean plants in each treatment and the amount of fixed nitrogen transferred to wheat. The statistical analysis showed that rhizobial inoculation had a significantly positive effect on shoot dry weight and total shoot N in faba bean and wheat plants. There was no significant effect of the type of culture (pure vs mixed cultures) on plant growth of wheat but mixed culture had a positive effect

on shoot total N, all Rh inoculation treatments combined. By contrast, in faba bean, the type of culture had no statistically significant effect on shoot total N while pure culture had a positive effect on shoot dry weight. Whatever the type of culture and Rh inoculation treatment applied, the proportion of nitrogen derived from atmosphere (Ndfa%) was very high, varying from 78 to 91% whereas nodule number was significantly higher in Rh OF147 treatment. The total N fixed by faba bean was 18% significantly higher in RhOF147 treatment compared to RhOF19.These results suggest that the rhizobia stimulate the transfer of fixed nitrogen from faba bean to wheat, which could contribute significantly to the plant-to-plant facilitation process in the intercropping cultural practice under phosphorus-deficient soil conditions. In addition to this benefits of the intercropping cultural practice are not limited to a trophic effect (enhancement of N plant nutrition) but could result from microbial interactions that can act directly on the wheat growth (PGPR effect) or indirectly through a N_2-fixing symbiosis establishment.

PP94: Evaluation of pre-emergence herbicides for the control of weeds in lentil in Zaer region of Morocco

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Zaer region is a major area of lentil cultivation. However, despite the importance of lentil in crop rotation and in human nutrition, lentil yields remain low and fluctuating with averages yield of 0.5 t/ha. Low yields of the lentil are caused by several factors among which the traditional mode of cultivation and production techniques that heavily relies on human labor. The rising costs of labor, combined with low mechanization, makes legumes production unprofitable and less attractive to farmers. This situation led farmers to abandon grain legumes cultivation or reduce input for these crops which in turn reduces yield further. Controlling weeds in lentil fields is a necessity since this crop is less competitive with weeds. The search for an alternative weed control technology that is effective and less costly, including the use of chemical herbicides can help make legumes production more profitable. The objective of this study was to assess the effectiveness of different pre-emergence herbicides on productivity of lentil. For this purpose, a field experiment was carried out at INRA Marchouch experiment station. The experiment was sown on Jan 02/2015 using conventional seeding rates of 50 kg/ha using variety Bakria. The experimental treatments consisted of several pre-emergence herbicides used at recommended and lower rates. The herbicides used were selected on the basis of their use in major legumes producing countries and on their availability in the Moroccan market. The experimental treatments were (1) Control, (2) PROWL 2 L/ha (Pendimethalin, 330 g/l), (3) PROWL 4 L/ha (Pendimethalin, 330 g/l), (4) PRIMEXTRA 2 L/ha (S-Metholachlor, 312 g/l + Terbuthylazin, 187,5 g/l), (5) PRIMEXTRA 4 L/ha (S-Metholachlor, 312 g/l + Terbuthylazin, 187,5 g/l) and (5) ARZIN 0,5 kg/ha (Metribuzin, 75%). Phytotoxicity was observed in PROWL 4 (4 L/ha) as it significantly reduced the lentil emergence rate. The reduction was 48% compared to non-weeded control. The treatments Prim4 and Arzin showed good efficacy against weeds of lentils, with an average weed biomass reduction of 84% compared to the non-weeded control. Treatments PROWL4 and PROWL2 had an average efficacy of 68%. PRIM2 treatment showed low efficacy of 52%, which can be explained by the low rate used that was not sufficient to adequately reduce weeds. Chemical weed control treatments, using pre-emergence herbicides, significantly increased grain yield of lentil. Across all treatments, including the control, lentil grain yields varied from 4 and 9 quintals/ha. The highest yield was obtained using Arzin herbicide (9.3 q/ha) followed by treatment using Primextra herbicide (Prim4) (8.5 q/ha) and Prowl4 (6.6 q/ha). The remaining herbicides had yields of about 5 q/ha which were not significantly different from the non-weeded control. The grain yield increase over the non-weeded control was 53% for ARZIN, 48% for PRIM4, 32% for PROWL4, 8% for PRIM2 and 6% for PROWL2. These results showed the great potential of the active ingredients Metribuzin, S-Metalachlor and Pendimethalin at recommended rates to effectively control weeds in lentil fields in the Zaer, the major growing area for lentils.

PP95: Faba bean (*Vicia faba* L.) yield potential and gap under supplementary irrigation in Ethiopia

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The major faba bean (*Vicia faba* L.) growing countries are China (0.9 million ha) and Ethiopia (0.5 million ha) accounting for 37.6 and 20.5%, of the total world area, respectively. The average national yield of faba bean is very low (1.7 t/ha) in Ethiopia compared to the yields reported in countries like Argentina (8.9 t/ha), Bulgaria (5.7 t/ha), United Kingdom (5.4 t/ha), Uzbekistan (4.8 t/ha), and Belgium (4.5 t/ha). Factors which include climatic, edaphic, moisture stress, physiological, pests and crop management cause large yield gaps in Ethiopia. Thus, the objective of this study was to determine the potential and yield gap of faba bean grown under supplemental irrigation. Two field experiments were carried out at Holetta Agricultural Research Center during 2014/2015 and 2015/2016 cropping seasons, where supplemental irrigation was applied at 4-6 days interval to avoid water stress for normal plant growth. Two improved varieties (Gora and Gebelcho) released for the red soils were grown in 6.8 m x 10 m plots. Yield potential was determined using the CROPGRO-Model, included in the Decision Support System for Agrotechnology Transfer (DSSAT) suit of models, calibrated using measured weather, soil, crop management and crop data collected from the two season field experiments. The actual yield of faba bean was obtained from the Annual Agricultural Sample Survey report of the Central Statistical Agency of Ethiopia reported for rainfed faba bean production around the study area. The results showed high yield potential with substantial yield gaps (44%) indicating high opportunity to double faba bean yield through improved varieties and crop management practices.

PP96: Agronomic and farmer-participatory comparison of legume-based crops for livestock systems of different Mediterranean regions

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Livestock systems in the Mediterranean basin are facing different challenges, such as insufficiency of high-protein feedstuff, overexploitation of forage resources, and climate changes. Growing forage crops that include annual legumes, such as vetches or pea, has considerable potential and interest farmers. Cropping systems including these crops can also be more sustainable in terms of energy use, water efficiency, greenhouse gas emissions, and safeguard of soil fertility. This study was carried out in Morocco (Marchouch, area of Rabat) and Italy (Sassari, Sardinia) during 2014 and 2015, aimed to assess the forage dry matter yield and the farmers' participatory acceptance of innovative forage crops including pea (semi-dwarf or tall plant type), common vetch or Narbon vetch, in pure stand and in binary mixture with oat or triticale. We assessed also complex mixtures including two legume and two cereal species, and cereal pure stands (N-fertilized at double rate as mixtures). Experiments were designed as randomized complete blocks with four replications. Farmer-participatory assessments were performed in both years using visual scores of acceptability (ranging from 1=lowest value to 5=highest value) that were assigned to individual plots by independent groups of farmers. In both locations, pea was the highest-yielding legume pure stand crop (with minor differences between plant types), tending to out-yield even the best-performing cereal pure stand, i.e., oat. On average, pea-cereal binary mixtures tended to be somewhat higher-yielding than common vetch-cereal mixtures, and much higher-yielding than Narbon vetch-cereal mixtures. Pea- and common vetch-based crops outperformed Narbon vetch-based crops also for control of unsown species. Oat-based mixtures outperformed triticale-based ones in terms

of forage yield and weed control. Complex mixtures displayed a slight trend towards better production and weed control than binary mixtures including the same components. Farmer-participatory assessments revealed appreciation scores in close agreement with forage yields of the crops. Legume pure stands and legume-cereal mixed stands including pea or common vetch were particularly appreciated, whereas Narbon vetch-based crops and cereal monocultures got low acceptability scores.

PP97: Improving production of pulses through inoculation with rhizobia and rhizobacteria containing ACC-deaminase activity

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Pulse production is an integral component of low-input agriculture system run by resource poor farmers of arid and semi-arid areas. Harsh, erratic and less predictable climatic conditions are characteristic features of such areas which limit the sustainable production of pulses. Elevated level of ethylene (plant endogenous stress hormone) is one of the key factors, which contribute for poor growth and yield of pulses under arid/semiarid regions and responsible for failure in rhizobium-legume symbioses. Some plant growth promoting rhizobacteria (PGPR) having an enzyme 1-aminocyclopropane-1-carboxylate (ACC) deaminase can facilitate plant growth by decreasing the ethylene levels. In the present study, number of rhizobial strains and PGPR having ACC-deaminase activity were isolated from nodules and rhizosphere of mung bean, chickpea and lentil, respectively, collected from different areas of Pakistan. The rhizobial and rhizobacterial isolates of each pulse crop were tested alone as well as in combinations under axenic conditions to screen effective multi-strain combinations for promoting the growth and nodulation. Selected combinations of rhizobia and rhizobacteria were evaluated in pot and field conditions for promoting growth, nodulation and yield. Locally available carrier materials were tested with efficient multi-strain combination for enhancing its efficiency under pot and field conditions. Survival competency of efficient multi-strain combinations was also tested in these carriers. In extensive field evaluation, efficient multi-strain bacterial combinations with appropriate carrier improved the grain yield of mung bean, lentil and chickpea by 14, 16 and 19%, respectively. Thus, it can be concluded that use of multi-strain inoculation with appropriate carrier could be the most effective and novel approach for promoting the yield of legumes.

PP98: Increased yield of faba bean/durum wheat rotations under drought conditions

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Cereals continue to be the most extensive type of cultivation in most Mediterranean countries. Today, the most dominant cropping systems in Tunisia are a monoculture of durum wheat or a rotation of durum wheat and barley. Breaking cereal monoculture by incorporating legumes in rotation systems permits an increase in sustainability and yield. This study aims a comparative evaluation of agricultural systems in plot-scale field experiment in semi-arid environment. Durum wheat was seeded after faba bean or after durum wheat in six farmers' fields in Nebeur Delegation/Kef in Tunisia during 2013/2014 and 2014/2015 cropping seasons. The same management practices and experimental design were applied in two adjacent fields of the same soil type and different rotations. Grain yields were compared with conventional wheat monoculture. Variance analysis showed a clear significant difference between plots of durum wheat cv.

Salim after faba bean compared to durum wheat/durum wheat. Results showed that the use of legume (faba bean) as preceding crop increased significantly the grain yield of the durum wheat (cv. Salim) of all farmers for 2014/2015. An increase of yield of about 35% was recorded for durum wheat cv. Salim after faba bean compared to durum wheat/durum wheat. Marking these systems is promising for improving sustainability and stability of cereals yields under rainfed conditions.

PP99: Effect of weed management practices on weed dynamics, yield and economics of lentil (*Lens culinaris* Medik subsp. *culinaris*) under vertisols

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A field experiment was conducted during winter season (2010-11 and 2011-12) at Agricultural Research Station, Ummedganj, Kota to identify the best weed management practice for getting high yield and economic net return of lentil under vertisols. The experimental field was clay loam, low in organic carbon (4.1 g/kg), available phosphorus (20.5 kg/ha), sulphur (16.1 kg/ha) and medium in available potassium (292.5 kg/ha) and slightly alkaline in reaction (pH 7.5). The experiment was laid out in randomized complete block design with 10 treatments i.e. quizalofop ethyl 50 g/ha applied at 30 days after sowing (DAS), quizalofop ethyl 60 g/ha at 30 DAS, imazethapyr 37.5 g/ha at 30 DAS, imazethapyr 50 g/ha at 30 DAS, chlorimuron ethyl 4 g/ha as PPI, pendimethalin 1.0 kg/ha as PE, pendimethalin + imazethapyr (readymix) 0.75 kg/ha as PE, pendimethalin + imazethapyr (readymix) 1.0 kg/ha as PE, hand weeding twice at 20 & 40 DAS and weedy check with three replications. The results of 2 years pooled data revealed that hand weeding twice at 20 & 40 DAS significantly curtailed weed density and dry weight at recorded 70 DAS and significantly increased weed control efficiency (88.6), branches/plant (3.3), pods/plant (111) and grain yield (1768 kg/ha) over the rest of the treatments. Amongst herbicides, pre-emergence application of pendimethalin + imazethapyr (readymix) 1.0 kg/ha reduced significantly weed density and dry weight at 70 DAS and allowed higher weed control efficiency (87.4 %), branches/plant (3.2), pods/plant (105), grain yield (1700 kg/ha), net return (Rs. 48765/ha) and B: C ratio (3.6:1) over weedy check, quizalofop ethyl 50-60 g/ha and chlorimuron ethyl 4 g/ha. The gain over the weedy check reached the magnitudes of 592 kg/ha in grain yield and Rs. 19181/ha in net return.

PP100: Management of irrigation water on lentil and pea cultivation under drought environment areas of Bangladesh

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Lentil (*Lens culinaris* Medik. subsp. *culinaris*) and pea (*Pisum sativum* L.) are important cool season legume crops grown in Bangladesh which have significant contribution to food, feed and sustainable development of agriculture. Lentil and pea are normally cultivated under rainfed condition after harvest of monsoon rice. But due to late harvest of rice sometimes moisture goes down which failed to ensure proper germination and optimum plant stand, and sub-sequent crop growth also stunted due to moisture stress in the drought environment under changing climate long time normally no rain in the cropping season. Whereas, water is a major factor determining for crop growth and yields in different regions. Now- a-days farmers in Bangladesh are growing lentil and pea with haphazard irrigation schedules. In this situation, experiments on lentil and pea were carried out at two dry locations of Bangladesh during two consecutive *Rabi* seasons of 2012-13 and 2013-14 for effective water management in lentil and pea

for better crop establishment and achieving higher yield. Nine different combinations of pre-sowing and post- sowing irrigations were used in the experimental plots under clay-loam soil. It was found that two times irrigations at pre-sowing and vegetative stages (30-40 days after emergence) are effective for better crop growth and higher seed yield (2050 kg/ha) and (1850 kg/ha) which was higher by 46% and 37% over control (1400 kg/ha) and (1350 kg/ha) in lentil and pea, respectively. It was also found that irrigation increase disease development especially Stemphylium blight and rust on lentil, and powdery mildew on pea. It was estimated that a total of 100-120 mm water is needed for lentil and pea cultivation. This technology was validated in farmer's field is getting popularity in the dry environment.

PP101: Nitrogen fertilization of bean crop in the semi-arid Tunisian conditions

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In Tunisia the cultivation of bean crop is not common; In fact, to study the nitrogen fertilization effects on the crop of bean in the Kef region; two varieties Soisson nain Hatif and Nain Contender and three doses of Ammonium nitrate (0,100 and 200Kg /ha), a l split plot trial was arranged at the experimental station of the Higher School of Agriculture of Kef. The results showed that the application of nitrogen did not affect the development cycle of the crop, except delaying flowering at 100 kg of ammonium nitrate / ha .Moreover, nitrogen application did not improve the yield of fresh pods in the two varieties.

PP102: Potential of foliar potassium and phosphorus fertilization on lentil and chickpea in Zaer region, Morocco

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Phosphorus and potassium are essential mineral elements for crop growth and development. Their use in crop fertilization aims to increase productivity and improve the quality of the harvested product. Phosphorus and potassium fertilizers are essentially applied to the soil but may not be totally available to plants during certain growth periods due to high instant demand of the plant in these elements, to soil and environmental constraints or to limited root development. Foliar fertilization supplies directly nutrients to the plant which make fertilizers readily available to the plant to promptly satisfy phosphorus and potassium plant needs when constraints for their acquisition from the soil are impaired. Foliar fertilization proved to be efficient in instantly correcting nutrient deficiencies, in improving the use efficiency of fertilizers added to the soil, in increasing yield, in improving product quality and in increasing tolerance to disease. To evaluate the potential of phosphorus and potassium foliar fertilization on lentil and chickpea, two field experiments were conducted at INRA, Marchouch experiment station during the 2014-15 cropping season. The crop varieties used were Bakria for lentil and Farihane for chickpea. Experiments were sown on Dec 31/2015 at conventional seeding rates of 50 kg/ha for lentil and 80 kg/ha for chickpea. The previous crop was barley and the plots were fertilized before sowing with 20 kg/ha of ammonium nitrate. The factors studied were (1) soil fertilization of 40 units of K_2O/ha and 60 units of P_2O_5/ha, (2) foliar fertilization using K_2O 5% and 2% P_2O_5 either individually or in combination and (3) the stage of foliar application either at flowering and/or at pod filling stages. Results from this research on the potential of foliar fertilization technology in improving productivity of lentils and chickpea showed that small amounts of foliar fertilizer could increase grain yield of lentils by up to 40% and that of chickpea by 32%. The potential of yield increase in lentils and chickpea by foliar

fertilization is greater when soil is not supplied with optimum fertilization and when foliar fertilization is applied at flowering. The benefit of foliar fertilization with potassium and phosphorus is largely positive in regard to the low amounts of fertilizers used (less than 15 kg/ha) and the cost associated with application that can be minimized when foliar fertilization is combined with pesticides. Further research is needed to determine the exact conditions where foliar fertilization is to be recommended.

PP103: Productivity and potential of legume crops in an agroforestry system basis on olive tree

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According to Moroccan Green Plan, 1 million ha of cereal land will be converted to more adaptable crops to face climatic change. The focus was made on olive, almonds and fig trees to replace cereals. During the first years of the reconversion, farmers maintain as usual the association of annual crops and perennial ones so we faced integration of trees in annual area rather than reconversion from cereals to trees. Agroforestry system is a practice in mountainous and oasis regions where water and/or land resources are limited. In these locations many crops are mixed and their monitoring is complicated. The aims of this work, were to a) determine the importance of olive tree and annual crops association; b) to perform an agronomic diagnosis of the system; and c) to evaluate advantages and disadvantages of such practice according to farmers and scientists point of views. Methodology included a) an agronomic diagnosis mainly carried out in the region of Meknes-Fez-Sefrou and others regions, where experimentation was also implemented including description of crops between olive tree rows, olive tree density, distance left between olive tree and annual crops and different crops. Results showed that 75% of farmers growing olive trees are also producing annual crops between tree rows. Those crops included cereals, legumes, and vegetables. Cereals are dominant in 50% of land occupation. We estimated an average density of 100 tree ha annual crops may occupy 75% of the land, while olive tree may occupy the remaining part. Farmers indicated that technical interventions (ploughing, fertilizing) concerns mainly annual crops and then can promote olive tree production. Olive tree monoculture is described by plantation age, density or accessibility. According to farmer's estimations: legume crops like faba bean do not affect negatively olive production, when compared with cereals like durum, soft wheat or barley. Olive production is reduced by about 39%, when cereals are intercropped between the rows. However, farmer produces an added value of cereals or legume of respectively 0.9 and 0.7 t/ha. We hypothesized that legume do not affect negatively olive production since these crops have short cycle and may provide nitrogen to plantation as a result of biological N fixation. Also as legume crops are cultivated in rows, this can reduce competition with tree comparatively to cereals that are sown near tree trunk. Also mechanical weeding on legume crops may reduce water and soil losses. Legume crops by their diversity, practices and benefits on soil fertility are more suitable for intercropping with olive trees. Research should be continued to develop more suitable legume crops, varieties and practices suitable in such system for more land profitability and climatic change adaptability.

PP104: Pulse based cropping systems as alternative to Bt cotton under rainfed vertisols

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Cotton (*Gossypium* sp.) is the most important commercial crop cultivated over 30% of the total cultivated area of the Telangana State. The indiscriminate expansion of cotton leading to not only pest and disease problem but also seriously threatening food security of the country. Though some of the crops were tried

as alternative to cotton, a System- based approach was never tried, so the present investigation was conducted. The experiment was conducted at Cotton Unit of Regional Agricultural Research Station, Warangal. During *kharif* (June-September) cotton, soybean. maize, green gram were sown with onset of monsoons (3rd week of June). The *rabi* crops (October-January chickpea and safflower were dibbled as and when green gram (65 days), soybean (90 days) and maize (100 days) were harvested under zero-tillage. the experiment was conducted in RCBD with three replications for two seasons. individual crop yields as well as cotton equivalent yields were calculated besides cost production. in the first year soybean-safflower crop sequence recorded same cotton equivalent yield (2973 kg/ha) as cotton (2760 kg/ha), where as in second year maize-safflower was the best cropping system (2543 kg ha) followed by cotton (2459 kg/ha). In both years higher net returns were realized with green gram-safflower crop sequence *viz.*, Rs. 2.02 and 1.99, respectively. The study showed that Bt cotton-soybean or Bt cotton-green gram based cropping systems is profitable to farmers.

PP105: Response of faba bean to organic amendments in calcareous soil

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Faba bean (*Vicia faba* L.) is one of the principal winter legume crops in Egypt as a source of protein for food and feed. Growth and yield of faba bean are greatly influenced by both physical and chemical properties of calcareous soil. Field experiment was carried out at Nubaria region during two successive seasons of 2012/2013 and 2013/2014 to study the effect of different organic amendments on growth, nodulation, yield and nutrients uptake of two faba bean cultivars namely; Nubaria 1 and Nubaria 2 and four organic amendments, (compost, humic acid, fulvic acid and compost tea). Humic acid combined with 50% mineral NPK fertilizer achieved the highest significant increase in plant height and number of branches for both cultivars in the two seasons. Fulvic acid application accompanied by 50% NPK significantly increased yield up to 1455 and 1705 kg acre-1 for Nubaria 1 and Nubaria 2, respectively. The yield of cv. Nubaria 1 was greater than cv. Nubaria 2 in the seasons. Humic and compost applications resulted in substantial increases in number and fresh weight of nodules. The total counts of rhizosphere bacteria, fungi and actinomycetes as well as the dehydrogenase activity were increased due to compost and compost tea application. Meanwhile, humic acid amendment enhanced nitrogenase activity as measured by the acetylene reduction assay (ARA) in 2013 season. On the other hand, the amendment with fulvic aid improved nitrogenase activity during the second growing season of 2013/2014. The highest NPK uptake was recorded in shoot and grains of plants grown in soil amended with fulvic acid. Fulvic acid application, however, resulted in a significant increase in grain protein content of both cultivars in the two seasons.

PP106: Role of faba bean in cropping systems via its biological nitrogen fixation and improved soil balance

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The exploitation of efficient N_2-fixing legumes in cropping systems is emerging as an essential and/or complementary strategy for sustainable agricultural intensification of low-input cropping systems. The objective of this study was to examine to what extent improved faba bean varieties lead to positive effects on wheat grown in rotation. Hence, a two-phase field experiment was conducted on farmer's fields in in

the tropical highlands of southwest Ethiopia involving faba bean and wheat. In the first phase, three improved faba bean varieties (Degaga, Moti, Obse) were grown at four levels of P application (0, 10, 20 and 30 kg P ha^{-1}) along with a local faba bean variety and wheat without N fertilization. N_2-fixation was quantified by the ^{15}N natural abundance technique. The N balance was determined via two possible residue management scenarios: Scenario-I (i.e. common practice) assumed that all the aboveground biomass is exported from the fields; scenario-II assumed that all the above ground biomass except grains and empty pods is returned to the soil. In the second phase, agronomic efficiency of faba bean residues for a subsequent wheat crop was assessed. Again, no N fertilizer was applied to the succeeding wheat crop. The amount of N_2-fixed by faba bean varieties ranged from 258 ±16.8 to 387 ±14.8 kg N ha^{-1}. Scenario-I gave a negative net N balance in the range of -86.5 ±5.8 (variety, Degaga) to -9.4 ±8.7 (variety, Moti) kg N ha^{-1} with significant differences between varieties. Scenario-II showed that all balances were significantly ($P < 0.01$) improved and the varieties were positively contributing N to the system in the range of 50.6 ±13.4 (variety, Degaga) to 168.3 ±13.7 (variety, Moti) kg N ha^{-1}, which is equivalent to 110-365 kg N ha^{-1} in the form of urea (46% N). The superior straw and total biomass production by Moti could be related to its high N_2-fixation potential. P addition did not bring any significant difference in N_2-fixation, grain or total biomass yield of faba bean varieties, which suggested that soil P was not limiting. In the second crop phase, biomass and grain yield of wheat grown after the faba beans increased significantly ($P < 0.05$) by 112 and 82%, respectively, compared to the yield of wheat following wheat. The incorporated legume residues might have improved the wheat yield through N addition via fixed N and likely also via increased P availability due to the high P acquisition of faba beans. This study clearly demonstrates the prospects and importance of faba beans as a valuable component in sustainable agricultural intensification of cereal-based cropping systems in the humid tropical highlands of Ethiopia and Sub-Saharan Africa.

PP107: Role of rhizobia inoculation in promoting effective nitrogen fixation in legume green manures in the United States

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Biological nitrogen fixation (BNF) is a major contributor of nitrogen to managed agroecosystems in the United States (U.S.), with the presence of effective rhizobia strains being essential for optimal nitrogen fixation by legume cover crops. ‘Cover crops’ are defined here as crops planted not for harvest, but for improving soil health improvement and nutrient availability. Cover crop legumes, often called ‘green manures’ in a global context, can be an important management approach to contribute new N to farming systems, but also to improve degraded soils, or those low in organic matter. To maximize nitrogen contribution from legume cover crops, a better understanding of interactions between high-performing inoculant strains that may be added at planting, and established soil rhizobia, is needed. Our objectives were to 1) evaluate rhizobia inoculant effectiveness with three popular legume including crimson clover (*Trifolium incarnatum* L.), hairy vetch (*Vicia villosa* Roth), and Austrian winter pea (*Pisum sativum*), and 2) evaluate genetic diversity of nodule occupants. Legumes were planted in a randomized split plot design with and without commercial seed inoculation on three organically managed farms in North Carolina, U.S. Legume biomass, biomass nitrogen, nodule number, and nodule dry weight were measured and a Most Probable Number assay carried out to determine soil rhizobia population. A total of 576 rhizobia strains isolated from surface sterilized nodules were fingerprinted using rep-PCR and the nodulation gene nodC sequenced to determine origin and diversity of nodule rhizobia strains. Across both inoculated and uninoculated treatments, plant biomass nitrogen ranged from 80 to 206 kg ha-1. At three field sites, inoculation did not result in an increase in plant biomass, biomass nitrogen, nodule number, or mass. A majority of rhizobia isolates belonged to 13 DNA fingerprint clusters whose occupants were over 70% similar, with similar strains not grouping by cover crop host, farm location, or

inoculation treatment. As few as 8.5% of strains isolated from inoculated nodules had DNA fingerprints similar to the commercial inoculant. Rhizobia isolated from inoculated legume nodules displayed genetically distinct nodC sequences from inoculants, suggesting that applied inoculant strains were not present in host nodules.

PP108: Effect of sowing date and seed treatment on food legume insects

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In Morocco food legume crops are attacked by a number of insect pests. Among the important pests are Sitona weevil and Stem borer on faba bean and pea aphid on lentil. Seed treatment with systemic insecticides is becoming an important component of integrated pest management. In this context we tested the efficacy of a liquid formulation of the seed dressing insecticide Celest ®Top (a.i. Difenoconazole + Fludioxonil+ Thiamethoxam) with three doses (1.5 cc, 2 cc, 2.5 cc), and of planting date on the control of Sitona weevil and Stem borer on faba bean and of pea aphid on lentil, under field conditions during the cropping seasons 2013-2014 and 2014-2015. The results showed that foliage damage caused by Sitona weevil was reduced by thiamethoxam with highest dose (2,5cc) compared to untreated control for both years, with a visual damage score of 3 (1-25%) of the leaflet damage for first date, and reduced nodules infestation of about 75% for second planting date. For faba bean stem borer, the seed treatment reduced the infested plants to about 35% with highest dose (2,5cc) for both sowing dates. The highest dose of the same product (2,5cc) did reduce significantly pea aphid infestation on lentil by about 44%. The results of this study showed that seed treatments with neonicotinoid (thiamethoxam) provided good level of protection against the three pests and thus could be used as one of the IPM components for the management of food legumes insect pests.

PP109: Test of post-emergence herbicide for the control of weeds in food legumes in Sais region, Morocco

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Legumes leave significant residual nitrogen in growing in association or in rotation. Among the problems of food legumes, the unavailability of post-emergence herbicides for the control of weeds. The objective of this study was to test new active ingredients as post-emergence herbicides for weed control in food legumes (bean, chickpea, peas and lentil. This study was conducted at the experimental station of Douyet during the 2014-2015. Six herbicide treatments were tested and compared to a control treated by a super Gallant herbicide and weeded twice: Bentazone 480 g / l (1.5 l/ha), Glyphosate under salt Isopropylamine (0.5 l/ha), Linuron (0.5 l/ha), mixing Linuron + Glyphosate under salt applied at a dose of (0.5 + 0.5 l/ha); (1 + 1 l/ha) and (1.5 + 1.5 l/ ha), respectively. The results showed that Bentazone 480 g/l (1.5l/ha), Glyphosate under salt isopropylamine (0.5 l / ha), the technique of hoeing combined with anti-grass herbicide, Haloxyphop-R Methyl Ester 104 g/l (0.5 l / ha) ensured a good level of weed control. The mixture of Linuron (0.5 l/ha) + Glyphosate under salt Isopropylamine (0.5 l/ha) also provided an acceptable level of weed control and low phyto-toxicity in chickpea and lentil. Also, Glyphosate under salt Isopropylamine (0.5 l / ha), the technique of hoeing combined with anti-grass herbicide Haloxyphop-R Methyl Ester 104 g/l (0.5 l / ha), also gave a good level of weed control on lentil. Among the tested

herbicides, mixing Linuron + Glyphosate under salt Isopropylamine applied at a dose of 1.5 l + 1.5 l/ha; 1+1 l/ha and 0.5 l + 0.5 l/ha, respectively, showed excessive phytotoxicity (> 80%) on chickpea and pea.

PP110: The effect of residual nitrogen, mulch and zero tillage on lentil (*Lens culinaris* Medik.) in rainfed agriculture of Abda, Morocco

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Water stress is a limiting factor for crop production in semi-arid region of Abda. Production of lentil takes an important place in the region of Abda and is affected by water stress makes it difficult to manage in this area. The research was conducted in the experimental field Jemâa Shaïm to study the effects of residual nitrogen, mulch and zero tillage on lentil using cv. Hamria. Three doses of residual nitrogen (30, 60 and 90 kg / ha), mulch, zero tillage were tested by adopting an experimental split-split-plot scheme, with three replications. The observations were collected concerned: the evolution of soil moisture, phenological, the dry matter yield components (thousand seed weight, number of pods and seeds per plant), the biological yield and grain and chemical composition (N, P, K) of dry matter and seed. Direct seeding has promoted the content of dry matter in potassium and harvest index, and he still favored the grain yield and density, when combined with mulch under a dose of residual nitrogen 30kg/ ha. Biological yield, seed size, the phosphorus content in the dry matter and the amount of protein in seeds, were not affected by tillage system or by different residual nitrogen. Generally the seed yield of lentil was low this year, given the conditions of stress, so that direct seeding will not show a great advantage under these conditions, and especially that it is the second year of its application.

PP111: The introduction of vetch and pea feed: an alternative for a sustainable improvement of the productivity of subsequent corn

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The objective of this study was to evaluate the effect of the introduction of the vetch and the field pea in pure cultures and mixed with barley on the productivity of the subsequent corn compared to previous feed barley and corn. Two experiments were conducted in two contrasting sites during three successive years 2010, 2011 and 2012. The first site is located in the commune of Had Bartlett, with a type of alkaline sandy soils poor in organic matter and total nitrogen with an annual average temperature of 19 °C and an average annual rainfall of 200mm. The second site is located in the town of Tizi N'Test with medium organic matter-rich clayey-silty-sandy soil and in total nitrogen and a semi-arid climate cold winter with rainfall average of 300 mm. The randomized complete block with four replications and 6 treatments was adopted: vetch-corn, peas, feed corn, vetch/barley-corn and peas feed/barley-corn, barley forage-corn and corn-corn. Results showed that vetch and the field pea set significant amounts of atmospheric nitrogen under conditions of soil and climate of the region Souss-Massa. Vetch fixed an average of 132 kg/ha in pure culture and 126 kg/ha in a mixture, while field pea fixed respectively, an average of 114 and 93 kg/ha. The results of the leftovers of mineral nitrogen left each year by various precedent show a highly significant difference between them for the two test sites. At both sites, the previous, barley and corn recorded the lowest leftovers of respectively 11 and 13 kg/ha for the INRA Station and 13 and 20 kg/ha for Tizi N'Test site. Instead, two legumes in pure cultures and mixtures recorded the most important balances. Two legumes in pure culture and in mixtures significantly

improved growth and development of the following corn crop. They have improved the lifting of corn between 25 and 42% compared with rotations of monocultures of barley and corn. Also, the dry biomass of 8.71 and 12.96 t/ha of these crops after vetch and field pea were recorded while the biomass yields are estimated 5.08 and 5.90 t/ha respectively for continuous barley and corn cultivation. This represents efficiencies of 38 and 58% compared to the previous barley and corn. Also, the preceding vetch and field pea crops allowed also the enrichment of 21 and 39% for nitrogen, between 48 and 52% for phosphorus and between 39 and 43% for potassium compared to continuous barley cropping. Compared to continuous corn planting, these enrichments vary between 21 and 34% for nitrogen, between 44 and 66% for phosphorus and between 45 and 62% for potassium. Vetch and field pea in pure cultures and mixed with barley also have the advantage of reducing attacks of diseases, pests and weeds.

PP112: The power of novel inoculant formulations on the nodulation of pea

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Biological nitrogen fixation by *Rhizobium leguminosarum* bv. *viciae* can contribute with up to 80% of the N requirements of a pea crop (42 kg of N/ton), thus leading to lower fertilizer use, a consequent decrease in its carbon footprint and a more sustainable agricultural system. When performing seed inoculation, a proper amount of bacteria inoculum load should be placed on each seed in order to assure once they are planted and germination starts, the symbiotic process gets started and nodulation occurs. In this trial, pea seed was treated with 2 different commercial and experimental (osmo-protected) inoculants with and without the addition of a bacteria protector and stored at room temperature. During this period of time cfu/seed and nodulation assessments in growth chamber were performed at 0, 1, 2, 3 and 6 days after inoculation (dai). Environmental conditions in the growth chamber were controlled, with a temperature of 25 degrees, light intensity of 7000 lux and irrigation maintaining field capacity in the rhizobia-free soil employed. From 1 to 6 dai, cfu/seed counts significantly decreased in all of treatments progressively. This was not equivalently observed in the nodulation assessments, where performance varied both within inoculants and pre-inoculation time. Treatments which included the experimental formulation showed a stable performance regarding nodulation throughout the whole trial, while treatments with the commercial one decreased significantly with the longest periods of pre-treatment. New inoculant formulations offer the chance to increase the treatment-to-planting window, giving flexibility and increasing the rate of success of the process. The efficacy of the product is not altered when a pre-sowing treatment of 6 days is carried out. Future work will be carried out at lab, growth chamber and field in order to validate the results obtained as well as the compatibility with commonly used seed care products.

PP113: How does water deficit affect legume-rhizobia symbiosis performance and its contribution for agrosystems sustainability?

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Faba bean is mainly grown as food and feed legume due to its high protein content and it is widely used in cereal-dominated rotations because of its improvement of nitrogen content in the soil. Like other legumes, this species is able to fixe symbiotically atmospheric nitrogen through soil rhizobia to ensure its necessary nitrogen nutrition. This biological process is severely affected by abiotic stresses

particularly water deficit. The main objective of our study was to use agro-physiological and molecular criteria to select more performing *Vicia faba*-rhizobia symbiosis for biological nitrogen fixation under water deficit. Four *Vicia faba* varieties (AG, AL, LO and RM), frequently cultivated in the Haouz region, were grown in the field and under greenhouse and were inoculated with native rhizobia. The water deficit was applied by adopting two irrigation regimes, without any nitrogen fertilization. The results showed that at plant flowering stage, water deficit affected negatively plant growth and nodulation in all of the tested symbiotic combinations with difference between them. The water constraint reduced also the physiological parameters such as relative water content, leaf water potential, efficiency of photosystem II, and symbiotic nitrogen fixation activity in nodules; but, it enhanced solutes accumulation. The expression of some genes, involved in physiological responses of *Vicia faba* to drought, is down regulated under water deficit. At plant maturity stage, the water deficit stress reduced the yield parameters such as the number of pods per plant, number of seeds per pod and the weight of 100 seeds. Considering almost all of the assessed parameters, the symbiotic combinations involving AG variety were more tolerant and those involving RM variety were less tolerant to water deficit.

PP114: The effect of anti-drought chemical agents application on the performance of lentil crops under dryland farming system of Abda

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Lentil (*Lens culinaris* Medik.) occupies an important place in cereal systems of semi-arid areas of Morocco. Water stress is one of the main causes of the decline in crop yields. The objective of the study was to evaluate the effect of the application of anti-drought chemical agents (Tebuconazole and Fulvic acid) on the agronomic traits of lentil. The trials were conducted at INRA experimental station of Jemâa Shaïm. The treatments applied, in a Latin square design with four replications, were control (C); seed coating with Tebuconazole (SC), seed coating with Fulvic acid (SFA) and leaf spray with Fulvic acid (LFA) at flowering stage. The results showed a significant effect of these chemical agents applied on the crop phenology of lentil. Biological yields of the lentil were significantly decreased for the various treatments ranging from 5.91 to 5.03 t / ha. For the yields components, LFA treatments significantly increased the grain yields from 1.689 t/ha for the control to 1.955 t /ha. However, treatment SC allowed to have a highly significant harvest index (40.2%) followed by SFA (38.9%) and LFA (39 %). The thousand seed weight was also highly significant in the treatment SC (40.2 g). In conclusion, the effects of anti-drought chemical agents were remarkably observed for the lentil.

PP115: Special technology demonstration for harnessing black gram productivity through Frontline Demonstrations in Bidar region of Hyderabad Karnataka

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Front line demonstrations were conducted in different regions in the Bidar district of Hyderabad Karnataka where predominantly pigeonpea, greengram, Blackgram and chickpea based cropping systems was present. During the period of four seasons (2010-11, 2011-12, 2012-13 and 2014-15) a total of 56 demonstrations were successfully conducted in farmers' fields to educate farmers through live field demonstrations. The results indicated that, the highest yield achieved by adopting improved technologies

was 1.43 t ha^{-1} whereas, the corresponding yield under farmers practice was with an average of 0.9 t ha^{-1}. Adoption of improved technologies also resulted in better utilization of the natural resource.

PP116: Special technology demonstration for harnessing pigeonpea, *Cajanus cajan* productivity through Frontline Demonstrations in Bidar district

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Pigeonpea is one of the important commercial crop and an important source of income of small and marginal farmers of Hyderabad Karnataka region. The low production and productivity of traditional varieties of pigeonpea and the age old production practices were cause of concern for the farmers at large. To overcome this problem of low yield, Krishi Vigyan Kendra Bidar has conducted 50 frontline demonstrations. Cultivation of high yielding variety BSMR-736 of pigeonpea has given the yield increase of 70.28 and 51.41, percent during 2010-11 and 2011-12 over local check. The technology gap ranges from 8.2 to 14.6 during the experimental period. The highest extension gap of 14.8 was recorded in during 2010-11. This high extension gap in this crop requires urgent attention from planners, scientists, extension personnel and development departments. The technology index varies from 21.6 to 38.2. The changes will accelerate the adoption of newer technologies to increase the productivity of pigeonpea in this area. There is a need to address integrated crop management strategy which involves enhancing pigeonpea production through horizontal and vertical expansion and productivity improvements through better adoption of improved technology.

PP117: Evaluation of Frontline Demonstrations of chickpea in Bidar district of Northern Karnataka

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Chickpea is one of the important *rabi* season commercial crop. To overcome low production and productivity in chickpea crop, Krishi Vigyan Kendra Bidar has conducted 27 frontline demonstrations. Cultivation of high yielding variety JG-11 of chickpea has given an increased in grain yield of 70 and 42.6 percent during 2010-11 and 2011-12 over local check. The technology gap ranges from 19.2 to 21.2 during the experimentation. The highest extension gap of 8.75 was recorded in during 2010-11. This needs urgent attention from planners, scientists, extension personnel, development departments and farmers. The technology index varies from 3.4 to 12.5. The changes will accelerate the adoption of newer technologies to increase the productivity of chickpea in this area. Hence, there is a need to address ICM practice in this region.

PP118: Rehabilitating and promoting food legumes through crop rotations with cereals: Enhancing Food Security in Arab countries

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Food legumes are the major sources of plant proteins that are useful for both human and animal nutrition. They also have a very important role in the crop rotations. However, their productivity have been

decreasing the last few years because of adverse weather conditions and damages due to several associated pests. The objective of this study was to disseminate all new legume crop improvement technologies that have been developed by international research centers and NARS institutions, for two species, Faba bean and winter planted chickpea. Large scale on-farm demonstration trials, of 1 ha each, were established in farmers' fields in the Chaouia region under rainfed conditions, and one of these were selected to serve as a farmer field school (FFS). Improved faba bean and winter planted chickpea varieties were seeded and new pest control technologies were applied and demonstrated to farmers during the several field days that were held throughout the season. An FFS was organized for Orobanche control all around the season. About 15 farmers participated in the FFS activities. Moreover, around each demonstration pilot site, five to ten neighbouring farmers used the same package as used in the pilot site. The major pests that occurred during each season were successfully controlled in an integrated pest management approach. The monocotyledonous weeds were controlled by herbicides while the broad leaf ones were mainly controlled thru cultivation and hand weeding. Orobanche, the most noxious weed, was controlled by applying glyphosate at a rate of 167 g a.i/ha, applied three times at 15 days interval on faba bean and only once at 50 g a.i./ha on chickpea. The high humidity levels that were associated with the spring rain favoured chocolate spot and Ascochyta blight development. Diseases were controlled by applying appropriate fungicides one to 2 times, depending on disease severity in each pilot site, at 10 days apart. As to insects, two pests were very abundant and needed chemical control, aphids on faba bean and leaf minor on chickpea. The results showed that the technological and IPM package was successfully transferred to farmers and contributed largely to yield improvement. The productivity of these two food legumes varied from 2 to 4 folds as compared with the farmers' managed trials.

PP119: Increasing production of pigeonpea through intensive application of Integrated Pest Management

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The large scale demonstration on Integrated Pest management (IPM) of pigeonpea pod borer was conducted on an area of 2000 acres in 21 villages of Bidar district of Karnataka. The activity of pest was recorded from flower bud initiation till harvest. Whenever the ETL was crossed the control measures as per the IPM schedules were imposed and managed the pest successfully. However in Non-IPM fields the calendar-based sprays were given. The average seed yield in IPM fields was 1375 kg and 780 kg/ha in non IPM fields. The per cent increase in yield recorded was 28.57 by adopting the IPM module farmers got an additional income of Rs. 23870 per hectare.

PP120: Increasing production of chickpea through intensive application of Integrated Pest Management

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The large scale demonstration on Integrated Pest Management (IPM) of pigeonpea pod borer was conducted during 2013-14 on an area of 1000 acres in eight villages of Bidar district of Karnataka. The activity of pest was recorded from seedling stage to till pod development stage. Whenever the ETL was crossed the control measures as per the IPM schedules were imposed and managed the pest successfully. However in Non-IPM fields the calendar-based sprays were given. The average seed yield in IPM fields was 1350 kg and 1050 kg/ha in non IPM fields. The per cent increase in yield recorded was 76.28 as the

state average yield was 555 kg/ha. By adopting the IPM module farmers got an additional income of Rs. 46285 per hectare.

PP121: Effect of *rhizobium* inoculation on growth and yield of common bean and maize

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The most frequent system of cereal production in Algeria is undoubtedly fallow-wheat system representing 42% of the agricultural area. This is an extensive system that meets only half of the needs in cereals grain and fodder. Resorption of fallow has become a strategic necessity to ensure food security in response to the instability of supply and the persistence of high food prices in the world market. Despite several attempts to establish a more appropriate rotation, the question of the choice of the alternative crops to replace fallow still remains. Today, the agronomic and economic interests of legumes are demonstrated. However, their cultivation remains marginalized because of the low and instable of their performance. In the context of improving legumes and cereals crops as well as fallow resorption, we undertook to test under field conditions the effect of rhizobial inoculation of *Phaseolus vulgaris* in association with *Zea Mays*. We first studied the genetic diversity of rhizobial strains that nodulate on *P. vulgaris* isolated from fifteen (15) different regions. ARDRA had shown 18 different genetic profiles. Symbiotic characterization highlighted a strain that highly significantly improved fresh and dry weight of the host plant, in comparison to the negative control (un-inoculated) and the positive control (inoculated with the reference strain CIAT 899). In field, the selected strain increased significantly the growth and yield of *P. vulgaris* and *Zea mays* comparing to the non-inoculated control. However, the mix inoculation (selected strain+ Ciat 899) gave the best parameters. These results indicated the relevance of replacing fallow with a legume crop in association with cereal crops.

PP122: Yield enhancement of food legumes for sustainable productivity in rainfed areas of Madhya Pradesh

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Globally, India covers about 35 % of area and 25% production of total the pulse production. However the productivity of the pulses is too low. The main cause of this is that the majority of the pulses are grown under rainfed conditions with no supplemental irrigation except chickpea where about 20-30 % the crop is given one to two supplemental irrigations. Access to knowledge on improved varieties and technology for pulses production and its availability is another constraint to boosting the productivity of pulses in India. Sustainability of production depends mainly on climate, playing major role in fluctuating the annual area and production of pulse crops. The central State of Madhya Pradesh accounts 25% of total pulse production of India with largest area under pulses; the productivity of kharif pulses is far below the national average. Under IFAD-ICRISAT Grant Project I-R-1363 “Sustainable Management of Crop-Based Production System for Raising Agricultural Productivity in Rainfed Asia” implemented from 2012-13 to 2015-16 efforts were made for making awareness regarding varieties and production technology of pulses in two rainfed districts (Rajgarh & Shajapur) of the State. Seeds of newly developed varieties of similar climatic regions, of pigeonpea in rainy season and chickpea and lentil in winter season were provided to farmers free of cost. In pigeonpea 3 early, 2 mid-early and 4 medium maturing genotypes, in chickpea 7 Kabuli and 4 desi genotypes and in lentil 5 genotypes were tested under Farmers

Participatory Varietal Evaluations at 215 farmers' fields. The yield increment of these genotypes over local ones ranged from 14 to 38 per cent. Amongst them ICP 88039 and Pusa 991 in pigeonpea, RVG 202, JAKI 9218 in desi chickpea, JGK 3, Phule G 517 (Kripa), RVKG 102; in lentil JL 3, RVL 31 proved to be adaptable and promising genotypes.

PP123: Effect of tillage methods on productivity of double cropped mungbean in the irrigated areas of Central Asia

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Wheat, barley and maize continued to be the major crops grown by private and public sectors in Central Asia. In the irrigated areas of Central Asia, farmers usually finish harvesting winter wheat and barley during mid-June through mid-July, and they undertake next planting of these winter cereals during the first fortnight of October. Thus, the land remained idle for more than three months after wheat harvest, and efficiency of the land could be made through double cropping with legume crops. Climatic conditions of Uzbekistan, Tajikistan and Southern Kazakhstan allow growing two crops per year. Multiple cropping offers a good opportunity to increase annual crop production. Multiple cropping is one of the most important modern agricultural developments for intensification. In double-cropping, timing of planting of the second crop becomes limited along with pressures of harvesting of the mature crop on time. The main objective of this experiment was to study the effect of different tillage methods on productivity of double cropped mungbean in the irrigated conditions of Tajikistan. Mungbean grain yield increased with tillage methods. The greatest grain yield response was recorded with no-till mungbean 1898 and 2365 kg/ha compared to 1595 and 1365 kg/ha from conventional tillage in 2014 and 2015 seasons respectively. The cause of such increase is not clear yet, but we hypothesize that soil moisture content could explain the gain in yield. The maximum (2002 USD), medium (1183 USD) and minimum (926 USD) net revenue was obtained with no-till, minimum tillage with disking and conventional tillage methods respectively. It can be concluded that no-till treatment is the best on the basis of cost-benefit analysis of the present study. Mungbean is one of the best second crop that can be grown after winter wheat harvest in entire southern part of the Central Asia. The research results shows that no-till mungbean had higher productivity than conventional and minimum tillage mungbean in the irrigated conditions of Central Asia.

PP124: On-farm weed dynamics in rainfed no-till food legumes in Central Morocco

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Weeds are the major constraints for sustainable production of food legumes. Weed density and weed shoot fresh biomass were monitored from planting to harvest in 11 food legume fields during 2014-15 in central Morocco (Settat and Oued Zem). Glyphosate (720 g/ha) prior to planting, propaquizafop (50 g/ha) for post emergence grass weed control, hoeing between rows by animal drawn plow, and glyphosate (60 + 60 + 60 g/ha) for broomrape control reduced weed density only by 44% in rows and 55% between rows in five no-till horse bean fields. Glyphosate (720 g/ha) prior to planting and hand pulling weeds during the crop reduced weed density by 82% in 3 no-till lentil fields and 68% in 3 no-till chickpea fields. The weed flora at the end of crop cycle of food legume crops showed low weed density but significant seeds

and biomass produced. Weed management, in no-till food legumes during the first year requires more investment in herbicides and mechanical controls. Integrated weed management under appropriate crop rotations and sequences is essential for sustainable food legumes production.

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PP125: On-farm evaluation of new faba bean varieties under sub-humid climate conditions of Northern Tunisia

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Faba bean is a major food legume crop in Tunisia. It is used for human consumption and animal feeding. Faba bean is grown mainly under rainfed conditions in the northern part of the country where average annual rainfall exceeds 400 mm. The average area sown by this crop is about 56,000 hectares. Around 55% of the area is planted with large seeded faba bean and the remaining 45 % with small seeded. The national average yield of small seeded faba bean is somewhat low and varies from year to year. The average yield recorded during the period 2012 to 2014 was 1.3 t/ha and is considered to be low. This is due mainly to the use by farmers of local populations which have low yielding potential and to inadequacy of agronomic practices followed by farmers. On the other hand the national breeding program has developed new improved varieties with yielding ability substantially higher than that of the local populations currently used by farmers. The new faba bean varieties were tested and compared to farmer's populations during the period 2010-2013 growing seasons in 31 on-farm verification trials conducted in farmers' fields in Fernana district in the North-West of Tunisia. Fernana is characterized by its deep and fertile soil and receive an average rainfall of more than 600 mm/year. In this district faba bean is frequently grown in the cropping systems on an area of about 5,400 ha. Results showed that under improved agronomic package the new varieties Badi and Bachar produced respectively 2.0 and 1.9 t/ha against 1.7 t/ha for the local populations. This represents an average grain yield increase of 17% attributed to the use of the new varieties. Moreover, an increase of grain yield of 47% was recorded with cv. Badi grown under recommended agronomic practices as compared to the farmer's own population and practices. The results of large-scale dissemination plots of the recommended package with cv. Badi implemented in 90 others farmers' fields showed an average increase in yield of 32 % compared to the common farmers' practices. This represents an improvement in average gross margin estimated at 554 Tunisian Dinars per ha (2.0 TD=1 $US).

PP126: Relay cropping of lentil in the rice field: An approach for intensification of production in the medium high to medium low lands of Bangladesh

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Lentil (*Lens culinaris* Medik subsp. *culinaris*) is an important pulse crop for human food and animal feed. Lentil is the second highest pulse crop in area and production in Bangladesh while it ranks first in terms of consumer's preference. However its area and production has been declining since nineties due to priority given to spring rice production for food security. Among pulses, lentil is mainly grown after the harvest of monsoon-rice in the winter season (October-March) in Bangladesh but in most cases, lentil

cultivation is delayed due to late harvest of rice in medium high - medium low lands resulting in lower yields. In this situation lentil relay cropping in the standing rice field, 10-15 days before of rice harvest is the best solution which ensures timely sowing and best use of residual soil moisture. For better adaptation and successful crop production, various combination experiments on lentil as relay crop with monsoonal rice have been conducted at on- station as well as on-farm during last five years. It was found that, lentil as relay crop produced up to 2070 kg/ha seed yield which was 64% higher over sole crop. Now this technology is gaining popularity among the farmers of medium high- medium low land areas where the lands would have remained fallow otherwise. The cost of cultivation in relay cropping is also 45% lower than sole cropping of lentil. The increased production of lentil also has multi-dimensional impacts on livelihood improvement and nutritional security of Bangladeshi people.

PP127: Yield and economics impacts of transplanted pigeonpea (BSMR-763) under irrigated condition

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Pigeonpea is the most important pulse crop in Kalaburagi distinct of Karnataka, India. Yield of pigeonpea continually decreasing as cost of cultivation increases and its productivity is adversely affected by various biotic and abiotic stresses. Krishi Vigyan Kendra, Kalaburagi conducted 30 demonstrations in farmers' field at different villages of Kalaburagi district during the period of 2014-15 to enhance the yield and yield parameters of transplanted pigeonpea (BSMR-763). There are two treatments consist of T1: Pulse magic spray (Pulse magic is product developed by from KVK, Kalaburagi, UAS Raichur. Which contain the mixture of primary, micro nutrients and PGR. The pulse magic contains 10% of nitrogen, 40 % of phosphorus, 3% of micronutrients. 10 g of nutrient mixture and 0.5 ml of tonic mixed in one liter water sprayed two times in pigeonpea, one at 50 % flowering stage and another at 15 days after first spray of pulse magic) with two times drip irrigation, nipping at 30 day after transplanting, INM, IWM, IPM and improved production technology compared with farmer practices. The results indicated that due to front line demonstration resulted in high average yield (2.9 t/ha).

PP128: Farmer participatory approaches for improved production technologies in chickpea grown in Kalaburgi district of Karnataka through frontline demonstrations

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Chickpea (*Cicer arietinum*) is the most important *rabi* pulse crop in Karnataka, occupying the largest area. Gulbarga district alone contributes to 50 % of total area. Its productivity is adversely affected by various biotic and abiotic stresses which made its cultivation unreliable and uneconomical. Even though many technologies for chickpea cultivation have been evolved for increasing the productivity but farmers only adopted few packages. Therefore the frontline demonstrations (FLDs) were conducted on chick pea crop by the Krishi Vigyan Kendra, Gulbarga, Karnataka state at different farmers' field under the real farm situations to show the worth of improved variety with integrated crop management practices and convincing farmers to adopt integrated crop management technology for enhancing the productivity of Chickpea. The results clearly indicated the positive effects of FLDs over the existing practices towards enhancing the productivity of Chick pea in the rainfed region of Kalaburgi District. Demonstrated technologies proved most remunerative and economically feasible compared with traditional production system. The year wise data reveals that demo yield 13.25 q/ha and check plot yield 11.6 q/ha in 2011-12

during implementation period and it is 14.4 q/ha and 11.3 q/ha respectively in 2014-15 and 15.12 q/ha in 2015. The higher average grain yield in demonstration plots over the years compared to local check due to knowledge and adoption of full package of practices by the farmers with help of KVK Kalaburgi and also through coverage in mass media, print media and trainings.

PP129: Increasing the yield and economics of pigeonpea through Frontline Demonstration in Kalaburagi district, Northern Region of Karnataka

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Pigeonpea is the second most important pulse crop in India after chickpea. It has multiple uses and occupies an important place in the prevailing farming systems in the country and vegetarian diet. Kalaburagi district, the Pulse bowl of Karnataka, contributes 48.3 per cent area and 52per cent production of pigeonpea in the state. One of the major constraint of its low productivity is non- adoption and lack of knowledge of improved technologies by farmers. The Frontline demonstrations were organized on 60 farmer's field to demonstrate the impact of integrated crop management technology on Pigeonpea productivity, to demonstrate production potential and economic benefits of improved technologies comprising of seed treatment with biofertilizers, Proper spacing and timely sowing, Integrated Weed Management, Integrated Nutrient Management, Integrated Disease Management and Integrated Pest Management . The improved technologies revealed that a mean yield of demonstrated field (13.24 q/ha) which was 24.08 per cent higher than the farmer's practice (10.7 q/ha). The improved technologies resulted in higher income with a benefit cost ratio of 3.7 as compared to local practice (2.98). The demonstrated technology also recorded less incidence of sterility mosaic and Fusarium wilt (< 4 %), Helicoverpa pod borer (5-10 %) and pod fly (< 6 %) when compared to farmers practice. The technology was further disseminated horizontally through KVK extension approach or activities like training, print media, mass media and field day.

PP130: Maximization of productivity of pigeonpea through improved production technology in Kalaburagi district of Karnataka

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In Karnataka, pigeonpea is largely grown in northern parts, especially in Gulbarga, Bijapur and Bidar districts. Gulbarga is called as "Pulse bowl of Karnataka" and pigeonpea is one of the most important pulse crop grown in this region. Krishi Vigyan Kendra, Kalaburagi conducted 78 demonstrations in farmers fields of different villages of Kalaburagi district during the period from 2012-13 to 2014-15 to enhance the yield of transplanted pigeonpea (cv.BSMR-763) through improved production technology. The result showed that, the highest yield achieved by adopting improved production technology was 2.7t/ha, compared to farmers practices (to 19.54 q/ha (BSMR-763). Adoption of improved production technology will increase the yield 39.35 % over farmer practices. The average technological gap, extension gap and technological index were noticed 27.74 q/ha, 7.72 q/ ha and 50.44 % respectively. The economics of data indicated that an average of Rs. 96697 per ha was recorded net profit under recommended practices while it was Rs. 65076 per ha under farmer practices. Cost benefit ratio was 4.74 under demonstration, while was 3.85 under farmer practices. Practicing of improved production technology and sustainable development will improve the farmer socio-economical level and sustain the fertility of soil efficient utilization of natural resources.

PP131: Maximization of yield of Black gram through improved production technology in farmer's fields in Karnataka

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Front line demonstrations were conducted on black gram crop in different farmer's fields in the Kalaburagi district of Karnataka having predominantly vertisols soil type where growing of pigeonpea and Black gram based cropping systems. Within a span of four years (2011-12 to 2014-15) a total of 60 demonstrations were conducted by the Krishi Vigyan Kendra, Kalaburagi district of Karnataka state on black gram crop to educate farmers through live field demonstrations with the concept of learning by seeing and doing. Demonstrated technologies proved most remunerative and economically feasible against traditional production system. The results showed that the highest yield achieved was 1.2 t/ha whereas, from farmers practice ranged from 0.7 1t/ha. Adoption of improved technologies also resulted in better utilization of natural resource as reflected in terms of water use efficiency, weed suppression and improved harvesting.

PP132: Success story of transplanting technique in pigeonpea – A changing in the cropping pattern of the Vijayapura district of Karnataka, India

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Pigeonpea is an important pulse crop in India after chickpea. In Karnataka, pigeonpea is largely grown in northern parts, especially in Kalaburagi, Vijayapura and Bidar districts with average productivity of 560 kg ha^{-1}. The level of productivity of pulses in India lies between 600-700 kg/ha, which is far below the world average yield. One of the major constraint of its low productivity is lack of knowledge, awareness and non-adoption of improved technologies by farmers and erratic rainfall pattern. Outbreak of pest and diseases also common. Due to severe outbreak of viral disease on sunflower farmers shifted to alternative crop. During this period pigeonpea was substituted crop of sunflower. To convince to pigeonpea as a remunerative crop and to Demonstrations of improved production technologies for two years (2008-09 and 2013-14) involving 50 farmers i.e. transplanting technique and package of practices. This made a huge impact on the farmers due to learning by seeing and doing concept. The result concluded that the highest yield observed in high yield (4.5 t/ha) was obtained. The adoption of improved technologies increase pigeonpea growing area from 28050 ha in 2008-09 to 183000 ha in 2013-14.

PP133: Yield and Economics of pigeonpea as influenced by improved production technology in farmer's fields of Kalaburagi district of Karnataka state

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Pigeonpea, (*Cajanus cajan* (L) Millsp is the second most important pulse crop in India after chickpea. District Kalaburgi of Karnataka occupies 375000 ha of land with average productivity of 560 kg ha^{-1} of pigeonpea. In order to make the nation self-sufficient in pulses productivity levels of pulses need to be increased. One of the major constraint of low productivity of pigeonpea is lack of knowledge, awareness and non-adoption of improved technologies by farmers. The Krishi Vigyan Kendra of Kalaburagi, Karnataka state has conducted 96 Frontline demonstrations (FLDs) on 39 farmer's field to demonstrate the impact of integrated crop management technology on yield and economics of Pigeonpea over four years (2011-12 to 2014-15) during *Kharif* . Each frontline demonstration was laid out on 0.4 ha area and

adjacent farmer plots (0.4 ha) were used as controls. The productivity gain under FLD over existing practices of pigeonpea cultivation created greater awareness and motivated the other farmers to adopt suitable production technology. The results revealed that due FLDs the average yield was recorded was 1.4t/ha compared to 1.2t/ha on farmers plots. The highest yield in the FLD plot was 1.4t/ha in 2014-15 with net returns of Rs. 36, 437 compared to farmer's practice with net return of Rs. 27,763.

PP134: Effect of three plant growth regulators on crop growth and productivity of Kabuli chickpea cultivars CDC Frontier and CDC Orion

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Chickpea (*Cicer arietinum* L.) has an indeterminate growth habit, and excessive soil moisture conditions encourage secondary vegetative growth of the crop causing delay and uneven seed maturation, which interns lower seed quality by increasing immature (green) seed fraction. Plant growth regulators (PGRs) are applied to control excessive vegetative growth in cereals, fruits and grasses. A field study was conducted to examine the effect of three PGRs [Cycocel (CCC), Prohexadione Calcium (PC) and Trinexapac ethyl (TE)] on crop growth and productivity of two Kabuli chickpea cultivars CDC Frontier and CDC Orion under rainfed and supplementary irrigated conditions at two test sites in southern Alberta. Each PGR treatment was applied at two concentrations (CCC at 4,000 or 6,000 mg L^{-1}; PC at 750 or 1,500 mg L^{-1} and TE at 1,000 or 2,000 mg L^{-1}) at three crop growth stages [21 days after seedling emergence (DAE), and 20 days and 30 days after flowering (DAF)], and untreated plots were maintained to serve as controls. Our results revealed that PGR effect on plant height was dependent upon the type and concentration of PGRs and crop growth stage of PGR treatment. Both PC and TE applied at 21 DAE and 20 DAF effectively reduced plant height only for a few weeks, and then the effect gradually diminished, consequently the final plant heights of all treatments were statistically comparable with respective untreated controls. PGRs applied at 30 DAF, however, had no significant impact on plant height at either site. Regardless of type, concentration or growth stage of treatment, PGRs had no significant effect on the number of nodes of the main stem or the number of pod bearing branches $plnat^{-1}$. Regardless of concentration PC and TE delayed crop maturation only at one site. In contrast, CCC had no effect on crop maturation. In general, PGR had no significant impact on 1000-seed weight (TSW), except at one irrigated site, where PC applied at 20 DAF, at both concentrations significantly increased TSW, and TE applied at 2000 mg L^{-1} applied at 30 DAF significantly reduced TSW. Regardless of growing conditions, neither concentration of CCC nor the crop growth stage at which it was applied had a significant effect on marketable seed yield at either site. Under rainfed condition, on average, both concentrations of PC and TE at 2000 L^{-1}, applied at 20 DAF, significantly reduced marketable seed yield. Under supplemental irrigation conditions, regardless of growth stage and concentration, only TE reduced marketable seed yield. In summary, our results suggested that, regardless of the concentration and growth stage of treatment, none of PGRs evaluated in this study had a significant impact on controlling of excessive vegetative growth or improving marketable seed yield in either Kabuli chickpea cultivar.

PP135: Use of the biological control in food legumes as alternative to ensure sustainable diversification of agriculture

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The impact of repeated use of the pesticides on food legume fields conducted under zero tillage calls for the need for an appropriate biological approach to ensure sustainable diversification of farming systems.

The approach suggested as alternative to the pesticide use is based on the use of extracts from medicinal plants such Marrubium vulgare, Allium sativum and Syzygium aromaticum to control fusarium oxysporum isolated from lentil fields conducted under zero tillage in Zaer region of Morocco. Five concentrations (20, 40, 60, 80 and 100 g/l) of the decoctions of these plant species were used. The results showed that the extract from Marrubium vulgare did not stop the growth of pathogen. However, the diametrical growth of the pathogen was inhibited by 39.55% under 20g/l of A. sativum at the second day of incubation to reach 53.2 % after six days of incubation, while total inhibition was recorded at 80 g/l concentration on the first day. In the case of S. aromaticum, a total inhibition of the diametrical growth was recorded starting from 20g/l. The research of the minimal concentration responsible for the total inhibition of the growth of Fusarium oxysporum f.sp lens by *S. aromaticum*, is obtained under the action of 15g/l. The characterization of the inhibiting effect of the extract of S. aromaticum on the isolate of *Fusarium oxysporum* f.sp. *lens* showed that the effect is fungicidal. In conclusion, biological control can be used within an integrated pest management approach.

Theme 4
Seed systems, input markets and mechanization

PP136: On-farm seed storage is critical in strengthening pulses seed systems in India

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The establishment of appropriate seed systems for rainfed crops for supply of seeds of improved varieties to smallholder farmers in Semi-Arid Tropics is a big task especially for pulses. In the case of chickpea, inappropriate seed storage facilities at farmers' level are forcing smallholder farmers to buy and look for quality seed every season because of storage pests' problem. Ensuring quality seed supply of improved variety to smallholder farmers is a difficult task for public sector agencies as private seed industry has shown limited interest because of economic reasons. However, we demonstrated and conducted experiments with Purdue Improved Crop Storage technology based triple layer plastic bags in storing chickpea seed at village level to mitigate storage constraints from severe infestations of bruchid (*Callosobruchus chinensis* L.). A village-based seed enterprise promoted in the project village produced 12 tons of chickpea variety JG-11 in 2013-14 season was stored in triple layer plastic bags for a period of 8 months. Farmer's conventional practice of storing in jute bags and polypropylene woven sacks included as check. Our results showed significant differences in terms of seed damage and seed germination between triple layer bags and control bags. Seed damage by bruchid was 2% and germination was 95% in triple layer bags as compared to 55% and 80% respectively in control bags. Overall cost effectiveness and easy to adopt nature of the technology for storing precious seed was well received by farmers and has potential in strengthening pulses seed systems.

PP137: Reconstructing quality seed production system of pulses through FPA in Jammu region of North-Western Himalayas for livelihood security

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More than 10 per cent of world's population inhabits in mountainous areas. Agriculture and its allied sectors are the main stay of 60-79 per cent of the population in the mountains despite very small irrigated area. The dominant feature of such agriculture system is largely rainfed on slopy marginal farm lands and small holdings of households. The mountain ecosystems are highly fragile, due to their geographical, topographical, climatic, demographic conditions. Therefore, the formal system of pulses production in the prevailing situations is not sufficient and not fulfilling even the requirement of their own .Since, pulses are the major mainstay of farmers in the domain. In spite of several efforts, productivity has not much increased because of staggered approach .Yields of pulses at the research farm are between 15-20 q/ha compared to 4-8 q/ha in the farmers field indicating large yield gaps. Seed is the back bone of agriculture which plays a vital role in accelerating and sustaining the crop productivity. The quality of seed alone is known to account for at least 10-15 % of increase in pulses production. Seed act as a catalyst for realizing the potential of high yielding varieties. In absence of quality seed, the investment on fertilizers, water, herbicides, and other inputs will not pay the desired dividends. In cereals, the availability of quality seed of improved cultivars has led to a phenomenal increase in area and production. However, in pulses lack of quality seed continues to be one of the greatest impediment in bridging the vast yield gap between the one realizable and being realized at farmer's fields. It is widely felt that pulses productivity can substantially be increased if the availability of right kind of various seed of right variety

in right time is ensured at farmers' level. The quality seed production of pulses under the National food security Mission project is providing the quality seed to the farmers and helpful in realizing the pulse production in the domain.

PP138: Development of molecular seed genetic purity test for pigeonpea

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In agriculture using quality seeds of improved varieties is very important to ensure higher productivity thereby food security and sustainability. To ensure good productivity, seeds should have characters as described by the breeder. To know whether the characters as described by the breeder are expressing in a variety such as genuineness or genetic purity, field grow out test (GOT) is done. In pigeonpea which is long durational crop, conducting a GOT may take very long time and expensive. Since pigeonpea flower character is a most distinguishing character from the contaminants, conducting a field grow out test require 120-130 days or till flower emergence, which may increase cost of storage and seed production. This will also delay the distribution of seed inventory to the pigeonpea growing areas. In 2014-15 with financial support of Govt. of Karnataka, India, a project was developed a molecular genetic test for newly developed variety of pigeonpea cv.TS3R was commissioned at Seed Unit, UAS, Raichur. A molecular test using 44 primer pairs were screened to identify the specific marker associated with this variety. Pigeonpea cv. TS3R could be clearly identified by using the primer CCM 293 based on the banding pattern resolved on gel electrophoresis and PCR reactions. However some of the markers like AHSSR 46, CCM 82 and CCM 57 can also be used to test other popular varieties in the region like Asha, GRG-811 and Maruti respectively. The lab test results were validated with actual field GOT test results and found variations within the acceptable limit of 1%. This molecular method can now be employed to test the genetic purity in pigeonpea cv TS3R which reduces the time and can be a cheaper alternative method for field GOT.

PP139: Participatory on-farm demonstration of food legumes in Afghanistan: Role in enhancing food and nutrition security

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In Afghanistan, per capita availability of pulses was 2.4 kg in 2013 against the annual per capita requirement of 18.25 kg to fulfill the recommended pulse dietary requirement of 50 g per capita per day (FAOSTAT, 2013) resulting in chronic malnutrition. Productivity of locally grown food legumes in wheat-fallow rotations, is very low and the production does not meet the demand of a growing human population. This is mainly due to poor adoption of improved varieties and of good agricultural practices. An attempt was made to assess the performance of introduced improved varieties of chickpea and mung bean with associated agronomic practices in comparison to local varieties. On-farm participatory demonstrations (272) were done in eight districts of Baghlan, Mazar and Uruzgan provinces from 2010 to 2012. Impact of the intervention on enhancing food and nutrition security, and on improving the income of farmers adopting such technologies was assessed. Two improved chickpea cultivars, Sehat and Madad, and two mung bean varieties (Mai-2008 and Mash 2008) individually and overall yielded significantly higher than the local ones in each of the demonstrations and more stable compared to the

local varieties over the environments evaluated. On an average, improved varieties out yielded local ones by 100 and 41% in case of chickpea varieties Sehat and Madad, respectively. In case of mung bean, Mai 2008 and Mash 2008, yielded 14 and 32% more, respectively. The gains on grain yield and residues were 1.24±0.28 and 1.24±0.29 t ha^{-1} respectively for Sehat and 0.97±0.11 and 1.08±0.089 t ha^{-1} respectively for Madad. In all these cases, there is high probability (more than 90%) of gaining substantial yield over the local varieties. The study highlights the need for an effective mechanism to disseminate improved varieties and associated best practices in Afghanistan and in other countries facing similar problems. This will highly improve the food and nutrition security, and will enhance the farm income.


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Theme 5
Nutrition, fortification, health and food security

PP140: Accumulation ability of three heavy metals in two legumes (bean and faba bean) in vegetative stage at different concentrations

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In this study build-up of three heavy metals (Pb, Cu and Cd) in two local varieties of *Vicia faba* and bean at vegetative stage, irrigated with two different concentrations of each metal are studied using Atomic Absorption Spectrophotometer. The highest concentration was used according to the assessments made by WHO/FAO. For lead, lead nitrate was used at the highest and lowest concentrations (6 mg/l and 3 mg/l, respectively), while for copper, we used copper nitrate, the two concentrations were 0.3 and 0.15 mg/l for the highest and the lowest concentrations respectively. For cadmium, cadmium acetate was used with 0.03 and 0.01 mg/l for the highest and the lowest concentrations respectively. Plants irrigated with tape water are the control. The most heavily contaminated parts for these two varieties were roots; the accumulation of Cu was 15.56 mg/kg of dry matter (DM) and 15.35 mg/kg DM in shoots respectively in bean and faba bean for lower concentration. Heavy metals concentrations were lower in shoot parts than in roots and then permissible limits of WHO/FAO either in bean and faba bean. The concentration of Cu in vegetative parts was the highest, where the accumulations were respectively of 14.48 mg/kg DM and 16.54 mg/kg DM in bean and faba bean for lower and higher concentrations respectively. The present study provides the evidence that the local variety of faba bean could accumulate and tolerate higher concentrations of lead and cadmium at vegetative stage better than the locale variety of bean which accumulate and tolerate higher concentration of copper which is less dangerous than Pb and Cd which can affect human health and environment.

PP141: Evaluation of toxicity levels of micronutrient and macronutrient strengths on regeneration of grasspea under in-vitro condition

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Murashige and Skoog (MS) medium is composed of different micro and macro nutrient elements and vitamins including iron (Fe), zinc (Zn), boron (B), molybdenum (Mo), barium (Ba) and macronutrient calcium (Ca). The study reports the effect of availability of 1×, 2×, 3× and 4× concentration of Fe, Zn, B, Mo, Ba and Ca in MS medium containing 1 mg/l thidiazuron (TDZ) and 0.25 mg/l naphthaleneacetic acid (NAA) on regeneration capacity of grass pea (*Lathyrus sativus*) cv. Gurbuz. The results demonstrated significant variations in regeneration capacity of the cultivar in respective media and showed inhibited response to enhanced micronutrient and macronutrient supplies. All enhanced micronutrient and macronutrient treatments resulted in poor shoot induction and reduced number of shoots per plants as compared to the control (1× concentration of Fe, Zn, B, Mo, Ba and Ca in MS medium containing 1 mg/l TDZ and 0.25 mg/l NAA). Each increase in concentration of micro- (Fe, B, Ba) and macronutrient (Ca) significantly increased shoot length, number of nodes per plant and internode length whereas, significant decrease in same traits were noted on MS medium containing enhanced concentrations of Zn and Mo. The enhanced availability of micronutrients Fe and Zn in MS medium

induced early maturity and flowering as compared to MS medium containing rest of the micro/macronutrient elements and control. Root induction was completely inhibited using enhanced concentration of Fe and B. whereas, root induction was promoted by enhanced Zn and Mo micronutrients compared to rest of the micronutrients in MS medium. The results showed that optimum micronutrient supply are key factors in success regeneration of grass pea under culture conditions. Furthermore, the results also indicated importance of Zn in enhancing the quality of the grass pea growth compared to other micronutrients.

PP142: Genotype and environment effects on seed mineral concentrations of chickpea and lentil grown in the USA Pacific Northwest

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Dietary mineral deficiencies contribute to a wide range of human health issues. Developing pulse crops with elevated seed mineral concentrations can contribute to alleviating the effects of these deficiencies. The objectives of this study were to determine the relative effects of genotype, environment, and their interaction on seed mineral concentrations of lentils and chickpea grown in the "Palouse," which is the region of eastern Washington and North Idaho where pulse crops are grown in the USA Pacific Northwest. This study examined 22 Kabuli chickpea entries, which included the four cultivars namely, Dwelley, Dylan, Sierra, and Sawyer and 18 Kabuli chickpea breeding lines from the USDA-ARS Grain Legume Genetics and Physiology Research Unit (Pullman, WA). All entries were planted in 2010 and 2011 at three locations (Kendrick, ID; Genesee, ID, and Pullman, WA). Seed concentrations of the following minerals were determined for all chickpea entries: Bo, Ca, Co, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, S, and Zn. The study also examined seed mineral concentrations of 16 large yellow lentil entries, which included the cultivars Avondale, Merrit and CDC-Richlea, and 13 large yellow lentil breeding lines from the USDA-ARS. The lentils were planted in 2010 and 2011 at two locations in Washington, Pullman, and Fairfield. For lentils, seed concentrations of Bo, Ca, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, S, and Zn. Genotype, environment, and genotype x environment interaction effects were significant ($P \leq 0.05$) for seed concentrations of all minerals except Boron (Bo), for which the genotype x environment interaction was not significant. Mean square analysis suggests that chickpea seed concentrations of Calcium (Ca) and Potassium (K) are more conditioned by genetic effects than environment effects. Genetic and environment effects were approximately equal for Molybdenum (Mo) but for all other minerals the effect of environment was much larger than the genetic effect. Among the minerals tested in chickpea, Potassium (K) was present at the highest average concentration (10.37 mg/g) and Nickel (Ni) and Cobalt (Co) had the lowest seed concentrations, 4.72 µg/g and 0.18 µg/g, respectively. For lentil, genotype effects were significant for all seed mineral concentrations, and environment effects were significant for all minerals but Magnesium (Mg) and Sulfur (S). Genotype x environment interactions were significant for concentrations of Copper (Cu), Manganese (Mn), Nickel, and Phosphorus (P). Mean square analysis suggests that lentil seed concentrations of Iron (Fe), Magnesium (Mg), and Sulfur are more conditioned by genetic effects than environment effects. Genetic and environment effects were approximately equal for Calcium, Copper, and Manganese. Among the minerals tested in lentil, Potassium (K) was present at the highest average concentration (10.28 mg/g) and Nickel and Sodium (Na) had the lowest seed concentrations, 4.10 µg/g and 1.98 µg/g, respectively. Correlations between different mineral concentrations and between mineral concentrations and other agronomic traits including yield and seed size will be presented.

PP143: Biochemical and morpho-physiological changes associated with heavy metal toxicity in chickpea

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Heavy metals are major environmental pollutant when they are present in high concentrations and have toxic effects on growth and development of plants. In the present study chickpea seedlings were grown using glass plate method where concentrations of 5 ppm arsenic trioxide (As_2O_3), 20 mercuric chloride ($HgCl_2$) and 40 ppm lead nitrate ($PbNO_3$) were applied under laboratory condition. The physiological, biochemical, cytological and anatomical data were collected on 6th, 9th and 12th days of seedlings growth stages. The result showed morpho-physiological changes. In fact, the length, fresh weight and dry weight of both root and shoot, were more drastically affected by arsenic treatment than by mercuric chloride and lead nitrate as compared with control. Lipid peroxidation on both root and shoot was maximum in the case of arsenic treated seedling followed by lead and mercury. The total phenol content in root was high in arsenic treated seedling; whereas shoot lead treated seedling showed higher amount of total phenol content than those obtained under mercury and arsenic and also control treatments. Free phenol concentrations on both root and shoot showed higher values in lead treated seedling than mercury and arsenic as compared to the control. In root system, superoxide dismutase (SOD) activities in the case of arsenic treatment were much lower in comparison to the other two heavy metal treatments and control. Higher levels of SOD activity were observed in lead treatment in the shoot of chickpea seedling followed by mercury and arsenic treatments. From this study, we can conclude that, considering the adverse effects of different heavy metals on the seedlings of chickpea, arsenic can be considered as the most harmful heavy metal and the use of it should be restricted.

PP144: Comparative study of chemical composition of three local forage legumes from semi-arid region of Tunisia

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Perennial and annual forage legumes are important components of sustainable cropping systems. Forage legumes are a primary source of forage to supply protein and fiber for livestock rations. They can be grazed, or stored as hay or silage. They contribute biologically fixed N and sustain the soil by reducing erosion and increasing soil organic matter levels. Despite the benefits of forage legume in ruminants nutrition there is an absence of data that adequately describe the nutritional value of local forages resources in Tunisia. With this study, we aimed at evaluating the nutritional value and chemical composition of three spontaneous *Trifolium* species. During 2014-2015 we collected plants of *Lotus edulis* L., *L. creticus* L. and *L. ornithopodioides* L. at flowering stage from the semi-arid regions of Tunisia at Zaghouan. The nutritive value of Lotus species was studied on the basis of their chemical composition. For the three species, dry matter (DM), organic matter (OM), crude protein (CP), ether extracts (EE) and fiber: NDF crude fiber (CF) and ADF were performed according to the AOAC procedures. Results indicated that dry matter ranged from 1.70 to 4.08 g/plant fresh matter. Dry matter was higher for *Lotus creticus* plants compared to the other two plants species. Mean crude protein content at harvest was highest for *Lotus creticus* (16.6% of DW) and lowest for *L. edulis* and *L. ornithopodioides* (16% DM). Differences in minerals contents, OM and EE in all species were not statistically significant between species. For all *Lotus* species, fiber content as estimated by CF, NDF and, ADF content was

below optimum for ruminal function. This study provided information on genetic potentials of *Lotus* species in terms of its nutritional properties. The results indicated that plants selected have high feed value and can be used to improve grasslands and forage crops. These parameters could be considered as indicator of high feed value of *L. creticus* L. compared to the two other *Lotus* species.

PP145: Nutritional value and perspectives for sustainable uses of Moroccan lentil

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Lentil (*Lens culinaris* Medik) is one of the main food legumes produced widely in the world for its agro-ecological and nutritional interest. Lentil grains are an important dietary source of protein, fiber, minerals, vitamins, and antioxidant compounds. The nutritive value of lentil seed may be highly significant for improvement of human nutritional quality and health status. In Morocco, lentil is produced in rainfed and semi-arid areas using mainly landraces despite development of improved varieties. Landraces of lentil were conserved at -farm over generations for ingenious farmers' practices. Thus, farmers select, produce and maintain their landrace to satisfy their food security, ecological and economical needs. The main goal is to reduce prevalence of nutrient deficiency and micronutrient malnutrition by increasing consumed rate of lentil seeds, improving bioavailability of nutrients through some technological approaches and by improving nutritional quality through cross-breeding programs using landraces as valuable gene pool. Our study is focused on determination of the nutritional value of four improved varieties and ten landraces. Quantitative and qualitative chemical analyses were conducted to estimate seeds content on crude proteins, carbohydrates, fat, fibers, minerals and ant-nutritional elements such as condensed tannins and lignin. The results revealed that Moroccan lentils are rich in proteins (28.2 - 35.6% of dry matters) which are containing seven of the eight essential amino-acids needed in the human body, in carbohydrate (37-55%DM), in insoluble fibers (38-70% DM) and low concentration of fat (1.43-2.51 mg/100g DM) which are mainly composed of unsaturated fatty acids (85%) type Omega ω3 and omega ω6. Furthermore, landraces are rich in iron (7.67% MM), in Magnesium (103 % MM), in Phosphorus (245 – 479.5 % MM), and in Potassium (388 – 841.5 % MM). On the other hand, analyses made on the components of the seed showed that the anti-nutritional factors (condensed tannins) are more concentrated in seeds coat (more of 62%) where from the interest of dehulled seeds to improve availability of lentil nutritional value. Thus, Moroccan germplasm of lentil may contribute to insure food security of vulnerable people. National agricultural policy might provide farmers with strategies to increase farmer's interest by integrating farmers into agricultural production chain, and labeling lentil as quality and healthy product. Moreover, lentil landraces might be useful in breeding program as source of optional value of nutritional traits.

PP146: Physicochemical and nutritional characterization of advanced Kabuli chickpea lines in Moroccan chickpea varieties

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Chickpea breeding was begun in the 80s and considerable efforts are being made to select new lines from germplasm introduced mainly from international centers (ICARDA, ICRISAT). This research has produced seven officially released cultivars. However, these varieties have not been studied for their food quality. The objective of this study was to evaluate released varieties, newly promising lines and the local

variety of Kabuli chickpea for seed quality parameters. Twenty-four genotypes of chickpea were evaluated for their chemical composition and physico-chemical properties. Significant genotypic differences ($p<0.05$) were revealed for all traits except calcium and magnesium content. Mean values for protein, phosphorus and potassium were 15.1%, 0.5% and 1.1% on dry weight basis. A high diversity among genotypes were found for physico-chemical properties such as seed weight (20-66 g), swelling capacity (0.30-0.70 ml/g) and hydration capacity (0.23-0.68ml/g). The means values were respectively 38 g, 0.40ml/g and 0.39 ml/g. The means values of minerals such as iron, zinc, calcium, and magnesium contents for the genotypes were 6.61, 3.73, 115.8 and 103.8 mg/100 g, respectively on dry weight basis. Some genotypes had high mineral content and potential to improve the nutritional value of cultivated chickpea. A positive and significant association of 100-seed weight occurred with hydration capacity (0.970) and with swelling capacity (0.757). Selection based on hydration capacity and swelling capacity in large seeded genotypes may help to improve quality traits in chickpea. Our results provide an initial step toward identification of genotypes that may be useful for breeders to develop high-quality chickpea cultivars.

PP147: Screening of elite lentil lines for phenols, flavonoids and antioxidants

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Non-nutritive bio-active compounds were earlier considered as anti-nutrients because of their activity to reduce protein digestibility and mineral bioavailability. Now it has been established that these act as anticancerous/ and antioxidants and help in preventing cardiovascular diseases. Seventy-five lentil genotypes (released varieties, elite germplasm line and exotic collections) were evaluated for phenols, flavonoids and antioxidants. The antioxidants ranged from 0.95 (Fasciated mutant) to 12.13 (IPL321) µmol TE/g, phenols ranged from 0.86 (L4698) to 22.64 (EC 1) mg/g and flavonoids ranged from 1.98 (L4698) to 16.85 (SKL259) mg QE/g. The antioxidant activity was higher in the samples that contained higher quantities of phenolic compounds. The present study will help lentil breeders to develop genotypes with good biochemical profile.

PP148: The effect of micronutrients application on lentil (*Lens culinaris* Medik.) grown under semi-arid area of Abda, Morocco

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Lentil (*Lens culinaris* Medikus) is one among the main food legume crops which is mainly used worldwide for its high contents in proteins, minerals (K, P, Fe, Zn) and vitamins., Lentil crop does not benefit from any fertilizer input however, the low Zinc and Manganese availabilities limits crop performance in Morocco and particularly in Abda area. The objective of this study is to examine the effect of foliar application of zinc and manganese on the seed yield, quality, biomass and protein content of lentil. Treatments consisted of applying an amount of 5 kg/ha of zinc sulfate and/or manganese sulfate with an amount of 3 kg/ha. The experimental design applied was Latin Square with four replications. Results show that grain yield was increased by all the treatments (485, 477 and 430 kg/ha respectively for Zn, Mn and both Zn and Mn). The quality of seed was not affected by any of the treatments. The crude protein content in the plant at early growth stages was high with respective values of 18.88 % for the control and 19.56, 20.72 and 18.42 % for Zn, Mn and combination. In the opposite, grain crude

proteins showed that the control has a slightly higher protein level when compared to other treatments. Manganese resulted in higher proteins content in straw, but the protein content of the seeds was not influenced by any treatment. We conclude that under dry land farming, applying zinc and manganese fertilization alone or combined could improve lentil productivity through the increase of yield components, harvest index, grain yields but the results have not confirmed what is mentioned by the literature on the effect of zinc on improving protein. This could be due to weather conditions that limited the availability of zinc to the plant.

PP149: *Lupinus angustifolius* seed proteins as food ingredient: human health benefits and cross-allergenicity implications

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Now-a-days, considerable interest has been focused towards legume seed proteins. Narrow-leafed lupin or NLL (*Lupinus angustifolius* L.), a legume crop belonging to the Fabaceae family, is a worldwide important pulse, which displays a wide range of benefits for agriculture, acting as a disease break for crops in rotation, and at molecular level, lupin seed proteins may also be involved in possible plant pathogens suppression. Therefore, NLL, with low content in alkaloids, is attracting great attention lately because of their nutritional attributes and human health benefits. These properties are associated to the high protein, dietary fiber content, absence of gluten, helping to reduce blood pressure the risk of cardiovascular disease, and contributing to reduction of glucose and cholesterol blood levels. NLL as an important source of proteins for human consumption, seems to be particularly promising as a source of innovative food ingredients due to average protein content similar to soybean and an adequate composition of essential amino-acids. However, and with the rapid introduction of novel foods and as a new ingredients in traditional foods, the number of allergic people becoming a serious and a growing problem in the Western world. The aim of the current work was to evaluate different functional features of NLL seed proteins, focusing on their health promoting properties and allergy. Our results indicate that particular seed proteins might be potential new bioactive molecules with antioxidant, anti-inflammatory and anti-diabetic activities, opening the gate for possible plant-based prevention, management and therapeutic approaches to the world main health concern and increasing disease diabetic epidemics. It also highlight multiple forms of polypeptides with IgE-binding characteristics in patients with lupin specific allergy, having the potential to trigger an immune response leading to allergy symptoms. The comparison of the IgE-binding to several legumes and nuts/seeds proteins has allowed us to get an overall broad picture of the immunological cross-reactivity among proteins of widely used different seed species and to hypothesize the role of the most conserved specific polypeptides. Based on current molecular data, lupin allergy might be more complicated than previously thought because of the involvement of a large number of polypeptides.

PP150: Cultivar-dependent variation in lentil (*Lens culinaris* L.) and implications for selecting food-feed varieties

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Lentil straw is one of the extensively used livestock feed in mixed crop-livestock systems in Sub-Saharan Africa. To identify the importance of varietal and environmental sources of variation in the nutritive

value of straw for livestock feed, 71 genotypes of lentil were evaluated for straw fodder quality and their potential trade-offs with straw and grain yield. Straw fodder quality traits chosen were crude protein, in-vitro digestibility and in-vitro metabolisable energy content, analyzed using a combination of conventional laboratory techniques and Near Infrared Reflectance Spectroscopy (NIRS). Results from eight trials across three sites using randomized complete block design showed highly significant genotypic variation in grain and straw yields as well as in straw fodder quality traits. A positive correlation between grain yield and straw yield was observed ($r=0.55$, $P<0.01$). The correlation between crude protein of the straw and grain yield was strong and negative ($r=-0.73$; $P<0.01$), the correlations were weak and negative between grain yield and total in-vitro organic matter digestibility ($r=-0.12$; $P<0.01$) and between grain yield and metabolisable energy ME ($r=-0.03$; $P>0.05$). Crude protein can, therefore, be considered as an important criteria for varietal selection for food-feed traits. The study pinpoints to the possibility of incorporating straw traits to generate food-feed varieties of lentil to address the high demand for grain and livestock fodder in the mixed crop-livestock farming system of Ethiopia.

PP151: Variation in the straw traits of morphological fractions of faba bean and implications for selecting for food-feed varieties

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Five varieties of faba bean (four improved released varieties and one local variety) were investigated for varietal variation in straw yield, nutritive value of straw morphological fractions and grain yield. Samples of the whole plant biomass were collected and separated into grain and straw. The straw was further divided into leaves, stems and pods. Straw samples were analyzed for their chemical composition (CP, NDF, ADF, ADL, TIVOMD) and ME. The PUI was employed to rank the varieties. The results demonstrated significant varietal variation in grain yield, straw yield and in the proportions of botanical fractions of straw, grain yield and straw yield. The improved varieties were superior to the local variety in grain yield, straw yield and PUI. The local variety had the highest proportion of stem and the lowest proportion of leaf and pods. Significant varietal differences ($P<0.001$) were detected in TIVOMD, ME, NDF, ADF and ADL of whole straw. The leaves showed the highest TIVOMD and content of CP, while pods were highest in ME. Canonical correlation analysis showed significant ($P<0.001$) correlations between the nutritive value of the whole straw and the nutritive value and proportions of its botanical fractions. Grain and straw yields were positively, strongly and significantly ($P<0.001$) correlated. Weak correlations were detected between the grain yield and straw quality traits. Ranking the varieties differed when the grain yield, straw quality scores and PUI were considered. However the weak correlation existed between straw quality, including straw quality index or PUI to select food-feed varieties of faba bean. These findings indicate the possibility of selecting faba bean varieties which combine superior grain and straw traits.

PP152: Lentil seed quality as influenced by environmental factors

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Field experiments consisting of eighteen lentil genotypes were evaluated at research stations under Nepal Agricultural Research Council located at varied agro-ecological zones with the elevation ranging from

96 meters in central Terai to 1360 to1740 meters above mean sea level in central mid hills during 2009/10 and 2011/12. Seed harvested from experimental plots and seeds collected from farmer's field of six Terai districts were analyzed for nutrient contents at University of Saskatoon, Canada and at ICARDA, Beirut. Seed nutrient analysis results showed non-significant variation in Se content among genotypes, but significant differences in Fe (65 to 98 mg/kg) and Zn (25 to 73 mg/kg), Ca (497 to 879 mg/kg) and Cu (12.3 to 14.3 mg/kg) among genotypes. Mean values of Se, Fe and Zn in seed ranged from 0.0161 to 0.9924 mg/kg, 65 to 93 mg/kg and 24 to 73 mg/kg, respectively across locations. Lowest Se of 0.008 mg/kg was recorded in lentils from central mid hill, while the highest of 1.249 mg/kg was found in lentil grown in mid-western mid hills. Zn content was the highest (70 to 78 mg/kg) in lentil grown at while lowest in Surkhet (21 to 34 mg/kg). ILL6467, ILG12, IL1, ILL3111, ILL6256 and WBL77 were found to be rich in Se (1.137 mg/kg). PL4, ILL9926, ILL6256 and ILL7537R with high Fe contents were also found to be rich Zn (59 to 65 mg/kg) under Rampur condition. Lentil grown in Khajura had low potash (7898 mg/kg), Cu (10.7 mg/kg), Mg (1026 mg/kg) and Mn (19.1 mg/kg), while lentils from Rampur showed maximum potash (10913 mg/kg) and Mg (20.2 mg/kg). Genotypes with high level of Se in seed showed low Fe and Zn contents. Mean grain yields of ILL6467, LG12, IL1, HUL57, ILL7715, ILL3490 and ILL7979 were comparable to check varieties, Shital and Sagun. Grain yield was positively correlated with Se (r^2 = 45) contents in seed while negatively correlated with Fe (r^2 = -0.33**), Zn (r^2 = -0.14**), Cu (r2 = -0.64**) and potash (r^2 = -0.56**). Lentil with high Cu content in seed had shown high contents of Zn (r^2 = 0.26**) and Fe (r^2 = 0.44**).

PP153: Addressing household nutritional security through improved pulse technologies

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ICARDA South Asia and China Regional Program with a team of national partners in India comprising of institutes from Indian Council of Agricultural Research, State Agricultural Universities, State Agricultural Department and Non-governmental Organizations are working for "Increasing Food Legumes Production by Small Farmers to Strengthen Food and Nutritional Security through Adoption of Improved Technologies and Governance within South-South Cooperation" under India-Morocco Food Legume Initiative (IMFLI)supported by OCP-Foundation, Morocco. The IMFLI focus to replace low-yielding local cultivar with improved and farmers' preferred varieties; establish Village Seed Hubs; capacity development of small and marginal farmers. It is being implemented in West Bengal and Tripura states on lentil and grass pea; and in Madhya Pradesh (MP) state on Kabuli chickpea. Since its inception 6500 farmers from 378 villages covering 1310 ha in lentil; 2381 farmers from 110 villages covering area of 389 ha in grass pea; and 141 farmers from 58 villages in 140 ha in Kabuli chickpea were covered. A total of 9022 farmers from 546 villages were the direct beneficiaries. In traditional areas higher productivity to reduce yield gap, and in rice-fallow lands introduction of pulses for extra-production of pulses were targeted. Quality seeds of improved varieties with technical guidance resulted up to 100% increase in yield (1546 kg/ha) in comparison to farmers' variety and practice (775 kg/ha) in lentil at West Bengal while at Tripura yield ranged between 338-1475 kg/ha, average of which is 20% higher than district average (623 kg/ha). Grass pea coverage at West Bengal resulted an increase up to 77% in comparison to farmers practice and local variety. Similarly, chickpea realized up to 25% higher yield compared to local practice and variety. In lentil, Moitri, Subrata, HUL-57, PL-6 and NDL-1 varieties performed well at different blocks/districts of WB and Tripura, and in grass pea, Pratik and Nirmal did well at WB. Farmers' preference in Kabuli chickpea were for Kripa and PKV-4, which are bold seeded and wilt tolerant varieties. For the capacity development, >500 events like, Farmer-Scientist interaction, Field Day, Farmer Field School and formal training of farmers were organized and about 21,000 direct

and indirect beneficiaries including 5800 women participated. More than 90 hubs in the form of societies, clubs, VBSEs, FPOs, women self-help groups were established/supported. The implementation of this program resulted in imparting technologies to landless/ marginal farmers of West Bengal and Tripura, resulting in enhanced livelihood with nutritional security through high yielding varieties of lentil and grass pea with low ODAP content. Disease tolerant varieties of Kabuli chickpea with package of practices were provided to overcome crop failure due to diseases, hence to increase the household security.

PP154: Nutritional evaluation of Ricebean (*Vigna umbellata)* based Food Multi Mix.

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In the twenty first century, the vagaries of malnutrition like chronic hunger, starvation and micronutrient deficiency continue to affect millions of individuals throughout the developing world; especially among South Asian countries like India, Bangladesh and Burma. Food diversification or food borne strategies like food fortification can be employed to prevent hunger, starvation and micronutrient deficiencies on a long term basis. One of the best food based approach to address these issues is by development of new value added products like Food Multi-Mix (FMM) from local ingredients for better affordability, accessibility and availability among the vulnerable section of our community. WHO and FAO focus on utilization of underutilized legumes which are of high quality protein, dietary fiber and other micronutrients having numerous health benefits. In the present study FMM was developed using underutilized legume (Ricebean), millet (Konidhan), Flex seed, Rice (luit variety) and tomato powder. The objective of the study was to evaluate the nutritional quality of the developed FMM. In the present study two FMM were developed namely FMM-I from unmalted ricebean and FMM-II from malted rice bean. Rice, millets and flex seeds were toasted and ground to fine powder individually. Tomato was oven dried and ground to fine powder. As such half part of Rice bean seeds were malted and other were slightly toasted and ground to fine powder separately. FMM-I and FMM-II were formulated based on energy density (ED) value between 15.12-18.90kJ/g by mixing all the ingredients at appropriate amount. Nutritional evaluation revealed that the anti-nutritional factors like Phytate phosphorus and saponins significantly decreased after malting. Similarly the energy, protein and available carbohydrate showed marked increase in FMM-II (AOAC 925.09 19th Edition) which may be because of malting of ricebean. There was also an increase in total dietary fibre in FMM-II (12.61g/100g) compared to FMM-I (12.09g/100g). FMM-II also revealed a higher value of micronutrients like iron (11.41g/100g), calcium (0.28g/100g) and zinc (5.31mg/100g) when compared to FMM-I which comprises of iron (10.30mg/100g), calcium (0.35g/100g) and zinc (5.50mg/100g). From the present study it can be concluded that the FMM developed from malted Ricebean with low level of anti-nutritional factors and high nutritional composition can be used for development or incorporation of different value added products like cakes, cookies and savoury items to enhance food and nutritional security.

PP155: Arid legumes for improved nutrition and livelihood: the way forward

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Legumes are integral component of crop-livestock farming system in India due to their value for food, feed and fodder and also in improving the soil health. Four legumes comprising of clusterbean (*Cyamopsis tetragonoloba*), mothbean (*Vigna aconitifolia)*, cowpea (*Vigna unguiculata*) and horse gram (*Dolichos biflorous*) are grown in arid areas often on marginal lands and under limited resources.

Clusterbean is grown over an area of 3.5 million ha in the states of Rajasthan (83%), Haryana (9%) and Gujarat (6%). In view of a vast range of value-added products and derivatives, clusterbean has become an important commercial crop of arid zone providing raw material to guar gum industries and earning foreign exchange of >1200 millions USD. Moth bean is an important crop of arid region grown in 1.3 million ha receiving less than 250 mm rainfall. More than 90% of its cultivation is restricted to western parts of Rajasthan where soils are sandy, low in organic matter and have highly erratic rainfall distribution. Besides household consumption in various food preparations, the major part is consumed in making local snacks (*Bhujia* and *Papad*) preparations. Cowpea is a versatile legume grown from 250 mm rainfall to 1000 mm rainfall both for its tender pods and seeds used in different food preparations. Besides food value it is very good crop for green manuring and soil conservation. Horsegram is being grown in arid and semi-arid regions of the country particularly as a pulse crop due to its medicinal properties especially for the cure of kidney stones. These arid legume crops are grown exclusively under rainfed conditions on very poor soils under minimal inputs resulting in very low (200 – 400 kg) yield against the potential of 1000 – 1500 kg/ha under optimal conditions. Besides, economic returns from seed and nutrition to humans, their protein-rich fodder is supporting livestock which is backbone of arid zone economy. Moreover, role of these crops in soil fertility restoration has to be taken into account under climate change scenario. Therefore, it is high time to attend these crops particularly mothbean and clusterbean by exploiting their full potential as industrial crop with holistic approach. Alteration of moth bean to avoid shattering losses, profuse pod bearing and bold seeds should be priority coupled with better production technology to realize full yield potential. Strengthening seed supply chain, enhancing adoption of high yielding varieties, promoting cooperative and contract farming and linking farmers to marketing would be very critical to make these crops more productive and profitable. Fortunately, government current policies also favour promotion of pulses to improve soil health and support skill development for establishing small scale industries.

PP156: Iron, Zinc and Selenium biofortification of lentil in Bangladesh: Farmers' field survey

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Biofortification is a new agriculture-based approach to help reduce micronutrient malnutrition especially in rural areas at minimal cost. Recent biofortification has mainly focused on iron (Fe), zinc (Zn) and vitamin A deficiency. However there are other essential nutrients that can be deficient in human. For example, selenium (Se) is essential to humans and more than one billion people suffer from Se deficiency. Research is also needed to develop a biofortification method for multiple elements e.g. Fe, Zn and Se. Keeping in view the above discussion, a research work planned to investigate the potential for agronomic biofortification of lentil for Fe, Zn and Se to improve global human health. A total of 140 randomly selected lentil fields, in the major lentil growing areas of Bangladesh, were surveyed during rabi season of 2014-15 to delineate the Fe, Zn and Se status of lentil seeds of varying genotypes and soils. Soil samples were collected from the same location as lentil sample collection, covering the major lentil growing regions of Bangladesh. Selected study locations were research farms and farmer's fields. Se concentration in lentil varied from 132.3 to 364.6 µg/kg. Consumption of 50 g lentil will supply 12-33% RDA of Se. Zn was found from 32.6 to 52.9 mg/kg in lentil and it will supply 17-24% RDA for male and 24-33% RDA for female. Fe was found 53.3-82.0 mg/kg in lentil which will fulfill 33-51% RDA for male and 15-23% RDA for female. Farmers reported growing eight lentil cultivars e.g. BARImasur-3, BARImasur-4, BARImasur-5, BARImasur-6, BARImasur-7, BINAmasur-5, BINAmasur-6 and local/mixture. All these cultivars were small seeded with red cotyledon because of consumers' preference. There was variation among cultivars for seed Se, Zn and Fe concentration. Se concentration

was highest (359.0 µg/kg) in early sowing. Whereas Zn was found highest (44.2 mg/kg) in optimum sowing and Fe was reported highest (65.1 mg/kg) in late sowing. There was variation for seed Se, Zn and Fe in lentil associated with the different preceding crops. Soil OM was a key factor, which correlated positively with Se, Zn and Fe uptake. This study had been designed a biofortification strategy for lentil staring a baseline survey in farmers' fields in Bangladesh for further field experiments to unravel genotypic and environmental effects on seed Zn, Fe and Se concentration and to evaluate them through agronomic options as well.


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Theme 6

Social, economic and policy issues – increasing adoption and impacts assessment

PP157: Food legume value-chain study in Morocco: Supply analyses

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This study is part of IMFLI program conducted by INRA and ICARDA in five selected sites or platforms. It will contribute to set a basic situation of the cropping system and the main environment, social and economic benefits that can be used in assessing the impact of the selected technological alternatives. The study was conducted in IMFLI selected platforms used by the biophysics team. The objectives of the activity are; (i) Analyze food legume monograph by region in order to estimate growth rates of production area and grain yield, (ii) describe production system and the importance of food legumes at the farm level, (iii) Establish food legume enterprise budgets in order to estimate production cost and income, and (iv) identify farmers' perceptions of the main constraints for the development/rehabilitation of food legumes. According to the survey, food legumes play an important role in the areas of Zemmour-Zaier, Meknes-Taounate, Chaouia, Abda-Hmar and Tadla-Azilal with respective proportions of 31, 30 and 25, 20 and 13% of cropped land. This proportion is far from the reasonable rotation that was used by farmers. Lentil occupies 46% of total food legume area in Zemmour-Zaier region. In Meknes-Taounate region faba bean is the most grown crop and occupy 58% of total food legume area. Chickpea is occupying 56% of total food legume area in Chaouia and Abda. In Tadla we found that lentil and pea are grown over 37 and 34% of total food legume area, respectively. Production technologies have not changed significantly in Abda-Hmar and Tadla-Azilal according to what was practiced by farmers since 80's. The most applied crop rotation is wheat after food legume and it's used, in average (all regions) by nearly 45% of farmers. Other rotations are used such as cereals/fallow (20% of farmers) and continuous cereals particularly by small farmers in Chaouia and Meknes. For all crops planting and harvesting operations are representing over 60% of total costs. Exceptionally for Zemmour-Zaier region crop maintenance cost is high because farmers are using chemical control of weeds and insects. In general the use of inputs is very limited in all regions. The use of fertilizers is very limited. However it is important to notice that food legumes are labor intensive, especially for lentil and chickpea. Finally, we notice that cultural practices applied are traditional. This can be considered as a constraint to the improvement or rehabilitation of food legumes in Morocco. Food legumes were considered as share cropped crops and socially contribute to the involvement of landless households who were considered as experts.

PP158: Distribution and importance of chickpea fusarium wilt disease (*Fusarium oxysporum* f sp *ciceris*) in the Sudan

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A survey for Chickpea Fusarium wilt disease was conducted in 2011-2012 cropping season in four States in northern and central Sudan in respect to variety, soil type, sowing date, seeding rate, preceding crops, watering intervals, growth stage and fertilizers application. The small Kabuli Baladi variety predominated in more than 70% of the surveyed locations and it is the most susceptible variety to the disease with Shendi (ILC 1335) and Jebel Marra (ILC 915) varieties compared with the other improved

varieties. The heavy clay soils of Gezira State supported the highest disease percentage whereas the light clay and sandy clay soils of Gezira north and River Nile States supported the lowest average percentage. Mid November sowing predominated between farmers and about 60% of them grow their crops between the first and mid of November but the early sowings during this period were highly subjected to wilting incidence. The late sowings of the crop on early and late December although they escape the high temperatures of early winter and hence the disease, they affect the crop yield potentials. The seeding rate varied from farmer to farmer in a range of 15-125 kg seeds/ha and the disease is more severe in the higher population densities of the crop. Cereals predominated other preceding crops to chickpea in the rotation and more than 40% disease incidence was recorded in monocropping system. For watering intervals 45% of the farmers irrigated their crops in two weeks interval while the others irrigated in 2 to 3 weeks interval. The longer intervals subjected the crop to higher disease incidence than shorter intervals. Around 54% of the farmers did not apply any kind of fertilizers to chickpea and 45% apply starter dose of Urea and foliar fertilizers. Adding fertilizers to chickpea was not significant in reducing disease incidence. The correlations between these cultural practices and wilt per cent, indicated that only the preceding crop and sowing date significantly affected the disease incidence.

PP159: Economic impact of broomrape (*Orobanche crenata*) on pulse crop production in northeastern Ethiopia

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Broomrape (*Orobanche crenata*) is a parasitic weed that has become a nuisance to pulse crop production in many parts of Ethiopia. Despite the challenges posed by the weed, there has not been any study on its economic impact at farm household level in Ethiopia. With the aim of filling this gap, this study reports the impact of broomrape on farm level productivity and farm income based on 540 randomly selected households in northeastern Ethiopia. We have employed nearest-neighbor matching and propensity score matching methods to estimate the impact of broomrape infestation and dose-response function to assess the impact of degree of infestation. The results show that farm households are being affected significantly by broomrape. We have suggested research and development interventions that might help in abating the economic losses farmers incur due to this parasitic weed at least in northeastern Ethiopia.

PP160: Evaluation of productivity, profitability and farmer's adoption potential of direct seeding of lentils in Zaer region (Morocco)

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Morocco is increasingly confronted with drought effects on crop production as 93% of the country comes under semi-arid climate zone. To mitigate the effects of drought on agricultural production, farmers should combine all available production technologies and practices to produce more food per cubic meter of water. Direct seeding or no till is one of those practices to mitigate impact of drought. Crop yield potential with direct seeding in rainfed systems is often greater than with conventional tillage systems, particularly where sub-optimal rainfall limits yield. No-till lentil holds promise for minimizing soil and crop residue disturbance, controlling soil evaporation, minimizing erosion losses, sequestering carbon and reducing energy needs. These effects reduce overall cost of production while improving yields and returns. The potential of direct seeding technology of grain legumes for small farmers is important. The objectives of this study were to (1) evaluate direct seeding technology on lentil productivity and

profitability in the Zaer region and (2) assess with farmers the ease of implementation and adoption of direct seeding technology of lentils. Two sets of farmer's lentil fields, one under direct seeding and the other under conventional cultivation, were compared for their productivity during the 2015 season. In addition, 80 lentil farmers from Brachwa, Ain-Sbit and Marchouch regions, were surveyed to get their experience with lentil direct seeding and their prospects for its adoption for the coming years. Results from on-farm trials, when compared to the conventional and direct seeding of lentils, and from a survey of 80 lentil fields showed that for this year, direct seeding is not superior to conventional cultivation in either grain yield or profitability. The average yields obtained in direct seeding lentil cultivation vary from 4 to 13.5 q/ha and those from conventional lentil cultivation vary from 4 to 15 q/ha. Lentil production cost are on average about 5300 DH/ha, with no significant difference between conventional and direct seeding systems. Weed control and harvest are the two operations that dominate production cost of lentils, in either conventional or direct seeding system. They respectively represented 30% and 23% of total production cost. Results could be explained by the fact that the majority of farmers surveyed were in their fourth year of adoption of direct seeding system. Many years of practice are needed before direct seeding benefits become noticeable. Furthermore, the weather conditions this year were very favorable, which may explain the lack of difference in performance between the two lentil seeding systems. The benefits of direct seeding appear especially during years of less water.

PP161: *Vicia faba* cultivation as seen by farmers: diversity of practices in two Moroccan regions

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This study aims to highlight the diversity of farmers' cultural practices regarding *Vicia faba L* in major faba bean growing areas in Morocco. For this purpose, a survey was conducted, in Haouz irrigated perimeter and Sais under rainfed conditions, in 41 and 29 farms. The results showed that legumes occupy between 3 and 25% of the total cultivated area in Haouz and around 10% in Sais; whereas faba beans exceeds rarely 20%. Faba bean yields range from 0.7 to 2.2 t/ha. The production of this species is generally for family or animal consumption or sales in local or national markets. The Haouz perimeter was dominated by fresh faba beans as a vegetable crop; whereas in the Sais area dry faba bean grains are more produced in rotation with cereals. Under irrigation, faba beans occupy crop free areas such as a relay crop in young orchards or a catch crop following a drip irrigated melon or water melon to valuate land, water, irrigation equipment and residual nutrients. Faba bean can be associated with other legumes (alfalfa) or perennial crops such as olive or citrus in small plots in the Haouz; while it is usually cultivated in monoculture in larger fields in the Sais. Fertilization includes both nitrogen (N) and phosphorus (P) in 75% of farmer plots, showing a relative ignorance by farmers of N fixation processes. However, most of the farmers consider faba beans as a way to improve soil fertility through a better weed and disease control. Orobanche problem seems now under control through glyphosate treatment (0.18 l/ha). Other agronomic factors should be improved in order to increase faba beans yields and profits.

PP162: Farmers' desired traits, selection criteria for faba bean (*Vicia faba* L.) varieties, perceptions on faba bean diseases and implications

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Faba bean (*Vicia faba* L.) is an important legume crop used as a major source of dietary protein for subsistence farmers and serves as a source of foreign currency in Ethiopia. However, yield has remained

low due to local varieties used, which are susceptible to plant diseases, thereby threatening food security. A study was undertaken to assess the major threats to faba bean production, determine farmers' varietal preferences and selection criteria, and assess farmers' perceptions of faba bean diseases with special reference to chocolate spot (*Botrytis fabae*) disease. Participatory rural appraisal methodologies were implemented on 240 households selected from 12 villages of three administrative zones within two regional states. Major threats to faba bean production were chocolate spot disease, which was a persistent problem in the Ethiopian highlands along with lack of improved seeds. Many farmers (>85%) recognized symptoms of chocolate spot disease but had various names for it. Disease severity was associated with growing susceptible local landrace varieties which resulted in low yields (0.56 to 2.8 t ha^{-1}). About 66.4% of the farmers preferred local landraces for their adaptability to the environment, tolerance to frost, early maturity, good food taste and higher straw yield, while improved varieties grown by 10% of the farmers were preferred for high grain yield and bigger grain size. Farmers were also willing to grow improved varieties if the main production constraints are addressed and seeds are accessible. Therefore, opportunities exist to improve farmers preferred landraces for yield and disease resistance through breeding.

PP163: Impact of improved legume varieties on technical efficiency of crop production in Ethiopia: Application of doubly-robust treatment effects model

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This paper presents the impact of improved food legume varieties on technical efficiency and productivity of crop production in a farming system where mono-cropping of cereals is the norm. Data on 600 randomly selected farm households were collected and plot level input and output data were generated on food crop production. We estimated technical efficiency of food crop production using stochastic frontier models. Then, a set of doubly-robust treatment effects models was employed to see whether there is any difference in technical efficiency level and productivity between adopters and non-adopters of improved faba bean and field pea varieties. The results show that the efficiency of crop production does not vary between adopters and non-adopters of improved faba bean and field pea varieties. However, the adopters were found to be more productive when productivity is defined in terms of cereal or energy equivalent per adult equivalent. Although, we are reporting results based on cross-sectional data, it is clear that pulses increase productivity both in terms of quantity of crop produce or nutrition without any apparent contribution towards technical efficiency. Although the immediate need might be increasing productivity per unit of limiting factor, it is important to pay attention to reducing inefficiency in crop production to ensure that pulse crops break into the unsustainable on-cropping production system in the study area.

PP164: Income and nutrition impacts of rotation and adoption of improved faba bean varieties: A Moroccan case

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By applying a combination of the two-step Heckman model, propensity score matching and endogenous switching regression to a nationally representative sample of 1230 farm households from Morocco, this paper provided empirical evidence on adoption and impacts of faba-bean. The paper also provides

estimates of the livelihoods impacts of cereal-legume rotations. Survey results show that only 3 out of 13 faba bean varieties in farmers' hands are improved varieties covering only 23% of total faba bean area. Farmers reported that only 17% of total faba bean seeds used was certified originating from seed companies while the remaining 83% was uncertified - 63% kept from previous harvest and 20% bought from local seed retailers. Among many other factors, farmers who purchase certified seeds are found to have higher tendency to adopt improved varieties than those who use uncertified seeds. This shows that certified seeds constitute more of improved varieties which are not too old than seeds which are uncertified. Number of years of education, being active or leader in the community and access to credit have positive and significant effect on the decision whether or not to adoption. The adoption of improved faba bean varieties leads to 206.2 kg/ha (16%) increase in yields, US$100/ha (11%) higher net returns and 16 kg/capita/year (28%) increase in faba bean consumption and hence equivalent gains in protein, carbohydrate and starch intakes for every household member of the adopter households . All these results show that the improved varieties of faba-bean are contributing to livelihoods improvement and nutrition security at household level. Moreover, 26% higher yields were obtained by wheat farmers rotating with faba-bean than cereal-cereal and other rotations. Wheat-faba bean rotations also increased wheat net returns by 38%. At the same time the results show that the combined effect of the adoption of improved varieties of faba bean and rotations is an increase in total farm income of 33%. At current adoption level of 23%, improved varieties of faba beans led to additional production of about 15.7 thousand tons per year (14%) – showing a clearly substantial contribution to national food and nutrition security.

PP165: Technology validation and value chain interventions for commercial promotion of lentil in rice fallows in Terai of Nepal

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Lentil accounts for 63 per cent of the area and 64 per cent of the production of legumes in Nepal contributing to the livelihoods of more than 600,000 smallholder households (MAOD, 2014). Although 10 lentil varieties with associated production technologies have been recommended from the national system, the adoption has not been encouraging due to poor access to seeds of improved varieties among farmers and lack of marketing interventions. To address the issue, the Forum for Rural Welfare and Agricultural Reform for Development (FORWARD Nepal) initiated on-farm validation and dissemination of lentil varieties and production technologies generated by Nepal Agricultural Research Council (NARC) along with promotion of community-based seed production (CBSPs) systems since 2008. Collaboration with ICARDA has played significant roles in the development of lentil varieties by Nepal Agricultural Research Council (NARC), whereas HarvestPlus, and OFID projects led by ICARDA has contributed for the up-scaling of those varieties and associated technologies in the country. NGO FORWARD has intervened in the wider dissemination of those varieties and technologies through distribution of informal research and development (IRDs) kits of lentil varieties among 32,795 farmers in 16 Terai districts, facilitation for group level production of 183 mt of lentil seed, demonstration of technology package among 1,842 households and market facilitation. Technology package consisted of improved varieties, rhizobium inoculation, seed priming and basal application of fertilizer DAP. Linkages among lentil value-chain actors were strengthened, and supports provided for upgrading the processing and storage facilities of producer groups. The analysis of data from 1442 households from 11 districts showed an increase in average yield of lentil by 18 per cent, sale of marketable surplus of lentil from beneficiary households by 29 per cent and household income by 115 per cent over the base year. We concluded that in addition to delivery of technology packages to farmers, improvements in lentil value chain and marketing play crucial roles in enhancing farm level profitability.

PP166: Socio-economic impacts of introducing short duration lentil and mungbean into rice-based cropping system

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Pulses fit well in the existing cropping systems of Bangladesh because of its short duration, low input & minimum care requirements, and drought tolerant nature. Thus, BARI scientists with the support of ACIAR disseminated some improved pulses technologies and provided necessary inputs among farmers during 2011-2015 for improving their food and nutritional status. The study evaluated the performance of improved technologies at farm level for providing feedback and output of the project. The study analyzed data and information that were randomly collected from 480 lentil (Masur) and mung bean farmers spread over eight project districts. Half of the farmers cultivated lentil and mung bean under direct supervision of the project and the rest farmers were treated as control. Sampled farmers comprised of lentil and mung bean growers on an equal share basis. Most of the trained lentil (78%) and mung bean (90%) farmers used leaflet which was provided to them during training. Due to the efforts of ACIAR project, 64-83% farmers adopted BARI masur-6 variety and 64-70% farmers adopted BARI mung-6 due to their high yielding performance and disease resistance. Demo farmers collected improved seed from government/project source, whereas non-demo farmers mostly purchased seed from market and neighbors. 52-79% demo and 41-74% non-demo farmers had sown lentil and mung bean seeds at optimum sowing time (within 15 November). Line sowing was followed by 53% demo and 25% non-demo mung bean farmers, which was 25% in the baseline survey. About 51% demo lentil and 60% demo mung bean farmers treated their seed before sowing. All sampled farmers irrigated their crops once a season. Around 64% lentil demo and 45% mung bean demo farmers were interested to increase pulses cultivation in the next year due to various benefits. Around 54% non-demo lentil and mung bean farmers also wanted to expand pulse cultivation due to lower cultivation cost, higher profit, increase soil fertility, required less time and irrigation. They will replace wheat, maize, tobacco and Boro paddy with pulse crops. They demanded biotic and abiotic stress tolerant varieties, small seed with high yielding mung bean variety, quality fertilizers, pure pesticides, hand-on training on production practices, fair price of produces, institutional credit facilities, and mechanized harvester for picking mung bean pods with low cost and time. The technology dissemination programme created many socioeconomic impacts in the study areas. A substantial increase was recorded in the area expansion, productivities, and pulse consumption. Improved seeds are now available at farm level and most farmers become enthusiastic towards lentil and mung bean cultivation due to less cultivation cost and higher financial benefit. Farmers could save cultivation cost for the next crop through using less fertilizer. The adoption of improved mung bean has created employment opportunities for women, children and unemployed youth. ACIAR project had also a strong demonstration effect on non-demo farmers in adopting different improved pulse techniques. The study recommends that the existing short-duration pulses technologies dissemination program should be extended to other new and promising areas for fostering pulses cultivation and improving farmers' income in Bangladesh.

PP167: Plausible futures of pulses in different socio-economic and climate change scenarios and its implication on food security

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Pulses play an important role in the diets and in sustaining farming systems of the poor people around the world and for achieving food and nutritional security in the developing countries. Over the years the agriculture research and development policies favored cereal crops to increase their production and

enabling many countries like India to become self-sufficient in cereal production. However, in this process pulses were, by and large, ignored and grown in marginal rainfed lands resulting in stagnant and low yields and increased dependence on imports to meet growing domestic demand. The sluggish growth in pulses production in Asia and Sub-Saharan Africa, increasing population and rising per capita incomes are fueling growth in demand and their prices are increasing and per capita consumption has been declining. The changing climate and socio-economic conditions like increase in population, income and change in diet creating uncertainty about pulses availability and access in the future. A long-term outlook is essential for formulating appropriate policy and investment strategies for increasing pulses production in order to ensure future food and nutritional security in Asia and Africa where pulses are main and cheap source of protein. After a brief discussion of trends in in area, production and productivity of important pulse crops like beans, chickpea, cowpea, lentils and pigeonpea, this paper presents projections by the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) on pulses production, trade, demand, prices, and food security up to 2025 and 2050. The simulations results are used to compare the baseline scenario without climate change with two Shared Socioeconomic Pathways (SSPs) (one with high population and less income growth and other with low population and high income growth) and with two climate change scenarios. The results highlighted that production of pulses in developing world was not been able to meet demand due to the secondary treatment of pulses in Asian countries and low input agriculture system in Africa. The growth in pulses production in future is low compared to cereals and oilseeds because of low yield growth and less expansion of area under these crops. With current technologies and support policies for pulses, the supply-demand gap will increase in the future with climate change and the price of these crops will also increase which could have serious consequence on food and nutritional security in the developing countries. To meet the increasing demand of pulses for both food and feed, there is need to improve the average yield to bridge the yield gaps and profitability of the pulse crops by developing short duration, drought resistant, high yield varieties and ensuring competitive prices to increase the adoption of new technologies by farmers in the regions.

PP168: Participatory approaches to maximize pollination successes in cross-pollinated pulses

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Pollinators play a key role for sustainable agricultural production, biodiversity and ecosystems conservation. The global decline in pollinators diversity can endanger the production of faba bean, grass pea and other cross-pollinated pulses significantly, as they benefit from wild pollinators. Breeding pollinator-independent pulses might accelerate pollinators decline and will result in cultivars lacking heterosis-mediated resilience and high yield. We present the governance approach “Farming with Alternative Pollinators (FAP)” and the breeding approach “Crop Design System (CDS)”, both enhancing cross-pollination and thus creating a win-win situation for pollinators protection, farmers’ incomes and food security. FAP is a stepwise participatory approach focusing on the highest income gain by habitat enhancement in fields and in pollinator corridors using diverse marketable plants, nesting support etc. The higher income is an incentive to gain farmers’ cooperation. FAP can enhance the productivity of faba bean or grass pea as main crop, but faba bean, string bean, sainfoin and other legumes can likewise play a role in the habitat zone attracting a high diversity of efficient pollinators, predators and parasitoids also to the main crop. Crop Design System adjusts that cultivars are generally bred by selecting primarily according to commercial interest, but not with regard to their potential to attract pollinators and trigger cross-pollination. Crop Design System employs participatory breeding to develop cultivars with enhanced yield and resilience, as result of the provision of floral resources-discovery, attraction and reward traits- within the crop, for supporting insect pollinator populations to be used as agents of crossings, to increase heterozygosity and heterogeneity.

PP169: Occurrence of major seed-borne fungi associated to chickpea seeds in post-harvest in some regions in Morocco

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The health of chickpea seed greatly impacts crop stand, disease development and yield. High infections of seeds by pathogenic and saprophytic fungi may adversely affect quality, vigor, and longevity of seeds. These organisms are carried internally or externally on seed which may become a major inoculum source for disease development a survey was conducted on chickpea seeds from Chaouia and Doukkala-Abda regions to assess seed- borne fungi associated with chickpea seeds. A total of 59 seeds samples of winter and spring chickpea varieties were collected in 2013-14 cropping season from different areas. The detection of fungi was conducted using a method recommended by International Seed Testing Association in agar plat test. Six fungi species namely, *Ascochyta rabiei*, *Fusarium* spp., *Penicilium* sp., *Rhizopus* sp., *Phoma* sp. and *Botrytis cinerea* were isolated. *Ascochyta rabiei* and *Rhizopus sp.*, were more common on spring planted chickpea (45.5 and 42.4% respectively) than winter planted chickpea (19.2 and 11.5%). Seed infection rate with the pathogen *A. rabiei* in spring varieties exceeded 3% that can be considered a high risk of seed to seedling transmission and leads to epidemics. Therefore fungicide seed treatment and use of healthy seeds are recommended in producing chickpea production in Morocco.

PP170: Estimates of quantitative and qualitative losses due to Bruchids damage in stored food legumes in Morocco

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Bruchids are considered the most destructive insect pest of food legumes during storage in Morocco and worldwide. The knowledge of the nature and extend of post-harvest losses is much more extensive for cereal grains than for legumes. The objective of this study, which was carried within the "India-Morocco food legume initiative" is to identify the different species of insect pests attacking food legumes in Morocco, evaluate their qualitative and quantitative damage and associated losses after summer storage. The results obtained highlighted the dominance of the Bruchidae family; especially for faba bean. More than 50% of the beans carried bruchid attacks. Quantitative losses and correlations between the number of bruchids emerging holes and the germination capacity were also studied.

PP171: Adaptation to climate change in the dry areas: Case study of Jeffara Tunisia using integrated analysis modelling

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Climate change is at the major environmental concerns to agriculture and environment worldwide. Initially the concern was focused on the impact more than adaptation. According to the fourth report of the Intergovernmental Expert Group on Climate Change (IPCC), it will be better to stress the importance of adaptation in all regions of the world, especially the Mediterranean region. Tunisia is one of the most

affected countries by this phenomenon. It has deployed many efforts to apply strategies and policies for adaptation to climate change particularly in the agricultural sector. Despite these efforts, the situation is still far from meeting the objectives particularly in arid southeastern Tunisia (plain of Jeffara). In this region, agriculture is the main economic activity, however affected by land degradation and climate change. The question is not to know whether the agricultural should adapt to different climatic conditions in Jeffara but how to do it? From the literature, two main approaches have been used in the field of climate change in agricultural economics: ricardian and bio-economic approaches. These two approaches are applied at farm and regional levels in Jeffara Plain. Econometrics ricardian approach has identified some appropriate adaptation options such as irrigation, the family labor, farming and agricultural vulgarization. These options allowed us to develop adaptation strategies that have been the subject of an ex-ante evaluation across three scenarios by applying bio-economic modeling from the farm to the regional level. The results of the bio-economic approach showed that the economic and environmental impacts of climate change can affect rainfed agriculture and especially for large farms. They noted the importance of livestock activity in the context of climate change adaptation and also local know in agriculture and irrigation technology. The high cost of adaptation will prevent large farms to achieve economic growth. The adoption of incentive policies based on pricing and cost of irrigation water and the subsidy will improve the economic and environmental conditions for rainfed agriculture in general and irrigated agriculture in particular, showing that high adaptability and strong sustainability are in favor of these types of agriculture as future prospects for regional agriculture in Jeffara plain.

PP172: Agricultural policy and pulses sector in Morocco

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In Morocco, legumes exist since long in the farming systems and eating habits. However, the recent investigations show no progress in legumes secotr. This research was performed under the India-Morocco Food Legumes Initiative project to carry out an in-depth analysis of the legumes sector around three basic parts. The first part aimed at analyzing past and current agricultural policies and their impact. The second part focused on the analysis of the main determinants of supply and demand. The last part was to identify guidelines for a recovery of the sector. The methodology adopted was based on the analysis of secondary data and interviews with the stakeholders along the value-chain. The review of agricultural policies revealed not only a virtual absence of strategies and policies specific to the sector, but also distortions and perverse effects of support and incentive measures for other competing crops. Moreover, market incentives and cereal price policy create a huge competition on land even in rotation pushing legumes to decrease drastically. The sector marked by the lack of professional and inter-professional organizations of the actors and the weakness of downstream subsector. On the supply-side, the results showed that the production modes remained traditional and not mechanized resulting in a deterioration of the profitability of legumes production. Agro-industry is still at the embryonic stage explaining the weak valorization and diversification of uses and a lack of diversification of derivatives. On the demand side, all the trends point out that the evolution of the annual consumption of dried legumes was rather modest, weakly diversified, and very seasonal and dependent on residence localization and income level as well as on regions. On the basis of the observed results as well as the guidelines of the Green Morocco Plan, three axes of interdependent interventions have been identified for the recovery of this sector. The first axis is related to the governance of the sector through the creation of the professional and inter professional organizations of the sector and the recognition of its specificity through a program-contract to make more visibility for the stakeholders. The second axis, aims to increase sustainably the profitability of the crops in favorable areas by promoting contract farming projects (aggregation) and by exploring alternative of valorization and differentiation of the products and their derivatives. The last axis is to inform and educate consumers on the benefits of legumes in nutrition and human health.

PP173: Analysis of social and organizational aspects of food legumes chain

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The present work was performed as part of the IMILA initiative funded by OCPF, with an objective to develop south-south cooperation in food legumes between Morocco and India. It is part of a series of studies including biophysical, economic and organizational aspects, conducted in ten representative rural municipalities of the five innovation platforms identified by the project. While the overall objectiveof this study was to improve the production of food legumes and household incomes, the specific objectives were to analyse the roles and tasks according to gender in the production system, identify forms of collective and individual organization to manage production systems, identify the OPA to drive the actions of the initiative and contribute to the rehabilitation of food legumes. The approach is based on a methodology based on the combination of an analysis of the existing documentation and participatory research through workshops and discussions with farmers and agricultural organizations present in the study area represented by five sites drivers. Despite their importance, the authorities have not paid much interest in the development of these crops. They were considered second-rated crops and their interest is limited to their role as preceding crop. Their rehabilitation is possible through social organization that can play a crucial role. Small producers account for a majority of farmers and contribute strategically to food security, but their contribution is still limited by: (i) lack of access to capital for investment, (ii) the uncertainty of the markets and (iii) the lack of institutions and organizations, including collective actions for return on investment. Besides that pulse crops suffer from labor availability problems, mechanization and declining social forms of production (type of land tenure). Certainly these elements associated to diseases and pests and climate change have contributed to the regression of acreage and to lower yields. In addition to technological alternatives, political and organizational interventions are crucially needed. The study showed that the diversity and magnitude of the tasks of women in the conduct of food legumes in different production systems through the study areas leaves no doubt about the vital role they play. Therefore, any proposed intervention to improve the sector must take into account the ramifications of these interventions on women. The improvement of production should not be based on increasing women's work. Indeed, we must not forget that women's contributions are routinely accompanied by a series of domestic and social activities that only women are responsible for. Women need recognition of their role, value their contributions and support in strengthening their capacity and their participation in actions, decisions, and possible development opportunities in their community. The typology of professional organizations present in the project sites revealed that they are quite numerous and fall under various statutes and regulations. They can be grouped into different types depending on the level of their intervention and according to the role they play in the organization of agricultural professional life. Examination of inventoried professional organizations highlighted the following types: Organizations formed around a common interest (WUAs); Professional organizations by sector (beekeeping, milk, meat); Professional development organizations. Participatory diagnosis made during the workshops attended by all stakeholders (CCA officers, presidents and members of cooperatives and associations) showed the existence of a large and diverse fabric of professional organizations. Based on these considerations, a food legumes development strategy is essential and should take into consideration:

- The importance of involving all stakeholders and strengthen the platforms as a space of exchange, learning and negotiation to allow the installation of trust and collaboration between stakeholders.
- The OPA has an important role to play in ensuring effective supervision of farmers.
- Cooperatives can play an important role in regulating prices.
- Agricultural Organizations in agreement with public authorities should work towards certification of local products and creating specific labels.
- The government must encourage the development of storage systems to limit the fall in agricultural prices during the years of high production

Theme 7

Country successes, lessons learnt and challenges (knowledge sharing event)

PP174: Agroforestry systems in Morocco, grain legumes and olive trees in Saïs region: Moulay Driss Zerhoun case study

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Agroforestry systems based on grain legumes such as faba bean, chickpea and lentil are expected to benefit the production of olive while improving the soil fertility, because legumes have the ability to fix atmospheric nitrogen (N) symbiotically. In Morocco, intercropping of legumes and olive trees has a long tradition in oasis and mountains areas, where land resources, soil fertility and water are scarce; but this system has received a little research attention aiming at the assessment and improvement of its performance in the context of climate change, more drought and land degradation. The main objectives of this work were: i) to determine the importance of agroforestry systems in Saïs region, Morocco, ii) to identify the main reasons and farmers motivations underlying these association types, iii) to catch local knowledge and iv) finally to better understand the role of legumes in the system. In the first step, socio-economic and technical data were collected from 45 households-farms randomly chosen in Moulay Driss Zerhoun area. The information collected was used to analyze determinants of intercropping legume use intensity. Since the species grown between olive trees are mainly legumes and forages, the surveyed farmers believe that these crops do not affect the olive trees production because they do not compete too much with a tree for water and nutrients, because legumes provide nitrogen to the olive trees. The survey showed also that farming techniques of intercropping legumes with trees are not well mastered by farmers. In fact, the farmers do not take into account the whole system (crop and trees) when managing their fields, especially when they supply fertilizers. In our sample, organic fertilization is the most practiced in the area, 76% of the farmers apply different amounts of organic manure which ranged from 25 to 40 Kg/tree; on intercropping plots and the rest 24 % of farmers bring mineral fertilizers for legumes and olive trees. Grain yield is not interesting compared to the potential of the area; in intercropping grain yield of faba-bean is 0.5 ton/ha while in monoculture it can reach 1.5 ton/ha, chickpea 0.3 ton/ha and lentil 0.5 ton/ha. Studies demonstrated also that, mixed crops are generally more productive and ensure higher economic net return than monoculture. However the selection of appropriate legume species and the development of targeted and innovative agronomic practices are important to improve more the system efficiency and maximize the ecosystem services.

PP175: Determinants of farmers' decision on utilizing cereal and legume residue as feed and soil mulch in the Ethiopian highlands

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Crop residues (CR) are dual purpose resources in mixed crop-livestock systems of the Ethiopian highlands. They serve as animal feed, income sources and inputs for soil and water conservation. However, multiple uses are two competing functions. Characterization of the determinants of use

intensity of cereal crop residue (CCR) and legume crop residue (LCR) help in designing strategies for more efficient utilization. Data on CR utilization were collected from 160 households in two highland regions in Ethiopia using a structured questionnaire and were analyzed using multivariate Tobit model. The results showed that farmers prefer using LCR to CCR for feed. The proportion of LCR used as feed was increased by education level of the farmer, livestock extension service, density of small ruminants and CR production from the previous season. Distance of farm plots from residences of the farm households decreased the use of CCR and LCR as feed. The use of LCR as feed increased when women participated in decision making on CR utilization. The proportion of LCR and CCR used for mulch was positively affected by the education of the farmer, the distance between the homestead and the cultivated land, extension service, awareness about mulch, the slope of cultivated land, farmer-to-farmer extension and CR produced in the preceding season. Better utilization of CR could be achieved by maximizing the use of LCR as feed and optimizing the use of CCR as mulch. Increasing the awareness among farmers about the use of CCR as mulch and the superiority of the LCR over CCR as feed could optimize the utilization of CR in the household. That could be achieved by conducting on-farm trials which show the difference in feeding value between CCR and LCR, livestock and crop extension provision, and encouraging informal social networks. More livestock extension on the feeding value of LCR should be provided to the farmers who cultivate sloppy plots. Encouraging the culture of labor exchange among the farmers could result in increased labor availability on the farms. This would facilitate the transport and storage of LCR and increase its use as feed.

PP176: Food legume crop in Algeria, situation and prospect: A case of lentil

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Food legumes play an important and diverse role in the farming systems and in the diets of poor people around the world. In Algeria, among pulses, lentil (*Lens culinaris* Medik.) is one of the most important grain legume consumed by the population. It is grown mainly in semi-arid environment (Tiaret, Sidi Belabbas and Setif governorates) under rainfed conditions. The production of lentil crops lags far behind faba bean and chickpea, with an average cultivated area of 6458 ha. The increasing world interest in pulse has stimulated the need to document what is known about lentil in Algeria. This paper provides a review of current state of lentil production in Algeria.

PP177: Innovation platforms: A novel tool for improving food legume productivity and farmer's livelihood, and enhancing food security in Morocco

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Food legumes (Faba bean, lentils, chickpea and pea) are important crops that come in rotation with cereals in the rainfed regions of Morocco where the cereal/food legume cropping system predominates. While these crops were very abundant in the seventies when Morocco was an exporter of these commodities, presently, the productivity is very low, and the country is obliged to supplement the deficit in its needs via increasing imports. The main focus of the present study, which is conducted within the India-Morocco Food Legume Initiative, was to initiate innovation platforms (PI's) for the different food legume species. The objective of these PI's is to bring together efforts and contributions of all stakeholders (farmers, decision makers, input companies, dealers etc.) in order to diagnose and resolve

the pit falls and bottlenecks and boost these crops productivity and rehabilitation. In the Chaouia region, the Innovation Platforms were created in 2 different communities (El Gara and Ouled Bouziri) where food legume producer associations were appointed as key players of the PI's. Farmers' fields were selected to establish trials of the PI, were the different new crop management technologies that are practical, environmentally sustainable and economically and socially appropriate, were demonstrated to farmers in collaboration with the various regional development agencies. More than 30 trials were established over the last 2 years, and hundreds of farmers were able to participate in the different events held around these trials. The results showed that the PI's are an excellent tool to disseminate integrated crop management options of chickpea, such as IPM and cultural practices. Indeed, the major pests were controlled (weeds, chickpea leaf minor, and Ascochyta blight) using appropriate methods, in addition to good crop management practices such as fertilization as a starter and use of seed drill. These options helped to clearly reduce crop losses and productivity gap due to damage inflicted by noxious insect pests, weeds and diseases. A very net increase in yield, up to 4 folds, was obtained as compared with farmers' practices and spring sown chickpea. This yield gain will boost farmers' income and improve their livelihoods, in addition to improving the national production of chickpea. Involvement of all actors of the chickpea value-chain will result in functional innovation platform that will enhance the food security.

PP178: Pulse Panchayats - Innovative approach in promoting South – South collaboration, closing the supply and demand gap of pulses

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Pulses are produced on 12-15% of the global arable land and their contribution to total human dietary protein requirement is about 30%. Africa and Asia together contribute 49 MT (67%). In India, pulses are grown in marginal lands in 22-23 million hectares with an annual production of 13-18 Mt. 3 -5 Mt of pulses is imported annually to meet the domestic demand. To achieve self-sufficiency in pulses, domestic demand for 2030 is projected to be 32 Mt. Hence the productivity needs to be doubled and an additional area of about 3 Mha to be brought under pulses besides reducing pest related and post-harvest losses. OCP Foundation, Morocco has initiated a programme through South – South Collaboration an India Morocco Food legume Initiative (IMFLI) involving partners in India and Morocco. This paper explains the research work done at M.S. Swaminathan Research Foundation in promoting the concept of "Pulse Panchayats" in two Semi- Arid States, (Tamilnadu and Odisha). Vulnerability assessment of the project villages has enabled understanding of coping mechanisms by farmers to climate variability. Climate resilient improved varieties of black gram, green gram, red gram and moth bean to abiotic and biotic stresses were identified from over 100 trials. Promotion of pulses in rice fallow has brought an additional area (40%) under pulses production. Farmers were capacitated in Integrated Crop Management practices with adoption of new improved varieties and packages of practices based on climate variability. This has enhanced productivity by more than 30% compared to traditional variety with additional incomes. The adaptive capacity of improved varieties and new farm management practices has increased to 70%. Knowledge management through Farmers Field Schools and Farmers Field Days using ICT tools were integrated through Village Knowledge Centers. Support services of Custom Hire of farm equipment's in the right time with affordable rental charges has enabled small farm holders to benefit economically. A Pulse Seed Value Chain System was established through Farmer Producer Organizations. The Seed Replacement Rate has increased to more than 40%. Pilot testing of innovative seed/grain storage methods were demonstrated for storing seeds for next season without any significant loss of seed quality due to storage pest and germination. Access to nominal credit and timely farm inputs through Community Based Organizations like Farmer Producer Companies has enabled small farm holders to market their produce on a profitable basis without interference of the commission agencies. The "Pulse Panchayat" movement

has demonstrated through multi-stakeholder platforms and policy making networks is key to effective adoption and up scaling, if paired with knowledge management enhancement and innovative approaches to support decision making of farmers who are facing challenges of price volatility and climate change. This is envisaged to bridge the production gap and have significant importance in Grain Legume research and development especially in countries with low income and high rates of undernourishment.

PP179: Chickpea yield losses due to Leaf miner (*Liriomyza cicerina. R*) in Morocco

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Chickpea leaf miner *(Liriomyza cicerina R*) is one of the main insect pests damaging chickpea (*Cicer arietinum L.)* in the Mediterranean region. The surveys carried out in 2014 and 2015 in the regions of Abda- Doukala, Chaouia- Ourdigua, Zemour- Zair and Fes- Sais have confirmed that leaf miner was the most important pest of chickpea in Morocco. We assessed yield losses caused by the chickpea leaf miner on four local varieties using a split plot design with planting dates as the whole plot and treatment as sub-plots at two stations, Marchouch and Douyet. The grain yield losses caused by this pest were on average 20% for winter planting and 42% for spring-sown crop. In addition, the percentage infestation by the Leaf miner was about 25%, 43% and 3% for untreated winter planting, untreated spring planting and the treated plots, respectively. The chickpea Leaf miner could be effectively managed using several integrated pest management options such as winter planting and the use of insect resistant varieties.

PP180: Knowledge promotion on pigeonpea: Leveraging sustainability of farm family incomes

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The study examined the awareness and knowledge of farmers on pigeonpea in selected municipalities in the province of Camarines Sur, Philippines to serve as basis for its promotion. With the use of structured questionnaire and interview, a total of 387 farmers from 5 districts were taken as respondents. Frequency counts and percentages were used to describe the profile of farmers, their knowledge and awareness on pigeonpea.Chi-square test was used to determine the association of gender, age, district/location and type of ecosystem on the farmers' knowledge on pigeonpea. Findings showed that 91% of the respondents were aware of pigeonpea. Statistical analysis showed that there is a degree of association with knowledge on age but no association exists on knowledge with other factors such as gender, district/location and type of ecosystem. Farmers' highest information needs were on breakthroughs and the preferred media for information dissemination is through assembly/fora and print media. Promotional activities had been conducted in various municipalities through the conduct of seminars and trainings, seed distribution, product development and cooking demonstration for rural women and entrepreneurs, information dissemination through mass media and IEC materials development. Recommendations include continued promotion and information dissemination to increase the knowledge of farmers on other aspects of pigeonpea, provision of financial assistance as seed money to start a small scale business for product development, active involvement of researchers and extension workers with farmers to address their location-specific needs on pigeonpea farming, production of additional materials preferably in the local dialect and participatory approach in planning research and extension programs that will ensure continuous dissemination of research outputs from the academic community to the farm level.

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