June 28, 2010

Dr. Mahmoud Solh
Director General
International Center for Agricultural Research in the Dry Areas
P.O. Box 5466
Aleppo, Syria

RE: Center Commissioned External Review of Food Legume Research at ICARDA

Dear Dr. Solh:

The review of food legume research within Biodiversity and Integrated Gene Management (BIGM) at ICARDA has been completed and a pdf of the report is sent by email.

It was indeed a great pleasure for me to participate in the review and to hear first hand of the research on food legumes being conducted at ICARDA. I was impressed with the progress made in the recent past and to observe the significant outcomes and impacts. The review panel has made 18 recommendations that we feel are needed to make ICARDA a center of excellence in food legume research. Many of the recommendations will require increased investment and some will require some will require some refocusing of the program. Overall, the panel felt that the food legume program within BIGM is performing well and prospects for the future are excellent.

On behalf of the review panel and resource persons, I would like to thank you again for all the hospitality and generosity shown by ICARDA management and staff.

Sincerely,

CC. Dr. Maarten van Ginkel, DDG-R

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Center Commissioned External Review of Food Legume Research within Biodiversity and Integrated Gene Management (BIGM) Program at ICARDA

13 May to 3 June 2010

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13 May to 3 June 2010

Executive Summary

ICARDA's Board of Trustees constituted a Center Commissioned External Review Team comprised of Dr. Fred Muehlbauer as chair, and Dr. Xuxiao Zong and Dr. Masood Ali as panel members, Dr. Pramod Kumar Joshi and Dr. Bassam Snobar served as resource persons to review its food legume research program. The review was carried out from 13 May to 3 June 2010 at ICARDA, Aleppo, Syria. The three week timeframe for the CCER was appreciated by the panel as it provided sufficient time for on-site visits to research institutes in Syria and to farmers. The three week timeframe also allowed panelists to make on-site visits to NARS (Morocco and Turkey) which were highly informative. The panel members represented expertise in the areas of genetics, plant breeding, genetic resources, biotechnology, agronomy and integrated pest management. Dr. Snobar provided expertise in agricultural mechanization while Dr. Joshi provided insight into socio-economic issues. The timing of participation of the resource persons during panel deliberations was somewhat arbitrary; nevertheless their contributions to the discussions were invaluable. In constituting future CCER panels, the timeframe for participation by resource persons should be given careful consideration.

The approach for the review was multi-pronged. The panel interacted with the management, the BIGM program director, group leaders and scientists. Panel members also made field visits and had discussions with stakeholders, including farmers and government officials. The panel members reviewed available documents, reports and publications provided by management and scientists.

Food legumes play an important role in providing an inexpensive source of highly nutritious food for humans and feed for animals. These legumes fit very well in farming systems in dry areas and especially those of resource poor farmers and promote sustainable productivity in harsh and fragile ecosystems. The demand for food legumes is rising, but constrained supply is leading to higher prices and making them unaffordable to low income consumers. The future drivers of increasing demand are expected to be changing food consumption patterns, rising incomes in developing countries and growing trade opportunities. The supply side problems are increasing production constraints, changing domestic policies, rising wages, and climate change. To augment incomes of farmers in dry areas and alleviate poverty, ICARDA's food legume program has been reoriented. Its program is realistic and forward looking, and addresses the needs of the poor by developing international public goods.

In regard to food legumes, ICARDA's BIGM program is conducted on genetic resources, chickpea, lentil, faba bean and grasspea breeding, Integrated Pest Management (IPM), and biotechnology. The chickpea breeding section focuses on developing improved chickpea germplasm with ascochyta blight resistance, cold tolerance, medium to large seed size and suitable for winter planting. The section is also producing drought tolerant and fusarium wilt resistant germplasm suitable for traditional spring planting. The lentil breeding section is focused on increasing yields, resistance to fusarium wilt, rust and stemphylium blight. The section is also addressing the need for varieties with tall and upright plant habit and good standing ability for mechanical harvesting. The faba bean breeding section is concentrating

on developing varieties with resistance to biotic (Orobanche, rust, chocolate spot, ascochyta blight, aphids, bruchids, and viruses) and abiotic (drought, heat and cold) stresses for CWANA, China, Nile Valley and sub-Saharan Africa. The section also aims to develop varieties with low concentrations of tannins, vicine and convicine. In the grasspea breeding section, the goal is to develop improved genetic stocks with high seed yield, low β-ODAP and high biomass through conventional and biotechnological approaches.

The biotechnology section is concentrating on identifying molecular markers closely linked to traits of interest such as resistance to ascochyta blight and fusarium wilt in chickpea; stemphylium blight, fusarium wilt and rust resistance in lentil; and chocolate spot and ascochyta blight resistance in faba bean. The approach is to develop robust molecular markers for mapping genomes of these crops and to provide closely linked markers to the genes of interest to the respective breeding programs. IPM sections in virology, pathology and entomology are engaged in screening for resistance in the germplasm and breeding materials. Development of transgenics against drought and other traits is a research priority. The genetic resources section is conserving and evaluating the genetic material *in situ* and/or *ex situ*. The biotechnology, IPM and genetic resources sections are expected to develop genetic information, management options for disease and insect control and provide germplasm and other information to the breeding sections to accelerate development of improved varieties.

ICARDA's scientific contribution in food legumes is quite significant. The research efforts have yielded significant outputs. In Genetic Resources, 4617 new accessions were added to the gene bank, and approximately 36,900 accessions were evaluated and characterized over the past five years. A large number of international screening nurseries were developed by the commodity sections. The Integrated Pest Management section has identified a new pathogen (*Clonostachys rhizophaga)* affecting chickpea, and a number of resistant and tolerant lines in chickpea, lentil and faba bean were identified.

The program developed and released numerous varieties in collaboration with NARS partners during 2005-10. Included in the released varieties were 25 chickpeas, 21 lentils, 10 faba beans, and one grasspea. ICARDA scientists, technical staff and students also published a substantial number of journal articles in reputed and highly rated peer reviewed journals and prepared a large number of documents for its stakeholders.

The impact studies have shown that the winter/early spring planting technology developed by ICARDA for improving chickpea productivity was adopted on over 600,000 hectares, providing farmers with additional income of US$ 72 million per year. In Bangladesh, improved lentil varieties added an estimated US$ 30 million per year to farmers' income. The improved technology of faba bean has helped to alleviate poverty in rural Ethiopia, Egypt and Sudan. Similarly, improved varieties of lentil and chickpea have contributed in increasing its area and production in Ethiopia. Additional studies with NARS partners are needed to assess and document the impact of improved varieties and new technologies. Constraint assessment to identify factors inhibiting spread of promising varieties and technologies are also needed. In this context, the seed sector needs to be understood for evolving effective linkages between research systems, seed sector and the farmers.

ICARDA has developed a very strong program in human resource development in its mandated areas. The Center has accorded due importance to the human resource development by offering various kinds of programs. The Center is engaged in facilitating non-degree as

well as degree programs in priority areas. These programs are improving the capacity of the national partners in frontier research areas, and strengthening the national agricultural research systems of the developing countries. ICARDA should undertake need assessment for capacity building under theme-based programs to meet the expectations of NARS. Degree programs in high priority areas should be further strengthened and made more attractive to students.

ICARDA has developed a good network of partnership with NARS, CGIAR Centers and advanced research institutes. Through this partnership ICARDA facilitates exchange of knowledge for enhancing NARS research capacity and dissemination of improved technologies to improve income and livelihood of farmers in dry areas. A holistic approach adopted by ICARDA in addressing the problems of its target dry areas has been and continues to be highly rewarding. For effective regional cooperation and partnership, a 'hub-and-spoke' policy should be adopted.

The panel recognizes the increased expectations of the Center by NARS for genetic resources and crop management technology. Accordingly, ICARDA has expanded its commitment and workload without a commensurate increase in scientific and technical staff. In view of the NARS growing requirements for germplasm and crop production packages, additional human scientific and technical associates should be provided. The panel also observed that finances for the Food Legume sections are inadequate both from the standpoint of restricted and unrestricted budgets. To expect the sections to become centers of excellence for genetic improvement of the food legume crops will require additional resources.

Additional resources for the panel recommended increased scientific effort in plant breeding and pre-breeding would enhance output toward solving some of the intractable production constraints. The area of pre-breeding is in need of new approaches that take full advantage of the available wild and exotic germplasm. Use of molecular markers for introgression of new genes from wild sources into a cultivated genetic background will require increased resources and scientific effort. Additional resources are also needed to support the other recommended scientific staff appointments. The expanded reach of the center into dry areas of South Asia and China will require additional travel and support funds for section leaders to form effective collaboration and partnerships. Also, additional resources are needed for organization of scientific workshops throughout the region such as described in recommendation 18. Enhancing the food legume research program and providing leadership to CWANA, South Asia, China and other dry regions of the world will require increased restricted and unrestricted budgets.

Recommendations:

I. *Research Program*

1. ICARDA has assembled a large and impressive collection of food legume germplasm that includes the related wild species. However, there has only been minimal use of the wild species in the breeding programs. ICARDA with a global mandate for these food legumes should take the lead in the area of pre-breeding and utilize this collection to the fullest extent possible. A strong pre-breeding component to each of the breeding programs would be a major step in making ICARDA a center of excellence for improving these crops. **It is therefore recommended that pre-breeding using the crossable wild species should be increased and become an integral part of the lentil and chickpea breeding programs.**

2. An insufficient number of co-dominant molecular markers are available for genetic mapping in lentil and faba bean. The number of genetic markers can be increased substantially through close collaboration with advanced research institutions (ARIs) such as the University of California – Davis, or the University of Saskatchewan and groups in Australia. Collaboration with the University of Frankfurt has been fruitful toward increasing the number of markers for chickpea genetic mapping.
    a) **It is therefore recommended that the biotechnology laboratory strengthen collaboration with ARIs for marker development in lentil, chickpea and faba bean.**
    b) **It is also recommended that the biotechnology laboratory validate and accelerate the use of molecular markers in the breeding and pre-breeding programs for chickpea and lentil.**
3. The current chickpea wilt sick plot lacks uniformity of infestation, which causes errors in screening for resistance. Also, dry root rot is becoming a constraint to chickpea production and currently there is no facility for screening for resistance. **Therefore the panel recommends that a new wilt sick plot with greater uniformity of infestation be developed. A dry root rot sick plot should also be established at the center.**
4. Helicoverpa pod borer is the most important pest of chickpea in South Asia and sub-Saharan Africa. With climate change, it may become a more important pest in CWANA region. Research on Heliocoverpa is currently underway at ICRISAT. It would be highly desirable for entomologists at ICARDA and ICRISAT to collaborate on research on the biology and control of this important pest. **Therefore the panel recommends that collaboration between ICARDA and ICRISAT be established for comprehensive research on Helicoverpa pod borer.**
5. Anti nutritional factors in faba bean and grasspea restrict their use in CWANA, South Asia and East Africa. Reducing concentrations of these anti-nutritional factors would increase the value of these legumes for food. **Therefore the panel recommends strengthening research on anti-nutritional factors in grasspea and faba bean through additional technical staff and up to date high-pressure liquid-chromatography equipment to conduct nutritional quality evaluations.**
6. In the context of climate change, it is necessary to quantify the effects of higher CO_2 concentration, temperature and soil moisture on crop growth, nitrogen fixation and yield of food legumes under controlled conditions. **The panel recommends that a program to quantify the effects of climate change on biological nitrogen fixation and yield of chickpea, lentil and faba bean be initiated.**
7. Some of the activities of the IPM program are not well focused on addressing the goals of the breeding programs.
    a) **The panel therefore recommends that the integrated pest management program become pro-active in collaboration with the Germplasm Resources Section and the breeding sections in identifying new sources of resistance to important diseases and pests.**
    b) **The panel also recommends that the IPM program consider the effects of climate change on the likely emergence of new pests and diseases of the food legume crops**

II. Personnel

8. ICARDA has the global mandate for lentil, faba bean, grasspea and shares the mandate for chickpea. Since these legumes contribute substantially to the fertility status of soils through biological nitrogen fixation, it is imperative that all aspects of

BNF be studied in depth. **Therefore the panel recommends that ICARDA renew its' efforts to appoint a microbiologist with sole responsibility to undertake comprehensive research on biological nitrogen fixation.**

9. Each food legume breeding section has several projects and activities but only one scientist for each crop (grasspea combined with lentil). This creates constraints to paying required attention to program objectives, timely publication, and interactions with NARS partners. **Therefore the panel recommends that research associate/post doctoral positions be established for each breeding section to assist in plant breeding and to enhance output and contribute to high quality science.**
10. The Genetic Resources Section (GRS) has part time curators, one for cereals and one for legumes, which limits their opportunities for research on the germplasm. **Therefore the panel recommends the appointment of an additional curator for food and feed legumes to more effectively carry out the functions of the GRS.**
11. In the context of climate change and changing fertility status of soils in addition to releases of new germplasm, crop management practices for the region need to be updated and refined. Specifically, new sets of crop management trials should be initiated at selected NARS sites on tillage options, nutrient application and status, drought and weed management. **We therefore recommend that an Agronomist be appointed for food legumes to work with NARS agronomists and field crop specialists to develop and refine crop management practices for newly released varieties and the changing environment throughout the region.**

III. Training and Capacity Building

12. ICARDA has a highly qualified and competent scientific staff to offer training and guidance to students pursuing degree programs. **To attract students from NARS the panel recommends that fellowships be provided to support degree programs. In-service candidates may also be given the opportunity to acquire advanced degrees.**
13. Many of the professional and technical staff of the NARS programs lack sufficient training in the areas of crossing techniques and plant breeding. This is especially true for programs where there have been recent personnel changes. **It is therefore recommended that ICARDA expand opportunities for NARS scientists and technicians to upgrade their skills in these areas.**

IV. General Recommendations:

14. A major constraint to adoption of new chickpea and lentil varieties has been the seed production and distribution system in most of the non-tropical dry areas, including Syria. A more efficient system is crucial to delivering new varieties and production packages to the farmers. **It is therefore recommended that ICARDA take the lead in formulating and promoting an efficient seed delivery system in cooperation with NARS partners that will enable the timely distribution of improved varieties and production packages to the farmers.**
15. Over the years ICARDA has contributed to the development of new and promising varieties of food legumes and production technology for NARS; however, many new varieties are not taken up by the farmers. **The panel recommends timely assessment of the impact of improved varieties and new production technology.**
16. With climate change, the scenario of insect pests and diseases will be altered and new races of pathogens and insects may emerge and pose serious threats to productivity. **Therefore the panel recommends that a spatial disease map be developed in collaboration with the GIS unit to formulate prediction models on occurrence and severity of diseases that can be used to plan research and design management practices.**

17. Zero tillage has proved promising in several areas as it reduces the cost of production, facilitates timely planting and improves soil health. Limited research on zero-tillage has been carried out by the center. **Therefore the panel recommends that a comprehensive research program on zero tillage be established, emphasizing food legumes.**
18. Faba bean is an important food legume crop in North Africa where it is produced on over 300,000 hectares. From the visit to Morocco, it was apparent that most faba bean breeders in North Africa are isolated and lack current information on technical aspects needed to conduct effective breeding programs to alleviate constraints to production. **It is therefore recommended that a faba bean workshop be organized by ICARDA to bring scientists and plant breeders together to share information on faba bean for mutual benefit and to develop regional cooperation and networking.**

Administrative and Financial Management

Administration and financial services are supportive of research programs and effectively promote excellence in science and technology for sustained improvement of the food legumes.

Chapter 1. Introduction

Ensuring food security and eliminating hunger and malnourishment are essential for global peace and prosperity. In the past, several efforts were made to ensure food security and alleviate poverty. During the first World Food Summit in 1996, the world leaders committed to achieve food security for all and actively contribute in their efforts to eradicate hunger in all countries. In 2000, world leaders again set the far-sighted goal of reducing poverty in the planet by half in 2015. However, 2009 Millennium Development Goals Report revealed that 'the progress towards the goals is threatened by sluggish – or even negative – economic growth, diminishing resources, fewer trade opportunities for the developing countries and possible reductions in aid from donor nations. At the same time, climate change is apparent and may have devastating effects and hamper progress in achieving Millennium Development Goals. Between 1990 and 2005 the number of people living on less than US$ 1.25 a day has marginally declined from 1.8 billion to 1.4 billion. But in 2009, an estimated 55 million to 90 million more people are expected to be living in extreme poverty than anticipated before the economic crisis. The prevalence of hunger in developing countries has risen from 16% in 2006 to 17% in 2008.

The recent Rome Summit in 2009, after the serious food crisis, observed that the past neglect to agriculture has led to a steep rise in food prices, food riots and pushed approximately 100 million more people to the poverty trap. Ensuring food security is the primary responsibility of the state to its citizens. It is realized that support to agricultural research, effective policies and institutional innovations would contribute in reshaping agriculture and meeting the future demand for food and eliminate hunger. Technology-led agricultural growth may be achieved if agricultural R&D is accorded high priority. It requires higher R&D funding and qualified scientific human resources. This calls for building strong national and international research centers and developing regional cooperation and partnerships.

ICARDA, through its 2007-2016 Strategic Plans on Improving Livelihoods in Dry Areas, emphasized the urgent need to develop technical, policy and institutional options that

improve livelihood and food security, which in turn will contribute to achieving the Millennium Development Goals by reducing poverty.

Food legumes continue to play an important role in providing a cheap source of nutrition for humans and animals, and promoting sustainable productivity in harsh and fragile ecosystems of dry areas. However, several biotic and abiotic stresses encountered by these crops, poor crop management practices, and narrow genetic base continue to constrain their productivity, resulting in reduced availability and high prices. Therefore, concerted efforts are needed to harness the yield potential of food legumes by fully utilizing the available germplasm to develop improved varieties and technology for increasing productivity and reducing production costs.

ICARDA's Strategic Plan to insure that rural populations have a choice of livelihood options as well as appropriate methods to conserve their natural resources in the face of climate change and globalization through reorienting its research emphasis from a commodity-based, top-down technology-driven agenda to an integrated, demand-driven, people-oriented approach is most relevant and forward looking. Under this strategy, ICARDA will extend its focus to address the challenges to the non tropical dry areas by developing international public goods.

Chapter 2. Progress in Addressing 5th EPMR Recommendations

The 5th EPMR completed in July 2006 made 22 recommendations of which one (Recommendation 10) pertained to legumes. The panel recommended that the forage (field) legume section should be merged with one or all of the food legume sections on the basis of crop area potential impact and technology transfer, similarity of the species, and need for synergism among the research groups. The recommendation has been accepted with the forage grasspea being merged with the food legume improvement sections.

Chapter 3. Progress in Addressing Recommendations of the CCER on Integrated Gene Management November 2005

Responses to the 37 Recommendations of the CCER 2005 indicate that most have been accepted and implemented or accepted in principle. The recommendations that have not been accepted or implemented are as follows:

Recommendation 7.
ICARDA should consider the establishment of a permanent training unit on participatory plant breeding.
Response: ICARDA manages Human Resource Development centrally in a HRD Unit. So we will not set up a permanent training unit specifically for PPB. However, we organized a training course on PPB in 2005 with EU-support in cooperation with CIHEAM Zaragoza and will seek further special project funding to extend this initiative.

The panel agrees with the response.

Recommendation 19.
Enhance investment to introduce underutilized species into the farming system and diets of CWANA populations, peas for example.

Response: ICARDA will consider expanding into the selection of peas for adaptability to Mediterranean climate. ICARDA used to have a modest program on pea and we maintain a pea collection of > 6000 accessions from 96 countries, of which 1700 accessions are evaluated for 46 traits.

ICARDA agrees with this recommendation but could not implement. ICARDA may implement this recommendation if resources are available.

Recommendation 20.
a) Develop markers for various traits and use marker-assisted selection as appropriate.
b) Participatory approaches with farmers and NARS should be systematically studied for comparative purposes with non-participatory methods.
Response:
a) The development of markers for traits such as ascochyta blight of chickpea and fusarium wilt of lentil and chickpea has started. Appropriate recombinant inbred populations (RILs) have been produced. This will be continued.
b) The chickpea and lentil programs have used Participatory Varietal Selection (PVS) (rather than Participatory Plant Breeding) with Syria and other NARS for food legumes for many years as a standard practice. PVS has helped to identify superior adapted genotypes of food legumes in such countries as Syria, Turkey, Kazakhstan and Yemen. This experience is being documented.

The panel recommends greater focus on marker development and utilization to advance the breeding programs. The panel also recognizes that PVS is appropriate and effective in the selection of new varieties of the food legumes

Recommendation 3.5. The CWANA Network Steering Committee should be replaced by a regional seed committee or board with one member from each CWANA country that contributes an annual fee.
Response: The Seed Unit is exploring different options for the future of the WANA Seed Network. First, an attempt is made to reorganize the network to encourage and involve the participation of the private sector. An International Seed Trade Conference will be organized in November 2005 in Antalya, Turkey, where these issues will be discussed. The basic idea is to organize an annual Seed Trade Conference in one of the countries of the region, where the private and public sector meet to discuss seed industry development issues and agree on action plans.
The second avenue, which is being investigated, is the integration of the network into the APSA (Asia Pacific Seed Association). APSA is a very strong seed association operating in South East Asia, with public and private membership.
The Director of APSA has expressed interest and will participate in the International Seed Trade Conference in Turkey, where further discussion will be held.
Replacing the WANA Seed Network Council (which is 100% public sector) by a regional seed committee or board with one member from each CWANA country that contributes an annual fee is at this moment not considered a viable option because of the payments involved.

ICARDA has not agreed with the recommendation as other more suitable options are available. The panel supports this assessment.

Recommendation 37:

c) The panel recommends that the study of impact of adoption of improved varieties be linked with attendant impacts on the quality of natural resources including biodiversity and soil and water quality and pollution from pesticides and fertilizers to sustainable increased productivity taking in consideration risk aspects that require further quantification.
Response:
c) The genotype is one aspect of integrated natural resources management. ICARDA is working with the Standing Panel on Impact Assessment on case studies of the impact of natural resources research and on appropriate methodologies to measure the impact of NRM. As this research develops we will ensure integration of the genetic component.

Accepted in principle and will be implemented as the research develops. The panel agrees with this approach.

Chapter 4. Research Program

Breeding sections for chickpea, lentil, grasspea and faba bean are well focused and led by newly appointed, energetic and forward looking scientists. They address major global issues related to the constraints to production in the dry areas. However the sections need additional scientific support in the form of research associates/post doctoral research associates and technical staff. The breeding sections are meeting the challenges of biotic and abiotic stresses of the food legumes and developing germplasm that begin to meet the needs of CWANA. However, pre-breeding should have a more prominent role in the breeding sections and be focused on introgression of genes from wild and exotic sources into cultivated genetic backgrounds. Emphasis in this area is needed to provide solutions to the problems of disease and insect depredations and the expected effects of climate change. New sources of resistance to biotic and abiotic stresses should be transferred to cultivated germplasm in an aggressive pre-breeding program to provide the needed genetic diversity not only for the breeding sections of the center but also for their NARS partners.

4.1 Chickpea

Chickpea is a high value crop that provides good income to small farmers in the CWANA region. The crop is the third most important food legume worldwide and has seen an increase in production over the past 10 years; however, yield fluctuation is a persistent problem. Most of world production is in South Asia where yields are relatively low but stable. It is an important crop in West Asia where yields are low and variable from year to year depending on available moisture. Latin America has the highest yields followed by North America.

Traditionally chickpea has been spring planted and grown on residual soil moisture; however, yields are chronically low due to moisture limitations and terminal drought. Research at ICARDA in the early 1980s has shown yield benefits from winter planting leading to increased productivity in the region. Chickpea germplasm developed at ICARDA with cold tolerance and resistance to ascochyta blight was in the forefront of a change in chickpea production from spring to winter planting. By taking full advantage of available soil moisture, yields of winter planted chickpea are significantly increased over spring planted chickpea. Also, varieties developed using ICARDA germplasm are taller and more upright than the traditionally planted spring varieties, traits that make them more suitable for combine harvesting. The relatively small seed size of available winter chickpea varieties has constrained their adoption in some countries of CWANA where large seeded chickpea is preferred. Ascochyta blight continues to be an important disease of winter chickpea and there

is evidence for the evolution of new pathotypes capable of causing disease on previously resistant varieties. Continued research to identify germplasm with resistance to these new and developing pathotypes is needed for continued successful winter planting of chickpea. Other constraints include drought, fusarium wilt, dry root rot (collar rot), Helicoverpa pod borer, leaf miner and cyst nematode.

Objectives and approach

The chickpea breeding section at ICARDA is developing improved chickpea germplasm with ascochyta blight resistance, cold tolerance, medium to large seed size and suitable for winter planting. The tall and upright plant habits of winter chickpea germplasm is essential for mechanical harvesting. The breeding approach for chickpea improvement is the bulk-pedigree system. Breeding is done in collaboration with NARS breeders and their breeding objectives are taken into account in the planning stages and development of segregating populations from crosses. Material is shared according to the needs of the NARS and their specific production constraints. The smaller seed size of winter chickpea has restricted adoption of the technology in some countries of CWANA, particularly Morocco where chickpea with large seed size is preferred for their traditional dishes. In some areas, weed infestations have restricted adoption of winter chickpea.

For spring sowing, the objectives are to develop varieties tolerant to drought, resistance to fusarium wilt, leaf miner, and cereal cyst nematodes (CCN), early maturing, and medium to large seed size. For South Asia and East Africa, phenology (early maturity), fusarium wilt resistance, drought tolerance, ascochyta blight resistance, cold tolerance at the reproductive stage, medium to extra large seed size (>50 g/100), resistance to botrytis grey mold and pod borer. For Latin America including Argentina, Brazil, Chile, México objectives are resistance to fusarium wilt, root rot, viruses, and large seed size.

Genetic research is developing mapping populations and genetic stocks to determine the genomic locations of the genes responsible for resistance to biotic and abiotic stresses. The goal is a better understanding of the inheritance of traits important to breeding and to identify closely linked genetic markers that can be used in marker assisted selection to accelerate the breeding program and make improved germplasm available in a shorter period of time.

Chickpea breeding research is conducted at Tel Hadya, Syria with 350 mm rainfall, Breda Research Station, Syria with 250 mm rainfall, and Terbol in the Beka valley, Lebanon with 450 mm rainfall for off-season planting. The experiments are conducted in the field where stresses are imposed by delayed planting whereby the material can be evaluated under more extremes of heat and drought. Through this approach, the chickpea breeding section effectively addresses the issues of climate change and the expected increases in abiotic stresses, heat and drought.

The chickpea breeding section is primarily concerned with improving production of chickpea, improving livelihoods and alleviating poverty. Feedback from farmers through visits and on-farm trials is used to identify and prioritize constraints to productivity within the prevailing production system. Close attention is paid to quality aspects, particularly seed size. Constraints to productivity are considered in the formulation of research priorities.

The breeding and selection procedures being used are appropriate for the production systems in the region. To the extent possible, participatory variety selection is practiced for chickpea breeding.

Relevance to NARS priorities, EPMR/CCER recommendations and Climate change issues

The chickpea breeding section addresses NARS priorities by providing a range of improved germplasm such as drought and cold tolerant, ascochyta blight and fusarium wilt resistant germplasm through a system of international nurseries. The program is within the framework of ICARDA's strategic plan for 2007-16 and implemented within the existing production system. Material suitable for winter planting is provided to the CWANA region and germplasm is also provided to other dry regions of the world, including Latin America and South Asia. Breeding chickpea with tolerance/resistance to biotic and abiotic stresses addresses the issues of climate change, UN millennium development goals and the CGIAR systems priorities for maintaining and enhancing yields and yield potential of food staples and tolerance to selected biotic and abiotic stresses.

Research thrusts

Research on ascochyta blight resistant and cold tolerant germplasm should continue to provide improved germplasm for winter planting. Germplasm with larger seed size is needed for some countries of the CWANA region. Research on drought, fusarium wilt resistance and resistance to leaf miner in both winter and spring type germplasm should continue. Genetic research is focused on development of molecular markers for important traits such as ascochyta blight, drought and leaf miner resistance/tolerance.

Research outputs and progress

A total of 137 varieties of chickpea were released using ICARDA germplasm of which 25 have been released since 2005. The research program was successful in developing the concept of winter planting of chickpea by providing germplasm with cold tolerance and resistance to ascochyta blight. Under this project winter chickpea varieties (Ghab3, Ghab4, and Ghab5) were developed and a production package composed of main components and optional components was recommended. In the optional components, the use of grain drill and mechanical weeding were included. Also, mechanical harvesting is more feasible with winter chickpea. In a study made by ICARDA, 71% of the farmers questioned indicated that mechanical harvesting of winter chickpea was easier than spring chickpea. The study also indicated that two of the most important factors affected the productivity of winter chickpea were date of sowing and seeding rate. The grain drill is used by 62.5% of the farmers questioned and provided near optimum plant densities and uniform emergence.

Winter chickpea has significantly increased production in CWANA. An impact study conducted in Syria showed that winter chickpea technology has been adopted at a high rate in most of the provinces. In the wetter zones adoption has been up to 75% while in the drier zones there has been a lower percentage of adoption. The less than 100% adoption may be attributed to the relatively small seed size of available chickpea varieties as well as concerns about ascochyta blight and other production constraints relative to winter planting,

particularly weed and insect control. Breeding for increased seed size of new winter chickpea varieties holds promise toward greater adoption of winter chickpea in CWANA.

In Turkey, Gokce chickpea developed using germplasm (FLIP87-8C) from ICARDA has become the predominant variety grown. The variety has exceptionally high yields and can be mechanically harvested.

Quality of science applied in the program

The project leader has initiated a strong and comprehensive program using high quality science in the areas of plant breeding and genetics. The quality of science is demonstrated in peer reviewed publications that indicate innovative approaches. Recombinant inbred line (RILs) populations for genetic research on major production constraints such as ascochyta blight, fusarium wilt, heat and drought and also leaf miner are under development. These RIL populations will provide genetic tools that can be used effectively to determine the genomic locations of important genes and quantitative trait loci. The information will enable the use of marker assisted selection to be practiced in the program and accelerated variety development. Markers developed for these traits may also be used for directed introgression of genes from wild sources into cultivated genetic backgrounds.

Capacity building and regional cooperation

There is regional cooperation in the form of International nurseries, training courses at the center on breeding techniques and laboratory procedures, and selection opportunities by cooperators in the breeding material grown at the center. Over the past 5 years the chickpea breeding section has developed 78 international nurseries that were distributed to 44 countries. These nurseries are being used by the NARS for selection of fixed lines and also for selection within segregating populations. In most NARS of CWANA, nurseries from ICARDA are the main source of improved germplasm leading to the development and release of new varieties. Twenty five varieties of chickpea based on ICARDA germplasm have been released over the past 5 years. For example, in India the variety ‘BAUG’ was selected from ICARDA materials at Ranchi, also at IARI a line with extra large seed size was selected from the cross of ICARDA line FLIP90-166C with BG1082. At Ludhiana, line GLK26177 was selected from ICARDA line FLIP98-52C crossed to GLK95075. Also, at Kanpur, elite lines from ICARDA and two wild relatives are being used in the crossing program to introgress seed size genes and to enhance yield.

Support needed

The chickpea breeder is solely responsible for developing winter chickpea for CWANA and short duration drought and fusarium wilt resistant germplasm in collaboration with NARS partners around the world. More recently the full-fledged integration of molecular marker technology with conventional breeding and the focus on pre-breeding have substantially increased the work load of the section. Due to the nature of the project and the global reach, there is a critical need for additional scientific support in the form of a research associate/post-doctoral research fellow and additional technical support.

Recommendations

With increased disease pressure from diseases such as ascochyta blight, fusarium wilt and collar rot, and the perception that progress in breeding is hampered by a narrow genetic base, a pre-breeding program to identify genetic variation for these traits and introgression of those genes into a cultivated genetic background is needed. Co-dominant molecular markers are available and can be used effectively for marker directed introgression of genes from wild and exotic sources into cultivated genetic backgrounds.
Therefore the panel recommends increased collaboration between GRS, IPM and the chickpea breeder to strengthen pre-breeding and to identify new and novel genes in the wild species that can be used to improve cultivated chickpea. (Recommendation 1)

The chickpea breeding section has only one scientist. This creates constraints to paying required attention to section objectives, timely publication, and interactions with NARS partners. **Therefore the panel recommends that a research associate/post doctoral position be established to enhance output and quality of science. (Recommendation 9)**

A major constraint to adoption of new chickpea varieties has been the seed production and distribution system in most of CWANA including Syria. A more efficient system is crucial to delivering new varieties and production packages to the farmers. **Therefore the panel recommends that ICARDA take the lead in formulating and promoting an efficient seed delivery system in cooperation with NARS partners that will ensure the timely distribution of improved varieties and production packages to the farmers. (Recommendation 14)**

4.2 Lentil

Lentil is an important food legume crop in CWANA and South Asia where it is grown in rotation with cereals. Development of winter varieties, with better water use efficiency for cold highland areas, promises to provide substantial yield advantages in CWANA. In South Asia, short duration varieties have great potential for utilization of rice fallows. Tall and upright varieties with the pods near the top of the plant are needed for CWANA to better adapt the crop to combine harvesting. The production of the crop is stable in South Asia and West Asia, but declining in North Africa because of the labor cost of hand harvesting. The crop is being reintroduced in Central Asia and the Caucasus.

In CWANA region the crop is grown in small holdings and is mostly hand harvested. The demands for labor for hand harvesting the lentil crop has caused many of the larger farmers to reduce their lentil production and concentrate more on cereals that can be machine harvested leading to a greater degree of mono-culture wheat. This situation can be reversed if suitable varieties and mechanical harvesting techniques for lentil can be developed. Machine harvesting of lentil depends on the availability of varieties that are tall and upright, lodging resistant and with pods that are near the top of the plant. These traits are available in the germplasm and have become an important consideration in the breeding section. The development of winter hardy lentil for fall/winter planting in cold highland areas has been a positive development and provides additional biomass, higher yields and the ability to harvest mechanically. Winter lentil has shown earlier maturity and a near doubling of yields. Winter lentil fits well in cereal based cropping systems and it can be planted no-till directly into standing cereal stubble.

The primary constraints to lentil production in most of CWANA are short plant stature making the crop difficult to harvest mechanically, rust, ascochyta blight, Sitona weevil and

Orobanche. In South Asia the crop is adversely affected by fusarium wilt, stemphylium blight, rust and drought.

Objectives and approach

Lentil breeding is focused on increasing yield, resistance to fusarium wilt, rust and stemphylium blight. The section is also addressing the need for varieties with tall and upright plant habit and good standing ability for mechanical harvesting. For the Sub-Saharan region the objectives are earliness, resistance to fusarium wilt, rust and ascochyta blight. For the Mediterranean highlands the objectives are cold tolerance, resistance to ascochyta blight and standing ability. For the Mediterranean lowlands, the objectives are resistance to rust, fusarium wilt, ascochyta blight, Sitona weevil and Orobanche. Tolerance to abiotic stresses, heat, drought and salinity are also important objectives.

For fusarium wilt resistance breeding, a wilt sick plot has been developed and is used for effective screening. However, there is a need to identify the races of the pathogen present in the plot. The effects of heat and drought on lentil breeding materials is assessed through the use of delayed plantings to determine the effects on productivity by comparison to performance from normal planting times.

The lentil breeding program relies on a decentralized breeding approach whereby specific crosses are planned and made in agreement with NARS partners. Joint selections are made and entered into trials and based on performance, variety releases follow. This approach is essential and expands the scope of the lentil breeding program.

Relevance to NARS priorities, EPMR/CCER recommendations and Climate change issues

The lentil breeding section addresses NARS priorities by providing lentil germplasm that can be evaluated and selected in the target environments. . The program is within the framework of ICARDA's strategic plan for 2007-16 and implemented within the existing production system. For CWANA region, tall erect types (suitable for mechanical harvest) with resistance to fusarium wilt and tolerance to drought and cold are being developed. For South Asia, the priorities are large seeded short duration varieties with fusarium wilt, rust and stemphylium blight resistance and suitable for rice fallows. Machine harvest will expand lentil area as it will reduce production costs and ensure timely harvest and thus improving incomes and livelihoods of all stake holders in the lentil supply chain.

Breeding of lentil with tolerance/resistance to biotic and abiotic stresses addresses the issues of climate change, UN millennium development goals and the CGIAR system's priorities for maintaining and enhancing yields of food staples. Food security is enhanced through higher and more stable lentil yields.

Research thrusts

Breeding of lentil with tall - upright plant habits and adaptable to machine harvest should continue and will provide the needed germplasm to further the trend toward mechanical harvest by the farmers. Continued development of cold tolerant lentil is encouraged.

Genetic research is focused on development of molecular markers for important traits such as resistance to fusarium wilt, ascochyta blight, rust and stemphylium blight, as well as drought tolerance. Research on biofortification (Zn and Fe) is important and addresses nutritional needs of populations in the dry areas.

Pre-breeding should be emphasized in the program with the goal of identifying new genes and genetic variation in the wild species. Introgression lines from interspecific crosses should be developed to determine gene expression in a cultivated genetic background. For example, the wild species *L. ervoides* is known to have genes for resistance to important foliar pathogens. Introgression lines involving that species or other *Lens* species may reveal genes for other important traits that would be valuable in a cultivated genetic background.

Research outputs and progress

The lentil section has made over 2000 crosses over the past 5 years using 516 parents. International nurseries were established that included 297 FLIP entries and distributed to 42 countries worldwide. Twenty-one varieties have been released in 12 countries; four were in West Asia, three in Central Asia and Caucasus, two in North Africa and Sub-Saharan Africa, 10 in South Asia and China and two in Australia.

In countries with relatively well developed seed production systems, such as Nepal, Bangladesh, Ethiopia, Iran, Syria, and Turkey, the released varieties based on ICARDA germplasm has been well received by the farmers.

The lentil section has developed recombinant inbred line populations for mapping the genes for resistance to fusarium wilt, rust, stemphylium blight and Sitona weevil, drought and cold tolerance.

Quality of science applied in the program

The quality of science is demonstrated in peer reviewed publications that indicate innovative approaches. Recombinant inbred line (RILs) populations for genetic research on major production constraints such as ascochyta blight, stemphylium blight, rust, fusarium wilt, drought and cold have been developed and are available for mapping important genes and identifying closely linked markers. Over the past 5 years, 36 refereed journal articles, 10 book chapters and one book have been published.

Capacity building and regional cooperation

There is regional cooperation in the form of international nurseries, training courses on breeding techniques and laboratory procedures, and selection opportunities for cooperators in the breeding material at the center. Crosses are planned in consultation with the NARS plant breeders to provide segregating material for selection in their specific environments. This decentralized breeding approach is especially appreciated by NARS plant breeders. The program is conducted in a participatory framework whereby NARS plant breeders have input into decision making concerning crossing. They also conduct the evaluations of breeding material in the target environments in collaboration with the ICARDA lentil breeder.

Over the past 5 years the lentil program has developed international nurseries that were distributed to 44 countries. These nurseries are being used by the NARS for selection of fixed lines and also for selection within segregating populations. In most NARS of CWANA, nurseries from ICARDA are the main source of improved germplasm leading to the development and release of new varieties.

Support needed

The project leader has global responsibility for lentil and grasspea breeding. Due to the expanded research activities concerning these two crops, there is a critical need for additional scientific and technical support. We therefore recommend a research associate/post-doctoral research fellow be appointed to assist the project leader and to conduct breeding and genetic research on lentil.

Recommendations

The panel recommends that a research associate/post-doctoral research fellow be appointed to assist the project leader and to conduct breeding and genetic research on lentil. (Recommendation 9)

The panel also recommends collaboration between GRS, IPM and the lentil breeder to initiate pre-breeding in lentil to identify new and novel genes in the wild species that can be used to improve cultivated lentil. (Recommendation 1)

4.3 Grasspea

Grasspea has potential for food and nutritional security in dry areas where other crops do not perform well. The crop is a valuable food with 30% protein content in seed. However, it also has an anti-nutritional factor, β-ODAP, a toxin which causes neuro-lathyrism and paralysis of the lower limbs when consumed in excess. This has forced many countries to impose some restrictions on its cultivation and trade. Therefore, research efforts to reduce the toxin levels have high priority. Since it is also used feed and forage, breeding dual purpose varieties is important.

Objectives and approach

The main objectives in grasspea breeding are to develop improved genetic stocks with high seed yield, low β-ODAP and high biomass through conventional and biotechnological approaches.

Relevance to NARS priorities, EPMR/CCER recommendations and Climate change issues

As per recommendations of the EPMR, food and forage grasspea have been merged. The program is within the framework of ICARDA's strategic plan for 2007-16 and implemented within the existing production system. Grasspea research has focused on high and stable yields with low β-ODAP content, improved phenology and high biomass to fit the existing and potential niches of cropping systems. Assessments of out-crossing rates are being made.

The projects have been developed as per NARS priorities with a production system approach and implemented in participatory mode. Besides low β-ODAP, earliness and powdery mildew resistance have priority for South Asia and Sub-Saharan Africa; whereas for the Mediterranean region, high biomass and feed value have priority.

Research thrusts

Emphasis should continue on low β-ODAP, high seed and forage yields. In context of climate change, the program proposed on earliness is appropriate. Special research efforts are needed for developing varieties for rice fallows of South Asia. Studies on β-ODAP content as influenced by environment and management practices deserve attention. There is a need to improve plant type for higher productivity. Bio-fortification of the seed for human consumption is not a priority research issue. In South Asia, thrips sometimes cause economic loss. Powdery mildew may occur under humid conditions. However, these biotic stresses are not priority areas for research.

It was noticed that no research work on developing varieties suitable for mechanical harvesting was included in the grasspea activities. Developing tall erect varieties suitable for mechanical harvesting will encourage more farmers to include this important crop in their rotations.

Research outputs and progress

Several parental lines with low ODAP have been identified in the germplasm. 'Wasie', a low β-ODAP content variety was developed and released in Ethiopia. Another variety (Sel. 190) is being proposed for release in Bangladesh. In addition to low β-ODAP content, high biomass and early maturing lines have been identified. When released, these lines promise to improve livelihoods and alleviate poverty.

The program was significantly strengthened during 2009-10. Several (50-100) crosses have been made involving regionally adapted land races from Pakistan, Ethiopia, Bangladesh, Nepal and India with low β-ODAP lines from West Asia. Mapping populations are being developed. Over 1700 genotypes (including 1268 germplasm accessions) were evaluated for β-ODAP content. This year, 2 to 4 International Screening Nurseries having 60 fixed lines were supplied to 17 countries for multi-environment evaluation.

Quality of science applied in the program

The quality of science is reflected in research publications and outcomes. Three research papers in peer reviewed journals and a research bulletin was published. One variety (Wasie) has been developed in association with NARS. Considering that the grasspea breeder has major responsibility for lentil breeding, research output/outcome is quite satisfactory.

Capacity building and regional cooperation

With strengthening of the grasspea research in 2009-10, capacity building was emphasized. Two scientists from Iran and a student from Australia have been trained in improved crop management and strong regional cooperation has been established. The International

Screening Nursery (ISN) has been provided to 17 countries and collaborative research programs have been established with India.

Support needed

Since the grasspea breeder has the major responsibility for lentil breeding, there is urgent need for appointment of a research associate/post-doctoral research fellow and additional technicians for effective execution of the proposed work. Since grasspea is a cross pollinated crop, plastic houses and insect exclusion cages are needed for effective breeding. With the emphasis on developing grasspea with low concentrations of anti-nutritional factors, equipment for high pressure liquid chromatography (HPLC) and Near Infrared Spectroscopy should be acquired.

Recommendations

The panel recommends that a research associate/post-doctoral research fellow be appointed to assist the project leader and to conduct breeding and genetic research on grasspea. (Recommendation 9)

4.4 Faba bean

Faba bean is a food legume with high yield potential and 29% protein content in seed, providing dual usage as a pulse and a green vegetable for human food. Green biomass and dry residues of faba bean are excellent feed and forage. It is the most productive and effective nitrogen fixing food legume crop. It has an upright growing habit that well suited to mechanical harvest. Faba bean fits well in rotation with cereals. Faba bean productivity is constrained by various biotic and abiotic stresses; and there are anti-nutritional factors (tannins, vicine and convicine) in seed. Research addresses productivity and quality for multiple purpose uses.

Objectives and approach

The main objectives of faba bean breeding section are to develop varieties with resistance to biotic (orobanche, rust, chocolate spot, ascochyta blight, aphids, bruchids, and viruses) and abiotic (drought, heat and cold) stresses for CWANA and China. The program also aims to develop varieties with low concentrations of tannins, vicine and convicine. Conventional breeding methods and biotechnological approaches are used.

Relevance to NARS priorities, EPMR/CCER recommendations and Climate change issues

As per recommendation 11 of CCER 2005, *several of the collections in the GRU suffered for lack of scientific leadership for several years and the faba bean improvement program is guided by a temporary employee. Permanent positions are* ***recommended to*** *stabilize these programs.* And as per recommendation 22 of CCER 2005, a *P-level plant breeder has been appointed.* The section is within the frame work of ICARDA's strategic plan for 2007-16. To address the global needs for ICARDA's faba bean section, breeding objectives are increased yield and yield stability, adaptability to warm environments and short cropping cycle, resistance to biotic stresses, increase digestibility and nutritional quality (low tannin, vicine

and convicine), and suitable to mechanical harvesting. The projects have been developed as per NARS priorities within a production system approach and implemented in participatory mode. Besides dual usage faba bean, disease resistance, orobanche resistance, cold tolerance, drought tolerance, aphid resistance and better nutritional quality has been addressed. Efforts on development of short duration and drought tolerant varieties address the issue of climate change.

Research thrusts

Emphasis should continue on anti-nutritional factors (tannins, vicine and convicine) and high seed and forage yields. In the context of climate change, the section proposed on winter hardiness and heat/drought tolerance is appropriate. Aphid and bruchid resistance should be brought into consideration. Special research efforts are needed for developing varieties well adapted in rice fallows of South and East Asia (China). There is a need to improve plant type for higher productivity. Improved seed quality for fresh green and dry seed production is essential in most faba bean production areas. Breeding for dual purpose is therefore important. Recombinant Inbred Line populations for genetic studies of biotic/abiotic stresses and anti-nutritional factors need further development.

Research outputs and progress

Nine improved varieties have been released by NARS over the past five years using ICARDA materials. Annually, 84 lines (including 57 new lines) were provided to NARS through international nurseries for evaluation. RILs are being developed from crosses of the major resistance sources with susceptible lines for Orobanche, botrytis gray mold, ascochyta blight, drought, and low contents of anti-nutritional factors. Three RIL populations in F_4 and three in the F_1 were established in 2009/10.

Quality of science applied in the program

Nine varieties have been developed and released in association with NARS (Egypt, Ethiopia, Australia, China, Turkey, etc). After joining of a P-level scientist in 2007, two research papers have been published in peer review journals that reflect high quality science.

Capacity building and regional cooperation

With strengthening of the faba been program in 2009-10, capacity building was emphasized. Two in-country training programs for faba bean improvement have been conducted in China in partnership with CAAS. For spring and winter sowing areas, 45 scientists attended. The International Screening Nursery was provided to five provinces of China and collaborative research programs have been established with China through CAAS, by ICARDA-CAAS joint research center of excellence.

Support needed

Facilities for plastic houses and insect exclusion cages should be enhanced. With the emphasis on developing faba bean with low concentrations of anti-nutritional factors, equipment for high pressure liquid chromatography (HPLC) and non-destructive Near Infrared Spectroscopy should be acquired.

Recommendations

1. The faba bean section has only one scientist. This creates constraints to paying required attention to section objectives, timely publication, and interactions with NARS partners. **Therefore the panel recommends that a research associate/post-doctoral research fellow be appointed to assist the project leader and to conduct breeding and genetic research on faba bean. (Recommendation 9)**

2. Based on the visit to Morocco observing firsthand the situation in North Africa regarding breeding of faba bean, it was clear that the NARS scientists are isolated. There is a definite need to develop a program for regional collaboration for exchanging the latest information and to develop a network among the scientists. **It is therefore recommended that a faba bean workshop be organized by ICARDA to bring scientists and plant breeders together to share information on faba bean for mutual benefit and to develop regional cooperation and networking. (Recommendation 18)**

4.5 Genetic Resources

The Genetic Resources Section is responsible for collection, conservation, characterization, evaluation, documentation and distribution of food legume genetic resources. Of the ICARDA collection, 34,155 are food legume accessions which accounts for almost 30% of the entire ICARDA holdings. Secure conservation and documentation of genetic diversity is the basic function for this section. Timely renewal and providing genetic resources to food legume improvement programs at the center and NARS are major activities.

Objectives and approach

The main objectives of the Genetic Resources Section are to ensure the maintenance, documentation and effective use of the genetic diversity of food legume germplasm. This is accomplished through *ex-situ* conservation, seed renewal, seed multiplication and a system of supplying germplasm to users. These activities are supplemented by establishment of *in-situ*/on-farm conservation sites in Jordan, Lebanon, Palestine and Syria.

Relevance to NARS priorities, EPMR/CCER recommendations and Climate change issues

Genetic resources are the key to crop improvement programs. National programs are deriving needed genetic diversity from ICARDA germplasm. As per recommendation of the 2005 CCER, Genetic Resources has been merged into BIGM. Exploration programs undertaken by ICARDA enable the collection and preservation of genetic diversity that may become extinct due to climate change. The collected germplasm may provide the needed genetic diversity for breeders to mitigate the effects of climate change.

Research thrusts

ICARDA in collaboration with NARS scientists should focus on full characterization and documentation of the existing germplasm collection. Further exploration and collection and

utilization of the collection should be based on the Focused Identification of Germplasm Strategy (FIGS) and shared with NARS. In collaboration with the breeding programs, the germplasm is screened for traits needed for improving the food legume crops. Collaboration of the GRS with the food legume breeders and IPM is needed to more fully utilize the germplasm collection for crop improvement.

Research outputs and progress

On average more than 20,000 accessions per year are being distributed upon requests from NARS, Universities, CGIAR centers, gene banks, regional organizations and commercial companies including food legume accessions. More than 4,617 new accessions of food legumes were added to ICARDA's gene bank since 2005 and more than 36,900 accessions have been characterized. Over the years, more than 149,450 accessions were supplied to ICARDA and NARS scientists. Around 80% of the food legume accessions have been placed in Svalbard Global Seed Vault (Norway) for safe long-term storage.

Quality of science applied in the program

The quality of science is reflected in research publications and outcomes. Several papers have been published in peer reviewed journals. Best practices for regeneration and conservation of lentil, chickpea, *Lathyrus* and faba bean were developed and are available in the Genebank Knowledge Base webpage (http://cropgenebank.sgrp.cgiar.org). Isolation cages were established for regeneration and multiplication of *Lathyrus* species.

Capacity building and regional cooperation

Knowledge and methodologies for food legume genetic resource management has been shared with NARS. Twenty scientists from NARS per year are trained in ICARDA in genetic resource management.

Recommendations

1. The Genetic Resources Section has part time curators, one for cereals and one for legumes which limits their opportunities for research on the germplasm. **Therefore the panel recommends the appointment of an additional curator for food and feed legumes to more effectively carry out the functions of the GRS. (Recommendation 10)**

4.6 Legume Biotechnology

The Legume Biotechnology Section is expected to provide genetic information in the form of trait-linked markers for use in marker assisted selection within segregating breeding populations of chickpea, lentil and faba bean. Molecular markers are needed for genes for resistance to fusarium wilt, ascochyta and stemphylium blights, rust, winter hardiness, and tolerance to drought and salinity. Genetic transformation is needed for traits that are difficult to transfer by conventional plant breeding. Tissue culture is required for genetic transformation procedures and to overcome sterility barriers and other constraints.

Objectives and approach

The objectives of the biotechnology laboratory are to identify molecular markers closely linked to traits of interest such as ascochyta blight and fusarium wilt resistance in chickpea, stemphylium blight, fusarium wilt and rust resistance in lentil and chocolate spot resistance in faba bean. The approach is to develop robust molecular markers for mapping genomes of these crops and to provide closely linked markers to the genes of interest to the respective breeding programs for use in marker assisted selection. Development of transgenics against drought and other traits is also a research priority.

Relevance to NARS priorities, EPMR/CCER recommendations and Climate change issues

The biotechnology laboratory aims to provide support to the breeding sections by providing molecular markers for traits that are important for improving lentil, chickpea and faba bean. The markers are intended for use in marker assisted selection to more efficiently breed new varieties. This is relevant to NARS priorities by accelerating the development of new biotic and abiotic resistant/tolerant germplasm for the non-tropical dry areas. This goal conforms to EPMR/CCER recommendations and addresses issues of climate change.

Research thrusts

The biotechnology laboratory should continue its efforts in developing and mapping molecular markers in lentil, chickpea and faba bean. The genetic linkage maps should be used to identify markers closely linked to traits of interest. Development of transgenics for drought tolerance should receive priority in chickpea, lentil, and faba bean.

Research outputs and progress

Recombinant inbred line populations have been developed for lentil and chickpea and are under development in faba bean. SSR markers have been developed for lentil (50) and faba bean (50). Germplasm accessions have been characterized for molecular markers and the data used for diversity analysis. Transformation protocols have been optimized for lentil and chickpea, and are under development for faba bean.

Quality of science applied in the program

Seven peer reviewed publications in the past five years. The lab published the first genetic map of lentil that included SSR markers. This development reflects quality of science.

Capacity building and regional cooperation

The lab provides hands-on-training in the use of advanced molecular techniques to scientists from NARS. Several training courses are conducted each year to train NARS scientists in the techniques of biotechnology.

Support needed

The facilities have been enhanced with the construction of a new Biosafety facility with a 200m^2 P2 biosafety glasshouse.

Recommendations

An insufficient number of co-dominant molecular markers are available for genetic mapping in lentil and faba bean. The number of genetic markers can be increased substantially through close collaboration with advanced research institutions (ARIs) such as the University of California – Davis, or the University of Saskatchewan (that is developing a SNP chip for lentil genotyping) There may be other ARIs that would be very willing to form collaborations. **It is therefore recommended that the biotechnology laboratory develops further collaboration with ARIs for marker development in the food legume crops. (Recommendation 2a)**

It is also recommended that the biotechnology laboratory validate and accelerate the use of molecular markers in the breeding and pre-breeding programs for chickpea and lentil. (Recommendation 2b)

It is also recommended that the biotechnology program in collaboration with GRS and the plant breeders expand molecular marker facilitated introgression of genes from the wild species into cultivated genetic backgrounds in support of increased emphasis on pre-breeding. (Recommendation 1)

4.7 Integrated Pest Management

Biotic stresses (insect pests, diseases and weeds) are major constraints to food legume productivity. Several insect pests and diseases are associated with faba bean, lentil and chickpea and cause considerable yield loss. The magnitude of loss, however, varies in different regions depending on, pest species and prevalence, crop stage and the nature and extent of damage. Host plant resistance is a noble strategy but may not be available for all stresses. Therefore, an integrated approach involving host plant resistance, cultural practices and use of eco-friendly pesticides is needed. The IPM program of ICARDA addresses issues of some key insect pests and diseases (viral and fungal) prevalent in CWANA, Nile valley and sub-Saharan African. The program includes virology, fungal pathology and entomology sections.

4.7.1 Virology

Objectives and approach

The major objectives are molecular characterization of viruses, developing diagnostic kits and screening techniques, testing for seed borne-viruses and studying variability among viruses.

Relevance to NARS priorities, EPMR/CCER recommendations and Climate change issues
Virus diseases pose serious threats to faba bean in CWANA region. Of particular concern is FBNYV in Egypt, Jordan, Syria and Turkey; BLRV in Iran; BWYV in Tunisia and Turkey; and BYMV in Egypt, Iran, Jordan, Sudan and Syria. Therefore, research on molecular characterization of these important viruses, developing diagnostic kits and screening techniques are important to developing control strategies. Detection methods for seed borne

viruses are needed to control unwanted spread through seed sources. These objectives of the virology program conform to ICARDA's strategic plan. No specific recommendations on these aspects were made by EPMR/CCER. With climate change, virus diseases may take on greater importance for food legume production. A proposed plan to survey for the presence of different viruses in different countries of CWANA is appropriate. Production of diagnostic procedures for NARS scientists will assist in timely diagnosis of viruses.

Research thrusts

With climate change being experienced globally, new viruses may emerge that will need to be monitored and diagnosed. Prediction models using GIS need to be developed for advanced warning of the spread of existing and new viruses. Development of new diagnostic kits and more efficient screening techniques should continue. Management options to control viral diseases should be developed.

Research outputs/outcomes

A new diagnostic kit has been developed for detection of chickpea chlorotic stunt and chickpea chlorotic dwarf viruses. A simple, fast, less expensive and reliable kit (TIBA) for detection of FBNYV developed earlier has been used in many countries including Libya, Tunisia, China, Iran and Azerbaijan. Many new legume viruses were identified for the first time and characterized by serological and molecular analysis. Screening methodology for aphids has been standardized. In screening, 15 faba bean lines have been found to be resistant to bean leaf roll virus (BLRV). A large number of seed samples received from NARS has been screened against seed-borne diseases each year. A mobile laboratory for on spot detection of viruses is used extensively.

Quality of science

Twenty-one research papers have been published in peer reviewed journals, five book chapters and a new kit for detection of chickpea chlorotic stunt and chickpea dwarf viruses has been developed which reflect quality of science.

Capacity building

Two Ph.D. and two M.Sc. students have been guided for their professional degrees. Several NARS scientists have been trained in virus detection techniques, identification and characterization.

Support needed

The unit has well equipped laboratories and four glass houses. Enhanced funding is required for production of diagnostic reagents for use by NARS scientists.

Recommendations:

Resistance to important viruses is an important goal of the breeding programs.
It is therefore recommended that the virology section become pro-active in collaboration with the Germplasm Resources Section and the breeding sections in

identifying new sources of resistance to important diseases and pests. (Recommendation 7a)

The panel also recommends that the virology section assess the effects of climate change on the likely emergence of new viruses and virus vectors of the food legume crops. (Recommendation 7b)

4.7.2 Pathology

Objectives

The main objectives are identification of sources of resistance to major soil-borne and foliar diseases, phenotyping of mapping populations, studying pathogenic variability and monitoring effects of weather and temporal and spatial variables on dynamics of pathogens of food legumes.

Relevance to NARS, EPMR/CCER recommendations and climate change issues

Ascochyta blight is a serious disease of faba bean and chickpea in CWANA region, South Asia and China. Similarly, fusarium wilt is a wide spread soil-borne disease of chickpea and lentil. Botrytis grey mold (Chocolate spot) and stemphylium blight are endemic in Bangladesh, Nepal and eastern India. Chocolate spot in faba bean and rust of lentil are also important diseases. Therefore a focused research program on these diseases is important. Several races/pathotypes of these pathogens exist in nature and need to be identified and characterized using tools of molecular biotechnology. Screening breeding materials and germplasm to identify sources of resistance is the core activity for development of varieties against diseases. The program on effects of weather variables on pathogen dynamics needs to be strengthened.

The recommendation of the recent EPMR on spatial mapping of diseases in collaboration with GIS unit has not been implemented.

Research thrusts

With climate change, new races/pathotypes may emerge that will need to be identified and characterized. Minor diseases are expected to become major and may include fusarium wilt in winter chickpea and chocolate spot caused by *Botrytis cinerea* and/or *Botrytis fabae* in faba bean. Extensive surveys and monitoring of diseases are important. Presently there is no source of highly durable resistance to chocolate spot, ascochyta blight and stemphylium blight of faba bean and chickpea. Further the crops are often attacked simultaneously by one or more of these diseases. Therefore, new sources of multiple and stable resistance need to be identified. The plant pathologist collaborates with the breeders in screening breeding materials for resistance and assists in constituting international screening nurseries. The research on evaluation of silicon fertilizers for wilt management and salinity for wilt interactions are of academic interest and do not fit well in priority areas. The chickpea wilt sick plot lacks uniformity of infestation which causes errors in screening for resistance. Also,

dry root rot is becoming a constraint to chickpea production and currently there is no facility for screening for resistance.

Research outputs/outcomes

Several lines have been identified for resistance to ascochyta blight, Fusarium wilt and chocolate spot and used by ICARDA breeders. Stemphylium blight resistant lines, ILL 6002 and Barimasur 4, 5 and 6 have been used by Washington State University, Pullman and Bangladesh to determine the inheritance of resistance and to map the quantitative trait loci for resistance. Similarly, chocolate spot resistant lines, ICARUS, ILB 4726, ILB 4427 and ILB4615 have been used in Australia and Ethiopia. New techniques have been developed for screening for resistance to ascochyta blight and collar rot in chickpea and rust in faba bean. A new wilt of chickpea caused by Verticillium has also been reported. IPM techniques for management of ascochyta blight in winter chickpea has been developed and demonstrated on farmers' fields in Syria.

Quality of science applied

Sixteen research papers have been published or accepted in peer review journals. New races/pathotypes of chickpea wilt and many resistant lines to ascochyta blight and stemphylium blight have been identified and shared with NARS and ICARDA breeders. This clearly reflects the quality of science applied in the program.

Capacity building and partnership

Sixty research personnel from NARS have been trained at ICARDA and nine students have been guided to M.Sc. and Ph.D. degrees.

Support needed

Growth chambers and incubators are required for carrying out research during the hot summer season. Since some diseases do not occur in Syria, pathologists from ICARDA and NARS need to collaborate. The new containment facility should be made available to pathologist for research on exotic pathogens. In collaboration with the GIS unit there is need to map the occurrences and likely spread of important diseases and insect pests with climate change.

Recommendations:

With climate change the scenario of insect pests and diseases will be altered and new races of pathogens and insects may emerge and pose serious threats to legume productivity. **Therefore the panel recommends that a spatial disease map be developed in collaboration with the GIS unit and prediction models on occurrence and severity of diseases be developed for planning research and design management practices**. **(General Recommendation 16)**

The panel also recommends that a new wilt sick plot with greater uniformity of infestation be developed. **A dry root rot sick plot should also be established at the center. (Recommendation 3)**

The panel therefore recommends that the plant pathology section become pro-active in collaboration with the Germplasm Resources Section and the breeding sections in identifying new sources of resistance to important diseases. (Recommendation 7a)

The panel also recommends that the plant pathology section consider the effects of climate change on the likely emergence of new diseases of the food legume crops. (Recommendation 7b)

4.7.3 Entomology

Objectives

The main objectives are to identify sources of resistance against key pests infesting food legumes and develop eco-friendly IPM practices for controlling insect damage in the CWANA region.

Relevance to NARS priorities, EPMR/CCER recommendations and climate change issues

In WANA region, leaf miner is an important insect pest of spring chickpea; whereas, aphids are important pests of lentil and faba bean. In some areas, Sitona weevils cause damage to root nodules and hamper biological nitrogen fixation. Helicoverpa pod borer may emerge as a major pest in chickpea in the near future with the expected warmer climate. Thus, the entomology research program is relevant. No specific recommendations were made by EPMR/CCER concerning insect pests.

Research thrusts

Leaf Miner is an important insect pest of chickpea and aphids are important pests of lentil and faba bean in CWANA. Development of eco-friendly and cost effective IPM practices for effective control of damage from insects is a priority. Resistance breeding against these pests has provided partial solutions to the problems of leaf miner of chickpea and sitona weevil of lentil when combined with other management options. Continued improvement of resistance to these pests will require a new approach that may include genes from related wild species. Sitona weevil affects lentil yields and biological nitrogen fixation; however, the extent of the damage from the insect should be more clearly quantified. Collaboration with the soil microbiologist, expected to be appointed soon, regarding quantification of the effects of sitona on biological nitrogen fixation is encouraged.

With climate change helicoverpa pod borer may emerge as a major pest of chickpea in CWANA and therefore studies on its occurrence, life cycle, nature and extent damage/yield losses should receive greater attention. Conservation and enhancement of natural enemies of helicoverpa pod borer should receive priority.

Research outputs/Outcomes

Screening techniques against sitona and leaf miner have been refined. Successful IPM packages have been developed for chickpea leaf miner, pea aphid on lentil and aphids on faba

bean. Screening germplasm against these pests has provided partial resistance to leaf miner and has successfully identified accessions of wild lentil as having some resistance to sitona. Accessions of chickpea with resistance to leaf miner have been registered and are available to plant breeders.

Quality of science

Seven research papers on resistance to sitona of lentil and leaf miner of chickpea have been published in peer reviewed journals. Also, IPM modules have been developed for leaf miner of chickpea and aphids of lentil and faba bean.

Capacity building and partnership

Schools for demonstrating IPM for the control of aphids have been conducted in Ethiopia and Sudan and for chickpea leaf miner in Morocco.

Support needed

In addition to legume responsibilities, the entomologist has responsibility for wheat and is conducting impressive work on Hessian fly resistance. Additional Technical assistance is needed to augment research on insect resistance in the food legumes.

Recommendations

Helicoverpa pod borer is the most important pest of chickpea in South Asia. With warmer climate, it may become a more important pest in CWANA, Nile valley and Sub-Saharan Africa region region. **Research on Heliocoverpa is currently underway at ICRISAT. Entomologists at ICARDA and ICRISAT should conduct collaborative research on the biology and control of this important pest. Therefore the panel recommends that collaboration between ICARDA and ICRISAT be established for comprehensive research on Helicoverpa pod borer. (Recommendation 4)**

The panel recommends that the entomology section form collaboration with the Germplasm Resources Section and the breeding sections in identifying new sources of resistance to important insect pests of the food legumes. (Recommendation 7a)

The panel also recommends that the entomology section consider the effects of climate change on the likely emergence of new insect pests of the food legume crops. (Recommendation 7b)

Chapter 5. Seed Section and Seed Supply Chain

ICARDA has established a seed section with basic objective of providing seed services within the Center to meet the requirements of its own commodity and natural resources programs. It also facilitates strengthening national seed delivery systems and creating vibrant seed markets in which seed and crop varieties are exchanged freely for larger adoption and greater impact. It has done well in delivering the required quantities of seeds of improved varieties within ICARDA and in some of the countries with good seed production and

delivery systems. The seed section is also playing a key role in providing technical backstopping to formal and informal seed sectors by stimulating the private sector in seed supply chain. It is also involved in capacity building in seed production, storage and marketing to seed producers in NARS.

The seed section needs to be strengthened with respect to seed production capacity to meet the needs of ICARDA and also to supplement the seed requirements of the collaborating partners. Therefore, seed processing, sanitation and storage facilities need to be given priority for modernization.

Seed sector plays a key role in accelerating adoption of improved varieties. Effective linkage between R&D organizations (national and international), seed industry and line (???) departments is critical in promoting improved varieties. Incentives to public and/or private sector and legal and regulatory framework influence multiplication of seed of improved varieties. Unfortunately, the formal seed sector covers less than 10 percent of the total seed demand in most of the developing countries. It may be much less for legumes as both public and private sectors do not have incentive because of low profitability. In the absence of an effective seed supply chain, the benefit of improved varieties of legumes cannot reach the farmers and consumers. Therefore, studies need to be targeted to develop mechanisms for developing seed supply chains. The following research programs should be initiated in partnership with the national programs:

- Document national seed polices of important countries in view of new IPR regime.
- Understand the existing seed supply chains in food legumes and identify key factors that inhibit multiplication of improved seeds by public or private sectors.
- Draw lessons across different countries and evolve farmer-friendly seed policies for major countries

ICARDA economists have tracked the role of informal farmer-to-farmer seed distribution in diffusion of new barley varieties in Syria. More such studies are needed for food legumes in order to understand the seed supply chain and evolve institutional arrangements for accelerating adoption of improved varieties. The research programs need to be undertaken in collaboration with the Social, Economics and Policy Research Program because the seed sector is linked with adoption studies and assessing stakeholders' preferences.

A major constraint to adoption of new chickpea and lentil varieties has been the seed production and distribution system in most of CWANA including Syria. A more efficient system is crucial to delivering new varieties and production packages to the farmers. **It is therefore recommended that ICARDA take the lead in formulating and promoting an efficient seed delivery system in cooperation with NARS partners that will enable the timely distribution of improved varieties and production packages to the farmers. (Recommendation 14)**

Chapter 6 Capacity Building and Regional Cooperation

ICARDA has a very strong capacity building program in its mandated areas. The Center has accorded due importance to the human resource development by offering various kinds of

training programs. It was reported that more than 16,000 people across the world have been trained by ICARDA since its inception. During the reporting period, 526 people from 39 countries were given training through short-term courses, individual no-degree programs, and degree programs. This is an excellent accomplishment in the area of human resource development. It is notable that each project of the Center has a built-in mechanism for capacity building. The Center is engaged in providing non-degree as well as degree programs in priority areas. Broadly, the non-degree capacity building program of ICARDA is divided into four areas: (i) center level programs; (ii) thematic programs; (iii) project specific programs; and (iv) country specific programs. These programs are improving the capacity of the national partners in frontier research areas, and strengthening the national agricultural research systems of the developing countries.

ICARDA is also engaged in offering degree programs with reputed universities and institutions. It provides an opportunity to students to conduct research in ICARDA's projects as part of their master or doctoral thesis. This graduate research program is especially designed to provide an opportunity to young researchers from developing countries to undertake research with international professionals and expose them to state-of-art research facilities. Under this program, the graduate students have access to research facilities and they also receive financial support to cover their research and subsistence. The research under this program has been carried-out in following broad categories: (i) biodiversity and integrated gene management; (ii) integrated water and land management; (iii) socio-economics and policy research; and (iv) diversification and sustainable intensification of production systems. It is reported that more than 600 M.Sc. and Ph.D. students did their research with ICARDA scientists. During the reporting period, 104 students from 15 countries (Algeria, Australia, Azerbaijan, Bangladesh, Ethiopia, Georgia, Germany, Iran, Iraq, Japan, Lebanon, Morocco, Pakistan, Palestine and Syria) did their degree programs with ICARDA scientists, and significantly contributed in research outputs. The program is contributing in developing future scientists. These are instrumental to strengthening ICARDA's relations with research institutions and universities in developing and developed countries.

ICARDA acknowledges the importance of capacity improvement of its national partners. It recognizes that quality research cannot be achieved without a well trained cadre of scientists in national programs. However, during the reporting period, the number of trainees under non-degree programs has shown a declining trend. It needs to be reversed and more project-based and theme-based programs should be organized for developing a strong network of professionals in food legume. Need assessment for capacity building under theme-based programs may be done to meet the expectations of NARS. Degree programs in high priority areas should be further strengthened by making the program more popular in developing countries. ICARDA should initiate post-doctoral programs by hiring post-docs for two years in different food legume programs by assigning specific research activity. Modern approaches, like e-learning and distance education, may be used to reach more stakeholders. Since emphasis has been given to capacity building, it would be good to take stock of how the capacity building program has influenced and improved the NARS capacity.

Recommendations

ICARDA has a highly qualified and competent scientific staff to offer training and guidance to students pursuing degree programs. **To attract students from NARS the panel recommends that fellowships be provided to support degree programs. In-service**

candidates may also be given the opportunity to acquire advanced degrees. (Recommendation 12)
Many of the professional and technical staff of the NARS programs lack sufficient training in the areas of crossing techniques and plant breeding. This is especially true for programs where there have been recent personnel changes. **It is therefore recommended that ICARDA expand opportunities for NARS scientists and technicians to upgrade their skills in these areas. (Recommendation 13)**

Chapter 7. Partnership and Regional Cooperation

ICARDA has a strong research partnership with NARS, CGIAR Centers and advanced research institutes. It recognizes the importance of partnership for larger impact of research and capacity building programs. In this process, ICARDA has developed a good network of partners for its outreach programs in all the mandated commodities and socio-economic program. It has signed 185 agreements of collaboration with national governments and other partners. It is indeed remarkable and deserves panel's appreciation. **Through this partnership ICARDA facilitates exchange of knowledge for enhancing NARS research capacity and dissemination of improved technologies to improve income and livelihood of farmers in dry areas. The holistic approach adopted by ICARDA in addressing the problems of the non-tropical dry areas is highly rewarding.**

Since NARS in dry areas have diverse strengths with respect to excellence in research capacity and infrastructure, strategic partnerships should be formalized. Through NARS, ICARDA should also reach to Civil Society Organizations, private sector and policy makers, who would play an important role in accelerating adoption of research outputs.

For effective regional cooperation and partnership, a 'hub-and-spoke' policy should be adopted. Regional offices should be strengthened with more facilities and decentralization. Regional level need assessment on research, capacity building and constraints should be taken up for prioritizing research, human resource development and identifying key partners.

Chapter 8. Gender Implications

Legumes are more prone to diseases and insect pest infestations during production and storage. Invariably, farmers' own stored grain from the previous harvest is used as seed. The infested seed adversely affect the production and productivity of the crop, and hence the income and livelihood security. Studies show that women play an important role in production and storage of food legumes. They are also engaged in livestock production, which uses legumes as a source of feed and fodder. In many developing countries, especially in dry areas, male migration is transforming the traditional role of women in agriculture. Also, female-headed rural households are the poorest and most marginalized in dry areas. Therefore, there is a need to empower women through technology intervention, institutional reforms and policy changes. ICARDA can play an important role by introducing improved technologies and facilitate institutional reform to empower women in agriculture. Therefore, women farmers may be given training on seed production, storage and judicious use of legumes. Location-specific capacity building programs may be organized with national partners in the region to acquaint women farmers about best production and utilization practices for legumes.

ICARDA did some studies showing the impact of improved technologies on the livelihood of women farmers. Such studies should continue while assessing impact of improved technologies. The studies may also diagnose how women farmers can be effectively used in the entire supply chain of legumes.

Chapter 9 Impact

Three impact studies by socio-economic program have shown:

- The winter/early spring chickpea planting technology developed by ICARDA is adopted in more than 600,000 hectares, providing farmers with additional income of US$ 72 million per year.

- A lentil study in Bangladesh showed that the annual economic gains resulting from the release of an improved variety were about US$ 30 million per year.

- A study on faba bean in Ethiopia, Egypt and Sudan showed that new technology brought a degree of 'upward mobility' of adopter farmers against poverty; 30% in Egypt, 12% in Sudan and 3% in Ethiopia.

More studies are needed to determine the impact of ICARDA developed technology. Such studies would also attract donors for their support in alleviating poverty and malnutrition in dry areas.

Earlier review missions have recommended that each research activity should have an impact and adoption assessment included in the project plan from the outset. This panel fully supports this and strongly recommends that adoption and impact assessment should be a part of the research program. Impact studies should be planned by the socio-economic and policy division with key national partners to assess impact of improved varieties, and document constraints in their adoption. Such a study will also provide insights on the key characteristics (or traits) preferred by different stakeholders in the food legume supply chain in different agro-ecosystems for prioritizing research strategy for higher impact. Socio-economic and policy program should also be involved in technology targeting based on the resource endowments and government policies for accelerating impact.

Recommendations

The panel recommends timely assessment of the impact of improved varieties and new production technology. (Recommendation 15)

Chapter 10. Oscillating Prices and Prospects of Food Legumes

Prices of most of the food legumes, especially of chickpea and lentil, are rising due to demand-supply gap in major pulse consuming countries. The demand-supply gap is likely to grow more in coming years due to increasing population and rising incomes. The growing gap between demand and supply of chickpea and lentil would further raise their prices and would lead to more trade between surplus and deficit countries. The relative profitability of these crops would increase manifold due to rising prices. Higher prices and profitability will induce more farmers to grow chickpea and lentil, raise their incomes, alleviate poverty and improve food and nutritional security.

Therefore, this is an opportune time for legume research to demonstrate its impact. ICARDA should not miss such an opportunity to show its impact as there is demand for more legumes and supply is severely constrained. The current scenario is expected to expand area under these crops in traditional areas. These crops will also move to non-traditional areas due to higher profitability, as was seen in case of winter chickpea in Syria, which started expanding in Zone 2. Higher impact is expected in non-traditional areas as the farmers in these regions are receptive to new seeds and better management practices. Such a move will cover more poor farmers in dry areas for raising their incomes and alleviating poverty. This can be achieved by: (i) ensuring an effective seed supply chain of improved varieties; (ii) capacity building of farmers on cultivation practices in non-tradition areas, (iii) improving markets in traditional producing areas, and (iv) developing new markets in non-tradition areas.

Unfortunately, in most developing countries, markets for chickpea and lentil are inefficient. A large share of higher prices is taken by market intermediaries in the food legume supply chain. The challenge is to link farmers with remunerative markets. Appropriate institutional arrangements, domestic market policies and trade policies would benefit farmers as well as consumers of chickpea and lentil. Therefore comprehensive studies of demand, supply and trade should be undertaken in selected countries.

Chapter 11. Balance of R&D Funding to Food Legumes between Public and Private Sectors

Food legumes receive relatively lower priority for R&D funding in view of their limited area and contribution to the value of agricultural output. Funding criteria for legumes may be expanded in view of their contribution to nutritional security and environmental services. These commodities are rich sources of protein and also contribute significantly to soil health. In addition, they deserve more R&D funding because these are grown in marginal and difficult areas where probability of research success is lower than in more favorable and better endowed areas. They deserve more funding as a large proportion of poor and poverty ridden population rely on their production for their food security. Additionally, their prices are oscillating and also rising due to high production uncertainty, growing demand-supply gap and unfavorable national policies for food legumes. In view of these, the food legumes should receive high priority for increased funding.

It is clear that the private sector is unlikely to fund R&D in food legumes without incentives such as hybrid technology and/or transgenics. The private sector may also possibly join to fund R&D programs if high-value processed products from legumes are developed and marketed. These appear to be not possible in the near future. Therefore, the support to R&D for legume research will come largely from the public sector and organizations concerned with alleviating poverty and malnutrition. To attract higher R&D funds for food legumes, ICARDA should have a multi-pronged strategy:

(i) Approach donors who are more concerned for poverty alleviation and food and nutritional security,

(ii) Explore new donors who are concerned about environment, natural resources and climate change,

(iii) Develop a consortium of donors for restricted funding from developed and developing countries where legumes are grown and/or have high potential,

(iv) Develop a network of legume researchers in NARS to jointly utilize existing resources and explore sources of supplement funds for on-going research.

One area that may attract more R&D resources to legumes is by projecting their contributions towards improvement in environmental services, and mitigation and/or adaptation of climate change. Some empirical analysis from the point of environmental services by legumes needs to be undertaken to justify additional research resources. Their adaptation and/or mitigation in the event of climate change also need to be projected for seeking R&D funds. This aspect would attract new donors who are more inclined to fund for environmental services.

It is the opportune time to attract more R&D funds as the current global situation is favorable for legumes.

Chapter 12. Farm Management at ICARDA

12.1 *Crop Management*

Integrated crop management practices like seedbed preparation, plant population, nutrient and pest management, are imperative to realize high yields and correct assessments of genetic potential of advanced breeding lines/varieties. The following farm management considerations are important to obtaining the best estimates of the genetic potential of new selections and improve farm productivity.

1. Timely crop residues incorporation.
2. Seed rates appropriate to the variety and farming practices.
3. Depth of planting appropriate to the soil conditions and time of planting
4. Soil nutrition analysis. (It was mentioned that soil fertility map of research farm was prepared about 15 years ago.)
5. Addition of nitrogen fertilizer as a starter
6. Use of Rhizobium bacteria for seed inoculation.
7. Weed control

In the context of climate change and changing fertility status of soils, a new set of crop management trials should be initiated on tillage options and nutrient, drought and weed management. **We therefore recommend that an Agronomist be appointed for food legumes to work with NARS agronomists and field crop specialists to develop and refine crop management practices for newly released varieties in CWANA and South Asia. (Recommendation 11).**

12.2 *Farm Machinery and Equipment*

Farm machinery and equipment at the Center are intended to perform operations needed in the research fields (about 250 ha) and in the cover crop/production areas (about 510ha). The mechanical operations performed by that machinery and equipment include:

- Land preparation (primary, secondary tillage and rolling).
- Planting.
- Herbicides, pesticide and fertilizers application.
- Harvesting.

In the ”Annual Plan of Work” of the Center, the field activities carried out for plant production in ICARDA’s Research Station was discussed. Residue removal is not common practice on the station. Primary tillage operations depend on the crop rotation, however, deep plows such as the moldboard is used in most cases. Secondary tillage operations depend on; a) previous tillage, b) soil type and condition, c) requirements of the new crop, and requirements of available planting equipments; however, several secondary tillage implements such as sweep, and rotating spike tooth harrow are used. Fertilizing operations are performed by manure spreader if organic fertilizers are used or by broadcaster if granular fertilizers are used. In both methods of adding fertilizers prior to planting, secondary tillage implements are used to incorporate the added fertilizers into the soil. The most common way of adding granular fertilizers is with the grain drill with planting. Additional doses of solid or liquid fertilizers if needed are applied using a broadcaster or sprayer. Planting research trials is accomplished with field plot planters for small and medium sized seeds, however, large seeded crops are planted by hand. Planting in the cover fields are done with the grain drill. Rolling after planting is important for better germination and to form a smooth surface for ease of mechanical harvesting. Therefore the use of a roller attached behind the seed drill or in a separate operation is used in the research and cover crop fields. Herbicides and pesticides are added after germination by using boom sprayers or granular spreaders. Harvesting is done by the plot harvester in the research fields and by grain combine in the larger cover crop fields; however, grain losses are high when using the grain combine with single knife cutter bar to harvest the legume crops. Use of double knife cutter bar on the grain combine reduces grain losses of legume crops. One combine harvester from Class with double knife cutter bar is being used at the station.

The following table shows the farm implements used in the research and cover crop/production fields at ICARDA’s Station for the legume crops. The same farm implements are used for cereals and other crops.

Name of operation	**Research fields**	**Cover/Production crops**
Land preparation for: a) lentil b) chickpea c) faba bean d) grasspea after cereals	Moldboard plow followed by roller with 2 rows of sweeps in front then powered rotating spike harrow for soil pulverization and leveling	Moldboard followed by powered spike harrow
Seeding for: a) lentil b) chickpea c) faba bean	Experimental plot drill Experimental plot drill Furrow opener (sweep) then	Grain drill attached to spike Pneumatic seeder at 45 cm spacing between rows

d) grasspea	hand drilling Experimental plot drill	Not planted Grain drill attached to spike harrow
Fertilizing for: a) lentil b) chickpea c) faba bean d) grasspea	Broadcaster before spike tooth harrowing and/or after germination if needed	Same as in the research fields
Weed control for: a) lentil b) chickpea c) faba bean d) grasspea	Mechanical (inter-row) cultivation and chemical by boom sprayer	No Inter-row cultivation
Harvesting of: a) lentil b) chickpea c) faba bean d) grasspea	Plot harvester Plot harvester Plot harvester Plot harvester	Combine with double knife cutter bar for lentil, chickpea, and grasspea
Threshing of: a) lentil b) chickpea c) faba bean d) grasspea	Thresher after hand harvesting	No

When asked why such slow and costly farm implements were used in performing the agricultural farm operations, the answer was that the plot planters used in the research fields were appropriate. However, no explanation could be given for the excessive use of such implements in the cover crop fields. From the long term studies made and experiences gained, chisel plow, sweep, roller, sprayer, fertilizer applicator, grain drill, double knife cutter bar, swather, rake, baler and combine harvester are the most suitable farm implements needed for the cultivation of dry lands for the production of cereals and food and feed legumes. Visits made to the farm machinery units showed that there is a need for new machinery and equipment to gradually replace the rundown and obsolete implements with most appropriate ones. However, replacement should not be done before scientists and farm machinery specialists discuss the situation together and come to agreement on the types of farm machinery needed. In principle, moldboard and rotary powered harrows are certainly not the type of farm implements needed to perform the farm operations in the research and production operations. Furthermore, if zero tillage is successful, the chisel and sweep may not be needed; however, no-tillage grain drills will be needed in place of standard grain drills.

Releasing improved varieties of food legume crops should be coupled with recommendations of agronomic practices similar to these used to develop and test the released varieties,

otherwise, the potential productivity of such varieties will not prevail in the farmers fields when the traditional agronomic practices are used (as observed in several visited farmers fields).

12.3 *Zero tillage*

Lately, ICARDA is performing limited work on zero-tillage; however, it was noticed that such work is not being done in a holistic manner. Therefore, ICARDA should establish a comprehensive research program to generate data and understand all aspects of zero-tillage over a long term basis. Such work should be done with the involvement of agronomists and soil scientists for an extended period of time to formulate recommendations on application of zero tillage to food legume production.

Zero tillage has proved promising in several areas as it reduces the cost of production, facilitates timely planting and improves soil health. Limited work on zero-tillage has been carried out by the center. **Therefore the panel recommends that a comprehensive research program on zero tillage be established. (Recommendation 17)**

12.4 Mechanical Harvesting

One of the major constraints to cultivation of lentil is lack of suitable mechanical harvesting. Hand harvesting is a time consuming and costly operation. The main reason for hand harvesting is short plant stature and seed and pod shattering. The uneven and stony soil surface prevents the use of combine harvesters.

ICARDA's research program on breeding of food legumes includes work on developing cultivars suitable for mechanical harvesting and was successful in doing so in winter chickpea. However, lentil and spring chickpea needs continued work toward a more erect and upright plant habits. However, through visits made to several growers of food legumes in Syria it was noticed that farmers were finding difficulties in mechanizing the harvesting operations. Among the reasons mentioned for such difficulties were short plant stature and method of sowing, hand broadcasting followed by mechanical covering, which results in an uneven soil surface and difficulties for machine cutting.

Chapter 13. Personnel

ICARDA has highly qualified scientists and technicians; however, to implement the program as envisioned in the strategic plan 2007-2016 and to expand research activities as suggested by the panel, increased scientific staff through research associates/post docs and technicians is required. **(Recommendation 8)**

Chapter 14. Coordination, Partnership and Regional Cooperation

ICARDA has a strong research partnership with NARS, CGIAR Centers and advanced research institutes. It recognizes the importance and relevance of partnership for larger impact of research and capacity building programs. In this process, ICARDA has developed a good network of partners for its outreach programs in all the mandated commodities and socio-economic programs. It has signed 185 agreements of collaboration with national governments and other partners. It is indeed remarkable and deserves the panel's

appreciation. Through this partnership ICARDA facilitates exchange of knowledge for enhancing research capacity and information about improved technologies to meet the needs of farmers in dry areas.

Since NARS in dry areas are of diverse strength, mainly with respect to excellence in research and infrastructure, a strategic partnership is to be evolved. ICARDA should take advantage of strong NARS (such as Brazil, China and India) in expanding its research program. Through NARS, ICARDA should also reach to CSO, private sector and policy makers, who would play an important role in accelerating adoption of research outputs.

For effective regional cooperation and partnership, a 'hub-and-spoke' policy should be adopted. Regional offices should be strengthened with more facilities and decentralization. Regional level need assessment on research, capacity building and constraint assessment should be taken up for prioritizing research, human resource development and identifying key partners. ICARDA should also develop strategic partnership in mega programs proposed by CGIAR.

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Annex I. Schedule for CCER Activities

13 May – 3 June 2010	Panel carries out review at Tel Hadya. A detailed program for the presentations, meetings, and visits to outreach sites and NARS will be developed in consultation with the Panel chair.
3 June 2010	Panel presents preliminary findings to ICARDA management and staff
14 June 2010	Panel submits draft report to ICARDA management
21 June 2010	ICARDA submits to the Panel chair "factual" corrections and remarks
28 June 2010	Panel submits final report to ICARDA
28 June – 5 July 2010	Review of final report and development of draft response. Draft response reviewed by ICARDA Management Committee
12 July 2010	Center's draft response finalized for submission to Board
BOT48 2010	Board of Trustees reviews the report and the Center's draft response.

Annex II. Panel members and Their Bio-data:

Genetics and breeding:
Dr. Frederick J. Muehlbauer, Grain Legume Genetics & Physiology Research Unit, Research Geneticist (Collaborator), USDA-ARS and Washington State University, Pullman, Washington, USA (Panel Chair)
Dr. Xuxiao Zong, Group Leader, Principal scientist (Professor), Minor Legumes Research Group, Institute of Crop Sciences (ICS), Chinese Academy of Agricultural Sciences, Beijing, China
Cropping systems & dry land agriculture:
Dr. Masood Ali, Ex-Director, Indian Institute of Pulses, ICAR, Kanpur, India
Resource Persons:
Socio-economics: Dr. Pramod Kumar Joshi, Director, National Academy of Agricultural Research Management (NAARM), Hyderabad, India; former Director, National Centre for Agricultural Economics & Policy Research (NCAP), New Delhi, India
Mechanization of legume crops: Dr. Bassam Snobar, Professor of Agricultural Engineering, University of Jordan

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EDUCATION:

B.S.	Agronomy	University of Georgia, Athens, GA	1963
M.S.	Agronomy	Pennsylvania State University, University Park, PA	1965
Ph.D.	Genetics	Pennsylvania State University, University Park, PA	1969

PROFESSIONAL EXPERIENCE:

2006-present	Research Geneticist (retired). Currently serving as Collaborator, USDA-ARS, Washington State University, Pullman, WA
1981-2006	Supervisory Research Geneticist, USDA-ARS, Washington State University, Pullman, WA
1969-1981	Research Geneticist, USDA-ARS, Washington State University, Pullman, WA
1968-1969	Instructor, Agronomy, Pennsylvania State University, University Park, PA
1963-1968	Research Assistant, Agronomy Department, Pennsylvania State University, University Park, PA

Graduate Faculty Specialization:
Crop Science, Genetics and Cell Biology, Plant Breeding

Research Interests:
Genetics and breeding of crop plants with major emphasis on cool season food legumes and developing disease resistant cultivars and germplasm. Development of genetic maps of sufficient density to permit quantitative trait loci analysis. Introgression of genes from wild species closely related to cultivated chickpea and lentil. Identify molecular markers linked to disease resistance genes for use in marker assisted selection. Identify genes in *Pisum* and *Lens* for improved biomass and stem structural properties. Develop high biomass and residue producing germplasm of dry peas and lentils. Develop germplasm and cultivars of chickpea with resistance to ascochyta blight. Improve yield and quality traits of chickpea, lentil and dry peas.

Dr. Bassam A. Snobar, Member
Professor
University of Jordan
Amman, Jordan
snobar@ju.edu.jo

Dr. Snobar received his PhD and M.Sc. in agricultural engineering from Michigan State University in 1973 and 1970, respectively, and his B.Sc. from Alexandria University, Egypt, in 1967.

Professor Snobar served in Jordan as Vice-President of the Jordan University of Science and Technology, Dean of the Faculty of Agriculture and chairman of the Department of Plant production in the University of Jordan.

He also served as Member in the FAO Oversight Panel of the Special Program for Food Security (SPFS), 1997 to 2005, Team Leader of Tillage and Wheat Residue Management in Crop Rotation in Rainfed Areas of Jordan, 1989 to 2000, Project Director of Application of Biotechnology to the Development of Agriculture in Jordan, 1993 to 1997, Project Director of Improvement of Agricultural Productivity in Arid and Semi-Arid Zones of Jordan, 1993 to 1997, Chairman of Jordan Badia Research and Development Committee of the Higher Council of Science and Technology, 1993 to 1997, Member in the FAO Panel of Experts of Agricultural Engineering, 1990 to 1994 and Team Leader of Food Legume Improvement and Mechanization Project, 1989 to 1994.

Dr Masood Ali

Dr Masood Ali is former Director of Indian Institute of Pulses research, Kanpur, India. He has long research experience of 38 years on food legumes, dry land agriculture and cropping systems.

Born in 1947 in Uttar Pradesh, India, Dr Ali graduated in 1966 and obtained Ph.D. degree in agronomy from Indian Agricultural Research Institute, New Delhi, in 1971. He started his professional career as Scientist B in CSIR in August 1971 and then served State Agricultural Universities as Asst. Professor (GBPUAT Pantnagar) and Assoc. Professor (HPKVV Palampur) during 1972-76. He joined ICAR services in March 1976 as Agronomist at IGFRI, Jhansi and then moved to Indian Institute of Pulses Research (The then Project Directorate Pulses) Kanpur in 1982. He served there as Principal Investigator(Agronomy), Principal scientist and Head, Division of Crop Production and Project Co-ordinator (Chickpea) before taking over as Director of the institute in Feb. 2000.Dr Ali retired from this position in July 2009.

Dr Ali contributed significantly in improvement of food legumes and development of crop management practices for dry areas. In recognition of his outstanding contribution in food legume research and development, he has been awarded ISPRD Gold Medal, ISA Gold Medal and several other national and international awards. He served as President of Indian society of Pulses Research and Development for 7 years. He has worked as member of Senate of I.I.T., Kanpur and on Board of Management of Agricultural Universities. Dr Ali is Fellow of National Academy of Agricultural Sciences.

He has 328 research/scientific publications to his credit, edited/ authored 14 books, 13 research bulletins and contributed 27 chapters in books. He developed strategic partnership with ICRISAT, ICARDA and ACIAR on food legume research and created A-class research infrastructure and other facilities at Indian Institute of Pulses Research. Dr Ali participated in several international conferences/meeting /project development in various countries such as Australia, Germany, China, Egypt, Tunisia. Syria, Malawi, Thailand, Vietnam, Saudi Arabia, Myanmar etc

Dr. PK Joshi

Dr Pramod Kumar Joshi is currently the director of the National Academy of Agricultural Research Management (NAARM), Hyderabad, India. Prior to this, he was the director at the National Centre for Agricultural Economics and Policy Research (NCAP), New Delhi, India. Earlier, he has served the International Food Policy Research Institute (IFPRI), Washington, DC, USA as the South Asia Coordinator, and the International Crops Research Institute for the Semi Arid Tropics (ICRISAT), Patancheru, India as the Senior Economist. He has also worked as consultant for several international organizations such as the World Bank, Food and Agricultural Organization of the United Nations (FAO), and Consultative Group of International Agricultural Research (CGIAR). He has chaired the Governing Boards of SAARC Agriculture Centre, Dhaka, Bangladesh, and UN-CAPSA, Bogore, Indonesia. He was a member of the Bureau of the International Assessment of Agricultural Science and Technology for Development (IAASTD), and IBSA (India, Brazil and South Africa) Cooperation. He is a member of the International Steering Committee of the Challenge Program on Climate Change, Agriculture and Food Security (CCAFS); Member of the Independent Evaluation Group of the World Bank on Agriculture and Agribusiness; Fellow of the National Academy of Agricultural Sciences; Secretary, Agricultural Economics Research Association (India); Trustee and Treasure of the Trust for Advancement of Agricultural Sciences. He was Vice President of Agricultural Economics Research Association (India), and a Member of the Research Advisory Committee of the Indian Society of Agricultural Economics. He is also member of the editorial boards of several prestigious professional journals. He was the Secretary-General of the 4th World Congress on Conservation Agriculture. He is member of several committees and task forces constituted by various ministries in India. He is extensively traveled and published many journal articles and books. His areas of research interest are resource economics, impact assessment, institutions, markets and policies, and research management.

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Dr. Zong got his B.Agr.Sc. in agronomy, at Qingdao University of Agariculture, June 1984; got his M.Agr.Sc. in plant genetics and breeding, at Graduate School of CAAS, Beijing, June 1987; and got his Ph.D. in Plant Genetics, Breeding and Biotechnology, at China Agriculture University, Beijing, June 2008. Dr. Zong joined Chinese Academy of Agricultural Sciences (CAAS) in 1987 for 3 years as a junior researcher, at Minor Legume Crops Research Group, in the Institute of Crop Germplasm Resources (ICGR). As an assistant professor since 1991, as associate professor and Deputy Group Leader of Minor Legume Crops Research Group of ICGR since 1995, Zong took a responsibility on genetic resources, crop improvement projects of cool season food legume crops. Zong promoted to Group Leader of Minor Legume Crops Research Group, Institute of Crop Sciences (the new institute merged by Institute of Crop Germplasm Resources, Institute of Crop Breeding and Agronomy, part of Institute of Biotechnology), CAAS in 2003. As full professor (Principal Scientist), and group leader of Minor Legume Crops Research Group, Dr. Zong leads a team of 7 permanent staff (4 PhD holders) and 10 PhD/M.Sc. working on 17 species of food legume crops, with his sub-group concentrating in cool season food legume crops. As a member of Minor Crops Consultation Group, Ministry of Agriculture, Dr. Zong is responsible for guidance of food legume development in China. As an engaged professor of Fujian Agriculture University, Fujian province, Dr. Zong takes responsibility as a PhD supervisor on food legume researches. Dr. Zong takes also responsibilities as editors for *Journal of Plant Genetic Resources* (Chinese and English) and *Journal of Crops* (Chinese only), as peer reviewers for *ACTA GRONOMICA SINICA* (Chinese and English) and *Scientia Agricultura Sinica* (Chinese and English). Dr. Zong works also as a part time ICRISAT/CAAS international program coordinator.
During the past 23 years, Dr. Zong is directly working on pea, faba bean, chichpea, lentil, pigeonpea genetic resources, and genetic improvement of pea and faba bean. Dr. Zong involved over 40 national and international projects on food legume researches. DNA marker lab on food legume researches was established by Dr. Zong on genetic diversity studies, QTL analysis, linkage mapping development and gene mining. 20 PhD candidate and M.Sc. candidate got their degree from this lab. 4 pea varieties, 2 faba bean varieties and 1 chickpea variety were registered by Dr. Zong and his coordinators in provinces of China. 76 peer viewed papers were published in TAG, Genome, Plant Breeding, *ACTA GRONOMICA SINICA*, *Scientia Agricultura Sinica, Journal of Plant Genetic Resources,* Crop Science, Field Crops Research, Australasian Plant Pathology, by Dr. Zong as first author, corresponding author and coauthor. 38 book and book chapters were published edited/co-edited by Dr. Zong. 3 national prizes (1 first class and 2 second class), 3 ministry prizes (1 first class, 1 second class and 1 third class) and 1 provincial prize (second class) were awarded. 23 international trips, including scholarship, scientist position, consultant group member, trainee, meetings and workshops, were attended, with a 3 years international experiences.

Annex III. Terms of Reference

ICARDA has the global mandate for the improvement of four food legumes – lentil, kabuli chickpea, faba bean and grasspea. In light of the recommendations of the External Program and Management Review (EPMR) of 2006 and the CCER on Integrated Gene Management in 2005, and the development of ICARDA new Strategic Plan 2007-2016, the Center wishes to assess and review the progress made in its food legumes research and seek advice for future directions.

The Center is therefore commissioning an external review of its research program in food legumes that would address the aspects listed below and give recommendations for future improvement.

The review is expected to consider the entire scope of ICARDA's food legumes research for development: from plant genetic resources (PGR) conservation, evaluation and utilization, though plant breeding and crop management, to transfer to and adoption by farmers and its ultimate impact in the context of global food security and poverty alleviation.

The Review Panel is expected to develop a rigorous approach to conducting the review and a section on the methodology used should be included in the report. The Panel's final report shall include a summary of its findings together with its principal recommendations.

The review is expected to examine, through available documentation, meetings with Center staff and NARS partners, and visits to field research activities and outreach programs, the following issues and developments in ICARDA's food legume research program since 2005:

Research aspects

1. What is ICARDA's progress in addressing the recommendations of the 2006 EPMR and the 2005 CCER on Integrated Gene Management with respect to lentil, kabuli chickpea and faba bean?

2. Does the research program address the new directions and overall objectives adopted in the Center's Strategic Plan 2007-2016?

3. Are the program's research activities consistent with the CGIAR's systemwide research priorities and what is their relevance to the new research agenda and program structure of the CGIAR System?

4. In light of the recent food crisis, what is the role of legumes in global food security and how may this change over time? In this context, does ICARDA's food legumes research program address the priorities of national governments and agricultural research programs (NARS) in the dry areas? Are ICARDA's current research priorities for food legumes appropriate in addressing the constraints to increased productivity of these crops?

5. Is food legume research conducted within a production systems approach? Are there system-specific aspects of legume production within the farming system and farmer practices that demand a specific crop improvement strategy, which is identified and that could facilitate technology diffusion particularly among small scale producers?

6. Is the Center's food legumes research multidisciplinary and participatory? To what extent are socio-economic and policy aspects incorporated to improve research targeting, adoption and impact? To what extent is the research designed and conducted within a participatory framework with all partners and stakeholders including farmers? Are specific gender aspects associated with legume production, processing and consumption considered?

7. What are the implications of climate change for food legume production? Should ICARDA's food legume research be modified to address these challenges and, if yes, how?

8. What is the quality of the science applied in the research program, and are there approaches that should be newly implemented or expanded?

9. Should research on biological nitrogen fixation in food legumes be resumed?

10. How important is the need to strengthen research on anti-nutritional factors?

11. Is the research agenda addressing major pests and diseases affecting pulse production?

12. How effective are the activities of the Center's Seed Production Section in supporting both ICARDA's breeding program, and in assisting to transfer ICARDA's outputs to farmers' fields?

13. What is the scope and effectiveness of ICARDA's food legume PGR activities, including both *ex situ* and *in situ* approaches to agrobiodiversity conservation and utilization, plant genetic resource documentation and characterization, and the impact of the new International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) on conservation and exchange?

14. To what extent is research staff up to date with, and have the required capacity in, the latest research methods and technologies? Does the current mix of research staff provide the capacity needed to carry out the targeted activities?

15. Are the food legume technologies, including improved germplasm, developed by ICARDA, widely adopted by farmers and, if not, are the reasons known? Are appropriate routes to improving the adoption of these technologies being explored and followed? How is the feedback from the field on the constraints to legume productivity incorporated into the research priorities of the program?

16. What is the actual and potential impact emanating from food legume research and has it been adequately measured and published?

17. Has ICARDA clearly established its global position as an international Center of Excellence in lentil and faba bean research?

18. What research areas ICARDA should focus on more in the near future, and in the longer term?

19. Are there regions and/or agro-ecosystems in dry areas that require more attention and focus?

Coordination and Partnerships

20. Considering the balance of funding, globally, between the private and public sectors for R&D of food legumes, compared to other major crops, is ICARDA's food legumes research strategically well positioned in terms of research priorities, resources and partnerships?

21. Are current partnerships, including those with other CGIAR centers (e.g. ICRISAT for chickpea), advanced research institutions, national programs, civil society and the private sector, appropriate for advancing ICARDA's research in food legume improvement?

22. Is the research continuum, i.e. the relationship between strategic research at ICARDA's headquarters and collaborative research with NARS, adequate and effective? Are the research planning and coordination mechanisms between ICARDA and NARS partners sufficient and effective in maintaining the research continuum?

23. Are the Center's activities in institutional and human capacity development, and in strengthening regional cooperation, in food legumes improvement adequate?

24. Is the Center's relationship and advocacy with key national policymakers and NARS leaders effective in promoting the adoption of improved food legume production systems?

Program resources and management

25. Are the program's research resources (personnel, equipment and financial resources) adequate, and are they utilized and managed efficiently and effectively?

26. Are project management, monitoring and reporting arrangements effective and efficient?

27. Is the program successful in mobilizing funding and are resource mobilization efforts adequate?

Annex IV. Documents Made Available to Review Panel

ICARDA, 2005. Technical Guidelines for Quality Seed Production
Several brochures prepared by ICARDA on:

- Crop Biodiversity during conflicts and droughts in Northern Afghanistan
- Resilience of the informal seed system to conflict and drought in rainfed agriculture in Afghanistan
- Impact of emerging seed and fertilizer aid in Afghanistan
- Alternative seed delivery through village-based seed enterprises
- The ICARDA Seed Unit
- Seed health laboratory
- ICARDA Impact Brief (related to food legume), Nos. 2, 4 and 5
- Science Council Brief
- Fact Sheet
- Conservation Agriculture
- Management of Diseases and Insect Pests
- Helping Farmers Cope with Climate Change
- Salt Solutions
- Hot Spots of Vulnerability to Climate Change
- Food Legume Research

ICARDA, 2008. Annual Report
ICARDA, 2009. Caravan, Review of agriculture in the dry areas, Issue 26, 2009.
Book, 2009. The Lentil, Botany, Production and Uses.2009.
ICARDA, (Draft). Summary rewiew of faba bean research in the Nile Valley, Red Sea and sub-Saharan region and future recommendations
ICARDA, 2009. Medium-Term Plan 2010-12
ICARDA, 2007. Improving Livelihoods in Dry Areas, Strategic Plan 2007-2016
ICARDA, (Draft). Food Legume Strategic Focus Document 2011-2025
Report of 5th External Program and Management Review (EPMR) of ICARDA
Report of the Center-Commissioned External Review of the Integrated Gene Management Research of ICARDA, 2005.
ICARDA, 2009. Impact of crop improvement and Management, winter-sown chickpea in Syria.
ICARDA, 2007. Seed Production of Cool-Season Food Legume.
Book, 2---. Plant breeding and farmer participation. Variety release and policy options, Chapter 21

Annex V. Evaluation Methodology, Criteria and Approach

a. Presentations by group leaders to be followed by small group and individual interviews and discussions.
b. Examine the rationale, plans, execution and outcomes. Less attention to activities except as they detract from goals and expectations.
c. How do the plans and approaches address the center's mandate, strategic plans, long-, medium-, and short-term plans.
d. What is the status of the execution of the plans being discussed? Are there unforeseen obstacles? What is needed to complete the objectives?
e. What are the expected outcomes of the planned research? How will the outputs impact on strategic, short-, medium- and long-term plans? How will stakeholders benefit? What are the actual outcomes and impacts?
f. Questionaire given to project leaders
g. Visits to farmers and research institutes in Syria, Morocco and Turkey.
h. Interaction with research managers from NARS (India and Bangladesh)

Annex.VI. Schedule of Review Activities

International Center for Agricultural Research in the Dry Areas (ICARDA)

Biodiversity and Integrated Gene Management Program Review for the Food Legumes Research

Panel

Dr Fred Muehlbauer (Panel Chair)
Dr Masood Ali
Dr Zong Xuxiao
Dr Bassam Snobar
Dr Pramod Kumar Joshi

13 May – 3 June 2010

ICARDA Headquarters, Aleppo, Syria

Purpose: To review the Food Legumes Research at BIGM Program

May 11, 12, 13 and 14	Arrival of 4 panel members (Dr Muehlbauer, Dr Ali, Dr Snobar and Dr Zong successively)	Visitors Section
May 26	Arrival of Dr Joshi Accommodation at Park Hotel	Visitors Section
Thursday, 13 May		
08:30	Departure from Hotel to Tel Hadya	Visitors Section
09:00 – 10:00	Meeting with DG	Dr Mahmoud Solh
10:00 – 11:00	Meeting with ADG – CS	Mr Koen Geerts
11:00 – 12:00	Meeting with DDG – R	Dr Maarten van Ginkel
12:00 – 13:00	Lunch with Management	Canteen
13:00 – 14:30	Overview of Food Legume Program & discussion Michael Baum, Muhammad Imtiaz, Rajinder Malhotra, Fouad Maalouf, Seid Kemal, Safaa Kumari, Mustapha El-Bouhssini, Siham Assad and Zewdie Bishaw, Aladdin Hamwieh, Ken Street, Ahmed Amri	
14:30 – 15:30	Panel Preparation	
15:30	Departure to Hotel	Visitors Section

Friday, 14 May	Reading & preparing for CCER

Saturday, 15 May		
10:00	Sightseeing Tour in Aleppo	Visitors Section
Sunday 16 May		
08:30	Departure from Hotel to Tel Hadya	Visitors Section
09:00 – 12:00	Chickpea Improvement Program	Muhammad Imtiaz
12:00 – 13:00	Lunch	
13:00 – 14:30	Legumes Biotechnology	Aladdin Hamwieh
14:30 – 16:00	Meeting with IT Head	Zaid Abdul Hadi
16:00 – 17:00	Genetic Resources Section	Ken Street/Ahmad Amri
17: 00	Departure to hotel	Visitors Section
Monday, 17 May		
08:30	Departure from Hotel to Tel Hadya	Visitors Section
09:00 – 12:00	Faba bean Improvement Program	Fouad Maalouf
12:00 – 13:00	Lunch	
13:00 – 16:00	Lentil Improvement Program	Shiv Agrawal
16:00 – 17:30	Pathology, Entomology, Virology	Seid Kemal, Safaa Kumari, Mustapha Bouhssini
17:30	Departure to hotel	Visitors Section
Tuesday 18 May		
08:30	Departure from Hotel to Tel Hadya	Visitors Section
09:00 – 10:00	Meeting with SEPR program	Aden Aw Hassan & staff
10:00 – 11:00	Meeting with DISPS program	Barbara Rischkowsky & staff
11:00 – 12:00	Meeting with GISU Head	Eddy De-Pauw
12:00 – 13:00	Lunch	
13:00 – 14:00	Meeting with CDU Acting Head	Habib Ibrahim
14:00 – 15:00	Seed Health	Siham Assad
15:00 – 16:00	Meeting with IWLM program	Theib Oweis & staff
16:00 – 17:00	Report Writing	CCER panel
17:00	Departure to Hotel	Visitors Section
Wednesday 19 May		
07:30 – 09.00	Departure from Hotel to Breda farm	Visitors Section
09:00 – 12:00	Food Legumes Program at Breda & Farmer's Field	All
12:00 – 13:00	Lunch	
13:00 – 14:30	Grasspea improvement program	Shiv Agrawal
14:30 – 15:30	Seed Section	Zewdie Bishaw
15:30 – 16:30	Legumes Quality	Hani Nakkoul
16:30 – 17:00	Meet with Assistant Director General For Government Liaison	Dr Majd Jamal
17:00	Departure to hotel	Visitors Section
Thursday, 20 May		
	Panel members research tour and visit	Dr Majd Jamal

	to farmers' fields in Al-Ghab, Idleb and other possible sites	GL Office & Visitors

Friday, 21 May		
08:30 – 15:00	Panel discussions and preparations for travel	
Saturday, 22 May		
08:30 – 15:00	Preparing for travel to NARS partners in selected countries	
Sunday, 23 to Wednesday 26/27 May		
	- Panel visits to - Morocco, Ethiopia, Turkey - Program for each country to be developed in consultation with Drs Baum and Imtiaz	
Thursday, 27 May		
	Grouping and discussing the visit to GCSAR, Syria, ICARDA-Morocco, Ethiopia, Turkey	
09:00 – 11:00	IPM Field	
01:00 – 02:00	Biotechnology Lab	Aladdin Hamwieh
Friday, 28 May		
08:30 – 15:00	Panel discussions and writing	Visitors Section
Saturday, 29 May		
08:30 – 15:00	Panel discussions and writing	Visitors Section
Sunday, 30 May		
08:30	Departure from Hotel to Tel Hadya	Visitors Section
09:00 – 11:00	Report Writing	
11:00 – 12:00	Other Meetings as requested by Panel	
12:00 – 13:00	Lunch	
13:00 – 17:00	Report Writing	
17:00	Departure to hotel	Visitors Section
Monday, 31 May		
08:30	Departure from Hotel to Tel Hadya	Visitors Section
09:00 – 11:00	Report Writing	
11:00 – 12:00	Other Meetings as requested by Panel	
12:00 – 13:00	Lunch	
13:00 – 17:00	Report Writing	
17: 00	Departure to hotel	Visitors Section
Tuesday, 1 June		
08:30	Departure from Hotel to Tel Hadya	Visitors Section
09:00 – 11:00	Report Writing	
11:00 – 12:00	Other Meetings as requested by Panel	
12:00 – 13:00	Lunch	
13:00 – 17:00	Report Writing	
17: 00	Departure to hotel	Visitors Section

Wednesday, 2 June		
08:30	Departure from Hotel to Tel Hadya	Visitors Section
09:00 – 11:00	Report Writing	
11:00 – 12:00	Other Meetings as requested by Panel	
12:00 – 13:00	Lunch	
13:00 – 17:00	Report Writing	
17:00	Departure to hotel	Visitors Section

Thursday, 3 June		
- (Panel presents preliminary findings to ICARDA Management and Staff)		
08:30	Departure from Hotel to Tel Hadya	Visitors Section
09:00 – 12:00	Report Writing and Interviews as requested by Panel	
12:00 – 13:00	Lunch	
13:00 – 14:00	Presentation to Management and Staff of highlights of report and recommendations	
14:00 – 15:00	Wrap up Meeting with ICARDA Management	
15:00 – 17:00	Discussions with Staff (if needed)	
17:00	Departure to hotel	Visitors Section
Friday, 4 June		
	Panel's departure	Visitors Section

Monday, 14 June	Panel submits draft report to ICARDA Management
Monday, 21 June	ICARDA submits to the Panel Chair 'factual" Corrections and Remarks
Monday, 28 June	Panel submits final report to ICARDA
Monday, 28 June – 5 July	Review of final report and development of draft response. Draft response reviewed by ICARDA Management Committee
Monday, 12 July	Center's draft response finalized for submission to Board

Annex VII. Questionaires

Information to be submitted to Chair of CCER on Food Legumes Research at ICARDA 2005-2010 by 26th May 2010

1. Name of the program: Biotechnology/IPM/Genetic resources
2. Staffing:
    a. Scientists
    b. National Profession officer (NPO)
    c. Technicians
3. Budget (year-wise)
    a. Allocation
    b. Utilization
        i. Equipment/working contingencies
        ii. Travel
4. Research Projects (Year-wise)
    a. Projects in hand
    b. New initiatives/projects developed
        i. Projects submitted
        ii. Projects approved with fund
5. Research output/outcome/impact
    a. Output
        i. Biotechnology
            1. New techniques developed/refined
            2. Product developed (gene constructs, transformants, double haploids produced etc)

3. New molecular markers identified(please mention trait and crop)

ii. IPM

1. New screening techniques developed/refined
2. Identification of new races of pathogen/pests and their characterization
3. Number of IPM packages developed for management of pests (please indicate name of the pests, area, and regions for which developed)
4. Number of breeding lines evaluated
5. IPM demonstrated on farmers fields

iii. Genetic Resources

1. New accessions added to gene bank
2. Number of accessions evaluated and characterized
3. Number of accessions supplied to ICARDA and NARS scientists

iv. Number of peer reviewed papers published

b. Outcomes

i. Biotechnology

1. Products shared with ICARDA/NARS breeders
2. MAS implemented at ICARDA/NARS (please mention crop)

ii. IPM

1. Number of resistant/tolerant lines identified and shared with ICARDA/NARS breeders (indicate trait)

2. IPM packages adopted by ICARDA/NARS.

c. Impact

6. Human resource development (Year-wise)

   a. Advance training received by ICARDA staff (please mention area of training, country and period)

   b. Number of NARS scientists trained

7. Constraints if any in implementation of the program

Program Leader

Information to be submitted to Chair of CCER on Food Legumes Research at ICARDA 2005-2010 by 26th May 2010

8. Name of the program: Chickpea/Lentil/Faba bean/grasspea
9. Staffing:
    a. Scientists
    b. National Profession officer (NPO)
    c. Technicians
10. Budget (year-wise)
    a. Allocation
    b. Utilization
        i. Equipments/working contingencies
        ii. Travel
11. Research Projects (Year-wise)
    a. Projects in hand
    b. New initiatives/projects developed
        i. Projects submitted
        ii. Projects approved with fund
12. Research output/outcome/impact
    a. Output
        i. Number of International Screening nurseries developed
        ii. Number of entries added to ISN
        iii. Number of peer reviewed paper published
    b. Outcomes (Varieties/year-wise)

i. Number of varieties released by NARS partners with ICARDA elite lines (name varieties and country)

ii. ICARDA materials used in the development of varieties by NARS

iii. Varieties developed by NARS with their own breeding lines/land races

c. Impact

i. Have the materials developed by ICARDA spread in the target regions? If yes, please indicate the area (please mention area of the crop in the country and also if available provide impact studies document(s).

ii. In case the variety has not spread, please indicate reasons?

iii. Do you get adequate feedback on constraints for none adoption of varieties, whether the same is being utilized for setting research priority?

13. Human resource development (Year-wise)

a. Advance training received by ICARDA staff (please mentioned area of training, country and period)

b. Number of NARS scientist trained

14. Constraints if any in implementation of the program

Program Leader