Improving faba bean for sustainable agriculture in dry areas

Global Conference on Plant Science and Molecular Biology,

Fouad Maalouf

13 September 2017

Valencia, Madrid

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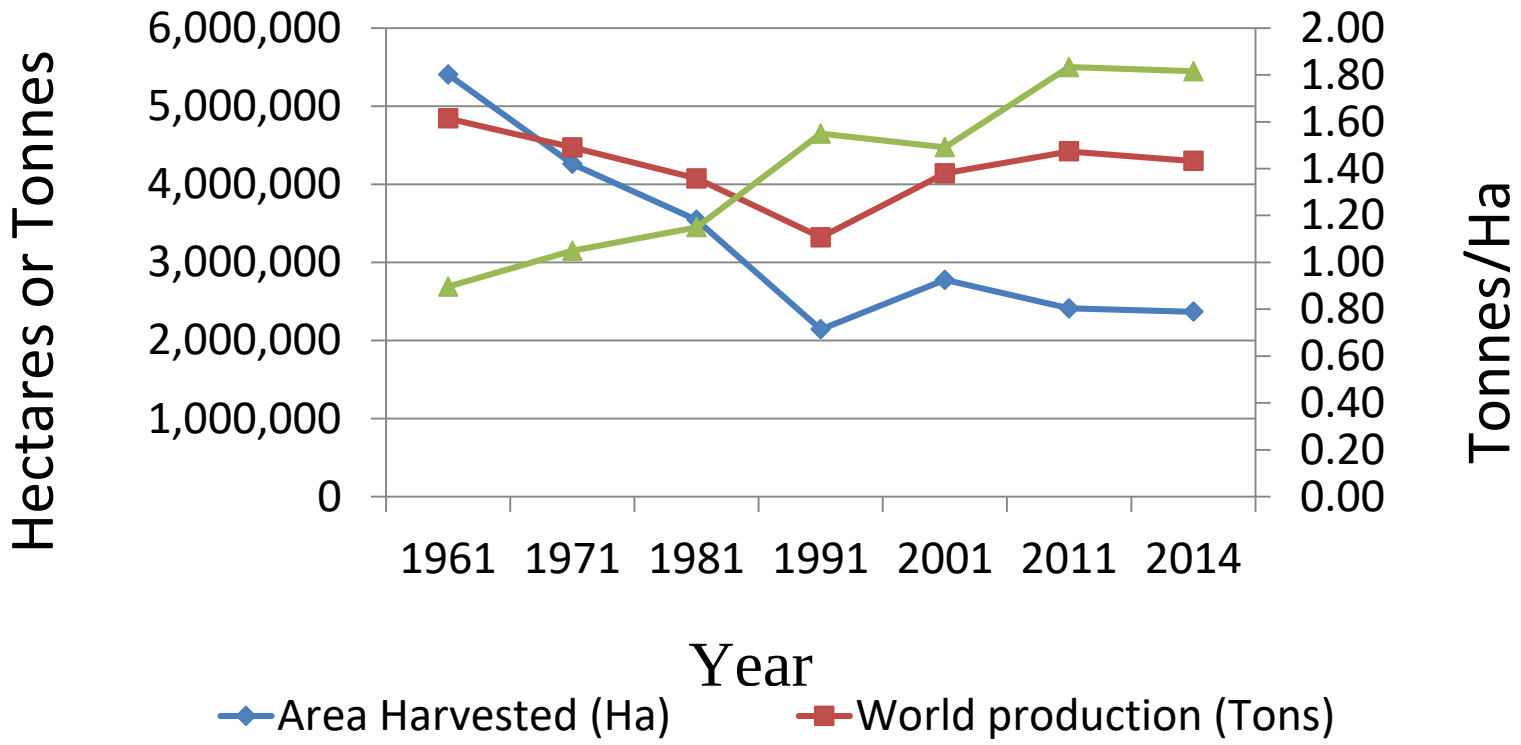
Trend of the world harvested area and production



- Wide latitudinal range ~50 °N to 40 °S
- Wide altitude range from the sea level to above 3000 m
- (Gnanasambandam et al., 2012).

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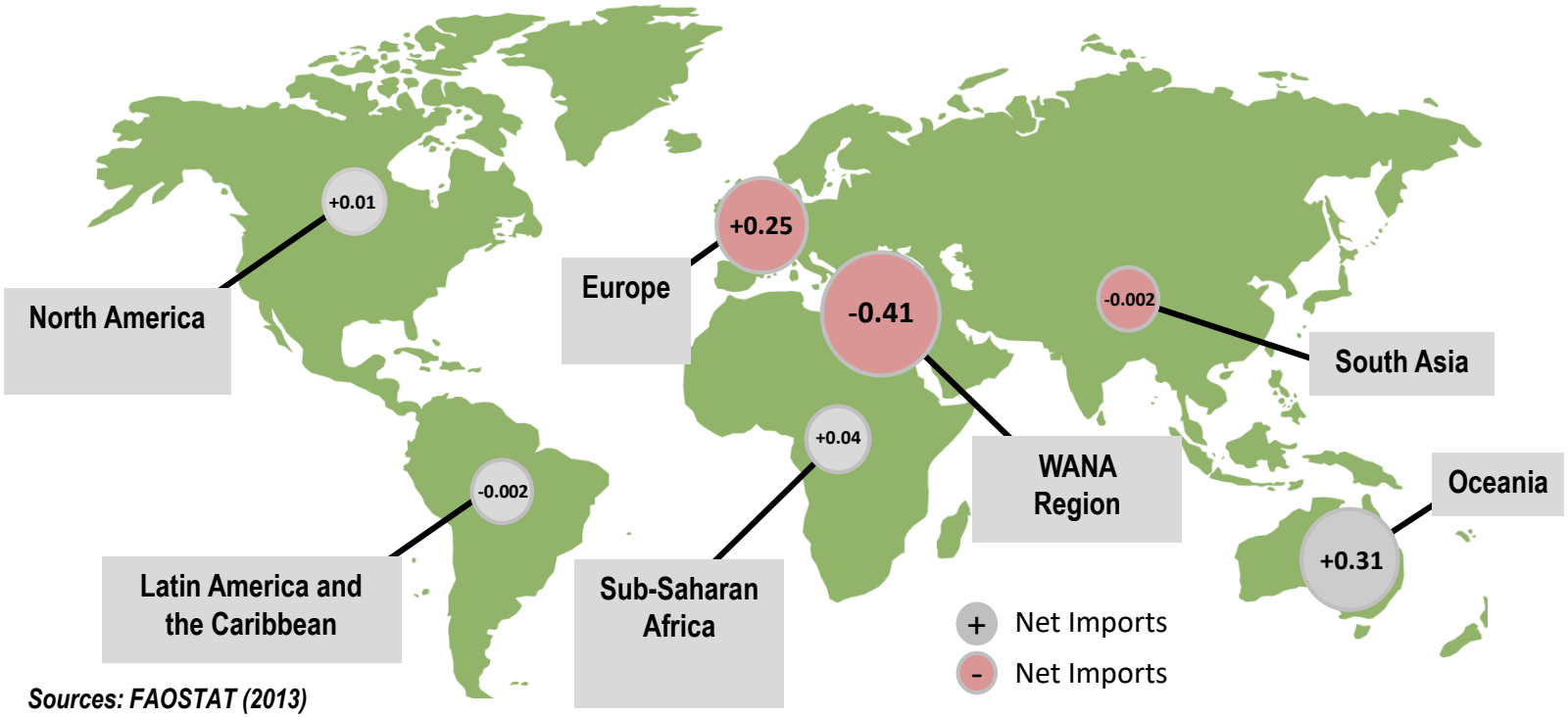
Global pulse trade at present: almost 0.8 million tonnes

Global Trade: Net faba bean imports (in million MT) by region, 2013



Sources: FAOSTAT (2013)

MENA region is a Faba bean deficit region

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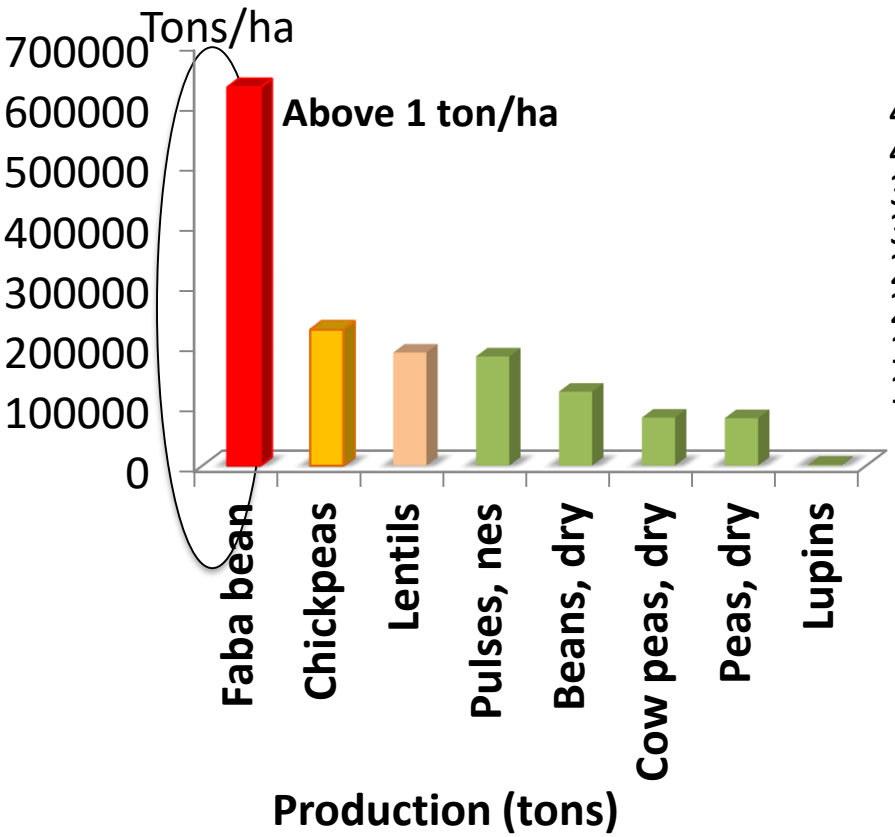
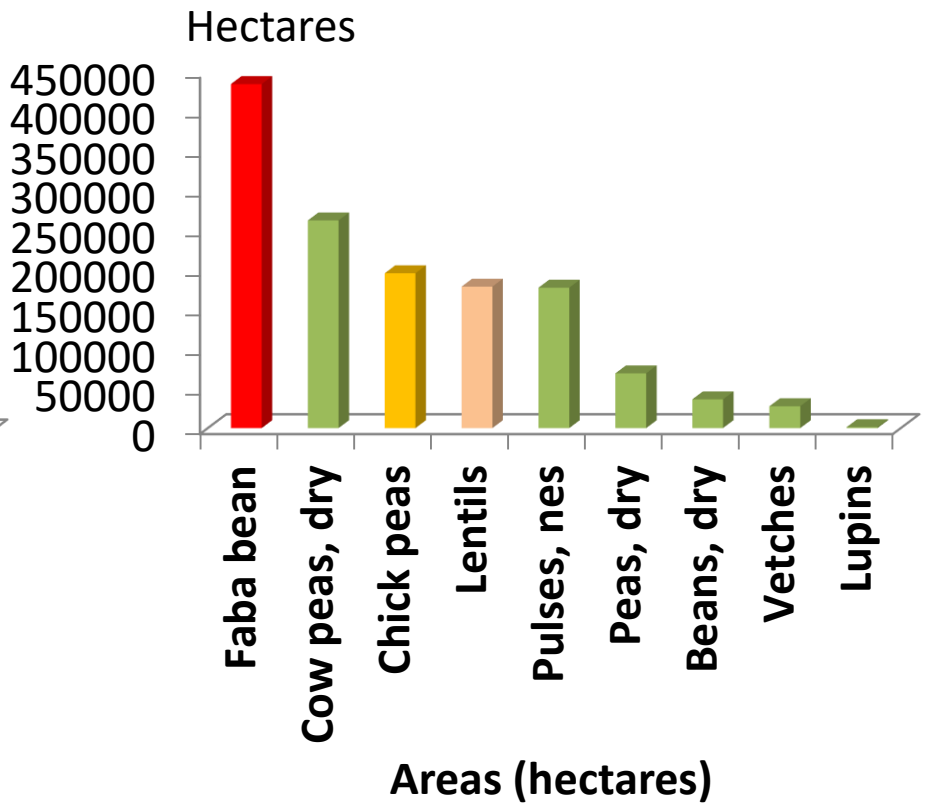
Major Pulses Production in Middle East, Nile Valley and North Africa





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Pulse roles in Food and Nutritional security

- **Nutritional security: Nutrient dense legume crop**
- **Provide balance diet with cereals**

	Min	Max	Average
Chickpea	16	26	20
Faba bean	18	36	29
Lentils	20	30	26
Grass pea	28	30	29

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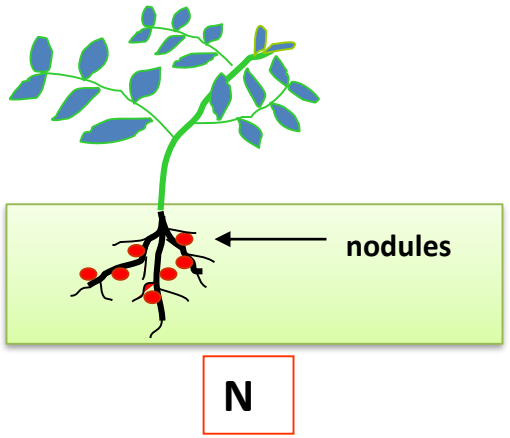
Pulses Faba bean Agronomic Role

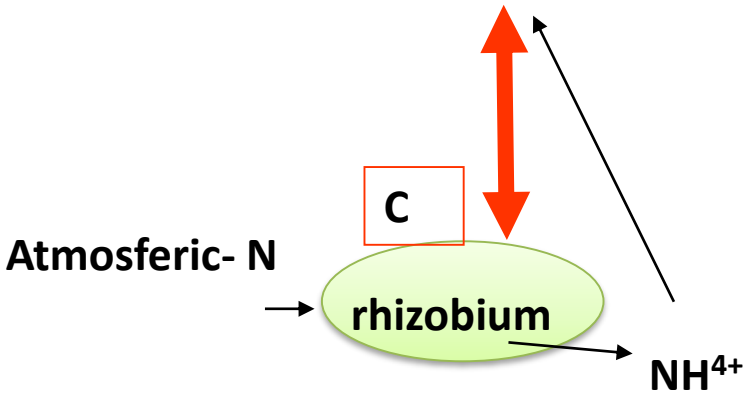
Food security:

- –Sustaining Cereals based cropping system
- –Nitrogen fixation
- –Low carbon footprint
- –Low water footprint
- –Break in diseases cycles



Chickpea	24-84
Beans	12-215
Faba bean	178-25
Peas	174-196
Lentils	167-189

N (kg/ha/year)



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Benefit of subsequent crops grown after faba bean.

Calculations of the impact of faba bean or barley on the N dynamics of a following wheat crop based on comparisons of N accumulated by wheat

	Faba bean–Wheat	Barley–Wheat
Residue N from faba bean or barley (kgN ha^{-1})	96[b]	73[b]
^{15}N-based estimated recovery of faba bean N (%)		
From shoot residues	3[e]	
From nodulated roots and rhizodeposition	8[e]	

Yield increase of wheat and barley after faba bean

Why are farmers not growing pulses ??

Increasing reliance by farmers on N fertilizers as a source of N input (Crews & Peoples, 2004)

- **Weak seed system**
- **biotic and abiotic stresses**
- **poor weed management.**

- **NRAFB represent 2-19% of the total N requirement of those following crops**

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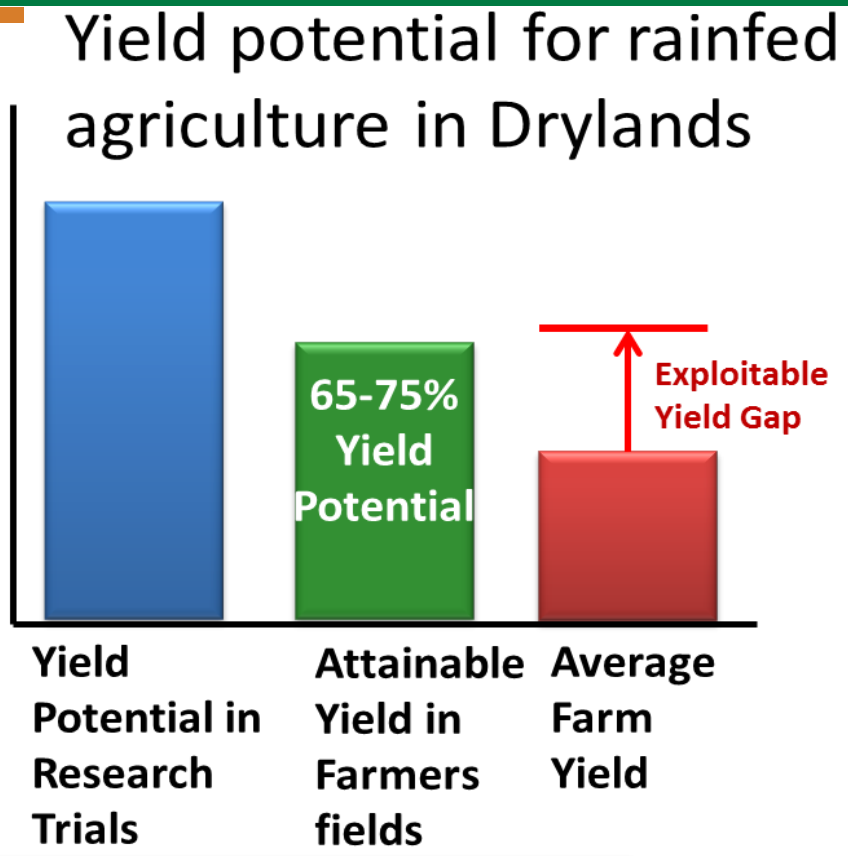
Strategy for Enhancing Pulses Production

- Closing the yield gaps
- New genetic gains
- Horizontal expansion
- Intensification
- Reduced post-harvest losses

  (16% losses in MENA)



- 25-60% yield gaps in pulses
- Reasons are many…….
- Closing the yield gaps can alone supply 60% of pulses deficit
- Farmers participatory research

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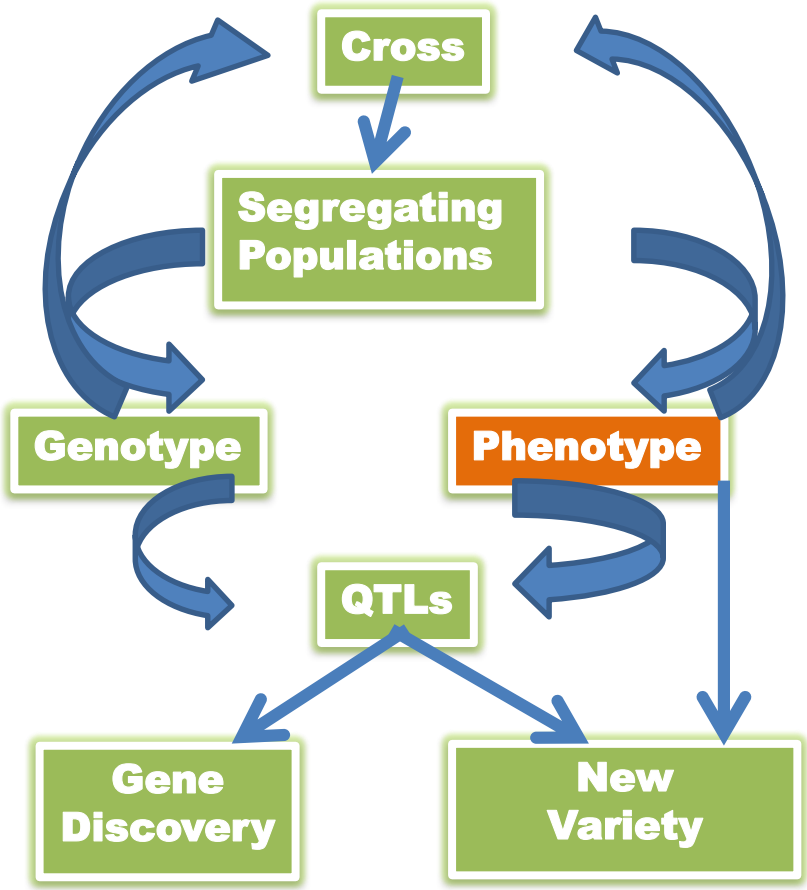
Gene Discovery & Deployment in Varieties

- Heat and drought tolerance
- Biological nitrogen fixation
- Extra short duration
- Herbicide tolerance
- Orobanche tolerance
- Machine harvestability

In addition to key diseases and insect pests of the target region



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ICARDA Gene banks

ICARDA Genebank for the Drylands holds in trust a unique collection of plant genetic resources of the world's most important drylands food crops and forages

Total collection: 145336 accessions (94.22 % Duplicated)

Crop	CROP	Duplicated	Holdings	Secured%
Chickpea	ILC	14864	15195	97.82
Faba bean	ILB	6681	6766	98.74
Faba bean BPL	BPL	3232	3268	98.9
Lathyrus	IFLA	4164	4277	97.36
Lentil	ILL	11873	13907	85.37
Medicago annual	IFMA	8620	8893	96.93
Pisum	IFPI	6054	6115	99
Vicia	IFVI	6003	6366	94.3
Wild Cicer	ILWC	265	547	48.45
Wild Lens	ILWL	600	602	99.67
Total		62356		

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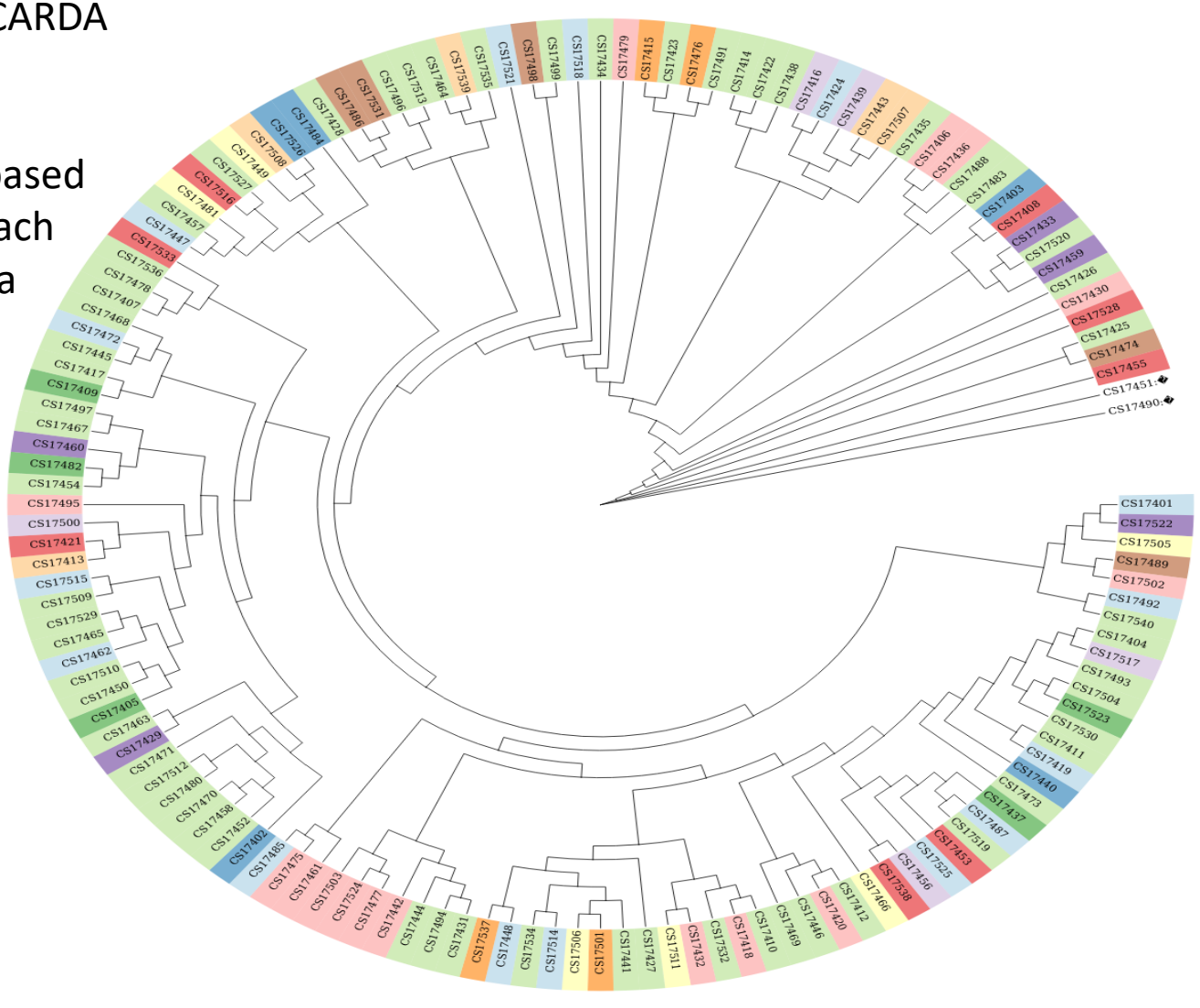
Genetic Diversity

Collaborative Research ICARDA with Washington State University

A neighbor-joining tree based on 1,862 SNP markers (each marker is with <10% data points missing).



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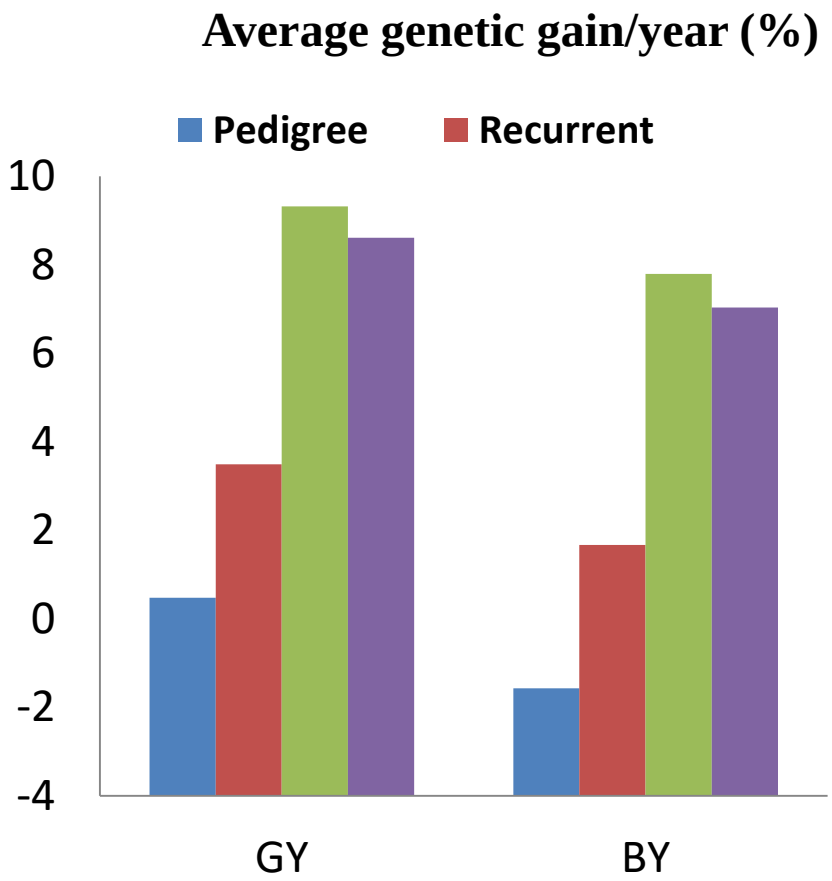
Genetic gains

- Genetic gains per year (%) for grain yield and biological yield higher in synthetics and recurrent lines than the inbred lines
- Yield potential increased through development of cultivar in open pollinated conditions.
- Insects' pollinators have a fundamental function in the agro-ecosystem



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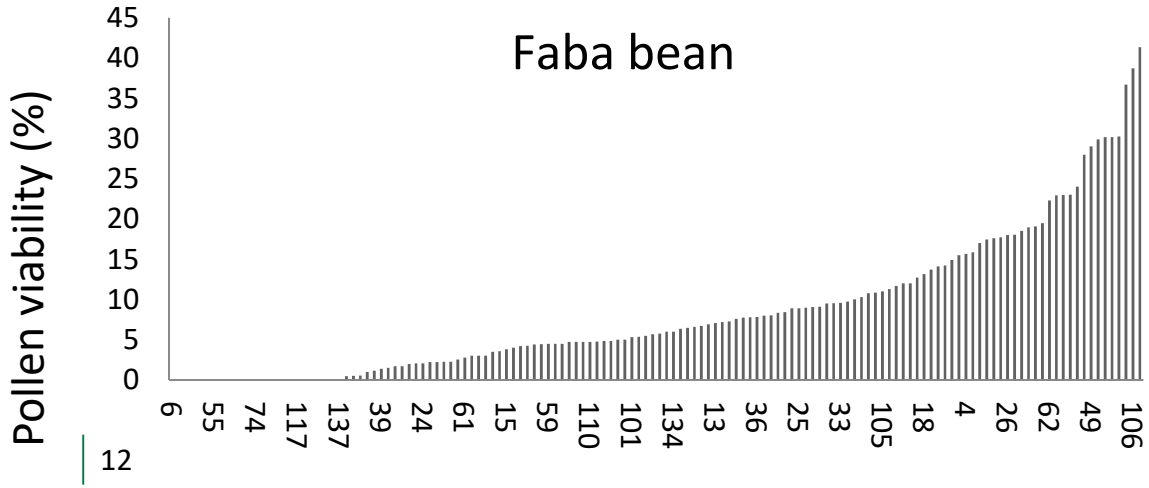
Heat tolerance in Faba bean

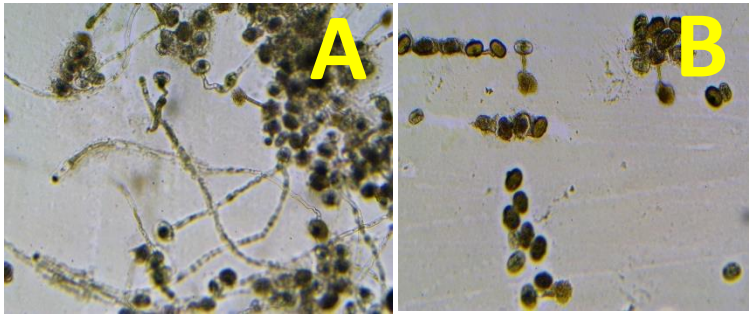
Pollen viability (%) of most tolerant lines under 35 degrees under 35 degrees in two summer seasons (2015 and 106)

Accession	Source	ORI	2015	2016
IG11742	ICARDA	ETH	23.04	20.5
VF351	IFAPA	TUR	22.18	32.53
VF626	IFAPA	UNK	29.96	31.27
INRA1197	INRA	GBR	28	24.44
INRA1512	INRA	DEU	38.56	24
INRA1631	INRA	DEU	24	22.24



Key points

- Pollen germination was found correlated with NSP (0.58 at p<0.001) and with Grain yield (0.3 at p <0.05 at Terbol station
- Grain yield is correlated wit Chlorophyll content at Hodeiba Station Sudan.
- Chlorophyll content correlated (+0.52, p < 0.001) with number of pods per plants



A: pollen viability of tolerant line
B: pollen viability of susceptible line

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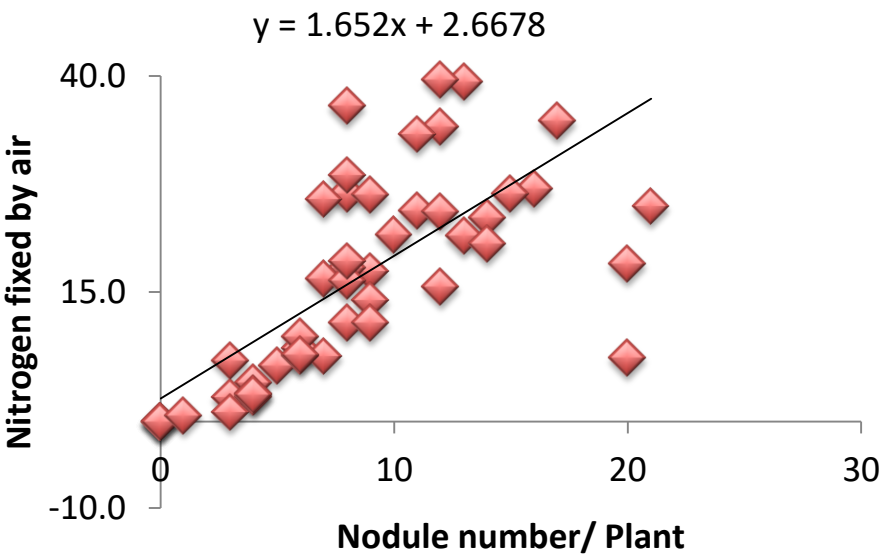
Biological Nitrogen Fixation



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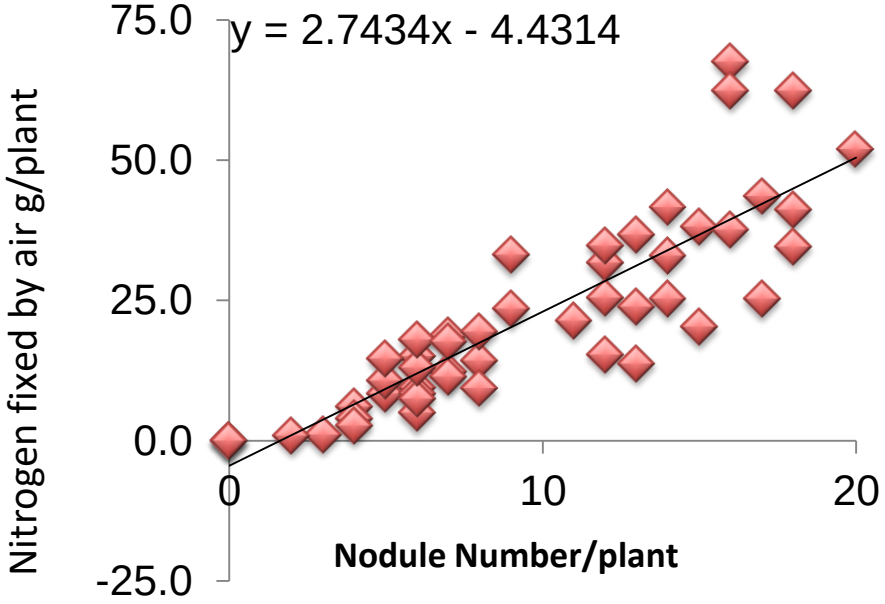

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- Number of nodules was found using two different strains highly correlated with nitrogen fixed by Air
- Selection for high Nitrogen fixation lines in faba bean can be done through selection of high Rhizobium nodulation varieties

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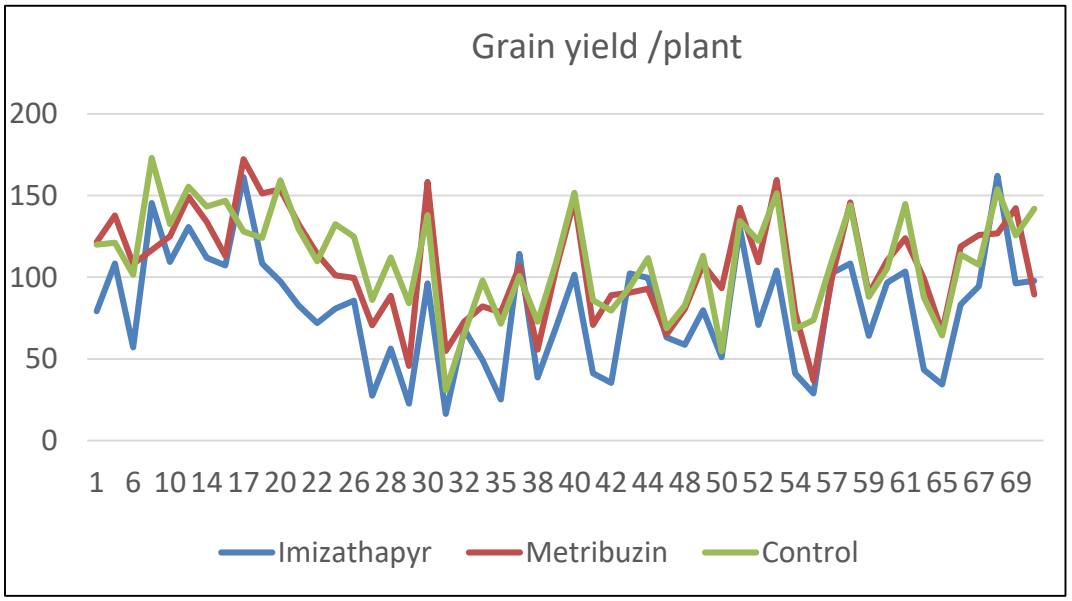
Herbicide Tolerance

- **Wide range of herbicide tolerance for Metribuzin and Imizathapyr obtained in GCP reference set.**
- **34 accessions were validated for tolerance to combined Imizathapyr and Metribuzin in three consecutive testing cycles.**
- **15 lines tolerant to both Imizathapyr and Metribuzin**
- **Delay in days to maturity of 22 lines among all the tested genotypes.**



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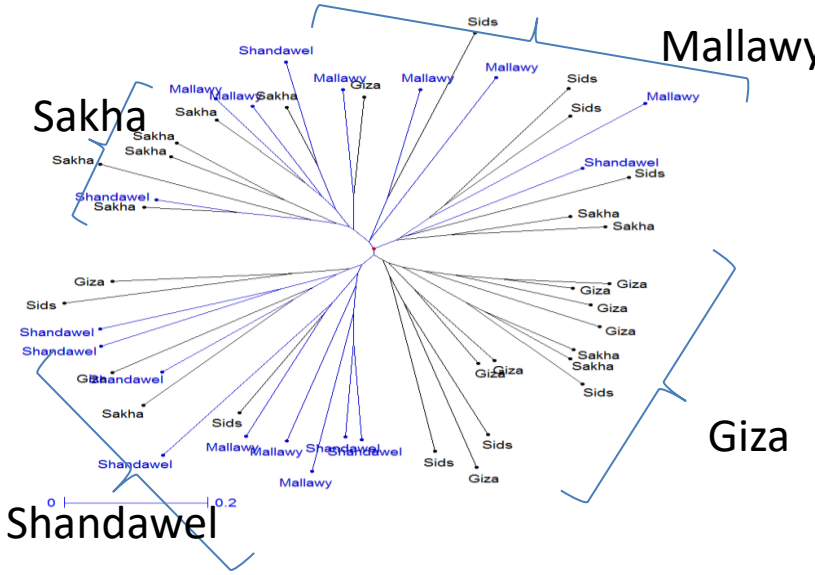
Genetic diversity studies of orobanche populations

- 48 Orobanche samples Collected from five locations in Egypt Five ISSR markers have been used
- Significant and high variation within population is observed
- Variation among population was not significant

Infested soil	ORBAN		OI	
Gemeiza	0 ± 7.89	a	0 ± 0.13	a
Giza	31.1 ± 7.89	ab	0.938 ± 0.13	b
Malawi	102.2 ± 7.89	c	1.296 ± 0.13	b
Nubaria	3.9 ± 7.89	a	0.802 ± 0.13	b
Sakha	0.7 ± 7.89	a	0.393 ± 0.13	ab
Shandaweel	22 ± 7.89	ab	0.8 ± 0.13	b
Sids	15.8 ± 7.89	ab	0.865 ± 0.13	b
LSD	24.22		0.3986	



Genetic relationships of Orobanche from 5 regions of Egypt, as estimated by Jaccard genetic distance based on the 5 ISSR markers using Neighbor joining cluster analysis.

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Development of Machine Harvestable Varieties

Crop	Country	Variety
Faba bean (4)	Syria	Hama 2, Hama 3
	Ethiopia	Didea
	Mexico	Santa Elena

Screening for Chocolate spot resistance in Faba bean

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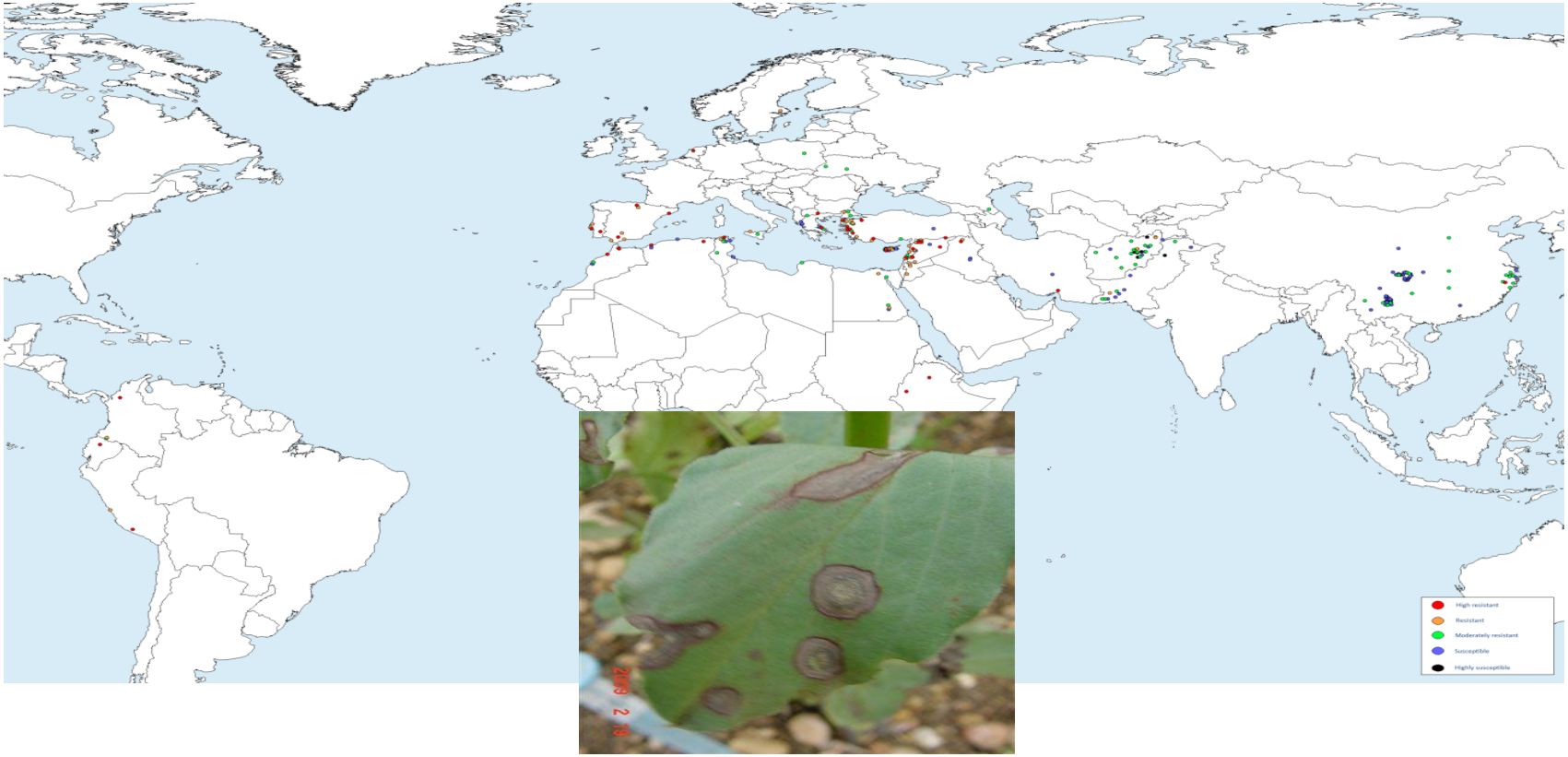
Screening for Ascochyta blight resistance in Faba bean



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Screening faba bean multiple disease resistance

- 200 lines were identified resistant to Ascochyta blight (AB) and Chocolate spot (CS)
- 32 lines were resistant to AB, CS and RT.

Disease nurseries	Number of test entries	Number of selections (1-3 ratings)	Percent selection	Susceptible check (1-9 rating scale)
Faba bean Ascochyta blight nursery	1179	466	39	7
Faba bean Chocolate spot screening nursery	1178	453	38	8-9
Faba bean Rust nursery	1169	214	18	7

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Faba bean Resistance to FBNYV

28 new sources for FBNYV resistance identified after 17 year of continuous research

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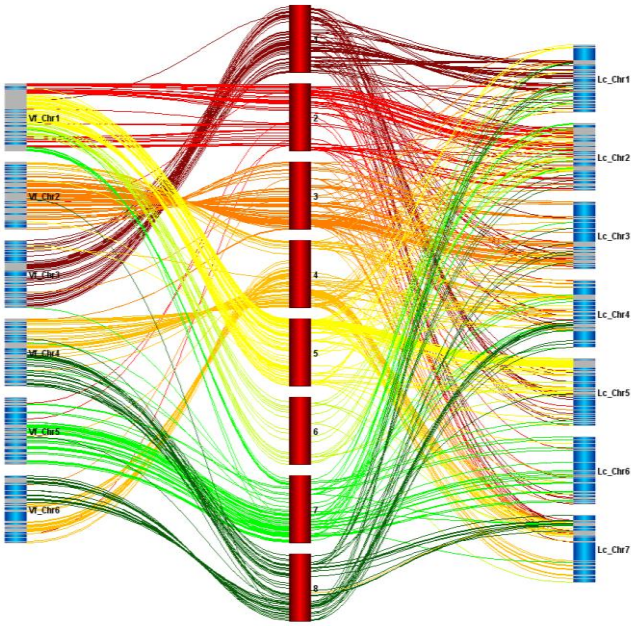
Genetic map for Synteny-based trait

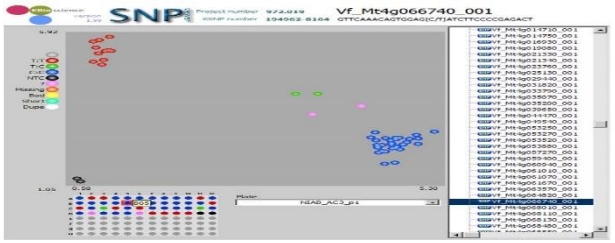
Collaborative research between United Kingdom Institutes (NIAB, University of Reading LGC Genomics, Hoddesdon, Herts) Finland (University of Helsinki), Germany (Georg-August-University) and ICARDA (Faba bean program)

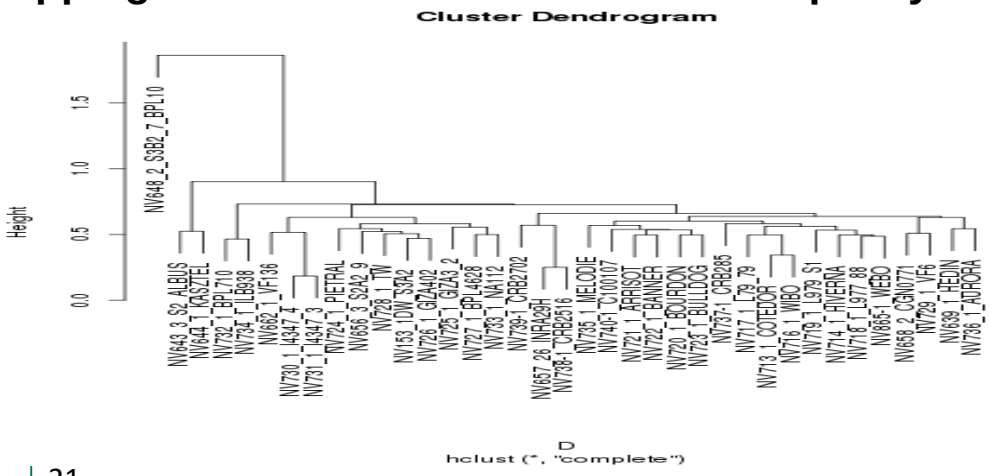
Collinearity of the faba bean genetic map with the sequenced *M. truncatula* genome and the first SNP map of *Lens culinaris*

Consensus SNP-based genetic linkage map

Mapping of the *ZT1* zero tannin end-use quality trait







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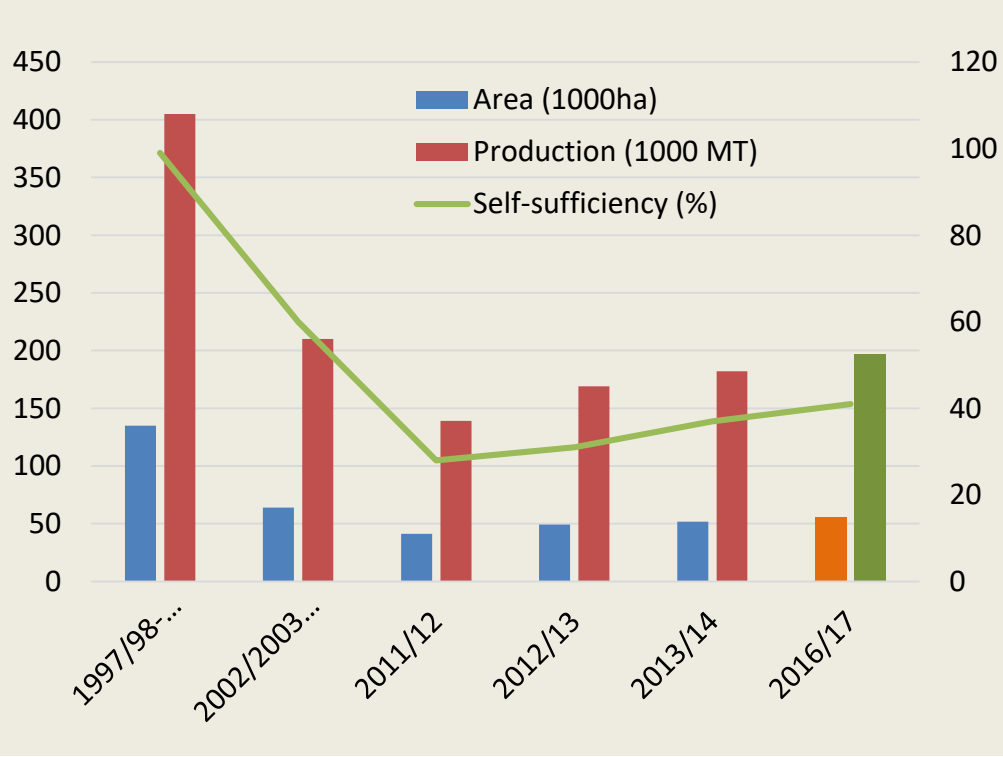
Impacts of Orobanche resistant Faba bean varieties

A survey indicated that 46% farmers were using new varieties and parts of the technology package and 14% were using the full package

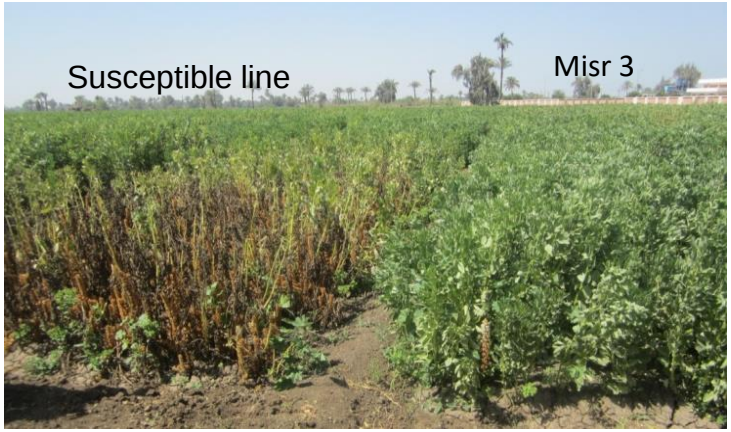
Recommended technology package increased farmers' grain yield by 256 kg/ha

Reduced production costs by USD 350/ha

Increased net income by USD 550/ha



Trends of Area and production of Faba bean in Egypt



Varieties	Country
Giza 843, Misr 3	Egypt
Najah, chourouk	Tunisia
Hachenge (ILB 4358)	Ethiopia

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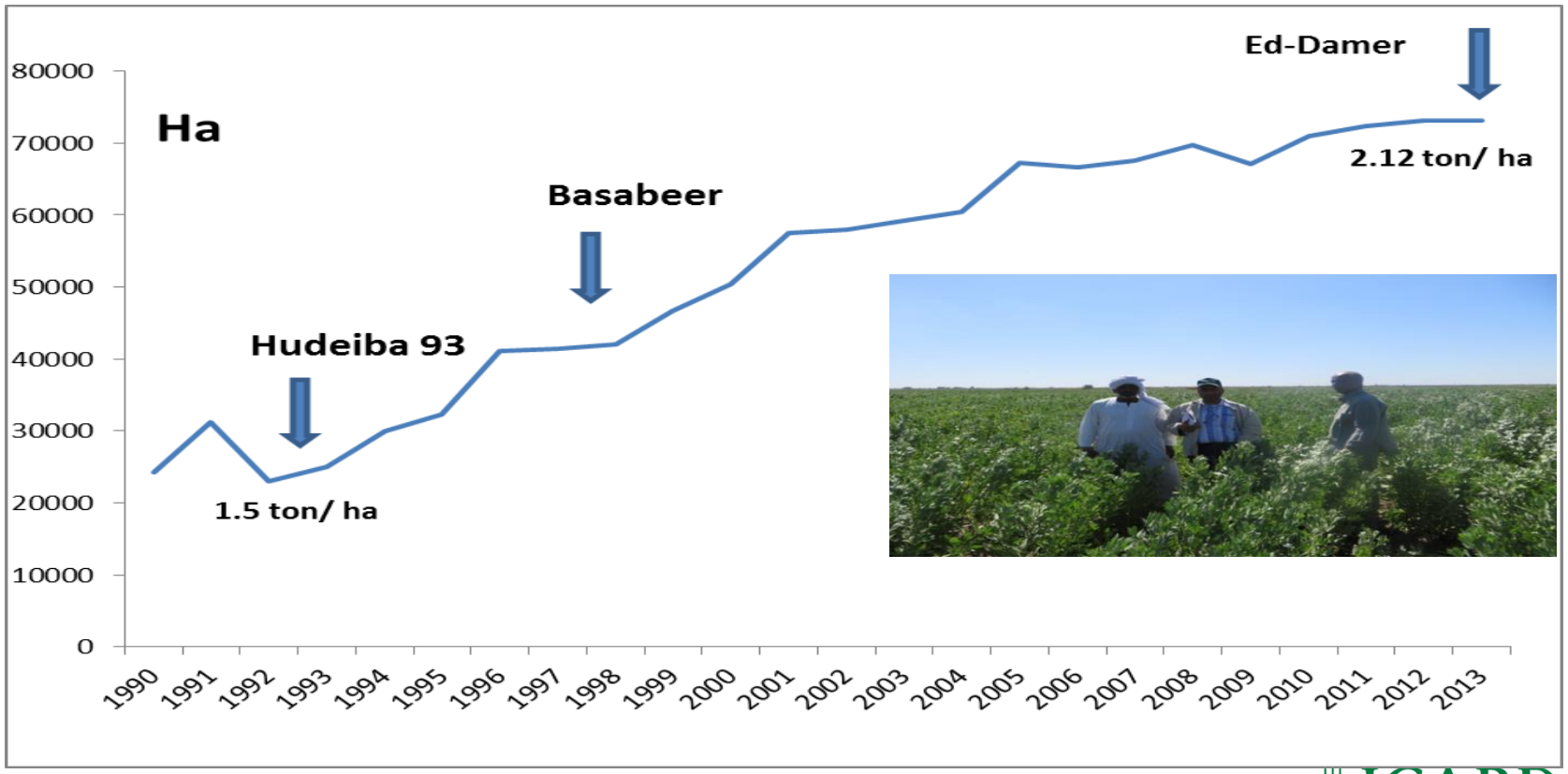
Impacts of Faba bean heat tolerance in Sudan

- **Faba bean production increased from ~40,000 t in nineties to 150,000 t at present.**
- **Increase in area (~20000 ha in nineties to ~70000 ha)**
- **Productivity from 1500 kg to 2120 kg per ha.**



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Adoption of faba bean cultivars in China

Yandoo 147 covered approximately 140000 ha

Chengdu 19 is becoming popularized in Chengdu province.

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Thank you for your attention

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