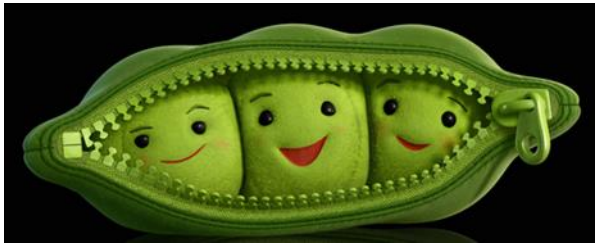
# Breeding priorities



**Prof. Diego RUBIALES**
**>250 SCI publications** with IF
h-index 32



CSIC


**Institute for Sustainable Agriculture**

Córdoba, Spain

**Legumes** are multifunctional crops with extraordinary importance for the **agriculture, environment and culture**

key role in animal feed





**being particularly important in the Mediterranean diet**




However **acreage in Europe and North Africa is continuously decreasing**

and we are **importing** legumes for food and feed

# Acreage of most legumes continuously decreasing in Europe

| Europe | 1962 | 1972 | 1982 | 1992 | 2002 | 2012 | |
|---|---|---|---|---|---|---|---|
| Million Ha, FAO 2013 | | | | | | | |
| **Pea** | 4,83 | 4,29 | 4,58 | 4,56 | 2,07 | **1,98** | **↓ 2.5x** |
| **Faba bean** | 0,89 | 0,53 | 0,33 | 0,25 | 0,25 | 0,21 | **↓ 4.2x** |
| **Common bean** | 4,03 | 2,14 | 1,19 | 0,43 | 0,36 | 0,26 | **↓ 15.5x** |
| **Lupin** | 1,14 | 0,69 | 0,36 | 0,16 | 0,06 | 0,15 | **↓ 7,6x** |
| **Lentil** | 0,14 | 0,15 | 0,11 | 0,05 | 0,04 | 0,1 | **↓ 1,4x** |
| **Soy bean** | 0,85 | 1,03 | 1,34 | 1,54 | 0,98 | **3,45** | **↑ 4x** |

**WHY?**

**Is it the same elsewhere?**

# At word level acreage of most cool-season legumes is decreasing whereas it is remarkably increasing for most war-season legumes.

| WORD ACREAGE Million ha | 1962 | 1972 | 1982 | 1992 | 2002 | 2012 | |
|---|---|---|---|---|---|---|---|
| **Cool-season legumes** | | | | | | | |
| Chickpea | 12,2 | 10,5 | 10,3 | 9,3 | 10,4 | 12,1 | = |
| Pea | 10,3 | 8,0 | 7,4 | 7,2 | 6,0 | 6,3 | ↓ 1.6x |
| Faba bean | 6,1 | 4,2 | 3,3 | 2,9 | 2,7 | 2,4 | ↓ 2,5x |
| Lentil | 1,6 | 1,8 | 2,6 | 3,3 | 3,6 | 4,2 | ↑ 2.6x |
| Vetches | 2,4 | 1,7 | 1,0 | 1,0 | 0,9 | 0,6 | ↓ 4,0 x |
| Lupins | 1,4 | 0,8 | 0,6 | 1,2 | 1,2 | 0,9 | ↓ 1.6x |
| **Warm-season legumes** | | | | | | | |
| Soy bean | 23,8 | 31,7 | 52,4 | 56,2 | 79,0 | 106,6 | ↑ 4,5x |
| Common bean | 23,5 | 22,8 | 26,2 | 24,8 | 27,5 | 28,8 | ↑ 1,2x |
| Peanut | 17,5 | 20,1 | 18,4 | 20,6 | 23,0 | 24,6 | ↑ 1,4x |
| Cowpea | 2,7 | 4,2 | 3,9 | 8,5 | 9,9 | 10,7 | ↑ 4,0x |
| Pigeonpea | 2,7 | 2,7 | 3,4 | 4,2 | 4,4 | 5,3 | ↑ 2,0x |
| **Major cereals, for comparison** | | | | | | | |
| Wheat | 207,6 | 213,8 | 238,5 | 222,5 | 213,8 | 216,7 | = |
| Rice | 119,5 | 132,2 | 141,6 | 147,4 | 147,6 | 163,5 | ↑ 1,4x |
| Maize | 103,5 | 114,9 | 124,4 | 136,8 | 137,6 | 177,0 | ↑ 1,7x |

*Rubiales & Mikic, 2015.* ***Introduction: Legumes in Sustainable Agriculture****, Critical Reviews in Plant Sciences, 34:1-3,*

# Remarkable increase in countries with little tradition of legume cultivation or consumption: Canada and Australia

| Canada | 1962 | 1972 | 1982 | 1992 | 2002 | 2012 | |
|---|---|---|---|---|---|---|---|
| Million Ha, FAO 2013 | | | | | | | |
| Pea | 0,02 | 0,03 | 0,08 | 0,26 | 0,98 | **1,48** | ↑ |
| Faba bean | 0 | 0 | 0,006 | 0,004 | 0,005 | 0,00x | - |
| Common bean | 0,03 | 0,05 | 0,04 | 0,06 | 0,21 | 0,12 | ↑ |
| Lupine | 0 | 0 | 0 | 0 | 0 | 0 | - |
| Lentil | 0 | 0 | 0,07 | 0,27 | 0,36 | 1 | ↑ |
| Soy bean | 0,09 | 0,16 | 0,36 | 0,62 | 1,02 | **1,7** | ↑ |

| Australia | 1962 | 1972 | 1982 | 1992 | 2002 | 2012 | |
|---|---|---|---|---|---|---|---|
| Million Ha, FAO 2013 | | | | | | | |
| Pea | 0,02 | 0,02 | 0,03 | 0,4 | 0,4 | **0,25** | ↑ |
| Faba bean | 0,0004 | 0,0002 | 0,001 | 0,08 | 0,17 | 0,16 | ↑ |
| Common bean | 0,0008 | 0,009 | 0,022 | 0,04 | 0,05 | 0,09 | ↑ |
| **Lupine** | 0,001 | 0,05 | 0,26 | 1 | 1,2 | 0,7 | ↑ |
| Lentil | 0 | 0 | 0 | 0,004 | 0,16 | 0,21 | ↑ |
| Soy bean | 0,0004 | 0,007 | 0,04 | 0,03 | 0,03 | **0,04** | ↑ |

**Canadians and Australians showed us that also lentil, pea or lupine can be successfully cultivated even in marginal areas.**

**Why this was not possible in Europe? Are the cultivars the limiting factor?**

# Major limitations for legume cultivation/breeding:

**Relatively low** yield potential-stability

Numerous species multiplying **breeder's investments**

**Sustainability of the system**:
Improving the cv registration system
Use of certified seeds

# Breeding priorities:

**Increased yield and yield stability**
**Addressing markets demands**

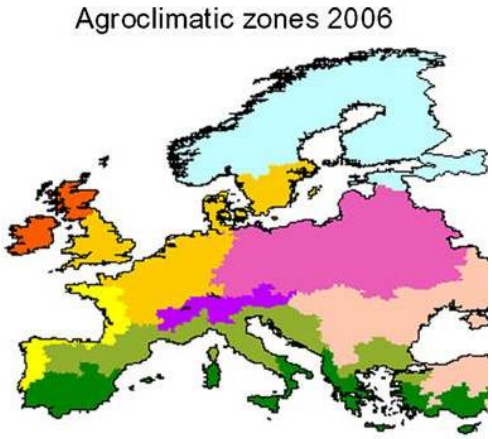
- **Grower satisfaction**:

Good yield, disease resistance, lodging, herbicide tolerance, high prize

- **Consumer satisfaction**

colour, size, appearance, nutrition, ….. low cost


*- Duc et al., 2015.* ***Breeding Annual Grain Legumes for Sustainable Agriculture: New Methods to Approach Complex Traits and Target New Cultivar Ideotypes.*** *Critical Reviews in Plant Sciences, 34:381-411*
*- Annicchiarico et al., 2015.* ***Achievements and Challenges in Improving Temperate Perennial Forage Legumes.*** *Critical Reviews in Plant Sciences, 34:327-380*



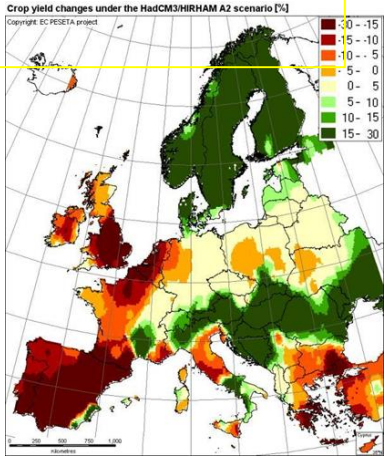

# Increased yield and yield stability

## Enlarging cropping area and stabilizing performance:

### Genotype, Environment, Management, and their interactions

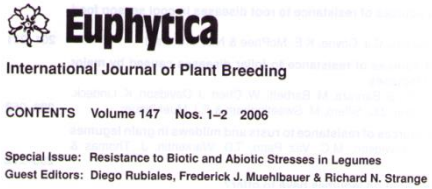
**tolerance to stresses** (drought, freezing, salinity, pest and diseases) combined with phenologies allowing **escape**

Important to develop **adaptation** to short spring cycles or long winter cycles to diverse geographical zones




**Additional demands arising for environment-friendly and food security**

- **resource use** efficiency including symbiotic performance
- **resilient** production in the context of **climate change**
- adaptation to **sustainable cropping systems**
- **diverse uses:** feeds, foods, non-food, forage or green manure
- Increased **biodiversity, ecological services**




# Major needs in breeding for stress resistance:

- gain knowledge about stresses
- identify, share and preserve sources of resistance
- develop faster and more reliable screening procedures for both phenotyping and MAS
- better understanding of the genetics and physiology of resistance
- translate molecular and genomic information into tools useful for MAS
- integrate MAS to compliment classical breeding


- Araujo et al., 2015. **Abiotic Stress Responses in Legumes: Strategies Used to Cope with Environmental Challenges.** Critical Reviews in Plant Sciences, 34:237-280
- Rubiales et al., 2015. **Achievements and Challenges in Legume Breeding for Pest and Disease Resistance.** Critical Reviews in Plant Sciences, 34:195-236

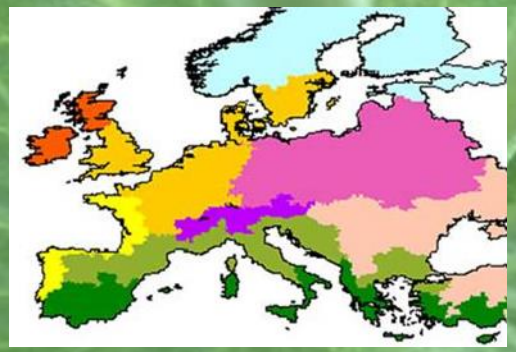
# Priorities change with the crop, the region and the cropping system

*Pseud. syringae*

*E. pisi*

*Fusarium* wilt

*M. pinodes*



*U. pisi*

*O. crenata*

Pea aphid
*Acyrtosiphon pisum*

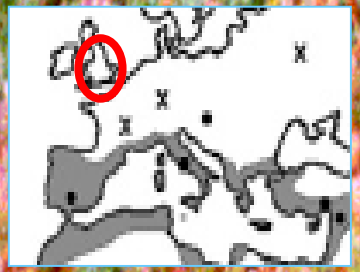
Pea weevil
*Br pisorum*

Drought






**Is expanding north: outbreak on vetch in central Spain, Salamanca 2007**



**Outbreak on faba bean in UK: Kent, 2013 and 2014**

***The bad news*: just as one of the possible examples**

***O. crenata*** is the major constraint for legume production in Mediterranean countries.

Rubiales & Fernández-Aparicio 2012. Innovations in parasitic weeds management in legume crops. *Agron Sust Devel* 32: 433–449

***The good news:***
***resistance has been identified now in all legume crops.***

faba bean

pea

lentil

vetch

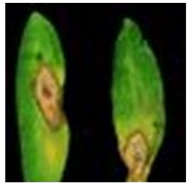
grasspea

chickpea

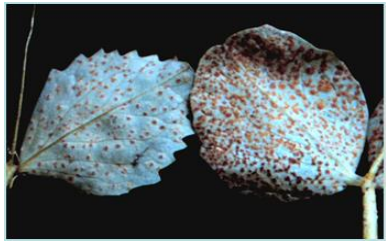
**Resistance complemented with a number of management practices:**
**Intercropping, suicidal germination, rotation, …**

***The good news*: resistance to most *biotic and abiotic* stresses has been identified now in all legume crops.**






Sources of resistance available to ascochytas







Sources of resistance available to rusts







# Resistance to insect pests available.

# Example: aphids and weevils in pea

- APHID INFESTATION (visual scale, 1-4):

1

No colony

2

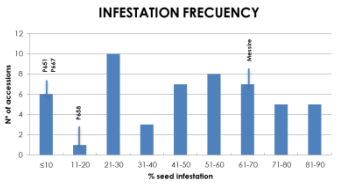
Colonization start

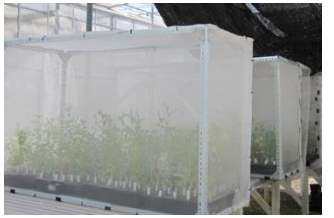
3

30% plant area covered

4

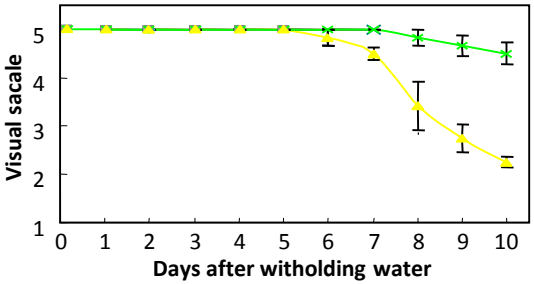
+50% plant area covered

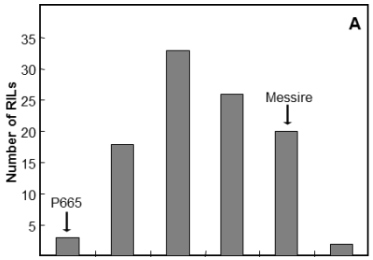


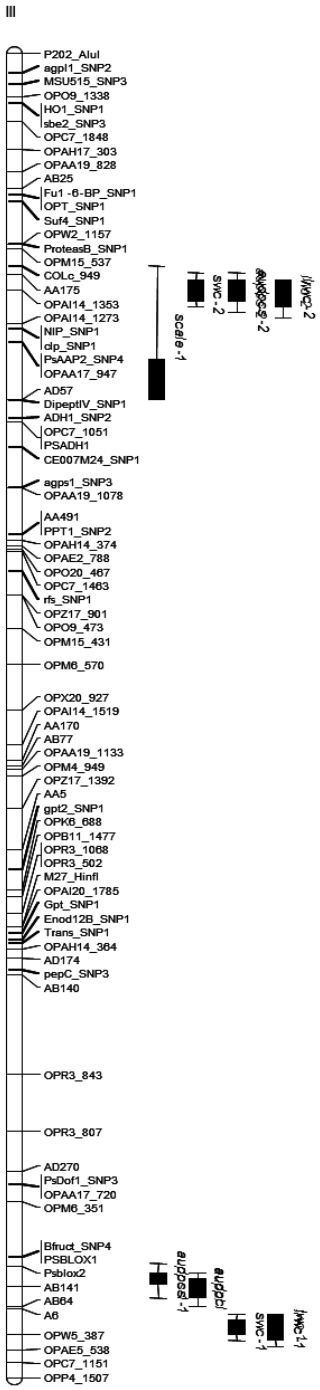



# *Resistance to drought available. Example: pea, QTLs identified*

5 4 3 2 1



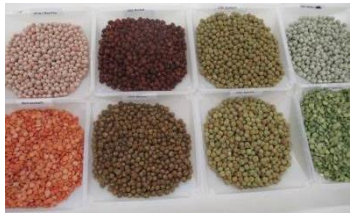
# Nutritional quality:
## chemical composition and antinutritional factors

***Vicia faba:***

- **Low tannin** for **monogastric** animals: but more susceptible to some diseases
- **Low vicine-convicine** for **favism in human and poultry**: no negative impact on yield with low v-c gene

***Lathyrus sativus***

**low ODAP:** impact on resistance to drought and insects?



Gaps to fill:

Focus in improving nutrition-related chemical composition, while somehow neglecting

**sensory or processing important traits**


- *Vaz Patto et al., 2015**. Achievements and Challenges in Improving the Nutritional Quality of Food Legumes.** Critical Reviews in Plant Sciences, 34: 105-143*

- *Arnoldi et al., 2015. **The Role of Grain Legumes in the Prevention of Hypercholesterolemia and Hypertension.** Critical Reviews in Plant Sciences, 34:144–168,*

## Consumers are increasingly discriminating and health conscious:

efforts should focus on developing attractive convenient **ready-to-eat and tasty legume -based food formulations**, contributing to the diversification of **healthier and more nutritional diets**

high protein and fiber content, gluten free status, low glycemic index, antioxidant potential, as well as functional properties like water binding capacity and fat absorption

- **adaptation to transformation**:

**Processing ('canning') quality of kabuli chickpea**

Overall quality: (1-5 scale)
Seed breakage
Seed colour
Brine colour

**dehulling efficiency**:

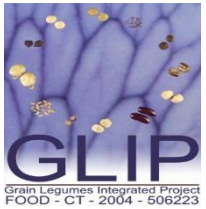
**Important for Desi chickpea**

Other uses: functional compounds, bioplastics, bioenergy,

# Relevant EU research projects covering (partly) legume breeding activities

FP5


FP6




FP6: *LEGRESIST*

FP7





As well as other projects (INTERCROP, LEGUME FUTURES, EUROLEGUMES) covering agronomics aspects and others on nutrition

H2020: a topic launched in 2013, contract in negotiation

**Was this sufficient? Did this impact the legume industry? What else is needed?**

# European Association for Grain Legumes Research

**President**

**Vice-president**

# International Legume Society

*http://ils.nsseme.com/*

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# Communication

## Legume Perspectives

ISSN 2340-1559

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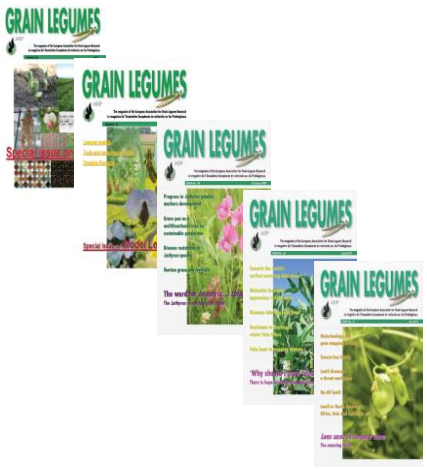


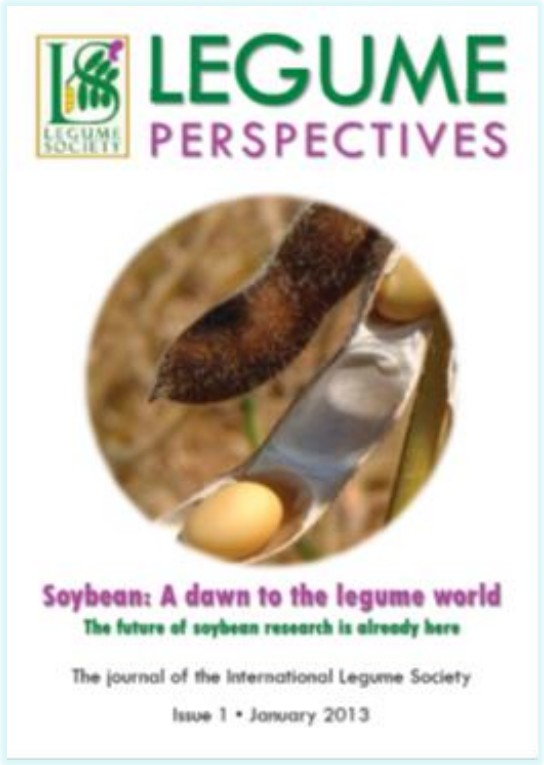


Several issues being currently edited

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http://ils.nsseme.com/

1ST LEGUME SOCIETY CONFERENCE
SERBIA, 2013

## 2ND International Legume Society Conference

+ ABSTRESS + LEGATO + MEDILEG + REFORMA

**LISBON, OCTOBER 2016**