2016 INTERNATIONAL YEAR OF PULSES

UNIVERSITY OF SASKATCHEWAN

Moving pulse crop breeding into the 21st century

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Global population vs productive land

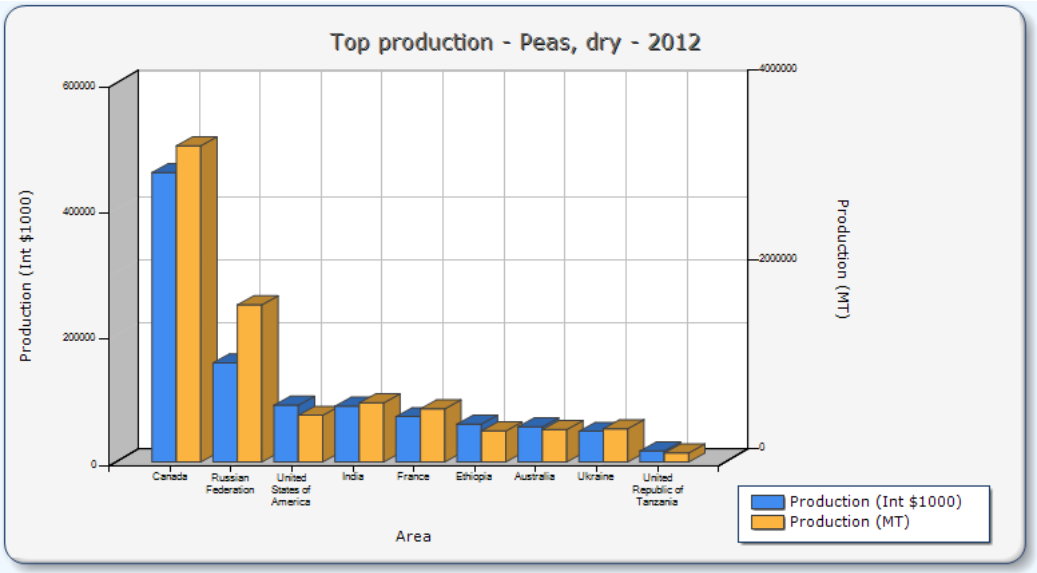
- Population increasing about 3 people per second
- Productive land decreasing about 1 ha every 7.7 seconds
- In the next 20 minutes we will gain 3,600 people and lose 156 ha

http://www.tranquileye.com/clock/

Feeding the world - pulses

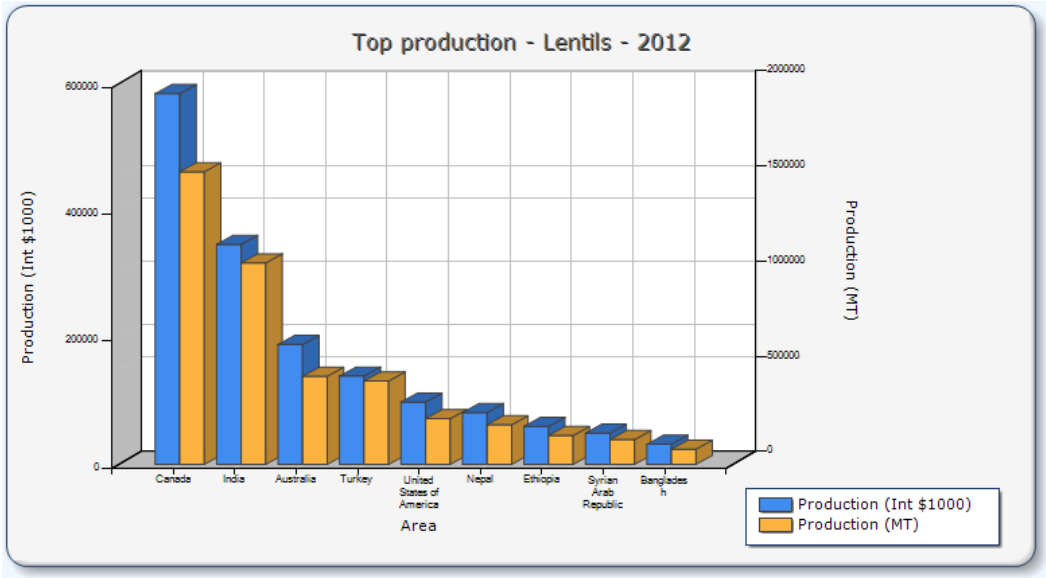
- Vegetable protein
- Complements cereals
  - complete protein
- Important micronutrients
- Inexpensive
- Quick cooking (some)
- Already part of the diet of billions

Feeding the world – from W. Canada



Peas

- 2015 – 3.2M t from 1.5M ha
- 2016 (est) - 4.1M t from 1.7M ha



Lentils

- 2015 – 2.37M t from 1.6M ha
- 2016 (est) - 2.85M t from 1.8M ha

FAOSTAT

AAFC

Consequences?

PULSE
January 201

SASKATCHEWAN pulse Growers

As it stands today, growers should seed at least 4.46 million (M) acres of lentils. Many market participants believe if grower bids remain at current levels, plantings will push past 5 M acres.

REACHIN

Brian Clancey
Stat Publishing

through the area targ
will take their best sh
target.

Based on current mar
are expected to seed
peas, and faba beans
edible beans, but see
in lentils and field pea
mimicked in the Unit

This has changed the topic of the new crop lentil debate from area to yields. Many market participants argue that this year's expansion cannot happen unless there is an influx of new growers, seeding lentils on lentils, and using marginal land. This has markets convinced yields will not reach their full potential. The recent five-year average yield for lentils is 1,464 pounds per acre (lbs/ac), which is 140 lbs higher last years crop average.

'16

All Red	Other	All
2,890,000	12,000	3,950,000
1,342	735	1,324
1,758,900	4,000	2,372,900
181,000	2,000	365,000
1,939,900	6,000	2,737,900
1,491,600	4,100	144,500
99,700	400	144,500
116,600	500	164,400
1,707,900	5,000	2,412,900
232,000	1,000	325,000

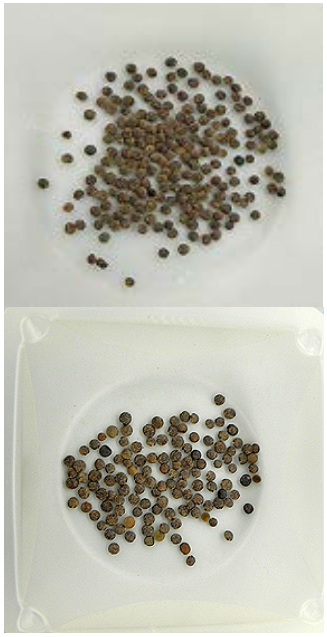
Need for more productive varieties

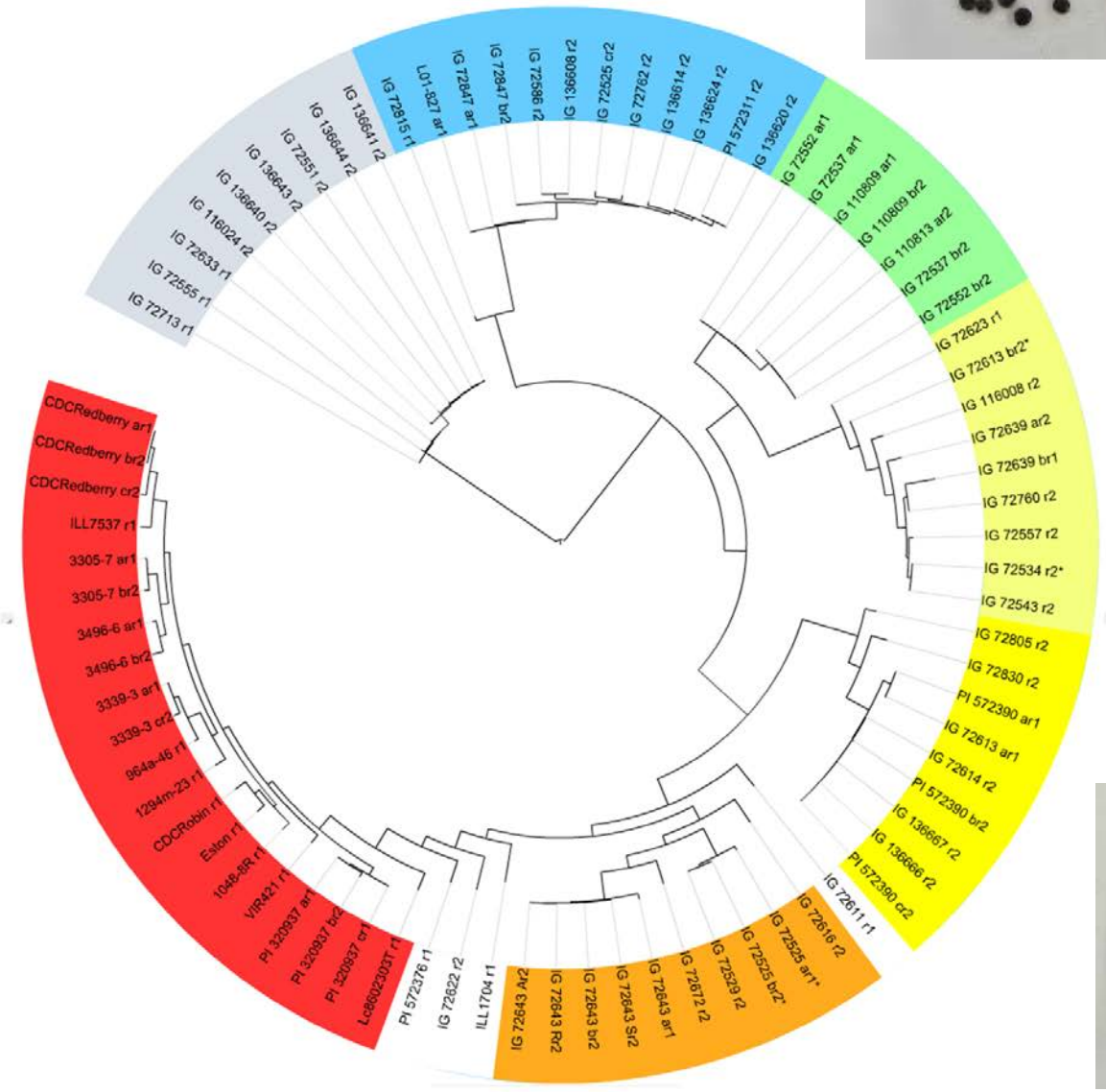
Steps in Plant Breeding

Collect variability

- Sources of resistance
- Sources of stress tolerance
- Yield genes
- Increased micronutrients
- Better quality

Crop Wild Relatives



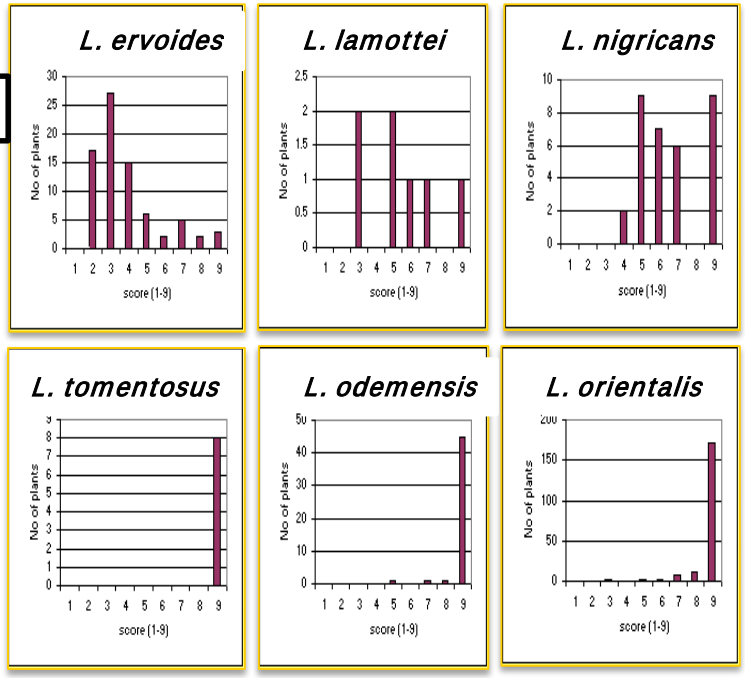


Looking for useful genetic variability in wild species

Outdoor- Anthracnose Race Ct1/Ct0

Indoor- Anthracnose Race Ct0

Anthracnose



Tullu et al., 2006. *Genetic Resources and Crop Evolution 53*: 111-119.

Ascochyta blight

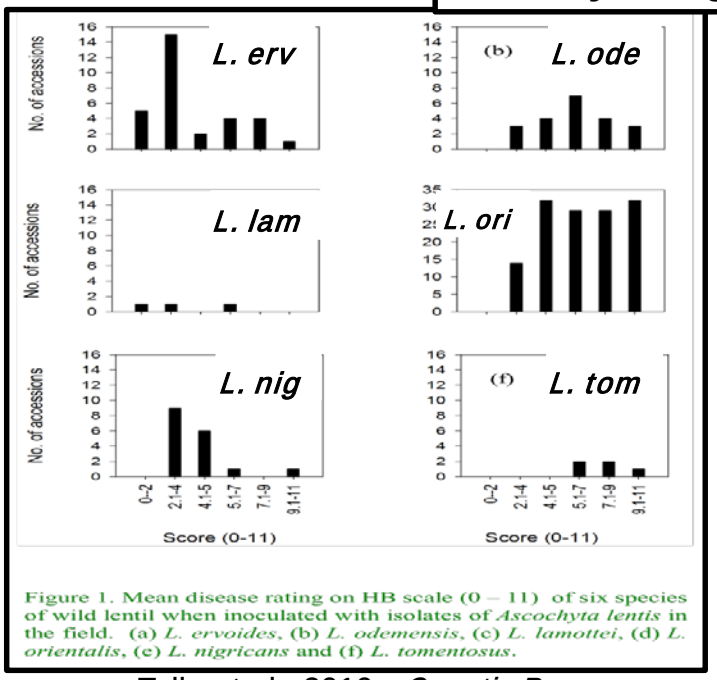


Figure 1. Mean disease rating on HB scale (0 – 11) of six species of wild lentil when inoculated with isolates of *Ascochyta lentis* in the field. (a) *L. ervoides*, (b) *L. odemensis*, (c) *L. lamottei*, (d) *L. orientalis*, (e) *L. nigricans* and (f) *L. tomentosus*.

Tullu et al., 2010. *Genetic Resources and Crop Evolution 57*: 1053-1063.

Deploying useful genetic variability from wild species

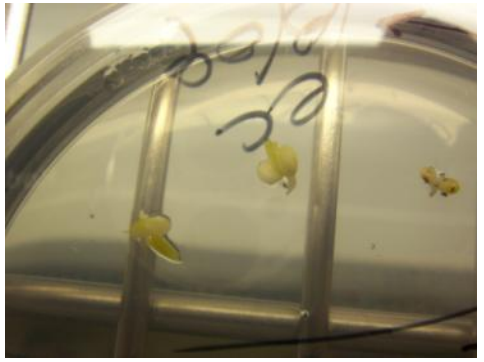
CROP TRUST

Steps in Plant Breeding

Collect variability

Cross

- Embryo rescue if interspecifics



Steps in Plant Breeding

Collect variability

Cross

7+ years field testing

Select the ‘best’ plants in segregating generations

A numbers game

- F2 population:

# genes	# genotypes	# phenotypes	Perfect population size
1	3	2	4
2	9	4	16
3	27	8	64
n	3^n	2^n	4^n

- And this assumes no environmental effect on the phenotype

Using Technology to Breed Smarter

- For accessing greater variability
- For selecting genotypes not phenotypes
- For more robust phenotyping
- For increased efficiency in the field

Pulse Crop Breeding

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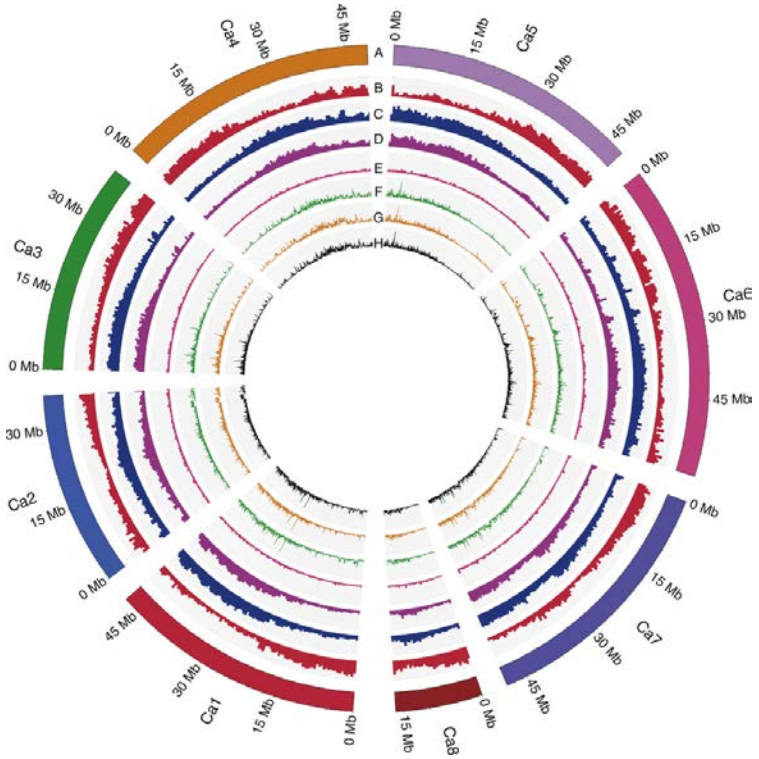
Pulse Crop Breeding

Sequencing genomes

- Chickpea (CDC Frontier) – 2013
- Common Bean – 2014
- Lentil (CDC Redberry) – 2016
- Pea – 2016?
- *Colletotrichum lentis*

  - 2016

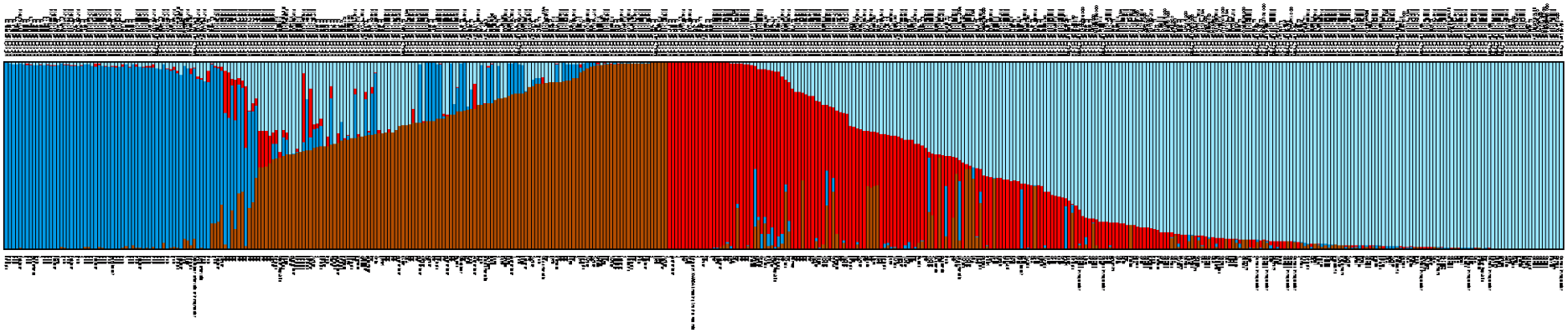
- But so what?



Varshney et al. 2013. doi:10.1038/nbt.2491

Variability: Know your germplasm

- Diversity data for ~450 lentil lines



S. Asia

Mediterranean/Middle East

Canada

<30

45

Average days to flower under long days

Agile

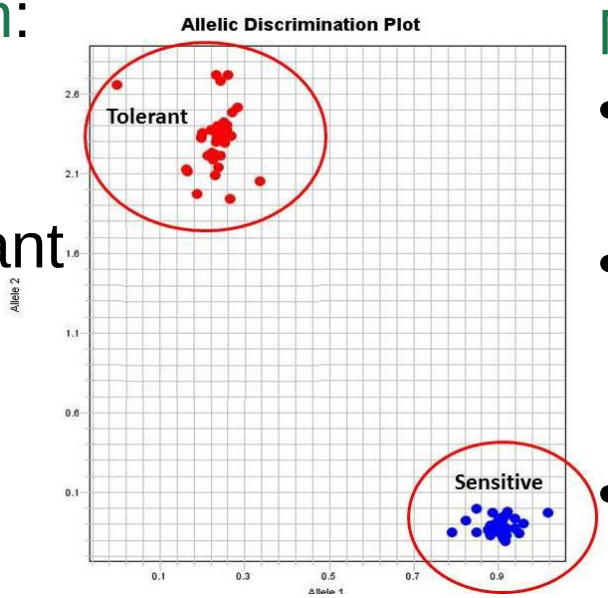
APPLICATION OF GENOMICS TO INNOVATION IN THE LENTIL ECONOMY

Tolerance to IMI herbicides in chickpea

Nucleotide Alignment	**653**
Medicago truncatula	AHAS1 ...TTC**C**CCGG...GATG**C**TT...
C. arietinum CDC Frontier	AHAS1 ...TTC**C**CCGG...GATG**C**TT...
C. arietinum IMI sensitive	AHAS1 ...TTC**C**CCGG...GATG**C**TT...
C. arietinum IMI tolerant	AHAS1 ...TTC**C**CCGG...GATG**T**TT...

Conventional selection:

- laborious
- heterozygous = homozygous resistant phenotype,
- potential escapes!



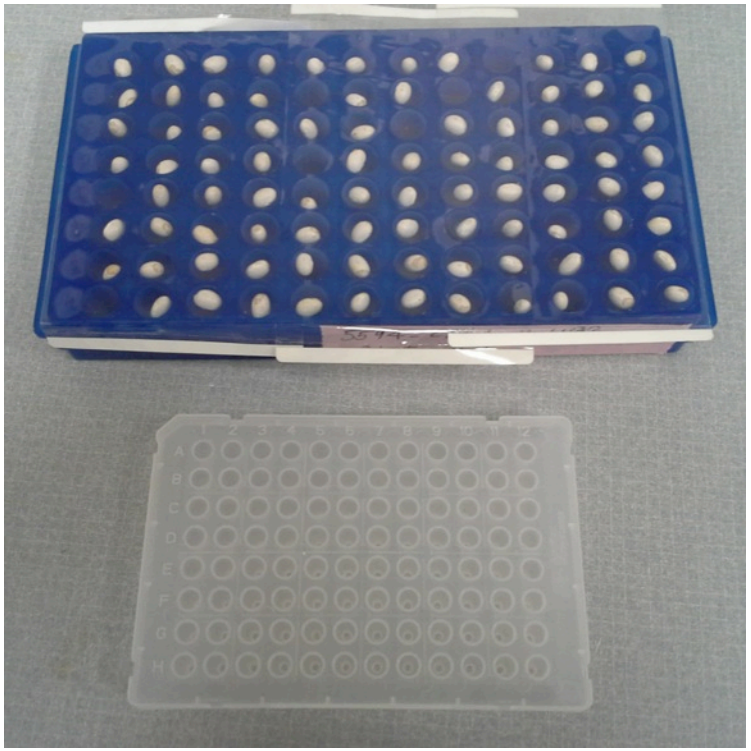
MAS:

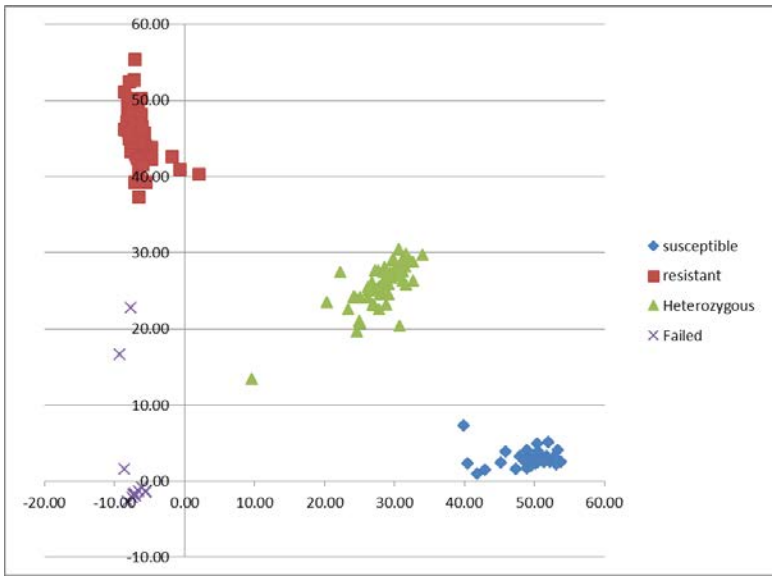
- far fewer resources required,
- homozygous and heterozygous can be separated,
- no escapes.

(Courtney Thompson)

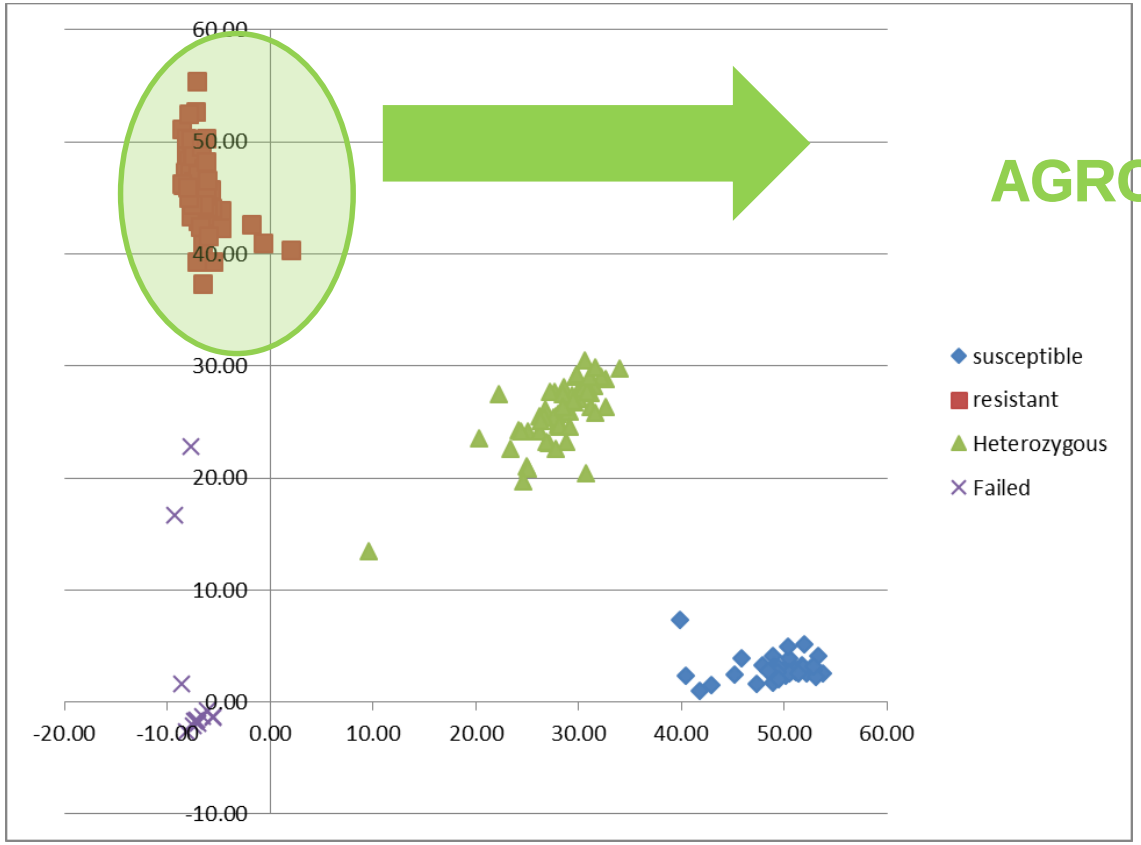
Marker-Assisted Selection

- Select on genotype not phenotype
- Heterozygotes can be identified
- Good for single genes
- Assay before even planting the seed





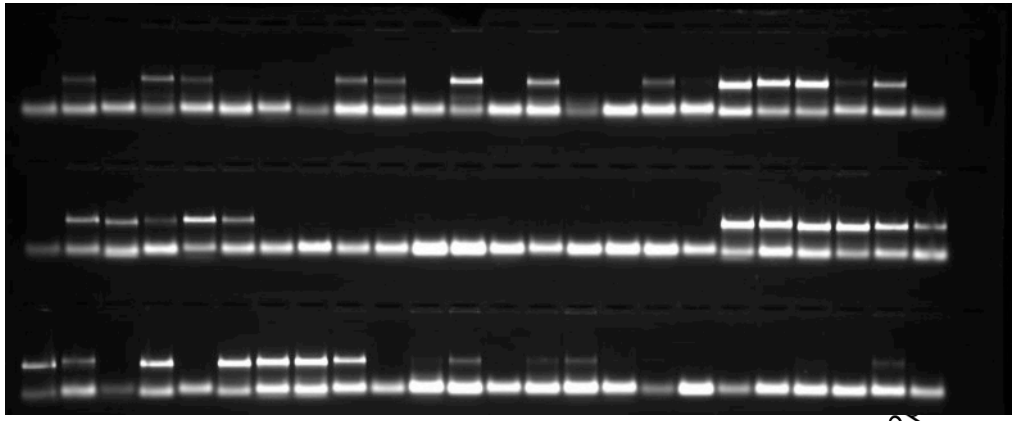
MAS for imi-tolerant lentils



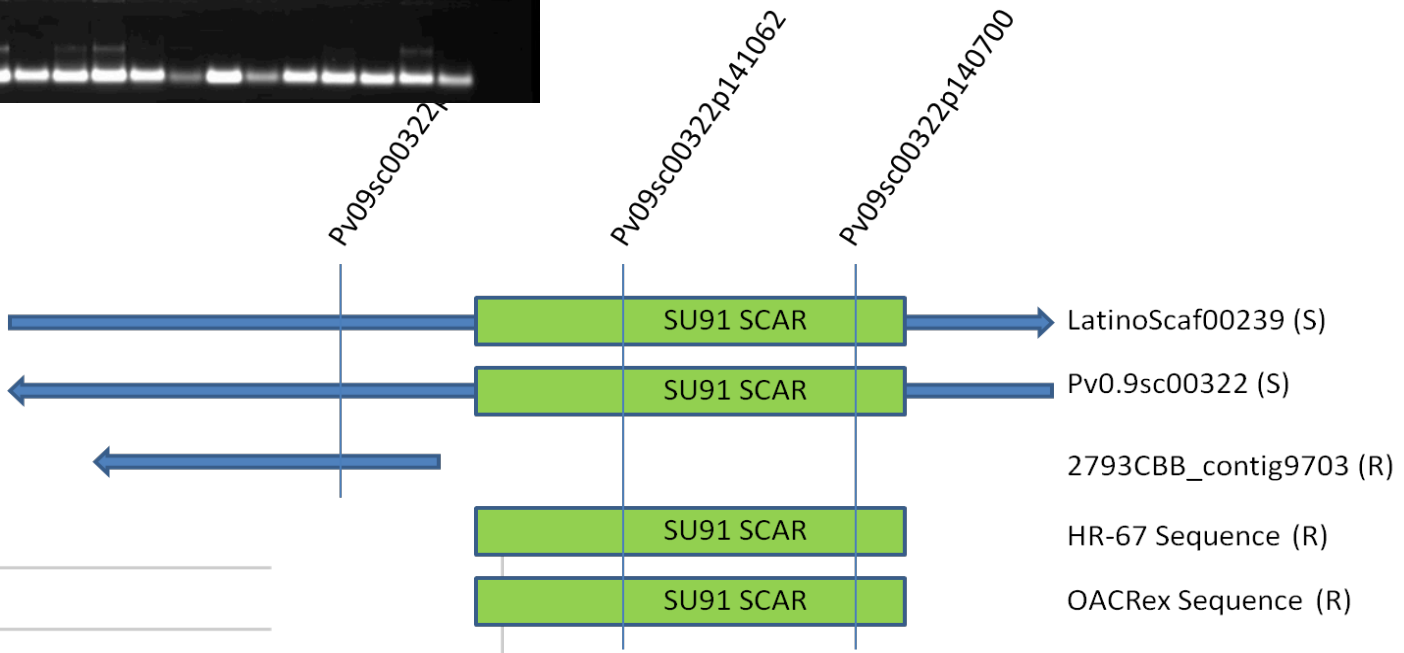
TO THE FIELD FOR AGRONOMIC EVALUATION

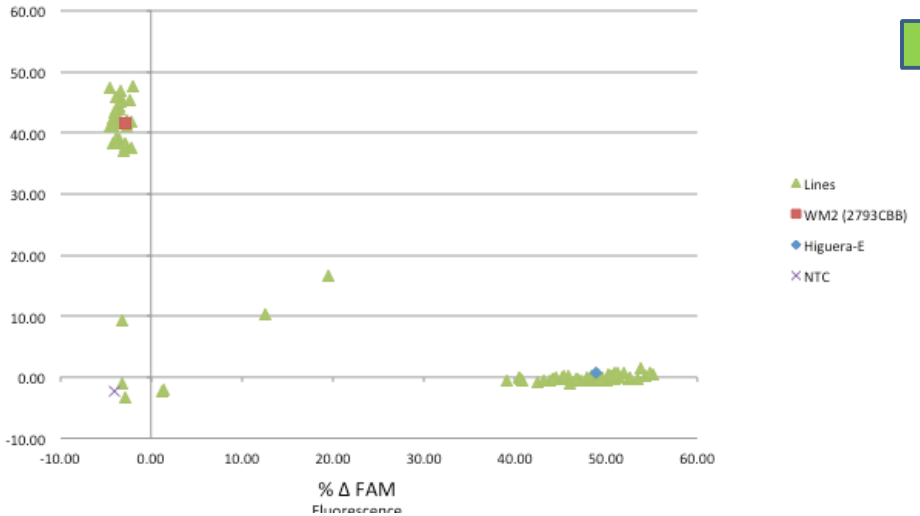
- Field screening = $40 per plot
- MAS = $0.40 per seed AND save a generation

SU91 – marker for common blight tolerance in common bean

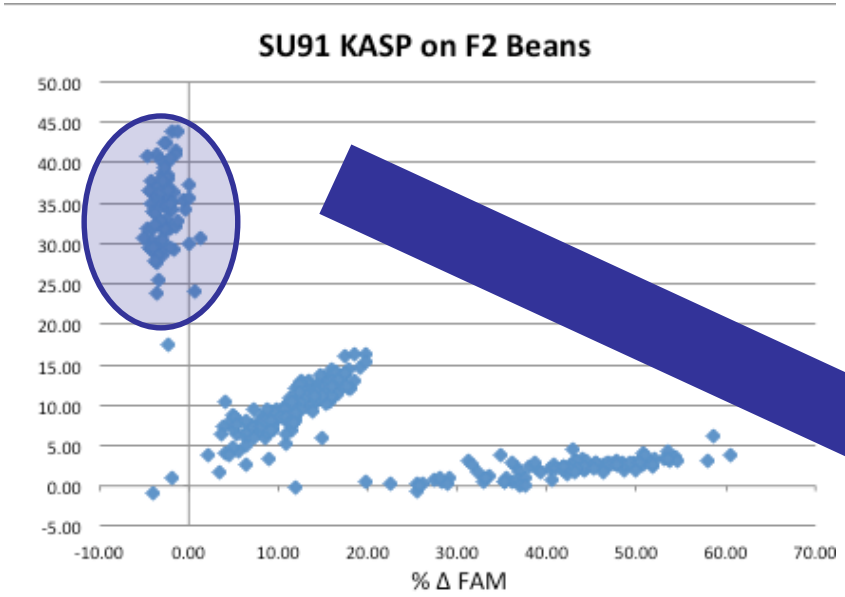


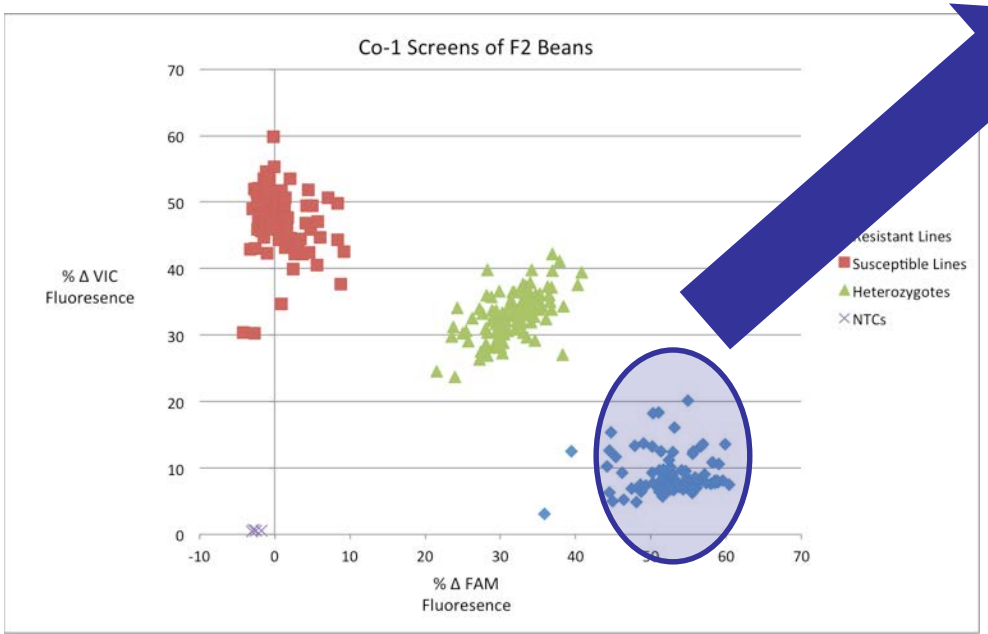
$1.50/individual





Gene Stacking

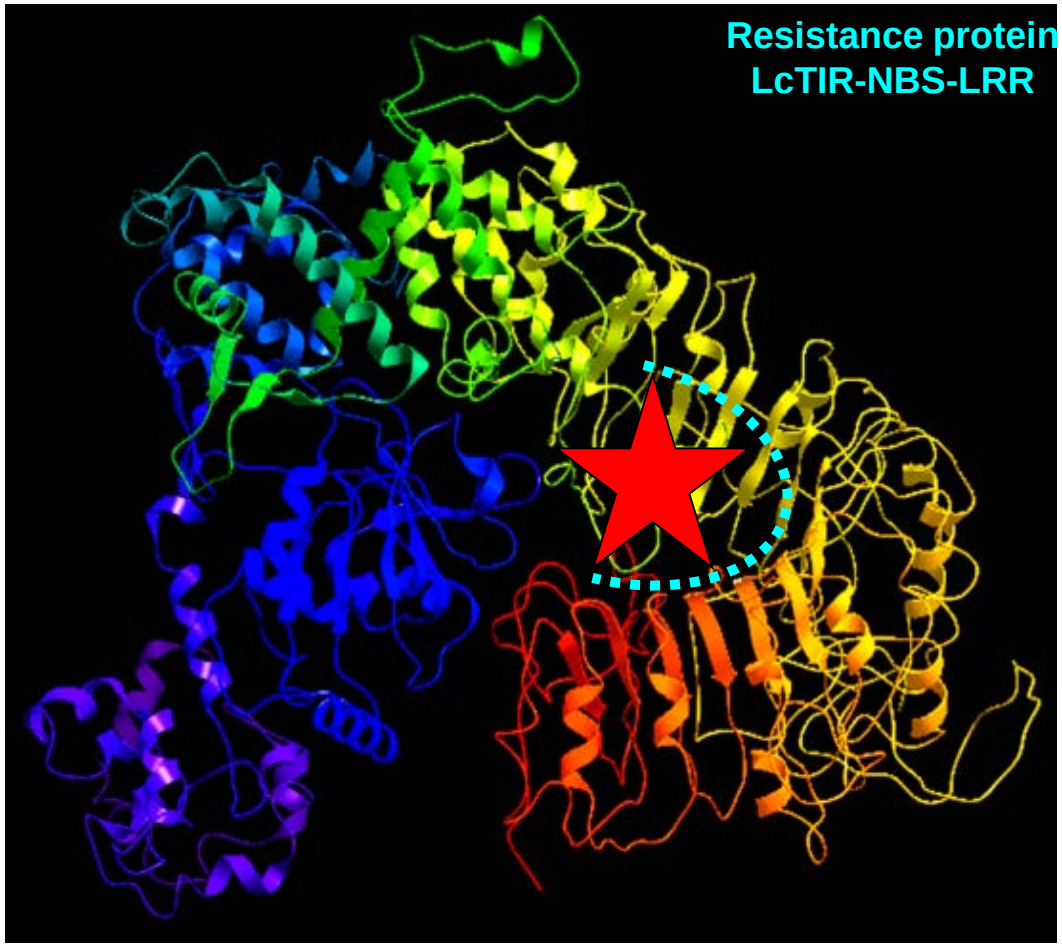




- Check SU91 & Co-1 marker status
- Only keep those with both resistance-linked marker alleles

Howard F. Schwartz

Tackling Disease Resistance Genes



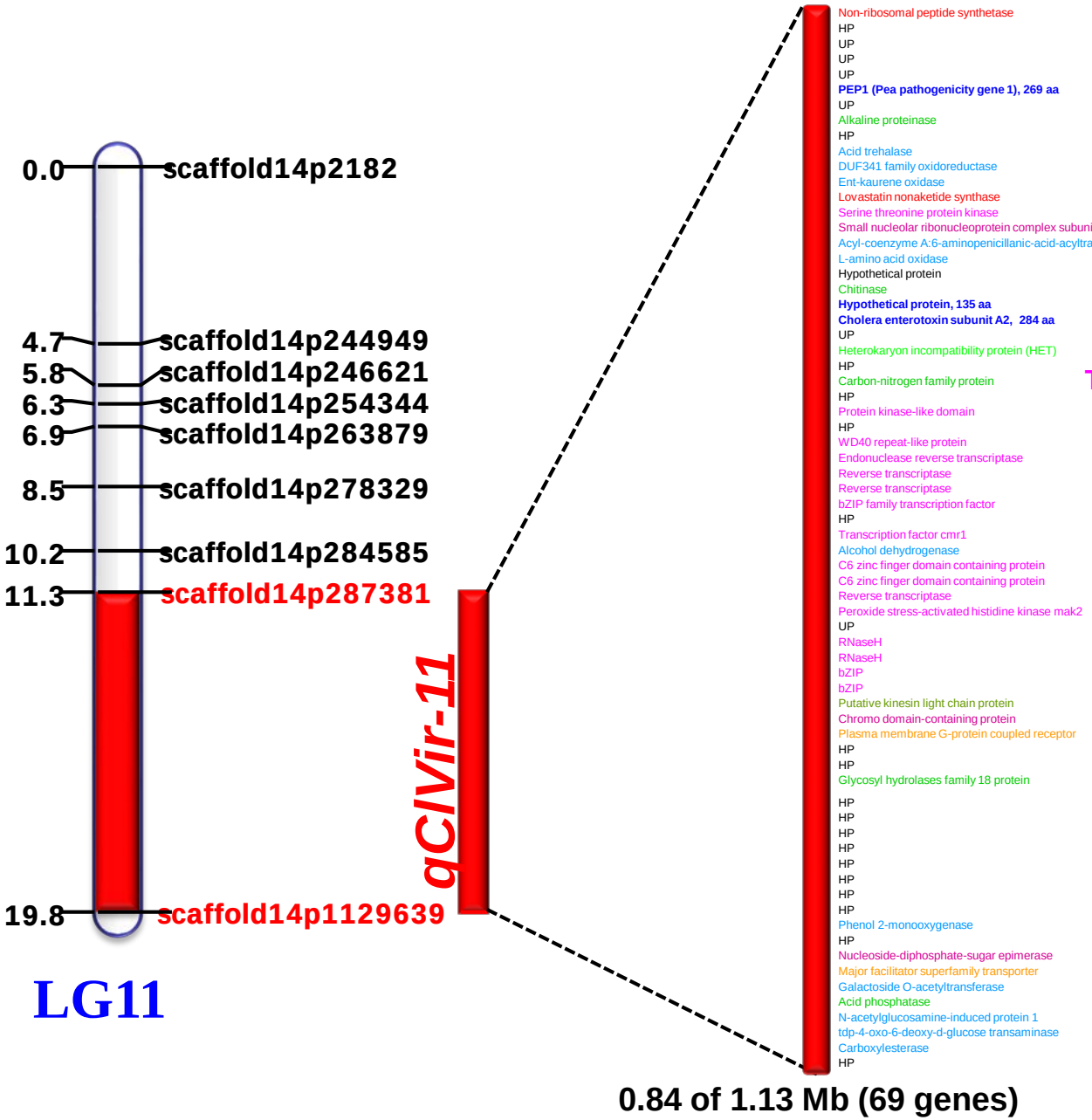
Pathogen effector

LRR domain of R-gene

Lentil - *C. lentis* interaction

Vijai Bhadauria &
Sabine Banniza

Mapping of candidate genes in the pathogen



Effectors: 3

Hydrolases: 5

Primary metabolism: 11

Secondary metabolism: 2

Transcription and signal transduction: 16

Receptors: 2

Structural: 3

Organelle transport: 1

Somatic incompatibility: 1

UP, uncharacterized proteins: 6

HP, Hypothetical proteins: 19

Vijai Bhadauria &
Sabine Banniza

Using Technology to Breed Smarter

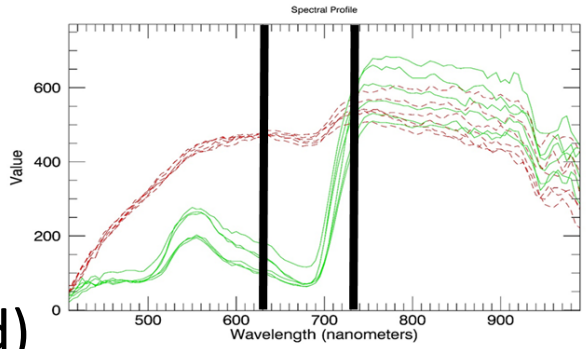
- For accessing greater variability
- For selecting genotypes not phenotypes
- For more robust phenotyping
- For increased efficiency in the field

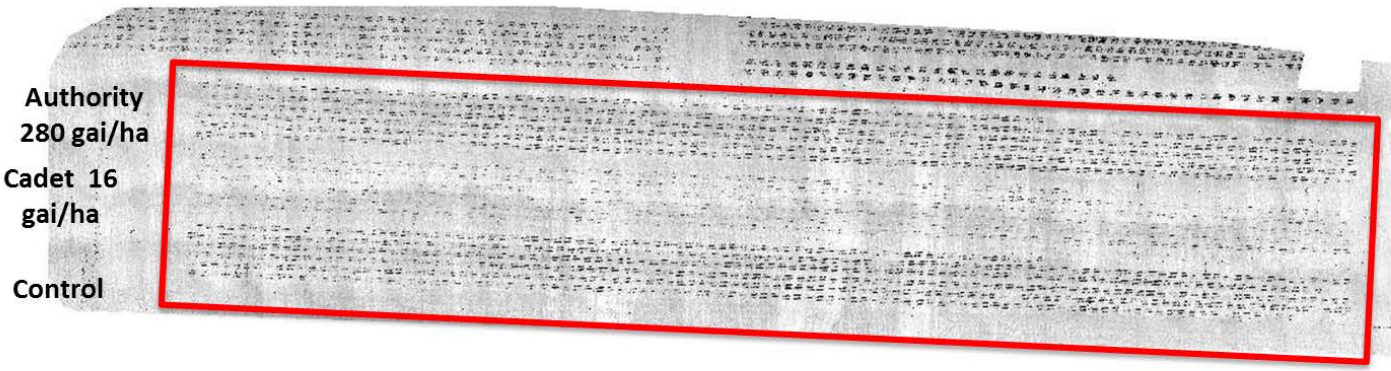
Pulse Crop Breeding

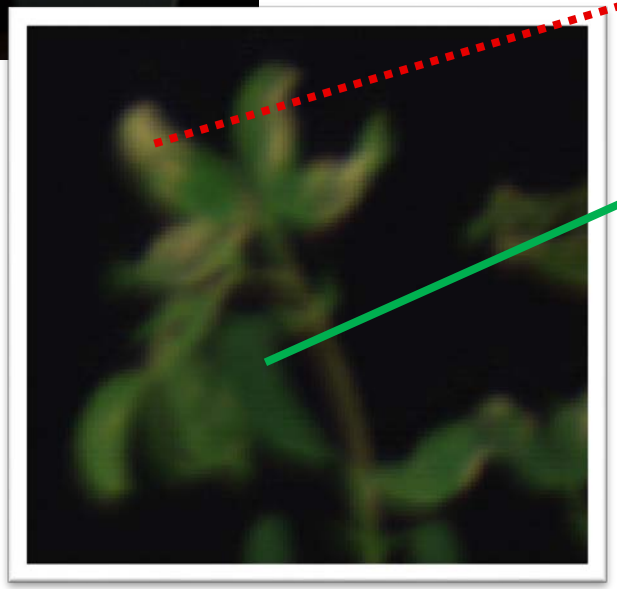
Imaging technologies

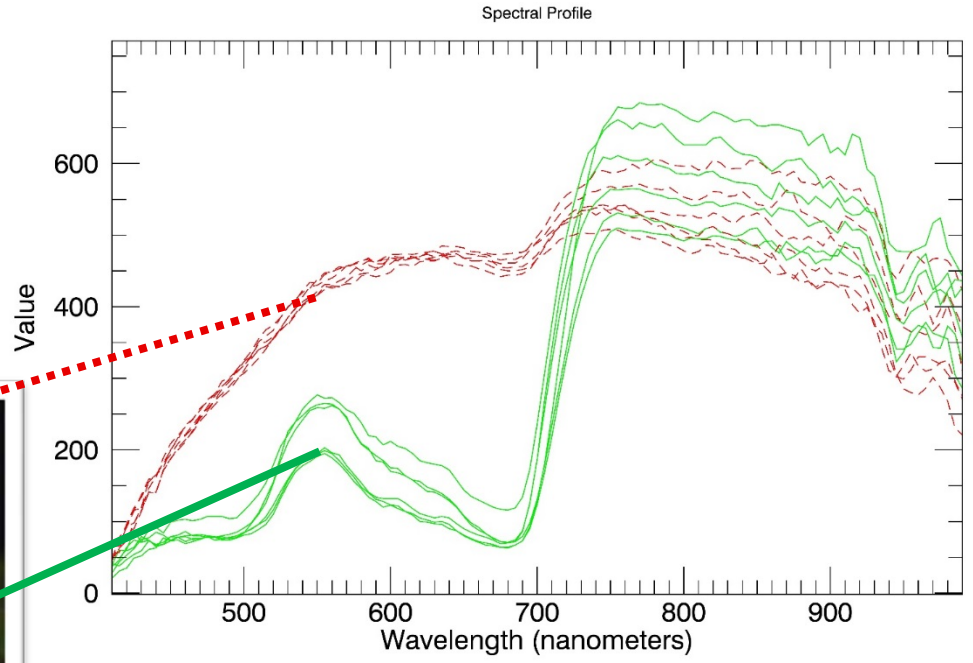
- Multispectral camera
- NDVI - Normalized Difference Vegetation Index
  - Indicator of plant health
  - High correlation with plant biomass

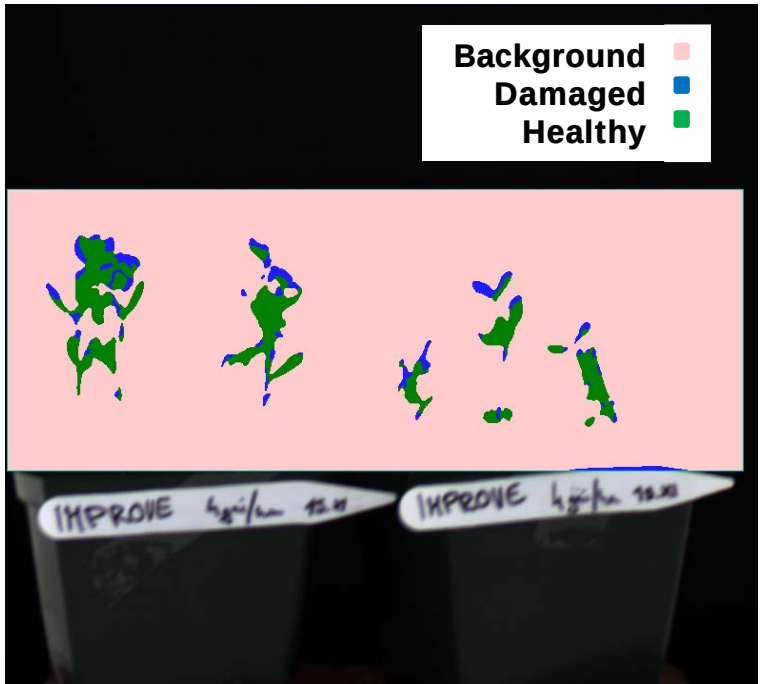
NDVI=(NIR-Red)/(NIR+Red)





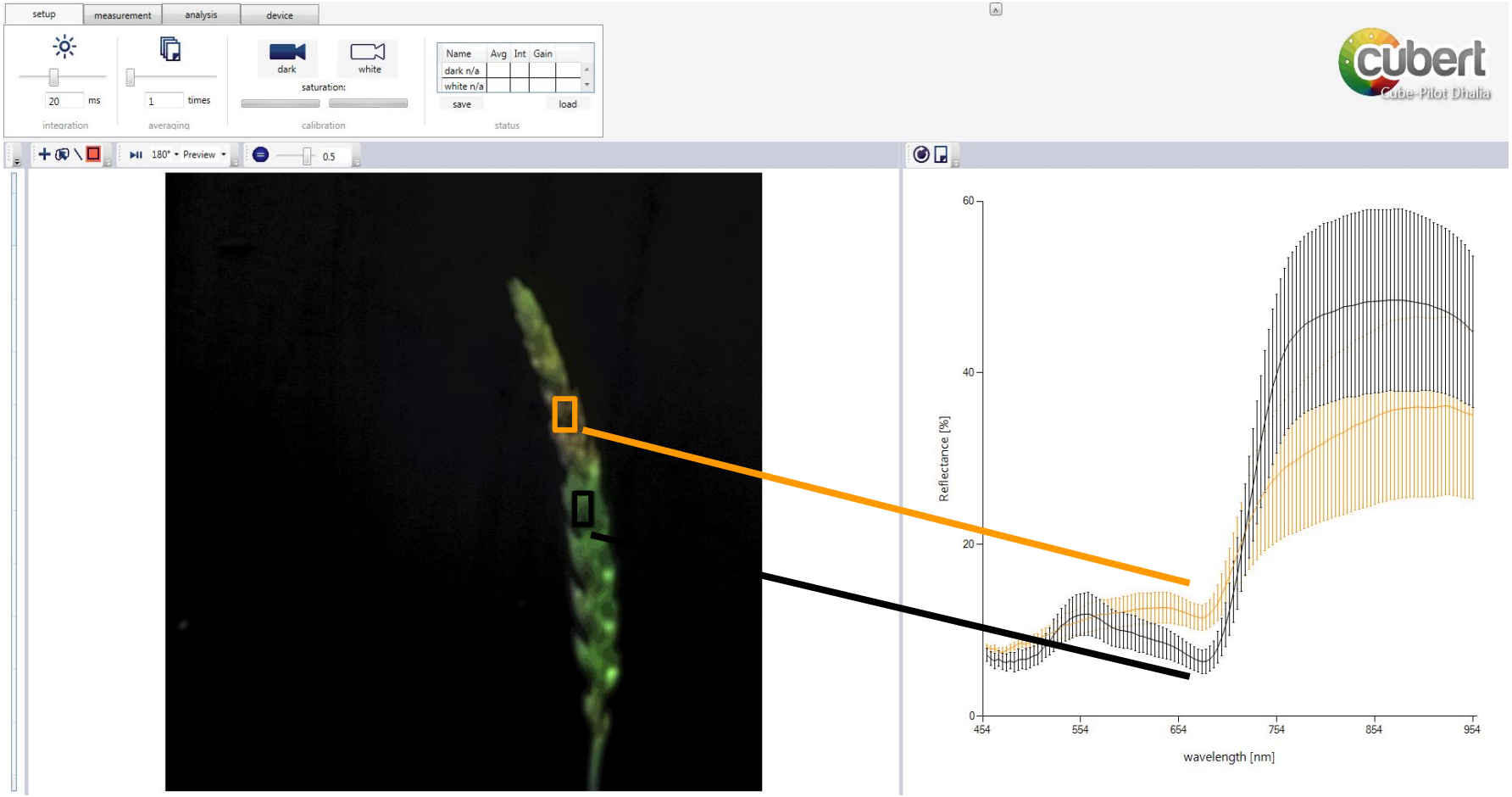






Hyperspectral imaging of lentil injury of Group 14 herbicides

Imaging technologies



Fusarium head blight (6 day after inoculation)

Pajic & Cory

Better equipment for greater efficiency

Barcode tracking

Double plot seeder with GPS tripping

Better equipment to keep crew happy

Acknowledgements

Bunyamin Tar'an
Tom Warkentin
Bert Vandenberg
Sabine Banniza

Pulse crop breeding lab
Pulse crop molecular lab
Grains innovation lab
Pulse crop pathology lab
Pulse crop tissue culture lab
Pulse crop graduate students, post-docs
Breeder seed crew
Plant Sciences admin staff

National/international collaborators (many)

Questions?