FIGS: taking the guesswork out of genebank selections

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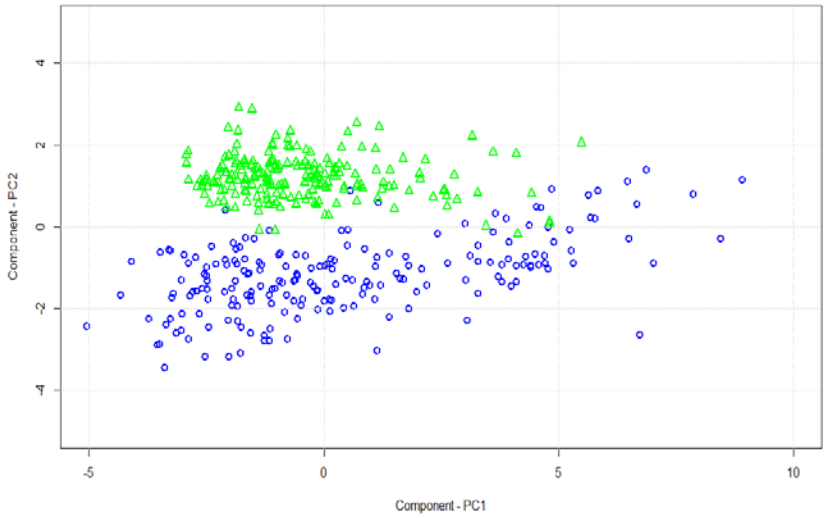
FIGS premise

If a dependency exits between environmental parameters and the emergence of an adaptive traits within an in-situ population then we can use this relationship to predict where adaptive traits are likely to occur elsewhere.



(Separation of two Faba bean FIGS sets selected from wet and dry environments based on stomatal and leaf morphology, water use parameters and leaf temperatures)

Recent improvements in the FIGS methodology

Accuracy metrics for an algorithm(SMV*) used to predict environments that are likely to yield stripe rust resistance for Durum when agro-climatic data are presented to the algorithm in different formats (Temperature, precipitation, aridity index).

Table 4 : Accuracy and agreement parameters of aligned data

Data type		AUC	OR	SE	SU	CC	Kappa	
monthly	Max	0.81	0.28	0.72	0.90	0.86	0.61	
daily data	Max	0.82	0.30	0.70	0.93	0.88	0.64	
daily data within growing period	Max	0.83	0.28	0.72	0.95	0.90	0.70	210 days

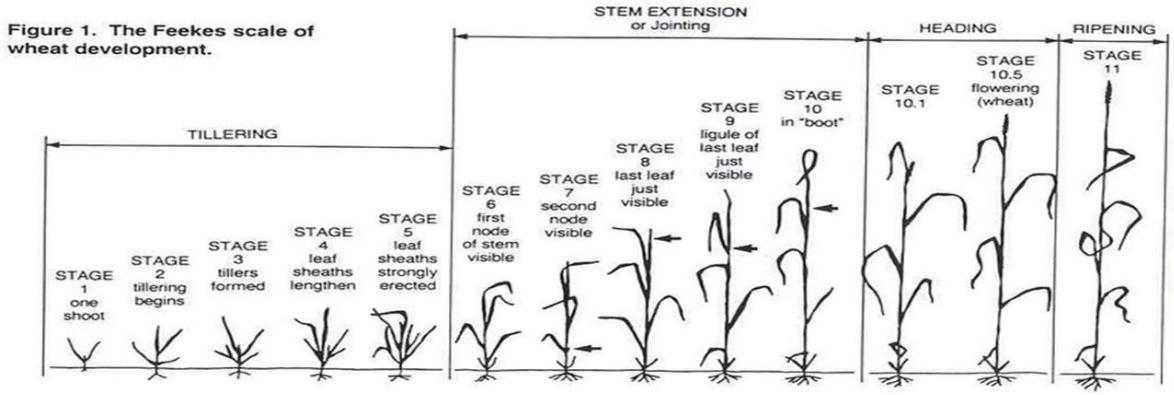
- An AUC value of 0.5 and lower indicates that model output is the same as a random outcome
- A Kappa value of 0.4 and above indicates the model is able to reliably predict trait states (better than random). An increase of 0.01 represents a significant improvement in model performance.

* Support Vector Machine

Recent improvements in the FIGS methodology

Conclusions

- Using daily data to define the environments yields improved predictions
- When the daily data is confined to the growing season for a given environment then further improvements in predictive power are realized.



Room for further improvement

- Daily data is currently generated from monthly long term averages. There are inherent errors in the results of the algorithms applied to do this.
  - ICARDA GIS department is currently generating a series of continuous surfaces for actual long-term daily data (Thus one parameter requires 365 surfaces that cover the whole of Euro-Asia – massive data processing required)

- The onset of growing period data necessary to estimate crop growth cycles within a given germplasm collection site is based on algorithms that yield significant errors for some environments. (Currently using an FAO model).
  - The onset model will be improved using actual long-term field data collected by CIMMYT for their international multi –site trials.

- Currently using temperature and moisture derived parameters. With more classes of data we can improve the predictive algorithms.
  - ICARDA GIS department will generate additional surfaces including vapour pressure, humidity, cloud cover, wind speed and vegetation indices.

FIGS sets produced and sent to assorted evaluation programs 2010 – 2013 (off-shore)

Crop	Traits
Barley	Drought, BYDV, Pm, Net blotch, Boron, Salinity, Frost, Stem gall midge
Bread wheat	Wheat blast, Hessian fly, Spot blotch, Sunn pest, Phosphorous use Efficiency, Heat, Cold, Drought, Nematode, Boron, Salinity, Crown rot, Stem rust, Yellow rust, Powdery mildew, Salinity
Durum wheat	Drought, Heat, Rust, Sunn pest, Salinity, Hessian fly, yellow rust
Chickpea	Salinity, Heat, Cold, Botrytis, Ascochyta, Fusarium, Virus, Leaf miner, Pod borer
Lentil	Cold, Vurus, heat
Faba bean	Heat, Cold, drought, virus

- In total the above sets totalled 17016 accessions. To import into Australia would have incurred quarantine costs in excess of $850,000 (at $50/acc)
- Thus the strategy is to import promising lines identified from the evaluation trials
- This will occur in 2014 as results become available

Key FIGS project milestones - summary

Milestones – 1 and 6

- Identify 5 target traits for each of bread wheat, durum wheat, lentil, chick pea, faba bean and field peas according to a priority list of key traits of importance to the Australian grains industry.

Milestones – 4 and 9

- Annually identify subsets of barley, durum and bread wheat, lentil, chickpea, faba bean and field pea accessions for **one the 5 traits** identified in milestone 1 and 6.

Milestones – 5 and 10

- Annual delivery of all subsets identified in milestone 4 and 9 along with all data and information associated with subsets to Australian grains genebank through CAIGE coordination project.

Summary of germplasm requirement survey

- To address milestones 1 and 6 a letter asking for a wish list of priority traits was sent to a comprehensive list of breeders and crop researchers – to guide FIGS set selections.
- Good response from cereal community - thank you ☺
- Not so enthusiastic response from legume community

Bread wheat	Stem, leaf and stripe rust, Crown rot, Heat tolerance, Terminal drought tolerance, Root lesion nematode, Acid soil tolerance, Tolerance to low fertility soils, P use efficiency, Frost tolerance
Durum wheat	Stem, leaf and stripe rust, Crown rot, Root lesion nematode, Heat tolerance, Terminal drought tolerance, Acid soil tolerance, Tolerance to low fertility soils, P use efficiency
Barley	Powdery Mildew , Rust diseases, Net form net blotch, Spot form net blotch, BYVD, Scald, Water logging tolerance, Acid tolerance, Salinity tolerance, Tolerance to low fertility soils, Boron tolerance, P use efficiency, Frost tolerance

Summary of germplasm requirement survey

lentil	Ascochyta blight, Botrytis grey mould (BGM), Cucumber mosaic virus (CMV), Beet western yellows (BWYV), Fusarium wilt (root rot), Lentil rust, Aphids (Bluegreen; Cowpea), Boron tolerance, Salinity tolerance, Insect resistance (viral vectors and herbivorous)
Chickpea	Ascochyta blight, Chilling tolerance – podset under cool temperature, Salinity, Virus resistance
Field pea	Blackspot, Ascochyta, Bacterial Blight, Downy Mildew, Viruses, Pea weevil (Bruchus pisorum), Salinity, Boron
Faba bean	Heat tolerance , Frost tolerance

Proposed FIGS sets for 2014

Your feedback is important at this point.

Bread wheat	Frost tolerance (frost initiative), Acid tolerance, P use efficiency, tolerance to low fertility soils.
Durum wheat	Acid soil tolerance, Tolerance to low fertility soils, P use efficiency
Barley	Acid tolerance, Salinity tolerance, Tolerance to low fertility soils, Boron tolerance, P use efficiency
lentil	Boron tolerance, Salinity tolerance
Chickpea	Salinity
Field pea	Salinity, Boron
Faba bean	Heat tolerance

* Estimated set sizes 50 -200 accessions. Delivery estimated– July 2014

Rationale:

- Pests and diseases as well climatic stresses rated more highly than edaphic constraints in terms of the frequency with which they occurred in the wish lists
- However, by August this year we should have greatly improved agroclimatic surfaces with which to construct disease and climatic focused FIGS sets. Thus it would be better to deliver these sets once the new data is available.

Use FIGS more often

FIGS is heuristic

Refine set selection process

Merci

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Gracias