User's experience of FIGS: seeking sources of drought resistance in faba bean

Fred Stoddard, Univ. Helsinki

Hamid Khazaei, now Univ. Saskatchwan

Kenneth Street and Abdallah Bari, ICARDA

Core collection or Focused Identification of Germplasm Strategy?

- “Horses for courses”: both needed in different conditions
- Core collection for traits of unknown relationship with provenance
  - e.g., lipoxygenase
- FIGS for traits where provenance is informative

FIGS approach “links traits (phenotype), environments (and associated selection pressures) with genebank accessions (e.g. landraces and crop wild relatives)”

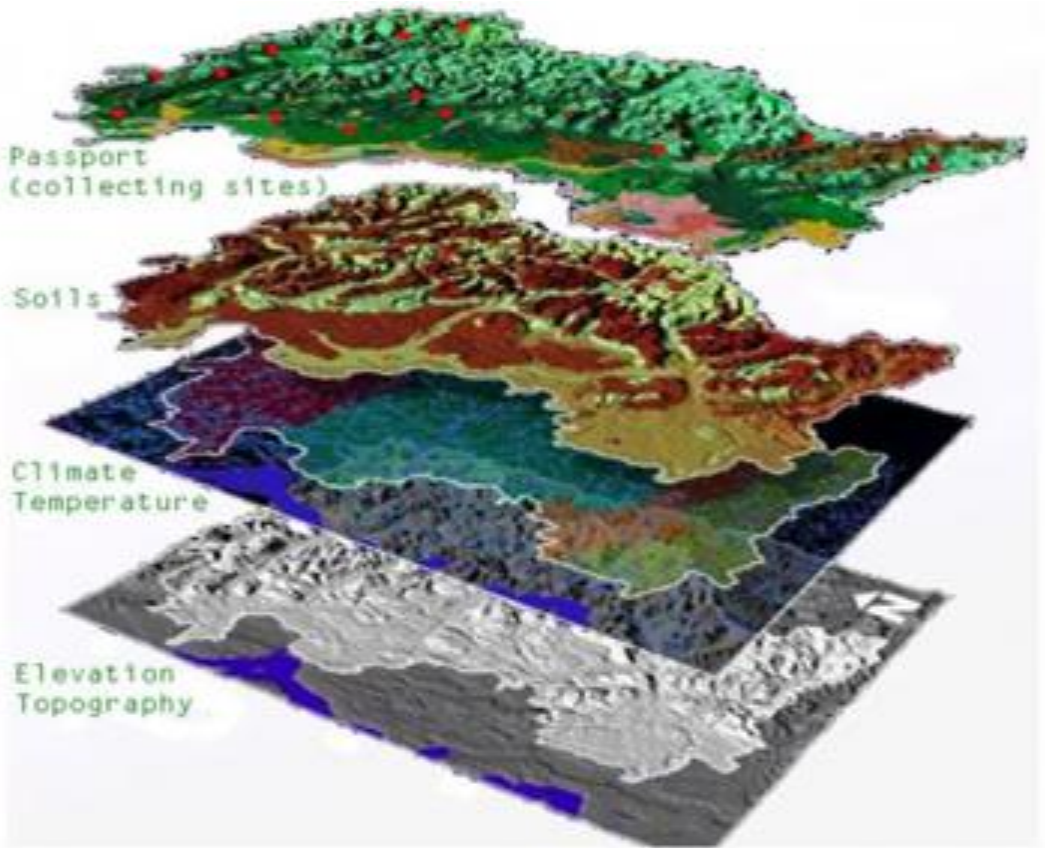
FIGS integrates passport data

Latitude - Longitude

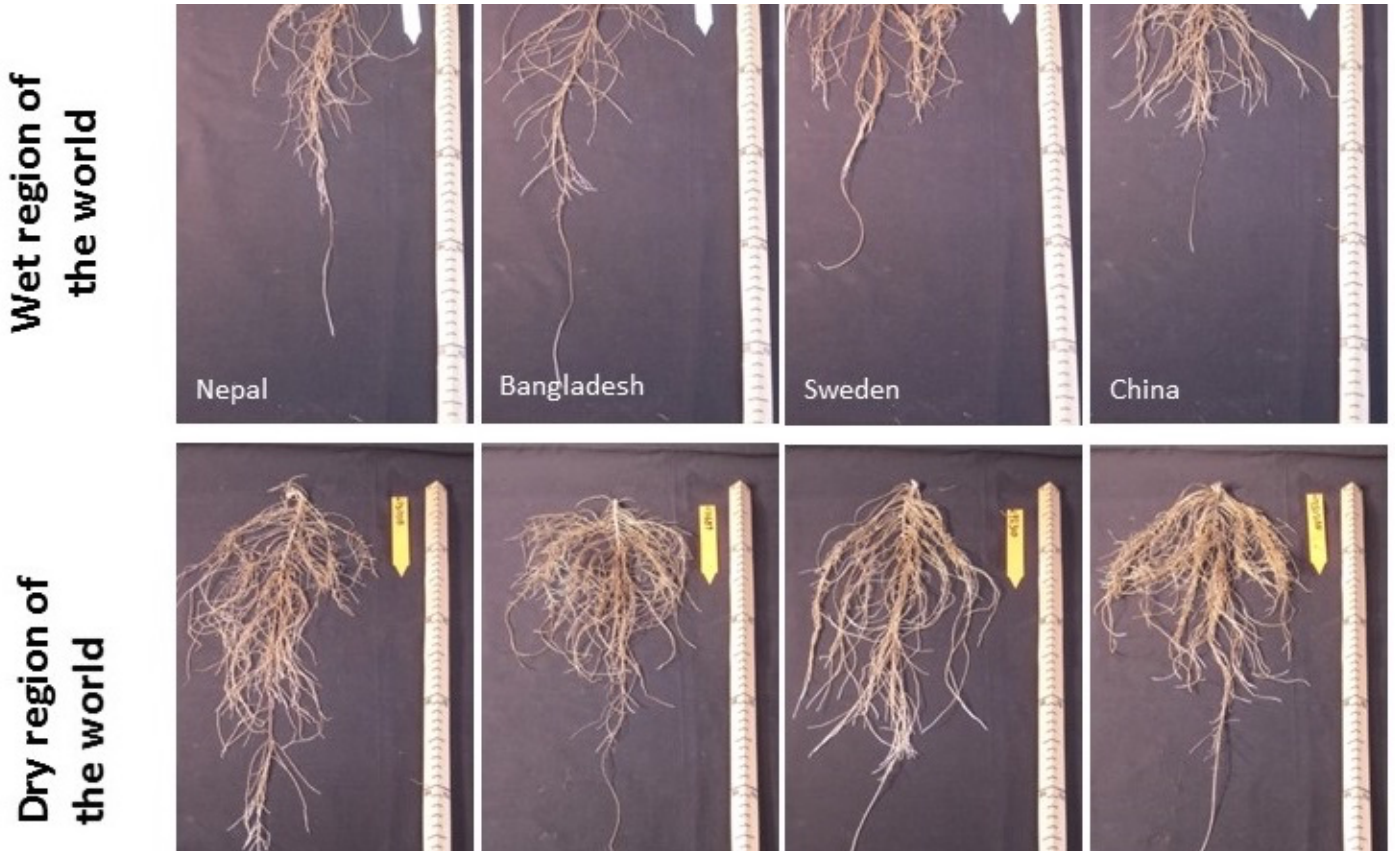
Soil type

Climate type

Elevation / topography

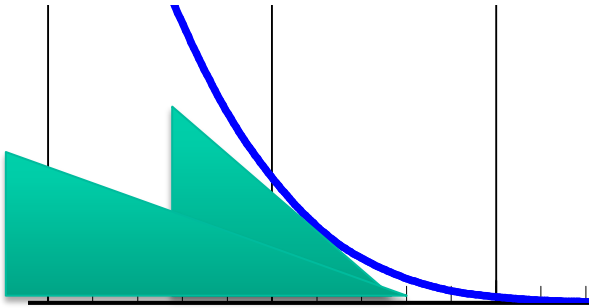


with trait information (here, faba bean roots)



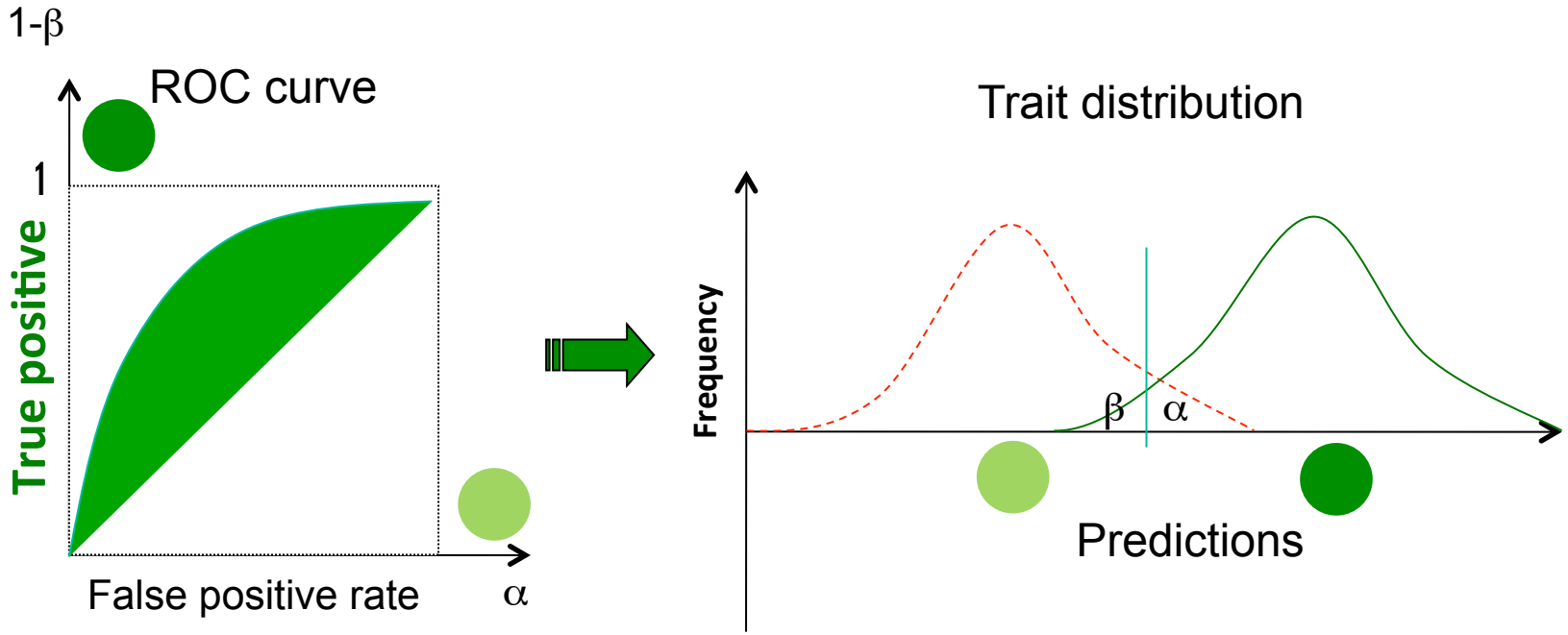
and uses complex mathematics to ask complex questions

- Neural networks, Bayesian inference, Support vector machines …
- How can we refine the simple association between the environment of place of provenance and incidence of useful trait expression?
- What is the best way to target the tail of the distribution?
  - Tight into the extremes, or accept that there are uncertainties so slightly more broadly?



FIGS detects/explores Environment x Trait relationships ("evolution pressure in reverse")

- High AUC (area) values indication of the presence of a trait-environment relationship

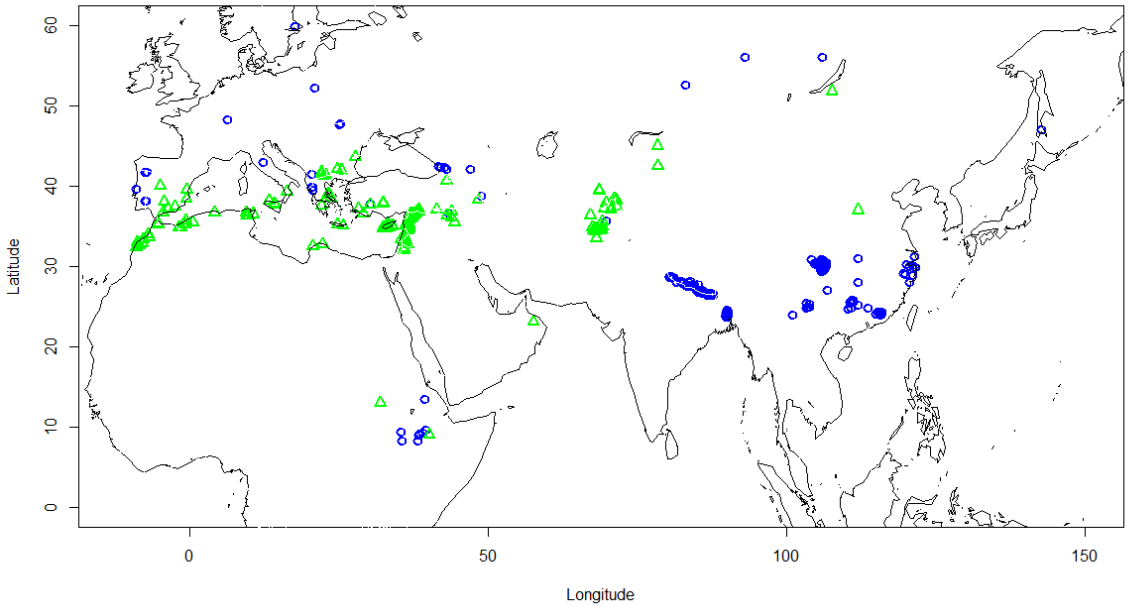


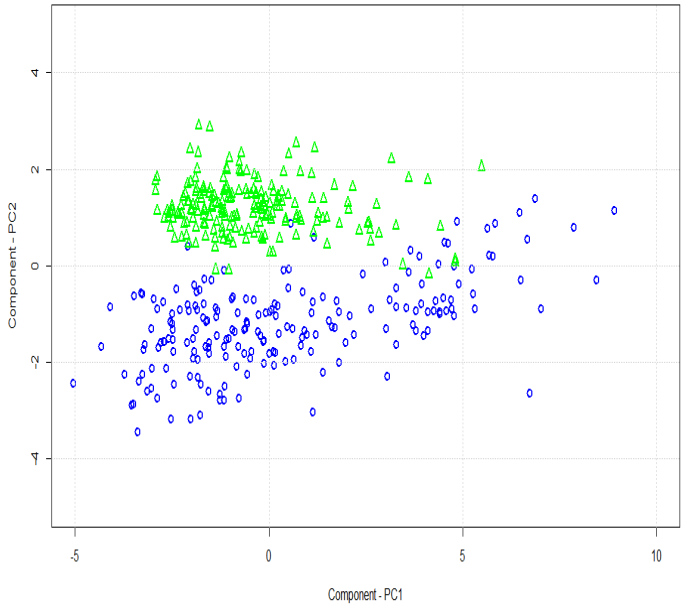
FIGS focuses on accessions having in fact the trait (TRUE POSITIVES)

Test case: drought tolerance in faba bean

- > 20 k accessions in gene banks, of which ~10 k in ICARDA
- We could handle 200 “dry-adapted” and 200 “wet-adapted”: FIGS used to select these (rainfall amount and distribution, aridity index)
- All 400 screened for numerous stomatal, phenological & morphological traits in well watered conditions, 10 + 10 in water-limited + well watered conditions
  - see papers by Hamid Khazaei et al.

Distribution of FIGS sets before and after evaluation



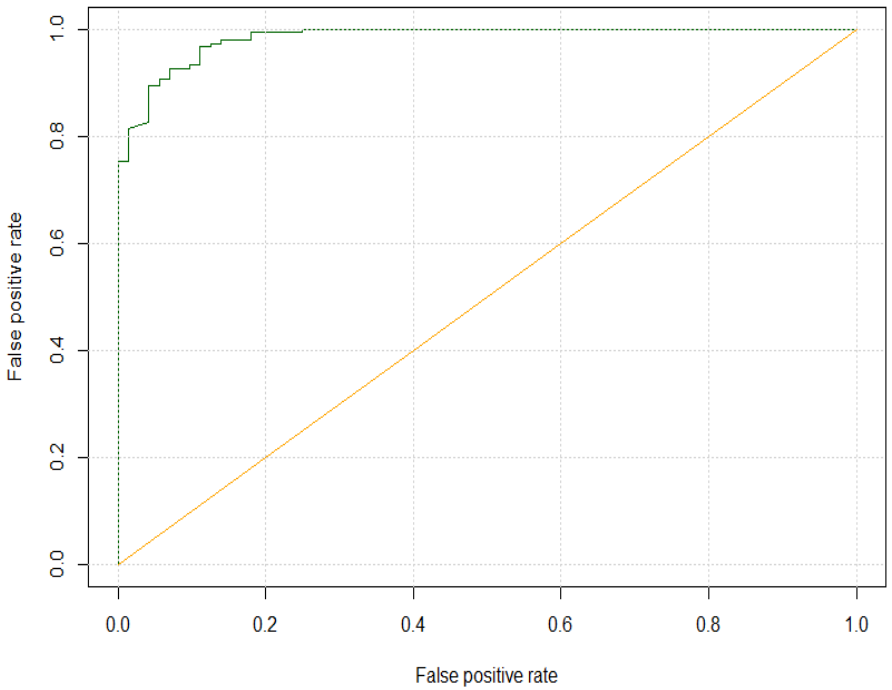


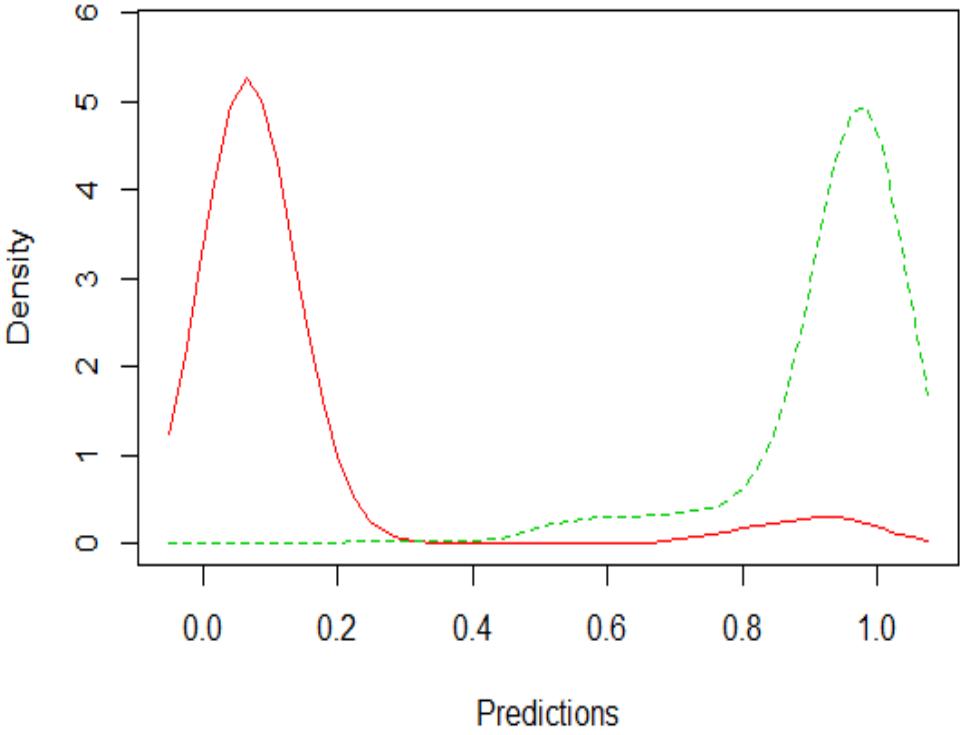
Geographical distribution of the two sets based on *a priori* information (climate data)

Distribution of the two sets based on PCA of evaluation data (*a posteriori* information)

Dry set = green
Wet site = blue

The sets overlapped very little, depending on analysis method





Something we should have done

- Screen the whole set for drought response. first
- Screening lentil for heat tolerance first narrowed the field from 200 to 20 interesting accessions
- We started with components, since drought response depends on water control (stomata), uptake (roots) and oxidative stress (osmotic substances in leaf cells)

Things we still have to do

- Screen for root traits
- Screen for osmotic responses
- Narrow the sets to more manageable numbers
- Combine components of favourable response

Conclusions

- FIGS appears to work for abiotic stresses just as well as for biotic stresses where previously tested
- Numerous phenotypes need to be measured for full benefit of FIGS
  - our “wet-set” and “dry-set” still need a lot of work!
- ICARDA and mathematics colleagues still playing with data
  - refining FIGS algorithms

Acknowledgments

Emil Aaltosen säätiö