

Developing drought-tolerant legume crops by agro-ecological and genomic approaches

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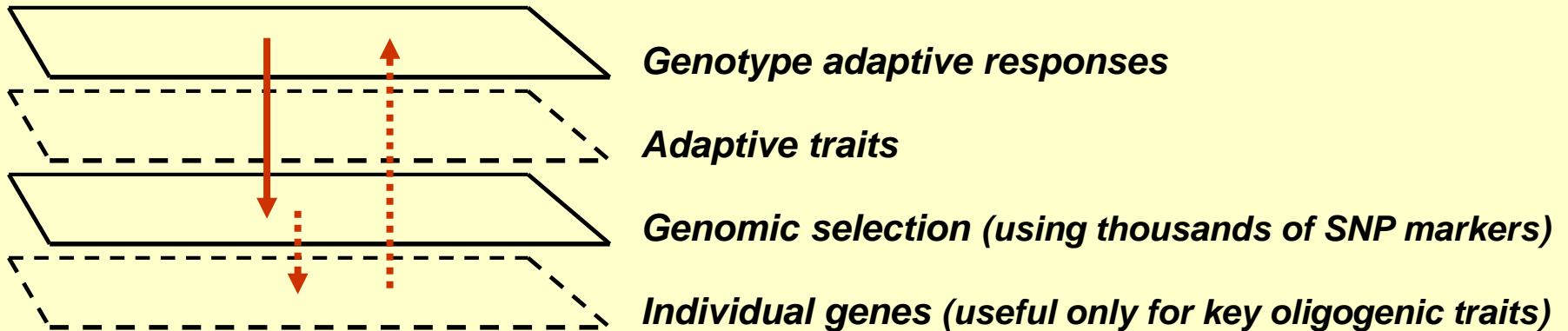
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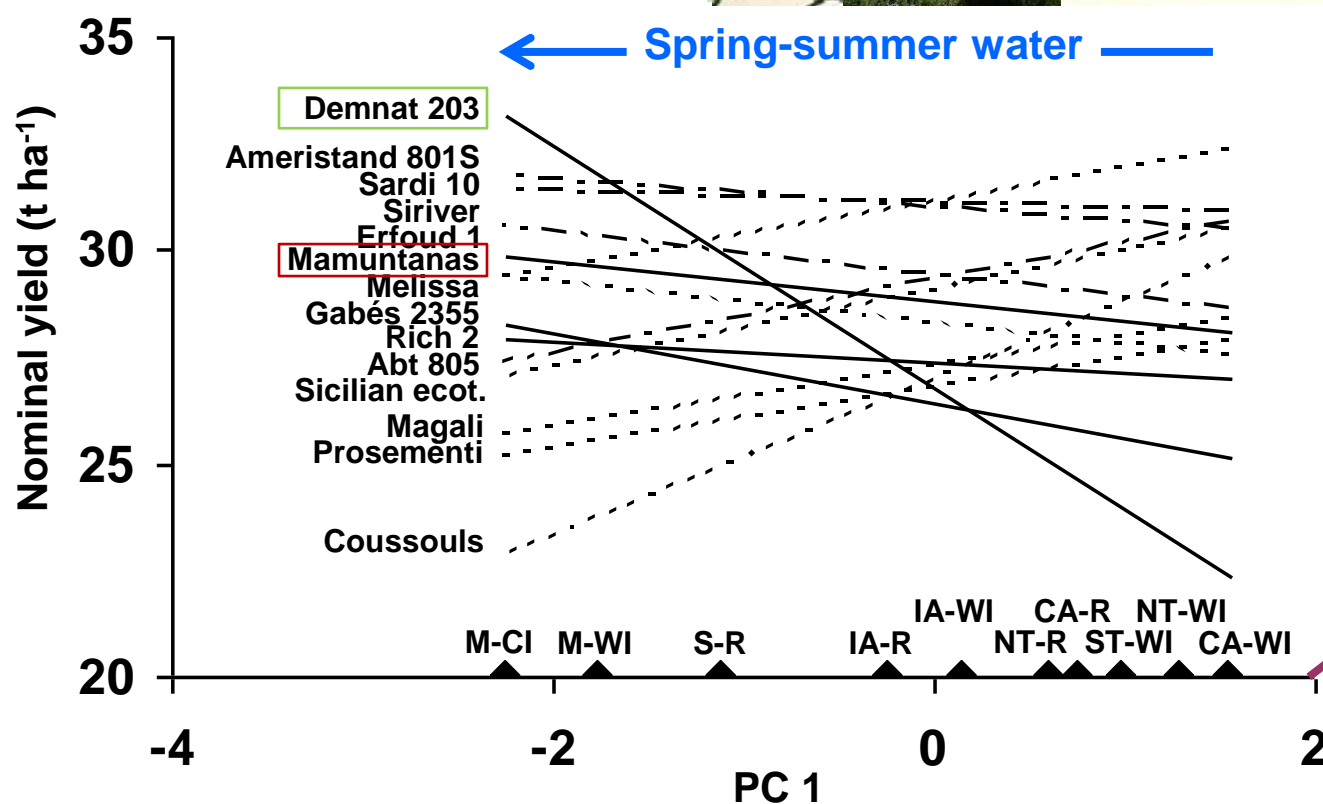
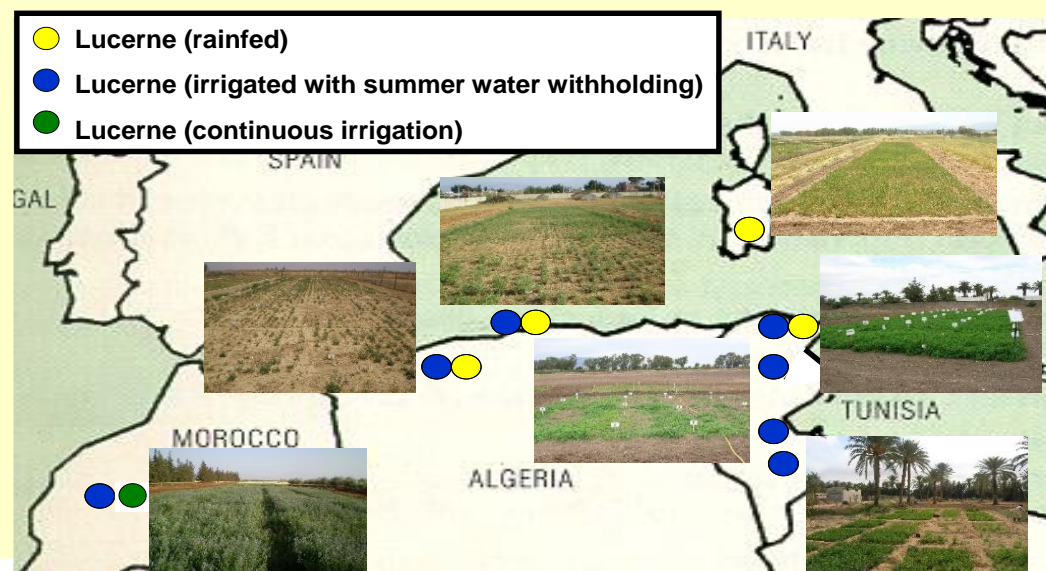
Adaptation targets according to an agro-ecological vision

Based on genotype adaptive responses to major stresses (genotype x environment interactions) and stress frequency in space and time across the target region

Layers of useful information for crop improvement



**Modelled nominal yield responses
of alfalfa varieties across sites of
the Western Mediterranean basin
(AMMI-1 display)**



*Annicchiarico et al.
(2011) Field Crops
Res. 120: 283-291*

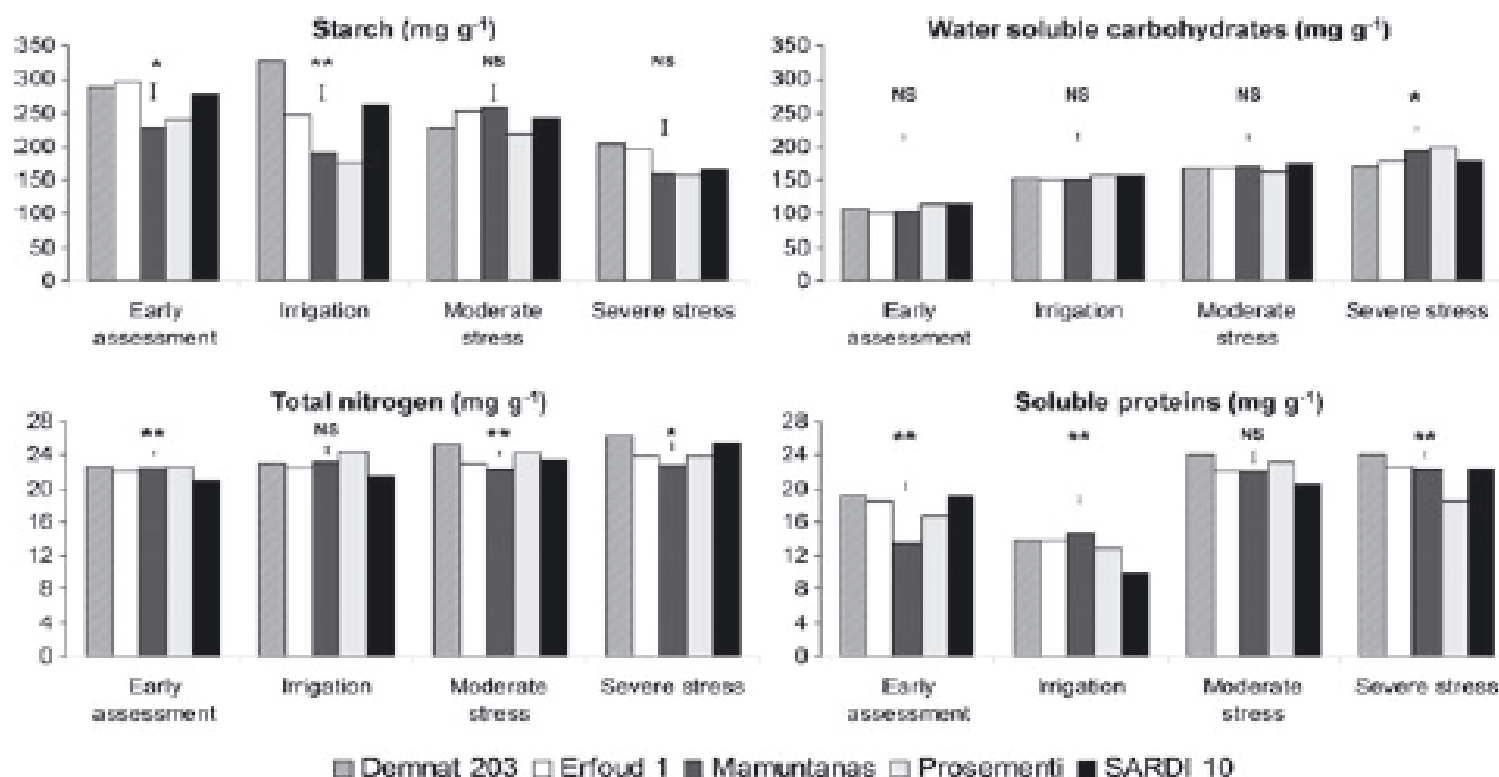
Alfalfa adaptive traits for drought-prone and favourable, frequently-mown conditions

Mamuntanas (drought tolerant) - more water soluble carbohydrates (WSC) in roots and crown under stress
- water conservation strategy
- smaller leaves; more stems / plant

Demnat (favourable conditions) - more starch, soluble proteins and total N in storage organs, due to larger root and higher concentration

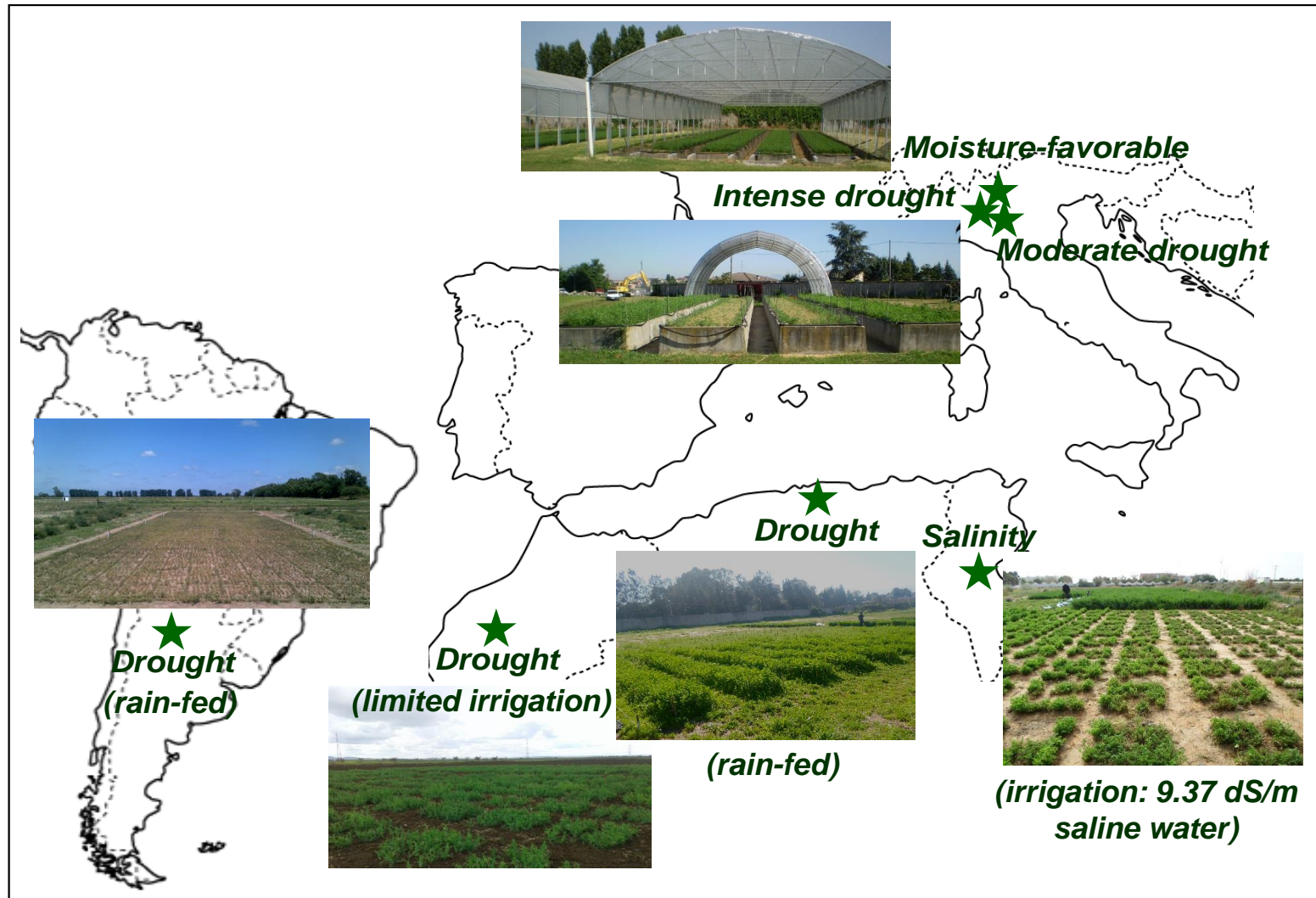


**Annicchiarico
et al. (2013)
Ann. Appl. Biol.
162: 27-40**



Genomic selection for biomass yield in a Mediterranean alfalfa reference population

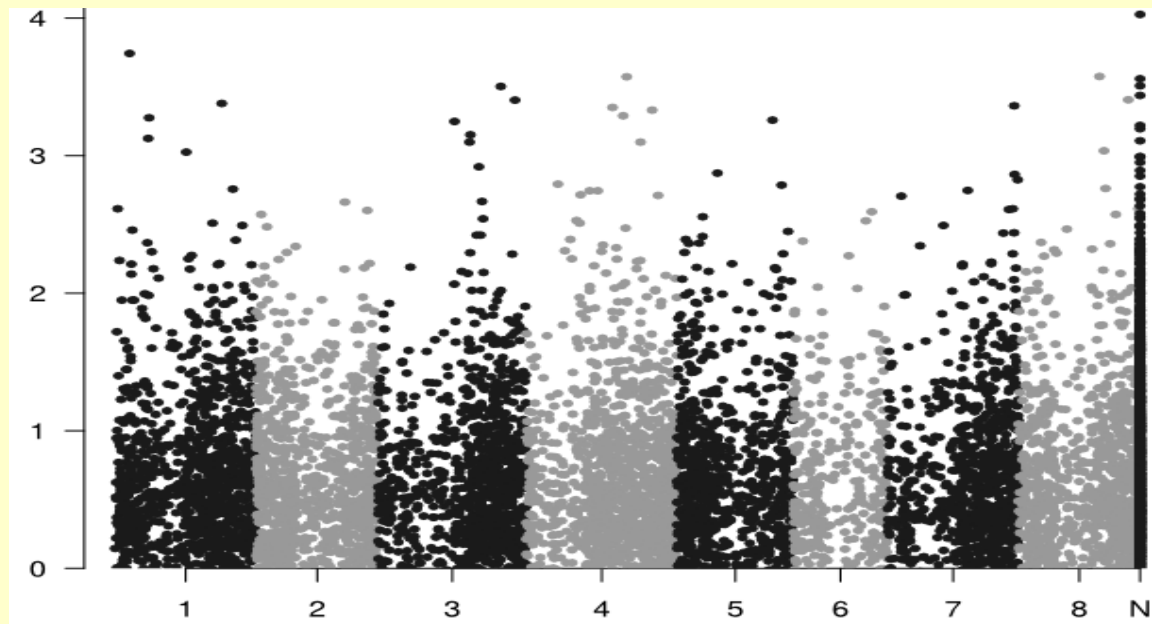
Importance of international cooperation: multi-site testing of half-sib progenies, for selection and development of genomic models in various countries (project REFORMA)



Selection assisted by molecular markers

- 1) Based on **individual markers** (conventional marker-assisted selection): for oligogenic traits
- 2) Based on **genomic selection** (i.e. a statistical model accounting for small effects of many genes linked to markers): for polygenic traits (which are the vast majority)

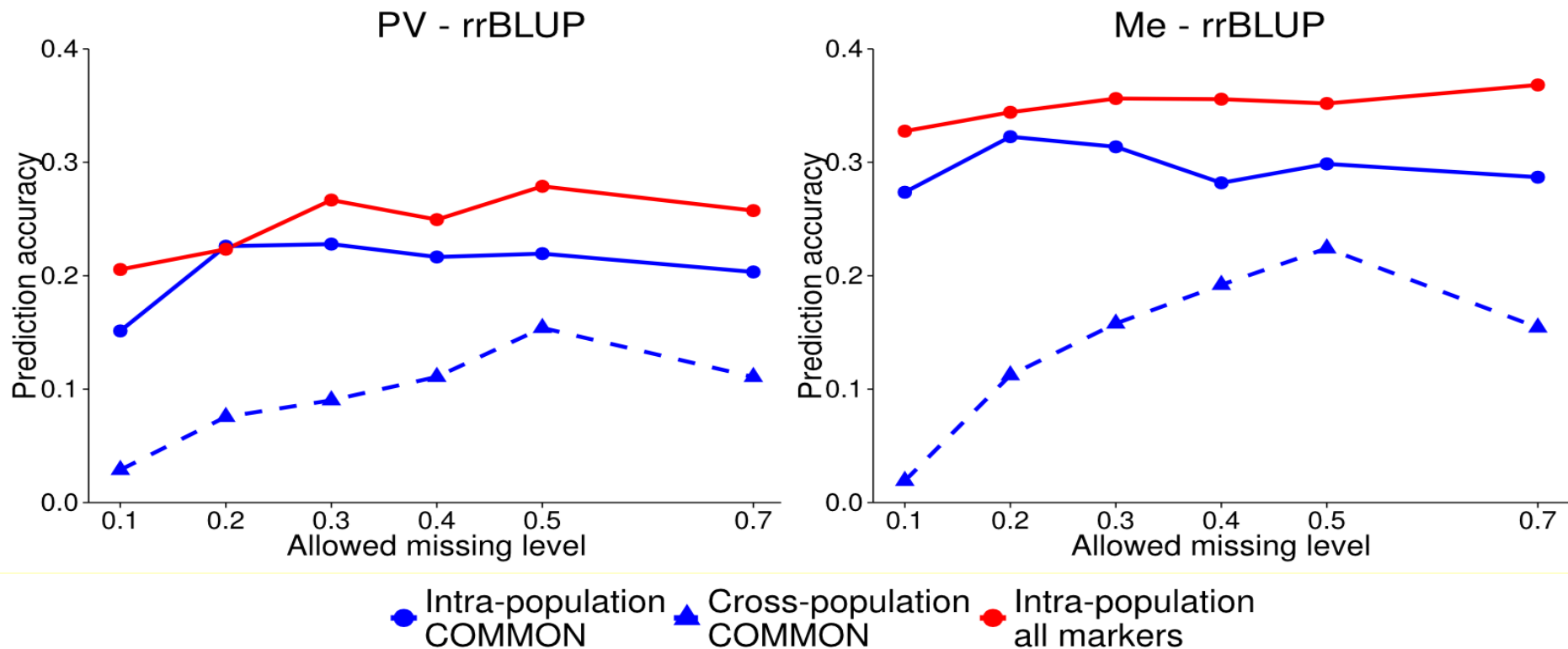
GWAS for alfalfa biomass yield: many linked markers, each with a small association / genetic effect (Manhattan plot based on 6453 M. truncatula-aligned SNPs)



*Annicchiarico et al. (2015)
BMC Genomics 16: 1020*

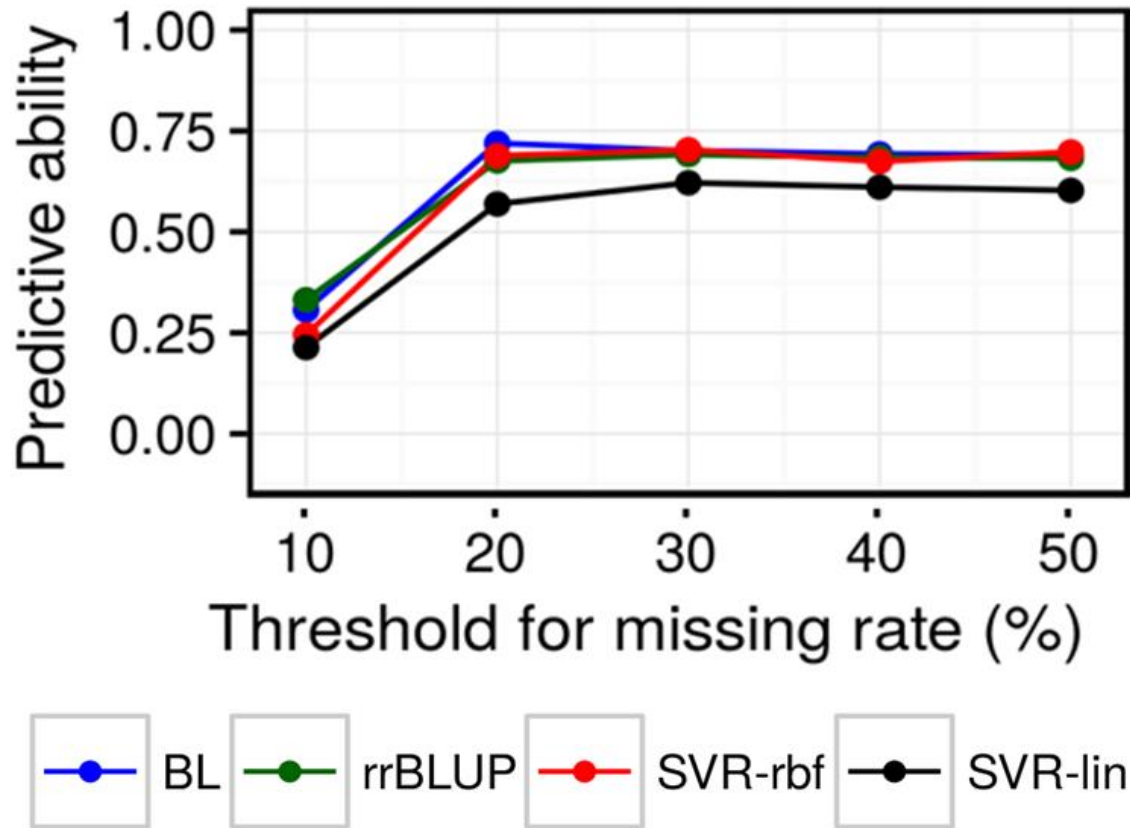
Genomic selection for biomass yield of alfalfa

Intra-population and cross-population prediction of breeding values for biomass yield, for Po Valley (PV) and Mediterranean (Me) populations



Annicchiarico et al. (2015) BMC Genomics 16: 1020

Genomic selection predictive ability for pea grain yield under severe terminal drought stress



Annicchiarico et al. (2017) Plant Genome 10:2



***Proof-of-concept experiments for genomic (GS) and phenotypic selection (PS)
for pea grain yield under severe terminal drought***

PS in a managed stress (MS) and a Moroccan site (Marchouch), both used to build GS

Line group	Total no. of lines	Yield (t/ha dry weight)	
		Value	Difference to parent line group
GS, RIL population-specific model	9	0.655 **	0.401
PS across MS Lodi and Marchouch	9	0.653 **	0.399
GS, model trained on all populations	9	0.642 **	0.388
Parent lines	3	0.254	-
LSD ($P < 0.05$)		0.104	
GS, top-performing lines	9	0.638 **	0.286
GS mid-performing lines	6	0.462	0.110
GS, bottom-performing lines	9	0.290	-0.062
Parent lines	2	0.352	-
LSD ($P < 0.05$)		0.114	

Annicchiarico et al. (2020) Int. J. Mol. Sci. 21:2414

Farmer-participatory breeding, with genomic prediction of farmers' appreciation

Correlation of pea line value for 8 selection criteria with yield in independent environments

Selection criterion^a	Average of four trials, organic management	One trial, conventional management
Farmer selection index	0.458^d	0.268^d
Breeder selection index	0.370^d	0.242^d
Farmer + breeder selection indexes	0.418^d	0.257^d
Grain yield	0.348^d	0.328^d
Farmer acceptability score	0.645	0.409
Breeder acceptability score	0.479	0.342^d
Genomic selection for grain yield^b	0.679	0.453
Genomic selection for farmer acceptability score^b	0.769	0.564

^a Phenotypic values or genomic predictions based on data from 2 organically-managed test environments (Lodi; Perugia). Organic trials, 31 lines; conventional, 306 lines.

^b Based on 7521 GBS-generated polymorphic SNP markers.

^d Lower ($P < 0.05$) than for genomic selection for farmer acceptability.

Annicchiarico et al. (2019) Field Crops Res. 232: 30-39



A photograph of a lush green field, possibly a rice paddy, with a thatched fence and palm trees in the background. The text "Thank you for your attention" is overlaid in the center.

**Thank you
for your attention**