



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

Paolo Annicchiarico & Luciano Pecetti



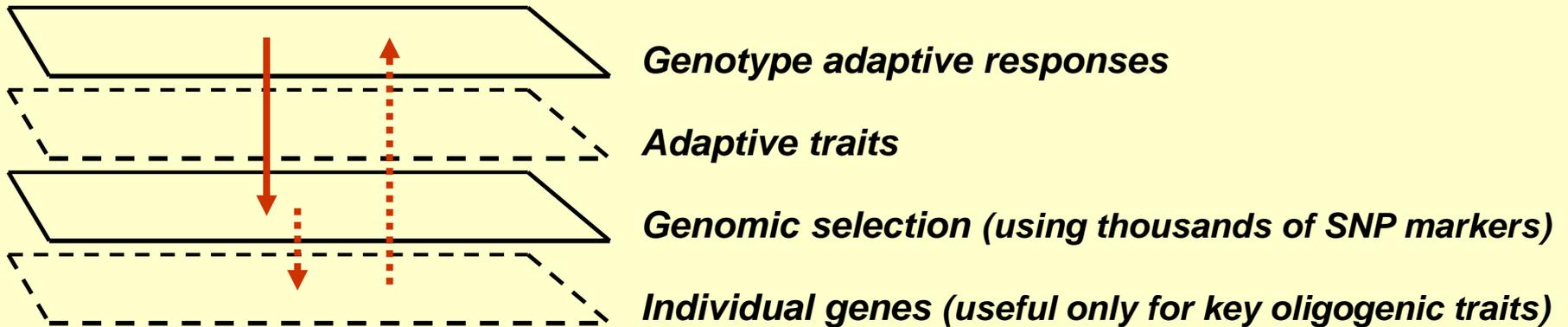
*Council for Agricultural Research and Economics (CREA),
Research Centre for Animal Production and Aquaculture, Lodi, Italy*



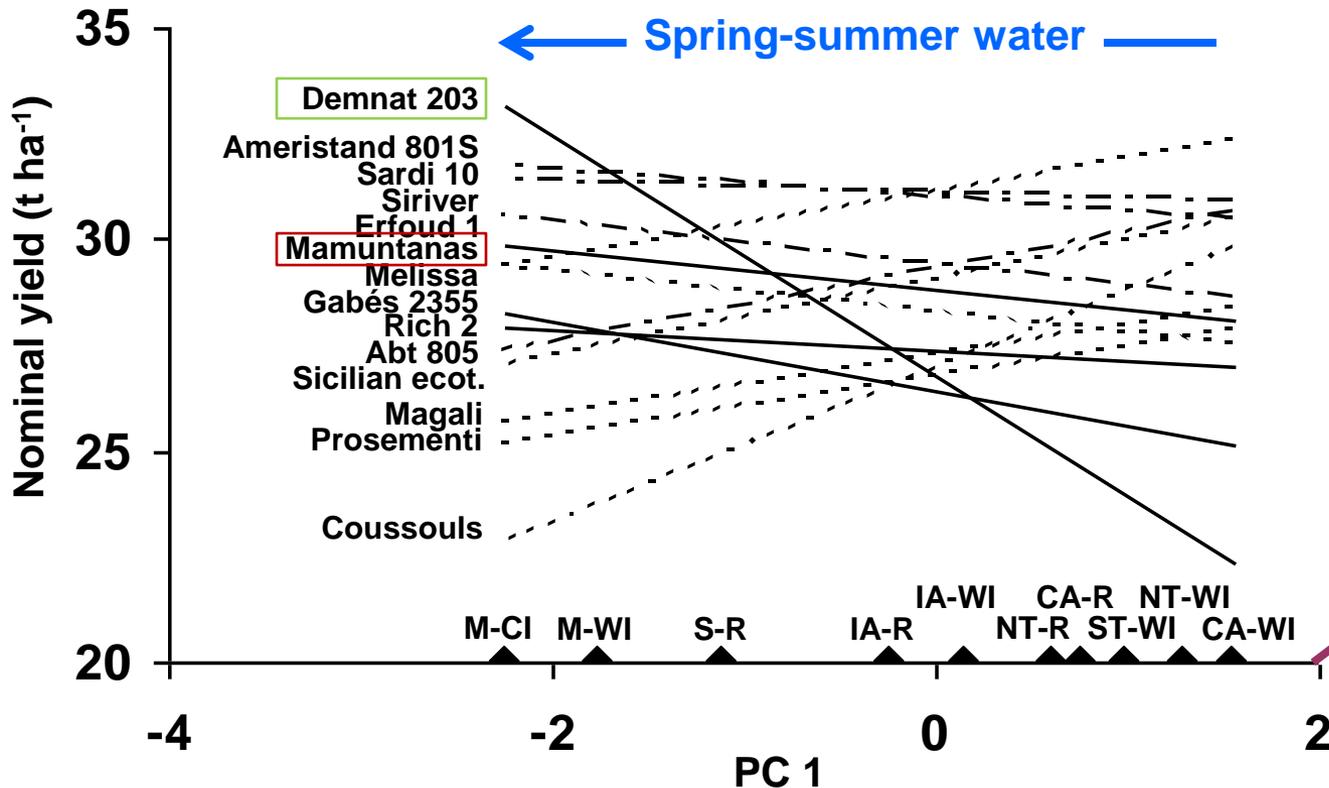
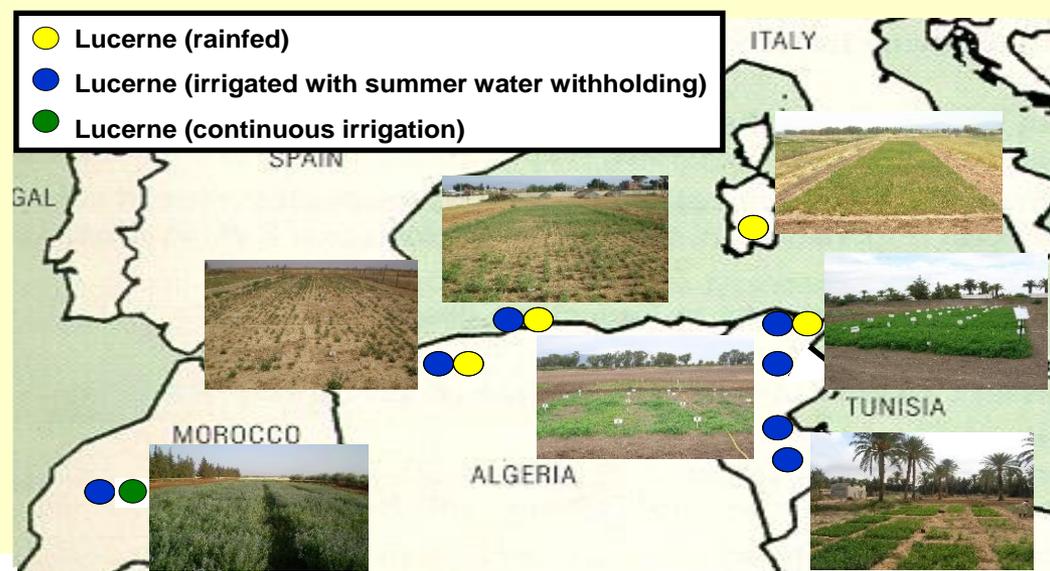
Adaptation targets according to an agro-ecological vision

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

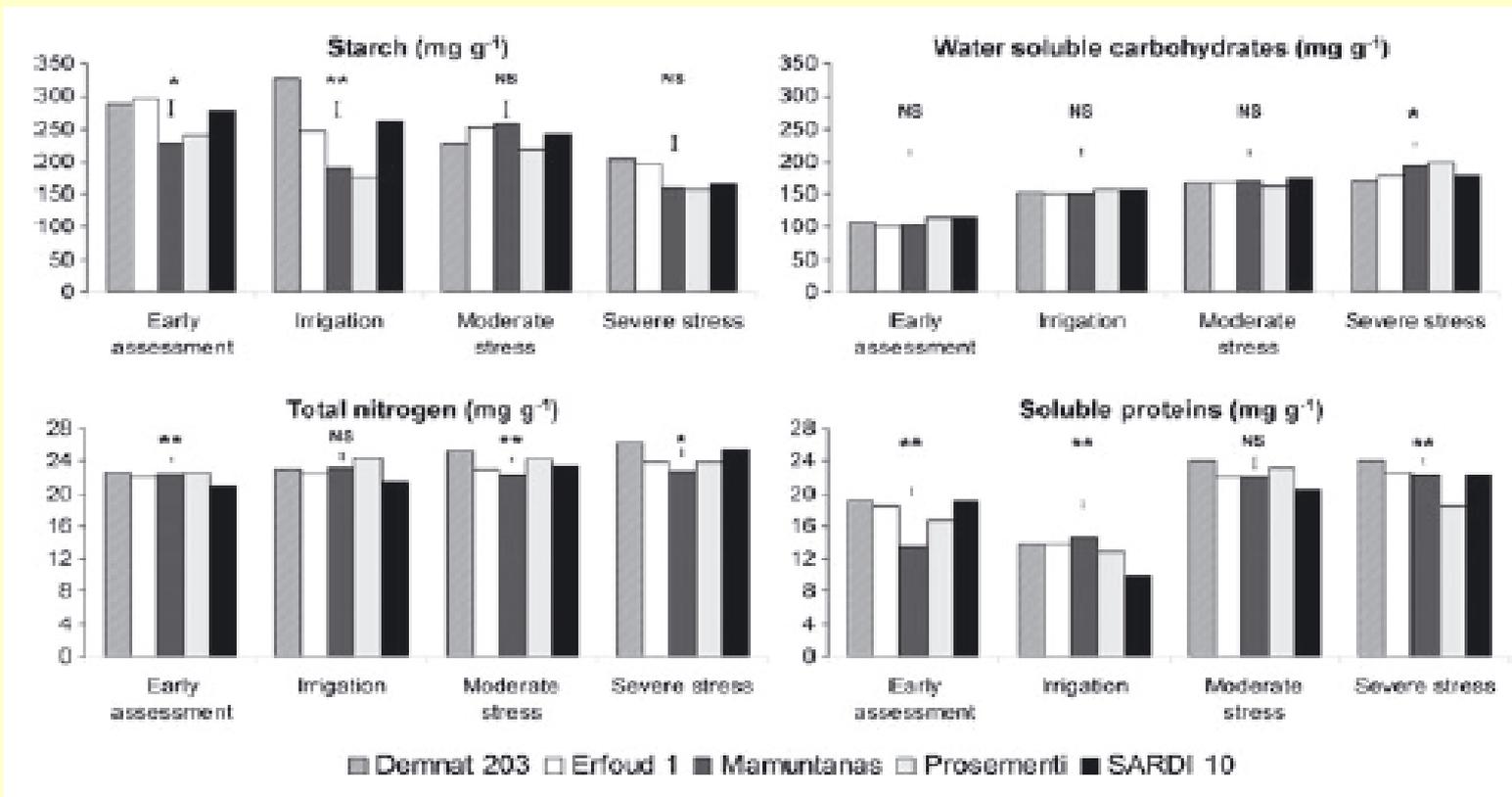
Alfalfa adaptive traits for drought-prone and favourable, frequently-mown conditions



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

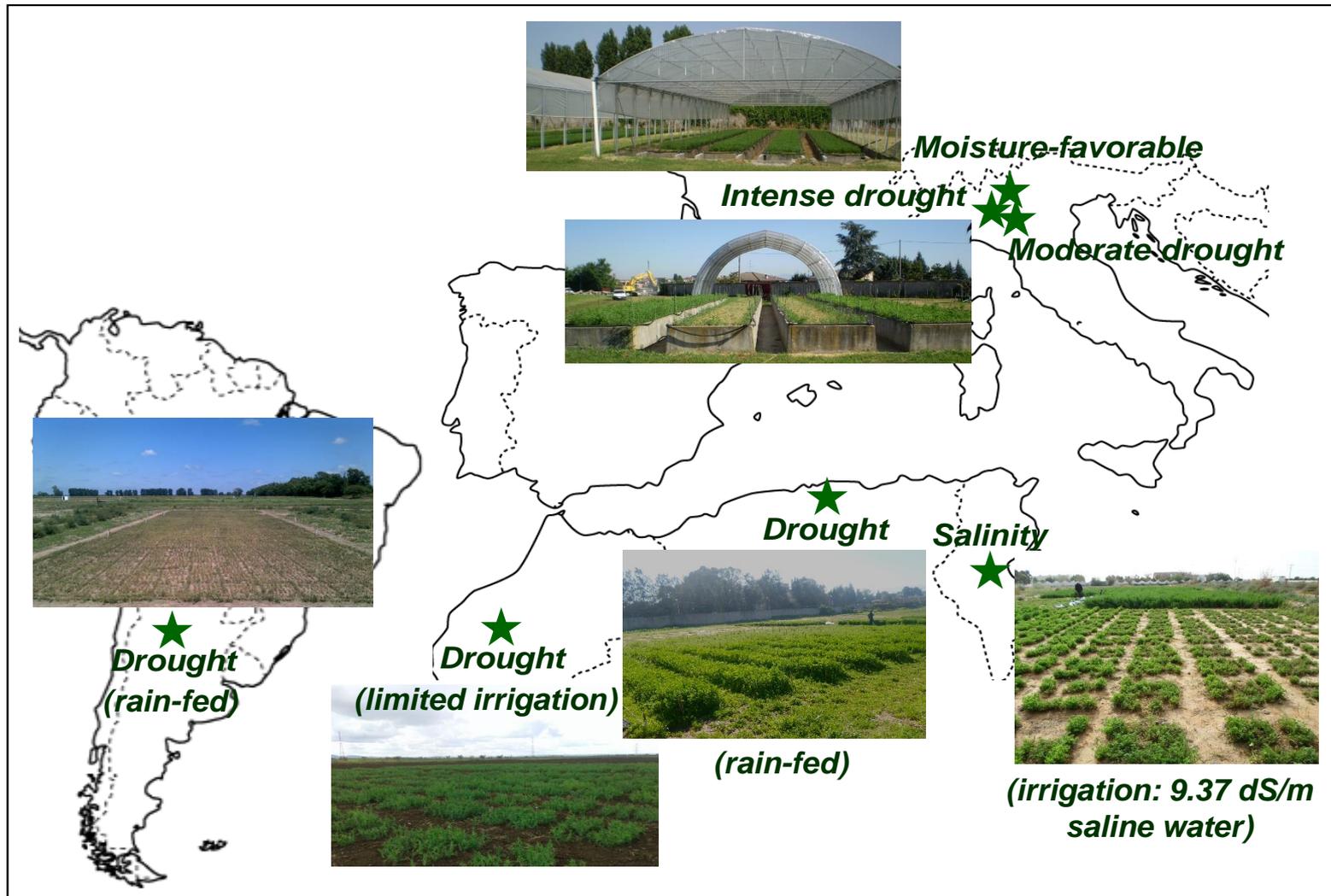
Demnat - more starch, soluble proteins and total N in storage organs,
 (favourable conditions) due to larger root and higher concentration

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



Genomic selection for biomass yield in a Mediterranean alfalfa reference population

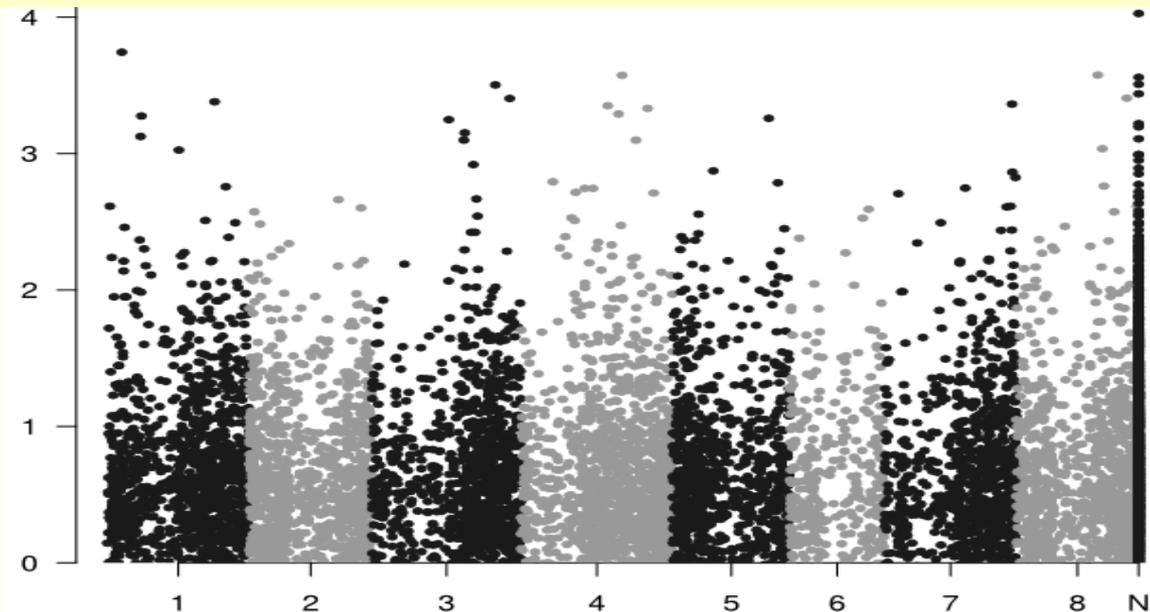
Importance of international cooperation: multi-site testing of half-sib progenies, for selection and development of genomic models in various countries (project REFORMA)



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)

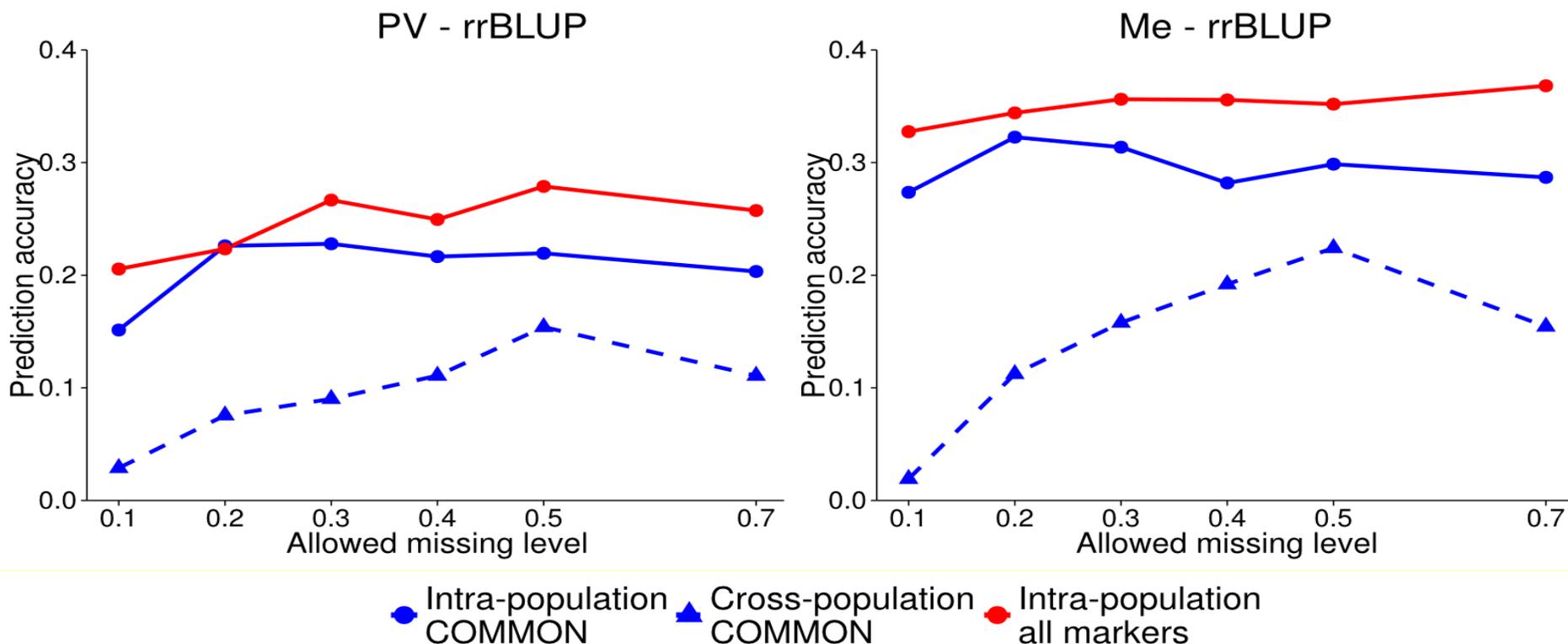
GWAS for alfalfa biomass yield: many linked markers, each with a small association / genetic effect (Manhattan plot based on 6453 M. truncatula-aligned SNPs)



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

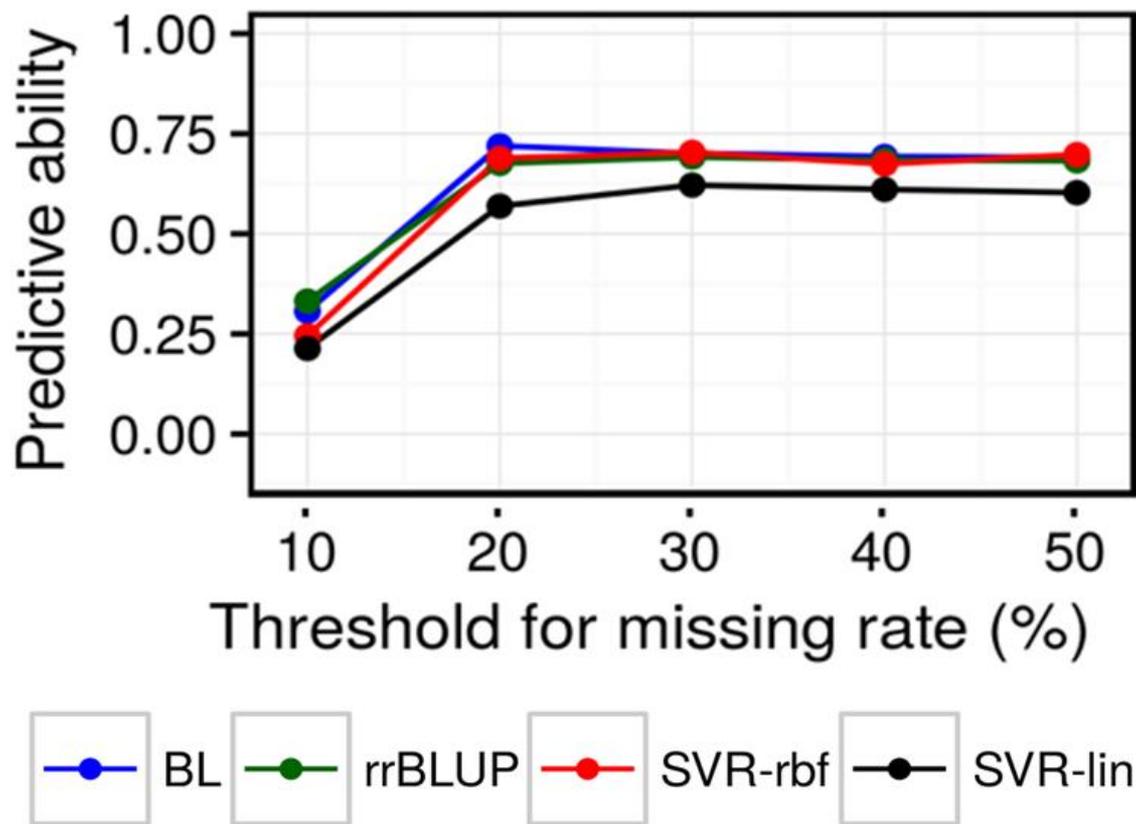
Genomic selection for biomass yield of alfalfa

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 landscape photograph showing a field of green crops in the foreground, a fence made of straw or dried grass in the middle ground, and a row of palm trees in the background under a clear blue sky. The text "Thank you for your attention" is overlaid in the center of the image.

**Thank you
for your attention**