Chickpea plant ideotype development for semi-arid subtropical climates to assist plant breeding

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Introduction

Empirically, plant breeders attempt to increase crop productivity by focusing their selection criteria on yield. However, this approach faces many challenges because of the low heritability of yield. Plant ideotype breeding which attempts to construct a model plant with the desired morphological and physiological traits augments empirical breeding. Selection of a combination of plant characters which can act through additive gene action can enhance crop productivity in the target environment. A plant ideotype gives plant breeders a structural framework to target in a defined environment. Terminal drought is a major problem in semi-arid subtropical climates due to the rapid warming experienced in spring causing huge yield losses. However, in some years there is sufficient in-season moisture to produce higher yields. A model plant in this type of environment should show plasticity and produce high yield in seasons with higher rainfall and limit yield losses under terminal drought in drier years.

Material and methods

Thirty chickpea genotypes were evaluated in the field (Narrabri, NSW) in till +/- irrigation and no till +/- irrigation. Data on phenology, morphology and physiological traits was recorded. Analysis of variance, correlation, multiple linear regression analysis and trait weighting were used to develop an ideotype. Review of literature was also used to benchmark some traits.

Results and conclusions

Drought tolerant genotypes were closer to the model ideotype and were high yielding in both well watered and water stress conditions (Fig. 1 & 2). No till crops had higher yields in both moisture regimes.

Important drought tolerance traits included early biomass accumulation and retention, high photosynthetic active radiation interception (PAR) and early maturity (Table 1 & Fig. 3).

These traits can be targeted for selection if they are highly heritable and easy to work with.

Table 1: Trait relationships and ranges

Trait (93% of variation in yield explained by these traits)	Wald statistic	F stat	F pr.	Correlation with yield	Trait range		LSD
					Lowest	Highest	
Early ground cover	50.65	50.65	<0.001	0.40	6.9	34.1	7.0
Canopy temp	26.62	26.62	<0.001	0.11	27.5	29.5	1.5
Chlorophyll content at mid podding	10.42	10.42	0.009	0.14	66.0	76.3	4.0
Days to 50% flowering	60.8	60.8	<0.001	-0.29	79.6	104.1	5.3
Days to last flower	92.62	92.62	<0.001	-0.28	121.1	128.9	3.2
Initial plant vigour	30.62	30.62	<0.001	-0.06	2.0	3.8	0.6
NDVI early podding stage	65.69	65.69	<0.001	0.46	0.672	0.769	0.034
NDVI at flowering	19.83	19.83	0.001	0.56	0.737	0.869	0.084
NDVI at mid vegetative stage	32.53	32.53	<0.001	0.53	0.319	0.603	0.085
No. of leaflets per leaf	81.82	81.82	<0.001	-0.01	12.2	15.2	0.8
No. of pods per plant	21.29	21.29	<0.001	-0.42	23.0	81.3	15.6
No. of seeds per pod	10.32	10.32	0.009	0.02	1.0	1.6	0.2
PAR at budding stage	8.55	8.55	0.015	0.25	61.8	81.8	12.1
PAR at early podding	79.84	79.84	<0.001	0.42	87.5	96.4	4.2
PAR at flowering	44.49	44.49	<0.001	0.42	82.9	96.5	8.6
Plant height at late flowering	49.14	49.14	<0.001	-0.04	50.7	66.3	5.0
Plant height at late podding	34.55	34.55	<0.001	-0.26	53.1	69.1	4.8
Pod biomass per plant	90.75	90.75	<0.001	-0.44	7.6	50.5	5.3
Pod harvest index	43.52	43.52	<0.001	0.05	0.8	0.8	0.0
Relative Water Content at late podding	42.13	42.13	<0.001	-0.06	46.6	65.5	5.9
Shoot harvest index	46.11	46.11	<0.001	0.11	0.3	0.5	0.0
Single leaf area	95.63	95.63	<0.001	-0.06	3.6	21.0	2.3
Single leaflet area	96.12	96.12	<0.001	-0.06	0.3	1.6	0.2
Single plant biomass	93.97	93.97	<0.001	-0.49	16.7	82.6	10.3
Specific leaf weight at late podding	7.460	7.460	0.021	-0.21	0.0070	0.0100	0.0006

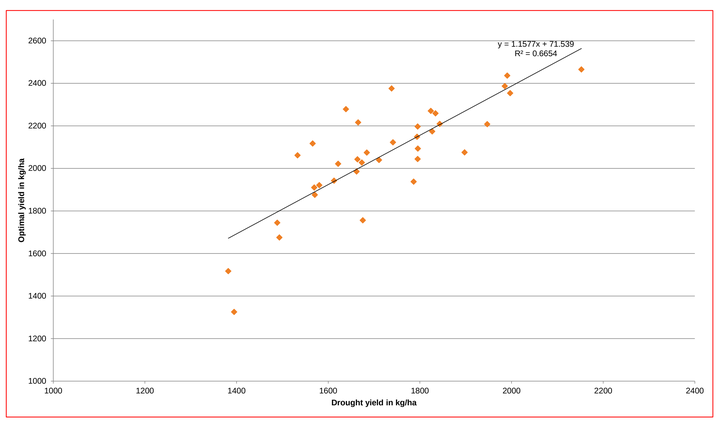

Figure 1: Chickpea optimal yields vs Drought yields

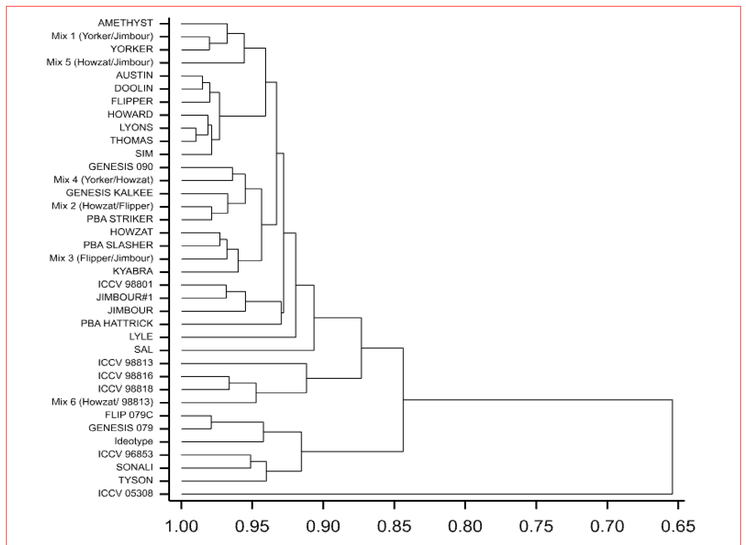

Figure 2: Chickpea genotypes vs Ideotype

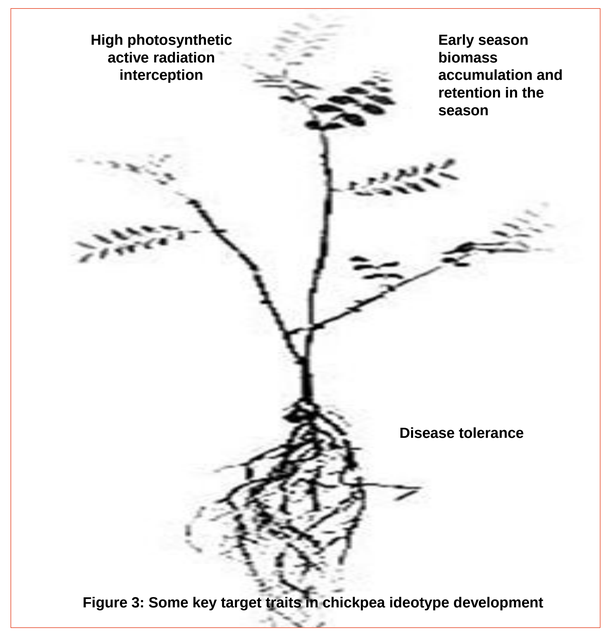

Figure 3: Some key target traits in chickpea ideotype development

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