

Interaction and Identifying High Yielding Stable Lines in Chickpea under Afghanistan Environments

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ABSTRACT: To meet increasing demand of protein for the growing population in Afghanistan, winter-sown chickpea is an important contributor and its productivity needs to be increased. Therefore this study was conducted to identify high yielding genotypes with wide adaptation and suitability for winter season in Afghanistan. Three field trials were conducted in alpha designs at three out of five provinces, Baghlan, Herat, Kabul, Mazar and Nangarhar, during 2014-15. In the CIEN-W trial, the genotypic variation was highly significant at all the three locations but the genotype x environment interaction (GEI) was low (P-value = 0.07). In CIAYT trial, the genotypes variation was significant at two of the three locations and also the GEI was non – significant, while in WTCYT trial, the GEI was significant. Stability analysis of the genotypes from three locations showed that in CIEN-W trial, ILC482 with mean yield of 2.23t/ha was the highest yielding genotype and stable with slope 1.75±1.20 (P=0.65 for slope =1), specifically adapted to Baghlan based on a GGE-biplot, followed by FLIP09-423C with mean yield of 1.91 t/ha (slope of 0.89 ± 0.68, P=0.89) and FLIP88-85C with mean yield of 1.87t/ha. In trial CIAYT, the FLIP98-121C with mean 1.91 t/ha was the top yielding genotypes than FLIP93-58C with 1.86 t/ha and in WTCYT trial, FLIP07-34C was the high yielding genotypes with mean 1.87t/ha followed by the location check with mean 1.80 t/ha. The selected high yielding materials will be further evaluated in replicated trials at much larger number of diverse locations in Afghanistan.

INTRODUCTION

Chickpea is the world's third ranking food legume, and is grown on about 11.5 million hectares; 96% of all production takes place in developing countries. Chickpea production has increased over the past 30 years from 6.5 million tons (1978-1980 average) to 9.6 million tons (2007-09). In Afghanistan, around 115 thousand hectares of land is cultivated. Chickpea is a major legume crop grown predominantly in 12 provinces in northeast and central region under irrigation. To meet the protein requirement of population in Afghanistan, therefore, highly productive and widely and specifically adapted chickpea varieties are needed for rainfed and irrigated systems. ICARDA – Afghanistan Program has been conducting field evaluation of chickpea genetic material for winter sowing with focus on high yielding, biotic and abiotic tolerance, and seed size. Using the series of three multi-environment trials,

the objectives of this study were:

- to examine genotypic variation in winter season chickpea,
- to detect the genotypes x environment interaction, and
- to identify specifically and widely adapted genotypes with high yield.

MATERIALS AND METHODS

Environment and Experiment Material: Three chickpea trials were conducted at five locations for winter season. Chickpea International Elite Nursery - winter (CIEN-W) at Baghlan, Kabul and Nangarhar; Chickpea International Adaptation Yield Trial (CIAYT) and

Winter Type Chickpea Yield Trial (WTCYT), both conducted at Baghlan, Mazar and Herat.

Province	Altitude (m)	N (Latitude)	E (Longitude)
Kabul	1836	34° 27 °	69° 7°
Mazar	398	36° 39 25.4	66° 57 39. 9
Baghlan	599	36° 05 29 03	68° 38 49 44
Nangarhar	552	34° 25	70° 27
Herat	964	39° 11	68° 131

Experimental Design:

- The trials were conducted in incomplete block designs (alpha design) with 10-36 genotypes blocks of sizes 5-6 plots and 2-4 replications. Plot sizes were 3.6m² and 2.4m². Row to row distance was 45cm and row length was 4 meters.
- The data were collected on grain yield (GY) and yield components such as days to flowering (DF), days to physiological maturity (DM), plant height (cm, PH), Plant Stand (%), PST), the number of pods per plant (PPP) for statistical analysis.

Statistical Methods:

- Individual trials were analyzed by fitting the mixed model, and incorporating the incomplete block design factors, to evaluate experimental error variability, significance of genotypic differences, and heritability (under assumed random effects of the genotypes).
- Genotype and Genotype x Environment and experimental error variance components were estimated from the plot-wise data.
- The best linear- unbiased predictor estimates and their standard errors were obtained for a standard analysis of multi-environment trials.

Identification of high yielding stable genotypes, Refer to Table 2.

- CIEN-W (2015):** G32, G30, G34, G3 and G16 were top five high yielding genotypes with mean values of 2.23 t/ha, 1.9 t/ha, 1.87 t/ha, 1.82 t/ha and 1.71 t/ha respectively. The G16 was the most stable genotype but G30 and G3 were not stable yielders.
- CIAYT (2015):** G8 and G6 were the stable genotypes with mean yield of 1.91 t/ha and 1.86 t/ha. G8 was unstable where as G6 was a stable genotype. In WTCYT trial, the G12, G15 and G8 were high yielder genotypes with mean of 1.87 t/ha, 1.80 t/ha and 1.76 t/ha, and all of them are the stable genotypes.

Table 2. Adjusted mean grain yields of five top yielding genotypes and their stability statistics in terms of slope and weighted deviation sum of squares and percent variance accounted for regression of genotype mean on environmental mean.

Slope	Genotype Number	Genotype name	Adjusted Mean-Grain Yield (t/ha)	Slope	Prob1 [†]	WDeviSS [‡]	Prob2 [§]	WR ^{2%} [¶]
CIEN-W-2015	G32	ILC482	2.23	1.75	0.646	5.23	0.022	35.9
	G30	FLIP09-423C	1.91	0.89	0.894	1.67	0.197	26.4
	G34	FLIP88-85C	1.87	1.29	0.763	1.98	0.159	50.6
	G3	FLIP09-131C	1.82	0.33	0.323	0.51	0.474	-13.8
	G16	FLIP09-441C	1.71	2.18	0.285	1.18	0.278	87.3
		Av. SES ±	0.17					

Prob1[†]= Probability of the slope deviating from unity using t-distribution
WDeviSS[‡]= Weighted deviation sum of squares from linear regression

Prob2[§]= Probability of deviation mean square from linear regression equal to zero using chi-square distribution WR^{2%}[¶]= percentage variation accounted for by the weighted

Genotype x Environment Interaction:

- The combined analysis of data on grain yield indicated that genotypic variance was highly significant (P<0.001) in CIAYT and WTCYT but non - significant (P>0.05) in CIEN-W trial.
- GEI was highly significant (P<0.001) in CIEN-W and significant (P<0.05) in WTCYT but non- significant (P>0.05) in CIAYT trial.

Genotypic Variability in Individual Trials: Refer to Table 1. Trial and location names mean overall genotypes, coefficient of variation (CV), and design efficiency

Trial name	Location Name	Grain Yield (t/ha)				DF			
		Mean	CV (%)	P-Value	Heritability	Mean	CV (%)	P-Value	Heritability
CIEN-W-2015	Baghlan	1.66	18.5	<0.001	0.47	130.59	0.5	<0.001	0.90
	Kabul	1.80	27.7	<0.001	0.51	44.18	1	<0.001	0.97
	Nangarhar	1.07	29.1	<0.001	0.64	110.39	2.6	<0.001	0.47
CIAYT-2014-15	Baghlan	1.52	53	0.777	0.00	115.5	1.4	0.029	0.00
	Herat	1.42	10.2	<0.001	0.87	NA	NA	NA	NA
	Mazar	2.13	18.6	0.032	0.53	134.6	0.6	<0.001	0.93
WTCYT 2014-15	Baghlan	2.81	22.5	0.013	0.52	77.28	4.1	0.069	0.38
	Herat	0.77	24.4	0.004	0.58	NA	NA	NA	NA
	Mazar	1.24	30	0.325	0.11	98.15	3.4	0.649	0.00
Trial name	Location Name	DM				PH			
		Mean	CV (%)	P-Value	Heritability	Mean	CV (%)	P-Value	Heritability
CIEN-W-2015	Baghlan	154.50	1.8	0.514	0.00	47.91	17.2	0.856	0.00
	Kabul	64.30	1.5	<0.001	0.55	33.6	12.2	0.004	0.36
	Nangarhar	155	1.6	0.972	<0.001	73.43	3.9	<0.001	0.92
CIAYT-2014-15	Baghlan	115.5	1.4	0.959	0.00	43.63	12.7	0.066	0.44
	Mazar	134.6	0.6	<0.001	0.93	39.55	4.9	<0.001	0.95
	Baghlan	NA	NA	NA	NA	47.02	7.4	<0.001	0.85
WTCYT 2014-15	Herat	NA	NA	NA	NA	NA	NA	NA	NA
	Mazar	134.2	0.7	0.032	0.47	43.15	7.4	0.029	0.45
Trial name	Location Name	PST%				PodPP			
		Mean	CV (%)	P-Value	Heritability	Mean	CV (%)	P-Value	Heritability
CIAYT-2014-15	Baghlan	94.95	5.6	0.8378	0.00	NA	NA	NA	NA
	Mazar	74.62	4.3	<0.001	0.91	39.10	5.5	<0.001	0.01
	Baghlan	95.35	2.5	0.0882	0.35	NA	NA	NA	NA
WTCYT 2014-15	Mazar	66.53	9.3	0.4883	0.00	36.35	21.4	0.7479	0.00

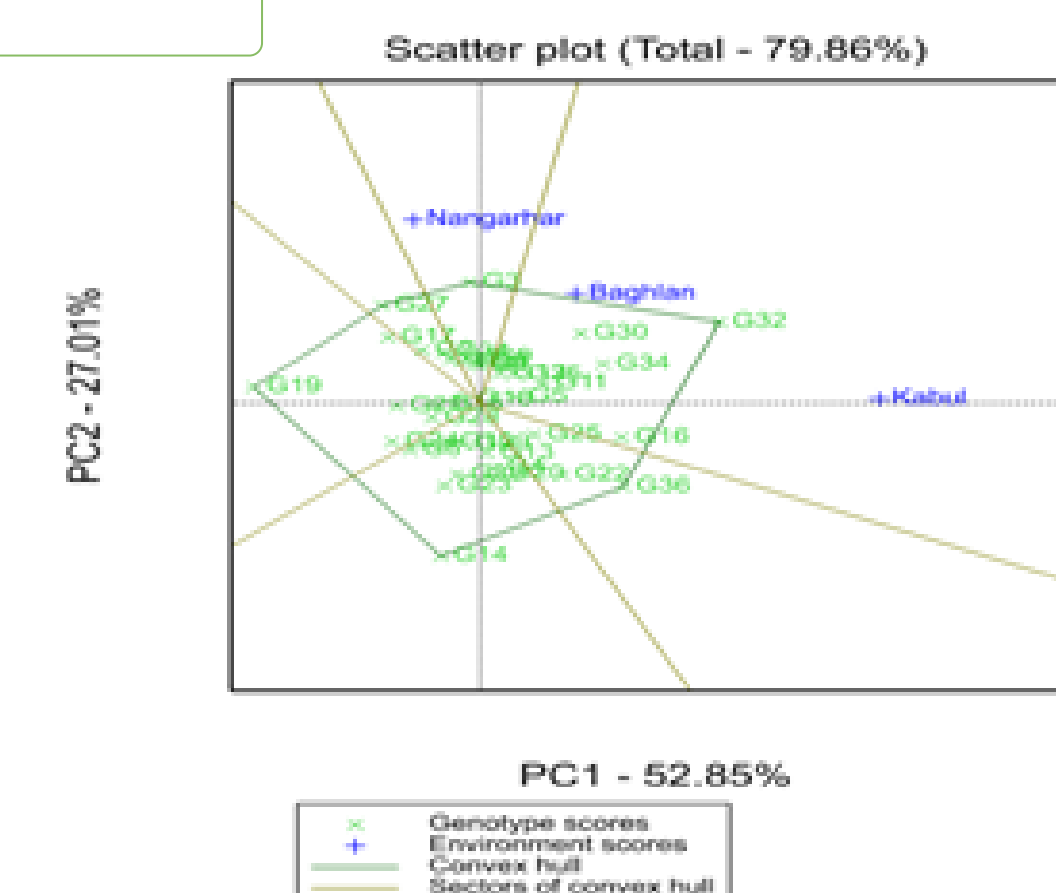


GGE Biplot:

Fig -1 exhibits GGE biplot for grain yield in trial CIEN-W.

- A singular value decomposition of GGE interaction (G + GEI) in two dimension explained 80% of its variation.
- Of the three locations, Kabul showed the highest discrimination of genotypes.
- G32 was the highest yielding and specifically adapted to Baghlan.
- Since, the two locations namely Baghlan and Kabul fell in the same sector, in future trials, Kabul could be retained in place of Baghlan which has lower genotypic differentiation than Kabul.

Figure 1



Conclusion: the result of study showed, in the CIEN-W trial, the genotypic variation was highly significant at all the three locations but the genotype x environment interaction (GEI) was low (P-value = 0.07). In CIAYT trial, the genotypes variation was significant at two of the three locations and also the GEI was non – significant, while in WTCYT trial, the GEI was significant. Stability analysis of the genotypes from three locations showed that in CIEN-W trial, ILC482 with mean yield of 2.23t/ha was the highest yielding genotype and stable with slope 1.75±1.20 (P=0.65 for slope =1), specifically adapted to Baghlan based on a GGE-biplot, followed by FLIP09-423C with mean yield of 1.91 t/ha (slope of 0.89 ± 0.68, P=0.89) and FLIP88-85C with mean yield of 1.87t/ha. In trial CIAYT, the FLIP98-121C with mean 1.91 t/ha was the top yielding genotypes than FLIP93-58C with 1.86 t/ha and in WTCYT trial, FLIP07-34C was the high yielding genotypes with mean 1.87t/ha followed by the location check with mean 1.80 t/ha.