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EFFECT OF GENOTYPE X ENVIRONMENT INTERACTION ON RELATIONSHIP BETWEEN GRAIN YIELD AND ITS COMPONENTS IN CHICKPEA [*CICER ARIETINUM* (L.)]

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Abstract

Effect of genotype x environment interaction was studied on relationship between yield and three yield components in 20 genotypes of chickpea. Significant differences were found between genotypes for the three yield components at all the locations. It was found that the pattern and strength of correlation between number of seeds pod^{-1} and yield, between number of seeds pod^{-1} and number of pods plant^{-1} and number of seeds pod^{-1} and number of branches plant^{-1} differed from location to location. The relationship of fruit bearing branches and number of pods plant^{-1} with grain yield remained positive at all the locations, though the strength of their correlation with grain yield was affected by environments. On the basis of this study it is proposed that importance should be placed on number of pods and number of fruit bearing branches while making selection from segregating populations for yield improvement.

Introduction

Chickpea [*Cicer arietinum* (L.) 2n=2x=16] is an important food legume of the semi arid tropics and the warm temperate zones. It ranks third after pea and common bean in world wide cultivation. Pakistan is one of the major chickpea growing countries where chickpea is cultivated on about one million ha. Seventy-five percent of this area is rainfed. Despite its importance, the yield of chickpea in Pakistan is very low i.e., 439 kg ha^{-1} (*Anon*., 2000-01). The major reason for low production of chickpea in Pakistan is unavailability of varieties with high yield potential that are well adapted to production conditions with stability across different environments.

Grain yield in any crop is a complex character and is final product of many contributory traits and their interactions. The knowledge of these factors and their relationship with each other and with yield, provide basis for breeding programs on yield improvement. The knowledge of character correlation provides basis for selection of parents for hybridization to pyramid desirable traits in a single genotype and to select plants with desired combination of these traits from segregating populations. Scientists have shown interest in this subject and have reported many studies on various crops (Güler *et al*., 2001; Bakhsh *et al*., 1998; Ihsanullah & Muhammad, 2001; Medhi *et al*., 1994 and Bakhsh *et al*., 1991).

The screening of literature reveals differences between results reported by various scientists on correlation and path analysis in chickpea. It appears that the pattern of relationship between traits changes with change in genotype. Bakhsh *et al*., (1998) showed that correlation of plant height, number of primary branches and harvest index with grain yield were different in F_1s and their parental population. They also reported that the pattern and level of correlation of yield with its components was different in some cases between F_1s and parents in chickpea. Some other studies show that the relationship between traits changes with change in environment and genotype. For example Singh & Singh (1989) showed 100 seed weight to be negatively associated with grain yield, whereas, the same trait appeared to be positively associated with grain yield in another study reported by Arshad *et al*., (2003b). Similarly, the harvest index was positively associated with grain yield in one of these studies whereas, this correlation was negative in the other. Güler *et al*., (2001) showed 100 seed weight to be positively associated with yield whereas, Singh & Singh (1989) reported it to be negatively associated with yield. Such differences in results become very obvious when studies of different workers are compared (Tomar *et al*., 1982; Singh & Singh 1989; Bakhsh *et al*., 1998; Güller *et al*., 2001; Arshad *et al*., 2003b). It has been suggested that these differences could be due to variations in genotypes studied in different environments (Bakhsh *et al*., 1998). Present study was designed to evaluate the effect of genotype-environment interaction on the pattern of relationship in chickpea. Another objective of this study was to find out most important and stable relationships of yield with its components for further exploitation in breeding program.

Materials and Methods

Twenty newly developed genotypes of chickpea constituted the experimental material of this study. The planting was done in Randomized Complete Block Design (RCBD) with four replications. Each genotype was planted in 4 row plot where row to row and plant to plant distance was maintained at 30 cm and 10cm respectively. The experiment was planted at three different locations i.e., Arid Zone Research Institute (AZRI), farmer field, Bhakkar; Mirpur, Azad Jammu & Kashmir (AJ & K) and National Agricultural Research Center (NARC), Islamabad. The first location is situated between 29° N to 30° N and has short duration environment, while the remaining two lie at 33° N, with long duration environments. At AZRI the experiment was planted on 15th October and at NARC and Mirpur AJ & K on 7th and 10th of November, respectively. Two irrigations were applied at AZRI while at NARC and AJ & K, the crop was raised under rainfed condition. The experiments at all the three locations were kept weed free by manual weeding. At the time of maturity, the data were recorded on number of fruit bearing branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1} and grain yield plant^{-1}. The data of each location was statistically analyzed separately to determine the significance of differences between genotypes. Genotypes X Location Interaction was determined through two factors analysis of variance (Steel & Torrie 1980). Correlation coefficients, between yield and its three components were estimated using the procedure of Dewey & Lu (1959).

Results

Environmental effect on genetic variability: The results of analysis of variance for three individual locations revealed that genotypes were significantly different for all the four traits at each location (Table 1). The pool analysis of variance also revealed significant interaction between genotypes and locations (Table 3). Number of primary branches plant^{-1} at Mirpur varied from 8.25 to 15.00 as compared to 3.60–5.20 at NARC and 2.15–6.05 at AZRI. Number of pods plant^{-1} at Mirpur varied from 32 to 56.75 whereas, it ranged from 35.10 to 64.25 at NARC and 15.30–30.20 at AZRI, Bhakkar. Grain yield varied from 14.33 to 30.18g plant^{-1}, 11.80 to 17.90g plant^{-1}, and 5.83 to 11.48g plant^{-1} respectively at Mirpur AJ&K, NARC and AZRI, Bhakkar.

Table 1. Mean values and analysis of variance for 4 traits over three locations.

Genotypes	NARC, Islamabad				Mirpur, AJ & K				AZRI, Bhakkar			
	PB	PP	SP	GY	PB	PP	SP	GY	PB	PP	SP	GY
NCS950183	3.75	35.45	1.96	11.76	10.50	53.00	2.00	29.97	2.75	18.95	2.19	7.63
NCS950012	3.60	35.10	2.04	11.22	13.00	30.00	1.00	24.25	3.10	20.55	1.84	7.16
NCS95003	4.20	44.95	1.92	13.10	13.00	44.75	2.00	23.93	3.00	27.10	1.88	8.75
NCS95002	4.15	42.50	1.85	11.13	10.00	56.75	1.00	30.18	2.95	17.20	1.93	5.95
NCS950010	4.06	52.51	1.84	15.60	11.00	36.75	1.00	30.83	2.9	24.56	1.76	8.39
NCS95004	3.55	34.95	2.02	12.30	10.50	43.00	1.00	26.50	2.25	21.00	1.93	7.30
Paidar-91	4.15	55.00	1.82	15.01	11.75	54.75	2.00	24.40	6.05	29.60	1.63	7.5
A-16	3.60	41.93	1.92	13.48	12.25	44.50	1.00	27.38	2.70	25.60	1.83	10.92
C-44	5.20	52.55	1.83	15.65	10.00	33.50	1.50	25.70	3.50	30.20	1.82	10.95
92CC076	4.35	47.70	1.92	11.80	8.25	42.00	1.25	25.25	3.30	18.80	1.88	8.75
96051	4.15	64.25	2.18	17.9	12.25	38.00	2.00	19.88	2.53	23.90	2.03	11.48
90280	4.05	38.2	1.97	13.69	12.75	47.75	1.00	18.60	3.18	21.15	1.90	8.77
93009	3.25	43.68	1.87	12.13	12.00	46.00	2.00	25.53	2.55	24.85	1.80	7.53
94014	4.20	39.35	1.97	13.10	11.50	34.5	2.00	25.05	2.90	22.80	2.00	8.75
90261	3.75	35.20	2.26	12.12	13.00	25.00	1.5	20.22	2.15	15.30	1.98	5.83
93012	3.55	52.07	1.78	14.63	13.25	42.50	1.00	23.45	2.85	27.80	1.84	9.46
82080	4.65	40.20	1.94	14.70	10.75	52.50	2.00	21.43	2.85	22.70	1.92	9.10
92CC079	4.20	41.55	1.81	14.15	12.75	56.75	2.00	22.33	3.20	18.90	1.84	7.58
91A001	4.85	44.73	1.77	13.35	11.00	39.75	2.00	23.45	3.20	26.65	2.79	11.00
91A039	4.95	47.38	1.82	16.83	14.75	36.25	2.00	20.05	3.15	25.10	1.99	8.33
BRC-14	4.70	36.25	1.82	12.73	15.00	46.00	1.00	14.33	3.60	14.80	1.67	10.78
CMNK28-3	5.15	53.15	1.51	14.48	12.25	32.00	1.50	21.13	3.25	26.05	1.49	5.97
MS (V)	1.20	356.01	0.09	12.98	10.02	313.47	0.86	63.49	2.28	76.19	0.24	11.54
MS (R)	3.64	556.10	0.11	20.20	11.08	58.03	0.10	499.29	4.84	370.36	0.63	49.96
MS (E)	0.69	124.15	0.03	9.60	5.07	11.75	0.09	94.10	2.37	54.75	0.14	7.13

BP- Primary branches plant^{-1} PP-Number of pods plant^{-1} SP-Number of seeds pod^{-1} GY-Grain yield plant^{-1}

Table 2. Genetic parameters for four characters in chickpea over three locations.

Location	Genetic parameter	Primary branches	Pods plant^{-1}	Seeds pod^{-1}	Grain yield
NARC, Islamabad	SE	0.42	5.57	0.09	1.55
	GV	0.13	57.97	0.02	0.85
	PV	0.82	182.12	0.048	10.44
	GCV	8.45	16.84	6.38	6.72
	PCV	21.65	29.86	11.49	23.63
	H	0.15	0.32	0.31	0.08
Mirpur, AJ & K	SE	1.13	1.72	0.15	4.85
	GV	1.24	75.43	0.19	-7.65
	PV	6.31	87.19	0.28	86.44
	GCV	9.36	20.41	28.74	11.62
	PCV	21.23	21.95	34.55	39.05
	H	0.20	0.87	0.69	-0.09
AZRI, Bhakkar	SE	0.77	3.70	0.19	1.34
	GV	-0.02	5.36	0.03	1.10
	PV	2.35	60.11	0.16	8.23
	GCV	4.77	10.12	8.39	12.29
	PCV	49.63	33.87	21.27	33.59
	H	-8.88	0.10	0.16	0.13

GV: Genotypic Variance, PV: Phenotypic Variance, GCV: Genotypic Coefficient of Variation, PCV: Phenotypic Coefficient of Variation, H: Heritability in broad sense (2.06).

Table 3. Pool analysis of variance of four characters for three locations.

Genetic parameters	Primary branches	Pods plant^{-1}	Seeds pod^{-1}	Grain yield
MS (V x L)	0.067	11.29	0.028	13.62
MS (E)	0.104	1.69	0.056	0.511
F value	0.639*	6.66**	0.51	26.67**

* and ** = Significant at 0.05 and 0.01 percent probability level, respectively

Correlation coefficient: Genotypic and phenotypic correlation coefficients calculated for individual locations are presented in Table 4. These coefficients revealed that genetic correlations were different from phenotypic correlations at each location. Arshad *et al*., (2003b) and Bakhsh *et al*., (1998) reported high genetic correlation than phenotypic correlations in chickpea. Comparisons of correlation coefficients from three isolated locations as obtained in present study revealed differences between locations with respect to strength and pattern. Such differences were recorded for association of yield with yield components and between yield components. The genetic correlation of primary branches was significant and positive with grain yield at NARC while it was non significant and negative at Bhakkar and highly significant and negative at Mirpur. The genetic correlation of primary branches with pods was positive at all the three locations but it was highly significant only at Bhakkar (1.552**).

Table 4. Genotypic (rG) and phenotypic (rP) correlation matrix for branches, pods, seed pod^{-1} with grain yield at NARC, Mirpur and AZRI, Bhakkar.

Character	Location		Primary branches	Pods plant^{-1}	Seeds Pod^{-1}	Grain yield
Fruit bearing Branches	NARC	rG	1	0.036	-0.193**	0.287
		rP	1	0.419	-0.084	0.495*
	Mirpur	rG	1	0.257	0.031	-0.389**
		rP	1	-0.097	0.005	-0.166
	Bhakkar	rG	1	1.552**	1.945**	-0.381
		rP	1	0.262	-0.116	0.069
Pods plant^{-1}	NARC	rG		1	-0.595**	0.649**
		rP		1	0.016	0.764**
	Mirpur	rG		1	0.139	0.308**
		rP		1	0.141	0.033
	Bhakkar	rG		1	-0.329**	0.469*
		rP		1	0.077	0.606**
Seeds pod^{-1}	NARC	rG			1	-0.762**
		rP			1	0.132
	Mirpur	rG			1	-0.139**
		rP			1	-0.476
	Bhakkar	rG			1	-0.463*
		rP			1	0.231**

* and ** = Significant at 0.05 and 0.01 percent probability level, respectively

The genetic correlation of grain yield with pods was positive and significant at Mirpur (0.308) at Bhakkar (0.469) and at NARC (0.649), Islamabad. Number of seeds pod^{-1} had negative genetic correlation with grain yield at NARC and Mirpur AJ &K whereas it was positive and significant at Bhakkar (Table 4). The average number of seeds pod^{-1}, and number of pods per plants had negative correlation at two locations, NARC (-0.595) and Bhakkar (-0.329). However, this relationship was positive but non significant at Mirpur. Similarly, number of seeds pods^{-1} and number of branches plant^{-1} were negatively inter-correlated at NARC and Bhakkar, whereas, positive but non significant correlation of seeds pods^{-1} with total number of branches was recorded at Mirpur (0.031). Pods plant^{-1} had positive and highly significant genetic correlation with fruit bearing branches at two locations (NARC and Bhakkar). This relationship at Mirpur was non significant although it was positive. Number of seeds pods^{-1} had negative and highly significant correlation with grain yield at NARC (-0.762) and at Mirpur (-0.139) locations, while at Bhakkar this correlation was negative and significant (-0.4623) with grain yield.

The phenotypic correlation matrix revealed major differences between locations for inter-relationship of yield components. Primary branches had significant and positive phenotypic correlation (0.495) with grain yield at NARC, non-significant (0.069) with grain yield at Bhakkar, whereas, non significant but negative correlation at Mirpur, AJ & K (-0.166). Number of pods plant^{-1} were phenotypically positively correlated with grain yield at all the location, though this correlation was non significant at Mirpur (0.033). Phenotypic correlation between seeds pod^{-1} and grain yield was positive and significant at NARC and highly significant at Bhakkar whereas it was negative at Mirpur (-0.476).

Discussion

The phenotypic expression of a trait in living organism is obtained by the interaction of genotype and environment. The quantitative traits as studied in the present investigation are more vulnerable to environmental changes. The differences between the locations for performance of varieties for these traits are an indication of reaction of genotypes to environmental changes. Arshad *et al*., (2003a) has already reported highly significant genotype x environment interaction in chickpea. The difference between genotypic means for all the traits at different locations indicated the significance of variation between three production conditions. The effects of environments on productivity of chickpea have been demonstrated by Arshad *et al*., (2003a); Ahmad *et al*., (1992) and Bakhsh *et al*., (1996). The mean values for all the four traits were higher at Mirpur followed by that of NARC. This indicated that production conditions at Mirpur were better than those of NARC and AZRI.

Correlation and path coefficient studies have been extensively conducted in various crops e.g., in chickpea (Bakhsh *et al*., 1998; Güler *et al*., 2001 and Arshad *et al*., 2002); in wheat (Ihsanullah & Muhammad, 2001; Quresh *et al*., 1977; and Quresh & Khan, 1980); in mungbean (Malik *et al*., 1983 & 1987; Ghafoor *et al*., 2000); in blackgram (*Vigna mungo*); in Soybean (Johanson *et al*., 1955) etc. The over all objective of such type of studies is to determine the role of various yield components in the determination of yield and to devise selection criteria for single plant selection from segregating population and also to identify parents with desirable traits for hybridization to pyramid various traits into a single genotype.

However, most of the previous studies in chickpea were conducted on different genotypes planted in different environments. Consequently, the variation in results was attributed to differences in genotypes and environments (Bakhsh *et al*., 1998). Hence, different selection criteria have been proposed by different researchers for grain yield improvement. Present study was conducted with the aim of estimating the effect of changes in environment on character inter-relationship. Yield components/traits used in this study were selected on the basis of their persistent relationship as reported by earlier workers (Bakhsh *et al*., 1998; Güller *et al*., 2001; Arshad *et al*., 2003b; Akdağ and Schirali 1992; Kumar *et al*., 1999). The results of this study revealed highly significant differences between genotypes at all the three locations for the four traits under observation. Significant differences in chickpea have been shown by many workers (Tomar *et al*., 1982; Arshad *et al*., 2002 & 2003b).

The correlation coefficients of yield with pods plant-1, fruit bearing branches and number of seeds pod^{-1} from three locations showed that fruit bearing branches and number of pods plant^{-1} were positively correlated with grain yield at all the locations. However, the strength of their association was different at different locations. Bakhsh *et al*., (1998) compared F_1s and their parental lines for correlation coefficients and demonstrated that pods plant^{-1} and secondary branches plant were consistently positively correlated with grain yield. The correlation of seed pods^{-1} with grain yield changed with location. Similarly, the association of this trait with fruit bearing branches and pods plant^{-1} also changed with change in locations. Again the inter-relationship of fruit bearing branches and pods plant^{-1} was positive at all the locations though its coefficient was different at different locations.

On the basis of present study, it can be proposed that while selecting parental genotypes or selecting single plant from segregating populations, emphasis should be placed on number of fruit bearing branches and number of pods plant^{-1} for stability in genetic gain in grain yield across the environment. Bakhsh *et al*., (1998) also proposed similar selection criteria. However, he included total; biological yield in selection criteria. Stable and positive correlation of pods plant^{-1} and secondary branches has been published by Dahiya *et al*., (1986), Naidu *et al*., (1986), Bahl *et al*., (1976) and Agrawal, (1986). The present study also showed that environmental changes affect both nature and strength of correlation in some cases. Therefore, it would be pertinent to keep the environmental factor into consideration while proposing selection criteria.

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