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STABILITY OF YIELD AND YIELD COMPONENT CHARACTERS IN CHICKPEA

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ABSTRACT

Sixtysix genotypes of chickpea (*Cicer arietinum* L.) were evaluated in nine microenvironments for stability of nine characters and for correlations of yield with component characters using joint regression and stability analyses. Independence of stability of yield vs yield contributing characters was tested by the χ^2-test. Variations due to genotypes, environments and genotype x environment interactions were highly significant for all characters. Forty eight genotypes were stable for plant height, 37 for days to flowering, 56 for days to maturity, 47 for primary branches/plant, 53 for secondary branches/plant, 46 for pods/plant, 38 for 100-grain weight, 54 for harvest index and 52 for yield/plant. Grain yield/plant had significant positive correlation with primary branches/plant and pods/plant, and its stability was dependent on stability of primary branches/plant and pods/plant, respectively. Likewise, grain yield had nonsignificant correlation with days to flowering, days to maturity, and 100-grain weight, and stability of grain yield was independent of stability of each of these three characters. Plant height had nonsignificant correlation with yield but its stability was not independent of stability of yield. Secondary branches and harvest index had significant correlation with yield but stability of each of these two characters had independent relationship with stability of yield. The noncoincidence between significance of r and χ^2 in case of plant height, secondary branches and harvest index were attributed to their low percentage of linear component of G x E, i.e. being nonpredictive in nature.

Key words: *Cicer arietinum* L., stability, correlation.

Chickpea (*Cicer arietinum*) is an important leguminous crop of the world. The improvement in chickpea depends on selection of stable genotypes suitable for different agroclimatic conditions. Selection for yield depends on the correlation of contributing characters with yield and their heritability. Moreover, the selected genotype should be stable for yield to give predictable returns under variable environments. An attempt has been made to determine the relationship between high yield and its stability.

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MATERIALS AND METHODS

Sixtysix chickpea genotypes were grown in nine microenvironments at the Experimental Research Farm, Meerut University, Meerut, in randomized complete block design with three replications in each environment. The microenvironments included winter season (October–March) of 1982-83 with fertilizers at the rate of 20 kg N, 50 kg P and 40 kg K/ha, and spacing of 30 x 15 cm. The remaining eight environments were created through combinations of two sowing dates with a gap of about a fortnight (spacings: first sowing = 50 x 20 cm and second sowing = 30 x 15 cm) and two levels of fertilizers (control and 20:50:40 NPK/ha) in the winter seasons of 1983-84 and 1984-85. The plot size for each treatment was one row of 3 m length.

Data were recorded on five random plants on plant height, days to 50% flowering, days to 75% maturity, primary and secondary branches/plant, pods/plant, 100-grain weight, harvest index, and grain yield/plant. Pooled analysis of plot means in nine microenvironments was done to determine correlation coefficient of yield with other characters. Joint regression analysis was done using the methods of [1] to detect G x E interaction and to estimate its linear and nonlinear (remainder) components. Mean squares were tested against error mean squares. In the cases where both linear and remainder components were significant, the linear components were retested against remainder. Mean squares due to genotypes and environments were tested against G x E mean squares. Stability of individual genotypes was estimated using the method of [2]. A genotype with unit regression coefficient (bi=1) and zero deviation from regression ($S^2di=0$) was considered stable. Correlation coefficient between yield/plant and total number of stable characters was also calculated. Independence of stability of yield with stability of rest of the characters was tested by χ^2 test by making two-way table. The standard method of Yate's correction method of χ^2 test was used where necessary.

RESULTS AND DISCUSSION

JOINT REGRESSION ANALYSIS

The joint regression analysis revealed highly significant differences among the genotypes, environments, and genotype x environment interactions for all characters. Significant linear mean squares for days to 75% maturity, primary and secondary branches/plant, pods/plant, harvest index, and grain yield/plant indicated that only predictable component shared the G x E interaction for these characters. Significant linear as well as remainder mean squares for plant height, days to 50% flowering, and 100-grain weight indicated that G x E interaction was shared by both predictable and nonpredictable components. Significant linear component against its remainder for days to flowering indicated that the major component for differences in stability was due to linear regression. Nonsignificant linear mean squares against remainder indicated that a reliable predictions of G x E interaction cannot be made for plant height and 100-grain weight. Individual line predictions, however, could be made on the basis of their bi and S^2di estimates.

STABILITY PARAMETERS

Stability estimates of bi and S^2di were obtained for each genotype and character. Forty eight genotypes were stable for plant height, 37 for days to flowering, 56 for days to maturity, 47 for primary branches and 53 for secondary branches/plant, 46 for pods/plant, 38 for 100-grain weight, 54 for harvest index, and 52 for yield/plant (Table 1).

Table 1. Yield of chickpea genotypes and their stability (marked +) for yield and its component characters

Genotype	Yield per plant (g)	Stability of yield components: plant height	days to flowering	days to maturity	primary branches per plant	secondary branches per plant	pods per plant	100-grain weight	harvest index	yield per plant	total stable characters
1	2	3	4	5	6	7	8	9	10	11	12
H 77-62	9.28	+				+	+		+	+	5
H 77-104	8.50		+	+	+		+	+	+	+	7
H 77-19	6.84		+	+	+	+	+		+	+	7
H 77-106	7.92	+	+	+	+	+	+	+	+	+	9
H 77-56	9.85	+	+	+	+	+		+	+	+	8
H 77-110	9.58	+	+	+	+	+	+	+	+	+	9
H 77-74	8.93	+	+	+					+		4
H 77-103	9.89	+	+	+		+		+		+	6
H 77-108	11.53	+	+	+		+			+		5
H 77-112	9.12	+			+	+	+		+	+	6
H 77-111	9.02	+	+	+	+	+	+		+	+	8
H 77-57	7.68	+		+			+		+	+	5
H 77-70	10.23		+	+	+	+	+		+	+	7
H 77-58	6.56	+	+	+	+	+	+	+	+	+	9
H 76-105	7.13	+	+	+	+	+	+		+	+	8
H 76-101	8.87	+		+	+	+	+		+	+	7
H 76-104	8.47	+	+	+	+	+	+	+	+	+	9
HMS 19	8.76	+	+	+	+	+	+		+	+	8
HMS 6	7.57	+	+	+	+	+	+		+	+	8
HMS 5	7.81			+	+	+	+		+	+	6

(Contd.)

Table 1. (contd.)

1	2	3	4	5	6	7	8	9	10	11	12
HMS 25	7.96	+	+	+			+	+	+	+	7
HMS 17	8.07	+		+		+	+	+	+		6
HMS 21	7.18	+		+	+	+	+	+		+	7
HMS 27	8.58	+		+	+	+	+	+		+	7
ICC 1134	7.53	+	+	+	+	+	+	+	+	+	9
ICC 1097	4.95			+	+			+	+		4
ICC 7710	10.28			+	+	+		+	+		5
ICC 8149	8.33	+		+	+		+			+	5
ICC 1994	7.83	+	+	+		+	+	+	+	+	8
ICC 3651	6.84			+	+				+	+	4
P 9695	7.71		+	+	+	+			+	+	6
BG 209	7.94	+	+			+	+	+	+	+	7
BG 212	6.50	+	+	+	+	+	+	+	+	+	9
Annigeri	8.35			+	+	+	+		+	+	6
12-071-05093	4.75			+		+		+	+		4
F_6 Wilt 115	10.00	+		+		+		+			4
F_6 Wilt 1865	8.37	+	+	+	+	+	+	+	+	+	9
GC 665	7.71			+		+		+	+	+	5
WR 315	6.67	+		+	+	+	+	+	+	+	8
P 179	8.95	+	+	+			+	+	+	+	7
P 289	8.24	+		+	+	+	+	+	+	+	8
E 100	6.17		+	+	+	+		+	+		6
P 678	6.01	+	+			+	+		+		5
P 992	8.92	+		+		+	+	+	+	+	7
P 1179	8.90		+	+	+	+		+	+	+	7
NEC 2305	11.35					+	+		+		3
F_6 Wilt 315	10.09	+	+	+	+						4
ICCC 3	9.29	+	+	+	+	+	+				6
NEC 1128	8.22	+		+	+	+		+	+	+	7
P 1786	8.46		+				+		+		3
PRP 1	9.65	+		+	+	+	+	+		+	7
P 4116-1	11.28	+	+	+	+	+	+	+	+	+	9
JG 221	8.29	+			+	+	+	+		+	6
PG 72-84	7.20	+		+	+	+	+	+		+	7

(Contd.)

Table 1. (contd.)

1	2	3	4	5	6	7	8	9	10	11	12
F 370	6.91	+		+		+	+	+	+	+	7
P 6308	5.25		+	+	+	+			+		5
P 345-1	8.40	+		+	+			+	+	+	6
JG 35	6.97	+	+	+	+	+	+			+	7
L 345	8.70	+				+		+	+	+	5
NEC 249	7.59	+	+	+	+	+	+	+	+	+	9
P 3765	7.94	+	+	+	+	+	+		+	+	8
NEC 2383	9.69			+	+	+	+		+	+	6
ICCC 4	10.58	+	+	+	+	+	+		+	+	8
P 184-1	7.94	+	+		+		+	+	+	+	7
ICCC 2	9.67	+		+	+	+				+	5
C 235	6.41		+		+			+	+	+	5
Total stable genotypes		48	37	56	47	53	46	38	54	52	

r between yield/plant and total stable characters = 0.956^{**}.
$^{**}P \geq 0.01$.

CORRELATION COEFFICIENTS

Correlation coefficient between yield/plant and total number of stable characters of a genotype (Table 1) showed that yield had highly significant correlation with total number of stable characters ($r = 0.956^{**}$, $P \geq 0.01^{**}$). This indicates that the higher yielding genotypes were stable for most of the component characters.

TWO-WAY TABLE

A two-way table was prepared showing number of stable and unstable genotypes for yield/plant and number of stable and unstable genotypes for other characters to test the independence between stability of yield vs stability of component characters (Table 2). Considering plant height and yield/plant, 66 genotypes were distributed in four groups: 41 stable for both characters, 11 stable for yield but unstable for plant height, 7 unstable for both characters, and 7 unstable for yield but stable for plant height. The number of stable and unstable genotypes for yield in relation to other characters can be explained likewise.

χ^2 TEST AND CORRELATION COEFFICIENT OF YIELD/PLANT WITH COMPONENT CHARACTERS

The χ^2-test in the two-way table revealed that stability of yield/plant was dependent on stability of plant height, primary branches/plant, and pods/plant (Table 3). The correlation coefficient between yield/plant and component characters revealed that yield/plant had significant correlation with primary and secondary branches/plant, pods/plant, and harvest index. The comparisons of correlations of yield and component characters, and independence of stability of yield vs component characters showed that a) primary branches and pods/plant had significant correlation with yield, and stability of genotypes for primary branches and pods/plant was dependent on stability of yield, b) days to flowering and maturity, and 100-grain weight had nonsignificant correlation with yield, and stability of each was independent of stability for yield, c) such coincidence for significance of r and χ^2 could not be observed in case of plant height, secondary branches/plant, and harvest index. Plant

Table 2. Twoway table showing stable and unstable genotypes for yield vs component characters

Character	Stability status	Yield/plant stable	Yield/plant unstable	Yield/plant total
Plant height	Unstable	11	7	18
	Stable	41	7	48
Days to flowering	Unstable	23	6	29
	Stable	29	8	37
Days to maturity	Unstable	7	3	10
	Stable	45	11	56
Primary branches/plant	Unstable	11	8	19
	Stable	41	6	47
Secondary branches/plant	Unstable	9	4	13
	Stable	43	10	53
Pods/plant	Unstable	11	9	20
	Stable	41	5	46
100-grain weight	Unstable	20	8	28
	Stable	32	6	38
Harvest index	Unstable	9	3	12
	Stable	43	11	54
Total in each set		52	14	66

Table 3. Relationship between stability for yield and its component characters in chickpea

Character	Stable genotypes	Correlation with yield (r)	Relationship with stability of yield	χ^2 value	P	G x E (% linear)
Plant height	48	0.18	Dependent	4.627*	0.01–0.05	13.6
Days to flowering	37	–0.06	Independent	0.008	0.90–0.95	35.1
Days to maturity	56	–0.11	Independent	1.341	0.10–0.25	36.8
Primary branches/plant	47	0.32**	Dependent	6.969**	0.00–0.01	32.8
Secondary branches/plant	53	0.37**	Independent	1.740	0.10–0.25	22.3
Pods/plant	46	0.79**	Dependent	9.716**	0.00–0.01	33.5
100-grain weight	38	0.07	Independent	1.576	0.10–0.25	13.1
Harvest index	54	0.53**	Independent	0.555	0.22–0.55	16.0
Grain yield/plant	52	—	—	—	—	33.3

*P ≥ 0.05; **P ≥ 0.01.

height had nonsignificant correlation with yield/plant, but its stability was not independent of stability for yield. Similarly, secondary branches/plant and harvest index had significant correlation with yield but stability of each was independent of stability for yield. Such deviations in plant height, secondary branches/plant, and harvest index were attributed to the unpredictable nature of their G x E interaction (low proportion of linear component, 13.6, 22.3 and 16.0%, respectively).

It is concluded, therefore, that plant height, secondary branches/plant, and harvest index behaved in an unpredictable way due to low value of the linear component of G x E interaction, though stability for yield could be dependent on stability of all the yield correlated characters. This hypothesis is also supported by the fact that grain yield had significant correlation with total number of stable characters. Thus, it seems that the high yielding genotypes of chickpea were stable for most of the yield contributing characters. Moreover, it appears that gene combinations in the present material for yield/plant, stability of yield and its component characters may be different, but their interactions may affect each other possibly due to pleiotropic effects. Hence breeding programmes aiming at improvement in these characters in chickpea (viz. yield, and stability of yield and of its component characters) will cause an overall improvement in the remaining characters.

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