GENERATION MEAN ANALYSIS OF DROUGHT TOLERANCE RELATED PHYSIOLOGICAL TRAITS IN CHICKPEA (*CICER ARIETINUM*)

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Abstract: Physiological traits directly related to the tolerance of plant to water stress are selected for inheritance studies in Chickpea. Generation mean analysis was undertaken using three crosses under rainfed condition to ascertain the inheritance of drought tolerance related physiological traits viz. leaf area, leaf area index, root length, drought tolerance efficiency, drought susceptible index and cell membrane injury index. The results indicated that the epistasis has major influence on these traits, hence breeding methods involving high volume of crosses viz. biparental mating, recurrent selection and diallel selective mating designs will be more promising to cover both additive and non additive gene interactions for future crop improvement.

Keywords: Gene action, generation mean analysis, drought tolerance.

Introduction: Among various kinds of abiotic (salinity, heat) stresses affecting the chickpea production, drought stress particularly at the end of the growing season is a major constraint in chickpea production and yield stability in arid and semiarid regions of the world (Krishnamurthy et al. 2010). Chickpea is mostly grown on residual moisture from monsoon rains on the Indian subcontinent and semi-arid regions of Sub-Saharan Africa (SSA). The soil moisture stress affects the physiological processes in the plants and leading to reduced plant growth mainly due to development of high osmotic pressure in roots and shoots. In a practical sense, drought tolerance is the relative ability of the crop to sustain adequate biomass production and maximize crop yield under increasing water deficit throughout the growing season, rather than the physiological aptitude of the plant for its survival (Serraj and Sinclair 2002). In the context of drought tolerance, the structure and function of the root system is expected to directly contribute to the transpiration while that of the shoot system structure and function to the transpiration efficiency (TE). Drought causes substantial annual yield losses up to 50 % in chickpea and the productivity remained constant for the past six decades (Ahmad et al. 2005; Varshney et al. 2010). Therefore, genetic improvement programmes must be concentrated on combining high yield with resistance to stresses.

The character expression is the manifestation of gene action and its interactions with the environment. The breeding methodology to be adopted for the genetic improvement of the characters primarily hinges on the type of gene action viz., additive, dominance and epistasis with their relative magnitude. A number of genetic models assuming basic requirements have been suggested for the estimation of the gene effects. Hayman (1958), Jinks and Jones (1958), Anderson and Kempthorne (1954) and Hayman and Mather (1955) have developed models for estimating the relative importance of additive and dominance gene effects. The six-generations model involving P1, P2, F1, F2, BC1 and BC2 generations in three crosses of chickpea was utilized to ascertain epistasis (additive × additive, additive × dominance and dominance × dominance) in addition to additive and dominance gene effects for drought tolerance and its attributing physiological characters.

Materials and methods: The present investigation to study the inheritance of drought tolerance related physiological attributes in chickpea was undertaken at Pulses Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, during 2005 to 2007. Three crosses viz., Phule G 96006 x Phule G 5, Phule G 96006 x Phule G 9426-2 and Phule G 5 x Phule G 9426-2 were effected among three promising parents (Table I). The experiment comprising of P1, P2, F1, F2, BC1 and BC2 generations of each of the three crosses conducted in the randomized block design with three replications in rainfed condition, during Rabi 2007. Inter and intra row spacing was kept 30 cm x 15 cm. Recommended agronomic practices and necessary plant protection measures were timely adopted for successful raising of the crop. The observations recorded for the physiological characters viz. Leaf area (LA), Leaf area index (LAI), Root Length (RL), Drought Tolerance Efficiency (DTE), Drought Susceptible Index (DSI) and Cell membrane Injury Index (CMII). Following procedure adopted for recording different physiological characters.

Leaf area (dm2/plant): Leaf area was measured with the help of automatic Leaf Area Meter in dm2 at 20 days interval from 30 days after sowing.

Leaf Area Index (LAI): This was calculated as;

$$LAI = \frac{\text{Leaf area / plant}}{\text{Land area/ plant}}$$

Root Length (cm): Roots were dug out and washed under running water. Bloted dry and tap root length per plant was measured in cm.

Drought Tolerance Efficiency (DTE):
This was calculated as;

$$DTE = \frac{I_0}{I_1} = \frac{\text{Yield under stress}}{\text{Yield under non stress}} \times 100$$

Drought Susceptible Index (DSI): Drought susceptible index was calculated by using formula suggested by Fisher and Maurer (1978) as below,

$$DSI = \frac{1 - (Yd/Yp)}{D}$$

Yd : Grain yield of genotype under moisture stress condition
Yp : Grain yield of genotype under irrigated condition

$$D: \frac{\text{Mean grain yield of all the strains under moisture stress condition}}{\text{Mean grain yield of all the strains under irrigated condition}}$$

Cell membrane Injury Index (CMII): Cell membrane injury index recorded by following standard method given by Deshmukh and Kushwaha (2002). Leaf tissues (0.1 g each) of five observational plants per replication were taken from the field and made dust free in 10 ml double distilled water in a tube (40 ml capacity). These tubes were incubated at 450C for 30 minutes in BOD incubator. Conductivity (C1) of these tubes was measured after 10-15 minutes. These tubes again kept in water bath at 1000 temperature for 10 minutes. The conductivity (C2) was measured again. The cell membrane injury index (CMII) was calculated as C1/C2.

The observations of CMII were compared with the rating scales as below :
When

CMII	=0.24- 0.34	Tolerant to drought
CMII	=0.35- 0.39	Medium tolerant to drought
CMII	=0.47- 0.55	Susceptible

The data were subjected to analysis of variance for Randomized Block Design following Fisher (1950). The crosses showing significant differences among the entries (progenies) for the character were subjected to generation mean analysis for the estimation of gene effects using six parameter model as suggested by Hayman (1958) and Jinks and Jones (1958). The scaling test as described by Haymen and Mather (1955) was used to check the adequacy of the additive dominance model for different characters in each cross.

Results and discussion: The estimates of gene effects of different yield traits are presented in table II.

Leaf area per plant: Leaf area of plant is directly related to the tolerance of plant to water stress therefore inheritance studies of this character have special importance. The cross, PG 96006 x PG 5 revealed that additive as well as dominance gene effects along with preponderance of dominance gene effects, while among interaction additive x additive (i) and additive x dominance (j) effects were influencing the inheritance of this trait. In cross PG 96006 x PG 9426-2 and PG 5 x PG 9426-2, showed the presence of additive, dominance and presence of all three non-allelic interaction effects viz. additive x additive, additive x dominance and dominance x dominance along with duplicate gene action. Suggesting the recurrent selection method would be effectively utilized for improvement of this character.

Leaf area index: All the three crosses reveal the presence of additive, dominance, additive x additive, additive x dominance and dominance x dominance interaction effects. Cross PG 96006 x PG 9426-2 revealed the duplicate gene action played an important role in the improvement of this trait. This proposes the heterosis breeding would be effective in the improvement of this trait.

Root length: In the cross PG 96006 x PG 5 and PG 5 x PG 9426-2 showed the presence of dominance gene effect along with additive x additive and dominance x dominance interaction effects. While, in cross PG 96006 x PG 5 opposite sign of dominance (h) and dominance x dominance (l) gene effects shows the role of duplicate gene action, hence heterosis breeding would be rewarding in the improvement of this trait for drought tolerance (Singh et al. 1988, Silim and Saxena, 1993 and Kalita and Upadhaya, 2001).. The cross PG 96006 x PG 9426-2 indicated the presence of additive (d) gene effects.

Membrane Injury Index: Additive gene effects along with dominance and all the three interallelic interactions were observed in crosses PG 96006 x PG 5 and PG 5 x PG 9426-2. Cross PG 96006 x PG 5 indicates duplicate while complementary gene action in cross PG 5 x PG 9426-2 suggests the recurrent selection method should be effective for improvement of this character. The cross PG 96006 x PG 9426-2 showed the presence of dominance, additive x additive, additive x dominance and dominance x dominance gene effects (Wrey et al. 1993, Gupta et al. 2000 and Deshmukh and Kushwaha, 2002).

Drought tolerance efficiency: Cross PG 96006 x PG 5 and Phule G 5 x Phule G 9426-2 revealed the presence of additive, dominance and all three types of non additive interactions viz. additive x additive, additive x dominance and dominance x dominance gene effects along with duplicate gene action. Suggesting recurrent selection would be effective for further improvement in this trait. Cross PG 96006 x PG 9426-

2 showed the presence of additive, dominance and dominance x dominance interactions along with complementary gene action.

Drought susceptible index: Additive, Dominance and all three types of non additive interactions viz. additive x additive, additive x dominance and dominance x dominance gene interactions were observed in Cross PG 96006 x PG 5 and Phule G 5 x Phule G 9426-2. The presence of duplicate gene action in inheritance of this trait, suggests recurrent selection for further improvement in this trait. Cross PG 96006 x PG 9426-2 showed the presence of additive, dominance, additive x additive and dominance x dominance interactions.

The present study revealed that appreciable amount of epistasis is present in selected physiological traits of three crosses under rainfed condition. Breeding methods involving high volume crossing viz. biparental, recurrent and diallel selective mating design, which are more efficient for both additive and non-additive gene action seems to be more promising for the improvement of various characters studied.

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Table 1. Salient features of the parents and their crosses used in the study.

Sr.	Parent	Pedigree	Special features of parents	Crosses under Study	Abbreviation
1.	Phule G 96006	ICCC-42 x ICCV-10	Drought tolerance	Phule G 96006 x Phule G 5	C-I
2.	Phule G 5	B-110 x N-31	Bold seeded, drought susceptible	Phule G 96006 x Phule G 9426-2	C-II
3.	Phule G 9426-2	VIJAY x ICC-4958	Intermediate to drought tolerance.	Phule G 5 x Phule G 9426-2	C-III

Table II. Estimates of genetic components of the mean for the characters studied in chickpea under rain fed

Character	Cross	Component					
		m	d	h	i	j	l
LA	C- I	6.53**	0.76**	1.60**	1.53**	-0.84**	-0.64
	C- II	6.98**	-0.48**	-1.72**	-1.50**	-0.50**	2.82**
	C- III	7.16**	0.63**	-1.60**	-1.80**	1.11**	4.64**
LAI	C- I	1.45**	-0.17**	0.35**	0.34**	-0.18**	-0.14
	C- II	1.55**	-0.10**	-0.39**	-0.34**	-0.10**	0.63**
	C- III	1.59**	0.14**	-0.37**	-0.42**	0.25**	1.07**
RL	C- I	20**	0.73	12.62**	14.96**	-0.45	-24.65**
	C- II	23.86**	1.40**	2.76	0.40	0.27	0.31
	C- III	24.26**	2.33**	-3.33*	-1.30	3.75**	6.75*
MII	C- I	0.47**	0.06**	-0.76**	-0.70**	0.07*	0.99**
	C- II	0.29**	-0.007	0.15**	0.12**	-0.06**	0.32**
	C- III	0.36**	0.03**	-0.122**	-0.03	0.11**	-0.18**
DTE	C- I	80.24**	-28.12**	134.19**	127.86**	-28.16**	-203.16**
	C- II	97.53**	-8.84**	-23.12**	-13.90	1.50	-60.24**
	C- III	100.81**	1.01	-50.88**	-52.80**	-5.87**	69.44**
DSI	C- I	8.27**	6.54**	-58.67**	-54.06**	6.03**	77.58**
	C- II	-0.07	0.55**	2.69**	1.96**	-0.22	3.57**
	C- III	-0.95**	-2.31**	10.64**	9.02**	-1.21*	-8.14**

***, ** significant at 0.05 and 0.01 level, respectively**

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