The Bioscan 16(1): 55-60, 2021
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

DIFFERENTIAL RESPONSE OF CHICKPEA GENOTYPES GROWN UNDER NORMAL IRRIGATED AND DROUGHT STRESS CONDITIONS

RAHUL V. CHAHANDE[1]*, PAWAN L. KULWAL[2], LAXMAN B. MHASE[3], CHARUDATTA A. NIMBALKAR[4] AND GANESH D. KHALEKAR[2]

[1]Department of Agricultural Botany, Post Graduate Institute, [3] Pulses Improvement Project,[4] Department of Statistics, College of Agriculture Pune,[2]State Level Biotechnology Centre
Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722 , Maharashtra, INDIA
e-mail: rahulchahande007@gmail.com

KEYWORDS
Chickpea
Drought
Yield

Received on :
29.11.2020

Accepted on :
10.01.2021

***Corresponding author**

ABSTRACT

Thirty two genotypes of chickpea were grown during rabi 2016-2017 under randomized block design (RBD) with two replications to evaluate response of chickpea genotypes under irrigated and drought stress conditions for mean values and various genetic parameters such as phenotypic (PCV), genotypic (GCV) coefficient of variation, heritability and genetic advance. Highly significant differences were observed between genotypes for all the traits under both the conditions. The values of studied traits significantly decreased in drought stress condition as compared to irrigated one. On the basis of mean performance studied, genotype Phule G-12113 was found to be least affected by drought stress condition, while genotypes NBeG-807 and Vishal were found to be highly sensitive to drought stress conditions. GCV and PCV for all characters under both conditions studied revealed that the PCV was higher than their corresponding GCV, indicating the influence of environment on the expression of these characters. Traits 100 seed weight and days to maturity showed high heritability coupled with high genetic advance. Therefore, result of the study suggest that characters 100 seed weight and days to maturity can be good selection criteria for improving seed yield per plant in chickpea for drought stress environments.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the world's third most important food legume crop, cultivated on 14.56 Mha with an annual production of 14.77 Mt at 1014.6 kg/ha productivity (FAOSTAT, 2017). India ranks first in terms of production and productivity, followed by Pakistan, Turkey, Iran, Myanmar, Ethiopia, Mexico, Australia, Mexico, Canada and the United States. Chickpea seeds are highly nutritious, comprising ~18-24% protein, 4-10% fat, 52-71% carbohydrate, and 10-23% fibre, minerals and vitamins (Jukanti *et al*., 2012). Furthermore, the seed protein contains essential amino acids like lysine, methionine, threonine, valine, isoleucine and leucine. Besides providing the essential components of human dietary and health requirements, they fix atmospheric nitrogen and enrich the soil fertility.

Chickpea is mostly grown under rainfed conditions. Availability of water in rainfed regions is mostly in the form of stored soil moisture in a subtropical environment. In these conditions, rainfed chickpea plantations encounter serious yield losses due to terminal drought stress (Toker *et al*., 2007 and Yadav *et al*., 2006), and drought stress is one of the major constraints for chickpea, which causes up to 50% yield losses (Varshney *et al*., 2014). The average of global temperatures has shown an increase of 1 .2ºCover the past century and it is estimated to rise up to 3ºC for 2100 because of global warming (Schneider *et al*., 2007). It is widely predicted to increase the frequency and intensity of drought, accompanied by the higher temperatures and higher CO_2 concentration in semi-arid and sub-tropical regions (Wang *et al*., 2017). Therefore, improvement for drought tolerance has become a major aim of breeders in these areas (Pouresmaeil *et al*., 2012).

Despite the general definition of drought tolerance in native plant species, it is defined in terms of productivity in crop species (Passioura, 1983). Therefore, grain yield and its components remain as the major selection criteria for improved adaptation to a stressful environment. Screening of genotypes for higher yield or stable performance under moisture stress conditions is a prerequisite for selection of drought tolerant genotypes (Ahmad *et al*., 2003 and Pouresmaeil *et al*., 2012). Hall (1993) reported that drought resistance indicates a relative yield of a genotype subjected to the same drought stress compared to other genotypes.

Any traits in a plant that is related to seed yield has its own genetic system and depending on heritability and nature of each trait, different environmental effects for yield components has been reported (Mohammadi andTalebi, 2015). Therefore, the separation of heritable and non-heritable components is necessary. This separation should be based on its genotypic and phenotypic coefficient of variation, heritability and genetic gain (Kahrizi and Mohammadi, 2009 and Maniee *et al*., 2009). Genetic variation among traits is important for breeding and selecting desirable types. Exploration of drought indices and the association analysis of various morpho-agronomic traits have been extensively utilized by several researchers to sort

out the drought-resilient chickpea genotypes. For this purpose, field screening has been found as a powerful tool to screen out the drought-tolerant germplasm (Hussain *et al*., 2015 and Ghasemi and Farshadfar, 2015). The present investigation was planned to identify drought-tolerant genotypes in chickpea for further exploitation in the breeding programmes.

MATERIALS AND METHODS

The present investigation was carried out at Agricultural Botany Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri. Rahuri is situated in western parts of Maharashtra on 19º38'N latitude and 74º65'E longitude with an altitude of 511.0 m above the mean sea level. The zone has a sub-humid tropical climate with an average annual rainfall of 455.0 mm, most of which is received during September. The experimental material consisted of 32 chickpea genotypes of diverse origin developed by various research institutes/stations (Table 1). These were grown under the irrigated condition as well as drought stress condition during rabi 2016-17. Only one irrigation was applied to the trial on drought stress to provide necessary moisture for germination and no supplementary irrigation was done. However, in case of normal irrigated trial, two supplementary irrigations were applied. The experiment was conducted in a randomized block design with two replications on medium black soil to evaluate the morphological and agronomic traits in relation to drought stress. Each entry was grown in two rows of 3.0 m length (30 plants/genotype) with inter and intra-row spacing of 30 cm × 10 cm. Observations were recorded for different traits like plant height after one month of sowing, plant height after second month of sowing, plant height at maturity, days to 50% flowering, number of primary branches per plant, number of pods per plant, days to maturity, 100 seed weight and yield per plant under irrigated and drought stress conditions.

The analysis of variance was carried out as per the standard method (Panse and Sukhatme, 1964) for all the characters under study. Mean values of each character were worked out by dividing the total with the corresponding number of observations, while the lowest and highest values of each character were taken as a range. Heritability in a broad sense for all characters was computed using the formula given by Falconer (1989). Genetic advance for each character was computed using the methodology described by Johnson (1955).

RESULTS AND DISCUSSION

Mean performances of genotypes

Results of variance analysis showed significant differences for all measured morphological characters under normal irrigated as well as drought stress conditions except primary branches per plant. These differences indicated high diversity for measured traits between genotypes under both the conditions

Table 1: Details of the chickpea genotypes used in the present investigation

Sl. No.	Genotypes	Pedigree	Source
1	H-12-01	GL-94022 × ICC-4958	Hissar
2	GNG-2300	HC-5 × GNG-663	Shriganganagar
3	JG-35	JG-130 × ICC-11551	Jabalpur
4	CSJ-859	RSG-143-1 × JG-315	Durgapura
5	GNG-2294	HC-5× GNG-1581	Shriganganagar
6	RVSSG-35	BG-362 × JG-16	Sehore
7	H-12-80	C-235 × HOO-216	Hissar
8	BG-3066	BG-391×BG-240	IARI, New Delhi
9	NDG-14-11	Avrodhi × NDG-30	Faizabad
10	IPC-2011-141	KWR-108 × EC-56270	IIPR, Kanpur
11	IPC-2012-31	Katila × ICCV-10	IIPR, Kanpur
12	Phule G-13107	ICCV-03112 × JAKI-9218	Rahuri
13	Digvijay	Phule G-91028 × Bhima	Rahuri
14	NBeG-806	(ICCV-10 ×ICC-4958) × ICCV-10	Nandyal
15	NBeG-807	(ICCV -10 X ICC-4958) × ICCV-10	Nandyal
16	Phule G-12113	ICCV- 03112 × JG-130	Rahuri
17	JG-74315-2	(JG-74×WR-315) × JG 74-2010-1-3-5-11-15-10-2	Jabalpur
18	H-12-26	HSC-5 × CSJ-8962	Hissar
19	GCP-101	GCP-2× ICCV-2	Junagad
20	PBC-508	ICC-5717 × ICC-96149-F3-BP-BP67P-BP	Bhanswara
21	RVSSG-32	BG-0-112 × JSC-37	Sehore
22	NBeG-738	(ICCV-93954 × ICC-4958) ×ICCV-93954	Nandyal
23	RVSSG-33	JG-130 × KAK 2	Sehore
24	JG-315	Self from Kanpur germplasm	Jabalpur
25	ICC-4958	Germplasm collection	Jabalpur
26	PG-160	ICCV 89445 × ICCV 88502	Pantnagar
27	BG-3064	BG-1088/ FLIP	IARI, New Delhi
28	JG-16	ICCV-42 × ICCV-10	Jabalpur
29	Vijay	P-1270× Annigeri	Rahuri
30	Vishal	K850 × ICCL 80074	Rahuri
31	PBC-507	ICCV-04112 × JAKI-9218	Bhanswara
32	Phule G-0616	Phule G-00109 × GCP-101	Rahuri

Table 2 : Analysis of variance (ANOVA) for nine characters under normal irrigated and drought stress conditions

Sources of Variation	D. F.	Characters								
		PH1	PH2	PHM	DF	P PB	PP	DM	SW	YP
Irrigated trial										
Replications	1	1.56	4.46	122.24	15.01	0.2	55.13	1.89	6.08	5.06
Treatments	31	23.52**	76.34**	116.89**	26.75**	0.29	479.45**	49.37**	63.98**	43.08**
Error	31	3.59	22.83	18.79	7.66	0.1	316.43	8.66	1.38	23.42**
Drought stress trial										
Replications	1	18.64	46.24	54.02	0.25	0.18	1808.37	8.26	0.36	72.67
Treatments	31	26.23**	22.93**	36.55**	35.93**	0.06	215.05**	39.53**	30.64**	16.16**
Error	31	5.3	38.59	33.44	6.95	0.08	128.63	5.52	1.29	5.28

PH1: Plant height after one month of sowing, PH2: Plant height after two month of sowing, PHM: Plant height at maturity, DF: Days to 50% flowering, PB: Primary branches per plant, PP: Pods per plant, DM: Days to maturity, SW:100 seed weight (g), YP: Yield per plant (g) *,**indicates significance at 5% and 1% level of significance

(Table 2).

In the present investigation moisture stress affected chickpea crop at all the stages, more particularly during terminal growth stages. In general, reduction in almost all the traits was observed under drought stressed condition as compared to normal irrigated condition. Chickpea genotypes showed significant variation for different traits under drought stress as compared to the genotypes grown under normal condition (Table 3). Among all the traits studied maximum variation was observed for character plant height.

Genotype H-12-01 showed maximum plant height at maturity (84.10 cm) in normal irrigated condition, while it was reduced to 48.65 cm in drought stress condition. Genotype IPC-2012-31 showed minimum reduction in plant height at maturity in drought stress condition as compared to normal irrigated condition. Meena *et al*. (2015) while evaluating 22 chickpea genotypes under irrigated and drought condition reported decreased plant height under drought stress condition as compared to irrigated condition.

Phenology of plants has an immense influence on productivity and stability (Upadhyaya *et al*., 2011), therefore, appropriate time of flowering is a major component of crop adaptation, particularly in environments where the growing season is restricted by terminal drought (Subbarao *et al*., 1995). Flower initiation in crop plant is highly influenced by variation in prevailing environments. Moisture stress usually leads to early flowering in plants. In case of normal irrigated condition, the overall mean for days to 50% flowering was 59.48 days with earliest genotypes PBC-508 and Phule G- 0616 (52.50 days). Genotype RVSSG-32 (67.00 days) took maximum days to attain 50 % flowering. In case of drought stress condition, the overall mean for days to 50% flowering was 57.03 days. Based on mean values, it was found that genotypes grown under drought stress condition took less time upto 3 days for attaining 50% flowering (Table 3). In case of drought stress condition the genotype Vijay was found to be earliest (49.00 days). Such extra earliness may be exploited in the improvement of chickpea for short growing environment. Pasandi *et al*. (2014) reported that the number of days from sowing to flowering (DSF) was significantly affected by irrigation regimes and cultivar.

However, genotype grown under normal irrigated and drought stress condition did not showed significant difference in relation to character primary branches per plant (Table 2). The overall mean for primary branches in case of normal irrigated condition was 2.52 branches per plant while in case of drought stress condition it was 2.31 branches per plant. This showed that number of primary branches were affected and reduced under stress condition as compared to the normal irrigated condition. The water deficit may adversely affects on plant phenology, phasic growth development, carbon assimilation, assimilates partitioning.

Pods per plant, the most important yield contributing character showed significant differences among genotypes grown under normal irrigated and drought stress conditions (Table 2). Majority of the genotypes exhibited decline in pods per plant under drought stress condition. In drought stress condition primary branches per plant were reduced resulting in decreased pods per plant.

Maturity, being a genetic trait is highly influenced by various stress environments. In case of normal irrigated condition, the overall mean for days to maturity was 114.82 days with earliest genotype PBC-508 (105.50 days) while genotype BG-3066 (125.50 days) took maximum days to attain the maturity. In case of stress condition, the overall mean for days to maturity was 105.39 days with earliest genotype CSJ-589 (97.50 days) while genotype PG-160 (119.00 days) took maximum days to attain maturity. Based on mean values, it was found that genotypes grown under drought stress condition took less time upto 9 days for attaining maturity (Table 3). It was clear that moisture supply during growing period had a strong influence on phenology. Time to maturity was extended by moisture supply and reduced by drought. These findings indicated that earliness plays a crucial role in drought escape. For most crop species, breeding for shorter duration is a major objective, not only to match phenology to season length but also to fit crop into more intensive crop rotations. Meena *et al*. (2015) and Maqbool *et al*. (2015) also reported greater variation in maturity of chickpea with early to late under drought environments.

The 100 seed weight varied significantly from 15.00 to 37.70 g (normal irrigated condition) and 15.70 to 30.90 g (drought stress condition). This result showed a wide range of variability among the genotypes grown under both conditions. Mean seed size was reduced under drought stress condition. The rapidly decreased photosynthesis under drought stress condition presumably had resulted in the production of smaller seeds. There were two genotypes namely, NBeG-807 (30.70 g) and NBeG-738 (35.50 g) which had larger seed size under normal irrigated condition, but showed little change in seed weight under drought condition (28.70 g and 30.90 g, respectively) (Table 3). The larger seeded genotypes grown

Table 3: Mean performance of chickpea genotypes in normal irrigated and drought stress condition

Sl. No.	Genotypes	PH1		PH2		PHM		DF		PB		PP		DM		SW		YP	
	I	D	I	D	I	D	I	D	I	I	D	I	D	I	D	I	D	I	D
1	H-12-01	18.21	17.3	65.01	43.54	84.1	48.65	63	57	2.8	2.1	53.6	17.6	114.5	111.5	15	24	9.9	6.1
2	GNG-2300	19.42	18.93	66.4	40.81	81.9	47.15	56.5	62.5	2.7	2.6	28.4	26.5	115.5	113.5	15.5	19.5	6	6.2
3	JG-35	23.36	23.13	54.31	39.55	60.25	44.6	57.5	55.5	2	2.7	47	46.3	116	107	24.3	26.7	13.3	11.1
4	CSJ-859	22.34	24.3	50.52	37.95	59.37	44.6	58	57	2.5	2.2	49.8	31.2	108.5	97.5	23.7	22.4	15.5	10
5	GNG-2294	17.98	18.04	61.77	44.29	82.3	55.65	61	63	2.6	2.2	52.3	46.4	115.5	99	20.8	18.8	9.4	6.8
6	RVSSG-35	15.63	18.25	43.35	38.1	52.9	44.9	60.5	59	2.4	2.1	45.1	19.4	111	100	26.9	23.1	15	6.9
7	H-12-80	15	15.65	61.56	41.8	69.85	51.15	63.5	65	2.6	2.3	52	37.2	117	108	24.6	19.6	13	10.2
8	BG-3066	14.77	15.95	52.06	38.29	62.7	44.4	60.5	57	2.8	2.6	47	43.2	125.5	106	23.8	22.2	12.2	9.4
9	NDG-14-11	13.32	19.15	51.11	42.24	61.6	52.85	62.5	60.5	2.8	2.7	63.2	45.7	112.5	107	26.8	23.8	19	13.5
10	IPC-2011-141	14.21	17.84	47.78	40.83	60.6	49.35	64	60	2.5	2.2	76.7	42.1	117.5	108	29.9	26.3	23	11.5
11	IPC-2012-31	17.64	20.81	55.4	51.45	62.1	59.4	63	61.5	2.5	2.4	54.8	40.2	121	108	24.6	23	13.5	10.5
12	Phule G-13107	22.65	24.66	50.65	47.45	63.75	58.55	54.5	53.5	2.2	2.3	53.4	36.4	117	102.5	27.9	24.8	16	10.1
13	Digvijay	19.94	21.27	53.59	41.7	59.5	53.05	56	54	2.3	2.2	40.4	39	113	107.5	24	22.8	10.8	11.4
14	NBeG-806	21.08	21.34	53.45	42.01	61.37	50.35	55.5	53.5	2.7	2.3	64.7	43.2	112	99	25.8	24.1	19	13.5
15	NBeG-807	17.73	19.94	53.57	44.83	63.3	50.85	58.5	57.5	3.6	2.4	98.6	43.4	113	105	30.7	28.7	30.3	13.9
16	Phule G-12113	22.42	25.79	63.02	44.89	66.5	51.75	57.5	53	2.5	2.4	49.9	48.7	119	103.5	26.1	24.5	14.00*	16.5
17	JG-74315-2	15.96	19.45	52.96	36.43	59.1	43.45	58.5	54	2.9	2.4	82.5	60.6	117.5	103.5	16.3	16.8	15.1	14.3
18	H-12-26	18.04	17.65	64.73	43.31	73.35	50.6	62.5	58	2.9	2.4	84.5	36.7	122	109	15.1	18.9	17	8.4
19	GCP-101	13.43	14.96	45.37	35.54	59.2	43.35	61.5	60	2.9	2.5	80.2	43.7	110.5	102.5	17.4	18.1	19.4	11.4
20	PBC-508	19.81	21.11	55.84	41.53	58.85	47.5	52.5	51.5	2.5	2.2	63.1	53.2	105.5	107	15.9	18.1	11.6	10.7
21	RVSSG-32	14.05	16.61	52.54	40.81	60.2	49.1	67	63	2.9	2.5	55.1	43.85	124	105.5	20.4	18.1	14	11.5
22	NBeG-738	19.85	22.78	60.3	42.67	63.9	52	59.5	55	1.9	2.2	58.6	40.5	109.5	104.5	35.5	30.9	16.2	15.4
23	RVSSG-33	18.11	21.49	53.55	37.12	58.55	48.1	61	57	2.2	2	39.9	34.8	108	104.5	24.9	25.7	13	11
24	JG-315	13.57	19.75	51.4	41.12	56.7	48	60.5	56.5	2.2	2.4	50.7	71.3	112.5	107.5	16	16.9	11.4	10.4
25	ICC 4958	20.3	26.17	51.5	42.09	56.8	51.95	60.5	57	2.3	2.4	43.2	38.8	114.5	107	37.7	29.1	19.6	14.9
26	PG-160	14.16	17.17	56.9	41.53	67.1	53.25	66.5	67	3.1	2.2	57	34.8	123	119	21.2	20.4	15.8	6.4
27	BG-3064	15.12	17.24	52.9	40.54	58.25	47.6	60	56.5	2.7	2.2	50.3	41.9	116	102.5	20.2	20.3	15	8.8
28	JG-16	13.54	16.6	47.9	37.34	57.82	44.45	60	54	2.2	2.4	75.4	32.6	119	103	18.7	15.7	16.1	6.6
29	Vijay	19.9	20.69	54.08	34.89	59.1	41.7	53.5	49	2.4	2.1	44.7	38.2	106.5	101	19.3	17.7	10.6	9.5
30	Vishal	23.36	29.1	69.55	41.72	73.35	48.15	56.5	53	1.8	2.1	49.5	30.5	111.5	99.5	26.4	25.9	21.7	8.4
31	PBC-507	23.66	27.8	59.38	41.03	63.9	47.7	59	51.5	1.9	2.4	47.8	35.55	113.5	106	27.1	24	17.5	14
32	Phule G-0616	22.51	22.25	54.74	40.26	65.1	45.75	52.5	52.5	2.5	2	77.5	47.7	112.5	107.5	21.4	19.9	19.5	11
Mean		18.15	41.17	55.22	41.17	63.85	49.05	59.48	57.03	2.52	2.31	57.4	40.35	114.82	105.39	23.42	22.2	15.41	10.63
Range		13.32-23.66	34.89-51.45	43.35-69.55	34.89-51.45	52.90-84.10	41.70-59.40	52.50-67.00	49.00-67.00	1.8-3.6	2.0-2.7	28.40-98.60	17.60-31.30	105.50-125.50	97.50-119.00	15.00-37.70	15.70-30.90	6.00-30.3	6.10-16.50

*I-Irrigated condition, D-Drought stress condition, *Less yield in irrigated condition due to some of the plants damaged by attack of Helicoverpa armigera

Table 4: Genetic parameters under normal irrigated condition and drought stress condition

Characters	GCV (%)		PCV (%)		Heritability (%)		Genetic advance (%)	
	I	D	I	D	I	D	I	D
PH1	17.38	15.84	18.88	17.74	84.7	79.8	5.98	5.95
PH2	9.36	6.79	11.18	8.22	70.1	-	8.92	-
PHM	10.96	2.53	11.97	8.71	-	-	-	-
DF	5.19	6.67	6.14	7.43	71.4	80.6	5.37	7
PB	12.07	3.26	15.12	8.06	63.7	-	0.5	-
PP	15.72	16.29	26.97	25.69	34	40.2	10.84	8.58
DM	3.92	3.91	4.32	4.21	82.5	86	8.43	7.88
SW	23.88	17.25	24.14	17.62	97.8	95.8	11.39	7.72
YP	20.33	21.93	30.1	26.73	45.6	67.3	4.36	3.94

- Not estimated due to large variation, *I-Irrigated condition, D-Drought stress condition

under normal irrigated condition in the present study had larger seeds under drought stress condition also, suggesting that selection for large seeds under favorable condition would also result in larger seeds under drought stress condition.

Biological yield per plant was reduced significantly under stress condition as compared to normal irrigated condition. The present findings clearly indicate that moisture stress at various stages resulted in reduction in plant height, number of primary branches per plant, pods per plant and overall growth under stress condition, which ultimately resulted into reduced biological yield. Golezani *et al*. (2013) and Shivkumar et al. (2014) reported decreased yield of chickpea under drought stress condition caused due to reduction in pods per plant and 100 seed weight.

Genetic Parameters

Success of the plant breeder in selecting genotypes possessing higher seed yield and favorable morphological traits depends on the existence and exploitation of genetic variability and high heritability for seed yield and its components. The GCV, PCV, heritability (broad sense) and expected genetic advance for nine characters under normal irrigated as well as drought stress condition is presented in Table 4.

In the present study, the information obtained on variability showed that the high estimates of GCV under normal irrigated condition was observed for trait 100 seed weight (23.88%). While in case of drought stress condition high estimates of GCV was observed for trait yield per plant (21.93%). Yield per plant showed high estimates of PCV under both the conditions (30.10% for irrigated and 26.73 % for drought stress condition). An estimate of GCV and PCV for all the characters under both conditions studied revealed that the PCV was higher than their corresponding GCV, indicating the influence of environment on the expression of these characters. Higher magnitude of GCV and PCV were recorded under both conditions for characters plant height after one month of sowing, pod per plant, 100 seed weight and yield per plant suggesting sufficient amount of variability and thus offer better scope for genetic improvement through selection of these traits. It was in conformity with results reported by other studies. Arora *et al*. (2018) reported close agreement between genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for number of days to flowering, number of days to maturity and 100-seed weight while studying genetic variability of kabuli chickpea genotypes.

High heritability is a good index of the transmission of characters from the parents to their off-springs. Heritability is an estimate of magnitude of phenotypic variation caused by the action of genes. For making effective improvement in trait for which selection is practiced, heritability has been adopted by large number of workers as a reliable indicator. High estimates of heritability under both the conditions observed for trait 100 seed weight (97.80% for irrigated and 95.80% for drought stress condition). These findings were similar to the results obtained by Yucel *et al*. (2006). The least values for heritability under both the conditions were observed for the trait pods per plant (34.00% for irrigated and 40.20% for drought stress condition).

Johnson *et al*. (1955) suggested that heritability and genetic advance, when calculated together could prove more useful in predicting the resultant effect of selection on phenotypic expression. Without genetic advance, the estimates of heritability will not be of practical values and emphasized the concurrent use of the genetic advance along with heritability. High heritability coupled with high genetic advance is important for improvement of crop plants through selection. The traits 100 seed weight and days to maturity exhibited high heritability coupled with high expected genetic advance under irrigated as well as drought stress conditions indicating the scope for improvement and genetic gain through the selection of these traits.

Overall these results revealed a wide range of variability for different morphological traits in both environmental conditions. On the basis of mean performance studied, genotype Phule G-12113 was found to be least affected by drought stress condition, while genotypes NBeG-807 and Vishal were found to be highly sensitive to drought stress conditions (Although these genotypes performed better in irrigated condition but showed more than 50% yield reduction in drought stress condition). High heritability for 100-seed weight and days to maturity in both environments indicated that additive gene effects are important in determining these traits. Crop improvement for these traits is assumed to be possible by simple selection, due to high heritability coupled with high genotypic variation and additive gene effects (Noor *et al*., 2003; Karami and Talebi, 2011).

ACKNOWLEDGMENT

Rahul V. Chahande gratefully acknowledges the UGC-Maulana

Azad National Fellowship for Minority Students for providing financial support to carry out research work.

REFERENCES

Ahmad, R., Qadir, S., Ahmad, N. and Shah, K. 2003. Yield potential and stability of nine wheat varieties under water stress conditions. *Int J Agric Biol*. **5:** 7-9.

Arora, R. N., Kumar, K. and Manav. 2018. Genetic variability studies for yield contributing traits in Kabuli chickpea *(Cicer arietinum* L.). *J Pharmacogn Phytochem*.**7(2):** 2675-2677.

Falconer, D. S. 1989. Introduction to Quantitative Genetics. 3rd Edition, Longman Scientific and Technical, New York.

FAOSTAT. 2017. Statistical database of Food and Agriculture of United Nations, Rome.

Ghasemi, M. and E. Farshadfar. 2015. Screening drought tolerant genotypes in wheat using multivariate and stress tolerance score methods. *Int. J. Biosci.* **(IJB).6:** 326-333.

Golezani, K., Ghasseni, S. and Bandehhagh, A. 2013. Effect of water supply on field performance of chickpea (*Cicer arietinum* L.) cultivars. *Intl J. Agron Plant Prod.*4(1):94-97.

Hall, A. E. 1993. Is dehydration tolerance relevant to genotypic differences in leaf senescence and crop adaptation to dry environment? In: Close and Bray, E. A. (Eds), Plant responces to cellular dehydration during environmental stress.pp.1-10.

Johnson, H., Robinson, H. F. and Comstock, H. S. 1955. Estimates of genetic and environmental variability in soybean. *Agron J*.**47:** 314-318.

Jukanti, A. K., Gaur, P. M., Gowda, C. L. L. and Chibbar, R.N. 2012. Nutritional quality and health benefits of chickpea (*Cicerarietinum* L.): *A review*. *Br J Nutr*.**108:**S12–S26.

Kahrizi, D, and Mohammadi, R. 2009. Study of Androgenesis and Spontaneous Chromosome Doubling in Barley (*Hordeum vulgare* L.) genotypes using Isolated Microspore Culture. *Acta Agronomica Hungarica*. **57:** 155-164.

Maniee, M. Kahrizi, D. and Mohammadi, R. 2009. Genetic variability of some morpho- physiological traits in durum wheat (*Triticum durumDesf.*). *J App Sci*.**9:** 1383-1387.

Maqbool, M. A., Aslmam, M., Ali, H., Mahmud, S., Farid, B. and Zaman, Q. U. 2015. Drought tolerance indices based on evaluation of chickpea advanced lines under different water treatment. Res Crops.16(2): 336-344.

Meena, H. P. and Kumar, J. 2015. Estimation of mean performance and genetic association of yield components and drought related traits in chickpea (*Cicer arietinum* L.). Legume Res.**38(1):** 85-90.

Mohammadi, K. H. and Talebi, R. 2015. Interrelationships and genetic analysis of seed yield and morphological traits in mini core collection of Iranian landrace, breeding lines and improved chickpea (*Cicer arietinum* L.) cultivars. Genetika.47:383-393.

Noor, F., Ashaf, M. and Ghafoor, A. 2003. Path analysis and relationship among quantitative traits in chickpea (*Cicer arietinum* L.). *Pakistan J Biol Sci*.**6:** 551-555.

Panse, V. G. and Sukhatme, P. V. 1995. Statistical Methods for Agricultural Workers. ICAR, New Delhi.

Pasandi, M., Janmohammadi, M. and Karimizadeh, R. 2014. Evaluation genotypic response of Kabuli chickpea (*Cicer arietinum* L.) cultivars to irrigation regimes in northwest of Iran. Agriculture (Po¾nohospodárstvo) . **60(1):** 22-30.

Passioura, J. 1983. Roots and drought resistance. *Agric water manag*.**7:** 265-280.

Pouresmaeil, M., Khavari-Nejad, R., Mozafari, M., Najafi, F., Moradi, F. and Akbari, M. 2012. Identification of drought tolerance in chickpea (*Cicer arietinum* L.) landraces. *CropBreed J*.**2:** 101-110.

Schneider, S. H., Semenov, S., Patwardhan, A., Burton, I., Magadza C. H. D., Oppenheimer M., Pittock, A. B., Rahman, A., Smith, J. B., Suarez, A. and Yamin, F.2007. Assessing key vulnerabilities and the risk from climate change. In: Climate change, Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J. and Hanson CE (eds). Cambridge: Cambridge University Press. PP.779-810.

Shivkumar, M. S., Salimath, P. M., Biradar, S. M. and Sridevi, O. 2014. Empirical selection of drought tolerant lines in early segregating generation of chickpea developed using a new source of drought tolerant germplasm line. *The Bioscan*. **9(2):** 793-794.

Subbarao, G. V., Johansen, C., Slinkard, A. E., Nageswara, Rao, R. C., Saxena, N. P.,Chauhan, Y. S. and Lawn, R. J. 1995. Strategies for improving drought resistance in grain legumes. *Crit Rev Plant Sci*. **14:** 469-523.

Talebi, R. and Karami, E. 2011. Morphological and physiological traits associated with seed yield in different chickpea (*Cicer arietinum* L.) genotypes under irrigated and water- deficit environments. *South Asian J Exp Biol*.**1:** 260-267.

Toker, C., Lluch, C., Tejera, N. A., Serraj, R. and Siddique, K. H. M. 2017. Abiotic stresses. In: Yadav SS, ReddenR, Chen W, Sharma B, editors. Chickpea Breeding and Management. Wallingford: CABI. PP.474-96.

Yadav, S. S., Kumar, J., Yadav, S. K., Singh, S., Yadav, V. S., Turner, N. C. and Redden, R. 2006.Evaluation of Helicoverpa and drought resistance in desi and kabuli chickpea. *Plant Genet Res*.**4:**198–203.

Upadhyaya, H. D., Dronavalli, N., Gowda, C. L. and Singh, S. 2011. Identification and evaluation of chickpea germplasm for tolerance to heat stress. *Crop Sci*.**51:** 2079-2094.

Varshney, R. J., Thudi, M., Nayak, S. N., Gaur, P. M., Kashiwagi, J., Karishnamurhy, L., Jaganathan, D., Koppolu, K., Bohra, A., Tripathi, S., Rathore, A., Jukanti, A. K., Jayalakshmi, V., Vimula, A., Singh, S. J., Yasin, M., Sheshshayee, M. S. and Viswanatha, K. P. 2006. Genetic dissection of drought tolerance in chickpea (*Cicer arietinum* L.). *Theo Appl Genet*.127:445–62.

Wang, J. Y., Xiong, Y. C, Li, F. M., Siddique, K. H. and Turner, N. C. 2017. Effects of drought stress on morpho-physiological traits, biochemical characteristics, yield, and yield components in different ploidy wheat: A meta-analysis. *Adv Agron*.**143:**139-173.

Yucel, O. D., Anlarsal, A. E. and Yucel, C. 2006. Genetic variability, correlation and PathAnalysis of yield and yield components in chickpea (*Cicer arietinum* L.). *Turk J Agric Forestry* (Turkey).**30(3):**183-188