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Estimates of Genetic Variability in Selected Advanced Breeding Lines of Groundnut for Morphological, Yield and Its Contributing Traits under Imposed End-of-Season Drought Stress

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Authors' contributions

This work was carried out in collaboration among all authors. Authors GC and BNHB designed the study and wrote the protocol. Author GC performed statistical analysis and wrote the first draft of manuscript. Author HN managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To study genetic variability for morphological, yield and its contributing traits in forty groundnut genotypes.
Study Design: Randomized complete block design with two replications.
Place and Duration of Study: College of Horticulture, Hiriyur, University of Agricultural and Horticultural Sciences, Navile, Shivamogga, Karnataka, India during Rabi 2016-17.
Methodology: Forty genotypes of groundnut were evaluated under irrigated and imposed end-season drought conditions. Crop was taken care as per recommended package of practices. Stress was imposed by withholding irrigation at pod development stage (@90DAS) for 20 days in drought block. However, control block was provided with regular irrigations. Observations on different morphological, yield and its related traits were recorded on randomly sampled five plants

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per genotype per replication in both stress-full and stress-free environments. The mean data was subjected to statistical analysis using Genstat 14.1 software.
Results: The analysis of variance revealed that highly significant differences observed for all the traits even at p <0.01 level indicating the sufficient variability exist among the entries for the traits under study. High genotypic and phenotypic co-efficient of variation, high heritability coupled with high genetic advance over mean was observed for number pods per plant, immature pods per plant, pod yield per plant and hectare, harvest index, kernel yield per plant, fresh weight of seedlings and kernels per plant under moisture deficit condition.
Conclusion: It's a clear evidence for lesser influence of environment and predominance additive gene action in germplasm for these traits which offers opportunity for selection, unvaryingly direct selection for these traits could be effective for developing high yielding drought tolerant genotypes.

Keywords: Groundnut; allotetraploid; drought; heritability.

1. INTRODUCTION

Groundnut is an allotetraploid (2n=4x=40), highly self-pollinated, monoecious annual leguminous oilseed crop with narrow genetic base and originated in Southern Bolivia and Northern Argentina, mainly grown for edible oil, food and animal feed in temperate and tropical regions of the world. Its kernel is a rich source of edible oil (40-55%) and protein (22-28%) [1-4]. Groundnut is cultivated mainly under rainfed condition worldwide where drought is a major abiotic constraint affecting productivity and quality of groundnut. Therefore, breeding for drought resistance is an important strategy in alleviating the problem and offers the best long-term solution [5-7]. Selection in segregating population has been a standard approach for developing cultivars with improved stress tolerance. Hence, if the selection for drought tolerance is trait based, the success in developing tolerance genotype will be high and more assured. The knowledge of the extent and nature of genetic variability present in genetic resources for the desired traits is of paramount importance to the breeder for successful planning of a breeding programme because of its wider scope for selection [8,5]. With this background, the present study was conducted to estimate the genetic parameters for yield and its contributing characters in groundnut genotypes under both well irrigated and managed terminal drought conditions.

2. METHODOLOGY

2.1 Plant Material

Forty groundnut genotypes including advanced breeding lines and local cultivars were obtained from International Crop Research Institute for Semi-Arid Tropics (ICRISAT), Patancheru, Hyderabad, National Bureau of Plant Genetic Resources (NBPGR), New Delhi and other institutes were included as genetic experimental materials in this study. The details of the genotypes are presented in the Table 1.

2.2 Research Location

The present investigation was carried at College of Horticulture, Hiriyur, (University of Agricultural and Horticultural sciences, Shivamogga) located in the Central Dry Zone (Zone-IV) of Karnataka at 13º57' North latitude, 76º40' East longitudes with an altitude of 630 meters above the mean sea level during Rabi 2016-17.

2.3 Experimental Design, Crop Cultivation and Its Management and Field Evaluation

The experiment was laid out in two sets of Randomized Complete Block Design (RCBD) in two replications. The experimental plot size per genotype was 0.6 m length X 3 m width which constitutes 1.87 m^2. On the other hand, plot to plot and replication to replication distance was 0.2 and 0.5 m respectively. Each entry was represented by two rows of 3 meter length following a spacing of 30 cm X 10 cm at a depth of 4cm approximately. Sound, mature and good quality kernels treated with Trichoderma and Chlorophyrifos were only used for sowing. Test materials were hand-sown on 1st October 2016 in field. Care was taken on the crop as per the recommended package of practices.

Accessions were evaluated in two experiments using two sets of RCBD with two replications under optimum moisture (non-stress) (irrigated experiment) and imposed end-season drought (moisture stress) (drought experiment) conditions. Two sets of the experiment were irrigated as per package of practices (once in 7-8 days) up to 90 days. Regular irrigation was provided for the non-moisture stressed plots (irrigated block). However, initially water was provided to the crop in the drought block of the experiment for better germination and establishment and thereafter irrigation was withholded at 90 days after sowing (@pod development stage) for 20 days to induce moisture stress to mitigate terminal drought.

2.4 Observations

Five plants from each genotype were sampled at 30 days after sowing for recording observations. Yield and its contributing parameters *viz.,* days to fifty per cent flowering, plant height at 30, 60 and 90 days after sowing and at harvest (cm), primary and secondary branches per plant at 60, 90 DAS and harvest, days to maturity [9], pods per plant, mature and immature pods per plant, pod yield per plant (g), pod yield per hectare (kg/ha), shelling percentage (%), kernel yield per plant (g) [10], kernels per plant, test weight (hundred kernel weight) (g), sound mature kernel percentage (%), harvest index [7], fresh weight of seedling (g) and total seedling length (cm) were recorded on five randomly tagged plants per entry per replication under both stress and stress free field conditions.

2.5 Statistical Analysis

The resulted mean data was subjected to statistical analysis using GENSTAT 14.1 software package at ICRISAT, Patancheru, Hyderabad. Analysis of variances for all the traits under study was performed in each of the experiments. To determine the most desirable drought tolerance criteria, genetic variability within the indices were estimated using GenStat. The formulae utilized to estimate the genetic

Table 1. List of genotypes employed in the present experimental study

Sl. no.	Genotype	Source of collection	Features (Branching type)
1	ICGV 15114, ICGV 15119, ICGV 15120, ICGV 15122, ICGV 15123 ICGV 15124, ICGV 15138, ICGV 15141, ICGV 15143, ICGV 15145, ICGV 15146, ICGV 15148, ICGV 15149, ICGV 15151, ICGV 15152, ICGV 15153, ICGV 15154, ICGV 15158, ICGV 15159, ICGV 15161	ICRISAT, Patancheru	Erect type
2	SB-1, SB-14, SB-15, SB-17, VB, VB-11, VB-14	NBPGR, New Delhi	Erect type
3	DH-86, DH-101, DH-234, GPBD-4, GPBD-5, TMV-2, G2-52	UAS, Dharwad	Erect type
4	K-9, K-6, KCG-6, KCG-2	UAS, Bangalore	Erect type
5	LOCAL-1	Local	Erect type
6	R-2001-3	UAS, Raichur	Erect type

ICRISAT – International Crops Research Institute for Semi-Arid Tropics; NBPGR – National Bureau of Plant Genetic Resources; UAS - University of Agricultural Sciences

Table 2. Genetic variability estimates

Sl. no	Name of the indices	Equation	Reference
1	Genotypic variance (σg^2)	$(\sigma g^2) = \frac{\text{MSS (treatment)} - \text{MSS (error)}}{\text{Number of replications}}$	[11]
2	Phenotypic variance (σp^2)	$(\sigma p^2) = \sigma g^2 + \text{MSS (error)}$	[11]
3	Environment variance (σe^2)	$(\sigma e^2) = \text{MSS (error)}$	[11]
4	Genotypic Coefficient of Variation (GCV) (%)	$(\text{GCV}) = \left(\frac{\sigma g}{\bar{X}}\right) \times 100$	[12]
5	Phenotypic Coefficient of Variation (PCV) (%)	$(\text{PCV}) = \left(\frac{\sigma p}{\bar{X}}\right) \times 100$	[12]
6	Heritability (h^2_{bs}) (%)	$(h^2_{bs}) = (\sigma g^2 / \sigma p^2) \times 100$	[13]
7	Genetic advance (GA)	$GA = h^2bs \times K \times \sigma P$	[14]
8	Genetic Advance as per cent Mean (GAM) (%)	$GAM (\%) = (GA/\bar{X} \times 100)$	

Where, h^2bs = Heritability in broad sense; K = Selection differential, a constant (z/p) the value of which is 2.06 at 5% selection intensities; σP = Phenotypic standard deviation; $\bar{X}$ = Grand mean of the character; σp = Phenotypic standard deviation; σ^2g = Genotypic variance; σ^2p = Phenotypic variance

Table 3. Categorization of genetic estimates

Estimates	Categories			References
	Low	Moderate	High	
GCV & PCV (%)	0-10	10.1-20	20.1 and Above	[4]
Heritability (h^2) (%)	0-30	30.1-60	60.1 and Above	[8]
GAM (%)	0-10	10.1-20	20.1 and above	[14]

estimates *Viz*., phenotypic, genotypic and environment variances, phenotypic and genotypic coefficient variation (PCV & GCV), heritability (h^2), genetic advance (GA) and genetic advance as percent mean (GAM @ 5%) cited in Table 2 and also their categorization is presented in Table 3.

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance

In present investigation, forty groundnut genotypes were studied to assess their performance for yield and yield related traits, under imposed moisture stress. Analysis of variance under both well-watered and water stress conditions (Tables 4 and 5, respectively) clearly indicated that genotypes differ significantly at both probability level (p=0.5, p=0.1) for all the traits under investigation inferring germplasm could be utilized in further breeding program.

3.2 Genetic Variability Parameters

The heritable portion of the overall (The extent of variability present in forty groundnut genotypes) observed variation can be ascertained by studying the components of variation such as GCV, PCV, heritability and genetic advance as per cent of mean for all traits under drought and irrigated conditions (Table 6).

3.2.1 Mean

Maximum and minimum mean values under both irrigated and terminal drought stress were observed for pod yield per hectare (1540.49, 1321.03 kg/ha) and harvest index (0.42, 0.22), respectively. The mean of different quantitative traits including pod yield as performed by the available genotypes suggested that selection of desirable genotypes based on the traits from materials evaluated, can be effective.

3.2.2 Range

The widest and narrow ranges were recorded for pod yield per hectare (690.91-1919.89; 516.51-2919.58 Kg/ha) and harvest index (0.11-0.31; 0.17-0.72) under both the environments, respectively. These findings (widest range) indicated the presence of sufficient variability among the genetic stock under study which would help in selecting the best genotypes from existing collection. However, narrow range value indicating minimum variation and less scope for selection from the present collection.

3.2.3 Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV)

The GCV and PCV was ranged between immature pods per plant (43.39, 47.28%) and days to maturity (2.39, 2.59%), under water stress condition, However, pod yield per plant (47.56, 61.17%) & days to maturity (2.14, 2.42%) exhibited minimum and maximum GCV & PCV under well-watered condition respectively. Environment play an important role in expression of various characters as the PCV was found to be higher than the corresponding GCV for all the characters. The difference between the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was found to be narrow for days to maturity followed by days to fifty percent flowering, secondary branches per plant @90DAS and harvest, respectively implying least influence of environment and preponderances of additive gene effects indicating present genetic collection can be improved and selected for these traits under stress condition for improvement of terminal drought tolerance. However, the traits like pods per plant, mature pods per plant, total seedling length and pod yield per plant exhibited highest difference between GCV&PCV implied that the variation for these traits is not only by genotypes but also due to environment. Selection based on phenotype may not be rewarding as their expression depends more on environmental factors. For rest of the characters, it was found to be moderate.

In the present investigation, immature pods per plant (44.06 & 61.12%; 43.39 & 47.28%), pod yield per hectare (47.56 & 61.17%; 23.46 &

26.41%), pod yield per plant (44.95 & 49.48%; 23.90 & 27.83%) and kernels per plant (43.74 & 49.19%; 24.54 & 27.64%) depicted very high GCV and PCV in both conditions, indicating the importance of these traits in evaluation and selection of superior genotypes in the respective environments. Similar results were reported by [15,5,16,3,1,17,18].

The phenotypic and genotypic coefficient of variance was found to be moderate for plant height at 30, 60 DAS & harvest (14.80 & 15.71%; 12.09 & 12.91%; 10.54 & 12.54%), primary branches at 60, 90 DAS & harvest (12.75 & 15.82%; 11.62 & 13.07%; 11.50 & 12.83%), secondary branches at harvest (14.32 & 14.82%) and shelling percentage (13.72 & 17.50%) under moisture deficit and, for plant height at 60 DAS & harvest (13.82 & 14.93%; 11.90 & 13.00%) and shelling percent (14.64 & 17.03%) under irrigated conditions. These findings of stress condition were clearly indicated that selecting genotypes through these traits will be effective for drought tolerance. The high magnitude of GCV further revealed that greater extent of variability presence in the characters, thereby suggesting good scope for improvement through selection of this crop. Similar results were reported by [1,2,3,15,18].

However, low GCV & PCV values were noticed for plant height at 90DAS (6.71, 7.95%), days to maturity (2.39, 2.59%), total seedling length (5.38, 9.93%) and sound mature kernels (6.42, 7.43%) under stress and days to fifty percent flowering (9.07, 9.50%), days to maturity (2.14, 2.42%) and total seedling length (8.38, 9.70%) under normal conditions indicated the presence of low variability among the tested genotypes. Early maturity is an important vehicle for drought escape, especially to the late-season drought (Janila, et al. 2013). Low GCV and moderate PCV was observed for test weight (9.93, 11.43%; 7.61, 10.38%) under both conditions and plant height @ 30DAS under irrigated condition only. The results are on par with the results of [19,20,18].

Plant height at 30, 60 and 90 days after sowing, primary and secondary branches at 60 and 90 days after sowing and days to fifty per cent flowering under moisture stress showed a minor decrease over normal condition. Since moisture stress was not imposed before or around these stages, this variation was probably due to environmental factors. These traits showed variable genotypic and phenotypic coefficients of variation besides having variable heritability with high genetic advance over mean.

The estimation of genetic coefficient of variation indicates the amount of genetic variation present for different desirable traits while the heritability gives an insight into the proportion of variation which is inherent.

3.2.4 Heritability (h^2)

The heritability values were distributed between secondary branches per plant at 90DAS (96.38%) and total seedling length (29.35%) in stress condition and, between primary branches at harvest (96.78%) and sound mature kernels (29.25%) under stress-free condition.

In this study, heritability in broad sense was found to be high for all the characters under both environments (except for all traits except SMK (29.25%), test weight (53.77%), pods per plant (52.41%), mature and immature pods per plant (42.87, 51.96%) under stress free condition) suggesting the important role of genetic constitution in the expression of the character and such traits are considered to be dependent from breeding point of view. From the above heritability estimates, it is clear that all the traits under study in stressful environment are less influenced by the environmental factors and are controlled by additive gene effect and selection will be effective for these characters.

3.2.5 Genetic advance over the mean (GAM)

The range of GAM was varied between immature pods per plant (82.02%) and days to maturity (4.55%) under moisture deficit situation. However, it observed between kernels per plant (80.13%) and days to maturity (3.91%) in stress-free condition.

The heritability estimate gives an idea about the proportion of observed variability, which is attributed to genetic difference. Heritability in broad sense may play greater role about information of relative value of selection, but Johnson, et al. (1955) had shown that heritability and genetic advance should be jointly considered for reliable conclusion. In crop improvement programme, selection is practiced directly or indirectly. Selection parameters include the study of heritability and genetic advance (direct selection parameters) and correlation between yield and component traits and path coefficient analysis (indirect selection parameters).

Table 4. Analysis of variance for yield and its component characters under normal moisture condition

Traits	Source of variance						
	Replications (df=1)	Genotypes (df=39)	Error (df=39)	S.Em	C.V. (%)	C.D. 5%	C.D. 1%
Plant height at 30 DAS (cm)	0.82	1.43**	0.7	0.59	7.99	1.69	2.26
Plant height at 60 DAS (cm)	0.04	6.76**	1.93	0.98	7.98	2.81	3.77
Plant height at 90 DAS (cm)	0.06	4.44**	1.91	0.98	6.46	2.79	3.74
Plant height at harvest (cm)	0.42	9.82**	3.21	1.27	7.43	3.62	4.85
Primary branches at 60 DAS	5.36	3.04**	0.37	0.43	11.69	1.24	1.66
Primary branches at 90 DAS	2.43	3.43**	0.24	0.35	7.15	0.99	1.33
Primary branches at harvest	26.66	4.63**	0.3	0.39	7.64	1.11	1.48
Secondary branches at 60 DAS	0.17	0.34**	0.03	0.12	15.63	0.34	0.46
Secondary branches at 90 DAS	0	2.51**	0.04	0.15	6.62	0.43	0.57
Secondary branches at harvest	1.68	3.73**	0.25	0.36	9.93	1.02	1.36
Days to 50% flowering	0.11	20.34**	0.93	0.68	2.81	1.95	2.62
Days to maturity	46.51	13.93**	1.69	0.92	1.13	2.63	3.52
Total seedling length (cm)	47.8	12.65**	5.63	1.68	6.52	4.8	6.42
Fresh weight of seedling (g)	403.2	1083.31**	359.86	13.41	24.56	38.37	51.37
Harvest Index	0.01	0.06**	0.01	0.05	17.62	0.15	0.2
Shelling percentage (%)	192.2	101.48**	30.46	3.9	8.7	11.16	14.94
Percentage of sound mature kernels (%)	71.55	52.66**	28.82	3.8	6.37	10.86	14.54
Test weight (g)	140.45	31.60**	9.5	2.18	7.06	6.23	8.35
Pods per plant	1.68	129.33**	40.39	4.49	12.48	12.85	17.21
Mature pods per plant	6.61	95.04**	38.01	4.36	16.3	12.47	16.69
Immature pods per plant	0.04	4.39**	1.39	0.83	12.36	2.38	3.19
Pod yield per plant (g)	15.84	65.18**	22.8	3.38	9.11	9.66	12.93
Pod yield per hectare (kg)	1726739.59	2595801.79**	181619.48	301.35	18.81	862.01	1154.03
Kernels per plant	48.67	137.05**	57.35	5.35	8.21	15.32	11.51
Kernel yield per plant (g)	0.54	21.46**	11.13	2.36	11.84	6.75	9.03

Table 5. Analysis of variance for various yield and its component characters under moisture stress condition

Traits	Source of variance						
	Replications (df=1)	**Genotypes (df=39)**	**Error (df=39)**	**S.Em**	**C.V. (%)**	**C.D. 5%**	**C.D. 1%**
Plant height at 30 DAS (cm)	0.86	2.38**	0.54	0.52	7.47	1.48	1.99
Plant height at 60 DAS (cm)	7.97	4.60**	1.13	0.75	6.41	2.15	2.88
Plant height at 90 DAS (cm)	172.2	3.02**	1.73	0.93	6.02	2.66	3.56
Plant height at harvest (cm)	0.04	8.40**	4.92	1.57	9.59	4.48	6
Primary branches at 60 DAS	0.57	1.12**	0.24	0.34	9.35	0.98	1.32
Primary branches at 90 DAS	2.46	1.23**	0.14	0.27	5.98	0.77	1.03
Primary branches at harvest	0.05	0.09**	0.03	0.13	16.91	0.37	0.5
Secondary branches at 60 DAS	0.05	0.09**	0.03	0.13	16.91	0.37	0.5
Secondary branches at 90 DAS	0.02	1.23**	0.05	0.16	6.81	0.44	0.59
Secondary branches at harvest	0.0003	1.16**	0.04	0.14	3.83	0.4	0.54
Number of days to 50% flowering	22.05	28.77**	0.95	0.69	2.75	1.97	2.64
Number of days to maturity	74.11	16.03**	1.27	0.8	0.99	2.28	3.05
Total seedling length (cm)	172.73	14.09**	7.7	1.96	8.35	5.61	7.51
Fresh weight of seedling (g)	1049.37	358.90**	16.4	2.86	6.47	8.19	10.96
Harvest Index	0.0002	0.0052**	0.0005	0.02	10.05	0.04	0.06
Shelling percentage (%)	37.26	165.20**	39.47	4.44	10.87	12.71	17.01
Percentage of sound mature kernels (%)	96.29	37.57**	19.21	3.1	5.28	8.87	11.87
Test weight (g)	15.31	37.86**	9.24	2.15	7.22	6.15	8.23
Number of pods per plant	26.35	25.21**	5.74	1.69	16.41	4.84	6.49
Number of mature pods per plant	27.81	13.87**	3.13	1.25	12.45	3.58	4.79
Number of immature pods per plant	0.01	1.77**	0.15	0.28	18.78	0.79	1.05
Pod yield per plant (g)	4.02	17.72**	2.68	1.16	14.27	3.31	4.43
Pod yield per hectare (kg)	6.66	1661.42**	126.69	7.96	14.44	22.77	30.48
Number of kernels per plant	7.68	51.92**	6.16	1.75	12.73	5.02	6.72
Kernel yield per plant (g)	0.16	22.35**	2.03	1.01	15.59	2.88	3.86

*Where, * - Significant at 5% ** - Significant at 1%*

Table 6. Estimates of Genetic parameters for yield and yield attributes under stress (S) and non-stress (N) condition

Characters	Conditions	Mean	Range	GCV (%)	PCV (%)	h^2 (%)	GAM (%)
Plant height at 30 DAS (cm)	N	10.45	9.32-13.23	9.93	11.43	75.55	17.79
	S	9.82	8.38-12.08	14.8	15.71	88.69	28.71
Plant height at 60 DAS (cm)	N	17.42	14.35-22.13	13.82	14.93	85.7	26.36
	S	16.62	14.44-21.25	12.09	12.91	87.69	23.32
Plant height at 90 DAS (cm)	N	21.37	18.80-24.87	8.73	9.86	78.52	15.94
	S	21.88	19.46-23.88	6.71	7.95	71.35	11.68
Plant height at harvest (cm)	N	24.1	21.55-29.49	11.90	13.00	83.68	22.42
	S	23.11	19.15-28.53	10.54	12.54	70.72	18.26
Primary branches at 60 DAS	N	5.23	4.40-11.75	32.32	33.36	93.86	64.49
	S	5.2	4.00-8.25	12.75	15.82	65.04	21.19
Primary branches at 90 DAS	N	6.87	5.70-13.95	26.47	26.95	96.48	53.57
	S	6.33	5.20-9.53	11.62	13.07	79.05	21.28
Primary branches at harvest	N	7.16	6.10-15.31	29.59	30.08	96.78	59.96
	S	7.32	6.20-11.62	11.5	12.83	80.27	21.22
Secondary branches at 60 DAS	N	1.09	0.80-3.55	35.86	39.12	84.04	67.72
	S	1.09	0.80-2.15	22.56	25.53	78.06	41.05
Secondary branches at 90 DAS	N	3.19	2.70-10.05	34.76	35.38	96.5	70.34
	S	3.22	2.80-8.00	24.82	25.28	96.38	50.19
Secondary branches at harvest	N	5.07	3.80-13.20	25.99	27.82	87.27	50.02
	S	5.22	4.80-9.84	14.32	14.82	93.32	28.5
Number of days to 50% flowering	N	34.34	29.50-42.50	9.07	9.5	91.23	17.85
	S	35.4	29.50-43.50	10.54	10.89	93.62	21
Number of days to maturity	N	115.46	111.00-120.00	2.14	2.42	78.34	3.91
	S	113.64	108.50-119.50	2.39	2.59	85.35	4.55
Total seedling length (cm)	N	36.42	31.80-41.91	8.38	9.70	74.5	14.89
	S	33.24	27.84-40.67	5.38	9.93	29.35	6
Fresh weight of seedling (g)	N	77.23	31.60-116.20	38.92	42.62	83.39	73.22
	S	62.61	27.50-88.93	20.9	21.88	91.26	41.13
Harvest index	N	0.42	0.17-0.72	37.96	41.85	82.27	70.92
	S	0.22	0.11-0.31	22.19	24.36	82.98	41.63
Shelling percentage (%)	N	63.43	48.50-79.00	14.64	17.03	73.9	25.93
	S	57.79	43.00-76.00	13.72	17.5	61.43	22.15

Characters	Conditions	Mean	Range	GCV (%)	PCV (%)	h^2 (%)	GAM (%)
Sound mature kernels (%)	N	84.27	72.17-92.02	4.10	7.57	29.25	4.56
	S	82.97	70.01-92.39	6.42	7.43	74.72	11.44
Test weight (g)	N	43.68	37.00-57.00	7.61	10.38	53.77	11.5
	S	42.11	35.00-57.00	8.98	11.52	60.78	14.43
Number of pods per plant	N	19.57	8.00-35.50	34.08	47.08	52.41	50.83
	S	14.59	7.65-21.84	21.38	26.96	62.92	34.94
Number of mature pods per plant	N	16.98	6.80-31.20	31.45	48.03	42.87	42.41
	S	14.2	9.11-23.35	16.32	20.53	63.19	26.72
Number of immature pods per plant	N	2.78	0.40-6.20	44.06	61.12	51.96	65.42
	S	2.07	0.70-4.50	43.39	47.28	84.22	82.02
Pod yield per plant (g)	N	16.32	6.40-26.60	44.95	49.48	82.51	84.11
	S	11.48	5.40-19.38	23.9	27.83	73.72	42.27
Pod yield per hectare (kg)	N	1540.49	516.51-2919.58	47.56	61.17	60.46	76.18
	S	1321.03	690.91-1919.89	23.46	26.41	78.91	42.93
Number of kernels per plant	N	23.8	10.50-42.50	43.74	49.19	79.08	80.13
	S	19.5	10.50-34.00	24.54	27.64	78.79	44.86
Kernel yield per plant (g)	N	10.48	4.20-15.80	38.06	44.22	74.07	67.47
	S	9.13	5.00-19.00	34.9	38.23	83.36	65.65

3.2.6 Heritability (h^2) and Genetic Advance over the Mean (GAM)

Out of 25 characters studied, in the present study, High heritability estimates were accompanied by lower genetic advance over the mean for days to maturity (85.35, 4.55%). This suggests that selection may not be useful for the improvement of this trait because of the narrow range of phenotypic variation among the genotypes in respect to this character. The results are on par with several authors [1,18,16].

High heritability coupled with moderate GAM was observed for plant height at 90DAS and harvest (71.35, 11.68; 70.72, 18.26%), sound mature kernels (74.72, 11.44%), test weight (60.78, 14.43) implied equal importance of additive and non-additive gene action. In other words, these traits indicated that their manifestation is governed by both additive and non-additive genetic effects and therefore, selection should be practiced in later segregating generations i.e. by hybridization programme to exploit hybridity. The results are on par with the results of several authors [1,19,20,18]. However, moderate heritability alongside with low GAM was noticed for total seedling length (29.35, 6.00%) indicating this trait is governed by non-additive gene action with little influence of environment in its inheritance. The traits controlled by non-additive gene action can be improved by hybrids and inter-mating among selected ones in early generation followed by selection [21]. Rest of the characters under stress full environment exhibited high heritability coupled with high GAM indicating the predominance of additive gene components in governing these traits. Thus, there is ample scope for improving these characters based on direct selection from the genetic stock studied which means if these characters are subjected to any selection scheme for exploiting fixable genetic variance; a widely adopted genotype can be developed. Similar results were reported by several authors [15,5,16,3,1,17,18,21].

4. CONCLUSION

It can be concluded from the results that since high GCV and PCV with High heritability coupled with high genetic advance as percentage of mean was observed for The number pods per plant, immature pods per plant, pod yield per plant and hectare, harvest index, kernel yield per plant, fresh weight of seedlings, and kernels per plant. These genetic parameters provide clear evidence for predominance of additive nature of genetic variation in the germplasm for these traits and based on which, selection would be effective in both moisture stress and normal conditions even in early generations to fix its performance.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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