Assessment of genetic variability, heritability, and genetic advance for morpho-physiological traits in Finger millet [*Eleusine coracana* (L.) Gaertn]

ABSTRACT

A field experiment was conducted during the Kharif season of 2022 with 39 genotypes to assess the genetic variability, heritability, and genetic advance for morpho-physiological traits in finger millet(*Eleusine coracana* (L.) Gaertn.).The analysis of variance revealed significant genetic variation for all the characters studiedamong the genotypes. Moderate to high values of PCV and GCV were recorded for the characters studied except for days to 50 percent flowering, days to maturity,the relative water content in leaves, and chlorophyll stability index. High heritability coupled with moderate to high genetic advance as percent mean was observed for all the traits except chlorophyll stability index and relative water content indicating that the presence of more additive gene effects for potential crop improvement and so these characters could be improved through selection. This research indicates that opting for a direct selection approach in finger millet landraces could result in a more significant increase in yield response.

Keywords: Finger millet, variability, heritability, genetic advance

1. INTRODUCTION

Finger millet *(Eleusine coracana* L. Gaertn.), also known as African millet or ragi, holds significant importance as a versatile member of the small millets group, particularly in the North Eastern region of India. Millets, including ragi, are predominantly cultivated in marginal areas where major cereal crops consistently fail to produce acceptable harvests. This crop adapts well to diverse environments and boasts extended storage capabilities [1]. It is highly nutritious andrich in minerals and constitutes an essential ingredient in the human diet [2]. Moreover, it is a source of antioxidants and anti-ageingcompounds. The crop thrives in high-temperature, arid areas with poor soil fertility due to its excellent carbon-concentrating mechanism within the C4 pathway [1]. In the face of climate change and depleting natural resources, finger millet emerges as a valuable nutritional resource for less developed nations. Recognizing the economic significance of millets, the Indian government declared 2023 as the "International Year of Millets," receiving support from 72 countries and the United Nations General Assembly (UNGA) [3].Ragi is grown in over twenty-five African and Asian nations, with India, Uganda, Nepal, and China being the top producers. India, holding the position of the world's largest producer, recorded 1.74 million tonnes produced on 0.99 million hectares with an average yield of 1761 kg per hectare in 2019-20 [4].

In Assam, finger millet cultivation is limited, with productivity trailing behind the national average. However, a survey by the Regional Agricultural Research Station (RARS) in Gossaigoan for 2019-20 indicates a gradual increase in production and productivity. Tribal and siaothali farmers in Assam primarily cultivate finger millet for local wine production, pithas (chapatti), and laddu. Even in the Muslim community in Assam's "char" areas, there's a growing emphasis on millet cultivation for both domestic consumption and commercial purposes, often replacing rice. In certain hilly areas of Assam, the crop is integrated into Jhum systems. Cultivation occurs during the kharifseason, locally known as “Marubadhan,” with one-month-old seedlings transplanted in the first week of September and harvested in November.

The available genetic variability in finger millet necessitates the characterization of these resources for genetic improvement [5]. A diverse Germplasm collection is crucial for both breeding and genomic research in any crop species. Beyond genetic variability, knowledge of heritability and genetic advance measures the extent to which a trait is passed on to offspring, aiding breeders in implementing suitable breeding strategies to achieve specific objectives. Hence, the present investigation was aimed to assess the genetic variability, heritability and genetic advance with regard to morpho-physiological traits in a set of 39 diverse finger millet genotypes.

2. METHODOLOGY

The investigation was conducted at the experimental field and laboratory of Plant Breeding and Genetics, Biswanath College of Agriculture, AAU, Biswanath Chariali, during the Kharif season of 2022. The materials for this investigation comprised of39 diverse finger millet genotypes, mainly collected from Regional Agricultural Research Station (RARS), AAU, Gossaigaon. These 39 finger millet genotypes were sown in a

Completely Randomized Block Design (CRBD) with 3 replications. Each plot consisted of 3 rows, each 3.0 m in length, with a spacing of 10 cm between plants and 25 cm between rows. Seedlings were transplanted 30 days after sowing in the seedbed. Recommended cultural practices were followed for weeding, irrigation, and fertilization, and plant protection measures were implemented when necessary. Observations were taken on 13 metric traits *viz*. days to 50 % flowering, days to maturity, plant height (cm), basal tillers per plant, panicle length (cm), ear per plant, 1000 grain weight (g), biological yield per plant (g), harvest index (%), grain yield per plant (g), total chlorophyll content (mg per g fw), chlorophyll stability index (%) and relative water content (%) of leaves.Observations about these 13 quantitative traits were recorded based on five randomly selected plants in each replication for all the characters except days to 50 % flowering and days to maturity which were recorded on a plot basis.The data were subjected to analysis of the variability parameters, heritability and genetic advance and were calculated with the help of standard statistical procedures given by Panse and Sukhatme (1957)[6].

3. RESULTS AND DISCUSSION

In the present investigation, significant genetic variation was observed for all the characters studied as revealed by the analysis of variance. The comparison of the mean performance (Table 1) of the different genotypes with respect to grain yield per plant revealed that the genotypes VL 408, VL 391, CFMV 1 (i), and CFMV 2 (i) exhibited high mean values. These four genotypes also recorded high mean values for a few other important yield-attributing morpho-physiological traits. VL 391 recorded the highest mean value for grain yield per plant and also exhibited high mean values for harvest index, 1000grain weight, and physiological traits like total chlorophyll content and chlorophyll stability index. Interestingly, the genotype CFMV 1 (i) which gave high grain yield matured early (about 98 days). It also recorded the highest mean value for basal tiller per plant and harvest index. The genotype VL 408 recorded the highest mean values for total 1000grain weight, biological yield per plant, and relative water content with high grain yield per plant. The genotype CFMV 2 (i) also accounted the high mean value for 1000grain weight, harvest index, and grain yield per plant. The low-yielding genotypes in general, were low performers for most of the yield-attributing traits under study. The four genotypes VL 408, VL 391, CFMV 1 (i), and CFMV 2 (i) could be considered potential genotypes for incorporation in finger millet breeding programmes.

Table :1.Variation in morpho-physiological traits in finger millet genotypes

Sl. No.	Genotypes	DF	DM	PH	BT	PL	EP	1000 GW	BYP	HI	TC	CSI	RWC	GY/P
1	BR 14-28	73.67	107.67	112.00	4.77	5.75	4.50	2.73	23.79	35.76	2.34	60.23	83.90	8.53
2	CFMV 2 (i)	73.67	108.67	116.60	3.97	9.84	8.17	3.45	30.01	37.07	2.29	58.77	81.65	11.11
3	KMR 711	85.33	119.33	124.73	3.40	8.24	8.57	2.36	27.62	24.75	2.14	60.32	81.87	6.88
4	IIMR FM-7066	71.00	103.67	99.33	2.83	5.06	5.00	3.04	25.45	38.64	2.13	61.05	75.81	9.83
5	VR 1149	75.33	107.33	97.00	3.30	6.36	6.13	2.76	23.33	35.46	2.26	61.02	82.16	8.29
6	TNEc 1335	64.00	96.00	81.37	2.10	4.87	2.77	2.90	16.79	25.14	1.92	54.23	73.89	4.22
7	WN 572	76.67	119.33	120.63	3.40	7.41	7.23	2.55	25.16	29.66	1.95	58.89	78.00	7.40
8	GPU 67 (i)	76.00	105.33	118.17	3.60	7.68	5.47	2.24	24.84	23.71	1.87	58.86	81.33	5.89
9	DPLM 2	74.00	105.67	106.80	4.53	11.03	7.30	2.09	31.41	19.78	2.23	62.66	80.40	6.22
10	VL 410	78.00	112.00	107.83	3.50	9.05	6.20	2.21	25.79	20.87	2.17	58.65	77.22	5.41
11	KOPN 1056	75.00	109.33	126.50	3.80	10.91	8.83	2.37	32.78	21.38	1.99	58.18	80.91	7.03
12	DHFM-13-6	73.33	102.00	111.50	4.60	7.78	5.30	2.53	24.78	29.66	2.18	63.73	76.46	7.27

13	KMR 710	73.33	112.33	128.73	4.10	8.60	6.90	2.24	25.30	20.80	2.70	60.61	80.83	5.27
14	PR 202 (i)	78.67	117.33	148.33	4.07	6.13	6.40	2.34	22.12	26.31	1.96	58.17	82.49	5.80
15	WN 566	73.33	116.33	135.17	4.87	10.10	7.80	2.76	28.53	30.49	3.00	65.55	77.65	8.66
16	BR 9	70.33	97.00	107.93	4.93	9.81	5.40	2.31	21.75	27.21	2.54	57.57	85.03	5.77
17	DHFM-78-33	78.33	120.33	128.33	4.73	5.43	4.47	2.65	22.09	35.22	2.06	57.74	70.72	7.72
18	IIMR FM-7202	73.67	103.67	123.00	3.60	8.01	5.47	2.72	25.92	33.24	1.93	59.32	80.44	8.55
19	DPLM 3	75.33	107.00	119.67	4.03	10.98	8.07	2.24	33.81	19.06	1.86	57.18	79.08	6.44
20	IIMR FM-7835	80.00	120.67	134.00	3.73	8.96	6.47	2.64	32.31	24.90	2.49	62.09	81.65	8.01
21	KOPN 1055	78.67	119.33	135.40	3.47	8.80	9.33	2.67	31.55	26.05	2.88	66.08	83.69	8.14
22	CFMV 1 (i)	72.00	98.33	122.67	5.47	6.43	4.30	3.30	28.42	36.70	2.34	60.99	81.76	10.38
23	IIMR FM-7028	73.00	104.00	123.00	4.10	13.36	11.33	2.26	32.07	19.55	2.10	59.27	76.42	6.22
24	VR 1152	74.00	106.67	125.33	4.43	8.83	8.00	2.45	27.52	23.87	1.86	62.72	84.26	6.52
25	TNEc 1338	82	114	128.17	3.90	12.13	7.6	2.78	30.50	28.22	2.13	59.66	83.14	8.63
26	VL 391	73.00	103.67	101.40	3.43	6.86	7.07	3.42	26.85	41.77	2.46	62.81	79.53	11.24
27	VL 376 (i)	69.33	99.00	80.00	3.87	5.04	3.93	2.72	20.78	36.80	2.26	63.79	77.41	7.61
28	CFMV 1	84.00	119.33	130.00	3.30	10.36	5.67	2.25	25.73	24.29	1.87	57.71	83.94	6.17
29	VL-376	74.33	108.00	120.00	3.50	8.33	6.27	2.46	23.18	23.60	2.26	62.95	76.94	5.43
30	PR 1731	74.00	105.00	111.00	5.20	8.88	4.80	1.90	21.32	19.18	2.14	57.46	78.93	4.09
31	DPLN 2	72.67	101.67	103.17	3.37	6.13	4.47	2.46	22.18	30.72	2.17	58.07	79.05	6.83
32	OEB 610	82.67	118.00	115.00	3.37	9.29	6.33	2.64	34.43	23.52	2.26	60.17	80.58	8.11
33	PR 1506	78.33	114.33	126.00	3.77	7.31	5.20	2.64	31.09	26.59	2.02	57.07	78.99	8.24
34	CFMV 2	72.33	100.33	113.67	3.47	9.35	6.93	2.50	28.73	24.29	2.31	56.50	77.85	6.94
35	VL 408	75.33	103.00	119.00	4.10	6.98	7.93	2.48	27.60	24.73	2.32	60.89	82.24	6.83
36	GPU 67	73.67	104.00	140.33	3.63	9.48	9.20	2.43	31.00	26.84	2.38	60.28	78.59	8.29
37	VL 408	71.67	100.33	141.07	3.17	6.32	6.67	3.49	26.82	39.46	1.80	60.60	86.46	10.58
38	PR 202	78.33	120.33	146.33	4.87	7.98	7.07	3.09	26.54	37.68	2.36	61.69	82.45	9.89
39	GossaigaonMaruadhan 1	81.33	123.00	135.67	3.53	8.53	7.07	3.00	28.01	25.74	1.90	60.27	80.31	8.17
Mean		75.38	109.06	119.61	3.89	8.27	6.55	2.62	26.87	28.17	2.20	60.10	80.10	7.50
C.V		2.32	1.95	4.97	11.57	9.35	11.05	7.88	8.83	14.15	7.60	3.30	3.39	12.68
S.E		1.01	1.23	3.43	0.26	0.45	0.42	0.12	1.37	2.30	0.10	1.14	1.57	0.55
C.V 5%		2.84	3.46	9.67	0.73	1.26	1.18	0.34	3.86	6.48	0.27	3.22	4.42	1.55

**Chlorophyll stability index (%)(CSI), Total chlorophyll content (TC), Ear per plant (EP), Grain yield per plant (GY/P), Relative water content in leaves (%)(RWC), Panicle length (PL), Number of basal tillers per plant (BT), plant height (PH), Biological yield per plant (BY/P), Days to 50% flowering (DF), Days to maturity (DM), 1000 grains weight (1000GW), and harvest index (HI). Coefficient of Variance (CV), Standard Error(SE).*

The estimates of the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), heritability in a broad sense, and genetic advance as per cent of mean (GAM) were computed for the 13 traits. These results are presented in Table 2,Fig 1, and Fig. 2. The variance components revealed that the phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV), with a narrow difference observed for all traits. This implies that a significant portion of the variability in these traits is attributed to genetic factors, as the influence of the environment is minimal.In the present study, high, moderate as well as low GCV and PCV were exhibited by the characters. High magnitude of PCV and GCV were recorded for ear per plant, panicle length, grain yield per plant, and harvest index. These results indicated that a sufficient amount of variation existed for these characters and offered greater scope for selection for improvement programmes. These results are in accordance with the findings of Saundaryakumari and Singh [7] for harvest index, and grain yield per plant; Suryanarayana *et al*.[8] for grain yield per plant and panicle length; Karad and Patil [9] for ear per plant.
Moderate PCV and GCV were observed for plant height, basal tiller per plant, 1000grain weight, biological yield per plant, and total chlorophyll content in leaves. Similar results were observed by Lule et al.[10] for plant height, basal tiller per plant, and 1000grain weight in finger millet.Contrary to the above, low estimates of PCV and GCV were recorded for days to 50 per cent flowering, days to maturity, the relative water content in leaves, and chlorophyll stability index. This indicated that the selection of these characters might not be effective. Similar works were reported by Ulaganathan and Nirmalakumari [11], Lule *et al*.[10], and Reddy *et al.*[12] for days to 50 percentand days to maturity in finger millet.Johnson et al. (1955) proposed that combining the calculations of heritability and genetic advance is more valuable for predicting the success of selecting superior individuals compared to relying on information from heritability and genetic advance alone. Consequently, for selection to be efficacious, a character with high heritability should ideally be associated with a substantial genetic advance.
In the present study, characters such as 1000grain weight, panicle length, biological yield per plant, grain yield per plant, ear per plant, number of basal tillers per plant, total chlorophyll content, plant height, and harvest index exhibited high heritability along with a substantial genetic advance as a percentage of the mean. This suggests that these traits are more influenced by additive gene action, and their expression is less influenced by the environment. Consequently, these traits are highly conducive for selection and using simple methods like mass selection based on phenotypic value will be effective for their improvement. Moreover, the investigation revealed high heritability coupled with a moderate genetic advance as a percentage of the mean for characters like days to 50 percent flowering and days to maturity. This indicates that selection for these traits will also be effective. Similar results were reported by Saundaryakumari and Singh [7] for panicle length, harvest index, basal tiller per plant, 1000-grain weight, and grain yield per plant; Selvi *et al*. [13] for plant height and biological yield per plant; Priyadharshini *et al*. [14] for harvest index, grain yield per plant, basal tiller per plant, and plant height; Karad and Patil [9] for days to 50 percent flowering and days to maturity.In the present investigation, both chlorophyll stability index and relative water content displayed moderate heritability along with a low genetic advance as a percentage of the mean. This suggests the presence of non-additive gene action for these traits.The heritability of grain yield per plant in the present study was moderately high, approximately 75.5 %. However, when compared to most other characters, it appeared comparatively lower. This discrepancy can be attributed to the complexity of yield as a character, heavily influenced by environmental factors. Nevertheless, the substantial heritability coupled with a high genetic advance as a percentage of the mean implies that selection can be effectively employedin this crop for improving grain yield per plant.

Table 2: . Genetic variance and other related parameters for grain yield and component characters

Sl. No.	TRAITS	Mean	SE	Range		GV	PV	EV	GCV (%)	PCV (%)	Hbs (%)	GA	GAM (%)
				Min.	Max.								
1	DF	75.38	1.01	64	85.33	16.85	19.89	3.04	5.45	5.92	84.675	7.78	10.32

Sl. No.	TRAITS	Mean	SE	Range		GV	PV	EV	GCV (%)	PCV (%)	Hbs (%)	GA	GAM (%)
				Min.	Max.								
2	DM	109.06	1.23	96	123	59.03	63.56	4.53	7.05	7.31	92.873	15.25	13.99
3	PH	119.61	3.43	80	148.33	229.45	264.84	35.39	12.66	13.61	86.636	29.04	24.28
4	BT	3.89	0.26	2.1	5.47	0.40	0.60	0.20	16.33	20.02	66.584	1.07	27.46
5	PL	8.27	0.45	4.87	13.36	3.85	4.45	0.59	23.74	25.52	86.573	3.76	45.51
6	E/P	6.55	0.42	2.77	11.33	2.81	3.34	0.52	25.59	27.87	84.289	3.17	48.39
7	1000GW	2.62	0.12	1.9	3.49	0.12	0.17	0.04	13.63	15.75	74.932	0.64	24.31
8	BY/P	26.87	1.37	16.79	34.43	14.61	20.25	5.63	14.23	16.75	72.168	6.69	24.90
9	HI	28.17	2.3	19.06	41.77	36.20	52.10	15.89	21.36	25.62	69.49	10.33	36.68
10	TC	2.2	0.1	1.8	3	0.06	0.09	0.02	11.73	13.98	70.42	0.45	20.28
11	CSI	60.1	1.14	54.23	66.08	5.03	8.96	3.92	3.73	4.98	56.186	3.47	5.77
12	RWC	80.1	1.57	70.72	86.46	7.73	15.12	7.39	3.47	4.86	51.121	4.10	5.11
13	GY/P	7.5	0.55	4.09	11.24	2.79	3.69	0.90	22.27	25.62	75.515	2.99	39.86

**Chlorophyll stability index (%)(CSI), Total chlorophyll content (TC), Ear per plant (EP), Grain yield per plant (GY/P), Relative water content in leaves (%)(RWC), Panicle length (PL), Number of basal tillers per plant (BT), plant height (PH), Biological yield per plant (BY/P), Days to 50% flowering (DF), Days to maturity (DM), 1000 grains weight (1000GW), and harvest index (HI), Standard Error(SE), Genotypic Coefficient of Variability (GCV),Phenotypic Coefficient of Variability(PCV) , Coefficient of Variance (CV), Broad Sense Heritability(Hbs), Genetic Advance over Mean (GAM).*

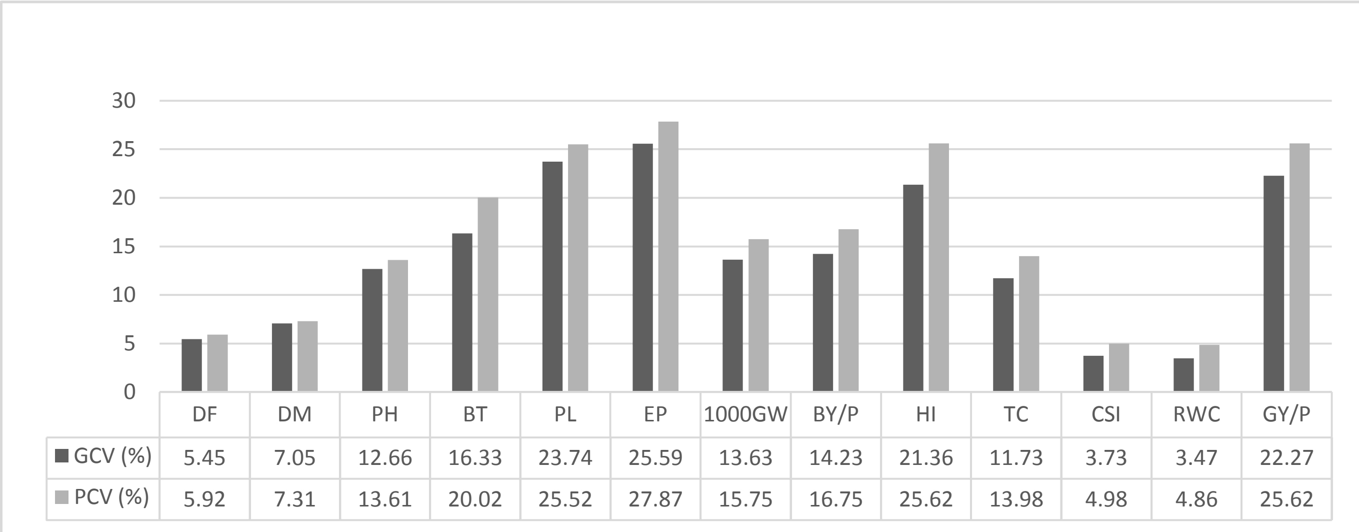

Fig 1. Genotypic Coefficient of Variability (GCV) and Phenotypic Coefficient of Variability(PCV)for various characters of Finger millet

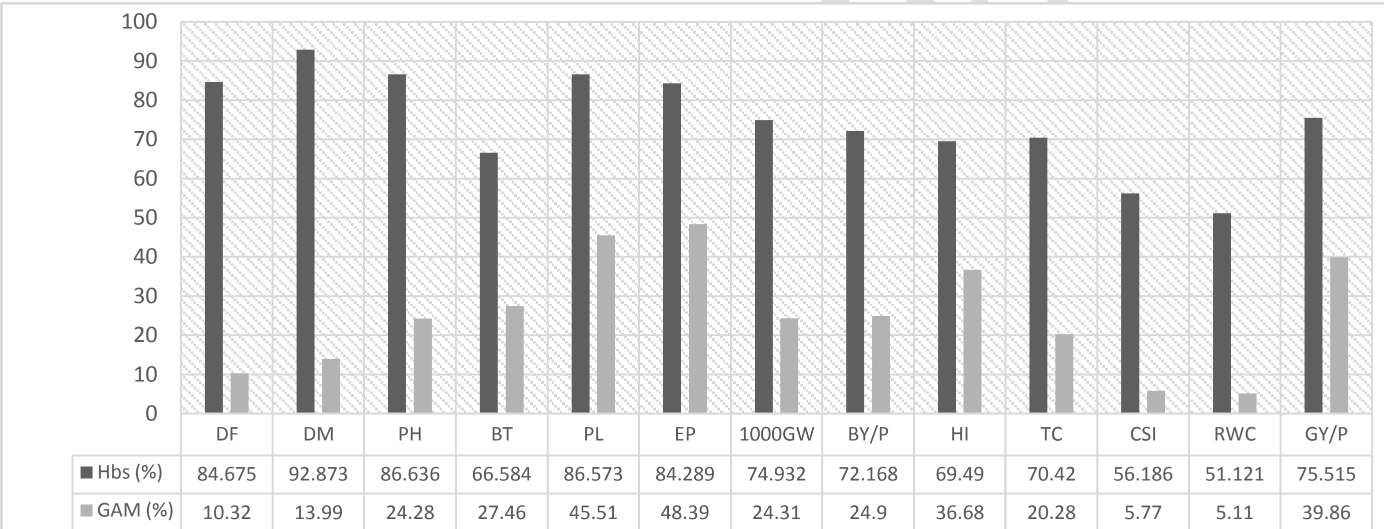

Fig 2. Heritability (Hbs%) and genetic advance as per cent mean (GAM %) for various characters of Finger millet genotypes

4. CONCLUSION

The analysis of variance in the 39 genotypes of finger millet revealed the presence of significant variation for all the characters studied. Hence, there is ample scope for selection with respect to all these traits for further improvement of finger millet. Based on the per se performances, the genotypes, viz., CFMV 2 (i), CFMV1 (i), VL 391 and VL 408 was found promising for higher yield.Moderate to high phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were observed for all the traits except for the days to 50 per cent flowering, days to maturity, relative water content in leaves and chlorophyll stability index. This indicated the presence of considerable heritable variation among the genotypes justifying the utility of the genotypes in future crop improvement programme. However, the relative water content in leaves, chlorophyll stability index, days to 50 per cent flowering, and days to maturity exhibited low estimates of PCV and GCV.In the present study, a high estimate of heritability (broad sense) coupled with moderate to high genetic advance as per cent of mean was recorded for 1000grain weight, plant height, number of basal tillers per plant, panicle length, biological yield per plant, ear per plant, harvest index, grain yield per plant, total chlorophyll content, days to 50 percent flowering and days to maturity which demonstrated the presence of additive gene action indicating the effectiveness of selection for improvement of these traits.

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