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Stability Analysis and Genetic Variability in Buckwheat (*Fagopyrum esculentum* Moench.)

Om Priya B. [a++*], Vijayakumar B. Narayanapur [a#], Bhuvaneshwari G. [b†], Rekha Chittapur [c‡], Bapurayagouda Patil [d‡] and Lokesh [a++]

[a] *Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, University of Horticultural Sciences, Bagalkot-587104, Karnataka, India.*
[b] *Department of Postharvest Management, College of Horticulture, University of Horticultural Sciences, Bagalkot-587104, Karnataka, India.*
[c] *Department of Genetics and Plant Breeding, College of Horticulture, University of Horticultural Sciences, Bagalkot-587104, Karnataka, India.*
[d] *Seed Unit, College of Horticulture, University of Horticultural Sciences, Bagalkot-587104, Karnataka, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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[++] *PhD Scholar;*
[#] *Associate Professor and Head;*
[†] *Professor and Head;*
[‡] *Assistant Professor;*
**Corresponding author: E-mail: ompriyab1@gmail.com;*

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ABSTRACT

Aims: To estimate the genetic variability and to identify the stable buckwheat genotype for growth and yield parameters.

Study Design: Eberhart and Russell model.

Place and Duration of Study: Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Bagalkot, Karnataka during Jan-April 2021-2022.

Methodology: Fifteen genotypes of buckwheat were assessed for stability parameters for 15 characters across three environments *i.e,* full dose of recommended fertilizer (RDF), 3/4th dose of RDF and 1/2nd dose of RDF. The pooled data of these environments were used for estimation of genetic variability.

Results: The heritability estimates were moderate to high for all the characters. The genetic advance over mean was found highest for number of clusters per cyme (35.05%), seed yield per plot (32.68%) and seed yield per hectare (32.72%). The genotype EC-104035 was found stable for seed yield per plant, per plot and hectare, EC-386667, EC-3222, Nilgiri local, PRB-1 and Sangla B-460 for thousand seed weight, IC-313134 and EC-3222 for plant height at 45 days after sowing and at harvest, Shimla B-1 for plant height at 15 days after sowing, IC-49671, IC-274429 and Sangla B-460 for number of branches at 30 DAS, PRB-1 for days to first flowering and Nilgiri local for days to 50 percent flowering.

Conclusion: The genotypes stable for more traits with high genetic variability, will be considered for future breeding program.

Keywords: Buckwheat; Fagopyrum esculentum; stability; genotype; genetic variability.

1. INTRODUCTION

Common buckwheat (*Fagopyrum esculentum* Moench.) is a dicotyledonous annual herb with erect branches with 2n = 16, belongs to the family Polygonaceae. The genus includes four cultivated species, *i.e.,* common buckwheat (*Fagopyrum esculentum Moench.)*, tartary buckwheat (*Fagopyrum tataricum), coarse buckwheat (Fagopyrum sagittatum) and Kashmir buckwheat (Fagopyrum kashmirianum Munshi)* out of the 19 species under Fagopyrum [1,2]. The word “buckwheat” is derived from the Anglo-Saxon word “boc whoet (beech-wheat)” due to its seed resemblance [3]. Globally, 1.87 million tonnes of buckwheat is produced with Russian Federation as leading producer (919,147 tonnes) [4].

Buckwheat is grown on large scale in Jammu and Kashmir, Himachal Pradesh and Uttarakhand and to some extent in North-Eastern states *i.e.,* Sikkim, Assam, Arunanchal Pradesh, Nagaland and Manipur. It is also cultivated in some parts of Nilgiris and Palani hills in Southern India [5]. The most important components of this plant are flavonoids such as rutin (2729.9 mg/100 g), quercetin (12.23 mg/100 g), fagopyrin, anthocyanins, catechins, chlorogenic acid, 4-hydroxy-3-methoxy benzoic acid, caffeic acid, epicatechins, p-courmaric acid, ferulic acid *etc* [6].

Buckwheat is climatically more resilient and nutritionally richer than major cereal crops. They contain adequate amount of dietary fibers that helps in improving lipid metabolism. It is gaining much importance due to gluten free seeds and rich in protein and has strong resistance to biotic and abiotic stresses. As a medicine, buckwheat is used to improve blood flow by strengthening veins and small blood vessels. It helps in decreasing the incidence of vascular complications such as retinal haemorrhage, apoplexy and coronary occlusion. Rutin is also used to treat the harmful effects of X-rays and used for persons exposed to dangerous atomic radiation [7]. Germany declared buckwheat as a medicinal plant of the year during 1999, because of its lot of health benefits.

Recommendation of widely adaptable and stable genotype is important for successful commercial cultivation of buckwheat. Joshi [8] made a study on yield stability of 17 tartary buckwheat genotypes during two seasons of 1999 and 2000. Genotypes, GF-212, Sample-6-l and Sample-7 had above average yield and well adapted to all environment. Acc-2223 was adapted to low-yielding environments and Acc-2227-l, MY-2-27-l, GF-5234 and Sample-8 were adapted to high-yielding environments. Kandel and Shrestha, [9] conducted an experiment, stability analysis in seven buckwheat genotypes for grain yield at 8 different hilly regions of Nepal during winter seasons of 2017 and 2018. The results showed that, the genotype x environment interaction for grain yield was significant (p=0.05) and genotypes, ACC#2227-1 and ACC#2223-1 were identified as more stable and adaptive across the locations. The performance of genotypes varies in different environments, the same is true with respect to buckwheat therefore, present study entitled "Genetic variability and stability analysis in buckwheat (*Fagopyrum esculentum* Moench.)" was proposed with an objective, to estimate the genetic variability and to identify the stable buckwheat genotype for growth and yield parameters.

2. MATERIALS AND METHODS

The present experiment was conducted during the period between January 2022 to April 2022 at the experimental field of Department of Plantation, Spice, Medicinal and Aromatic crops, College of Horticulture, University of Horticultural sciences, Bagalkot, Karnataka. Fifteen genotypes of buckwheat were grown in randomized complete block design with two replications at a spacing of 30 X 10 cm. The 15 genotypes *viz,* IC-79147, EC-323729**,** EC-386668, EC-386667, IC-313134**,** IC-49671**,** EC-104035**,** EC-3222**,** IC-274429, Shimla B-1, Nilgiri local**,** PRB-1**,** Sangla B-1**,** Sangla B-460 and EC-125940 were analyzed for stability, under three different environments *i.e.,* Environment-I: Full doze of recommended dose of fertilizers (40:20:10 kg/ha of NPK), Environment-II: $3/4^{th}$ of RDF (30:15:7.5 kg/ha of NPK) and Environment-III: $1/2^{nd}$ of RDF (20:10:5 kg/ha of NPK). The pooled data of these environments were used for estimation of genetic variability. All the readings were recorded according to IPGRI descriptors for buckwheat.

Observations were recorded and data were analyzed to identify the stable genotype with stability parameters, *i.e.,* mean ($\overline{X}$), regression coefficient (b_i) and deviation from regression (S^2_{di}) were computed by the method given by Eberhart and Russell [10].

Analysis of variance was done from the pooled data of three different environments obtained for each character. Genotypic and phenotypic coefficients of variation (GCV and PCV, respectively) were estimated as suggested by Burton and Devane [11]. Heritability (h^2) was estimated as given by Falconer [12]. Genetic advance over percent mean (GAM) was calculated according to Johnson et al*.* [13].

Both stability and genetic variability were analyzed using INDOSTAT software.

3. RESULTS AND DISCUSSION

3.1 Estimation of Genetic Variability

Variability among the traits was compared with coefficient of variation. Estimation of genetic variability of buckwheat genotypes based on pooled analysis of three environments are given in Table 1. The genotypic and phenotypic coefficient of variation varied from 2.71 to 19.51 and 3.3 to 22.37 respectively. While GCV and PCV were low for plant height at 30 days after sowing (DAS), 45 DAS and at harvest, number of branches at 45 DAS, days to first flowering and days to fifty percent flowering, number of seeds per plant and thousand seed weight. Whereas, it was moderate for plant height at 15 DAS, number of branches at 30 DAS, number of cymes per plant, seed yield per plant, seed yield per plot and seed yield per hectare. For number of days to first germination and number of clusters per cyme GCV was low and PCV was moderate. The characters like, days to first flowering, days to 50 percent flowering, number of seeds per plant, seed yield per plot and seed yield per hectare showed least difference between GCV and PCV which indicates there is least environmental influence on these traits. Similar results were also obtained by Hiremath et al. [14], Bisht et al. [15] and Dutta et al. [16].

Heritability, or the degree to which a characteristic is handed down to the next generation is another factor that influences the choice of yield traits. Heritability in the current study was calculated as the proportion of genotypic variance to the phenotypic variance. In the present study, there were low to high estimates of genetic advance (0.46 to 92.08). The range of genetic advance over mean was from 4.57 percent to 35.05 per cent, which is low to high. Heritability ranged from 43.09 percent to 97.23 percent which is moderate to high.

The characteristics like number of branches at 30 days after sowing, number of cyme per plant, number of cluster per cyme, seed yield per plant, seed yield per plot and seed yield per hectare had higher heritability with higher genetic advance over mean. The impacts of additive genes are shown by significant genetic progress and higher heritability, and selection of these highly heritable qualities was found successful in breeding programmes. Results of the research are near to the findings of Dutta et al. [16], Hiremath et al. [14] and Bisht et al. [15].

3.2 Stability Analysis

Pooled analysis of variance for growth and yield parameters across the three environments is presented in Table 2. The results revealed that there was significant difference among the genotypes tested for all the characters.

The results revealed that there was highly significant (p=0.01) differences among the genotypes for number of branches at 30 and 45 days after sowing, number of flower clusters per cyme, seed yield per plant, per plot and per hectare (p≤0.001). The environment was found highly significant (p=0.01) for number of cyme per plant, whereas for plant height at 30, 45 days after sowing and at harvest, number of seeds per plant, seed yield per plot, seed yield per hectare and 1000-seed weight, it was significant at p=0.05. Genotype X environment interaction and environment and genotype X environment was found significant for number of flower clusters per cyme at p=0.05. Environment (linear) was found highly significant (p=0.01) for plant height at 45 days after sowing and at harvest, number of cyme per plant, number of seeds per plant, seed yield per plot, seed yield per hectare and 1000 seed weight. But, it was found significant for plant height at 30 days after sowing and seed yield per plant only at p=0.05. Genotype X environment (linear) was found highly significant (p=0.01) only for number of flower clusters per cyme. Pooled deviation was found highly significant (p=0.01) for most of the characters *i.e*., plant height at 15, 30, 45 DAS and at harvest, days to first flowering, days to 50 percent flowering, number of cyme per plant, number of seeds per plant, seed yield per plot, per hectare (p≤0.01) and 1000-seed weight. For number of flower clusters per cyme and seed yield per plant, it was significant only at p=0.01. Similar results for various characters were also reported by Mohanty and Prusti [17] in brinjal, Prakash et al. [18] in okra and Kandel and Shrestha [9] in buckwheat.

3.2.1 Stability analysis for growth and flower parameters

The genotype Shimla B-1 was found stable for plant height at 15 DAS. The genotypes like IC-313134 and EC-3222 were found stable for plant height at 45 DAS, the genotypes like IC-313134 and EC-3222 were found stable for plant height at harvest, the genotypes like IC-49671, IC-274429 and Sangla B-460 were found stable for number of branches at 30 DAS with higher mean values and regression coefficients near to unity with non-significant deviation from regression. The genotype PRB-1 was found stable for number for days to first flowering and the genotype Nilgiri local was found stable for number of days to 50 per cent flowering with lower mean value and regression coefficient near to unity with non-significant deviation from regression. Similar results were also noticed by Rai et al. [19] in brinjal, Jyothi et al. [20] in tomato and kakani et al. [21] in fenugreek. The genotypes which show below-average stability with higher mean values and regression coefficients greater than one with non-significant deviation from regression, indicates that genotypes are specifically adapted to favourable environments. The genotypes which show above-average stability with higher mean values and less than one regression coefficient with non-significant deviation from regression, indicates that genotypes are specifically adapted to unfavourable environments. Stability parameters for growth and flower parameters are mentioned in Table 3 and Table 4 respectively.

3.2.2 Stability analysis for yield parameters

The genotype EC-104035 was found stable for seed yield per plant, per plot and per hectare and the genotypes like EC-386667, EC-3222, Nilgiri local, PRB-1 and Sangla B-460 were found stable for 1000-seed weight with higher mean values and regression coefficients near to unity with non-significant deviation from regression. The genotypes which show below average stability with higher mean values and regression coefficients greater than one with non-significant deviation from regression, indicates that genotypes are specifically adapted to favourable environments. The genotypes which show above average stability with higher mean values and less than one regression coefficient with non-significant deviation from regression, indicates that genotypes are specifically adapted to unfavourable environments. Results found are close to the findings of Joshi [5] and Dhiman and Chahota [22] in tartary buckwheat, Kandel and Shrestha [9] in common buckwheat. Stability parameters for yield parameters are mentioned in Table 5.

Table 1. Estimation of genetic variability of buckwheat genotypes based on pooled analysis of three environments

Parameters	Range	Mean	GV	PV	GCV (%)	PCV (%)	Heritability (%)	GA	GAM (%)
Days to first germination	4.17-5.50	4.8	0.11	0.23	6.85	10.08	46.26	0.46	9.6
Plant height at 15 DAS	5.74-9.70	7.97	0.67	1.55	10.25	15.62	43.09	1.1	13.86
Plant height at 30 DAS	35.74-45.30	39.8	8.02	10.55	7.11	8.16	76.03	5.09	12.78
Plant height at 45 DAS	52.47-61.19	58.04	4.79	8.47	3.77	5.01	56.58	3.39	5.85
Plant height at harvest	52.97-61.67	58.56	4.99	8.68	3.82	5.03	57.48	3.49	5.96
No. of branches at 30 DAS	3.80-6.03	4.86	0.41	0.53	13.13	15	76.62	1.15	23.68
No. of branches at 45 DAS	8.47-11.07	9.88	0.58	0.67	7.73	8.27	87.5	1.47	14.9
Days to first flowering	25.64-29.00	26.74	1.01	1.15	3.76	4.01	87.87	1.94	7.25
Days to 50% flowering	29.34-32.17	30.43	0.68	1.01	2.71	3.3	67.22	1.39	4.57
No. of cyme per plant	17.22-31.09	24.4	12.95	18.27	14.75	17.52	70.9	6.24	25.58
No. of cluster per cyme	2.60-5.27	3.89	0.58	0.76	19.51	22.37	76.05	1.36	35.05
No. of seeds per plant	47.30-57.28	52.59	7.71	9.64	5.28	5.9	79.97	5.12	9.73
Seed yield per plant	3.19-5.61	4.78	0.47	0.54	14.41	15.45	86.98	1.32	27.68
Seed yield per plot	185.93-342.42	281.54	2056.13	2116.08	16.09	16.33	97.17	92.08	32.68
Seed yield per hectare	14.33-26.40	21.72	12.23	12.3	16.11	16.34	97.23	7.11	32.72
1000-seed weight	17.32-21.30	19.01	0.94	1.96	5.11	7.36	48.23	1.39	7.32

Table 2. Pooled analysis of variance (mean square) for various growth and yield parameters of buckwheat genotypes

Sl. No	Source of variation	Genotype	Environment	Genotype x Environment	Environment + (genotype x environment)	Environment (linear)	Genotype x Environment (linear)	Pooled deviation	Pooled error
	Degrees of freedom	**14**	**2**	**28**	**30**	**1**	**14**	**15**	**42**
1	**Plant height at 15 DAS (cm)**	3.18	3.88	1.71	1.85	7.77	1.03	2.22**	0.383
2	**Plant height at 30 DAS (cm)**	27.85	207.98*	37.98	49.32	415.96*	17.02	55.02**	3.73
3	**Plant height at 45 DAS (cm)**	19.89	311.16*	65.59	81.96	622.32**	77.78	49.84**	3.93
4	**Plant height at harvest (cm)**	20.53	314.45*	65.63	82.22	628.90**	76.61	51.00**	3.73
5	**No. of branches at 30 DAS**	1.41**	0.03	0.15	0.14	0.06	0.09	0.193	0.16
6	**No. of branches at 45 DAS**	1.87**	0.24	0.19	0.20	0.49	0.191	0.192	0.13
7	**Days to 1st flowering**	3.15	0.91	1.39	1.35	1.81	1.24	1.43**	0.44
8	**Days to 50% flowering**	2.52	4.65	2.42	2.56	9.3	1.70	2.92**	0.79
9	**No. of cyme per plant**	46.85	263.66**	27.50	43.24	527.33**	18.98	33.62**	10.24
10	**No. of flower clusters per cyme**	1.99**	0.24	1.14*	1.08*	0.48	1.82**	0.43*	0.19
11	**No. of seeds per plant**	26.03	153.34*	28.46	36.79	306.68**	28.88	26.18**	2.46
12	**Seed yield per plant (g)**	1.53**	0.64	0.32	0.35	1.28*	0.37	0.26*	0.13
13	**Seed yield per plot (g)**	6258.29**	2948.38*	830.00	971.23	5896.77**	969.16	644.78**	184.72
14	**Seed yield per hectare (q/ha)**	37.27***	17.47*	4.94	5.78	34.94**	5.79	3.82***	1.10
15	**1000-seed weight (g)**	4.36	22.25*	3.82	5.05	44.51**	3.88	3.53**	1.21

, ** and * indicate significance at p=0.05, p=0.01 and p≤ 0.001 respectively*

Table 3. Stability analysis for growth parameters

Sl. No	Genotype	Plant height at 15 DAS			Plant height at 30 DAS			Plant height at 45 DAS			Plant height at harvest			No. of branches at 30 DAS			No. of branches at 45 DAS		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1	**IC-79147**	5.73	0.41	-0.61	38.06	-0.24	23.916*	54.60	-1.07	45.418**	55.10	-1.08	41.80**	3.80	1.82	-0.08	8.47	-2.10	-0.04
2	**EC-323729**	8.03	1.02	5.66**	40.48	0.98	74.521***	55.03	-1.31	155.159***	55.50	-1.27	161.20***	4.17	-1.12	0.653*	9.37	-1.54	-0.09
3	**EC-386668**	9.10	1.73	1.18	41.57	1.71	-0.17	61.18	1.41	17.19	61.67	1.44	16.30	5.27	6.18	-0.11	10.60	0.41	-0.07
4	**EC-386667**	8.10	2.414*	-0.64	41.80	1.74	8.74	58.10	2.33	-4.59	58.67	2.31	-4.23	4.33	1.12	0.533*	9.67	2.74	-0.10
5	**IC-313134**	6.97	1.42	-0.06	36.40	0.37	33.842**	60.87	1.13	-4.71	61.30	1.12	-4.13	4.80	2.74	0.08	9.70	-2.62	-0.12
6	**IC-49671**	8.53	-0.86	0.18	36.53	2.44	4.71	57.23	2.55	15.07	57.70	2.57	17.07	5.57	1.01	-0.15	10.70	3.38	-0.13
7	**EC-104035**	7.27	3.60	-0.53	35.73	2.35	83.875***	57.07	2.78	144.99***	57.47	2.73	149.83***	4.40	-1.82	-0.08	9.30	-0.61	0.03
8	**EC-3222**	7.87	-1.65	3.731*	36.03	0.97	92.079***	60.50	0.56	-5.99	61.20	0.56	-5.85	4.40	-1.22	0.41	9.37	3.90	-0.13
9	**IC-274429**	8.17	0.43	1.46	40.17	0.74	25.357*	57.77	1.18	0.13	58.27	1.14	-5.94	5.83	1.12	-0.15	10.53	3.75	0.25
10	**Shimla B-1**	9.30	0.84	0.93	37.73	0.65	109.929***	58.37	2.98	120.34***	58.90	2.94	123.98***	4.77	-5.07	-0.09	9.70	0.33	1.197**
11	**Nilgiri local**	7.63	3.07	1.28	42.10	1.19	76.855***	57.03	1.88	4.84	57.40	1.83	7.48	6.03	2.94	-0.10	11.07	0.18	0.05
12	**PRB-1**	9.70	1.52	-0.63	43.78	0.86	88.896***	59.43	-0.65	0.05	59.97	-0.63	1.74	5.17	0.10	-0.14	10.80	4.83	0.14
13	**Sangla B-1**	8.73	0.59	-0.39	45.30	-0.10	6.01	60.23	0.01	21.343*	60.87	0.07	25.05*	4.33	-6.79	0.18	9.13	2.30	-0.11
14	**Sangla B-460**	8.77	-0.61	9.772***	42.80	0.55	92.982***	60.77	0.299*	-6.14	61.43	0.291**	-5.95	5.70	1.22	-0.14	10.70	-1.72	-0.10
15	**EC-125940**	7.13	1.05	2.327*	38.60	0.79	33.742**	52.47	0.93	158.74***	52.97	0.98	157.54***	4.40	12.77	-0.14	9.07	1.77	0.00
Mean		8.07			39.8			58.04			58.56			4.86			9.88		
S.E.(mean)		1.05			5.24			4.99			5.05			0.31			0.31		
S.E.bi			2.07			1.4086			1.17			1.10			6.63			2.43	

, ** and * indicate significance at p=0.05, p=0.01 and p≤ 0.001 respectively.*
Env.1- Full dose of Recommended fertilizers (RDF); Env.2- 3/4th dose of RDF; Env.3-1/2nd dose of RDF

Table 4. Stability analysis for flower parameters

Sl. No	Genotype	Days to first flowering			Days to 50% flowering			No. of cyme per plant			No. of clusters per cyme		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1	**IC-79147**	25.67	-0.37	-0.66	30.00	0.32	-0.96	19.50	0.61	-11.27	2.83	-0.58	1.161*
2	**EC-323729**	26.33	-3.50	-0.12	29.83	-0.73	0.45	25.13	1.58	-11.02	3.33	3.01	0.879*
3	**EC-386668**	26.50	-2.76	1.77	30.67	-0.24	10.736**	30.50	0.32	-11.16	4.83	7.088*	-0.27
4	**EC-386667**	26.83	3.82	-0.41	31.00	3.55	-1.20	21.68	1.10	-11.34	3.97	3.46	0.08
5	**IC-313134**	25.83	-1.56	-0.44	29.33	2.10	0.55	31.08	1.67	9.92	3.13	-6.26	0.18
6	**IC-49671**	28.00	3.18	4.472*	31.50	-1.29	5.573*	23.93	1.50	1.78	2.60	-12.24	0.34
7	**EC-104035**	26.33	5.75	-0.64	30.00	4.36	0.35	28.70	1.70	11.89	3.97	2.18	-0.14
8	**EC-3222**	26.00	0**	-0.81	29.67	0.16	-0.74	24.73	1.08	61.578*	3.50	2.68	-0.25
9	**IC-274429**	28.17	4.33	4.097*	31.33	0.32	1.21	22.50	0.60	27.30	4.07	4.99	-0.19
10	**Shimla B-1**	26.50	3.45	-0.75	30.67	2.50	-0.10	20.42	1.55	14.87	3.80	-15.74	0.49
11	**Nilgiri local**	26.00	-0.41	-0.33	29.67	1.13	-0.02	23.83	1.30	43.241*	5.27	8.00	0.06
12	**PRB-1**	26.17	0.74	-0.21	29.50	2.10	-0.62	28.22	1.81	155.18***	3.57	-1.57	0.37
13	**Sangla B-1**	28.00	6.21	1.03	31.67	1.61	0.16	17.22	0.99	-10.77	4.63	1.85	0.02
14	**Sang la B-460**	26.00	-2.76	1.77	29.50	-0.16	8.089*	24.20	-0.04	69.42*	5.27	12.49	-0.19
15	**EC-125940**	29.00	-1.10	0.54	32.17	-0.73	-0.55	24.38	-0.77	-6.43	3.53	5.65	-0.22
Mean		26.76			30.43			24.40			3.99		
S.E.(mean)		0.85			1.21			4.10			0.46		
S.E.bi			3.44			2.17			0.98			3.64	

, ** and * indicate significance at p=0.05, p=0.01 and p≤ 0.001 respectively*
Env.1- Full dose of Recommended fertilizers (RDF); Env.2- 3/4th dose of RDF; Env.3-1/2nd dose of RDF

Table 5. Stability analysis for yield parameters

Sl. No	Genotype	No. of seeds per plant			Seed yield (g) per plant			Seed yield (g) per plot			Seed yiled (q) per hectare			1000-seed weight (g)		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1	**IC-79147**	56.47	1.06	14.705*	3.19	1.59	-0.08	185.93	3.09	-127.48	14.32	3.10	-0.75	17.40	1.09	2.16
2	**EC-323729**	52.83	-1.52	49.27***	4.04	4.85	-0.08	235.98	3.33	463.75	18.19	3.33	2.77	18.73	-1.48	5.89
3	**EC-386668**	51.14	-0.42	-2.34	5.43	3.81	-0.01	305.26	2.58	18.00	23.52	2.58	0.15	20.00	-0.44	-1.25
4	**EC-386667**	50.13	0.97	14.8*	4.58	1.71	0.12	283.59	1.35	2679.87***	21.88	1.33	15.57***	19.49	0.56	0.18
5	**IC-313134**	55.41	1.19	41.436***	4.20	-1.65	0.536*	238.70	-1.22	341.65	18.40	-1.23	1.96	17.97	1.41	4.11
6	**IC-49671**	53.94	0.74	15.49*	5.20	1.19	0.493*	299.31	0.95	975.376*	23.08	0.95	5.75*	18.63	1.09	1.00
7	**EC-104035**	57.28	4.09	4.33	5.37	0.55	-0.13	317.21	1.02	-141.63	24.46	1.04	-0.84	17.40	3.49	1.40
8	**EC-3222**	53.37	1.31	69.562***	4.11	0.23	-0.07	237.25	0.70	-13.19	18.28	0.68	-0.08	19.05	1.37	9.03
9	**IC-274429**	50.46	1.77	8.838*	5.14	-1.90	-0.12	298.93	-1.27	-139.19	23.05	-1.27	-0.83	20.19	1.87	0.06
10	**Shimla B-1**	47.47	1.61	0.62	5.04	1.71	0.01	297.54	1.73	239.79	22.94	1.74	1.46	21.30	2.41	-0.26
11	**Nilgiri local**	52.37	0.19	5.50	5.61	1.95	-0.08	338.80	1.51	26.15	26.12	1.53	0.15	19.06	0.67	-0.30
12	**PRB-1**	54.92	1.23	2.81	5.53	-1.00	0.27	342.41	-0.47	596.787*	26.40	-0.49	3.64*	19.07	0.98	1.12
13	**Sangla B-1**	52.06	0.98	12.609*	4.64	0.21	0.11	269.79	0.71	1671.05**	20.79	0.71	10.01**	18.80	0.36	-1.13
14	**Sang la B-460**	47.30	0.89	-1.76	5.43	3.60	1.115**	334.07	2.56	116.99	25.77	2.57	0.69	20.77	0.78	1.10
15	**EC-125940**	53.74	0.92	116.35***	4.15	-1.83	-0.12	241.58	-1.55	98.49	18.62	-1.56	0.62	17.32	0.85	10.37
Mean		52.59			4.78			281.8			21.72			19.01		
S.E.(mean)		3.62			0.36			18.00			1.38			1.33		
S.E.bi			1.13			1.74			1.30			1.28			1.10	

, ** and * indicate significance at p=0.05, p=0.01 and p≤ 0.001 respectively.*
Env.1- Full dose of Recommended fertilizers (RDF); Env.2- 3/4th dose of RDF; Env.3-1/2nd dose of RDF

4. CONCLUSION

From the present study, it can be concluded that the genotypic and phenotypic coefficients of variation were moderate for plant height at 15 DAS, number of branches at 30 DAS, number of cymes per plant, seed yield per plant, seed yield per plot and seed yield per hectare. The heritability estimates were moderate to high for all the characters. Whereas, least for plant height at 15 days after sowing (43.09%). The genetic advance over mean was found to be highest for number of clusters per cyme (35.05%), seed yield per plot (32.68%) and seed yield per hectare (32.72%). Selection of highly heritable traits was found successful in breeding programmes.

The genotypes stable for more number of traits will be considered for future breeding program. The genotype EC-104035 was found stable for seed yield per plant, seed yield per plot and seed yield per hectare. The genotypes, EC-386667, EC-3222, Nilgiri local, PRB-1 and Sangla B-460 were found stable for thousand seed weight. The genotypes like IC-313134 and EC-3222 were found stable for plant height at 45 days after sowing and also at harvest. The genotype, Shimla B-1 was found stable for plant height at 15 days after sowing. The genotypes like IC-49671, IC-274429 and Sangla B-460 were found stable for number of branches at 30 DAS. The genotype, PRB-1 was found stable for days to first flowering and genotype Nilgiri local was found stable for days to 50 percent flowering.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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