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GENOTYPE × ENVIRONMENT INTERACTIONS AND STABILITY ANALYSIS IN ADVANCED PROMISING LINES OF COWPEA [*VIGNA UNGUICULATA* (L.) WALP.]

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Abstract

The present experiment was carried out to understand the role of genotype × environment interactions on the expression of yield and yield attributes and stability of 32 cowpea genotypes including two checks (DC 15 and DCS 47-1) across four different environments. Variance due to genotypes, environments, Environment (linear) and genotype × environment (linear) were significant for all the traits except for pod length. The pooled deviation was found significant for most of the traits indicate the role of unpredictable portion of environments influencing these traits. Based on the stability analysis the genotypes *viz.*, DC 15 × DCS 47-1-1(F_6), C 152 × IC 202872 (F_7) and C 152 × IC 202860 (F_6) found stable and well adoptable across the environments for seed yield. TheF_6 line of cross DCS 47-1 × DC 15-1 and germplasm line IC97838 were specifically adapted favorable environments whereas, the genotypes, GC 3 × CPD 115 (F_6), DC 15 × Goa local (F_6) and DC 15 (Check) exhibited above average stability and adaptation to poor environments for seed yield.

Key words : Cowpea, stability, genotype × environment interaction.

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] is an important food legume crop of the world also called as lobia, black-eyed pea and southern bean which is grown as pulse crop, vegetable, fodder, cover crop and catch crop. It is a major staple component of the human diet in many developing countries, nutritionally on an average seeds of cowpea contain about 25 per cent protein, making it enormously valuable in areas where many people cannot afford proteinacious foods like fish and meat (Lephale *et al*., 2012) hence, it is often regarded as vegetable meat and poor man's meat. Further, tender pods are also be used as vegetable. Apart from this, the green and dry haulms are used to feed the farm animals. Cowpea, being a relatively drought tolerant and warm weather crop, it is well suited to drier regions where other legumes crops do not thrive well (Abate *et al*., 2011). As a legume, it plays an important role in maintaining the soil fertility and sustainability in the production from different cropping systems.

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Cowpea is growing in all most all the agro-ecological zones in India. The performance of genotypes exhibits a wide range of variation within and between environments because of genotype × environment interaction. This causes difficulty in demonstrating the superiority of particular variety, complicates the breeding work and hampers the progress of the crop improvement programme (Eberhart and Russell, 1966). Besides, stable performance of the variety over a wide range of environment is of major concern to the plant breeders and it has direct influence on the spread of the variety, production and total productivity of the crop. Each genotype has a specific environment for its maximum performance and thus a specific genotype performs better in a specific environment. Hence, there is a need to assess adaptation and yield stability of promising genotypes across environments.

In this context, the present study was undertaken to assess the genotype x environment interaction and stability of 32 genotypes including two checks (DC 15 and DCS 47-1) for seed yield and other attributes across four diverse environments.

Materials and Methods

The experimental material comprised of thirty promising advanced breeding lines of which 25 were superior stabilized lines (F_5, F_6, F_7, F_9, F_{10} and BC_1F_6 generations) and 5 were germplasm lines with two checks developed at department of genetics and plant breeding, College of Agriculture Dharwad. These 30 genotypes along with two checks (DC 15 and DCS 47-1) were evaluated under four different environments (E_1 - Dharwad *Kharif* 2016, E_2–ARS Mugad *rabi*-summer 2017, E_3 –ARS Malagi *rabi*-summer 2017 and E_4 - Dharwad summer 2017) representing diverse agro climatic conditions. At all the environments the experiment was laid out according to randomized complete block design with two replications. Each entry was raised in three rows of three meter length with the spacing of 45 cm between the rows and 15 cm between the plants. All the plant protection measures were attended as and when require for raising a good crop. The observation recorded on five randomly selected plants on each replication in each environment for number of pods per plant, pod length and 100-seed weight. The seed yield harvested from the net plot area of each genotype was added with the yield obtained from five earlier tagged and harvested plants and was recorded (kg) per plot and finally expressed in kilo grams per hectare (kg ha^{-1}). The stability analysis was done as per the model suggested by Eberhart and Russell (1966). The model involves the estimation of three stability parameters *viz*., mean, regression coefficient and deviation from regression, which are defined by the mathematical formula as given below.

$$Y_{ij} = \mu_i + b_i I_j + S_{ij}$$

Where, Y_{ij} = mean of the i^{th} genotype at j^{th} environment (I = 1, ..., G; j = 1, ..., L);

μ_i = Mean of i^{th} genotype over all environments; b_i = The regression coefficient that measures the response of i^{th} genotype to varying environments; I_j = The environmental index obtained by subtracting the grand mean from the mean of all genotypes at the j^{th} environment; S_{ij} = The deviation from regression of the i^{th} genotype at the j^{th} environment.

a. Environment index = I_j = mean of all the 32 genotypes at each environment – grand mean. $I_j = (S_j Y_{ij}/ t) – (Si\ S_j\ Y_{ij}/ t.s)$

Where, t = Number of genotypes, s = Number of environments with $S_j I_j = 0$.

b. Regression coefficient (for each genotype). $b_i = S_j Y_{ij} I_j / S_j I_j^2$

c. Deviation from regression. $S^2d_i = ((S_j d_{ij}^2)/S-2) – (S^2\ e / r)$

Where, S^2e/r = mean square for estimate of pooled error.

Results and Discussion

Pooled analysis of variance (table 1) revealed that mean sum of squares due to genotypes (G) and environments (E) were significant for number of pods per plant, hundred seed weight and seed yield. It indicated that the presence of sufficient amount of variability in the material chosen for the study and environments were different from each other, which provided the sound evidence for the validity of the experiments. G × E (linear) interactions was significant for the all characters except for pod length this revealed that genotypes responded to environmental changes in respect of all these characters. The linear component of G × E interaction is heritable and predictable, indicating the stability of the character. Similar findings were also reported by Sarvamangala *et al*. (2010) and highly significant variance due to environment (linear) for all the traits except for pod length indicated that environmental effects are additive in the present study. The non-linear component of G × E interaction (pooled deviations) was found significant against pooled error for all the traits except for hundred seed weight indicate the role of unpredictable portion of environments influencing these traits. Thus both predictable and unpredictable components contributed significantly to differences in stability among genotypes. The magnitude of linear component *i.e.,* environment (linear) and genotype × environment (linear) was many times higher than the non-linear component (pooled deviation) for most of the characters revealed that the prediction of stability could be reliable though it may get affected to some extent. The results obtained in the present study are in agreement with the findings of Patel and Jain (2012) and El-Shaieny *et al*. (2015).

Environmental index provide the basis for identifying the favorable environments for the expression of maximum potential of the genotype. Dharwad summer 2017 is the favorable environment for seed yield, Dharwad *Kharif* 2016 is the favorable environment for number of pods per plant, and ARS Malagi was most favorable for Pod length. However, for the character hundred seed weight ARS Mugad is the favorable environment (table 2).

In the present experiment, the stability model proposed by Eberhart and Russell (1966) was adopted to analyze the data over four environments. The model involves the estimation of three stability parameters *viz.,*

Table 1 : Pooled analysis of variance for stability parameters associated with yield and yield attributes among the promising lines.

	d. f.	Seed yield (kg ha^{-1})	Pods per plant	Pod length (cm)	Hundred seed weight (g)
Genotypes (G)	31	196101.29**	27.54**	1.9	2.70**
Env.+ (Gen.× Env.)	96	109709.70*	4.47	2.19	0.38
Environments (E)	3	728637.06**	10.92*	0.82	2.34**
Gen.* Env. (G×E)	93	89744.3	4.26	2.23	0.32
Environments (Lin.)	1	2185911.20**	32.75**	2.47	7.00**
Gen .×Env. (Lin.)	31	12818158.00*	5.86*	2.63	0.39*
Pooled Deviation	64	68321.74**	3.36**	1.97**	0.27
Pooled Error	124	17906.6	0.74	0.58	0.26
Total	127	130797	10.1	2.12	0.95

* - Significant at 5% level of significance, ** - Significant at 1% level of significance.

Table 2 : Mean values and environmental indices for yield and yield attributes among the promising lines across the environment.

S. no.	Character	Mean				Grand mean	Environmental indices			
		Dharwad *Kharif* 2016	Mugad *rabi*-summer 2017	Malagi *rabi*-summer 2017	Dharwad summer 2017		Dharwad *Kharif* 2016	Mugad *rabi*-summer 2017	Malagi *rabi*-summer 2017	Dharwad summer 2017
1	Seed yield (kg ha^{-1})	1377	1521	1300	1639	1459	-82	62	-160	180
2	Number of pods per plant	16.96	16.27	15.75	16.51	16.37	0.60	-0.10	-0.62	0.14
3	Pod length (cm)	15.73	15.74	16.16	16.15	15.94	-0.21	-0.20	0.22	0.21
4	Hundred seed weight (g)	11.70	12.30	12.08	11.82	11.97	-0.27	0.33	0.11	-0.15

mean (x), regression coefficient (b_i) and deviation from regression (S^2d_i). Taking these parameters into consideration, the results obtained are discussed character wise.

Seed yield

The stability parameters (x, b_i and S^2d_i) of the individual genotypes are illustrated in table 3. Among the 32 genotypes evaluated, 18 genotypes recorded *per se* mean value higher than population mean (1459 kg ha^{-1}). The regression coefficient (b_i) was found significantly deviating from unity for the nine genotypes. The deviation from regression (S^2d_i) was found significantly different from zero in 10 lines. The remaining all the genotypes showed non-significant S^2d_i.

Based on highest population mean, regression coefficient nearing unity (b_i) and S^2d_i with minimum deviation from zero the genotypes namely, DC 15 × DCS 47-1-1(F_6) (Mean-1920 kg ha^{-1}, b_i-0.64, S^2d_i-6892.97), C 152 × IC 202872 (F_7) (Mean-1573 kg ha^{-1}, b_i-1.58, S^2d_i -25249.40) and C 152 × IC 202860 (F_6) (Mean-1496 kg ha^{-1}, b_i-1.64, S^2d_i -382.02)were found to be most stable and well adaptable to all the environments. Similarly, the F_6 line of cross, DCS 47-1 × DC 15-1 and germplasm line IC97838 exhibited high mean value, regression coefficient (b_i) more than unity which indicated that these genotypes showed below average stability and specifically adapted favorable environments. Whereas, the genotypes namely,GC 3 × CPD 115 (F_6), DC 15 × Goa local (F_6) and DC 15 (Check) exhibited above average stability and adaptation to poor environments. However, the genotypes C 152 × IC 257425 (F_9), DC 15 × CPD 118 (F_6), V 118 × IC 257437 (F_7) and check DCS 47-1 exhibited higher mean values and b_i not significantly different from one, but S^2d_i for these genotypes deviated significantly different from zero indicating their unpredictable performance. Hence, these genotypes are suited for specific environment conditions in order to express their full yield potential. These results are in accordance with the findings of Sarvamangala *et al.* (2010), Chaudhari *et al.* (2013), El-Shaieny*et al.* (2015) and Vishwanathreddy (2016).

Apart from stability point of view in this study, the five best promising genotypes identified were, DC15 × DCS 47-1-1(F_6), DC 15 × C 152(F_6), DC 15 × DCS 47-1-2 (F_6), GC 3 × CPD 115 (F_6) and DCS 47-1 × DC 15-1 (F_6) these could be promoted to multilocation trials and also coordinated yield trials after one year of evaluation in the station trial.

Table 3 : Stability parameters among the promising lines in terms of seed yield (kg ha^{-1}) across the four different environments.

S. no.	Genotype	Seed yield (kg ha^{-1})					b_i	S^2d_i
		Dharwad *kharif*, 2016	Mugad *rabi*-summer, 2017	Malagi *rabi*-summer, 2017	Dharwad summer, 2017	Grand mean		
1	DC15 × DCS 47-1-1(F_6)	2,158	1,712	1,681	2,131	1,920	0.64	6892.97
2	DC 15 × C 152(F_6)	1,837	1,848	1,840	1,900	1,856	0.17**	-17502.05
3	DC 15 × DCS 47-1-2 (F_6)	1,857	1,840	1,861	1,756	1,828	-0.29*	-17098.6
4	GC 3 × CPD 115 (F_6)	1,620	1,753	1,743	1,725	1,710	0.11	-12627.42
5	DCS 47-1 × DC 15-1 (F_6)	1,314	1,914	1,486	2,049	1,691	2.08	15885.21
6	V 118 × Goa local (F_7)	1,647	1,636	1,632	1,630	1,636	-0.02*	-17768.43
7	C 152 × IC 202872 (F_7)	1,237	1,172	1,653	2,230	1,573	1.58	25249.40
8	C 152 × IC 257425 (F_9)	1,282	1,647	1,851	1,449	1,558	-0.56	62388.24*
9	C 152 × IC 202864 (F_{10})	1,385	1,672	1,118	1,965	1,535	2.41*	-16047.3
10	IC97838 (Germplasm)	1,461	1,647	1,056	1,975	1,535	2.47	-5031.89
11	C 152 × Goa local (F_7)	1,551	1,531	1,507	1,543	1,533	0.07**	-17433.55
12	DC 15 × CPD 118 (F_6)	1,927	1,648	1,375	1,117	1,517	-1.1	123885.39**
13	V 118 × IC 257437 (F_7)	1,646	1,780	1,211	1,383	1,505	0.44	73953.75**
14	Bailhongal local × C 152 (BC_1F_6)	1,331	1,623	917	2,128	1,500	3.33*	-7145.1
15	C 152 × IC 202860 (F_6)	1,210	1,612	1,347	1,815	1,496	1.64	382.02
16	DC 15 × Goa local (F_6)	1,441	1,463	1,472	1,499	1,469	0.10	-17317.81
17	C 152 × IC 202863 (F_{10})	1,312	1,605	889	1,970	1,444	2.99*	-7910.07
18	IC259106	697	1,542	1,167	2,152	1,389	3.49	131119.51**
19	V 118 × IC 257425-1 (F_9)	1,577	1,793	857	1,217	1,361	0.93	206329.91**
20	C 152 × IC 257425 (F_6)	1,201	964	1,472	1,667	1,326	0.37	119323.60**
21	Bailhongal local × IC 202710 (BC_1F_6)	1,150	1,462	943	1,741	1,324	2.32**	-17623.82
22	IC202702 (Germplasm)	1,535	1,193	921	1,396	1,261	0.76	69398.65**
23	V 118 × IC 257425-2 (F_9)	1,315	1,278	840	1,525	1,239	1.63	15814.6
24	IC 202823× IC 219550 (F_7)	844	1,362	879	1,726	1,203	2.7	-2070.84
25	GC 3 × IC 202718 (F_5)	1,383	1,538	986	877	1,196	-0.27	12884650.00**
26	C 152 × Goa local (F_5)	893	1,363	965	1,560	1,196	2.01	-3478.96
27	C 152 × IC 202711 (F_6)	543	1,141	1,763	1,306	1,188	-0.3	360633.21**
28	IC249133 (Germplasm)	1,232	1,075	911	1,444	1,166	1.16	13350.65
29	DCS 47-1 × DC 15-2 (F_6)	1,636	1,254	1,113	546	1,137	-1.99	152877.97**
30	IC257445 (Germplasm)	752	1,280	785	1,658	1,119	2.79	-1501.1
	Checks							
1	DC-15	1,604	1,798	1,833	1,805	1,760	0.17	-2278.53
2	DCS 47-1	1,488	1,533	1,521	1,562	1,526	0.16*	-17306.5
	Mean	**1,377**	**1,521**	**1,300**	**1,639**			
	S. Em. ±	241.95	170.17	184.15	147.77			
	C. D.	493.46	347.07	375.58	301.39			
	C. V. (%)	17.57	11.18	14.16	9.02			

Population Mean – **1459**

bi -Regression coefficient

S^2di - Mean square deviation from regression

* - Significant at 5% level of significance

** - Significant at 1 % level of significance

The genotype DC15 × DCS 47-1-1 (F_6) (1920 kg ha^{-1}) being stable across four environments also gave 9% more seed yield than the superior check DC-15 (1760 kg ha^{-1}) which can be further tested in multi locations, to confirm its superiority.

Number of pods per plant

The stability parameters (x, b_i and S^2d_i) of the individual genotypes are illustrated in table 4. Seventeen genotypes out of thirty-two registered highest number of pods per plant as compared to the population mean (16.37). Only two genotypes showed b_i values significantly different from unity. The S^2d_i was found significantly different from zero in the 17 genotypeswhile, in other genotypes it was found non-significant. The progenies of the crosses namely, DC 15 × Goa local (F_6), V 118 × IC 257425-2 (F_9), Bailhongal local× C 152 (BC_1F_6) and check DCS 47-1 exhibited average stability across environments with predictable performance. Whereas, the genotypes Bailhongal local × IC 202710 (BC_1F_6) and C 152 × IC 202872 (F_7) reported above average stability and are well adapted to poor environment. While, the genotypes namely, DC 15 × DCS 47-1-2 (F_6) revealed below average stability with suitability to favorable environment. The lines,DC15 × DCS 47-1-1 (F_6), DCS 47-1 × DC 15-1 (F_6), DC 15 × C 152 (F_6), C 152 × IC 202864 (F_{10}), C 152 × Goa local (F_5), IC202702, V 118 × Goa local (F_7), IC97838, GC 3 × CPD 115 (F_6), DCS 47-1 × DC 15-2 (F_6), IC257445, and check DC 15 possessed high mean accompanied with significant S^2d_i value and therefore, its performance was unpredictable in nature under changing environment. Similar results were also obtained by Pandey (2009) and Patel and Jain (2012).

Pod length

The stability parameters (x, b_i and S^2d_i) of the individual genotypes are illustrated in table 5. Among the genotypes tested, 19 genotypes exhibited longest pods than the population mean (15.94). The regression coefficient (b_i) was found non-significantly different from unity for all the genotypes except for genotypes, IC 249133, C 152 × IC 257425 (F_9), C 152 × Goa local (F_5) and V 118 × IC 257425-2 (F_9). Whereas, the deviation from regression (S^2d_i) was found significantly different from zero for 10 genotypes while, in other genotypes it was found non-significant (table 5). Only two genotypes namely, V 118 × IC 257425-2 (F_9) and check DCS 47-1 revealed the average stability across the environments with predictable performance. The genotypes *viz*., DC 15 × DCS 47-1-2 (F_6), IC202702, C 152 × IC 202860 (F_6), C 152 × Goa local (F_7), and DCS 47-1 × DC 15-2 (F_6) exhibited below average stability and adaptability to favorable environments. However, the genotypes which exhibited above average stability and adaptation to poor environment were C 152 × IC 202863 (F_{10}), DC 15 × Goa local (F_6), DC 15 × C 152(F_6), GC 3 × IC 202718 (F_5), DC 15 × CPD 118 (F_6) and check DC 15. While, the performance of DC15 × DCS 47-1-1 (F_6) cannot be predicted under changing environment as indicated by significant deviation from the regression coefficient even though they exhibited higher mean values. Trambadia (2006) and Chaudhari *et al*. (2013) also had the same opinion regarding pod length.

Hundred seed weight

The stability parameters (x, b_i and S^2d_i) of the individual genotypes are illustrated in table 6. As far as hundred seed weight is concerned, 17 genotypes recorded highest mean test weight in comparison with the population mean (11.97 g). The regression coefficient (b_i) was found non significantly different from unity for all the genotypes except for the F_7 line V 118 × Goa local. Similarly, the deviation from regression (S^2d_i) was found non significantly different from zero for all the genotypes except for the lines V 118 × IC 257425 (F_9), IC 202823 × IC 219550 (F_7) and C 152 × IC 257425 (F_9).It appears that the lines namely, IC202702, DC15 × DCS 47-1-1(F_6), C 152 × IC 202864 (F_{10}), C 152 × IC 257425-2 (F_6), DC 15 × C 152 (F_6) and C 152 × IC 202860 (F_6), exhibited better adaptability to all the four environments. Whereas, IC259106, C 152 × Goa local (F_5), IC249133, DCS 47-1 × DC 15-1 (F_6), C 152 × IC 202711 (F_6), C 152 × IC 202863 (F_{10}), and DCS 47-1 (Check) revealed below average stability with suitability to favourable environment. While, the lines namely, DCS 47-1 × DC 15-2 (F_6), DC 15 × DCS 47-1-2 (F_6), C 152 × IC 202872 (F_7), GC 3 × CPD 115 (F_6) and DC 15 (Check) found above averagely stable and were well adapted to poor environment. Whereas, only one line, V 118 × IC 257425-2 (F_9) exhibited higher mean values with unpredictable performance. These results were in line with the findings of Sarvamangala *et al*. (2010) and Chaudhari *et al*. (2013).

The present study revealed that, the F_6 progenies of cross, DC 15 × DCS 47-1-1, C 152 × IC 202860 and C 152 × IC 202872 (F_7) were identified to be well adapted to all the environments, they should be further analyzed for stability over seasons, locations and extensively used in breeding programmes to develop high yielding and stable varieties of cowpea. The genotypes such as DC 15 × DCS 47-1-2 (F_6) and DC 15 × C 152 (F_6) were observed to be specifically adoptable to paddy fallow situations (Mugad and Malagi). Hence, suitability of the above crosses should be further confirmed by repeated

Table 4 : Stability parameters among the promising lines in terms of number of pods per plant across the four different environments.

S. no.	Genotype	Number of pods per plant					b_i	S^2d_i
		Dharwad *kharif*, 2016	Mugad *rabi*-summer, 2017	Malagi *rabi*-summer, 2017	Dharwad summer, 2017	Grand mean		
1	DC15 × DCS 47-1-1(F_6)	21.50	19.00	19.10	22.50	20.53	1.62	2.35*
2	DCS 47-1 × DC 15-1 (F_6)	20.30	21.40	18.00	22.00	20.43	2.90	2.42*
3	DC 15 × DCS 47-1-2 (F_6)	20.50	20.20	18.00	21.00	19.93	1.99	-0.12
4	DC 15 × C 152 (F_6)	18.70	19.21	20.50	17.00	19.30	-2.61	6.38**
5	C 152 × IC 202864 (F_{10})	20.30	17.90	15.60	21.00	18.70	3.53	1.94*
6	C 152 × Goa local (F_5)	21.10	19.30	18.00	16.00	18.60	1.70	4.72**
7	IC202702 (Germplasm)	21.50	15.70	17.80	17.00	18.00	1.82	6.86**
8	C 152 × IC 202711 (F_6)	16.00	18.00	21.20	16.00	17.80	-3.89*	0.56
9	C 152 × IC 202872 (F_7)	17.90	15.80	17.00	19.00	17.43	0.23	1.09
10	DC 15 × Goa local (F_6)	17.10	17.40	16.00	18.00	17.13	0.99	-0.17
11	V 118 × Goa local (F_7)	20.10	15.60	14.20	18.50	17.10	1.00	1.86*
12	Bailhongal local × IC 202710 (BC_1F_6)	16.20	18.40	16.20	17.50	17.08	0.37	0.94
13	IC97838 (Germplasm)	18.60	15.30	13.60	20.00	16.88	3.75	5.05**
14	GC 3 × CPD 115 (F_6)	15.10	16.60	20.00	15.50	16.80	2.64	1.51*
15	DCS 47-1 × DC 15-2 (F_6)	18.50	16.50	17.40	14.50	16.73	0.22	3.55**
16	IC257445 (Germplasm)	15.10	17.80	21.20	12.50	16.65	-4.81	8.25**
17	Bailhongal local × C 152 (BC_1F_6)	17.00	16.40	16.10	17.00	16.63	0.64	-0.63
18	V 118 × IC 257425-1 (F_9)	15.80	17.60	15.10	17.00	16.38	0.87	0.81
19	DC 15 × CPD 118 (F_6)	19.50	15.30	14.00	16.50	16.33	1.85	-0.33
20	V 118 × IC 257437 (F_7)	15.00	17.20	14.00	16.50	15.68	1.18	1.69*
21	C 152 × IC 202863 (F_{10})	15.60	15.50	12.80	18.50	15.60	2.51	4.17**
22	V 118 × IC 257425(F_9)	17.00	14.20	11.80	17.00	15.00	3.81	1.29
23	C 152 × IC 257425 (F_6)	14.50	10.20	16.20	14.50	13.85	-1.79	7.47**
24	C 152 × Goa local (F_7)	11.90	15.40	16.10	11.90	13.83	-2.94	2.36*
25	IC249133 (Germplasm)	16.30	13.20	10.00	13.00	13.13	4.28*	-0.2
26	C 152 × IC 257425 (F_9)	14.20	13.60	11.40	13.00	13.05	2.01	-0.63
27	IC 202823 × IC 219550 (F_7)	15.50	14.10	9.60	12.00	12.80	4.13	0.48
28	IC259106 (Germplasm)	8.00	12.30	13.20	17.50	12.75	-3.11	3.31**
29	C 152 × IC 202860 (F_6)	11.80	12.90	10.10	10.00	11.20	1.26	1.41
30	GC 3 × IC 202718 (F_5)	11.70	9.90	10.40	12.00	11.00	0.86	0.42
	Checks							
1	DC-15	20.50	20.50	20.40	15.50	19.23	0.84	14.22**
2	DCS 47-1	20.00	18.20	19.00	18.50	18.93	1.07	1.26
	Mean	**16.96**	**16.27**	**15.75**	**16.51**	**16.37**		
	S. Em. ±	0.89	1.10	1.07	1.67			
	C. D.	1.80	2.26	2.17	3.40			
	C. V. (%)	5.29	6.82	6.95	10.26			

Population Mean – **16.37**

bi -Regression coefficient S^2di - Mean square deviation from regression

* - Significant at 5 % level of significance, ** - Significant at 1 % level of significance.

Table 5 : Stability parameters among the promising lines in terms of pod length (cm) across the four different environments.

S. no.	Genotype	Pod length (cm)					b_i	S^2d_i
		Dharwad *kharif*, 2016	Mugad *rabi*-summer, 2017	Malagi *rabi*-summer, 2017	Dharwad summer, 2017	Grand mean		
1	C 152 × IC 202860 (F_6)	17.35	15.65	18.60	16.49	17.02	7.38	-0.32
2	DC15 × DCS 47-1-1(F_6)	17.02	16.86	15.30	18.83	17.00	-4.76	1.52*
3	DC 15 × C 152 (F_6)	17.21	17.15	17.80	15.65	16.95	-4.48	0.11
4	DC 15 × DCS 47-1-2 (F_6)	17.92	15.20	16.80	17.06	16.75	2.82	1.03
5	C 152 × IC 202872 (F_7)	16.18	15.38	18.20	16.50	16.57	8.59	8.68**
6	IC202702 (Germplasm)	15.70	15.90	18.10	16.26	16.49	6.28	-0.31
7	IC259106 (Germplasm)	15.62	16.58	17.57	16.00	16.44	4.33	7.09**
8	C 152 × Goa local (F_7)	16.39	16.54	17.33	15.08	16.34	2.67	0.43
9	DC 15 × Goa local (F_6)	15.93	16.52	14.48	17.80	16.18	-5.83	0.94
10	GC 3 × IC 202718 (F_5)	16.78	17.20	15.08	15.62	16.17	-5.47	-0.29
11	IC249133 (Germplasm)	16.02	14.70	18.20	15.59	16.13	9.12*	-0.50
12	DCS 47-1 × DC 15-1 (F_6)	15.35	14.69	16.56	17.80	16.10	-3.37	-0.16
13	C 152 × IC 257425 (F_9)	14.89	17.10	17.50	14.67	16.04	10.45**	-0.53
14	C 152 × Goa local (F_5)	15.30	14.62	18.30	15.86	16.02	9.88*	-0.50
15	DCS 47-1 × DC 15-2 (F_6)	15.99	15.77	16.79	15.53	16.02	2.86	-0.46
16	V 118 × IC 257425-2 (F_9)	17.34	14.40	15.43	16.67	15.96	0.99	1.93
17	DC 15 × CPD 118 (F_6)	16.95	16.32	16.04	14.43	15.94	-0.42	0.72
18	C 152 × IC 202863 (F_{10})	16.70	15.50	14.18	17.15	15.88	-4.73	1.20
19	GC 3 × CPD 115 (F_6)	16.51	16.21	15.20	14.89	15.70	-2.71	0.03
20	C 152 × IC 202864 (F_{10})	16.61	17.38	14.20	14.62	15.70	-8.04	0.44
21	V 118 × Goa local (F_7)	16.26	15.08	13.66	17.75	15.69	-5.24	2.87**
22	V 118 × IC 257437 (F_7)	13.70	17.06	15.69	15.94	15.60	-2.02	2.18*
23	IC257445 (Germplasm)	16.43	13.20	16.00	16.70	15.58	5.60	2.10*
24	Bailhongal local × C 152 (BC_1F_6)	13.62	15.52	16.56	16.62	15.58	4.08	1.13
25	C 152 × IC 202711 (F_6)	16.47	12.00	15.65	16.98	15.28	7.08	5.07**
26	IC97838 (Germplasm)	14.11	15.20	17.10	14.63	15.26	6.07	0.53
27	Bailhongal local × IC 202710 (BC_1F_6)	13.28	17.33	14.10	15.20	14.98	-6.74	2.25*
28	V 118 × IC 257425-2 (F_9)	14.57	16.54	12.92	15.58	14.90	-9.15*	-0.23
29	IC 202823 × IC 219550 (F_7)	11.92	14.69	16.56	15.50	14.67	6.47	3.70**
30	C 152 × IC 257425 (F_6)	12.83	13.10	14.75	16.64	14.33	4.00	3.42**
	Checks							
1	DC-15	16.73	17.06	15.37	16.70	16.47	-4.69	-0.40
2	DCS 47-1	15.61	17.10	17.11	15.93	16.44	1.01	0.28
	Mean	**15.73**	**15.74**	**16.16**	**16.15**	**15.94**		
	S. Em. ±	1.31	1.06	0.94	0.92			
	C. D.	2.68	2.17	1.92	1.88			
	C. V. (%)	8.36	6.82	5.90	5.88			

Population Mean – **15.94**

bi -Regression coefficient

S^2di - Mean square deviation from regression.

* - Significant at 5 % level of significance

** - Significant at 1 % level of significance regression.

Table 6 : Stability parameters among the promising lines with respect to hundred seed weight (g) across the four different environments.

S. no.	Genotype	Hundred seed weight (g)					b_i	S^2d_i
		Dharwad *kharif*, 2016	Mugad *rabi*-summer, 2017	Malagi *rabi*-summer, 2017	Dharwad summer, 2017	Grand mean		
1	V 118 × IC 257425-2 (F_9)	14.45	13.60	13.38	14.00	13.86	-1.42	0.88*
2	IC202702 (Germplasm)	13.09	14.11	12.95	13.25	13.35	1.45	-0.09
3	DCS 47-1 × DC 15-2 (F_6)	12.99	13.00	13.68	13.07	13.19	0.19	0.30
4	IC259106 (Germplasm)	12.00	13.40	12.85	12.60	12.71	2.11	-0.25
5	DC15 × DCS 47-1-1(F_6)	13.50	12.30	12.50	11.93	12.56	1.13	-0.25
6	C 152 × Goa local (F_5)	10.70	14.10	13.55	11.55	12.48	5.72	0.05
7	IC249133 (Germplasm)	11.50	13.30	12.65	12.35	12.45	2.69	-0.22
18	DCS 47-1 × DC 15-1 (F_6)	10.75	13.20	13.15	12.50	12.40	1.62	-0.25
8	V 118 × Goa local (F_7)	11.65	13.40	12.50	11.90	12.36	2.85*	-0.24
10	DC 15 × DCS 47-1-2 (F_6)	12.25	12.10	12.50	12.50	12.34	-0.07	-0.16
9	C 152 × IC 202872 (F_7)	12.35	12.40	12.15	12.30	12.30	0.04	0.04
25	GC 3 × CPD 115 (F_6)	11.10	13.50	13.35	10.95	12.23	0.04	-0.19
11	C 152 × IC 202864 (F_{10})	12.35	12.50	12.20	11.50	12.14	0.64	-0.01
12	C 152 × IC 257425 (F_6)	12.25	12.60	12.25	11.40	12.13	1.00	0.02
13	C 152 × IC 202711 (F_6)	12.10	12.50	13.05	10.75	12.10	1.65	-0.09
14	DC 15 × C 152 (F_6)	12.50	12.30	11.90	11.65	12.09	0.56	-0.19
15	C 152 × IC 202860 (F_6)	12.20	12.50	12.30	11.15	12.04	1.06	0.16
16	C 152 × IC 202863 (F_{10})	11.55	12.50	12.55	11.35	11.99	1.90	-0.07
17	DC 15 × Goa local (F_6)	11.40	12.60	11.50	12.30	11.95	1.40	-0.05
19	DC 15 × CPD 118 (F_6)	12.80	11.10	11.10	12.20	11.80	-0.20	0.53
20	GC 3 × IC 202718 (F_5)	11.40	11.70	11.70	11.70	11.63	0.40	-0.15
21	C 152 × Goa local (F_7)	12.05	11.50	11.85	11.00	11.60	-0.35	0.05
22	IC 202823 × IC 219550 (F_7)	11.65	12.20	12.00	10.25	11.53	1.72	0.57*
23	IC97838 (Germplasm)	10.87	11.70	11.35	11.85	11.44	0.91	-0.07
24	V 118 × IC 257437 (F_7)	10.55	11.70	11.35	11.10	11.18	1.74	-0.24
26	C 152 × IC 257425 (F_9)	10.50	10.40	10.25	12.25	10.85	-1.18	0.91*
27	Bailhongal local × C 152 (BC_1F_6)	10.25	10.60	10.45	11.80	10.78	0.31	-0.10
28	IC257445 (Germplasm)	9.85	10.70	10.55	11.65	10.69	0.57	0.53
29	V 118 × IC 257425-1 (F_9)	10.20	10.80	10.25	11.45	10.68	0.27	0.24
30	Bailhongal local × IC 202710 (BC_1F_6)	10.15	10.70	10.65	10.25	10.44	0.95	-0.25
	Checks							
1	DC-15	12.38	12.50	11.55	12.50	12.23	-0.14	0.05
2	DCS 47-1	12.20	11.20	11.35	12.05	11.70	2.37	-0.16
	Mean	**11.70**	**12.30**	**12.08**	**11.82**	**11.97**		
	S. Em. ±	0.79	0.73	0.75	0.60			
	C. D.	1.62	1.49	1.54	1.23			
	C. V. (%)	6.85	6.00	6.32	5.17			

Population Mean – **11.97**

bi -Regression coefficient

S^2di - Mean square deviation from regression

* - Significant at 5 % level of significance,

** - Significant at 1 % level of significance.

testing and can be recommended to farmers for cultivation in the paddy fallows during *rabi*-summer season.

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