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COMPONENT COMPENSATION FOR STABILITY OF YIELD IN URAD BEAN AT HIGH ALTITUDES

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ABSTRACT

Nineteen diverse and elite strains/cultivars of urad bean were studied at three locations of Himachal Pradesh representing middle and lower hill regions of the state to characterise the stability of yield and its components. JU 78–3 was the most stable variety with yield potential above the overall mean. High stability for pods/plant and seeds/pod conferred stability for yield on JU 78–3. All the five components varied in compensatory fashion to impart homeostasis to the final and complex character of yield.

Key words: Component compensation, yield, high altitude, urad bean.

Breeders aim at evolving varieties which may give maximum economic yield over different environments and show consistent performance. Productivity of a population is the function of its adaptability while the latter is a compromise of fitness (stability) and flexibility. Stability may, in fact, depend on holding certain morphological and physiological attributes steady and allowing others to vary, resulting in predictable genotype × environment (G × E) interaction for the ultimate trait, i.e. yield.

A population which can adjust its genotypic or phenotypic state in response to environmental fluctuations in such a way that it gives high and stable economic return can be termed well "buffered."

Grafius [1] emphasised that the study of individual yield components can lead to simplification in genetic explanation of yield stability and hence are valuable to breeders in prediction and determination of the environmental effects. The present study, therefore, aims to investigate the stability of component characters in relation with the stability of the ultimate trait of yield and also to analyse as to how the component characters interact to bring about stability of the end product.

MATERIALS AND METHODS

Nineteen diverse and elite strains/varieties of urad bean (*Vigna mungo* (L.) Hepper) originated in different agroclimates of India were grown at three diverse

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locations: Experimental Block of Himachal Pradesh Krishi Vishwavidyalaya, Palampur (representing midhill region of the state; altitude 1265 m, rainfall 2523 mm), Crop Research Station, Sunder Nagar (representing low-hill region of the state; altitude 900 m, rainfall 1170 mm), and Regional Research Station, Berthin (also representing low-hill region; altitude 785 m, rainfall 1125 mm). At each location, the material was planted in randomized complete block design with three replications with inter- and intrarow spacing of 30 and 10 cm, respectively.

The recommended package of practices were adopted to grow a good crop. Observations were recorded on 10 random plants for clusters/plant, pods/plant, pod length, seeds/pod, 100–seed weight, and grain yield/ha.

The data were first subjected to the analysis of variance to test the significance of genotypes × environment interaction. Various stability parameters (μ, β_i and $S^{-2}{}_d$) were estimated using the models proposed by Eberhart and Russell [2] and Perkins and Jinks [3].

RESULTS

JOINT REGRESSION ANALYSIS OF VARIANCE

The joint regression analysis (Table 1) showed that the genotype and environments differed significantly for all the characters, except seed weight. The genotype × environment interaction was also significant, showing that the phenotypic expression of the genotypes varied in different environments. The linear component of variation was highly significant, indicating that the differences among the regression coefficients pertaining to various genotypes on the environmental mean were real. However,

The joint regression analysis (Table 1) showed that the genotypes and environments

Table 1. Analysis of variance for six metric traits pooled over three environments

Source	d.f.	Mean sum of squares					
		grain yield	clusters plant	pods plant	pod length	seeds per pod	seed weight
Varieties	18	18.6**	16.5**	191.5**	0.8**	0.6**	0.1**
Environments/joint regression	2	216.2**	99.6**	1533.3**	0.9**	0.7**	7.9**
Varieties × environment	36	6.2**	5.6**	75.7**	0.1**	0.2**	0.1**
Env. + (var. × env.)	38	14.4**	10.5	152.4**	0.1*	0.2**	0.5**
Env. (linear)	1	432.3	199.2**	3066.5**	1.9**	1.4*	15.9**
Var. × env. (linear)/hetero. between regression	18	1.9	2.3	126.2	0.1	0.2	0.1
Pooled deviation	19	4.2	8.3	23.8	0.1	0.2	0.1
Remainder	18	4.5	8.8	25.7	0.1	0.2	0.1
Pooled error	162	2.6	2.1	26.6	0.1	0.1	0.1

*P = 0.05, **P = 0.01.

the variances due to pooled deviations were not significant, which indicated that the major component for differences in stability is due to the linear regression and not the deviation from the linear function.

ESTIMATION OF STABILITY PARAMETERS

The estimates of environmental additive effects, (IJ) and three stability parameters (μ, β_i and S^{-2}_d) of different cultivars for different characters are given in Table 2. The cultivars were classified into the following four classes of stability.

(A) *Absence of G × E Interaction.* The estimates of β_i and S^{-2}_d were nonsignificant, suggesting average stability and wider adaptability.

(B) *Presence of G × E Interaction.* (i) The major portion of G × E interaction was accounted for by the linear environmental change (significant β_i). This suggests that responsiveness of the cultivars and their performance can be predicted with some reliance over the environments. (ii) Same as under (i), but estimate of S^{-2}_d,

Table 2. Estimates of stability parameters based on two models for grain yield and clusters/plant under three environments (locations)

Genotype	Grain yield							Clusters/plant						
	Palampur	Sunder Nagar	Berthin	μ	β_i^E	β_i^P	$\bar{S}_d^2$	Palampur	Sunder Nagar	Berthin	μ	β_i^E	β_i^P	$\bar{S}_d^2$
UG 135	8.3	5.2	12.9	8.8	1.1	0.1	−1.8	12.1	14.8	14.3	13.7	0.5	−0.5	−3.8
JU 78–3	10.3	8.2	14.9	11.4	0.9	−0.1	−0.9	3.4	9.8	14.0	10.7	1.2	0.1	−2.7
H21-40-17	6.6	2.8	7.7	5.7	0.7	−0.3	−1.7	15.4	22.0	17.5*	18.3	0.6	−0.4	14.2**
K80-4-9	6.0	3.0	10.2	6.4	1.1	0.1	−2.1	12.2	10.5	17.5	13.4	1.1	0.1	9.9**
UG 170	10.6	5.2	14.4	10.0	1.4	0.4	−2.5	13.9	15.8	21.8	17.2	1.6	0.6	−0.2
BP 3	10.9	4.1	15.1	10.0	1.6	0.6	−2.1	13.2	16.5	18.5	16.1	1.2	0.2	−5.1**
UG 157	11.4	6.7	11.1	9.7	0.7	−0.3	0.9	14.2	12.5	20.5	15.7	1.3	0.3	13.9**
Pant U19	11.3	10.8	16.8	12.9	0.9	−0.1	2.3	9.9	12.0	16.3	12.7	1.4	0.4	−3.4*
Co 4	10.3	4.4	11.6	8.8	1.1	0.1	0.1	11.5	15.5	13.3	13.4	0.5	−0.5	0.9
JU 27	11.7	4.8	11.7	9.4	1.1	0.1	3.9*	10.3	16.0	15.5	13.9	1.2	0.2	−0.3
HPU 51	7.0	2.8	11.9	7.2	1.3	0.4	−2.3	8.6	14.5	11.3	11.5	0.7	−0.3	7.5**
PDU 2	12.1	4.3	11.7	9.4	1.1	0.1	7.1	14.7	17.3	14.8	15.6	0.1	−0.9	−0.8
H21-40-17	6.7	3.2	7.5	5.8	0.6	−0.4	−1.7	12.7	18.0	18.5	16.4	1.3	0.3	−2.6
Pant U26	8.5	9.9	15.1	11.2	0.8	−0.3	9.1**	10.6	10.3	13.3	11.4	0.5	−0.5	−2.8
T9	18.5	7.6	12.9	9.7	0.8	−0.2	−0.1	10.4	8.8	16.3	11.8	1.1	0.1	12.0**
Pant U30	11.1	10.8	15.6	12.5	0.7	−0.3	0.8	9.8	21.5	17.8	16.3	1.9	0.9	28.1**
Kulu 4	9.8	2.1	8.4	6.8	0.9	−0.1	9.4**	10.8	10.8	13.0	11.5	0.5	−0.5	−3.9**
PDU 1	9.8	9.8	19.2	12.9	1.4	0.4	14.5**	12.9	16.8	19.5	16.4	1.5	0.5	−5.1**
C 5-61-1	5.6	1.7	6.5	5.6	0.7	−0.3	−1.3	10.3	9.0	15.0	11.4	0.9	−0.1	5.6**
Mean	9.3	5.6	12.4	9.1	1.0	—	—	11.7	14.3	16.2	14.1	1.0	—	—
SE±	—	—	—	1.5	0.4	—	—	—	—	—	2.0	0.9	—	—
CD at 5%	—	—	—	2.9	10.9	—	—	—	—	—	4.0	1.8	—	—
CD at 1%	—	—	—	3.8	11.1	—	—	—	—	—	5.3	2.3	—	—
Ij	0.2	−3.6	3.3	—	—	—	—	−2.4	0.3	2.2	—	—	—	—

significant suggesting high G × E interaction. (iii) The major portion of G × E interaction was accounted for by the deviation mean squares from the expectation; the estimate of S^{-2}_d was significant, whereas that of β_i nonsignificant. It indicated high unpredictability of cultivars.

All the genotypes had b = 1 for grain yield, indicating average sensitivity. JU 27, PDU 2, Pant U 26, Kulu 4 and PDU 1 had significant nonlinear component, hence most unpredictable. The remaining genotypes did not show any G × E interaction as neither the regression nor the remainder mean square were significant, indicating more prevalance of predictable G × E interaction. JU 78–3, Pant U 19 and Pant U 30, in that order, were the stable varieties with the yield potential above the overall mean, unit regression coefficient and deviation from regression not significantly different from zero.

Thirteen genotypes showed nonsignificant genotype × environment interaction for clusters/plant (Table 2) as neither that linear nor nonlinear components of G ×

Table 3. Estimates of stability parameters based on two models for pods/plant and pod length under three environments (locations)

Genotype	Grain yield							Clusters/plant						
	Palampur	Sunder Nagar	Berthin	μ	β_i^E	β_i^P	$\bar{S}^2_d$	Palampur	Sunder Nagar	Berthin	μ	β_i^E	β_i^P	$\bar{S}^2_d$
UG 135	21.8	41.3	23.8	28.9	1.2	0.2	43.9	4.0	4.3	3.9	4.1	0.6	−0.4	−0.2
JU 78–3	20.5	25.0	26.5	23.9	0.2	−0.8	−31.2	4.3	4.3	3.9	4.2	0.7	−0.3	−0.2
H 21-40-17	27.2	79.3	28.8	45.1	3.3	2.3	06.3	4.7	5.0	4.2	4.6	1.8	0.9	−0.3
K 80-4-9	26.9	27.3	29.5	27.9	−0.1	−1.0	−42.8	4.1	4.0	3.9	4.0	0.2	−0.8	−0.3
UG 170	25.1	46.3	26.3	32.5	1.3	0.3	−39.9	4.3	4.3	3.4	3.9	2.1	1.1	0.3
BP 3	28.5	42.8	32.3	34.5	0.8	−0.2	−46.3	4.7	5.0	4.1	4.7	1.8	0.8	−0.03
UG 157	26.4	27.3	33.8	29.1	−0.1	−1.1	−15.8	4.0	4.5	4.1	4.2	0.7	−0.3	−0.04
Pant U19	19.8	32.3	32.0	28.0	0.5	−0.5	8.6	4.1	4.3	3.8	4.0	1.1	0.1	−0.03
Co 4	25.1	53.0	22.3	33.5	1.8	0.8	−0.7	4.3	4.8	4.2	4.4	1.3	0.3	0.01
JU 27	20.8	40.8	24.0	28.5	1.2	0.2	−46.1	4.4	4.5	4.1	4.3	1.1	0.1	−0.01
HPU 51	17.4	43.5	25.3	28.3	1.5	0.5	−45.9	6.6	6.0	6.5	6.4	−0.9	−1.9	0.08
PDU 2	33.8	45.5	26.8	35.3	0.9	−0.1	7.5	4.1	4.8	4.0	4.3	1.5	0.5	0.08
H21-40-17	29.5	57.5	24.0	36.9	1.9	0.9	31.2	4.5	4.8	4.4	4.6	0.7	−0.3	−0.02
Pant U26	21.2	30.8	22.5	24.4	0.6	−0.4	−46.3	4.1	4.5	3.9	4.2	1.4	0.4	−0.02
T 9	20.2	26.3	32.3	26.2	0.1	−0.9	22.8	4.0	4.5	3.8	4.2	1.2	0.2	0.01
Pant U30	30.5	57.8	27.3	35.2	0.2	1.2	−45.9	4.0	4.5	3.9	4.1	1.3	0.3	0.01
Kulu 4	23.5	26.0	24.0	24.5	0.2	−0.8	−46.6	4.5	4.5	4.3	4.4	0.6	−0.5	−0.03
PDU 1	26.0	50.5	35.0	37.2	1.4	0.4	−37.9	4.6	4.8	4.1	4.5	1.5	0.5	−0.03
C 5-61-1	21.5	26.5	29.0	25.7	0.2	−0.8	−21.4	4.9	4.3	4.2	4.5	0.5	−0.5	0.34
Mean	23.9	41.0	27.6	30.9	1.0	—	—	4.4	4.6	4.2	4.4	1.0	—	—
SE±	—	—	—	3.5	0.4	—	—	—	—	—	0.2	0.7	—	—
CD at 5%	—	—	—	6.8	0.8	—	—	—	—	—	0.3	1.4	—	—
CD at 1%	—	—	—	9.0	1.0	—	—	—	—	—	0.4	1.9	—	—
Ij	−6.9	10.1	−3.2	—	—	—	—	0.1	0.2	−0.2	—	—	—	—

Table 4. Estimates of stability parameters based on two models for seeds/pod and seed weight under three environments (locations)

Genotype	Grain yield							Clusters/plant						
	Palampur	Sunder Nagar	Berthin	μ	β_i^E	β_i^P	S_d^2	Palampur	Sunder Nagar	Berthin	μ	β_i^E	β_i^P	S_d^2
UG 135	6.2	6.3	6.8	6.4	0.7	−0.4	−0.2*	3.7	3.8	5.0	4.1	1.0	0.1	0.2**
JU 78-3	6.1	6.5	6.5	6.4	1.3	0.3	−0.3**	4.1	3.6	5.3	4.3	1.3	0.3	−0.1
H21-40-17	6.6	7.0	6.3	6.6	0.3	−0.7	−0.0**	4.3	3.6	4.6	4.2	0.8	−0.2	0.1**
K80-4-9	5.7	6.3	6.3	6.1	1.8	0.7	−0.3*	4.3	3.9	4.6	4.3	0.4	−0.5	−0.1**
UG 170	4.8	6.5	6.8	6.0	5.4†+	4.4++	−0.2	4.3	3.6	4.6	4.2	0.8	−0.2	0.1
BP 3	6.5	6.8	6.0	6.4	−0.1	−1.1	−0.1	3.5	3.8	4.8	4.0	0.9	−0.1	0.2**
UG 157	6.6	6.5	6.5	6.5	−0.2	−1.2	−0.3**	4.2	3.7	5.1	4.4	1.1	0.1	−0.1
Pant U 19	5.3	6.3	7.0	6.2	3.9	2.9	0.2	3.9	3.7	4.9	4.1	0.9	−0.1	−0.1
Co 4	5.7	6.5	6.8	6.3	2.8	1.8	−0.2	4.1	3.9	5.4	4.5	1.2	0.2	0.1
JU 27	6.5	6.3.	7.0	6.6	0.1	−0.9	−0.1	4.9	3.9	5.0	4.6	0.8	−0.2	0.2
HPU 51	7.7	6.3	8.3	8.1	1.6	0.6	−0.3**	4.5	3.3	4.8	4.2	1.0	0.1	0.2**
PDU 2	7.2	6.3	6.5	6.6	−2.5†	−3.5†	−0.1**	3.7	3.9	5.0	4.2	0.9	−0.1	0.2**
H 21-40-14	6.7	6.3	7.0	6.6	−0.4	−1.4	0.8**	4.4	3.7	5.1	4.4	1.1	0.1	−0.1
Pant U 26	5.9	6.8	5.3	5.9	0.8	−0.2	−0.1**	3.8	3.8	5.3	4.3	1.2	0.2	0.1**
T 9	5.6	6.8	6.0	6.1	2.6	1.6	−0.3**	4.1	4.1	5.1	4.4	0.9	−0.1	0.1
Pant U 30	5.9	6.3	6.0	6.0	0.9	−0.2	−0.3**	4.0	3.5	5.5	4.3	1.6	0.6	−0.1
Kulu 30	6.4	6.5	6.8	6.6	0.6	−0.4	−0.2	4.5	3.9	4.9	4.4	0.8	−0.2	−0.0
PDU 1	6.8	7.0	6.5	6.8	0.1	−0.9	−0.3**	4.9	4.1	5.5	4.9	1.0	0.1	0.0
C-5-61-1	6.3	6.3	6.0	6.2	−0.4	−1.4	−0.3**	4.8	3.6	5.1	4.5	1.9	0.1	0.2**
Mean	6.2	6.6	6.5	6.5	1.0	—	—	4.2	3.8	5.0	4.3	1.0	—	—
SE ±	—	—	—	0.3	1.6	—	—	—	—	—	0.2	0.4	—	—
CD at 5%	—	—	—	0.6	3.2	—	—	—	—	—	0.5	0.7	—	—
CD at 1%	—	—	—	0.8	4.2	—	—	—	—	—	0.6	0.9	—	—
Ij	−0.2	0.1	0.1	—	—	—	—	−0.1	−0.6	0.7	—	—	—	—

†, ++ Significantly deviating from unity at 5% and 1% levels, respectively.
*, **Significant against error M.S. at 5% and 1% levels, respectively.
E—Eberhart–Russell model, P—Perkins–Jinks model.

E interaction were significant. Thus, these genotypes had predictable performance. The remaining genotypes, H 21–40–17, K 80–4–9, UG 157, T 9, Pant U 30 and C 5–61–1, showed significant values of $S^{-2}{}_d$. None of them exhibited linear and predictable G × E interaction.

H 21–40–17 had significantly large number of clusters, but was unpredictable. BP 3, followed by PDU 1 and H 21–40–14, were the most stable varieties with the mean performance greater than overall mean, regression around unity and deviation from regression not significantly different from zero.

As regards pods/plant, eight genotypes did not exhibit any G × E interaction, as neither regression nor remainder mean squares (M. S.) were significant (Table

3), indicating predictable behaviour. JU 78-3, H 21-40-17, K 80-4-9, UG 157, CO 4, H 21-40-14, T 9, Pant U 30, Kulu 4 and C 5-64-1 exhibited significant regression M.S. and nonsignificant remainder M. S., exhibiting higher degree of linear and predictable G × E interaction. UG 135 had regression around unity, but was unpredictable. H 21-40-17 with significantly more number of pods was highly responsive to better environment. PDU 1, PDU 2, BP 3 and UG 170 had mean performance greater than the overall mean, regression around unity and deviation from regression not significantly different from zero, thus more stable.

In case of pod length (Table 3), 16 genotypes had predictable behaviour, as is evident from the nonsignificant values of β_i and $S^{-2}{}_d$. Genotype HPU 51 had the longest pod, significant negative regression effect, as well as high deviation from the regression with reliable predictability. PDU 2 and C 5-61-1 were unpredictable. Pant U 19 and JU 27 were stable varieties but poorly adapted to all the environmental conditions, as indicated by unit regression coefficient and mean slightly lower than population mean.

Six genotypes showed nonsignificant G × E interaction, the two estimates of sensitivity, β_i and $S^{-2}{}_d$ being nonsignificant, indicating average response and high predictability of genotypes for seeds/pod (Table 4). UG 170 and PDU 2 exhibited significant linear regression, whereas deviation from mean square was negligible, indicating higher and reliable predictability of these genotypes. Pant U 26 showed preponderance and significant estimate of nonlinear sensitivity, suggesting that the performance of this cultivar was unstable and unpredictable. JU 78-3 and U 30 were stable varieties but poorly adapted to all environmental conditions. HPU 51 recorded highest number of seeds/pod.

Except seven genotypes with significant $S^{-2}{}_d$ all the genotypes exhibited nonsignificant linear as well as nonlinear components of G × E interaction for seed weight and were predictable (Table 4). PDU 1 was the stable variety having boldest seeds, unit regression coefficient, and deviation from regression not significantly different from zero.

COMPARISON OF TWO STABILITY MODELS

In Table 2, b^E stands for regression coefficient as per the model of Eberhart and Russel [2] and β^P is the regression coefficient from the Perkins – Jinks model [3]. It is evident that the order of ranking of various genotypes both with respect to response (b) and stability was the same under both the models. This was expected because the latter model, being b^E–1, is in no way different from the former. Consequently, the ranking pattern of the genotypes under the Perkins–Jinks model will be similar to the pattern with the Eberhart–Russell model.

DISCUSSION

Any generalization regarding stability of a genotype for all the characters is too difficult. The genotypes studied did not exhibit uniform stability and response pattern for all characters. In general, two to three attributes appeared to be specific for individual characters of a given genotype. This may be explained on the basis of compromises and compensations among the developmental patterns of different characters. The available evidence [1, 4–7] suggests the importance of component compensation in imparting homeostasis for complex trait like yield.

Table 5. Stability attributes of urad bean genotypes for six traits

Character	Group A	Group B		
	absence of G × E interaction,	presence of G × E interaction		
	bi and $\bar{S}_d^2$ nonsignificant	linear, only bi significant	linear and non-linear, bi and $\bar{S}_d^2$ significant	nonlinear, only $\bar{S}_d^2$ significant
Grain yield	UG 135, JU 78–3, H 21-40-17, K 80-4-9, UG 170, BP 3, UG 157, Pant U 19, Co 4, JU 27, HPU 51, H 21-40-17, T 9, Pant U 30, C 5-61-1	—	—	PDU 2, Pant U 26, Kulu 4, PDU 1
Cluster/plant	UG 135, JU 78-3, UG 170, BP 3, Pant U 19, Co 4, JU 27, HPU 51, PDU 2, H 21-40-14, Pant U 26, Kulu 4, PDU 1	—	—	H 21-40-17, K 80-4-9, UG 157, T 9, Pant U 30, C 5-61-1
Pods/plant	UG 170, BP 3, Pant U 19, JU 27, HPU 51, PDU 2, Pant U 26, PDU 1	JU 78-3, H 21-40-17, K 80-4-9, UG 157, Co 4, H 21-40-14, T 9, Pant U 30, Kulu 4, C 5-61-1	—	UG 135
Pod length	UG 135, JU 78-3, H 21-40-17, K 80-4-9, UG 170, BP 3, UG 157, Pant U 19, T 9, Pant U 30, Kulu 4, PDU 1	—	HPU 51	PDU 2, C 5-61-1
Seeds/pod	UG 135, JU 78-3, H 21-40-17, K 80-4-9, BP 3, UG 157, Pant U 19, Co 4, JU 27, HPU 51, H 21-40-14, T 9, Pant U 30, Kulu 4, PDU 1,, C 5-61-1	UG 170, PDU 2	—	Pant U 26
Seed weight	JU 78-3, H 21-40-17, K 80-4-9, UG 170, UG 157, Pant U 19, Co 4, H 21-40-14, T 9, Pant U 30, Kulu 4, PDU 1	—	—	UG 135, BP 3, JU 27, HPU 51, PDU 2, Pant U 26, C 5-61-1

A critical appraisal of the stability and productivity of various predictable genotypes for yield revealed interesting information regarding the relative importance of stability of the component characters in imparting stability to yield (Table 5, 6). JU 78–3, H 21–40–17, K 80–4–9, UG 157, T 9 and Pant U 30, the predictable genotypes for yield, did not show any G × E interaction for pod length, seeds/pod and seed weight, and below average responsiveness for pods/plant and clusters/plant.

Table 6. Stability of yield in relation to component traits and among the components

Grain yield		Clusters/plant		Pods/plant		Pod length		Seeds/pod		Seed weight	
predictable genotype	stability in other traits	predictable genotype	stability in other traits	predictable genotype	stability in other traits	predictable genotype	stability in other traits	predictable genotype	stability in other traits	predictable genotype	stability in other traits
UG 135	2,4,5	UG 135	4,5	UG 170	2,4,6	UG 135	2,5	UG 135	2,4	JU 78-3	3,2,4,5
JU 78-3	4,5,6	JU 78-3	4,5,6	BP 3	2,5	JU 78-3	2,5,6	JU 78-3	2,4,6	H21-40-17	4,5
H21-40-17	4,5,6	UG 170	4,6	Pant U 19	2,4,5,6	H21-40-17	5,6	H21-40-17	4-6	K80-4-9	4,5
K80-4-9	4,5,6	BP 3	3,4,5	JU 27	2,4,5	K80-4-9	5,6	K80-4-9	4-6	UG 170	2,3,4
UG 170	2,3,6	Pant U 19	3,4,5,6	HPU 51	2,5	UG 170	2,3,6	BP 3	2,3,4	UG 157	4,5
BP 3	2,3,4,5	Co 4	4,5,6	PDU 2	2	BP 2	2,3,5	UG 157	4,6	Pant U 19	2,3,4,5
UG 157	4,5,6	JU 27	3,4,5	Pant U26	2,4	UG 157	5,6	Pant U 19	2,3,4,6	Co 4	2,4,5
Pant U199	2,3,4,5,6	HPU 51	3,5	PDU 1	2,4,5,6	Pant U19	2,3,5,6	Co 4	2,4,6	H21-40-14	2,4,5
Co 4	2,4,5,6	PDU 2	3	—	—	Co 4	2,5,6	JU 27	2,3,4	T 9	4,5
JU 27	2,3,4,5	H21-40-14	4,5,6	—	—	JU 27	2,3,5	HPU 51	2,3	Pant U30	4,5
HPU 51	2,3,5	Pant U26	3,4	—	—	H21-40-14	2,5,6	H21-40-14	2,4,6	Kulu 4	2,4,5
H21-40-17	—	Kulu 4	4,5,6	—	—	Pant U26	2,3	T 9	4,6	PDU 1	2,3,4,5
T 9	4,5,6	PDU 1	3,4,5,6	—	—	T 9	5,6	Pant U30	2,3	—	—
Pant U30	4,5,6	—	—	—	—	Kulu 4	2,5,6	PDU 1	4,6	—	—
C5-61-1	5	—	—	—	—	PDU 1	2,3,5,6	C5-61-1	—	—	—

Characters: 2) clusters/plant, 3) pods/plant, 4) pod length, 5) seeds/pod and 6) seed weight.

The stability of UG 135, UG 170, BP 3, Pant U 19, Co 4, JU 27, and HPU 51 was primarily due to higher stability for clusters/plant, besides the stability for other yield components. UG 135, BP 3 and JU 27 had below average number of seeds/pod. Among all the cultivars, which were unstable for yield, most component characters exhibited high and unpredictable G × E interactions. Stability in yield components revealed that the varieties stable for a particular trait also had stability for other components either singly or jointly. Stability for pods/plant in all the cultivars was mainly due to the number of clusters/plant. Stability in cultivars for clusters/plant was primarily because of pod length and seeds/pod. The predictable genotypes for seed weight did not exhibit G × E interaction for pod length and seeds/pod. Similar behaviour was observed for other traits also. Bradshaw [6] suggested that maximum fitness can be obtained by adjustment in the plastic component traits. In a homeostatically buffered population, expression of the component traits may shift in a compensating manner in the changing environment in order to perform well for the final trait, otherwise high unpredictable G × E interaction would result. Bains and Gupta [7] in wheat observed that highly buffered populations for yield were poor or average in buffering ability for the component traits, whereas the reverse was true for low buffered populations. In the present study, it seems that the stability of component traits varies in a compensating manner in different cultivars and ultimately confers homeostasis for yield.

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