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Analysis of Quantitative and Qualitative G x E interaction in Mothbean [*Vigna acconitifolia* (Jacq.)] in the Hot -Arid Climate of Rajasthan, India

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ABSTRACT

The analysis of quantitative and qualitative G x E interaction was done in thirty six accessions of mothbean by conducting the experiments in six seasons *i.e. Summer* and *kharif* of the year 2014, 2015 and 2016 for nine quantitative traits and data were subjected to regression analysis and also the analysis to detect the presence of quantitative and qualitative G x E interactions. Ten accessions IC 39668, IC 39681, IC 39702, IC 370469, IC 402287, IC 472158, IC 39675, IC 39817, IC 39678 and IC 415164 were identified to be promising using regression analysis, whereas nine accessions IC 39806, IC 402288, IC 39817, IC 39683, IC 370476, IC 415152, IC 36510, IC 39678 and IC 39686 against standard check RMO 40 were identified as potential ones by using quantitative and qualitative G x E interaction concept. Of these accessions IC 39817 and IC 39678 have been identified as high yielding accessions having specific adaptability and responsiveness to specific environment both by regression analysis and quantitative and qualitative interactions concept.

Introduction

Mothbean [*Vigna aconitifolia* (Jacq.)] is a very hardy and drought tolerance legume crop. It is grown during *kharif* season in the arid zone. The productivity of mothbean in the hot-arid climate has always not been low it may be because of non-availability of high yielding varieties and poor management practices as this crop is grown on generally marginal lands. Because of small flower size, the breeding of mothbean is not easy therefore, efforts of breeders have on selection. National Bureau of Plant Genetic Resources has good collection of germplasm of mothbean therefore efforts have been to identify a suitable accession that can replace the existing varieties of the mothbean. Since mothbean is a hardy crop with inbuilt genetic resistance to drought tolerance therefore, it may be cultivated during s*ummer* season with minimum application of irrigation. There is a need to develop a variety separately for the *summer* season so in the present study a set of 36 accessions of mothbean germplasm has been evaluated during kharif an summer seasons to identify a suitable and stable accession for both season or a season specific accession using regression and qualitative and quantitative G x E interaction. To enhance productivity and production of moth bean it is advocated that breeders should look for environment specific varieties which are capable of giving high yield. This becomes more important in case of arid grain legumes to breed for their responsiveness to specific environment. Keeping in view the above, the present investigation was carried out over years during *Summer* and *kharif* seasons in the hot- arid climate of Rajasthan to identify season specific accessions in mothbean using regression analysis (Eberhart and Russell, 1966 and Perkins and Jinks, 1968) and cross and qualitative interactions concept (Gail and Simon, 1985). Earlier information on this aspect in mothbean germplasm is not available.

Materials and Methods

Thirty six diverse accessions collected in different years from different place from India and received from abroad also along with best performing local checks *i.e*. RMO 40, Jadia and Jwala were evaluated in a randomized block design with three replications over three years *i.e* 2014. 2015 and 2016 during *summer* and *kharif* seasons at Regional Station of National Bureau of Plant Genetic Resources, Jodhpur. Thus, evaluation was done broadly in six environments. In each environment plots consisted of four rows of 3 m length with row to row and plant to plant distances of 30 and 10 cm., respectively. Recommended doses of P_2O_5 @ 25 kg /ha and N_2 @ 15 kg/ha were also applied at the time of sowing. Recommended packages and practices were followed to raise good crop. The data were recorded on five randomly taken plants from middle rows of each plot in each environment on seed yield/plant (g), biological yield/plant (g), harvest index (direct values were used for statistical analysis), number of seeds/pod (average of 10 randomly taken pods from each plant), number of pods per plant, number of branches per plant, number of clusters per plant, number of pod per clusters and 100-seed weight (g) and data were analyzed separately for each environment. Adjusted progeny means were used for the combined analysis and for the traits exhibiting the presence of G x E interaction. Regression analysis and analysis to detect the presence of quantitative and qualitative interactions were carried out as per Eberhart and Russell (1966), Perkins and Jinks (1968) and Gail and Simon (1985).

Results and Discussion

Analysis of variance revealed significant differences among accessions for the eight traits in all six seasons. The combined analysis revealed the presence of G x E interaction for seed yield/plant (g), biological yield/plant (g), harvest index (direct values were used for statistical analysis), number of seeds/pod (average of 10 randomly taken pods from each plant), number of pods per plant, number of branches per plant, number of clusters per plant, number of pod per clusters and 100-seed weight (g). Regression analysis enables breeders to select desirable accessions with respect to the responsiveness and stability in different environments. In the studied materials the accessions IC 39675, IC 39668, IC 39681, IC 39702, IC 370469, IC 402287, IC 472158, IC 415164 IC 39678 and IC 39817 had above average performance and responsiveness with respect to seed yield/plant using regression analysis (Table 1). Among these high yielding accessions IC 39675, IC 39668, IC 39681, IC 39702, IC 370469, IC 402287, IC 472158 and IC 415164 can be designated as stable ones with average responsiveness. Whereas, nine accessions IC 39806, IC 402288, IC 39817, IC 39683, IC 370476, IC 415152, IC 36510, IC 39678 and IC 39686 against standard check RMO 40 were identified as potential ones by using quantitative and qualitative G x E interaction concept. They were significantly higher yielder than RMO 40. Though the accessions

IC 39678 and IC 39817 are above average yielder and also have shown above average responsiveness coupled with instability. Accession IC 39678 during *kharif* 2015 and *kharif* 2016 and IC 39817 during *kharif* 2015 were highest yielder followed by IC 415164, IC 39675 IC 39668, IC 39681, IC 39702, IC 370469, IC 402287 and IC 472158. The accession IC 39678 showed above average performance alongwith instability for Seed yield per plant, biological yield/plant, 100-seed weight, number of cluster per plant, number of pods per plant and number of branches per plant being the best performance of this accession for these traits again in *kharif* 2015 and 2016 and accession IC 39817 showed above average performance along with instability for seed yield per plant, biological yield/plant, number of pods per cluster, number of cluster per plant, number of branches per plant and number of cluster per plant being the best performance of this accession for these traits again during *Kharif* 2015.

The regression technique describes the response pattern of individual accession without differentiating the kind of G x E interaction involving change in magnitude of response or direction among the accessions (Baker, 1988; and Virk and Mangat 19915). Baker (1988) described a test, which was initially proposed by Gail and Simon (1985) and illustrated its application to test the kind of interaction in crop plants. The concept of quantitative and qualitative interaction is important in decision making relating to crop improvement strategies (Baker, 1988), since the presence of quantitative interaction is substantial evidence in favour of breeding for specific adaptation to certain situations. Baker (1988) further suggested that in the absence of quantitative interaction there is little substance for argument in the favour of breeding for adaptation to specific environment. The accessions exhibiting quantitative interaction against a standard variety can be said to have specific adaptability and can replace that standard variety in the specific environments.

The existence of prior scientific basis to explain quantitative interaction is crucial (Peto, 1982). Thus, it is advantageous to define the varietal combinations among which one has to look for qualitative interaction in advance. There will be enormous multiplicity of all possible varietal pairs for detection of quantitative interaction if there is no prior basis for comparison. Such a practice will greatly increase the experiment-wise error rate. In the present case the new accessions were therefore, compared with the best check RMO 40 for detection of quantitative interaction since the aim was to find a suitable alternative to RMO 40.

The H (heterogeneity of response) and Q^+ and Q^- (for the presence of quantitative interaction) against the standard variety RMO 40 were estimated for all the 33 accessions for the traits exhibiting the presence of g x e interaction, *i.e.,* seed yield/plant (g), biological yield/plant (g), harvest index, number of seeds/pod, number of pods per plant, number of branches per plant, number of pods cluster per plant, number of pod per clusters and 100-seed weight (g) and their significance was tested (Baker, 1988). The accession exhibiting either significant H or Q^+ and Q^- are given in Table 2.

For seed yield/plant H was significant for the 33 accessions against RMO 40. The presence of quantitative interaction was observed for 24 accessions, IC 39709, IC 472243, IC 39806, IC 39629, IC 402288, IC 39639, IC 402285, IC 39817, IC 39683, IC 370476, IC 415152, EC 100065, EC 251877, EC 251878, IC 39676, IC 415104, IC 39678, EC 251897, IC 39686, EC 251891, EC 251895, IC 472148, G-492 and Jwala for seed yield/plant against RMO 40. The 22 accessions i.e. IC 472243, IC

39668, IC 39681, IC 39702, IC 370469, IC 402287, IC 402288, IC 472232, IC 39675, IC 39817, IC 415152, IC 415164, EC 100065, EC 251878, IC 39676, IC 415104, IC 39678, EC 251897, IC 39686, EC 251891, EC 251895 and IC 472148 exhibited the presence of quantitative interaction for biological yield/plant. The 26 accessions namely, IC 472243, IC 39806, IC 39668, IC 39629, IC 402288, IC 472158, IC 39639, IC 472232, IC 39675, IC 402285, IC 39683, IC 370476, IC 415152, IC 415164, EC 100065, EC 251908, EC 251878, IC 39676, IC 415104, EC 251890, IC 36510, EC 251897, IC 39686, EC 251891, EC 251895, IC 472148 exhibited the presence of quantitative G x E interaction for harvest index. The 23 accessions exhibited the presence of quantitative interaction for number of seeds per pod for the accessions namely, IC 472243, IC 39806, IC 39668, IC 39681, IC 39702, IC 370469, IC 39683, IC 370476, IC 415152, IC 415164, EC 100065, EC 251908, EC 251878, IC 39676, IC 415104, EC 251890, IC 36510, EC 251897, IC 39686, EC 251891, EC 251895, IC 472148. The presence of cross over interaction showed by the accessions IC 39806, IC 39668, IC 39681, IC 39702, IC 402288, IC 39639, IC 39675, IC 370476, IC 415152, EC 251908, EC 251878, IC 415104, EC 251890, IC 36510, IC 39678, EC 251897, IC 39686, EC 251891, EC 251895, IC 472148 for number of pods per plant.

Table.1 Heterogeneity (H) test of response for the comparison of mean seed yield/plant (g) against the standard variety RMO 40 along with Q^+ and Q^- values for quantitative interaction and adaptability parameters for the accessions.

Accession	Adaptability Parameters			Against RMO 40		
	$u+d_i$	$B_i \pm SE$	$\sigma^2 d_i$	H	Q^+	Q^-
IC 36510	9.02	0.28 ± 0.08	0.05	85.41#	69.35	34.39$
IC 39668	6.89	0.09* ± 0.14	0.09	31.39#	39.85	25.36
IC 39675	7.37	0.25* ± 0.19	0.06	43.95#	33.28	50.15
IC 39678	9.87	1.25* ± 0.21	0.38*	109.98#	70.85	45.09$
IC 39681	7.22	0.34* ± 0.34	0.19	66.38#	48.97	29.34
IC 39683	10.63	0.07* ± 0.17	0.03	33.28#	27.21	57.86$
IC 39686	9.48	0.32* ± 0.30	0.19*	84.99#	66.72	32.60$
IC 39702	6.93	0.48* ± 0.48	0.14	68.64#	38.14	27.98
IC 39806	9.60	-0.15* ± 0.21	0.14*	66.72#	37.82	22.65$
IC 39817	10.32	1.19* ± 0.44	0.59*	93.12#	53.78$	29.94
IC 370469	7.04	0.20* ± 0.18	0.14	54.62#	19.69	35.55
IC 370476	10.20	-0.36* ± 0.31	0.017*	33.46#	42.22	54.10$
IC 402287	6.90	0.59* ± 0.49	0.09	76.33#	58.36	69.28
IC 402288	9.75	-0.13* ± 0.23	0.11*	43.45#	32.21	51.47$
IC 415152	9.82	0.17* ± 0.15	0.10	42.98#	25.24$	26.95
IC 415164	7.15	0.33* ± 0.14	0.05	38.24#	31.18	40.61
IC 472158	6.88	-0.26* ± 0.27	0.08	42.53#	41.85	34.09
Grand Mean	**6.13 ± 0.74**					
RMO 40	**8.13 ± 1.33**					

• Significant at $P < 0.05$; # H was significant against x^2 0.05 at s-l df, where s is the number of environments. $ minimum of either Q^+ or Q^- was significant against "e" value given by Gail and Simon (1985).

Table.2 Accessions exhibiting significant *, #H (heterogeneity of response), and Q^+ and Q^- against standard variety RMO 40.

Characters	H	Q^+ and Q^-
Seed yield/plant (g)	All accessions except EC 251890 and IC 36510,	IC 39709, IC 472243, IC 39806, IC 39629, IC-402288, IC 39639, IC 402285, IC 39817, IC 39683, IC 370476, IC 415152, EC 100065, EC 251877, EC 251878, IC 39676, IC 415104, IC 39678, EC 251897, IC 39686, EC 251891, EC 251895, IC 472148, G-492 and Jwala. (24 accessions)
Biological yield/ plant (g)	All accessions except IC 402285, EC 251908, IC 39683	IC 472243, IC 39668, IC 39681, IC 39702, IC 370469, IC 402287, IC 402288, IC 472232, IC 39675, IC 39817, IC 415152, IC 415164, EC 100065, EC 251878, IC 39676, IC 415104, IC 39678, EC 251897, IC 39686, EC 251891, EC 251895 and IC 472148 (22 accessions)
Harvest index	All accessions except IC 39709, IC 472243, IC 39681, IC 39702, IC 370469, IC 402287	IC 472243, IC 39806, IC 39668, IC 39629, IC 402288, IC 472158, IC 39639, IC 472232, IC 39675, IC 402285, IC 39683, IC 370476, IC 415152, IC 415164, EC 100065, EC 251908, EC 251878, IC 39676, IC 415104, EC 251890, IC 36510, EC 251897, IC 39686, EC 251891, EC 251895, IC 472148 (26 accessions).
Number of seeds/pod	All accessions except IC 402287, IC 39629, IC 402288, IC 472158, IC 39639, IC 472232, IC 402285	IC 472243, IC 39806, IC 39668, IC 39681, IC 39702, IC 370469, IC 39683, IC 370476, IC 415152, IC 415164, EC 100065, EC 251908, EC 251878, IC 39676, IC 415104, EC 251890, IC 36510, EC 251897, IC 39686, EC 251891, EC 251895, IC 472148 and Jwala (23 accessions).
No. pods /plant	All accessions except IC 472243, EC 100065, IC 370469, IC 402287, IC 39629, IC 39683	IC 39806, IC 39668, IC 39681, IC 39702, IC 402288, IC 39639, IC 39675, IC 370476, IC 415152, EC 251908, EC 251878, IC 415104, EC 251890, IC 36510, IC 39678, EC 251897, IC 39686, EC 251891, EC 251895, IC 472148
No. of pods clusters per plant	IC 472232, IC 402285, IC 39683, IC 370476 EC 251897, IC 39686 IC 370469 EC 100065, EC 251908 and EC 251878	IC 472243, IC 39806, IC 39668, IC 39681, IC 39702, IC 402287, IC 39629, IC 402288, IC 472158, IC 39639, IC 415152, IC 415164, IC 39676, IC 415104, EC 251890, IC 36510, EC 251891, EC 251895, IC 472148 and Jwala (20 accessions).
No. of branches/	All accessions except	IC 39709, IC 39806, IC 39629, IC 402288,

plant	IC 472243, IC 39639 EC 251895	IC 472158, IC 472232, IC 402285, IC 39683, IC 370476, IC 415152, IC 415164, EC 100065, EC 251908, EC 251878, IC 39676, IC 415104, EC 251890, IC 36510, IC 39678, EC 251897, IC 39686, EC 251891 and G-492 (23 accessions)
No. of pods/ cluster	All accessions except IC 39675, IC 402285 IC 39629 IC 39639 EC 251895	IC 39709, IC 472243, IC 39806, IC 39668, IC 39681, IC 39702, IC 370469, IC 402287, IC 402288, IC 472158, IC 39817, IC 39683, IC 415152, IC 472243, EC 100065, EC 251908, EC 251878, IC 415104, EC 251890, IC 36510, EC 251897, IC 39686, EC 251891, IC 472148 (24 accessions)
100-seed weight (g)	All accessions except IC 39678, IC 39686, EC 251895	IC 39806, IC 39668, IC 39681, IC 39702, IC 370469, IC 402287, IC 39629, IC 402288, IC 472158, IC 39639, IC 472232, IC 39675, IC 402285, IC 39683, IC 370476, IC 415164, EC 100065, EC 251908, EC 251878, IC 39676, IC 415104, EC 251890 (22 accessions)

*H was significant against x^2 0.05 at s-l df, where s is the number of environments. # minimum of either Q^+ or Q^- was significant against "C" value given by Gail and Simmons (1985).

The 23 accessions had the presence of cross over interaction for number of branches per plant were IC 39709, IC 39806, IC 39629, IC 402288, IC 472158, IC 472232, IC 402285, IC 39683, IC 370476, IC 415152, IC 415164, EC 100065, EC 251908, EC 251878, IC 39676, IC 415104, EC 251890, IC 36510, IC 39678, EC 251897, IC 39686, EC 251891 and G-492. The 20 accessions IC 472243, IC 39806, IC 39668, IC 39681, IC 39702, IC 402287, IC 39629, IC 402288, IC 472158, IC 39639, IC 415152, IC 415164, IC 39676, IC 415104, EC 251890, IC 36510, EC 251891, EC 251895, IC 472148 and Jwala showed the presence of number of pods clusters per plant. The 24 accessions expressed the presence of cross over interaction namely IC 39709, IC 472243, IC 39806, IC 39668, IC 39681, IC 39702, IC 370469, IC 402287, IC 402288, IC 472158, IC 39817, IC 39683, IC 415152, IC 472243, EC 100065, EC 251908, EC 251878, IC 415104, EC 251890, IC 36510, EC 251897, IC 39686, EC 251891, IC 472148 (24 accessions) for number of pods per cluster. The 22 accessions IC 39806, IC 39668, IC 39681, IC 39702, IC 370469, IC 402287, IC 39629, IC 402288, IC 472158, IC 39639, IC 472232, IC 39675, IC 402285, IC 39683, IC 370476, IC 415164, EC 100065, EC 251908, EC 251878, IC 39676, IC 415104, EC 251890 showed the presence of cross over interaction for test weight.

However, most of the accessions expressed the presence of quantitative interaction but all accessions failed to exhibit quantitative interaction for all traits against RMO 40. Thus, presence or absence of quantitative interaction was accession specific and trait specific (Rathore and Gupta, 1995). The accession IC 39806, IC 402288, IC 39817, IC 39683, IC 370476, IC 415152, IC 36510, IC 39678 and IC 39686 had significantly higher seed yield/plant than check RMO 40.

The conclusion drawn from regression analysis and quantitative and qualitative interactions concept about identifying accessions having specific adaptability differs considerably. The accessions IC 39675, IC 39668, IC 39681, IC 39702, IC 370469, IC 402287, IC 472158, IC 415164 IC 39678 and

IC 39817 identified as potential yielder having specific adaptability on the basis of regression analysis failed to exhibit significant min (Q^+ or Q^-) against standard variety RMO 40 except IC 39678 and IC 370508 which had significant min (Q^+, Q^-) against RMO 40.

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