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Analysis for Seed Yield and its Components in Moth-bean (*Vigna aconitifolia*) under Hot Arid Conditions

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Ten varieties of moth bean {*Vigna aconitifolia* (Jacq.) Marechal} were evaluated for seed yield and its components under rainfed conditions during *kharif* 2006 and 2007. Significant differences were observed among genotypes for days to flowering, plant height, peduncle length, days to maturity and seed yield/plant. The variabilities recorded were highest in seed yield/plant and peduncle length, and high for plant height, and moderate for days to flowering and 100-seed weight. Days to flowering, peduncle length and plant height had high heritability coupled with high genetic advance. Pod length was the only character, which had significant positive association with seed yield/plant whereas petiole length and days to maturity had significant negative association with seed yield. Association analysis showed that for higher seed yield, longer pods, short leaf stalk and early maturity should be given emphasis in breeding programme of moth bean. Among all the varieties tested, RMO 257 was identified as the best seed yielder for arid environment.

Key words: Correlation, genetic advance, heritability, mothbean, seed yield, variability.

Moth bean {*Vigna aconitifolia* (Jacq.) Marechal} is an important *kharif* food legume of arid and semi-arid areas of the country. It is the source of food, fodder, feed, green manuring, pasture and can easily be accommodated in a multiple cropping system. Drought and heat tolerance characteristics of moth bean make it an important pulse crop of arid areas. Rajasthan is the major moth growing state in the country contributing about 85% area of which 93% (1.2 million hectare) is confined to 12 arid districts and the productivity is about 200 kg ha^{-1}. The low productivity of moth bean in arid Rajasthan is a matter of concern. To enhance the productivity in these areas, breeding of short duration high yielding varieties can be a better proposition. Information on nature and magnitude of variability present in a population due to genetic and non-genetic causes is an important pre-requisite for a systematic breeding programme. Correlation of characters is a measure of strength between a group of characters and its estimation is an important step for developing a selection index. Therefore, an attempt was made to assess the variability, heritability, genetic advance and character association of different seed traits of moth bean.

Materials and Methods

The experiment was conducted at the Central Research Farm of the institute during *kharif* season of 2006 and 2007. Ten varieties, viz. Maru Moth, IPCMO 880, RMO 40, RMO 225, RMO 257, RMO 423, RMO 435, CAZRI Moth 1, CAZRI Moth 2 and CAZRI Moth 3 of moth bean were sown in a randomized block design with three replications in plot size of 4 m ´ 4 m with row spacing of 50 cm using 10 kg seed/ha. The experiment was under rain grown conditions and no fertilizer/manure was applied. Due to delayed rains, the experiment was sown on 11-8-2006 in first year and during second year the date of sowing was 26th July. Data were recorded on days to 50% flowering, plant height at 50% flowering (cm), peduncle length at 50% flowering (cm), days to maturity, petiole length at maturity (cm), pod length (cm), 100-seed weight (g) and seed yield/plant (g). Data were analyzed using a statistical package Windostat Version 7.5.

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Results and Discussion

Meteorological data

Numbers of rainy days were twenty in both the years, but the total rainfall was 270.4 mm during 2006 (first year) and 323.7 mm during 2007 (second year). July experienced more rains (73.4 mm) in 2007 than 2006 (27.7 mm). In 2007, there were 234.3 mm rains from July to September and it was 242.4 mm in 2006. Hence, rainfall of July to September was almost equal in both the years but the distribution of rains was uneven during first year as August received 185.5 mm rains, 76.5% of the total rainfall of the three months, while in second year

Table 1. Mean sum of squares for seed yield and its components in moth bean

Character	Years	Mean sum of squares		
		Replication	Varieties	Error
Days to flowering	Y_1	0.400	38.593**	0.215
	Y_2	0.300	60.107**	0.263
Plant height	Y_1	3.219*	8.259**	0.763
	Y_2	8.555	44.744**	8.475
Peduncle length	Y_1	0.009	1.858**	0.196
	Y_2	0.039	3.907**	0.110
Days to maturity	Y_1	0.033	2.893**	0.070
	Y_2	0.033	55.056**	0.033
Petiole length	Y_1	1.268**	0.158	0.154
	Y_2	0.189	1.743*	0.612
Pod length	Y_1	0.024	0.117**	0.022
	Y_2	0.056	0.031	0.027
100-seed weight	Y_1	0.096	0.137	0.057
	Y_2	0.005	0.110**	0.010
Seed yield/plant	Y_1	2.045**	0.523*	0.197
	Y_2	12.665	15.621**	3.761

*,**Significant at 5% and 1% levels, respectively; Y_1- Year 2006, Y_2- Year 2007.

the rains were uniform during the period. There were no rains during October in both the years. Highest mean maximum humidity was recorded in August and it was 86% in 2006 and 81% in 2007. Mean maximum temperature ranged from 32.6°C to 37.1°C in 2006 and 34.7°C to 36.4°C in 2007 from July to October.

Analysis of variance

The analysis of variance (Table 1) revealed significant differences among genotypes for days to flowering, plant height, peduncle length, days to maturity and seed yield/plant in both the years, and for pod length in first year and for petiole length and 100-seed weight in second year.

Variability and heritability

Mean, range, phenotypic and genotypic coefficients of variation (PCV and GCV), heritability and genetic advance expressed as percentage of mean are presented in Table 2. Range was wider for days to flowering in both the years, and for plant height, peduncle length, days to maturity and seed yield in second year. PCV values were higher than their respective GCV values for all the characters studied indicating the role of environmental variance in the total variance. The magnitude of PCV and GCV were mostly higher in the second year. Phenotypic coefficient of variation was maximum for seed yield/plant (32.2 and 62.0 in year 1 and 2) followed by peduncle length (25.4 and 31.0 in year 1 and 2). Value of PCV was also high for plant height. The difference in the extent of PCV and GCV was more for seed yield/plant in both the years, which revealed considerable influence of environment on expression of this trait.

Table 2. Estimates of variability, heritability and genetic advance in moth bean

Character	Year	Range	Mean	PCV	GCV	Heritabilty %(bs)	GA as %age of mean
Days to flowering	Y_1	32.3-41.3	35.0 ± 0.27	10.30	10.22	98.3	20.88
	Y_2	33.0-44.0	36.3 ± 0.30	12.38	12.30	98.7	25.18
Plant height (cm)	Y_1	7.9-11.9	9.3 ± 0.50	19.51	17.08	76.6	30.79
	Y_2	18.2-30.7	22.8 ± 1.68	19.91	15.27	58.8	24.11
Peduncle length (cm)	Y_1	1.9-4.3	3.4 ± 0.26	25.40	21.83	73.9	38.67
	Y_2	2.0-6.3	3.8 ± 0.19	31.04	29.78	92.0	58.85
Days to maturity	Y_1	61.0-64.0	62.4 ± 0.15	1.61	1.55	93.0	3.09
	Y_2	65.0-76.0	68.2 ± 0.11	6.29	6.28	99.8	12.93
Petiole length (cm)	Y_1	4.8-5.7	5.2 ± 0.23	7.57	0.65	0.7	0.11
	Y_2	10.1-12.4	11.1 ± 0.45	8.98	5.54	38.1	7.05
Pod length (cm)	Y_1	3.7-4.4	4.2 ± 0.08	5.54	4.27	59.5	6.79
	Y_2	3.7-4.0	3.8 ± 0.10	4.40	0.86	3.8	0.35
100-seed weight (g)	Y_1	2.46-3.25	2.77 ± 0.14	10.45	5.88	31.7	6.81
	Y_2	2.26-2.89	2.42 ± 0.06	8.60	7.54	76.9	13.62
Seed yield/plant (g)	Y_1	0.93-2.37	1.72 ± 0.26	32.22	19.21	35.6	23.60
	Y_2	1.87-9.75	4.48 ± 1.12	62.01	44.39	51.2	65.46

Phenotype reflects genotype truly when the character is highly heritable hence heritability is important from the breeder's point of view for adopting suitable breeding methodology for improvement. Burton (1952) suggested that genotypic coefficient of variation, along with heritability estimates, would give better idea about the efficiency of selection. Days to flowering, days to maturity, peduncle length and plant height had high heritability. The estimates of heritability were moderate to low for 100-seed weight, seed yield plant^{-1}, pod length and petiole length. Sihag *et al*. (2004) reported low heritability for pod length. Among the characters studied, the broad sense heritability was maximum for days to maturity (99.8%) and minimum for petiole length (0.7%) during second year. Expected genetic advance was maximum for

Table 3. Genotypic (G) and phenotypic (P) correlation coefficients for seed yield and its components in moth bean

Character	Year		Plant height	Peduncle length	Days to maturity	Petiole length	Pod length	100-seed weight	Seed yield/plant
Days to flowering	Y_1	GP	0.970**	-0.809**	0.662**	0.431*	-0.391*	0.906**	-0.308
			0.860**	-0.716**	0.643**	0.074	-0.271	0.514**	-0.183
	Y_2	GP	0.926**	-0.035	0.936**	0.602**	-1.818**	0.617**	-0.806**
			0.658**	-0.039	0.929**	0.347	-0.351	0.550**	-0.597**
Plant height	Y_1	GP		-0.923**	0.693**	0.683**	-0.437*	0.985**	-0.246
				-0.731**	0.608**	0.051	-0.234	0.433*	-0.052
	Y_2	GP		0.298	0.777**	0.504**	-0.865**	0.615**	-0.533**
				0.184	0.595**	0.557**	-0.077	0.414*	-0.242
Peduncle length	Y_1	GP			-0.431*	-1.656**	0.580**	-0.400*	0.261
					-0.386*	-0.088	0.366*	-0.378*	0.142
	Y_2	GP			0.058	-0.273	0.834**	-0.279	0.081
					0.060	-0.223	0.100	-0.238	0.024
Days to maturity	Y_1	GP				2.417**	-0.495**	0.686**	-0.693**
						0.131	-0.367*	0.307	-0.401*
	Y_2	GP				0.454*	-1.929**	0.350	-0.828**
						0.278	-0.390*	0.295	-0.596**
Petiole length	Y_1	GP					-4.151**	-1.620**	-1.052**
							-0.352	0.080	-0.131
	Y_2	GP					-1.756**	0.612**	-0.538**
							0.125	0.408*	-0.349
Pod length	Y_1	GP						0.393*	0.864**
								0.208	0.348
	Y_2	GP						-1.470**	2.950**
								-0.192	0.211
100-seed weight	Y_1	GP							0.447*
									0.247
	Y_2	GP							-0.533*
									-0.334

*,**Significant at 5% and 1% levels, respectively; Y_1- Year 2006, Y_2- Year 2007.

seed yield (65.5%) and peduncle length (58.9%) in second year. The genetic advance was high for peduncle length, seed yield, plant height and days to flowering, and it was low for days to maturity, petiole length, pod length and 100-seed weight during both the years.

Genetic advance depend on selection intensity, heritability and phenotypic standard deviation. Hence high heritability need not necessarily mean that the character will show high genetic advance but whenever this association occurs additive gene effects are probably important. In this study, such association was found for days to flowering, plant height and peduncle length. Simple selection may prove effective to improve these characters. On the other hand high heritability coupled with low genetic advance was estimated for days to maturity, whereas seed yield/plant had low heritability in first year and moderate in second year, and high genetic advance. Petiole length, pod length, and 100-seed weight had low to moderate heritabilty and low genetic advance. This indicated the effect of non-additive gene effects, such as epistatis, dominance type of interaction (Panse 1957).

Association analysis

The genotypic and phenotypic correlation coefficients between all the pairs of eight characters for two years are presented in Table 3. Most of the genotypic correlation coefficients were found to be higher than their corresponding phenotypic correlation coefficients because environmental effects were removed from these associations. Theoretically the value of correlation coefficient is not more than one, but it comes because it is an estimate. Similar to present study, Paul *et al.* (1996) also reported values of correlation coefficients more than one for many character pairs in pigeon pea. Seed yield/ plant, a complex character, had positive association with peduncle length and pod length in both the years, and 100-seed weight in first year. Pod length was the only trait, which had significant positive relationship with seed yield/plant in both the years, whereas 100-seed weight had significant

Table 4. Seed yield and its related traits in moth bean for the years 2006 and 2007

Varieties	Year	Days to 50% flowering	Plant height (cm)	Peduncle length (cm)	Days to maturity	Petiole length (cm)	Pod length (cm)	100-seed weight (g)	Seed yield/ plant (g)
Maru Moth	Y_1	40.0	11.9	1.9	64.0	5.7	3.7	2.81	1.23
	Y_2	43.0	23.6	2.0	76.0	11.5	3.7	2.42	1.87
IPCMO 880	Y_1	41.3	11.4	3.3	64.0	5.2	4.3	3.25	1.71
	Y_2	44.0	30.7	6.3	76.0	11.2	3.8	2.51	1.88
RMO 40	Y_1	33.3	8.0	3.7	61.0	5.4	4.1	2.63	2.15
	Y_2	34.0	21.1	4.0	65.0	11.1	4.0	2.29	5.88
RMO 225	Y_1	33.3	7.9	4.3	61.7	5.0	4.2	2.57	1.56
	Y_2	34.0	20.4	4.1	65.7	11.3	3.9	2.41	4.36
RMO 257	Y_1	33.0	9.8	3.6	62.0	5.1	4.3	2.88	2.37
	Y_2	33.0	23.5	3.9	65.0	10.5	4.0	2.28	9.75
RMO 423	Y_1	32.3	8.2	3.8	62.0	5.3	4.4	2.73	1.68
	Y_2	34.3	20.5	3.5	66.0	10.3	3.7	2.33	4.69
RMO 435	Y_1	32.7	7.9	3.6	62.0	5.3	4.3	2.79	1.87
	Y_2	33.7	18.2	3.8	66.0	10.3	3.8	2.53	5.26
CAZRI Moth 1	Y_1	39.0	11.2	2.1	62.0	4.8	4.2	2.85	1.71
	Y_2	41.0	27.9	2.3	69.0	12.4	3.8	2.89	2.89
CAZRI Moth 2	Y_1	32.3	8.1	3.9	62.7	5.2	4.2	2.75	1.94
	Y_2	33.0	20.0	3.9	66.0	10.1	3.9	2.29	3.86
CAZRI Moth 3	Y_1	32.7	8.2	3.9	63.0	5.2	4.0	2.46	0.93
	Y_2	33.0	21.9	4.0	67.0	12.1	3.8	2.26	4.36
LSD (P=0.05)	Y_1	0.8	1.5	0.8	0.5	NS	0.3	NS	0.76
	Y_2	0.9	5.0	0.6	0.3	1.3	NS	0.18	3.33
CV (%)	Y_1	1.3	9.4	13.0	0.4	7.5	3.5	8.64	25.87
	Y_2	1.4	12.8	8.8	0.3	7.1	4.3	4.13	43.30

positive relationship in first year. Seed yield/plant was negatively correlated with days to 50% flowering, plant height, days to maturity and petiole length in both the years and 100-seed weight in second year. Days to maturity and petiole length had significant negative relationship with seed yield.

Among the other characters, days to 50% flowering had significant positive association with plant height, days to maturity, petiole length, and 100-seed weight in both the years. Similarly, plant height had significant and positive association with days to maturity, petiole length, and 100-seed weight in both the years. Significant positive correlations were also observed between peduncle length and pod length, and days to maturity and petiole length in both the years. Pod length had significant negative correlations with days to flowering, plant height, days to maturity and petiole length in both the years.

The association of pod length and seed yield/ plant revealed that longer pods should be one of the important characters in seed yield improvement programme. Significant negative association of seed yield with maturity revealed that earliness had advantage over late maturity for increased seed yield under rainfed conditions in arid zone. Negative and significant correlation of seed yield with petiole length indicated that short leaf stalk should be preferred for the improvement of seed yield in moth bean but this character had low heritability, an appropriate method of recurrent selection may be used for breeding of short leaf stalk varieties.

Per se performance

The *per se* performance of seed yield and its components has been presented in Table 4. Days to flowering and days to maturity were less during first year because of shorter growing period. IPCMO 880 took longest time to flower and to mature in both the years and during second year it took 76 days to mature. Similarly, variety Maru Moth also matured in 76 days during second year. In a three-year experiment, mean maturity period Maru Moth bean was 76 days (Bhansali *et al.* 2004). Values for plant height, peduncle length, petiole length and seed yield/plant were mostly more during second year for all the varieties. Plant growth was less during first year and minimum plant height recorded was 7.9 cm with RMO 225 and RMO 435, while Maru Moth attained maximum height (11.9 cm) closely followed by IPCMO 880 (11.4 cm) and CAZRI Moth 1 (11.2 cm). Less height during first year was due to shorter growing period. During first year, peduncle length was minimum with Maru Moth (1.9 cm) and maximum with RMO 225 (4.3 cm), while IPCMO 880 had longest peduncle (6.3 cm) during second year.

The length of petioles was mostly more than double during second year and the value was maximum with CAZRI Moth 1 (12.4 cm) followed by CAZRI Moth 3 (12.1 cm). All the varieties produced comparatively longer pods during first year, except variety Maru Moth in which the pod length was same in both the years. Similarly, 100-seed weight was more during first year with all the varieties, except CAZRI Moth 1. It means pod length and 100-seed weight are probably more important in breeding short duration varieties as rains were late and crop growth period was shorter during first year. Seed yield/plant ranged from 0.93 g (CAZRI Moth 3) to 2.37 g (RMO 257) in first year, while the range was wider during second year, where it was 1.87 (Maru Moth) to 9.75 (RMO 257). Mishra *et al.* (2008) reported a wide range (1.6-19.1 g) for seed yield/plant in moth bean. In our study, seed yield/plant was more during second year and variety RMO 257 was the best seed yielder. In an experiment of eight genotypes conducted for three years variety RMO 257 ranked second for seed yield (Bhansali *et al.* 2004). The variety flowered early (33 days) in both the years and also matured early (62 and 65 days). Thus, it had both earliness and high seed yield. Therefore, variety RMO 257 should be considered for improvement while developing high yielding short duration varieties.

The study thus, revealed that earliness, short leaf stalk and longer pods are important characters for breeding high yielding varieties of moth bean for arid zone conditions. Days to flowering had high heritability and high genetic advance could be improved through simple selection. Days to maturity, petiole length and pod length had limited scope for improving through simple selection.

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