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Morphological and physiological characterization in mungbean [*Vigna radiata* (L.) Wilczek]

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Abstract
The present investigation was carried out with 35 diverse genotypes of mungbean [*Vigna radiata* (L.) Wilczek] during *Kharif* season in Bikaner region. Data were recorded on various agro-morphological and physiological characters including days to 50 percent flowering, days to maturity, plant height, number of pods per plant, number of seeds per pod, pod length, 100-seed weight, biological yield, harvest index, germination percentage, seed volume, water absorption capacity and seed yield. Hypocotyl colour, terminal leaflet length, petiole length and plant growth habit these qualitative characters were also observed. Analysis of variance revealed significant differences among all the genotypes for all the characters studied. Wide range of variation had been observed for all the characters. The study also provides information about the performance of some of the promising genotypes in respect of morphological and physiological characters and identifies some prominent genotypes. These genoypes may be further used for parental selection in breeding programmes for improvement of yield and various quantitative characteristics in mungbean.

Keywords: Morphological, physiological, characterization, mungbean, *Vigna radiata* L.

Introduction
Mungbean is also known as green gram or golden gram or chickasaw or oregon pea or green soy or mash bean and choup suey bean, which is originated from South-East Asia (Vavilov, 1926) [1]. *Vigna radiata var. sublobata* is the probable progenitor of mungbean (Singh *et al.* 2015) [2]. Pulse crops are in forefront among plant kingdom, to address malnutrition. Mungbean has an added advantage compared to other legumes that both protein and carbohydrates are easily digestible and create less flatulence. Reduction in productivity due to heat stress is primarily related to contraction in assimilatory capacity by altered membrane stability, amplify maintenance respiration and shrinkage in radiation use efficiency. Out of different growth stages, germination is affected firstly, followed by processes which are related to seed hormones; however, it is species specific and depend on the range of temperature. Decrease in germination percentage, seedling emergence, cell size, loss in vigour, decrease in the growth of radicle and plumule are prime impacts of it.
Yield is a complex quantitative character in crop plants as various physio-morphological plant characters contribute for yield. Yield contributing characters are inter-related with each other and exhibit multiple patterns of relationship, which is highly affected by the environmental conditions, The present investigation was, therefore, undertaken to morphological characterization and evaluation of mungbean genotypes for yield and attributing characters and identifies superior genotypes among them for various characters under studied.

Material and Methods
The observations were recorded on individual plant basis on five randomly selected plants from each genotype of each replication for 13 characters following DUS guideline of mungbean *viz.* days to 50 per cent flowering, days to maturity, plant height (cm), number of pods per plant, number of seeds per pod, pod length (cm), 100-seed weight, biological yield per plant (g), harvest index (%), and seed yield per plant (g). Observations under laboratory condition. The number of germinated seeds were recorded 7th day after planting in petri dishes and the germination percentage (%) was determined (Chartzoulakis and Klapaki, 2000) [3]. Seed volume (µl/seed) was measured by liquid displacement technique (Shepherd, 1986). 100 seeds from each replication were weighted, soaked in water and was maintained at a temperature of 22 ºC for 12 hours for water absorption capacity (mg/seed) Mohsenin (1986) [4].

Hypocotyl colour was observed after 10 days of emergence as green, greenish purple, purple, mixed and other. Terminal leaflet length was recorded for the leaf at fourth node as small, medium and large. Petiole length was recorded for the leaf at fourth node as small, medium and large. Plant growth habit was observed at 50 per cent flowering stage as erect, semi-erect and spreading type.

Results and Discussion

The analysis of variance revealed significant differences among 35 genotypes of mungbean for all the 13 characters, which indicates the presence of wide range of variability in the genotypes and scope for genetic improvement. Days to 50 per cent flowering showed mean value for this character varied from 35 to 44.33 days with an overall mean of 39.97 days and coefficient of variance was found to be 1.99 per cent. The differences among genotypes for days to maturity were found statistically significant having ranged from 65.33 to 74.33 days with the grand mean of 69.98 days and 1.31 per cent coefficient of variation. The plant height falls between 35.67 to 62.57 cm with an overall mean and coefficient of variation 49.84 cm and 6.95 per cent respectively. In the number of pods per plant differences among genotypes were found statistically significant with 6.96 per cent coefficient of variation, it varied from 14.94 to 55.27 with the population mean of 26.40.

Significant differences were found in genotypes for number of seeds per pod with the grand mean of 11.39 and 7.88 per cent coefficient of variation, it fluctuates from 8.96 to 13.72 seeds per pod. Pod length value falls between 7.54 cm to 10.47 cm with the population mean of 8.56 cm and 7% coefficient of variation. Weight of 100-seeds lies between 3.40 to 6.02 g with an overall mean of 4.30 g and 9.35 per cent coefficient of variance. Biological yield per plant range was 16.39 g to 27 g with the grand mean of 21.28 g and 9.65 per cent coefficient of variation. Statistically significant differences were found in harvest index with 12.13 per cent coefficient of variation, values for this character varied from 28.95 to 43.15 per cent with an overall mean of 36.78 per cent.

Grand mean of germination percentage was 91.33 per cent and coefficient of variation was 8.49 per cent. The minimum and maximum percentage lies between 70.00 to 100%. The highest and lowest value for water absorption capacity lies between 26.15 to 57.63 mg/seed with 6.82 per cent coefficient of variation, eighteen out of thirty-five genotypes exhibited greater water absorption capacity than population mean (41.36 mg/seed). Seed yield per plant was statistically significant with 8.49 per cent coefficient of variation. This character lies from 5.57 to 10.92 g with the overall mean of 7.75 g. With regards to qualitative characters among 35 Genotypes studied the highest frequency was recorded in 15 genotypes having green (42.85%) hypocotyl colour followed by 20 genotypes of green purple (57.14%). Highest frequency of small leaflet length was recorded in 25 genotypes of mung bean (71.42%) followed by medium leaflet length in 10 genotypes (28.57%). Fifteen genotypes (42.87%) having small and 20 genotypes with medium petiole length (57.14%). In plant habit out of 35 genotypes of mungbean highest frequency was recorded for semi-erect type plant in 20 genotypes (57.14%) followed by erect in 8 genotypes (22.85%) and 7 spreading type genotypes (20%).

Superior genotypes can be used for enhancement of various agro-morphological and physiological characters in mungbean (Ahmad and Belwal, 2020) [6]. Goodman (1999) [5] emphasized the importance of breeding stock and germplasm accessions by suggesting that although lines may be unpromising phenotypically but may contain untapped alleles or allelic combinations that could be utilized for plant breeding with adequate investment in conventional and marker assisted selection.

Conclusion

The list of promising genotypes in respect of various characters has been presented in table 2, which may be used for parental selection in breeding programmes for improvement of yield and to improve various qualitative and quantitative characteristics in mungbean. The present study shows the importance of morphological characteristics using DUS descriptors for the registration, maintenance and protection of genotypes. The genotypes namely Keshwanand mung-1, RMG-492, GM-4, SML-668, RMG-62, IPM-2-3, VIRAT, Ganga-8, MEHA and MH-421 were found superior for seed yield and other desirable traits (Table 1).

Table 1: Show the superior for seed yield and other desirable traits

Name of genotypes	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of pods per plant	No. of seeds per pod	Pod length (cm)	100-seed weight (g)	Biological yield per plant (g)	Harvest Index	Germination percentage	Seed volume (µl/seed)	Water absorption capacity (mg/seed)	Seed yield (g)
IC-39269	41.00	71.00	62.57	24.27	9.84	7.96	4.16	20.93	32.06	76.67	33.36	34.34	6.65
IC-39328	43.00	73.00	53.05	22.60	10.01	8.57	3.70	16.43	41.45	90.00	32.26	34.26	6.80
IC-39409	39.00	69.00	57.00	26.60	10.42	8.14	3.94	21.47	36.29	86.67	32.93	33.30	7.69
IC-39454	42.00	72.00	59.20	24.60	8.96	8.37	3.84	20.41	30.68	96.67	33.59	35.26	6.24
IC-39492	41.67	71.67	54.50	23.60	10.16	8.24	4.05	16.82	42.94	90.00	32.70	34.99	7.20
IC-39608	43.67	73.67	56.70	18.60	10.21	7.99	3.96	20.57	28.95	76.67	27.33	31.45	5.83
IC-39610	44.33	74.33	58.60	20.60	9.37	7.56	3.86	19.03	32.77	93.33	33.59	29.83	6.21
IC-52076	43.67	73.67	56.37	29.27	9.79	7.83	3.46	24.34	29.73	70.00	30.28	30.27	6.98
IC-102857	40.67	70.67	56.07	14.94	10.05	7.84	3.83	20.23	38.45	86.67	33.36	31.02	7.77
IC-103014	40.33	70.33	50.97	19.94	10.47	8.24	4.13	19.12	29.22	86.67	35.43	38.49	5.57
IC-103244	40.67	70.67	49.80	19.60	10.04	7.81	3.76	19.49	36.22	83.33	33.36	42.31	6.98
GM-4	35.00	65.33	48.20	27.60	13.60	9.51	5.13	22.29	43.15	96.67	40.88	54.41	9.61
GAM-5	39.00	69.00	46.80	20.94	13.54	9.44	4.06	16.39	43.01	90.00	36.91	41.84	7.02
GM-6	41.33	71.33	45.00	25.27	12.61	9.71	6.02	23.67	36.68	96.67	44.00	57.63	8.65
GM-7	40.67	70.67	47.00	25.27	11.82	9.54	5.03	25.67	30.37	86.67	36.78	39.73	7.73
MH-2-14	40.00	70.00	48.30	27.27	11.53	8.11	4.90	20.83	31.07	86.67	33.36	36.30	6.45

MH-2-15	40.00	70.00	45.24	31.27	11.89	8.84	4.74	21.07	40.00	96.67	33.36	43.11	8.39
MH-421	38.67	68.67	42.67	25.60	11.00	8.02	3.87	21.97	40.17	90.00	34.03	46.97	8.80
RMG-62	37.67	67.67	48.59	32.60	12.53	8.19	4.09	25.88	36.42	96.67	33.75	37.97	9.27
RMG-344	37.67	67.67	56.00	23.60	11.88	8.47	3.91	20.84	35.55	93.33	33.36	45.44	7.34
RMG-492	39.00	69.00	54.07	42.60	13.72	8.24	3.40	26.18	37.40	93.33	36.78	45.70	9.68
MEHA	38.33	68.33	48.47	23.27	12.82	9.99	4.32	21.06	42.43	93.33	37.45	49.98	8.94
VIRAT	39.00	69.00	46.44	28.94	12.64	9.66	4.80	21.85	42.16	93.33	37.43	37.26	9.20
SHIKA	40.00	70.00	42.57	21.60	11.54	7.96	4.61	19.62	35.98	100.00	34.03	38.41	7.02
SWETA	39.67	69.67	35.67	28.27	12.58	7.54	3.82	17.01	42.04	96.67	34.26	43.76	7.16
GANGA-1	41.33	71.33	45.24	27.94	11.61	8.54	4.11	21.12	33.69	96.67	34.12	50.36	7.10
GANGA-8	39.67	69.67	46.27	34.94	11.80	8.24	4.23	21.95	40.80	96.67	40.88	26.15	9.02
PANTMOONG-5	40.00	70.00	48.25	20.60	13.34	10.04	4.95	22.83	30.20	96.67	37.34	48.62	6.91
PDM-139	40.33	70.33	40.05	27.60	10.30	8.51	4.89	16.51	40.43	96.67	37.43	49.65	6.50
KESHWANAND MUNG-1	37.33	67.33	58.07	55.27	11.78	8.16	4.27	26.04	42.18	100.00	34.03	49.14	10.92
MUM-2	39.33	69.33	45.80	22.27	10.55	8.08	3.57	22.14	35.28	96.67	31.62	33.22	7.77
IPM-2-14	37.33	67.33	41.32	22.94	10.54	7.96	4.29	18.69	42.61	96.67	37.43	45.90	7.96
IPM-2-3	38.00	68.00	46.87	22.94	11.44	10.47	5.60	24.86	37.43	86.67	44.79	53.92	9.21
SML-668	41.33	71.33	54.74	34.94	12.74	9.96	4.95	27.00	35.76	90.00	40.88	52.17	9.59
SML-832	38.33	68.33	47.10	25.60	11.58	8.12	4.41	20.79	33.75	93.33	40.88	44.73	7.01
Overall mean	39.97	69.98	49.84	26.41	11.39	8.57	4.3	21.29	36.78	91.33	35.54	41.37	7.75
S.Em	0.45	0.463	2	1.06	0.51	0.34	0.23	1.18	2.57	4.96	1.28	1.63	0.38
CD (P=0.005)	1.296	1.305	5.64	2.99	1.46	0.97	0.65	3.34	7.26	14	3.61	4.59	1.07
CD (P=0.001)	1.721	1.734	7.5	3.97	1.94	1.29	0.87	4.44	9.65	18.6	4.79	6.1	1.42
CV (%)	1.99	1.14	6.95	6.96	7.88	7	9.35	9.65	12.13	9.41	6.24	6.82	8.49
min.	35.00	65.33	35.67	14.94	8.96	7.54	3.40	16.39	28.95	70.00	27.33	26.15	5.57
max.	44.33	74.33	62.57	55.27	13.72	10.47	6.02	27.00	43.15	100.00	44.79	57.63	10.92

Table 2: The list of promising genotypes in respect of various characters has been presented

S. No	Characters	Rank	Genotypes	Values
1	Days to 50% flowering	1	GM-4	35
		2	KM-1	37.33
		3	IPM-2-14	37.33
		4	RMG-62	37.67
		5	RMG-344	37.67
2	Days to maturity	1	GM-4	65.33
		2	KM-1	67.33
		3	IPM-2-14	67.33
		4	RMG-62	67.67
		5	RMG-344	67.67
3	Plant height	1	SWETA	35.67
		2	PDM-139	40.05
		3	IPM-2-14	41.32
		4	SHIKA	42.57
		5	MH-421	42.67
4	Number of pods per plant	1	KM-1	55.27
		2	RMG-492	42.6
		3	SML-668	34.94
		4	GANGA-8	34.94
		5	RMG-62	32.6
5	Number of seeds per pod	1	RMG-492	13.72
		2	GM-4	13.6
		3	GM-5	13.54
		4	PM-5	13.34
		5	MEHA	12.82
6	Pod length	1	IPM-2-3	10.47
		2	PM-5	10.04
		3	MEHA	9.99
		4	SML-668	9.96
		5	GM-6	9.71
7	100-seed weight	1	GM-6	6.02
		2	IPM-2-3	5.6
		3	GM-4	5.13
		4	GM-7	5.03
		5	PM-5	4.95

8	Biological yield per plant	1	SML-668	27
		2	RMG-492	26.18
		3	KM-1	26.04
		4	RMG-62	25.88
		5	GM-7	25.67
9	Harvest index	1	GM-4	43.15
		2	GM-5	43.01
		3	IC-39492	42.94
		4	IPM-2-14	42.61
		5	MEHA	42.43
10	Germination percentage	1	SHIKHA	100
		2	KM-1	100
		3	MH-2-15	96.67
		4	MUM-2	96.67
		5	GM-6	96.67
11	Seed volume	1	IPM-2-3	44.79
		2	GM-6	44
		3	GM-4	40.88
		4	SML-668	40.88
		5	SML-832	40.88
12	Water absorption capacity	1	GM-6	57.63
		2	GM-4	54.41
		3	IPM-2-3	53.92
		4	SML-668	52.17
		5	GANGA-1	50.36
13	Seed yield per plant	1	KM-1	10.92
		2	GM-4	9.61
		3	RMG-492	9.68
		4	SML-668	9.59
		5	RMG-62	9.27

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