

Characterization of Mung bean (*Vigna radiata* L. Wilczek) Genotypes Based on Plant Morphology

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ABSTRACT

The characterization and grouping of the forty four mung bean genotypes based on plant morphological characters was carried out at Junagadh Agricultural University, Junagadh during kharif 2018. Time of flowering varied with the genotypes ranging from 37.33 days (GJM 1011) to 53.67 days (Pant M-3). Based on time of flowering, the genotypes were grouped as early (two genotypes EC 482907 and GJM 1011), medium (41 genotypes) and late (one genotype Pant M-3). Flower colour of petal was yellow in two genotypes (EC 251810 and GM 06-08), while it was light yellow in 42 genotypes. Petiole colour was observed green (seven genotypes), green with purple (14 genotypes) and purple (23 genotypes). Based on plant habit, genotypes were grouped as indeterminate (seven genotypes) and determinate (37 genotypes). Based on plant growth habit, genotypes were grouped as erect (seven genotypes), semi-erect (21 genotypes) and spreading type (16 genotypes). Among 44 genotypes, plant height was short in one genotype (K 851), while it was long in 12 genotypes and medium in the remaining 31 genotypes. Pubescence was present in all the genotypes evaluated. Stem color was noted green in 17 genotypes and green with purple in 27 genotypes. Leaflet lobes were present in two genotypes (GJM 1103 and GM 06-08), whereas, it was absent in 42 genotypes. Leaf colour was dark green in 29 genotypes and green in 15 genotypes. Based on leaf vein color, the genotypes were grouped as green (five genotypes) and purple (39 genotypes). Shape of leaf was ovate in 41 genotypes, whereas it was deltoid in three genotypes (GJM 1020, GJM 1022 and GM 1924). Leaf size was large in three genotypes (EC 496841, GJM 1026 and OUM 11-5), small in seven genotypes and medium in 34 genotypes. All the genotypes evaluated were having green premature pod colour with pubescence on pods. Pod position was indeterminate in only one genotype (GM 1924), while it was observed above canopy in all the remaining 43 genotypes. Based on the pod colour of mature pods, genotypes were grouped into two groups as black (18 genotypes) and brown (26 genotypes) colour pods. Pod length of mature pods was long in three genotypes (GJM 1025, Kopergaon and TARM 18), short in 18 genotypes and medium in 23 genotypes. All the 44 mung bean genotypes evaluated were of green colour seeds. Based on seed shape, genotypes were grouped into drum (42 genotypes) and oval shape (two genotypes GJM 1011 and IC 24789). Seed size was medium in 32 genotypes and large in 12 genotypes.

Keywords: Characterization, Mung bean, Plant characters

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INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) or green gram is an important legume crop. It is a great source of proteins, vitamins, and minerals, particularly in South Asia. It is a self-pollinated crop having $2n = 2x = 22$ chromosomes with a genome size of 579 Mb/1C. Its capacity to restore soil fertility through nitrogen fixation makes it a valuable crop in various cropping systems, particularly wheat-rice.

According to International Union for Protection of New Plant Varieties (UPOV), any new characteristics used in genotype characterization should be clearly defined, accepted and should have standard method of observation, least or not affected by environment, accessible to breeders, associated with reasonable costs and efforts. To identify mungbean genotypes, international and national bodies like UPOV, IPGRI and IIPR have published relevant descriptors. Such types of classical taxonomic approach is still being employed by certification agencies for the purpose of grow out test to determine the genetic purity of seed lots. These morphological descriptors have a traditional significance and are immediately accessible on the spot without need of equipment. Thus, a clear basis for distinctness testing procedure prior to varietal registration can draw out of this. However, the approach demands a field assessment, which depends on the degree of experience of the operator. Further, the environmental influence can be eliminated or at least greatly reduced.

Maintenance of genetic purity of genotypes is of primary importance for preventing varietal deterioration during successive regeneration cycles and for ensuring varietal performance at an expected level. The aspects of Distinctness, Uniformity and Stability (DUS) are fundamental for characterization of genotypes. In countries having Plant Breeder's Right (PBR) in operation, a new variety is registered only, if it is distinct from other varieties, uniform in its characteristics and genetically stable. Keeping this in view, the present study entitled

“Characterization of mung bean [*Vigna radiata* (L.) Wilczek] genotypes based on plant morphology” was carried out.

MATERIALS AND METHODS

The study on characterization of 44 mung bean genotypes based on plant characters was taken up at the Sagdividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh during *Kharif* 2018. These forty four accessions were evaluated in the field using R.B.D. with three replications. Data were recorded for different plant morphological characters following standard procedures and the genotypes were grouped.

RESULTS AND DISCUSSION

Flower morphological characters

Based on the flower characteristics such as time of flowering, the genotypes could be grouped into different categories (Table.1). Time of flowering varied with the genotypes ranging from 37.33 days (GJM 1011) to 53.67 days (Pant M-3) with an average of 42.90 days. Based on time of flowering, the genotypes were grouped as early (< 40 days) with two genotypes (EC 482907 and GJM 1011), medium (40-50 days) with 41 genotypes and late (> 50 days) with one genotype (Pant M-3). The flower colour of petal varied among different mung bean genotypes (Table 4.7). Among 44 genotypes, flower colour of petal was yellow in two genotypes (EC 251810 and GM 06-08), while it was light yellow in all the remaining forty two genotypes. On the basis of flower morphological characters, Pant M-3 was late in flowering with light yellow purple colour, while EC 482907 and GJM 1011 were early in flowering with light yellow purple colour and EC 251810 and GM 06-08 were medium in flowering, but having yellow flower petal colour. Other genotypes can not differentiate based on flower morphological characters. Similar findings and grouping of genotypes based on flower morphological characters were made by Jain et al. (2002), Singh et al.

(2014) and Kaur et al. (2017) in mung bean; Chandrashekhar (2008) and Das et al. (2014) in french bean; Yadav and Srivastava (2002), Gnyandev (2009) and Joshi and Yasin (2014) in chickpea; Basavaraj et al. (2013) and Kumar and Shrikant (2016) in cowpea; Kumar et al. (2013) in guar; and Kanaka Durga et al. (2015) in horse gram.

Plant morphological characteristics

Use of plant diagnostic characteristics to identify a variety has been classical taxonomic approach for both varietal purity and varietal identification. On the basis of the plant morphological characteristics such as petiole colour, plant habit, plant growth habit and plant height, genotypes were grouped into different categories (Table 2, 6 and 9). Based on petiole colour, the genotypes were grouped as green with seven genotypes, green with purple with fourteen genotypes and purple with twenty three genotypes. Based on plant habit, genotypes were grouped as indeterminate (seven genotypes) and determinate (thirty seven genotypes). Based on plant growth habit, genotypes were grouped as erect with seven genotypes, semi erect with twenty one genotypes and spreading type with sixteen genotypes. Significantly the highest plant height was observed in GJM 1007 (94.07 cm) followed by GJM 1011 (93.80 cm), GM 1924 (85.67 cm) and GJM 1112 (84.53 cm) and the lowest plant height was observed in K 851 (45.73 cm). Among 44 genotypes, plant height was short (< 50 cm) in only one genotypes (K 851), while it was long (> 70 cm) in twelve genotypes and medium (50-70 cm) in the remaining thirty one genotypes. On the basis of plant morphological characteristics, genotype K 851 was distinct genotype with dwarf stature, green with purple petiole colour, determinate plant habit and spreading type plant growth habit. The genotypes viz., GJM 1011 and GJM 1012 were having similar plant morphology viz., green with purple petiole colour, indeterminate plant habit, semi-erect plant growth habit and tall plant height. The genotype EC 482907 was distinct genotype with tall stature with green petiole, indeterminate plant habit and spreading type plant growth habit. The other

genotypes cannot be distinguished clearly based on the plant morphological characters. Similar characterization and grouping of genotypes based on plant morphological characters were made by Jain et al. (2002), Singh et al. (2014) and Kaur et al. (2017) in mung bean; Gnyandev (2015) in chickpea, Basavaraj et al. (2013) and Kumar and Shrikant (2016) in cowpea; Kumar et al. (2013) in guar; Das et al. (2014) in french bean; and Kanaka Durga et al. (2015) in horse gram.

Stem morphological characters

All the 44 mung bean genotypes evaluated did not show any variation for stem pubescence (Table 3). Pubescence was present in all the genotypes evaluated. Based on stem colour, the genotypes were grouped into different categories as green and green with purple. Among 44 genotypes, stem colour was green in seventeen genotypes (EC 482907, EC 501569, EC 496841, GJM 1004, GJM 1011, GJM 1016, GJM 1110, GJM 1116, GM 04-02, GM 05-05, GM 02-16, GM 1925, GM 4, J 781, K 851, OUM 11-5 and RMG 268), whereas it was observed green with purple in twenty seven genotypes (EC 251810, EC 450450, GAM 5, GJM 1007, GJM 1008, GJM 1012, GJM 1020, GJM 1022, GJM 1025, GJM 1026, GJM 1027, GJM 1028, GJM 1103, GJM 1104, GJM 1112, GJM 1113, GJM 1117, GM 06-08, GM 02-13, GM 02-15, GM 1924, IC 12434, IC 24789, IC 8917, Kopergaon, Pant M-3 and TARM 18). Therefore, the evaluated 44 genotypes of mungbean can be differentiated on the basis of stem colour only. Similar characterization and grouping of genotypes based on stem morphological characters were made by Jain et al. (2002); Katiyar et al. (2008), Singh et al. (2014) and Kaur et al. (2017) in mungbean; Chakrabarthy and Agarwal (1989) in black gram; Yadav and Srivastava (15), Gnyandev (2009) and Joshi and Yasin (2014) in chickpea; Kanaka Durga et al. (2015) in horse gram; and Kumar and Shrikant (2016) in cowpea.

Leaf morphological characters

The leaflet lobes, leaf colour, leaf vein colour, leaf shape and leaf size plays an important role in the yielding ability of the genotypes, as the

leaves are the food synthesis site of the plants. In the present study, the characteristics related with leaves have been recorded and based on these characteristics, the genotypes were categorized into different groups (Table 4, 5 and 6). The leaflet lobes varied among the mung bean genotypes. Among 44 genotypes, leaflet lobes were present in two genotypes (GJM 1103 and GM 06-08), whereas, it was absent in remaining all the forty two genotypes. Leaf colour was dark green in twenty nine genotypes and green in fifteen genotypes. Based on leaf vein colour, the genotypes were grouped as green with five

genotypes (EC 482907, EC 501569, GJM 1004, GJM 1016 and GM 4) and purple with 39 genotypes. Among 44 genotypes, shape of leaf was ovate in 41 genotypes, whereas it was deltoid in three genotypes (GJM 1020, GJM 1022 and GM 1924). Based on leaf size, the genotypes were grouped as small, medium and large size leaves. Leaf size was large in three genotypes (EC 496841, GJM 1026 and OUM 11-5), while it was observed small in seven genotypes (EC 501569, GJM 1020, GJM 1103, GJM 1113, GM 04-02, GM 02-15 and IC 12434) and medium in remaining thirty four genotypes.

Table 1: Identification and grouping of mung bean genotypes based on time of flowering (days)

Sr. No.	Genotypes	Time of flowering	Groups	Sr. No.	Genotypes	Time of flowering	Groups
1	EC 251810	42.00	Medium	23	GJM 1113	42.33	Medium
2	EC 450450	43.33	Medium	24	GJM 1116	43.33	Medium
3	EC 482907	38.33	Early	25	GJM 1117	42.00	Medium
4	EC 501569	43.33	Medium	26	GM 04-02	42.33	Medium
5	EC 496841	41.67	Medium	27	GM 05-05	42.00	Medium
6	GAM 5	42.67	Medium	28	GM 06-08	43.00	Medium
7	GJM 1004	44.33	Medium	29	GM 02-13	43.33	Medium
8	GJM 1007	42.33	Medium	30	GM 02-15	42.67	Medium
9	GJM 1008	42.00	Medium	31	GM 02-16	43.00	Medium
10	GJM 1011	37.33	Early	32	GM 1924	42.67	Medium
11	GJM 1012	42.00	Medium	33	GM 1925	41.67	Medium
12	GJM 1016	42.33	Medium	34	GM 4	42.67	Medium
13	GJM 1020	41.67	Medium	35	IC 12434	43.00	Medium
14	GJM 1022	42.33	Medium	36	IC 24789	43.00	Medium
15	GJM 1025	42.33	Medium	37	IC 8917	43.00	Medium
16	GJM 1026	43.00	Medium	38	J 781	44.33	Medium
17	GJM 1027	44.67	Medium	39	K 851	46.67	Medium
18	GJM 1028	43.67	Medium	40	Kopergaon	42.33	Medium
19	GJM 1103	43.67	Medium	41	OUM 11-5	42.33	Medium
20	GJM 1104	43.67	Medium	42	Pant M-3	53.67	Late
21	GJM 1110	43.00	Medium	43	RMG 268	43.33	Medium
22	GJM 1112	44.33	Medium	44	TARM 18	41.33	Medium
	Mean	42.90					
	S. Em ±	0.88					
	C.D. at 5 %	2.46					
	CV %	3.53					

Note:

Time of flowering (days)

Early : < 40 days
 Medium : 40 - 50 days
 Late : > 50 days

Table 2: Identification and grouping of mung bean genotypes based on plant growth habit and plant habit

Sr. No.	Genotypes	Plant growth habit	Plant Habit	Sr. No.	Genotypes	Plant growth habit	Plant habit
1	EC 251810	Erect	Determinate	23	GJM 1113	Erect	Determinate
2	EC 450450	Erect	Determinate	24	GJM 1116	Semi-erect	Determinate
3	EC 482907	Spreading	Indeterminate	25	GJM 1117	Semi-erect	Determinate
4	EC 501569	Semi-erect	Determinate	26	GM 04-02	Spreading	Determinate
5	EC 496841	Semi-erect	Determinate	27	GM 05-05	Spreading	Determinate
6	GAM 5	Semi-erect	Determinate	28	GM 06-08	Spreading	Determinate
7	GJM 1004	Spreading	Determinate	29	GM 02-13	Semi-erect	Determinate
8	GJM 1007	Semi-erect	Determinate	30	GM 02-15	Spreading	Determinate
9	GJM 1008	Semi-erect	Determinate	31	GM 02-16	Semi-erect	Determinate
10	GJM 1011	Semi-erect	Indeterminate	32	GM 1924	Spreading	Determinate
11	GJM 1012	Erect	Indeterminate	33	GM 1925	Semi-erect	Determinate
12	GJM 1016	Erect	Determinate	34	GM 4	Erect	Determinate
13	GJM 1020	Semi-erect	Determinate	35	IC 12434	Erect	Indeterminate
14	GJM 1022	Semi-erect	Determinate	36	IC 24789	Semi-erect	Determinate
15	GJM 1025	Spreading	Determinate	37	IC 8917	Semi-erect	Determinate
16	GJM 1026	Spreading	Determinate	38	J 781	Spreading	Determinate
17	GJM 1027	Semi-erect	Determinate	39	K 851	Spreading	Determinate
18	GJM 1028	Spreading	Determinate	40	Kopergaon	Semi-erect	Determinate
19	GJM 1103	Semi-erect	Determinate	41	OUM 11-5	Spreading	Determinate
20	GJM 1104	Spreading	Determinate	42	Pant M-3	Semi-erect	Determinate
21	GJM 1110	Semi-erect	Indeterminate	43	RMG 268	Spreading	Indeterminate
22	GJM 1112	Semi-erect	Indeterminate	44	TARM 18	Spreading	Determinate

Table 3: Identification and grouping of mung bean genotypes based on stem colour and stem pubescence

Sr. No.	Genotypes	Stem pubes-cence	Stem Colour	Sr. No.	Genotypes	Stem pubes-cence	Stem colour
1	EC 251810	Present	Green with purple	23	GJM 1113	Present	Green with purple
2	EC 450450	Present	Green with purple	24	GJM 1116	Present	Green
3	EC 482907	Present	Green	25	GJM 1117	Present	Green with purple
4	EC 501569	Present	Green	26	GM 04-02	Present	Green
5	EC 496841	Present	Green	27	GM 05-05	Present	Green
6	GAM 5	Present	Green with purple	28	GM 06-08	Present	Green with purple
7	GJM 1004	Present	Green	29	GM 02-13	Present	Green with purple
8	GJM 1007	Present	Green with purple	30	GM 02-15	Present	Green with purple
9	GJM 1008	Present	Green with purple	31	GM 02-16	Present	Green
10	GJM 1011	Present	Green	32	GM 1924	Present	Green with purple
11	GJM 1012	Present	Green with purple	33	GM 1925	Present	Green
12	GJM 1016	Present	Green	34	GM 4	Present	Green
13	GJM 1020	Present	Green with purple	35	IC 12434	Present	Green with purple
14	GJM 1022	Present	Green with purple	36	IC 24789	Present	Green with purple
15	GJM 1025	Present	Green with purple	37	IC 8917	Present	Green with purple
16	GJM 1026	Present	Green with purple	38	J 781	Present	Green
17	GJM 1027	Present	Green with purple	39	K 851	Present	Green
18	GJM 1028	Present	Green with purple	40	Kopergaon	Present	Green with purple
19	GJM 1103	Present	Green with purple	41	OUM 11-5	Present	Green
20	GJM 1104	Present	Green with purple	42	Pant M-3	Present	Green with purple
21	GJM 1110	Present	Green	43	RMG 268	Present	Green
22	GJM 1112	Present	Green with purple	44	TARM 18	Present	Green with purple

Table 4: Identification and grouping of mung bean genotypes based on leaflet lobes and leaf shape

Sr. No.	Genotypes	Leaflet lobes	Leaf Shape	Sr. No.	Genotypes	Leaflet lobes	Leaf shape
1	EC 251810	Absent	Ovate	23	GJM 1113	Absent	Ovate
2	EC 450450	Absent	Ovate	24	GJM 1116	Absent	Ovate
3	EC 482907	Absent	Ovate	25	GJM 1117	Absent	Ovate
4	EC 501569	Absent	Ovate	26	GM 04-02	Absent	Ovate
5	EC 496841	Absent	Ovate	27	GM 05-05	Absent	Ovate
6	GAM 5	Absent	Ovate	28	GM 06-08	Present	Ovate
7	GJM 1004	Absent	Ovate	29	GM 02-13	Absent	Ovate
8	GJM 1007	Absent	Ovate	30	GM 02-15	Absent	Ovate
9	GJM 1008	Absent	Ovate	31	GM 02-16	Absent	Ovate
10	GJM 1011	Absent	Ovate	32	GM 1924	Absent	Deltoid
11	GJM 1012	Absent	Ovate	33	GM 1925	Absent	Ovate
12	GJM 1016	Absent	Ovate	34	GM 4	Absent	Ovate
13	GJM 1020	Absent	Deltoid	35	IC 12434	Absent	Ovate
14	GJM 1022	Absent	Deltoid	36	IC 24789	Absent	Ovate
15	GJM 1025	Absent	Ovate	37	IC 8917	Absent	Ovate
16	GJM 1026	Absent	Ovate	38	J 781	Absent	Ovate
17	GJM 1027	Absent	Ovate	39	K 851	Absent	Ovate
18	GJM 1028	Absent	Ovate	40	Kopergaon	Absent	Ovate
19	GJM 1103	Present	Ovate	41	OUM 11-5	Absent	Ovate
20	GJM 1104	Absent	Ovate	42	Pant M-3	Absent	Ovate
21	GJM 1110	Absent	Ovate	43	RMG 268	Absent	Ovate
22	GJM 1112	Absent	Ovate	44	TARM 18	Absent	Ovate

Table 5: Identification and grouping of mung bean genotypes based on leaf colour and leaf vein colour

Sr. No.	Genotypes	Leaf colour	Leaf vein colour	Sr. No.	Genotypes	Leaf colour	Leaf vein colour
1	EC 251810	Dark green	Purple	23	GJM 1113	Dark green	Purple
2	EC 450450	Green	Purple	24	GJM 1116	Green	Purple
3	EC 482907	Dark green	Green	25	GJM 1117	Green	Purple
4	EC 501569	Dark green	Green	26	GM 04-02	Green	Purple
5	EC 496841	Dark green	Purple	27	GM 05-05	Dark green	Purple
6	GAM 5	Green	Purple	28	GM 06-08	Green	Purple
7	GJM 1004	Dark green	Green	29	GM 02-13	Dark green	Purple
8	GJM 1007	Green	Purple	30	GM 02-15	Dark green	Purple
9	GJM 1008	Dark green	Purple	31	GM 02-16	Dark green	Purple
10	GJM 1011	Green	Purple	32	GM 1924	Dark green	Purple
11	GJM 1012	Dark green	Purple	33	GM 1925	Dark green	Purple
12	GJM 1016	Dark green	Green	34	GM 4	Dark green	Green
13	GJM 1020	Dark green	Purple	35	IC 12434	Green	Purple
14	GJM 1022	Dark green	Purple	36	IC 24789	Dark green	Purple
15	GJM 1025	Green	Purple	37	IC 8917	Green	Purple
16	GJM 1026	Green	Purple	38	J 781	Green	Purple
17	GJM 1027	Dark green	Purple	39	K 851	Dark green	Purple
18	GJM 1028	Dark green	Purple	40	Kopergaon	Dark green	Purple
19	GJM 1103	Dark green	Purple	41	OUM 11-5	Dark green	Purple
20	GJM 1104	Green	Purple	42	Pant M-3	Green	Purple
21	GJM 1110	Dark green	Purple	43	RMG 268	Dark green	Purple
22	GJM 1112	Dark green	Purple	44	TARM 18	Dark green	Purple

Table 6: Identification and grouping of mung bean genotypes based on petiole colour and leaf size

Sr. No.	Genotypes	Petiole Colour	Leaf size	Sr. No.	Genotypes	Petiole colour	Leaf size
1	EC 251810	Purple	Medium	23	GJM 1113	Purple	Small
2	EC 450450	Purple	Medium	24	GJM 1116	Green with purple	Medium
3	EC 482907	Green	Medium	25	GJM 1117	Green with purple	Medium
4	EC 501569	Green	Small	26	GM 04-02	Green with purple	Small
5	EC 496841	Purple	Large	27	GM 05-05	Green	Medium
6	GAM 5	Green with purple	Medium	28	GM 06-08	Purple	Medium
7	GJM 1004	Green	Medium	29	GM 02-13	Purple	Medium
8	GJM 1007	Purple	Medium	30	GM 02-15	Purple	Small
9	GJM 1008	Purple	Medium	31	GM 02-16	Purple	Medium
10	GJM 1011	Purple	Medium	32	GM 1924	Purple	Medium
11	GJM 1012	Purple	Medium	33	GM 1925	Green with purple	Medium
12	GJM 1016	Green	Medium	34	GM 4	Green	Medium
13	GJM 1020	Purple	Small	35	IC 12434	Purple	Small
14	GJM 1022	Purple	Medium	36	IC 24789	Purple	Medium
15	GJM 1025	Purple	Medium	37	IC 8917	Green with purple	Medium
16	GJM 1026	Purple	Large	38	J 781	Green with purple	Medium
17	GJM 1027	Green with purple	Medium	39	K 851	Green with purple	Medium
18	GJM 1028	Purple	Medium	40	Kopergaon	Green with purple	Medium
19	GJM 1103	Purple	Small	41	OUM 11-5	Green with purple	Large
20	GJM 1104	Purple	Medium	42	Pant M-3	Green	Medium
21	GJM 1110	Green with purple	Medium	43	RMG 268	Purple	Medium
22	GJM 1112	Green with purple	Medium	44	TARM 18	Green with purple	Medium

Table 7: Identification and grouping of mung bean genotypes based on flower colour of petal and pod colour of premature pod

Sr. No.	Genotypes	Flower colour of petal	Pod colour of premature pod	Sr. No.	Genotypes	Flower colour of petal	Pod colour of premature pod
1	EC 251810	Yellow	Green	23	GJM 1113	Light yellow	Green
2	EC 450450	Light yellow	Green	24	GJM 1116	Light yellow	Green
3	EC 482907	Light yellow	Green	25	GJM 1117	Light yellow	Green
4	EC 501569	Light yellow	Green	26	GM 04-02	Light yellow	Green
5	EC 496841	Light yellow	Green	27	GM 05-05	Light yellow	Green
6	GAM 5	Light yellow	Green	28	GM 06-08	Yellow	Green
7	GJM 1004	Light yellow	Green	29	GM 02-13	Light yellow	Green
8	GJM 1007	Light yellow	Green	30	GM 02-15	Light yellow	Green
9	GJM 1008	Light yellow	Green	31	GM 02-16	Light yellow	Green
10	GJM 1011	Light yellow	Green	32	GM 1924	Light yellow	Green
11	GJM 1012	Light yellow	Green	33	GM 1925	Light yellow	Green
12	GJM 1016	Light yellow	Green	34	GM 4	Light yellow	Green
13	GJM 1020	Light yellow	Green	35	IC 12434	Light yellow	Green
14	GJM 1022	Light yellow	Green	36	IC 24789	Light yellow	Green
15	GJM 1025	Light yellow	Green	37	IC 8917	Light yellow	Green
16	GJM 1026	Light yellow	Green	38	J 781	Light yellow	Green
17	GJM 1027	Light yellow	Green	39	K 851	Light yellow	Green
18	GJM 1028	Light yellow	Green	40	Kopergaon	Light yellow	Green
19	GJM 1103	Light yellow	Green	41	OUM 11-5	Light yellow	Green
20	GJM 1104	Light yellow	Green	42	Pant M-3	Light yellow	Green
21	GJM 1110	Light yellow	Green	43	RMG 268	Light yellow	Green
22	GJM 1112	Light yellow	Green	44	TARM 18	Light yellow	Green

Table 8: Identification and grouping of mung bean genotypes based on pod pubescence and pod position

Sr. No.	Genotypes	Pod - pubescence	Pod position	Sr. No.	Genotypes	Pod pubes -cence	Pod position
1	EC 251810	Present	Above canopy	23	GJM 1113	Present	Above canopy
2	EC 450450	Present	Above canopy	24	GJM 1116	Present	Above canopy
3	EC 482907	Present	Above canopy	25	GJM 1117	Present	Above canopy
4	EC 501569	Present	Above canopy	26	GM 04-02	Present	Above canopy
5	EC 496841	Present	Above canopy	27	GM 05-05	Present	Above canopy
6	GAM 5	Present	Above canopy	28	GM 06-08	Present	Above canopy
7	GJM 1004	Present	Above canopy	29	GM 02-13	Present	Above canopy
8	GJM 1007	Present	Above canopy	30	GM 02-15	Present	Above canopy
9	GJM 1008	Present	Above canopy	31	GM 02-16	Present	Above canopy
10	GJM 1011	Present	Above canopy	32	GM 1924	Present	Intermediate
11	GJM 1012	Present	Above canopy	33	GM 1925	Present	Above canopy
12	GJM 1016	Present	Above canopy	34	GM 4	Present	Above canopy
13	GJM 1020	Present	Above canopy	35	IC 12434	Present	Above canopy
14	GJM 1022	Present	Above canopy	36	IC 24789	Present	Above canopy
15	GJM 1025	Present	Above canopy	37	IC 8917	Present	Above canopy
16	GJM 1026	Present	Above canopy	38	J 781	Present	Above canopy
17	GJM 1027	Present	Above canopy	39	K 851	Present	Above canopy
18	GJM 1028	Present	Above canopy	40	Kopergaon	Present	Above canopy
19	GJM 1103	Present	Above canopy	41	OUM 11-5	Present	Above canopy
20	GJM 1104	Present	Above canopy	42	Pant M-3	Present	Above canopy
21	GJM 1110	Present	Above canopy	43	RMG 268	Present	Above canopy
22	GJM 1112	Present	Above canopy	44	TARM 18	Present	Above canopy

Table 9: Identification and grouping of mung bean genotypes based on plant height (cm) and pod colour of mature pod

Sr. No.	Genotype	Plant height (cm)	Group	Pod colour of mature pod	Sr. No.	Genotype	Plant height (cm)	Group	Pod colour of mature pod
1	EC 251810	84.20	Long	Brown	23	GJM 1113	73.73	Long	Black
2	EC 450450	53.93	Medium	Brown	24	GJM 1116	52.40	Medium	Brown
3	EC 482907	83.93	Long	Brown	25	GJM 1117	56.07	Medium	Brown
4	EC 501569	61.33	Medium	Brown	26	GM 04-02	63.20	Medium	Brown
5	EC 496841	79.80	Long	Brown	27	GM 05-05	53.00	Medium	Black
6	GAM 5	74.87	Long	Black	28	GM 06-08	59.40	Medium	Brown
7	GJM 1004	62.33	Medium	Brown	29	GM 02-13	54.53	Medium	Black
8	GJM 1007	94.07	Long	Black	30	GM 02-15	58.87	Medium	Brown
9	GJM 1008	58.73	Medium	Brown	31	GM 02-16	52.47	Medium	Black
10	GJM 1011	93.80	Long	Black	32	GM 1924	85.67	Long	Brown
11	GJM 1012	81.60	Long	Black	33	GM 1925	76.13	Long	Brown
12	GJM 1016	56.20	Medium	Brown	34	GM 4	63.60	Medium	Black
13	GJM 1020	55.47	Medium	Brown	35	IC 12434	63.60	Medium	Brown
14	GJM 1022	57.07	Medium	Black	36	IC 24789	64.07	Medium	Black
15	GJM 1025	64.33	Medium	Black	37	IC 8917	64.40	Medium	Black
16	GJM 1026	61.73	Medium	Brown	38	J 781	51.80	Medium	Black
17	GJM 1027	54.60	Medium	Brown	39	K 851	45.73	Short	Brown
18	GJM 1028	64.80	Medium	Brown	40	Kopergaon	56.40	Medium	Black
19	GJM 1103	62.60	Medium	Brown	41	OUM 11-5	57.47	Medium	Brown
20	GJM 1104	70.53	Long	Black	42	Pant M-3	55.87	Medium	Black
21	GJM 1110	64.67	Medium	Brown	43	RMG 268	56.13	Medium	Black
22	GJM 1112	84.53	Long	Brown	44	TARM 18	60.47	Medium	Brown
	Mean	64.77							
	S.Em ±	1.29							
	C.D. at 5 %	3.62							
	CV %	3.45							

Note: Plant height (cm)

Short : < 50 cm

Medium : 50-70 cm

Long : > 70 cm

The genotype GJM 1020 was distinct genotype amongst 44 genotypes based on leaf morphology with small leaf size, deltoid leaf shape, dark green leaf, purple vein and absent of leaflet lobes. Similarly, GM 06-08 was distinct with medium leaf size, ovate leaf shape, green leaf, purple vein and present of leaflet lobes and GJM 1103 with small leaf size, ovate leaf shape, dark green leaf, purple vein and present of leaflet lobes. Genotypes GJM 1022 and GJM 1924 had similar leaf morphology with medium leaf size, deltoid leaf shape, dark green leaf, purple vein and absent of leaflet lobes. Genotype GJM 1026 was differing from EC 496841 and OUM 11-5 with respect to leaf colour as leaf colour was dark in GJM 1026 and dark green in EC 496841 and OUM 11-5, while other leaf morphology was same in all these three genotypes. The other genotypes can not be differentiated based on leaf morphology.

Similar characterization and grouping of genotypes based on leaf morphological characters were made by Kaur et al. (2017) in mung bean; Chakrabarthy and Agarwal (1989) in black gram; Gnyandev (2009) and Joshi and Yasin (2014) in chickpea; Kanaka Durga et al. (2015) in horse gram; and Kumar and Shrikant (2016) in cowpea.

Pod morphological characters

The pod morphological characteristics influence the yielding ability of the plant. The genotypic variation was observed for various characteristics of pods such as colour of mature and premature pods, pubescence on pods, length of mature pods and pod position, which help in classifying the genotypes into different groups (Table 7, 8, 9 and 10). All the 44 mung bean genotypes evaluated did not show any variation for pod colour of premature pods as well as

Table 10: Identification and grouping of mung bean genotypes based on pod length (cm)

Sr. No.	Genotypes	Pod length (cm)	Group	Sr. No.	Genotypes	Pod length (cm)	Group
1	EC 251810	8.63	Medium	23	GJM 1113	9.38	Medium
2	EC 450450	8.70	Medium	24	GJM 1116	8.29	Medium
3	EC 482907	7.41	Short	25	GJM 1117	7.76	Short
4	EC 501569	8.37	Medium	26	GM 04-02	6.83	Short
5	EC 496841	8.24	Medium	27	GM 05-05	7.95	Short
6	GAM 5	8.13	Medium	28	GM 06-08	9.51	Medium
7	GJM 1004	8.72	Medium	29	GM 02-13	6.72	Short
8	GJM 1007	7.06	Short	30	GM 02-15	8.53	Medium
9	GJM 1008	6.37	Short	31	GM 02-16	8.01	Medium
10	GJM 1011	8.53	Medium	32	GM 1924	8.28	Medium
11	GJM 1012	8.56	Medium	33	GM 1925	8.23	Medium
12	GJM 1016	7.57	Short	34	GM 4	7.69	Short
13	GJM 1020	9.05	Medium	35	IC 12434	8.47	Medium
14	GJM 1022	8.76	Medium	36	IC 24789	8.25	Medium
15	GJM 1025	11.03	Long	37	IC 8917	7.37	Short
16	GJM 1026	8.37	Medium	38	J 781	8.70	Medium
17	GJM 1027	7.44	Short	39	K 851	6.80	Short
18	GJM 1028	7.87	Short	40	Kopergaon	12.19	Long
19	GJM 1103	7.21	Short	41	OUM 11-5	6.39	Short
20	GJM 1104	8.28	Medium	42	Pant M-3	6.76	Short
21	GJM 1110	8.85	Medium	43	RMG 268	6.83	Short
22	GJM 1112	6.64	Short	44	TARM 18	10.63	Long
	Mean	8.16					
	S.Em ±	0.12					
	C.D. at 5 %	0.35					
	CV %	2.61					

Note: Pod length (cm)

Short : < 8 cm
 Medium : 8-10 cm
 Long : > 10 cm

pubescence on pods. All the genotypes evaluated were having green premature pod colour with pubescence on pods. The pod position varied among the mung bean genotypes. Among 44 genotypes, pod position was indeterminate in only one genotype (GM 1924), while it was observed above canopy in all the remaining forty three genotypes. Based on the pod length of mature pods, genotypes were grouped into two groups as black (18 genotypes) and brown (26 genotypes) colour pods. The pod length at maturity varied among the mung bean genotypes. The mean mature pod length of the genotypes was 8.16 cm. Significantly the highest mature pod length was observed in Kopergaon (12.19 cm) followed by GJM 1025 (11.03 cm), TARM 18 (10.63 cm) and GM 06-08 (9.51 cm) and the lowest was observed in GJM 1008 (6.37 cm). Among 44 genotypes, mature pod length was long in three genotypes (GJM 1025, Kopergaon and TARM 18), while it was short in eighteen genotypes and medium in twenty three genotypes. On the basis of pod morphological characteristics, genotypes GM 1924 was distinct amongst 44 genotypes with indeterminate pod position with brown colour medium length pods at maturity, while TARM 18 was distinct with brown pod colour at maturity with long pod length and GJM 1025 and Kopergaon were distinct with black colour long pods at maturity. The other genotypes can not be differentiated with pod morphological characters. Similar observations and grouping of genotypes based on pod morphological characters were made by Singh et al. (2014) and Kaur et al. (2017) in mung bean; Yadav and Srivastava (2002), Gnyandev (2009) and Bayahi and Rezgui (2015) in chickpea; Chandrashekhar (2008) and Das et al. (2014) in french bean; Basavaraj et al. (2013) and Kumar and Shrikant (2016) in cowpea; Kumar et al. (2013) in guar; and Kanaka Durga et al. (2015) in horse gram.

CONCLUSION

In the present study, it was found that Pant M-3 was distinct genotype based on flower morphology, as it was late in flowering with

light yellow purple colour. On the basis of plant morphological characteristics, K 851 was distinct genotype with dwarf stature, green with purple petiole colour, determinate plant habit and spreading type plant growth habit, and genotype EC 482907 was distinct genotype with tall stature with green petiole, indeterminate plant habit and spreading type plant growth habit. Based on leaf characters, genotype GJM 1020 was distinct genotype with small leaf size, deltoid leaf shape, dark green leaf, purple vein and absent of leaflet lobes, while GM 06-08 was distinct with medium leaf size, ovate leaf shape, green leaf, purple vein and present of leaflet lobes and GJM 1103 with small leaf size, ovate leaf shape, dark green leaf, purple vein and present of leaflet lobes. Based on pod morphology, the genotype GM 1924 was distinct with indeterminate pod position with brown colour medium length pods at maturity, while TARM 18 was distinct with brown pods at maturity with long pod length and GJM 1025 and Kopergaon were distinct with black colour long pods at maturity.

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