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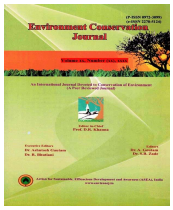

Characterization of the green gram (*Vigna radiata* L.) genotypes through both morphological and biochemical parameters

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ABSTRACT

Eight genotypes of greengram were collected in the present investigation from AICRP on MULLaRP, Bidhan Chandra Krishi Viswavidyalaya (BCKV) and they were characterized with ten quantitative, nineteen qualitative and two biochemical parameters as per the NBPGR descriptor. Grouping based on DUS descriptors indicate the existence of genetic diversity within the genotypes. These eight genotypes were evaluated and characterized for 31 DUS descriptors. However, 21 characters out of 31 characters of DUS descriptors differed significantly indicating a large and exploitable amount of genetic variability for the individual elite improved line profile development for identification and protection. The elite lines are similar for the important plant traits like semi erect and determinate growth habit but the development of erect types is the need of hour and indicates the incorporation of new germplasm for the improvement of this trait in the present material. Genotypes could be easily identified through some unique characters: SML-1822 could be identified amongst genotypes studied here in through its semi-erect growth habit, green stem colour with purple shade, dark green leaf colour, light yellow flower colour and bearing pods below canopy; identification of IPM-512-1 and TMB-37 could be made through seeds with drum shape and dull seed luster respectively; and Pusa Vishal through its leaves with dark green colour along with intermediate pod position and larger seed size. Samrat is having highest amount of protein as well as carbohydrate content among these genotypes. Thus, the DUS descriptor data generated with unique profiles of the elite improved lines can be used for the registration with PPV & FRA and seed purity testing.

Introduction

Vigna radiata L. wilczek which is commonly known as mungbean or greengram is one of the most widely distributed crop species among the six Asiatic *Vigna* species. Essential amino acids especially lysine and tryptophan are mainly found in green gram along with other proteins. It is also having certain other added features compared to other pulses like the crop is relatively drought tolerant and well adapted to a varied soil conditions including light soils and it can thrive well even under limited irrigation. Moreover, it is very well suited to crop rotation and crop mixtures (Uzoh *et al.,* 2019). However, green gram yield advantage is major drawback for this crop that is well below the optimum level. The average yield of mungbean is very low not only in India (425 kg/ha) as well as in entire tropical and subtropical Asia. Other than management factors, the major cause for the low productivity can be described to the inherently low yield potential of the cultivars coupled with susceptibility to diseases. Due to the limited variability prevailed among the parents used for

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hybridization; the success had been very limited in most of the studies (Bordolui *et al.,* 2015). There is always a possibility of improving the crop by incorporating diversified gene present in the germplasm. Sometime stepwise utilization of primary gene pools of this crop can result in tremendous improvement in yield. It is essential to evaluate the available germplasm collections in order to utilize the variability available in the primary gene pool, Hence, this study was taken up to evaluate and characterize available germplasm of green gram using NBPGR descriptors with a view to evaluate the available germplasm using the descriptors and to form the core collection.

Material and Methods

Characterization of greengram genotypes was traditionally carried out by using morpho-agronomic traits. PPV & FRA (Protection of Plant Varieties and Farmers' Rights Authority) has come up with a set of DUS (Distinctiveness, Uniformity and Stability) descriptors for characterization of the lines for their registration and protection. Thus, in the present study, eight genotypes were characterized using PPV&FRA descriptors to know the extent variability present in these genotypes.

The genotypes were collected from AICRP on MULLaRP, BCKV. The laboratory experiment was done in seed testing laboratory and field performance was observed in 'D'-Block Farm, Kalyani, BCKV, West Bengal during 2019 and 2020. Seeds were sown in individual plots following standard agronomic practices and intercultural operations in the plot, with three replications following Randomized Block Design. Spacing was 30 cm between the rows, 10 cm between the plants and 50 cm between the two plots. Each plot was 2m length and 2m breadth. The different morphological and biochemical parameters such as hypocotyl: anthocyanin colouration, growth habit, time of flowering, plant habit, stem colour, stem pubescence, leaf colour, leaf pubescence, leaf shape, flower colour, premature pod colour, pod pubescence, pod position, pod colour at maturity, curvature of pod, seed colour, seed luster, seed shape, seed size, protein content and carbohydrate content were recorded. The different quantitative characters like field emergence (%), plant height at 15 DAS (cm), plant height at first flowering (cm), days to first flowering, number of nodule plant^{-1}, days to 50 % flowering, days to maturity, number of pods plant^{-1}, number of seeds pod^{-1}, and seed yield plant^{-1} (g) were also recorded.

Results and Discussion

The results are discussions are detailed out below:

Characterization through qualitative parameters

Morphological characteristics provide the basic information about the genetic variability among different genotypes. For morphological characterization of such eight genotypes, 19 qualitative characters were recorded. The trait, anthocyanin colouration, was recorded at seedling stage and was noticed in all genotypes. This is the trait which is highly used in breeding programmes for differentiation of genotypes, and also useful in maintenance breeding and Intellectual property protection. Similar exploitation of morphological traits in mungbean was reported by Mukherjee and Pradhan (2002); Khattak *et al.* (2000); Bordolui *et al.* (2006) and Patel *et al.* (2019). The characters, time of flowering, plant habit and stem pubescence, were recorded at 50% flowering stage and variation among the genotypes was not observed. All the genotypes showed early flowering, determinate plant habit and presence of stem pubescence indicating these morphological characters are not useful in characterization of these genotypes. Erect type growth habit was noticed in Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37, whileSML-1822 exhibited semi-erect type. All the genotypes were of determinant plant habit. Stem colour was recorded at 50% flowering stage and it varied among the genotypes: for Meha and SML-1822, stem colour was green with purple tinge, while other genotypes were observed with green stem colour.

No variation was observed for leaf shape: all genotypes were of ovate leaf shape. Dark green leaves were observed for Pusa Vishal and SML-1822, while remaining genotypes recorded leaves of green colour. SML-1822 could be identified as the only genotype bearing light yellow flowers, while yellow colour flowers were noticed for all other genotypes. Jain *et al.* (2002) reported the usefulness of flower characteristics in characterization of greengram. Premature pod colour was recorded when pods were fully

Table 1: Characterization of green gram genotypes through qualitative characters.

SN	Characters	Genotypes							
		Pusa Vishal	**PM-11-9**	**IPM-2-3**	**Meha**	**Samrat**	**IPM-512-1**	**TMB-37**	**SML-1822**
1.	Hypocotyl: Anthocyanin colouration	Present	Present	Present	Present	Present	Present	Present	Present
2.	Growth habit	Erect	Erect	Erect	Erect	Erect	Erect	Erect	Semi-erect
3.	Time of flowering	Early	Early	Early	Early	Early	Early	Early	Early
4.	Plant habit	Determinate	Determinate	Determinate	Determinate	Determinate	Determinate	Determinate	Determinate
5.	Stem colour	Green	Green	Green	Green with purple	Green	Green	Green	Green with purple
6.	Stem pubescence	Present	Present	Present	Present	Present	Present	Present	Present
7.	Leaf colour	Dark green	Green	Green	Green	Green	Green	Green	Dark green
8.	Leaf pubescence	Present	Present	Present	Present	Present	Present	Present	Present
9.	Leaf shape	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate
10.	Flower colour	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Light Yellow
11.	Premature Pod colour	Green	Green	Green	Green	Green	Green	Green	Green
12.	Pod pubescence	Present	Present	Present	Present	Present	Present	Present	Present
13.	Pod position	Intermediate	Above canopy	Intermediate	Above canopy	Above canopy	Above canopy	Above canopy	Not visible
14.	Pod colour at maturity	Black	Black	Black	Black	Black	Black	Black	Black
15.	Curvature of pod	Straight	Straight	Straight	Straight	Straight	Straight	Straight	Straight
16.	Seed colour	Green	Green	Green	Green	Green	Green	Green	Green
17.	Seed luster	Shiny	Shiny	Shiny	Shiny	Shiny	Shiny	Dull	Shiny
18.	Seed shape	Oval	Oval	Oval	Oval	Oval	Drum	Oval	Oval
19	Seed size	Large	Medium	Medium	Medium	Large	Medium	Large	Medium

Table 2: Grouping of eight green gram genotypes based on DUS descriptors

Morphological characters	Characters	Genotypes
Hypocotyl-Anthocyanin colouration	Absent	None
	Present	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37, SML-1822
Time of flowering	Early	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37, SML-1822
	Medium	None
	Late	None
Growth habit	Erect	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37
	Semi-erect	SML-1822
	Spreading	None
Plant habit	Determinate	Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37, SML-1822
	Indeterminate	None
Stem colour	Green	Pusa Vishal, PM-11-9, IPM-2-3, Samrat, IPM-512-1, TMB-37
	Green with purple	Meha,SML-1822
	purple	None
Stem pubescence	Absent	None
	Present	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37, SML-1822
Leaf colour	Green	PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37,
	Dark green	Pusa Vishal,SML-1822
Leaf pubescence	Absent	None
	Present	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37, SML-1822
Leaf shape	Deltoid	None
	Ovate	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37, SML-1822
	Lanceolate	None
	Cuneate	None
Flower colour	Yellow	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37
	Light yellow	SML-1822
Premature Pod colour	Green	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37, SML-1822
	Green with pigmented suture	None
Pod pubescence	Absent	None
	Present	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37, SML-1822
Pod position	Above canopy	PM-11-9, Meha, Samrat, IPM-512-1, TMB-37
	Intermediate	Pusa Vishal, IPM-2-3
	Not visible	SML-1822
Pod colour at maturity	Brown	None
	Black	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37, SML-1822
Curvature of pod	Straight	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37, SML-1822
	Curve	None
Seed colour	Yellow	None
	Green	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, TMB-37, SML-1822
	Mottled	None
	Black	None
Seed luster	Shiny	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, IPM-512-1, SML-1822
	Dull	TMB-37
Seed shape	Oval	Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, TMB-37, SML-1822
	Drum	IPM-512-1
Seed size	Small	None
	Medium	PM-11-9, IPM-2-3, Meha, IPM-512-1, SML-1822
	Large	Pusa Vishal,Samrat,TMB-37

developed and all genotypes recorded to bear pods having green colour. Pod pubescence was noticed irrespective of the genotypes. All the genotypes exhibited straight pods but no curvature was noticed at all. During maturity each genotype was observed with black pods. Similar report of straight pods without curvature was reported by Sunil *et al.* (2014) in their study in greengram. Pod position was intermediate in Pusa Vishal and IPM-2-3, but it was below canopy in SML-1822 only, while other genotypes exhibited above canopy pod position.

All the genotypes produced seeds of green seed colour. Seed luster of TMB-37 were dull and the other genotypes exhibited shiny seed luster. For seed shape of the genotypes, Pusa Vishal, PM-11-9, IPM-2-3, Meha, Samrat, TMB-37 and SML-1822 were of oval, while IPM-512-1 only exhibited seeds of drum shape. Seed size (100 seed weight) was

Table 3: Characterization of green gram genotypes through quantitative characters (pooled).

	Field emergence (%)	Plant height at 15 DAS (cm)	Plant height at first flowering (cm)	Days to first flowering	Number of nodule plant^{-1}	Days to 50 % flowering	Days to maturity	Number of pods plant^{-1}	Number of seeds pod^{-1}	Seed Yield plant^{-1} (g)
Pusa Vishal	75.81 (60.52)	12.54	43.23	35.33	9.31	42.67	73.00	27.93	10.45	14.86
PM-11-9	77.73 (61.82)	9.13	34.64	36.33	9.40	44.00	73.67	24.57	10.67	13.33
IPM-2-3	76.09 (60.71)	10.02	35.57	37.67	8.22	44.67	71.00	24.88	10.47	13.27
Meha	79.65 (63.16)	10.44	36.39	36.00	9.69	43.00	74.00	22.89	9.42	10.97
Samrat	78.23 (62.17)	9.26	32.00	38.67	8.64	45.67	71.67	28.53	11.19	16.25
IPM-512-1	79.30 (62.91)	10.19	45.51	38.67	9.93	46.00	71.33	26.46	12.42	16.72
TMB-37	77.66 (61.77)	9.87	37.44	33.67	9.79	42.00	72.33	28.32	12.21	17.62
SML-1822	78.26 (62.18)	9.74	36.63	37.00	10.30	44.67	74.00	27.82	10.54	14.92
SEm(±)	0.135	0.184	0.26	0.398	-	0.496	0.57	0.559	0.153	0.386
LSD (0.05%)	0.413	0.565	0.797	1.22	-	1.519	1.747	1.713	0.468	1.183

(Figures in parenthesis are arc-sin transformed values.)

Table 4: Characterization of green gram genotypes through biochemical characters.

	Protein content (mg g^{-1})	Carbohydrate content (mg g^{-1})
Pusa Vishal	225.254	637.198
PM-11-9	221.232	635.856
IPM-2-3	225.219	636.221
Meha	222.751	636.087
Samrat	225.284	637.416
IPM-512-1	225.263	637.312
TMB-37	225.245	636.871
SML-1822	221.080	635.721
SEm(±)	0.045	0.087
LSD (0.05%)	0.137	0.264

medium for PM-11-9, IPM-2-3, Meha, IPM-512-1, SML-1822, while large seeds were produced by Pusa Vishal, Samrat and TMB-37. Similar reports of exploiting the seed characters' variability in greengram was reported by Venkateswarlu (2001), and Khajudparn and Tantasawat (2011).

Thus, it is clear from both the tables 1 & 2 that genotype(s) could be easily identified through some unique characters: SML-1822 could be identified amongst the eight genotypes studied here in through its semi-erect growth habit, green stem colour with purple shade, dark green leaf colour, light yellow flower colour and bearing pods below canopy; IPM-512-1 and TMB-37 could be identified through seeds with drum shape and dull seed luster respectively among the genotypes; and Pusa Vishal through dark green leaves with intermediate pod position and larger seed size.

Therefore, the present study indicates the importance of morphological characterization using DUS descriptors for the registration, maintenance and protection of genotypes.

Characterization through quantitative parameters

Significant variation was noticed for all the quantitative characters among the genotypes excepting number of nodules plant^{-1}. Highest field emergence was observed for Meha (79.65%) followed by IPM-512-1; while lowest field emergence (75.81%) was recognized for Pusa Vishal. Maximum number of nodule plant^{-1}(10.30) was found for SML-1822, though non-significant, followed by IPM-512-1 and minimum number of nodule plant^{-1} for IPM-2-3 but this trait varied non-significantly among the genotypes. After 15 days of sowing, the highest plant height (12.54 cm) was observed in Pusa Vishal followed by IPM-512-1 and it was lowest in PM-11-9**.** But during first flowering stage, Pusa Vishal and IPM-512-1 interchanged their position i.e., highest was observed for IPM-512-1 followed by Pusa Vishal and at that stage, lowest was observed for Samrat. Minimum days required for 50% flowering (42.00) was observed for TMB-37 preceded by Pusa Vishal; non-significant variation was observed between these two genotypes; but the genotypes varied significantly for this character. Least days were taken for maturity by IPM-2-3 (71.00) preceded by IPM-512-1 and Samrat. These three genotypes performed statistically at par with each other. Highest number of pods plant^{-1} was recorded for Samrat (28.53) followed by TMB-37, while it was lowest for PM-11-9. Seed yield plant^{-1}(g) was maximum for TMB-37 followed by IPM-512-1 and minimum was found in IPM-2-3. These results are similar with the findings of Uddin *et al.* (2010); Dash and Rautaray (2017). Thus, clear variation for these quantitative characters considered here for identification of the genotypes, therefore, could be utilized in a better way for identification of the genotypes, especially for the genotypes occupying lowest and/or highest position for individual character.

Characterization through biochemical parameters

Two biochemical parameters i.e., protein and carbohydrate contents were observed for quantitative characterization of the genotypes. Highest protein was recorded in Samrat followed by IPM-512-1, Pusa Vishal and TMB-37, though these genotypes were statistically at par. Lowest protein was observed in SML-1822**.** But among the genotypes protein content varied significantly. Highest carbohydrate content also was observed in Samrat followed by IPM-512-1, Pusa Vishal and TMB-37; non-significant variation was observed between Samrat and IPM-512-1 and lowest was observed for SML-1822**.** But among the genotypes, this trait varied significantly. Similar type of result was observed by Blessing and Gregory (2010). As a main storage protein mung beans contain higher amounts of protein with globulin and albumin in the seeds (Kirchhoff, 2002). However, the lack of raffinose may be the reason of having smaller amount carbohydrate, resulting in hydrolysis of sucrose to supply energy (Mubarak, 2005).

Conclusion

Genotypes studied in this experiment could be easily identified through some unique characters: SML-1822 could be identified amongst the eight genotypes studied here in through its semi-erect growth habit, green stem colour with purple shade, dark green leaf colour, light yellow flower colour and bearing pods below canopy; identification of IPM-512-1 and TMB-37 could be made through seeds with drum shape and dull seed luster respectively; and Pusa Vishal through its leaves with dark green colour along with intermediate pod position and larger seed size. However, Samrat is having highest amount of protein as well as carbohydrate contents among these genotypes.

Conflict of interest

The authors declare that they have no conflict of interest.

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