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Characterization in F_1 generation of mungbean [*Vigna radiata* (L.) Wilczek] for morphological traits

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Abstract
A total of nineteen morphological traits were studied on forty mungbean crosses during Summer-2021. All the crosses were grown in randomized complete block design with three replications. All the morphological traits were recorded as per crop DUS guideline. The maximum variability was noted in leaf vein colour, leaf colour, colour of petal, pod colour, pod curvature, seed lusture, seed shape, leaflet lobes and hypocotyl colouration. Low frequency was observed in leaf vein colour (15%) followed by seed colour (10%), leaflet lobes (10%), anthocyanin colouration (10%), seed colour (10%), seed size (7.5%) and stem colour (2.5%).Frequency distribution in these traits is very low and these traits are uniqe. On the basis of these traits germplasm can be identified very easily.

Keywords: Crosses, morphological, characterization, evaluated, traits

Introduction
Mungbean [*Vigna radiata* (L.) Wilczek] is an important legume crop. The mungbean is also known as green gram, golden gram and moong. Mungbean belonging to the sub-genus ceratotropis is diploid species with 2n=2x=22 chromosomes with a genome size of 579 Mb/1C. Mungbean is of Indian origin. *Vigna radiata* var. sublobata Verdc. is the closest wild relative of the cultivated mungbean. Its capacity to restore soil fertility through nitrogen fixation makes it a valuable crop in various cropping systems, particularly in wheat-rice. Due to rich in quality protein, minerals and vitamins they are inseparable ingredients in the diets of a vast majority of Indian population. A seed of mungbean is highly nutritious containing 24-28% protein, 1.0-1.5% fat, 3.5-4.5% fibre and 4.5-5.5% ash on dry weight basis and provide 334-344 kcal energy. Mungbean protein is considered to be easily digestible.
Heterosis has important implications for both in F1 and obtaining transgressive segregants in F2 generation. Genetic information regarding heterosis provides a clue for selecting the most suitable parents for hybridization. The presence of heterosis in food legumes has been demonstrated by (Singh *et al*., 1975., Shinde and Deshmukh 1989) [13, 11]. Little information about morphological characterization is available in F_1.
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 breeders 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 "Morphological characterization of mungbean [*Vigna radiata* (L.) Wilczek] crosses (F_1s) based on DUS guidelines" was carried out (Patel *et al*; 2019) [10].

Materials and Methods
The present study on Morphological characterization of 14 mungbean crosses was taken up at seed breeding farm, Department of Plant Breeding and Genetics. Selected 14 genotypes (10 lines and 4 testers) were crossed in Line x Tester fashion under BARC project and 40 crosses (F1s) were obtained. These 40 crosses were evaluated in the field using randomized block design with three replications. Data were recorded for different morphological characters following standard procedures and the F1s were grouped.

Results and Discussion

Anthocyanin: Hypocotyl colouration

Hypocotyl anthocyanin pigmentation has great importance in cross based breeding programme to detect the pure crosses due to its monogenic dominance inheritance pattern (Khattak *et al*., 2000; Mukherjee and Pradhan 2002) [8, 9]. This trait can be used as a morphological marker for screening of breeding material at seedling stage. In present investigation, 90% crosses exhibited anthocyanin colouration while 10% did not *viz*. TMB37XShikha, Ganga8XShikha, LGG460XVirat and HUM1XShikha (Table 2).

Flower characteristics

Based on flower characteristics such as time of flowering and petal colour, crosses could be grouped into different categories (Table 1). Time of flowering varied with the crosses ranging from 25% (medium) to 75% (early) whereas petal colour ranged from yellow (72.5%) to light yellow (27.5%) (Table 2). Similar findings and groupings of genotypes based on flower morphological characters were made by Jain *et al*., (2002) [5], Singh *et al*., (2014) [12] and Kaur *et al*., (2017) [7] in mungbean; Chandrasekhar *et al*., (2008) [2] and Das *et al*., (2014) [3] in french bean; Yadav and Srivastava (2002) [14], Gnyandev (2009) [4] and Joshi and Yasin (2014) [6] in chickpea.

Plant morphological characteristics

Use of plant diagnostic characteristics to identify a variety has been classical taxonomy approach for both varietal purity and varietal identification. On the basis of the plant morphological characteristics such as plant growth habit and plant habit, crosses were grouped in different categories (Table 1). Crosses for the plant growth habit ranged from 75% (spreading) to 25% (semi-erect) whereas the plant habit of all the crosses was indeterminate in nature (Table 2). Similar characterization in grouping based on plant morphological characters were made by Jain *et al*., (2002) [5], Singh *et al*., (2014) [12] and Kaur *et al*., (2017) [7] in mungbean.

Stem morphological characteristics

All the 40 mungbean crosses evaluated did not show any variation for stem pubescence (Table 1). Pubescence was present in all the crosses evaluated. Based on stem colour the crosses were grouped into different categories as green, green with purple splashes and purple. Among 40 crosses, stem colour was green in 25% of crosses whereas it was observed green with purple splashes in 72.5% of crosses and with purple in 2.5% crosses only (Table 2). Therefore, the evaluated 40 crosses of mungbean can be differentiated on the basis of stem colour only. Similar characterization and grouping based on stem morphological characters were made by Jain *et al*., (2002) [5], Singh *et al*., (2014) [12] and Kaur *et al*., (2017) [7] in mungbean; Chakarabarthy and Agarwal (1989) [1] in blackgram.

Leaf morphological characteristics

The leaflet lobes, leaf colour, leaf vein colour and leaf shape plays an important role in the yielding ability of plants, 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 crosses were categorized in two different groups (Table 1). The frequency of leaflet lobes, leaf colour, leaf vein colour and leaf shape ranged from 90% (absent) to 10% (present), 72.5% (green) to 27.5% (dark green), 62.5% (greenish purple) to 22.5% (purple) and 15% (green) and 100% ovate showing negligible variation respectively (Table 2). Similar characterization and grouping based on leaf morphological characters were made by Kaur *et al*., (2017) [7] in mungbean; Chakarabarthy and Agarwal (1989) [1] in blackgram.

Pod morphological characters

The pod morphological characteristics, influence the yielding ability of the plant. The genotypic variation was observed for various characteristics of pod such as mature pod colour and curvature of mature pod. All the 40 crosses evaluated did not show any variation for pod pubescence and pre-mature pod colour. Based on mature pod colour crosses were grouped in two different groups as black (57.5%) and brown (42.5%) and curvature of pod ranged from 67.5% (curved) to 32.5% (straight). Similar observations and grouping based on pod morphological characters were made by Singh *et al*,. (2014) [12] and Kaur *et al*., (2017) [7] in mungbean.

Seed morphological characters

Based on seed morphology crosses were grouped into seed colour, seed shape and seed size (Table 1). Seed colour ranged from 90% (mottled) to 10% (green). Seed lusture range from 67.5% (dull) to 32.5% (shiny). Seed shape ranged from 50% (oval) to 50% (drum shaped). Seed size ranged from 92.5% (medium) to 7.5% (large).

Table 1: Morphological characterization of 40 mungbean crosses

Characters	Stage of Observation	Crosses									
		TJM196 X PDM139	**TJM196 X Shikha**	**TJM196 X Kanika**	**TJM196 X Virat**	**TJM136 X PDM139**	**TJM136 X Shikha**	**TJM136 X Kanika**	**TJM136 X Virat**	**TJM3 X PDM139**	**TJM3 X Shikha**
Hypocotyl: Anthocyanin Colouration	Cotyledons unfolded	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Flowering time	50% plants with at least one open flower	Early	Early	Medium	Medium	Early	Early	Medium	Early	Early	Early
Plant: Growth habit	50% flowering	Semi-erect	Spreading	Semi-erect	Spreading	Spreading	Spreading	Semi-erect	Semi-erect	Spreading	Spreading
Plant: Habit	50% flowering	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate
Stem: color	50% flowering	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green	Green
Stem: Pubescence	50% flowering	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Leaflet lobe (terminal)	50% flowering	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Leaf: Shape (terminal)	50% flowering	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate
Leaf: Color	50% flowering	Green	Green	Green	Green	Green	Green	Green	Green	Dark green	Dark green
Leaf: Vein color	50% flowering	Purple	Greenish purple	Purple	Purple	Greenish purple	Purple	Purple	Greenish purple	Green	Greenish purple
Flower: Petal Color (Standard)	50% flowering	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Light yellow
Pod: Pubescence	Fully developed green pods	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Pod: Pre mature pod color	Fully developed green pods	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Pod: Color	Harvest maturity	Black	Brown	Black	Black	Black	Black	Brown	Black	Black	Black
Curvature: Mature pod	Harvest maturity	Curved	Curved	Straight	Straight	Curved	Straight	Curved	Straight	Curved	Curved
Seed: color	Mature seeds	Mottled	Green	Green	Green	Mottled	Mottled	Mottled	Mottled	Mottled	Mottled
Seed: Shape	Mature seeds	Oval	Oval	Oval	Oval	Drum shaped	Drum shaped	Drum shaped	Oval	Oval	Drum shaped
Seed: Lusture	Mature seeds	Dull	Shiny	Shiny	Shiny	Dull	Dull	Dull	Dull	Dull	Dull
Seed: Size	Mature seeds	Medium	Medium	Medium	Medium	Large	Large	Medium	Medium	Medium	Medium

Characters	Stage of Observation	Crosses									
		TJM3 X Kanika	**TJM3 X Virat**	**TMB37 X PDM139**	**TMB37 X Shikha**	**TMB37 X Kanika**	**TMB37 X Virat**	**Ganga8 X PDM139**	**Ganga8 X Shikha**	**Ganga8 X Kanika**	**Gang8 X Virat**
Hypocotyl: Anthocyanin Colouration	**Cotyledon unfolded**	Present	Present	Present	Absent	Present	Present	Present	Absent	Present	Present
Flowering time	50% plants with at least one open flower	Early	Early	Early	Early	Early	Early	Early	Early	Medium	Early
Plant: Growth habit	50% flowering	Spreading	Spreading	Semi-erect	Spreading	Semi-erect	Spreading	Spreading	Spreading	Spreading	Semi-erect
Plant: Habit	50% flowering	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate
Stem: color	50% flowering	Green with purple splashes	Green with purple splashes	Green	Green	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes
Stem: Pubescence	50% flowering	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Leaflet lobe (Terminal)	50% flowering	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Leaf: Shape (terminal)	50% flowering	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate
Leaf: Color	50% flowering	Dark green	Dark green	Dark green	Dark green	Green	Green	Dark green	Dark green	Green	Dark green

Leaf: Vein color	50% flowering	Greenish purple	Greenish purple	Purple	Green	Greenish purple	Greenish purple	Purple	Greenish purple	Green	Greenish purple
Flower: Petal Color (Standard)	50% flowering	Light Yellow	Light Yellow	Yellow	Light yellow	Yellow	Yellow	Light yellow	Yellow	Light yellow	Yellow
Pod: Pubescence	Fully developed green pods	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Pod: Pre mature pod color	Fully developed green pods	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Pod: Color	Harvest maturity	Black	Brown	Black	Black	Black	Brown	Brown	Brown	Brown	Black
Curvature: Mature pod	Harvest maturity	Straight	Curved	Curved	Curved	Curved	Straight	Straight	Straight	Curved	Curved
Seed: color	Mature seeds	Mottled	Mottled	Mottled	Green	Mottled	Mottled	Mottled	Mottled	Mottled	Mottled
Seed: Shape	Mature seeds	Drum shaped	Drum shaped	Oval	Oval	Oval	Drum Shaped	Oval	Oval	Oval	Drum shaped
Seed: Lusture	Mature seeds	Dull	Dull	Shiny	Shiny	Dull	Shiny	Dull	Dull	Dull	Dull
Seed: Size	Mature seeds	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

Characters	**Stage of Observation**	**Crosses**									
		LGG460 X PDM139	**LGG460 X Shikha**	**LGG460 X Kanika**	**LGG460 X Virat**	**HUM1 X PDM139**	**HUM1 X Shikha**	**HUM1 X Kanika**	**HUM1 X Virat**	**SL668 X PDM139**	**SL668 X Shikha**
Hypocotyl: Anthocyanin Coloration	Cotyledons unfolded	Present	Present	Present	Absent	Present	Absent	Present	Present	Present	Present
Flowering time	50% plants with at least one open flower	Medium	Medium	Early	Early	Early	Early	Early	Early	Early	Early
Plant: Growth habit	50% flowering	Spreading	Spreading	Spreading	Spreading	Spreading	Spreading	Spreading	Semi-erect	Spreading	Spreading
Plant: Habit	50% flowering	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate
Stem: color	50% flowering	Green	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes	Purple	Green with purple splashes
Stem: Pubescence	50% flowering	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Leaflet lobe (Terminal)	50% flowering	Present	Absent	Present	Absent	Absent	Absent	Absent	Absent	Present	Present
Leaf: Shape (terminal)	50% flowering	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate
Leaf: Color	50% flowering	Dark green	Dark green	Green	Green	Green	Green	Green	Green	Green	Green
Leaf: Vein color	50% flowering	Greenish purple	Greenish purple	Greenish purple	Greenish purple	Greenish purple	Greenish purple	Green	Greenish purple	Greenish purple	Greenish purple
Flower: Petal Color (Standard)	50% flowering	Yellow	Yellow	Yellow	Yellow	Light yellow	Light yellow	Light yellow	Yellow	Yellow	Yellow
Pod: Pubescence	Fully developed green pods	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Pod: Pre mature pod color	Fully developed green pods	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Pod: Color	Harvest maturity	Brown	Brown	Brown	Brown	Black	Brown	Black	Black	Brown	Black
Curvature: Mature pod	Harvest maturity	Straight	Curved	Curved	Curved	Straight	Curved	Curved	Straight	Curved	Straight
Seed: color	Mature seeds	Mottled	Mottled	Mottled	Mottled	Mottled	Mottled	Mottled	Mottled	Mottled	Mottled
Seed: Shape	Mature seeds	Drum shaped	Drum shaped	Drum shaped	Drum shaped	Oval	Drum shaped	Oval	Drum shaped	Drum shaped	Drum shaped
Seed: Lusture	Mature seeds	Dull	Dull	Dull	Dull	Shiny	Dull	Dull	Dull	Dull	Shiny
Seed: Size	Mature seeds	Medium	Medium	Medium	Medium	Medium	Large	Medium	Medium	Medium	Medium

Characters	Stage of Observation	Crosses									
		SL668 X Kanika	**SL668 X Virat**	**Pusa Vishal X PDM139**	**Pusa Vishal X Shikha**	**Pusa Vishal X Kanika**	**Pusa Vishal X Virat**	**PDM11 X PDM139**	**PDM11 X Shikha**	**PDM11 X Kanika**	**PDM11 X Virat**
Hypocotyl: Anthocyanin Coloration	Cotyledons unfolded	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Flowering time	50% plants with at least one open flower	Medium	Early	Medium	Early	Medium	Early	Medium	Early	Early	Early
Plant: Growth habit	50% flowering	Spreading	Spreading	Spreading	Spreading	Spreading	Semi-erect	Spreading	Spreading	Semi-erect	Spreading
Plant: Habit	50% flowering	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate	Indeterminate
Stem: color	50% flowering	Green with purple splashes	Green with purple splashes	Green	Green	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green	Green	Green
Stem: Pubescence	50% flowering	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Leaflet lobe (terminal)	50% flowering	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Leaf: Shape (terminal)	50% flowering	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate
Leaf: Color	50% flowering	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Leaf: Vein color	50% flowering	Greenish purple	Greenish purple	Purple	Green	Greenish purple	Greenish purple	Purple	Green	Greenish purple	Greenish purple
Flower: Petal Color (Standard)	50% flowering	Yellow	Yellow	Light yellow	Yellow	Yellow	Light yellow	Yellow	Yellow	Yellow	Yellow
Pod: Pubescence	Fully developed green pods	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Pod: Pre mature pod color	Fully developed green pods	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Pod: Color	Harvest maturity	Black	Black	Brown	Brown	Black	Brown	Black	Black	Brown	Black
Curvature: Mature pod	Harvest maturity	Curved	Curved	Curved	Curved	Curved	Straight	Curved	Curved	Curved	Curved
Seed: color	Mature seeds	Mottled	Mottled	Mottled	Mottled	Mottled	Mottled	Mottled	Mottled	Mottled	Mottled
Seed: Shape	Mature seeds	Oval	Drum shaped	Drum shaped	Drum shaped	Drum shaped	Oval	Oval	Oval	Oval	Oval
Seed: Lusture	Mature seeds	Shiny	Shiny	Shiny	Dull	Dull	Dull	Shiny	Shiny	Dull	Dull
Seed: Size	Mature seeds	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

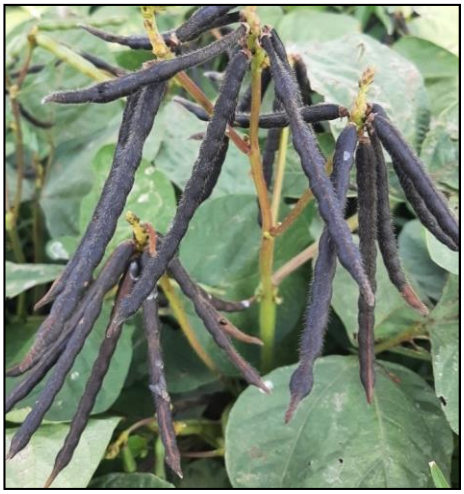
Table 2: Frequency distribution of morphological traits (40 Crosses)

Characters	Classes	Number of entry	Percentage of entry (%)
Hypocotyl: Anthocyanin Coloration	Present	36	90
	Absent	04	10
Time of flowering	Early (<40 days)	30	75
	Medium (40-50 days)	10	25
	Late (More the 50 days)	00	00
Plant: Growth habit	Erect	00	00
	Semi-erect	10	25
	Spreading	30	75
Plant: Habit	Determinate	00	00
	Indeterminate	40	100
Stem: Colour	Green	10	25
	Green with purple splashes	29	72.5
	Purple	01	2.5
Stem: Pubescence	Absent	00	00
	Present	40	100
Leaflet: Lobes (terminal)	Absent	36	90
	Present	04	10
Leaf: Shape	Deltoid	00	00
	Ovate	40	100
	Lanceolate	00	00
	Cuneate	00	00
Leaf: Colour	Green	29	72.5
	Dark green	11	27.5
Leaf: Vein colour	Green	06	15
	Greenish purple	25	62.5
	Purple	09	22.5
Flower: Colour of Petal	Yellow	29	72.5
	Light yellow	11	27.5
Pod: Colour of pre mature pod	Green	40	100
	Green with pigmented suture	00	00
Pod: Pubescence	Absent	00	00
	Present	40	100
Pod: Colour	Brown	17	42.5
	Black	23	57.5
Pod: Curvature of mature pod	Straight	13	32.5
	Curved	27	67.5
Seed: Colour	Yellow	00	00
	Green	4	10
	Mottled	36	90
	Black	00	00
Seed: Lusture	Shiny	13	32.5
	Dull	27	67.5
Seed: Shape	Oval	20	50
	Drum shaped	20	50
Seed: Size	Small (<3g)	00	00
	Medium (3-5g)	37	92.5
	Large (> 5g)	03	7.5

Brown Pod

Black pod

Shiny green seeds



Pod pubescence

Suggestion

Hybridization is the one of the breeding methodology to accumulate important genes for the development of new diverse genotypes. Characterization of F_1 progeny is also important to identify the genetics of breeding traits so that systematic breeding strategy may be followed for the

development of new morphologically variant genotypes/varieties. On the basis of this result, identification of such plant types which have heterozygous condition and appearance of their morphological traits at this stage can be easily carried out. This study will be fruitful for the identification of pure ones in their heterozygous condition.

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