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DUS Characterization of Elite Improved Lines of Greengram [*Vigna radiata* (L.) Wilczek]

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A B S T R A C T

The study was carried out to characterize elite improved lines of Greengram genotypes developed at Regional Agricultural Research Station (RARS), Lam, Guntur using DUS descriptors. The 29 elite improved lines and one released variety (LGG 460) were evaluated and characterized for 24 DUS descriptors i.e., anthocyanin colouration during cotyledonary stage, plant, stem, leaf, flower, pod and seed characters. 14characters out of 24 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. 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

Greengram [*Vigna radiata* (L.) Wilczek] (2n=2x=22), a self-pollinated crop of 579 Mb/1Cgenome size, is native to Indian subcontinent. It fixes atmospheric nitrogen in the soils like other pulse crops. It forms a major source of protein (240g/kg) and a range of micronutrients to the diet of vegetarian population of India (Ramakrishnan *et al.*, 2013). The easily digested proteins and carbohydrates of greengram are low in phytic acid, which reduces iron and zinc bioavailability after consumption. In 2018-19, the area and production of greengram in India are 4.25 m ha and 2.41 million tones, respectively (Anonymous, 2019). This short duration crop is amenable to diverse environmental situation including multiple cropping systems to expand its area and production and making India a nutritionally secure place for its growing population. The greengram production still depends on the small to medium varieties, which reach

maturity in 60-80 days. The major problems in greengram production are indeterminate growth types which need to be harvested multiple times; susceptibility to diseases and insect pests, and pod shattering. The average yields of the released varieties from various parts of the country are around 600kgs/ ha and this is far below the world average and is attributed to narrow genetic base and absence of suitable genotypes for different cropping situations. Further, it also highlighted the importance of development of new lines for yield to meet the growing needs of the nation (Abbas *et al.,* 2010; Pratap *et al.,* 2018).

Characterization of germplasm is the basic step in forming groups of lines having similar characteristics to get an idea of variability present in the lines and their utilization in breeding programmes (Lee *et al.,* 2004; Piyada *et al.,* 2010). Normally, agro-morphological traits are used for the identification of lines as they are seen easily with naked eyes during physical purity maintenance.

Characterization and identification of new cultivars is essential for their efficient utilization and conservation. Normal morphological descriptions of lines by the plant breeders are inadequate to get the complete picture of the lines and highlight the need of standard procedures described by a competent authority like PPV & FRA (Protection of Plant Varieties and Farmers' Rights Authority) to characterize the genotypes. Thus, characterization using Distinctness, Uniformity and Stability (DUS) is of great significance in the era intellectual property rights for the protection of lines as well as quality seed production and certification (Janghel *et al.,* 2020). These descriptors are simple, cheap and do not require any sophisticated laboratory techniques. Therefore, characterization and evaluation of variation in the elite improved lines of greengram would be of great significance in overall improvement of qualitative and quantitative characteristics and protection. Katiyar *et al.,* (2007) explained the genetic relationships among the breeding lines of greengram present in India using morphological characters. Keeping these points in view, this work is planned to study the DUS characteristics of the elite improved lines of greengram of Regional Agricultural Research Station (RARS), Lam, Guntur, Andhra Pradesh, India.

Materials and Methods

The experimental material consisted of 29 elite improved lines of greengram and a released variety (LGG 460) developed at Regional Agricultural Research Station (RARS), Lam, Guntur, Andhra Pradesh. The experiment was conducted in a randomized block design with three replications during *R*abi 2019-2020 at Regional Agricultural Research Station, Lam, Guntur. All the lines were planted in four rows of 4 meters length adopting 40x10 cm spacing among the lines and plants, respectively for the morphological characterization. The observations were recorded at specified stages of crop growth period when the traits under study had full expression *i.e.*, different growth stages. The anthocyanin pigmentation at cotyledonary stage was observed at unfolded stage (5-10 days after sowing). The characters, growth and plant habits, stem and leaf characters were noted at days to 50% flowering stage. The characters, plant height and premature pod colour were observed in fully developed pod. Pod characters like colour, curvature, position and length were recorded at maturity stage of the pod. Seed traits like colour, coat luster, shape, size were characterized after the harvest of the crop. The morphological traits observation was done as per the DUS guidelines suggested by the Protection of Plant Varieties & Farmers' Rights Authority (2007).

Results and Discussion

Characterization of thirty elite improved lines of greengram was carried out using DUS descriptors. The characters of anthocyanin colouration during cotyledonary stage, plant characteristics, stem, leaf, flower, pod and seed characteristics during different growth stages of crop growth differed significantly for 14 characters out of 24 characters of DUS descriptors indicating a large and exploitable amount of genetic variability for the individual elite improved line profile development for identification and protection (Table -1). Katiyar *et al.,* (2008) also exploited DUS characterization in greengram for the identification and protection.

Anthocyanin colouration is normally considered as important morphological marker in greengram to discriminate the lines into two groups based on their presence or absence and was recorded at cotyledonary stage (Mukherjee and Pradhan, 2002; Khattak *et al.,* 2000). In the present investigation, eleven genotypes were without pigmentation and nineteen genotypes showed anthocyanin colour indicating the existence of variation among the lines and to use as selection criteria for identification of the lines (Table-2).

Plant characters

Plant morphological characters like petiole colour, habit, growth habit and height were observed at days to 50 per cent flowering and at fully developed green pod stages of plant, respectively, and can be used as criteriain varietal purity maintenance and identification. All the genotypes showed green petiole colour with purple splashes. Further, all genotypes were grouped into semi- erect plant growth habit and determinate plant type suggesting they are highly similar for these traits. Normally, erect plant types are preferred as they get very good sun shine and efficiently synthesize food for the growth and development of plant. Thus, there is a need to incorporate this trait in RARS, Lam, Guntur germplasm for future new lines development with this trait. The genotypes were grouped into short (<50cm) with twenty eight genotypes and medium (50-70cm) with two genotypes *i.e.*, LGG695 and LGG696 based on plant height. The plant height was maximum in the genotype, LGG 696 (51.50cm) and was the lowest in LGG 687 (33.87cm). Sunil *et al.,* (2013) reported the presence of great variability for this traits in their study using 89 accessions from Andhra Pradesh.

Stem characters

Stem morphological characters, colour and pubescence, were recorded at days to 50% flowering stage of plant. All the genotypes showed green stem colour with purple splashes and pubescence indicating all the genotypes are similar for these traits and not useful in identification and purity maintenance.

Leaf characters

Leaf morphological characters like leaflet lobes, shape, colour, size and vein colour were observed at days to 50 per cent flowering stage of the plant. These characters play an important role in the yielding ability of the genotypes, as the leaves are the points of food synthesis and transpiration site of the plants. All these characters except leaf vein colour, showed variability and the genotypes were categorized into distinct groups (Table-2).

The leaflet was lobed in four genotypes, whereas, it was absent in remaining twenty six genotypes. Leaf shape was deltoid in eleven genotypes; ovate in fourteen genotypes

and lanceolate in five genotypes. Leaf colour was green in nine genotypes and dark green in remaining twenty one genotypes. Leaf size was small in two genotypes and medium in twenty eight genotypes. Leaf vein colour was greenish purple in all the genotypes. The leaf traits (foliage colour, leaf shape, leaflet lobes and leaf size) showed very good variation and are useful in the characterization but the effect of environmental factors is very high on these traits as they are polygenically controlled.

Flower characters

Flower characters *viz*., colour and time of flower, were observed at days to 50% flowering stage of plant. Flower colour is reliable morphological marker and distinguishing the greengram genotypes but all the thirty genotypes showed the similar flower petal colour *i.e.*, yellow (Table-2). Hence, this trait is of no use in discriminating the genotypes in the present material. Based on time of flowering, the genotypes were categorized into early (< 40 days) with nineteen genotypes and medium (40-50 days) with eleven genotypes.

Flowering time varied with genotypes ranging from 33 days (LGG 691) to 48 days (LGG 698). Therefore, these lines hold great promise as early maturing genotypes in greengram. The short duration genotypes can overcome the adverse effects of terminal heat stress and untimely rains at the time of harvest. These genotypes are helpful in expanding the area under greengram during summer season (Pratap *et al.,* 2013).Jain *et al.,* (2002) reported the usefulness of flower characteristics in characterization of greengram germplasm.

Pod characters

Greengram pod characteristics are highly useful in identification of the genotypes. The pod characters like colour of premature pod, pod pubescence and pod position, were observed at fully developed green pod stage while pod colour, curvature of mature pod and pod length were noted during plant maturity stage before harvest (Table-2). These characteristics influence the yielding ability of the plant and are considered as the main yield attributing traits. All these characters showed variation and were categorized into distinct groups except for the trait, pod colour.

The trait, colour of premature pod, was green in five genotypes and green with pigmented suture in remaining twenty five genotypes. Pod pubescence was absent in five genotypes and present in twenty five genotypes. Pod position was above canopy in twenty genotypes, intermediate in seven genotypes and not visible in three genotypes. Kaur *et al.,* (2017) also reported similar trend for this trait in their study. Pod colour is a quite useful morphological marker and may be used in quality seed production programmes at maturity stage to monitor the mixture of other varieties but all the lines showed black pods at the time of maturity indicating this trait is of no use for identification of lines in the present material.

Curvature of mature pod was straight in twenty four genotypes and curved in six genotypes. Pod length was observed to have limited variability in the present study as twenty four genotypes recorded short pod length and six genotypes showed medium pod length. The longest pod was observed in LGG 700 (8.77cm) and the lowest was seen in LGG 692 (6.03cm). Thus, these pod characteristics can be exploited for identification and characterization but are found to be variable due to more number of genes and environmental influence on the expression. Sunil *et al.,* (2014) observed straight pods without curvature in their study.

Table.1 DUS descriptors of thirty Greengram elite improved lines developed at RARS, Lam, Guntur, Andhra Pradesh

S.No	Genotypes	Antho Cyanin colour ation	Time of flowerin g	Plant growth habit	Plant habit	Stem colour	Stem pubesce nce	Leaflet lobes	Leaf shape	Leaf colour	Leaf vein colour	Petiole colour	Leaf size	Flower colour	Colour of prematu re pod	Pod Pubes cence	Pod positio n	Plant height	Pod colour	Curvat ure of mature pod	Pod length	Seed colour	Seed luster	Seed shape	Seed size
1.	LGG 684	1	5	5	1	2	9	9	1	2	2	2	5	3	1	9	1	3	2	1	3	3	1	1	5
2.	LGG 685	9	5	5	1	2	9	1	2	2	2	2	7	3	1	9	2	3	2	1	3	2	1	1	5
3.	LGG 686	9	3	5	1	2	9	1	1	2	2	2	7	3	2	9	1	3	2	1	3	3	1	1	5
4.	LGG 687	1	3	5	1	2	9	1	1	2	2	2	7	3	1	9	1	3	2	1	3	2	1	1	5
5.	LGG 688	9	3	5	1	2	9	1	3	1	2	2	7	3	2	9	1	3	2	1	3	2	2	2	5
6.	LGG 689	1	3	5	1	2	9	1	2	2	2	2	7	3	1	9	2	3	2	1	3	2	2	1	5
7.	LGG 690	1	3	5	1	2	9	1	2	2	2	2	7	3	1	9	1	3	2	1	5	2	1	1	5
8.	LGG 691	9	3	5	1	2	9	1	1	2	2	2	5	3	2	1	1	3	2	1	3	2	1	2	5
9.	LGG 692	9	5	5	1	2	9	1	2	2	2	2	5	3	2	1	1	3	2	1	3	2	2	2	5
10.	LGG 693	9	5	5	1	2	9	1	1	2	2	2	7	3	2	9	2	3	2	1	3	2	1	2	5
11.	LGG 694	9	3	5	1	2	9	1	2	2	2	2	7	3	2	1	1	3	2	1	3	2	1	1	5
12.	LGG 695	9	3	5	1	2	9	1	2	1	2	2	7	3	2	9	1	3	2	1	3	2	1	1	5
13.	LGG 696	9	3	5	1	2	9	1	2	2	2	2	5	3	2	9	1	3	2	3	3	2	1	1	5
14.	LGG 697	9	5	5	1	2	9	1	2	2	2	2	5	3	2	1	3	3	2	3	3	2	2	2	5
15.	LGG 698	1	5	5	1	2	9	9	2	2	2	2	5	3	2	9	1	3	2	1	5	2	1	2	5
16.	LGG 699	9	5	5	1	2	9	1	1	2	2	2	7	3	2	9	3	3	2	3	3	2	2	2	5
17.	LGG 700	1	3	5	1	2	9	1	1	1	2	2	7	3	2	9	1	3	2	1	5	3	1	2	5
18.	LGG 701	1	3	5	1	2	9	9	3	2	2	2	5	3	2	9	1	3	2	1	3	2	2	2	5
19.	LGG 702	1	5	5	1	2	9	1	2	2	2	2	5	3	2	9	1	3	2	3	5	2	1	1	5
20.	LGG 703	1	3	5	1	2	9	1	2	1	2	2	5	3	2	9	3	3	2	1	3	2	1	1	5
21.	LGG 704	9	3	5	1	2	9	1	3	1	2	2	5	3	2	9	2	3	2	1	5	2	1	2	5
22.	LGG 705	9	3	5	1	2	9	1	1	1	2	2	5	3	2	9	2	3	2	1	3	3	2	2	5
23.	LGG 706	9	5	5	1	2	9	1	1	2	2	2	5	3	2	9	1	3	2	3	3	2	2	2	5
24.	LGG 707	9	5	5	1	2	9	9	3	1	2	2	5	3	2	9	1	3	2	1	5	2	1	1	5
25.	LGG 708	9	5	5	1	2	9	1	2	1	2	2	3	3	2	9	2	3	2	1	3	3	2	2	5
26.	LGG 709	9	3	5	1	2	9	1	3	2	2	2	5	3	2	9	1	3	2	1	3	4	2	2	5
27.	LGG 710	1	3	5	1	2	9	1	2	2	2	2	5	3	2	9	2	3	2	1	3	2	1	1	5
28.	LGG 711	9	3	5	1	2	9	1	1	2	2	2	3	3	2	9	1	3	2	3	3	2	1	1	5
29.	LGG 712	1	5	5	1	2	9	1	1	2	2	2	5	3	2	9	1	3	2	1	3	3	2	2	5
30.	LGG 460	9	3	5	1	2	9	1	2	1	2	2	5	3	2	9	1	3	2	1	3	2	1	1	5

Anthocyanin colouration (1-Absent; 9-Present) Time of flowering (3-Early(<40 days); 5-Medium(40-50days); 7-Late(>50days) Plant growth habit (3-Erect; 5-Semi erect; 7-Spreading) Plant habit (1-Determinate; 3-Indeterminate) Stem colour (1-Green; 2-Green with purple splashes; 3-Purple) Stem pubescence (1-Absent; 9-Present), Leaflet lobes(1-Absent; 9-Present) Leaf shape (1-Deltoid; 2-Ovate; 3-Lanceolate; 4-Cuneate) Leaf colour(1-Green; 2-Dark green); Leaf colour(1-Green; 2-Dark green) Leaf vein colour (1-Green; 2-Greenish purple; 3-Purple) Petiole colour(1-Green; 2-Green with purple splashes; 3-Purple) Leaf size (3-small; 5-Medium; 7-Large) Flower colour (3-Yellow; 5-Light yellow) Colour of premature pod (1-Green; 2-Green with pigmented suture) Pod pubescence (1-Absent; 9-Present) Pod position (1-Above canopy; 2-Intermediate; 3-Not visible) Plant height (Short(<50cm); Medium(50-70cm); Long(>70cm); Plant height (Short(<50cm); Medium(50-70cm); Long(>70cm) Pod colour (1-Brown; 2-Black) Curvature of mature pod (1-Straight; 3-Curved) Pod length (3-Short(<8 cm); 5- Medium(8-10 cm);7-Long(>10 cm)) Seed colour (1-Yellow; 2-Green; 3-Mottled; 4-Black) Seed luster (1-Shiny; 2-Dull) Seed shape (1-Oval; 3-Drum shape) Seed size (3-Small(<3 g); 5-Medium(3-5 g); 7-Large(>5 g))

Table.2 Grouping of elite improved lines based on DUS descriptor in Greengram

Morphological characters	Character state	Genotypes
Hypocotyl Anthocyanin colouration	Absent	LGG684,LGG687,LGG689,LGG690, LGG698, LGG700, LGG701,LGG702, LGG703, LGG710,LGG712
	Present	LGG685,LGG686,LGG688,LGG699,LGG692,LGG693,LGG694, LGG695,LGG696,LGG697, LGG699, LGG704, LGG705, LGG706, LGG707, LGG708, LGG709, LGG711, LGG460
Plant growth habit	Semi-erect	All genotypes
Plant habit	Determinate	All genotypes
Petiole colour	Green with purple splashes	All genotypes
Plant height	Short	LGG684, LGG685, LGG686, LGG687, LGG688,LGG689, LGG690, LGG691, LGG692, LGG693,LGG694, LGG697, LGG698, LGG699, LGG700,LGG701, LGG702, LGG703, LGG704, LGG705,LGG706, LGG707, LGG708, LGG709, LGG710,LGG711, LGG712, LGG460
	Medium	LGG695, LGG696
Stem colour	Green with purple splashes	All genotypes
Stem pubescence	Present	All genotypes
Leaflet lobes (terminal)	Absent	LGG685, LGG686, LGG687, LGG688, LGG689,LGG690, LGG691, LGG692, LGG693, LGG694,LGG695,LGG696, LGG697, LGG699, LGG700,LGG702,LGG703,LGG704, LGG705,LGG706,LGG708,LGG709,LGG710,LGG711,LGG712, LGG460
	Present	LGG684, LGG698, LGG701, LGG707
Leaf shape (terminal)	Deltoid	LGG684, LGG686, LGG687, LGG691, LGG693, LGG699, LGG700, LGG705, LGG706, LGG711,LGG712
	Ovate	LGG685, LGG689, LGG690, LGG692, LGG694,LGG695, LGG696, LGG697, LGG698, LGG702,LGG703, LGG708, LGG710, LGG460
	Lanceolate	LGG688, LGG701, LGG704, LGG707, LGG709
Leaf colour	Green	LGG688, LGG695, LGG700, LGG703, LGG704,LGG705, LGG707, LGG708, LGG460
	Dark green	LGG684, LGG685, LGG686, LGG687, LGG689,LGG690, LGG691, LGG692, LGG693, LGG694,LGG696, LGG697, LGG698, LGG699, LGG701,LGG702, LGG706, LGG709, LGG710, LGG711,LGG712
Leaf vein colour	Greenish purple	All genotypes
Leaf size	Small	LGG708, LGG711
	Medium	LGG684, LGG691, LGG692, LGG696, LGG697,LGG698, LGG701, LGG702, LGG703, LGG704,LGG705, LGG706, LGG707, LGG709, LGG710,LGG712, LGG460
	Large	LGG685, LGG686, LGG687, LGG688, LGG689,LGG690, LGG693, LGG694, LGG695, LGG699,LGG700
Flower colour	Yellow	All genotypes
Time of flowering	Early	LGG686, LGG687, LGG688, LGG689, LGG690, LGG691, LGG694, LGG695, LGG696, LGG700, LGG701, LGG703,

		LGG704, LGG705, LGG709, LGG710, LGG711, LGG712, LGG460
	Medium	LGG684, LGG685, LGG692, LGG693, LGG697,LGG698, LGG699, LGG702, LGG706, LGG707, LGG708, LGG712
Colour of premature pod	Green	LGG684, LGG685, LGG687, LGG689, LGG690
	Green with pigmented suture	LGG686, LGG688, LGG691, LGG692, LGG693,LGG694, LGG695, LGG696, LGG697, LGG698,LGG699, LGG700, LGG701, LGG702, LGG703,LGG704, LGG705, LGG706, LGG707, LGG708,LGG709, LGG710, LGG711, LGG712, LGG460
Pod pubescence	Absent	LGG691, LGG692, LGG694, LGG697, LGG698
	Present	LGG684, LGG685, LGG686, LGG687, LGG688,LGG689, LGG690, LGG692, LGG693, LGG695,LGG696, LGG699, LGG700, LGG701, LGG702,LGG703, LGG704, LGG705, LGG706, LGG707,LGG708, LGG709, LGG710, LGG711, LGG712,LGG460
Pod position	Above canopy	LGG684, LGG686, LGG687, LGG688, LGG690,LGG691, LGG692, LGG694, LGG695, LGG696,LGG698, LGG700, LGG701, LGG702, LGG706,LGG707, LGG709, LGG711, LGG712, LGG460
	Intermediate	LGG685, LGG689, LGG693, LGG704, LGG705,LGG708, LGG710
	Not visible	LGG697, LGG699, LGG703
Pod colour	Black	All genotypes
Curvature of mature pod	Straight	LGG684, LGG685, LGG686, LGG687, LGG688,LGG689, LGG690, LGG691, LGG692, LGG693,LGG694, LGG695, LGG698, LGG700, LGG701,LGG703, LGG704, LGG705, LGG707, LGG708,LGG709, LGG710, LGG712, LGG460
	Curved	LGG696, LGG697, LGG699, LGG702, LGG706,LGG711
Pod length	Short	LGG684, LGG685, LGG686, LGG687, LGG688,LGG689, LGG691, LGG692, LGG693, LGG694,LGG695, LGG696, LGG697, LGG699, LGG701,LGG703, LGG705, LGG706, LGG708, LGG709,LGG710, LGG711, LGG712, LGG460
	Medium	LGG690, LGG698, LGG700, LGG702, LGG704,LGG707
Seed colour	Yellow	LGG686, LGG687, LGG688, LGG689, LGG690,LGG691, LGG692, LGG693, LGG694, LGG695,LGG696, LGG697, LGG698, LGG699
	Green	LGG685, LGG701, LGG702, LGG703, LGG704,LGG706, LGG707, LGG710, LGG711, LGG460
	Mottled	LGG684, LGG686, LGG700, LGG705, LGG707,LGG712
	Black	LGG709
Seed luster	Shiny	LGG684, LGG685, LGG686, LGG687, LGG690,LGG691, LGG693, LGG694, LGG695, LGG696,LGG698, LGG700, LGG702, LGG703, LGG704,LGG707, LGG710, LGG711, LGG460
	Dull	LGG688, LGG689, LGG692, LGG699, LGG701,LGG705, LGG706, LGG708, LGG709, LGG712
Seed shape	Oval	LGG684, LGG685, LGG686, LGG687, LGG689,LGG690, LGG694, LGG695, LGG696, LGG702,LGG703, LGG707, LGG710, LGG711, LGG460
	Drum shaped	LGG688, LGG691, LGG692, LGG693, LGG697,LGG698, LGG699, LGG700, LGG701, LGG704,LGG705, LGG706, LGG708, LGG709, LGG712
Seed Size	Medium	All genotypes

Table.3 DUS descriptors of Elite improved Greengram lines developed at RARS, Lam, Guntur, Andhra Pradesh

S.No.	Name of genotype	No. of traits	Specific traits
1.	LGG 684	15	Medium maturity, short plant height, presence of leaflet lobes, deltoid leaf shape, dark green coloured leaves, medium leaf size, green coloured premature pod, pod position was above canopy, straight curvature of pod, presence of pod pubescence, short pod length, black coloured mature pod, mottled seed colour, shiny seed luster, oval shaped seed.
2.	LGG 685	14	Anthocyanin colouration, medium maturity, short plant height, ovate leaf shape, dark green leaf colour, large leaf size, green colour premature pod, presence of pod pubescence, intermediate pod position, straight curvature of pod, short pod length, green coloured seed, shiny seed luster, oval shaped seed.
3.	LGG 686	13	Anthocyanin colouration, early maturity, deltoid leaf shape, dark green leaf colour, large leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod position was above canopy, straight curvature of pod, short pod length, mottled seed colour, shiny seed luster, oval shaped seed.
4.	LGG 687	12	Early maturity, deltoid leaf shape, dark green leaf colour, large leaf size, green coloured premature pod, presence of pod pubescence, pod position was above canopy, straight curvature of pod, short pod length, yellow seed colour, shiny seed luster, oval shaped seed.
5.	LGG 688	13	Anthocyanin colouration, short plant height, lanceolate leaf shape, green leaf colour, large leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod position was above canopy, straight curvature of pod, short pod length, yellow seed colour, dull seed luster, drum shaped seed.
6.	LGG 689	13	Anthocyanin colouration, short plant height, ovate leaf shape, dark green leaf colour, large leaf size, green coloured premature pod, presence of pod pubescence, intermediate pod position, straight curvature of pod, short pod length, yellow seed colour, dull seed luster, oval shaped seed.
7.	LGG 690	13	Early maturity, short plant height, ovate leaf shape, dark green leaf colour, large leaf size, green coloured premature pod, presence of pod pubescence, pod position was above canopy, straight curvature of pod, medium pod length, yellow seed colour, shiny seed luster, oval shaped seed.
8.	LGG 691	13	Early maturity, short plant height, deltoid leaf shape, dark green leaf colour, medium leaf size, green with pigmented suture coloured pod, pod pubescence absent, pod position was above canopy, straight curvature of pod, short pod length, yellow seed colour, shiny seed luster, drum shaped seed.
9.	LGG 692	14	Anthocyanin colouration, medium maturity, short plant height, ovate leaf shape, dark green leaf colour, medium leaf size, green with pigmented suture coloured pod, pod pubescence absent, pod position was above canopy, straight curvature of pod, short pod length, yellow seed colour, dull seed luster, drum shaped seed.
10.	LGG 693	14	Anthocyanin colouration, medium maturity, short plant height, deltoid leaf shape, dark green leaf colour, large leaf size, green with pigmented suture coloured pod, presence of pod pubescence, intermediate pod position, straight curvature of pod, short pod length, yellow seed colour, shiny seed luster, drum shaped seed.
11.	LGG 694	14	Anthocyanin colouration, early maturity, short plant height, ovate leaf shape, dark green leaf colour, large leaf size, green with pigmented suture coloured pod, pod pubescence absent, pod position was above canopy, straight curvature of pod, short pod length, yellow seed colour, shiny seed luster, oval shaped seed
12.	LGG 695	14	Anthocyanin colouration, early maturity, medium plant height, ovate leaf shape, green leaf colour, large leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod position was above canopy, straight curvature of pod, short pod length, yellow seed colour, shiny seed luster, oval shaped seed
13.	LGG 696	14	Anthocyanin colouration, early maturity, medium plant height, ovate leaf shape, dark green leaf colour, medium leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod position was above canopy, curved curvature of pod, short pod length, yellow seed colour, shiny seed luster, oval shaped seed.
14.	LGG 697	13	Anthocyanin colouration, medium maturity, short plant height, ovate leaf shape, dark green leaf colour, green with pigmented suture coloured pod, pod pubescence absent, podposition was not visible, curved curvature of pod, short pod length, yellow seed colour, shiny seed luster, drum shaped seed.
15.	LGG 698	14	Medium maturity, short plant height, presence of leaflet lobes, ovate leaf shape, dark green leaf colour, medium leaf size, green with pigmented suture coloured pod, pod pubescence absent, pod position was above canopy, straight curvature of pod, medium pod length, yellow seed colour, shiny seed luster, drum shaped seed.
16.	LGG 699	14	Anthocyanin colouration, medium maturity, short plant height, pod position was not visible, deltoid leaf shape, large leaf size, green with pigmented suture coloured pod, presence of pod pubescence, podposition was not visible,curved curvature of pod, short pod length, yellow seed colour, dull seed luster, drum shaped seed.
17.	LGG 700	13	Early maturity, short plant height, deltoid leaf shape, green leaf colour, large leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod

			position was above canopy, straight curvature of pod, medium pod length, mottled seed colour, shiny seed luster, drum shaped seed.
18.	LGG 701	14	Early maturity, short plant height, presence of leaflet lobes, lanceolate leaf shape, dark green leaf colour, medium leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod position was above canopy, straight curvature of pod, short pod length, green coloured seed, dull seed luster, drum shaped seed.
19.	LGG 702	13	Early maturity, short plant height, ovate leaf shape, dark green leaf colour, medium leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod position was above canopy, curved curvature of pod, medium pod length, green coloured seed, shiny seed luster, oval shaped seed.
20.	LGG 703	13	Early maturity, short plant height, ovate leaf shape, green leaf colour, medium leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod position was not visible, straight curvature of pod, short pod length, green coloured seed, shiny seed luster, oval shaped seed.
21.	LGG 704	14	Anthocyanin colouration, early maturity, short plant height, lanceolate leaf shape, green leaf colour, medium leaf size, green with pigmented suture coloured pod, presence of pod pubescence, intermediate pod position, straight curvature of pod, medium pod length, green coloured seed, shiny seed luster, drum shaped seed.
22.	LGG 705	14	Anthocyanin colouration, early maturity, short plant height, deltoid leaf shape, green leaf colour, medium leaf size, green with pigmented suture coloured pod, presence of pod pubescence, intermediate pod position, straight curvature of pod, short pod length, mottled seed colour, dull seed luster, drum shaped seed.
23.	LGG 706	14	Anthocyanin colouration, medium maturity, short plant height, deltoid leaf shape, dark green leaf colour, medium leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod position was above canopy, curved curvature of pod, short pod length, green coloured seed, dull seed luster, drum shaped seed.
24.	LGG 707	15	Anthocyanin colouration, medium maturity, short plant height, presence of leaflet lobes, lanceolate leaf shape, green leaf colour, medium leaf size, green with pigmented suture coloured pod, presence of pod pubescence, straight curvature of pod, medium pod length, green coloured seed, mottled seed colour, shiny seed luster, oval shaped seed.
25.	LGG 708	14	Anthocyanin colouration, medium maturity, short plant height, ovate leaf shape, green leaf colour, small leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod position was above canopy, intermediate pod position, straight curvature of pod, short pod length, dull seed luster, drum shaped seed.
26.	LGG 709	13	Early maturity, short plant height, lanceolate leaf shape, dark green leaf colour, medium leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod position was above canopy, straight curvature of pod, short pod length, black seed colour, dull seed luster, drum shaped seed.
27.	LGG 710	13	Early maturity, short plant height, ovate leaf shape, medium leaf size, dark green leaf colour, presence of pod pubescence, green with pigmented suture coloured pod, intermediate pod position, straight curvature of pod, short pod length, green coloured seed, shiny seed luster, oval shaped seed.
28.	LGG 711	14	Anthocyanin colouration, early maturity, short plant height, deltoid leaf shape, dark green leaf colour, small leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod position was above canopy, curved curvature of pod, short pod length, shiny seed luster, green seed colour, oval shaped seed.
29.	LGG 712	13	Early maturity, short plant height, deltoid leaf shape, dark green leaf colour, medium leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod position was above canopy, straight curvature of pod, short pod length, mottled seed colour, dull seed luster, drum shaped seed.
30.	LGG 460	14	Anthocyanin colouration, medium maturity, short plant height, ovate leaf shape, green leaf colour, medium leaf size, green with pigmented suture coloured pod, presence of pod pubescence, pod position was above canopy, straight curvature of pod, short pod length, green coloured seed, shiny seed luster, oval shaped seed.

Bold characters are the distinguishing characters of these improved lines for identification

Seed characters

The price of premium genotypes of greengram or consumer acceptance of a variety is decided by the seed characteristics like colour, size and shape (Pratap *et al.*, 2018). Varieties with oval shining green grains with medium size are preferred over dull/ brown/ black and drum shaped grains. Seed morphological characters like colour, luster, size and shape were observed at mature seed stage of plant in the present experiment (Table-2).

All these characters were grouped into distinct groups. Seed colour was yellow in fourteen genotypes, green in ten genotypes, mottled in five genotypes and black in one genotype (LGG 709), respectively. Seed color determines phytic acid levels in the seed and there are reports that yellow seeded genotypes had low phytic acid content which can be used as a donor for quality improvement of greengram seeds (Tajoddin *et al.*, 2011).

Seed luster was shiny in 19 genotypes and dull in 11 genotypes. Seed shape was oval in 15 genotypes and drum shaped in 15 genotypes. Medium seed size was noted in all the genotypes. Thus, seed morphological traits form very good markers for the purity testing and identification except seed size. Some of the lines are having consumer accepted seed traits for fetching premium price in the market. Venkateswarlu (2001) and Khajudparn and Tantasawat (2011) also discussed the usefulness of seed characters in the characterization of lines in greengram.

Among the 24 morphological DUS traits observed one character (seed colour) showed tetramorphic variation, four characters (leaf shape, leaf size, pod position and seed size) recorded trimorphic variation; eleven characters (anthocyanin colouration of cotyledons, plant height, leaflet lobes, leaf colour, time of flowering, colour of premature pod, pod pubescence, pod length, curvature of the pod, seed luster and seed shape) indicated the dimorphic grouping and plant habit, growth habit, petiole colour, stem colour and pubescence, leaf vein colour, flower colour, pod colour and seed size showed no variation *i.e.*, monomorphic grouping indicating the existence of remarkable amount of genetic variability in these genotypes which have great potential to assign distinctive morphological profiles from combination of morphological DUS traits which could be used for elite improved lines identification and characterization as well as selection of diverse parents in hybridization programme for more heterotic response and generation of better segregants in munbean breeding (Table-3). Verma *et al.*, (2017) also exploited DUS characterization for the identification during hybrid seed production in rice for the identification of off types.

In the present investigation, stem pigmentation and flower colour are same in all the lines and are not useful for discrimination but anthocyanin colouration at cotyledanory stage, plant, leaf, pod and seed characteristics are having lot of variability which can be exploited for the elite lines identification and utilization as reported by Patel *et al.*, (2019) and facilitate the easy registration with these distinct characters present in the genotypes with PPVFRA.

Further, the study also highlighted the importance of incorporation of new material in the breeding programmes to widen the genetic base of the crop at the Research Station. Thus, characterization of elite improved lines forms a great significance in the identification of lines, registration of lines with PPV &FRA and maintenance of lines along with the information on the genetic base of the breeding material at the Research Station.

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