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Morphological characterization of elite improved lines of green gram

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ABSTRACT

This study sought to differentiate and categorize 19 green gram varieties by employing DUS (Distinctiveness, Uniformity, and Stability) descriptors. Observations were meticulously recorded for 19 qualitative traits in accordance with DUS guidelines at both vegetative and maturity stages. Grouping based on DUS descriptors indicate the existence of genetic diversity within the genotypes. Genotypes could be easily identified through some unique characters: IGKM 2021-1 could be identified amongst genotypes studied here in through its Hypocotyl: Anthocyanin colour; identification of HUM-1 and IGKM 2021-2 could be made through Deltoid leaflet shape and Greenish Purple Leaf: Vein colour respectively; and HUM-16 through its long peduncle length. HUM-16 is having Mottled seed colour, however TRM-146 showed oval seed shape. The comprehensive analysis of the data revealed distinct morphological characteristics for the majority of the genotypes examined. This dataset, encompassing 19 qualitative traits, holds significance in identifying and selecting diverse germplasm. 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.

Keywords: Anthocyanin, DUS, Descriptors, Distinctiveness, Morphological traits

INTRODUCTION

Green gram (*Vigna radiata* (L.) Wilczek) is highly valued as a pulse crop for its short growth cycle, resilience in environments with low water and soil fertility, and extensive cultivation and consumption across India. Recognized by various names such as moong, greengram, or golden gram, it falls within the Fabaceae family and Papilionaceae subfamily, characterized by a diploid chromosome count of 2n=2x=22 (Ramakrishnan *et al.,* 2013). Germplasm characterization serves as the fundamental stage in organizing lines with shared traits, providing insights into the variability within the lines and their potential in breeding initiatives (Lee *et al.,* 2004; Piyada *et al.,* 2010). Typically, morphological traits are employed for line identification, given their visible nature, aiding in physical purity upkeep even to the naked eye. The study of morphological characters is helpful in assessing similarities and dissimilarities among the genotypes. The variations present in the genotype are prerequisite of any breeding program of crop improvement (Rajan *et al.,* 220). Efficient utilization and conservation of new cultivars necessitate thorough characterization and identification. Traditional morphological descriptions provided by plant breeders often fall short in offering a complete understanding of cultivars. Therefore, the endorsement of standard procedures by authoritative bodies like the Protection of Plant Varieties and Farmers' Rights Authority (PPV & FRA) becomes essential for comprehensive genotype characterization. In this context, Distinctness, Uniformity, and Stability (DUS) testing emerges as pivotal, especially in the landscape of intellectual property rights. It ensures that new plant varieties are easily distinguishable from existing ones, display uniform characteristics when grown under similar conditions, and maintain stability across successive generations. Characterization of a variety is prerequisite for providing protection to plant varieties based on distinctiveness, uniformity and stability (DUS) test apart from novelty (Parikh *et al.,* 2024). DUS descriptors offer several advantages: they are straightforward, cost-effective, and do not necessitate sophisticated laboratory techniques. Consequently, they provide a standardized framework for the evaluation and registration of new plant varieties. The significance of DUS testing extends significantly to the cultivation of green gram (*Vigna radiata*). Given its genetic diversity and adaptability, green gram stands out as a subject of intense agricultural research, particularly in the pursuit of sustainable

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agriculture and food security. Hence, characterizing green gram genotypes through DUS descriptors assumes paramount importance. This practice not only aids in enhancing qualitative and quantitative characteristics but also ensures effective protection and conservation efforts within the realm of agricultural innovation.Katiyar *et al.,* (2007) explained the genetic relationships among the breeding lines of green gram present in India using morphological characters. Thus, in our experiment, nineteen genotypes were characterized using PPV & FRA descriptors to know the extent diversity present in these genotypes.

MATERIALS AND METHODS

Experimental site and material

The experimental setup comprised 19 green gram genotypes (Table 1). The experiment followed a Completely Randomized Block Design (CRBD), with three replications, conducted during the *kharif* 2022 at IGKV, Raipur.

Table 1: Listof green gram genotypes including in thestudy

S. No.	Genotypes	S. No.	Genotypes	S. No.	Genotypes
1.	IGKM-5-6-27	8.	IGKM-2021-2	15.	TRM-250
2.	IGKM-6-27-5	9.	IGKM-2021-3	16.	TRM-251
3.	IGKM-6-10-7	10.	TRM-117	17.	HUM-1 (Ch)
4.	IGKM-6-4-2	11.	TRM-140	18.	HUM-12 (Ch)
5.	RMO3-71	12.	TRM-141	19.	HUM-16 (Ch)
6.	RMO3-79	13.	TRM-146		
7.	IGKM-2021-1	14.	TRM-230		

Study of descriptors

This study aimed to characterize green gram genotypes using Distinctness, Uniformity, and Stability (DUS) descriptors by meticulously recording observations across 19 distinct phenotypic traits. These traits were observed from the seedling to maturity stages of the plant. Each genotype was evaluated for specific characteristics, including Hypocotyl: anthocyanin coloration, Plant: growth habit, Plant: habit, Stem: pubescence, Stem: colour, Leaflet: shape, Leaf: vein colour, Foliage: color, Leaf: pubescence, Petiole: colour, Pod: Intensity of green colour of premature pods, Pod: Pubescence, Pod: Colour of mature pod, Peduncle: Length, Pod: Length, Pod: Curvature of mature pod, Seed: Colour, Seed: Lusture and Seed: Shape (Table 2). Morphological trait observations were carried out following the DUS guidelines suggested by the Protection of Plant Varieties & Farmers' Rights Authority (2007).

S. No.	Characteristics	States	Note	Stage of observation
1	Hypocotyl: Anthocyan in colour	Absent Present	1 9	Cotyledons unfolded
2	Plant: Growth habit	Erect Semi-erect Spreading	3 5 7	50% flowering
3	Plant: Habit	Determinate Indeterminate	1 3	50% flowering
4	Stem: Pubescence	Absent Present	1 9	50% flowering
5	Stem: Colour	Green Green with purple plashes Purple	1 2 3	50% flowering
6	Leaflet: Shape (terminal)	Deltoid Ovate Lanceolate Cuneate	1 2 3 4	50% flowering
7	Leaf: Vein colour	Green Greenish Purple Purple	1 2 3	50% flowering
8	Foliage: Colour	Green Dark Green	1 2	50% flowering
9	Leaf: Pubescence	Absent Present	1 9	50% flowering
10	Petiole: Colour	Green Green with purple splashes Purple	1 2 2	Fully developed green pods
11	Pod: Intensity of green colour of premature pods	Yellowish Green Green Dark green	3 5 7	Fully developed green pods
12	Pod: Pubescence	Absent Present	1 9	Fully developed green pods
13	Pod: Colour of mature pod	Brown Black	1 2	Harvest maturity
14	Peduncle: Length	Short Medium Long	3 5 7	Harvest maturity
15	Pod: length	Short Medium Long	3 5 7	Harvest maturity
16	Pod: Curvature of mature pod	Straight Curved	1 3	Harvest maturity
17	Seed: Colour	Yellow Green Mottled Black	1 2 3 4	Mature seeds
18	Seed: Lusture	Shiny Dull	1 2	Mature seeds
19	Seed: Shape	Oval Drum Shaped	1 2	Mature seeds

RESULTS AND DISCUSSION

Morphological characteristics provide the basic information about the genetic variability among different genotypes. To establish distinctiveness among the 19 green gram cultivars, DUS descriptors were utilized along with their corresponding characteristics. A total of eighteen qualitative characters were recorded among the genotypes, and they are presented in Tables 2 and 3. The frequency distributions for all the studied characters are represented in Fig. 1. All of the mungbean genotypes displayed a significant degree of variance for all DUS characteristics.

Table 2: Characterization of green gram genotypes through qualitative characters

S. No.	Variety Name	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*	*n*	*o*	*p*	*q*	*r*	*s*
1	IGKM 05-6-27	9	3	3	9	1	2	3	1	2	5	9	2	5	2	1	2	1	9	5
2	IGKM 06-27-5	9	3	3	9	1	2	1	1	2	5	9	2	5	2	1	2	1	9	5
3	IGKM 06-10-07	9	3	3	9	1	2	3	1	2	5	9	1	5	2	1	2	1	9	5
4	IGKM 06-4-2	9	3	3	9	1	2	3	1	2	5	9	2	5	2	1	2	1	9	7
5	RM 03-71	9	3	3	9	1	2	3	1	2	3	9	2	3	2	1	2	1	9	5
6	RM 03-79	9	3	3	9	1	2	3	1	2	5	9	2	5	2	1	2	1	9	5
7	IGKM 2021-1	1	3	3	9	1	2	3	1	2	5	9	2	5	2	1	2	1	9	5
8	IGKM 2021-2	9	3	3	9	1	2	2	2	2	3	9	2	3	2	1	2	1	9	5
9	IGKM 2021-3	9	3	3	9	1	2	3	2	2	5	9	2	5	2	1	2	1	9	7
10	TRM- 117	9	3	3	9	1	2	3	2	2	5	9	2	5	2	1	2	1	9	7
11	TRM- 140	9	3	3	9	1	4	3	2	2	3	9	2	5	2	1	2	1	9	7
12	TRM- 141	9	3	3	9	1	2	3	2	2	5	9	2	5	1	1	2	1	9	7
13	TRM- 146	9	3	3	9	1	2	3	2	2	5	9	1	3	2	1	1	1	9	7
14	TRM- 230	9	3	3	9	1	2	3	1	2	5	9	2	5	2	1	2	3	9	7
15	TRM- 250	9	3	3	9	1	4	3	2	2	3	9	2	5	2	1	2	3	1	7
16	TRM- 251	9	3	3	9	1	4	3	2	2	3	9	1	5	3	1	2	3	9	7
17	HUM-1 (CH)	9	3	3	9	1	1	3	1	2	3	9	1	5	2	1	2	1	9	7
18	HUM-12 (CH)	9	3	3	9	1	2	1	1	2	5	9	1	5	2	1	2	1	9	5
19	HUM-16 (CH)	9	3	3	9	1	2	3	1	2	3	9	1	7	2	1	2	1	9	7

a= Hypocotyl: Anthocyanin colour, b= Plant: Growth habit, c= Plant: Habit, d= Stem: Pubescence, e= Stem: Colour, f= Leaflet: Shape (terminal), g= Leaf: Vein colour, h= Foliage: Colour, i= Petiole: Colour, j= Pod: Intensity of green colour of premature pods, k= Pod: Pubescence, l= Pod: Colour of mature pod, m= Peduncle: Length, n= Seed: Colour, o= Seed: Lusture, p= Seed: Shape, q= Pod: Curvature of mature pod, r= Leaf: Pubescence, s=Pod: Length

Plant characters

The trait, anthocyanin colouration, is the trait which is highly used in breeding programmes for differentiation of genotypes, and also useful in maintenance breeding. The characteristics observed for the Hypocotyl: Anthocyanin colors were categorized as absent or present. Among the 19 genotypes, only IGKM 2021-1 exhibited the absence of anthocyanin coloration, while the remaining 18 genotypes displayed the presence of anthocyanin coloration in their hypocotyls. 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. Regarding Plant: growth habit, the genotypes exhibited variations classified as Erect, Erect to semi-Erect, Semi-erect, Semi-erect to spreading, and Spreading. However, all 19 genotypes were recorded to have an erect growth habit. Similarly, for the Plant: Habit characteristic, all genotypes were found to exhibit an indeterminate growth habit. Previous studies by Sunil *et al.,* 2013 and Das *et al.,* 2014 have reported significant variability in this trait.

Stem characters

The characteristic observed for Stem: Pubescence was categorized as either present or absent. In this study, all 19 genotypes exhibited the presence of Stem: Pubescence. Additionally, Stem: Color was recorded as green across all genotypes. This observation aligns with findings from a similar study conducted by Patel *et al.*, 2019; Sabatina *et al.,* 2021.

Leaf and flower characters

The Leaflet: Shape characteristic exhibited variations among the genotypes,

Table 3: Grouping of eight green gram genotypes based on DUS descriptors

S. No.	Characteristics	Category of states	No. of genotypes	Frequency distribution (%)	Genotypes
1	Hypocotyl: Anthocyanin colour	Present	18	95%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 146, TRM- 230, TRM- 250, TRM-251, HUM-1 (CH), HUM-12 (CH), HUM-16 (CH).
		Absent	1	5%	IGKM 2021-1.
2	Plant: Growth habit	Erect	19	100%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 146, TRM-230, TRM- 250, TRM- 251, HUM-1, (CH), HUM-12 (CH), HUM-16 (CH)
		Erect to semi-Erect	0	0%	None
		Semi-erect	0	0%	None
3	Plant: Habit	Determinate	0	0%	None
		Indeterminate	19	100%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 146, TRM-230, TRM- 250, TRM- 251, HUM-1, (CH), HUM-12 (CH), HUM-16 (CH)
4	Stem: Pubescence	Absent	0	0%	None
		Present	19	100%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 146, TRM-230, TRM- 250, TRM- 251, HUM-1, (CH), HUM-12 (CH), HUM-16 (CH)
5	Stem: Colour	Light Green	0	0%	None
		Green	19	100%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 146, TRM-230, TRM- 250, TRM- 251, HUM-1, (CH), HUM-12 (CH), HUM-16 (CH)
		Dark Green	0	0%	None
6	Leaflet: Shape (terminal)	Ovate	15	78.9%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM-117, TRM- 141, TRM- 146, TRM- 230, HUM-12 (CH), HUM-16 (CH)
		Cuneate	3	15.8%	TRM- 140, TRM- 250, TRM- 251.
		Deltoid	1	5.3%	HUM-1, (CH)
7	Leaf: Vein colour	Purple	16	84.2%	IGKM 05-6-27, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 146, TRM- 230, TRM- 250, TRM- 251, (CH), HUM-16 (CH), HUM-12 (CH)
		Greenish Purple	1	5.3%	IGKM 2021-2
		Green	2	10.5%	IGKM 06-27-5, HUM-12 (CH)
8	Foliage: Colour	Light Green	0	0%	None
		Green	11	57.9%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, TRM- 230, HUM-1, (CH), HUM-12 (CH), HUM-16 (CH).
		Dark Green	8	42.1%	IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM-140, TRM- 141, TRM- 146, TRM- 250, TRM- 251
9	Leaf: Pubescence	Absent	1	5.3%	TRM- 250
		Present	18	94.7%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 146, TRM-230, TRM- 251, HUM-1, (CH), HUM-12 (CH), HUM-16 (CH)
10	Petiole: Colour	Green	0	0%	None

S. No.	Characteristics	Category of states	No. of genotypes	Frequency distribution (%)	Genotypes
		Green with Purple splashes	19	100%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 146, TRM- 230, TRM-250, TRM- 251, HUM-1, (CH), HUM-12 (CH), HUM-16 (CH)
		Purple	0	0%	None
11	Pod: Intensity of green colour of premature pods	Green	12	63.2%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, IGKM 2021-1, IGKM 2021-3, TRM- 117, TRM- 141, TRM- 146, TRM- 230, TRM- 250, TRM- 251, HUM-1, (CH), HUM-12 (CH), HUM-16 (CH).
		Yellowish Green	7	36.8%	RM 03-79, IGKM 2021-2, TRM- 140, TRM- 250, TRM- 251, HUM-1 (CH), HUM-16 (CH).
		Yellow	0	0%	None
12	Pod: Pubescence	Absent	0	0%	None
		Present	19	100%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 146, TRM- 230, TRM-250, TRM- 251, HUM-1, (CH), HUM-12 (CH), HUM-16 (CH)
13	Pod: Colour of mature pod	Black	13	68.4%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 230, TRM- 250.
		Brown	6	31.6%	IGKM 06-10-07, TRM- 146, TRM- 251, HUM-1, (CH), HUM-12 (CH), HUM-16 (CH).
14	Peduncle: Length	Short	3	15.8%	RM 03-71, IGKM 2021-2, TRM- 146
		Medium	15	78.9%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-79, IGKM 2021-1, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 230, TRM- 250, TRM- 251, HUM-1, (CH), HUM-12 (CH)
		Long	1	5.3%	HUM-16 (CH)
15	Pod: Length	Short	0	0%	None
		Medium	8	42.1%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, HUM-12 (CH)
		Long	11	57.9%	IGKM 06-4-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 230, TRM- 146, TRM- 141, TRM- 250, TRM- 251, HUM-1, (CH), HUM-16 (CH)
16	Pod: Curvature of mature pod	Straight	16	84.2%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 146, HUM-1, (CH), HUM-12 (CH), HUM-16 (CH)
		Curved	3	15.8%	TRM- 230, TRM- 250, TRM- 251
17	Seed: Colour	Green	16	84.2%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 230, TRM- 250, , HUM-1, (CH), HUM-12, (CH), HUM-16 (CH).
		Yellow	2	10.5%	TRM- 141
		Mottled	1	5.3%	TRM- 251
18	Seed: Lusture	Shiny	19	100%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 146, TRM- 230, TRM-250, TRM- 251, HUM-1, (CH), HUM-12 (CH), HUM-16 (CH)
		Dull	0	0%	None
19	Seed: Shape	Oval	1	5.3%	TRM- 146
		Drum Shaped	18	94.7%	IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM- 117, TRM- 140, TRM- 141, TRM- 146, TRM- 230, TRM-250, TRM- 251, HUM-1, (CH), HUM-12 (CH), HUM-16 (CH)

including ovate, cuneate, and deltoid shapes. Ovate shape was predominant, observed in 15 genotypes, while cuneate shape was found in 3 genotypes (TRM- 140, TRM- 250, TRM- 251), and deltoid shape in 1 genotype (HUM-1, (CH)). Additionally, Leaf: Vein color varied among the genotypes, with 16 genotypes displaying a purple vein color, 2 genotypes exhibiting green (IGKM 06-27-5, HUM-12), and 1 genotype displaying greenish-purple vein color (IGKM

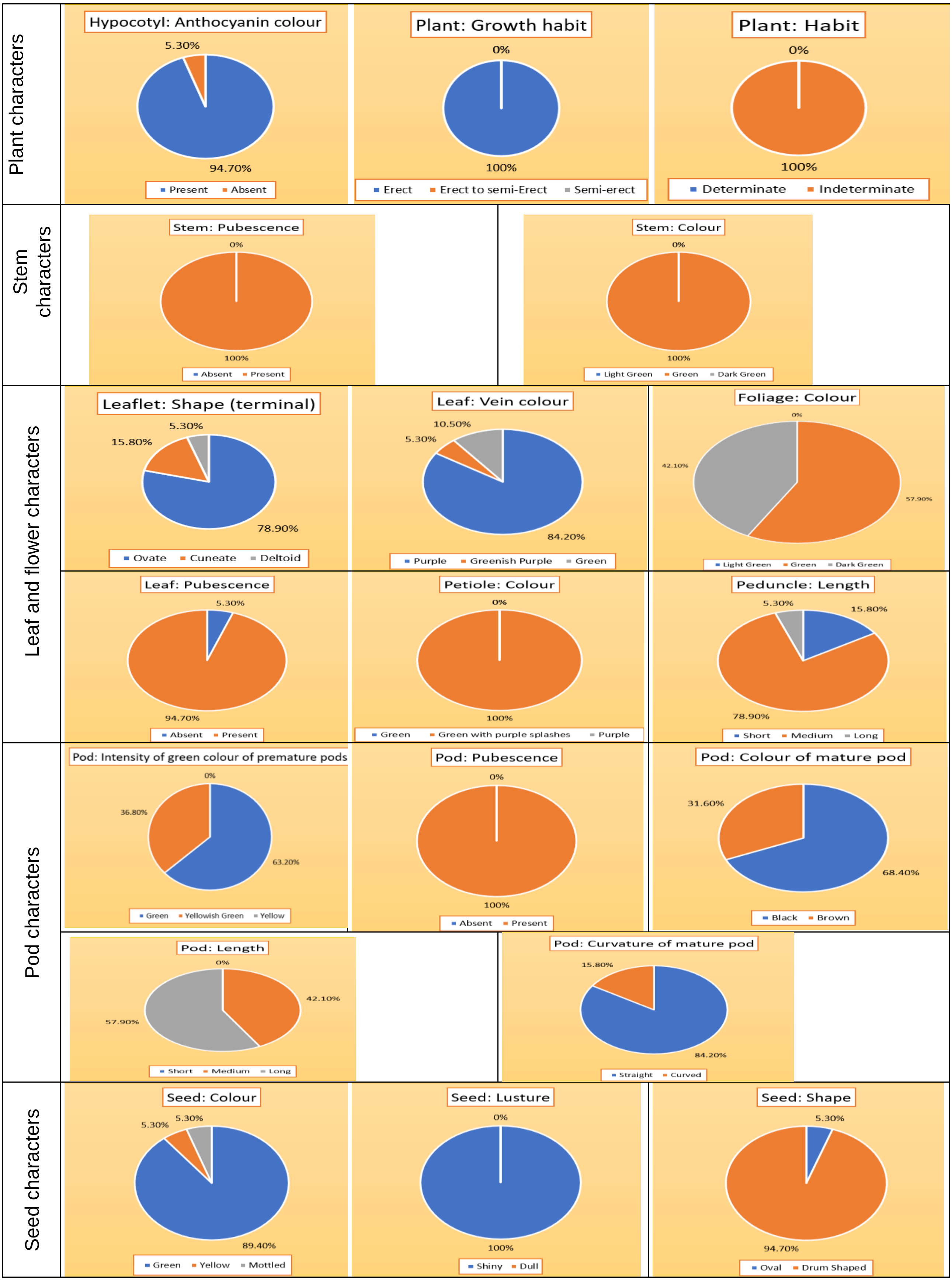

Fig. 1: Frequency distribution of different morphological traits according to DUS descriptors in green gram genotypes

2021-2). Foliage: Color was recorded as light green, green, or dark green, with 11 genotypes displaying green leaf color and 8 genotypes displaying dark green leaf color. In terms of leaf pubescence, it was present in 18 genotypes, with TRM-250 being the only exception, exhibiting absent leaf pubescence. Similar findings were reported in previous studies by Chakrabarthy *et al.,* 1989 and Patel *et al.,* 2019. Furthermore, all 19 genotypes exhibited Petiole: Color as green with purple. Regarding peduncle length, 15 genotypes, including IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-79, IGKM 2021-1, IGKM 2021-3, TRM-117, TRM-140, TRM-141, TRM-230, TRM-250, TRM-251, HUM-1 (CH), and HUM-12 (CH), exhibited medium-length peduncles. Conversely, 3 genotypes *viz.,* RM 03-71, IGKM 2021-2, and TRM-146, demonstrated short peduncles, while only 1 genotype, HUM-16 (CH), displayed a long peduncle. Previous studies by Jain *et al.,* 2002; Singh *et al.,* 2014 and Kumar *et al.,* 2014 have emphasized the importance of flower characteristics in the characterization of green gram germplasm, echoing the significance of such studies in understanding plant diversity and traits.

Pod characters

Among the 19 genotypes, IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, IGKM 2021-1, IGKM 2021-3, TRM-117, TRM-141, TRM-146, TRM-230, and TRM-250, showed green colour intensity of premature pods. Conversely, premature pods of 7 other genotypes *viz.,* RM 03-79, IGKM 2021-2, TRM-140, TRM-250, TRM-251, HUM-1 (CH), and HUM-16 (CH) exhibited yellowish hue intensity. All 19 genotypes demonstrated presence of Pod: pubescence. In terms of mature pod coloration, 13 genotypes, including IGKM 05-6-27, IGKM 06-27-5, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM-117, TRM-140, TRM-141, TRM-230, and TRM-250, displayed a black hue, while only 6 genotypes, namely RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, and TRM-146, showcased a brown coloration at maturity. Long pod: length was observed in 11 genotypes, however only 8 (IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, HUM-12) genotypes displayed medium Pod: length.

Regarding pod curvature at maturity, 16 genotypes displayed a straight curvature, including IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM-117, TRM-140, TRM-141, TRM-146, HUM-1 (CH), HUM-12 (CH), and HUM-16 (CH), while three genotypes, TRM-230, TRM-250, and TRM-251, exhibited a curved pod curvature. Sunil *et al.* (2014) also noted the presence of straight pods without curvature in their study, a finding consistent with observations made by Singh *et al.,* 2014, who similarly grouped genotypes based on pod morphological characteristics.

Seed characters

Seventeen genotypes, including IGKM 05-6-27, IGKM 06-27-5, IGKM 06-10-07, IGKM 06-4-2, RM 03-71, RM 03-79, IGKM 2021-1, IGKM 2021-2, IGKM 2021-3, TRM-117, TRM-140, TRM-230, TRM-250, HUM-1 (CH), HUM-12 (CH), and HUM-16 (CH), exhibited green seed coloration, while TRM-141 displayed yellow seed coloration, and TRM-251 showcased mottled seed coloration. All 19 genotypes demonstrated shiny seed luster; and in terms of seed shape, 18 genotypes displayed a drum-shaped seed, with only TRM-146 showcasing an oval seed shape. 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 green gram.

CONCLUSION

Grouping based on DUS descriptors indicate the existence of genetic diversity within the genotypes. Genotypes could be easily identified through some unique characters: IGKM 2021-1 could be identified amongst genotypes studied here in through its Hypocotyl: Anthocyanin colour; identification of HUM-1 and IGKM 2021-2 could be made through Deltoid leaflet shape and Greenish Purple Leaf: Vein colour respectively; and HUM-16 through its long peduncle length. HUM-16 is having Mottled seed colour, however TRM- 146 showed oval seed shape. 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. Therefore, the present study indicates the importance of morphological characterization using DUS descriptors for the registration, maintenance and protection of genotypes. This study underscores the utility of DUS descriptors in discerning distinctiveness among green gram cultivars, offering valuable guidance for breeding programs and germplasm conservation initiatives. Incorporating molecular markers such as SSRs can enhance understanding of genetic diversity and relationships among genotypes at the DNA level.

REFERENCES

Bordolui, S.K., Chattapadhyay, P. and Chandra, P. (2006) Comparative performance of low land indigenous rice genotypes in Gangetic *Alluvial Zone. Journal of crop and weed*, **2**(1): 33-36.

Chakrabarty, S.K., Joshi, M.A., Singh, Y., Maity, A., Vashisht, V. and Dadlani, M. (2012) Characterization and evaluation of variability in farmers' varieties of rice from West Bengal. *Indian Journal of Genetics and Plant Breeding,* **72**(2):136-142.

Das, R., Thapa, U., Debnath, S., Lyngdoh, Y.A. and Mallick, D. (2014) Evaluation of French bean (*Phaseolus vulgaris* L.) genotypes for seed production. *Journal of Applied Natural Science,* **6**(2):594-598.

Jain, S.K., Khare, D., Bhale, M.S. and Raut, N.D. (2002) Characterization of mung bean varieties for verification of genetic purity. *Seed Technology News,* **32**:200-201.

Katiyar, P.K., Dixit, G.P. and Singh, B.B. (2007) Ancestral relationship of greengram (*Vigna radiata*) advanced breeding lines developed in India. *Indian J. Agri. Sci.,***77**: 579-582.

Khajudparn, P. and Tantasawat, P. (2011) Relationships and variability of agronomic and physiological characters in mungbean. *African J. Biotechnol*., **10**: 9992-10000.

Khattak, G.S.S., Haq, M.A., Saleem, M. and Ashraf, M. (2000) Inheritance of hypocotyl colour and pubescence in mungbean (*Vigna radiata* L. Wilczek), *J. Sci. I. R. Iran*, **11**(2): 79-81.

Lee, Y.S., Lee, J.Y., Kim, D.K., Yoon, C.Y., Bak, G.C., Park, I.J., Bang, G.P., Moon, J.K., Oh, Y.J. and Kmin, K.S. (2004) A new high-yielding mungbean cultivar, "Samgang" with lobed leaflet. *Korean Journal of Breed Science,* **36**: 183-184.

Mukherjee, A. and Pradhan, K. (2002) Genetics of mungbean: I. Anthocyanin pigment in hypocotyl. *Journal Inter academicia,* **6**(4): 434-437.

Parikh, M., Chandrakar, D., Patel, D.P., Saxena, R.R. and Sharma, B. (2024) IGKM 05-18-2: identified as high yielding and multiple disease resistance rabi mungbean genotype for Chhattisgarh state. *Annals of Plant and Soil Research*, **26**(1): 43-49.

Patel, J.D., Patel, J.B. and Chetariya, C.P. (2019) Characterization of Mung bean (*Vigna radiata* L. Wilczek) Genotypes based on plant morphology. *Indian Journal of Pure and Applied Biosciences,* **7**(5): 433-443.

Patel, J.D., Patel, J.B. and Chetariya, C.P. (2019) Characterization of mungbean (*Vigna radiata* (L.) Wilczek) genotypes based on plant morphology. *Indian Journal of Pure and Applied Bioscience,* **7**: 433-443.

Piyada, T., Juthamas, T., Thongchai, P., Thanawit, T., Chutamas, P., Worapa, S. and Thitiporn, M. (2010) Variety identification and genetic relationships of mungbean and blackgram in Thailand based on morphological characters and ISSR analysis. *African Journal of Biotechnology*, **9**:4452-4464.

Protection of Plant Varieties and Farmers' Rights Authority (PPV & FRA), 2007.

Rajan, N., Debnath, S., Dutta, A.K., Pandey, B. and Singh, A.K.R. (2020) Characterization of indigenous brinjal (*Solanum melongena* L.) lines using morphological traits under Jharkhand condition. Annals of Plant and Soil Research, **22**(4): 425-431.

Ramakrishnan, M.N., Ray-Yu Yang, Warwick, J.E., Dil Thavarajah, Pushparajah, T. and Jacqueline d'A Hand Keatinge, J.D.H. (2013) Biofortification of mungbean (*Vigna radiata* L.) as a whole food to enhance human health. *Journal of Science in Food and Agriculture, **93**:*1805-1813.

Sabatina, A.S., Ahamed, M.L., Ramana, J.V. and Harisatyanarayana, N. (2021) DUS Characterization of Elite Improved Lines of Greengram [*Vigna radiata* (L.) Wilczek]. *Int. J. Curr. Microbiol. App. Sci,* **10**(01): 3380-3391.

Singh, C.M., Mishra, S.B., Pandey, A. and Arya, M. (2014) Morphological characterization and discriminant functions analysis in mung bean (Vigna radiata L. Wilczek) germplasm. *Electronic Jour. of Plant Breeding,* **5**(1):87-96.

Sunil Kumar, S.V., Chandra Prakash, J., Arunkumar, B., Onkarappa, T. and Manoj Kumar, H.B. (2014) Assessment of genetic variability for morpho-economic traits in chickpea (*Cicer arietanum* L.) genotypes. *Research in Environment and Life Science,* **7**(3): 143-146.

Venkateshwarlu, O. (2001) Correlation and path analysis in greengram. *Legume Res.,* **24**: 115-117.