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Morphological Characterization and Recognition of New Traits of Soybean [*Glycine max* (L.) Merrill]

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Distinctness, Uniformity, and Stability (DUS) characterization of ninety recently evolved soybean genotypes including three national checks were carried out at JNKVV, Jabalpur, during *Kharif* 2021. Sixteen DUS traits were evaluated as described by National DUS test guidelines. Observations were made on Hypocotyl Pigmentation, Growth type, Growth habitat, Leaf shape, Leaf size, Leaf colour, Flower colour, Flower colour, Pod hairiness, Pod pub colour, Pod intensity of brown colour, Seed size, Seed shape, Seed coat colour, Hilum colour, Seed coat Lustre and Colour of funicle at various phases. It revealed that there was a lot of variation in the soybean genotypes for DUS characters. Frequency distribution of data exhibited that presence of Hypocotyl: anthocyanin pigmentation (65.55 %), Semi-Determinate Growth type (75.55 %), Semi-erect Growth habitat (90.0 %), Pointed Ovate Leaf shape (83.33 %), Pod hairiness pubescent (84.44%), Seed size medium (64.44%), Seed coat colour yellow (84.44%), Seed coat Lustre intermediate (77.77%) and Colour of

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funicle brown (100%) were dominating traits in present set of genotypes. This soybean germplasm has a wide range of features and morphological variation, which may assist a breeder in further improvement of soybean. This will be extremely helpful in identifying, conserving and developing ideal plant type on the basis of distinguishing morphological characters.

Keywords: Germplasm; compound leaf; DUS; dominating traits.

1. INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] has long been considered the world's most significant seed legume. Because of its high oil and protein content, it is renowned as the "Wonder crop" of the twentieth century. The seed of soybean is a great source of protein (36.1−41.2%), sufficient edible oil (16.8−20.2%), various minerals, nutrients, amino acids, antioxidants and health beneficial compounds for human [1-4]. Nowadays, soybean has become prime agricultural commodity that contributes about 25% global edible oil production as well as two thirds of the world's protein concentrate for animal, poultry and fish feed [5]. In India, soybean is major oilseed crop (10.93 mt production and 10.83 mha area) grown in *Kharif* season and at the world level, country ranks fifth in soybean production after USA (1st), Brazil (2nd), China (3rd) and Argentina (4th) [6]. In India soybean cultivars and genotypes have narrow genetic bases [5,1].

Exploring and characterization of soybean genotypes are always beneficial for crop improvement [7]. Germplasm is the foundation of any crop improvement programme and plays a key role in crop growth [8]. Characterization using different morphological markers is required for genotype identification and intellectual property protection. In order to create incentives for research and fulfil commitments under Trade Related Intellectual Property Rights, India adopted laws for the Protection of Plant Varieties and Farmer's Right Act in 2001. (TRIPs). The fundamental conditions for granting protection to different varieties/germplasm variations are novelty, distinctiveness, uniformity, and stability [9]. "When employing DUS descriptors, attributes such as pod intensity of brown colour at maturity, pod pubescence, seed coat colour, seed shape, hilum colour, and seed size were demonstrated to be more effective in efficiently discriminating genotypes" [10,11]. This work may be useful to breeders and researchers in identifying these soybean genotypes and then employing them in breeding programmes to generate improved varieties. With this in mind, the major purpose of this experiment is to designate soybean genotypes based on physical traits. Extra early genotypes are in high demand in Madhya Pradesh's Malwa region to accommodate the next crop. Climate change, like every other crop, has a significant impact on soybean production. "When employing DUS descriptors, characteristics such as pod intensity of brown colour at maturity, pod pubescence, seed coat colour, seed shape, hilum colour, and seed size were demonstrated to be more advantageous in easily identifying the genotypes" [10]. This work may be useful to breeders and researchers in identifying these soybean genotypes and then employing them in breeding programmes to generate improved varieties.

2. MATERIALS AND METHODS

Ninety soybean lines, including three controls (JS335, JS20-69 and JS20-98), were received from the All India Coordinated Research Project (AICRP) on Soybean, Department of Plant Breeding and Genetics, JNKVV, Jabalpur, and the Indian Institute of Soybean Research, Indore (M.P.). In a Randomised Complete Block Design (RCBD), each genotype was accommodated in three rows of three metres in length in each replication, with a row to row spacing of 40 cm and a plant-to-plant distance of 7 cm after thinning. Observations were made Hypocotyl Pigmentation, Growth type, Growth habitat, Leaf shape, Leaf size, Leaf colour, Flower colour, Flower colour, Pod hairiness, Pod pub colour, Pod intensity of brown colour, Seed size, Seed shape, Seed coat colour, Hilum colour, Seed coat Lustre and Colour of funicle. On five plants from each genotype, observations on seventeen traits were recorded at random.

3. RESULTS AND DISCUSSION

All the ninety genotypes were classified based on of morphological characteristics described in the DUS guidelines [12] i.e., Hypocotyl Pigmentation, Growth type, Growth habitat, Leaf shape, Leaf size, Leaf colour, Flower colour, Flower colour, Pod hairiness, Pod pub colour, Pod intensity of brown colour, Seed size, Seed shape, Seed coat colour, Hilum colour, Seed coat Lustre and Colour of funicle. From the study of these characters, we can easily identify different genotypes of soybean. Hypocotyl coloration was found in 58 genotypes, but not in the rest of the genotypes. At 50% flowering, a key characteristic, growth habit, was noted. Twenty-two genotypes had a determinate growth habit and the rest 68 had semi-determinate growth habits. Only nine genotypes showed erect growth habits, whereas 81 had semi-erect growth habits. Leaf shape was mostly pointed ovate, 1 triangular and 14 lanceolate. Leaf size was medium in 86 genotypes two each for small and large sized leaf respectively. Normally trifoliate leaves are seen but the presence of penta, septa and octa foliate leaves were seen in some genotypes but this character is not stable and its expressivity is sometimes high and low, it is highly influenced by environmental condition but now some newly developed genotypes such as Dsb-31 were observed with quadra/pentafoliate leaves. Four seededness character is positively correlated with lanceolate leaves, its intensity 15-30% per plant. The multifoliate leaves is a qualitative gene governing character. It is also a tool for increasing yield. Four seededness character increases the intensity of three seeded pod. There is no study found for pod character with biotic and abiotic stress. The flowers of 46 genotypes were white, whereas the flowers of the other genotypes were violet. Insect resistance is influenced by the presence of hair on the pod. Frequency distribution of data exhibited that presence of Hypocotyl: anthocyanin pigmentation (65.55 %), Semi-Determinate Growth type (75.55 %), Semi-erect Growth habitat (90.0 %), Pointed Ovate Leaf shape (83.33 %), Pod hairiness pubescent (84.44%), Seed size medium (64.44%), Seed coat colour yellow (84.44%), Seed coat Lustre intermediate (77.77%) and Colour of funicle brown (100%) we're dominating traits in present set of genotypes. There is a lot of evidence that thick trichomes prevent herbivorous insect damage to plants [13]. The presence of pod pubescence was found in 76 genotypes, whereas rest were glabrous genotypes. Both of these characteristics enable resistance to a variety of insects. At maturity, the maximum 52 genotypes had medium pod intensity of brown colour. In 14 genotypes, large seed was found; Seed shape has a lot of variation. Twenty genotypes had spherical seed shapes, 70 had spherical flattened seed shapes. The seed coat lustre was shiny in 13 genotypes, dull in 7 genotypes, and intermediate in 70 genotypes. Hilum colour was found to be grey in 31 genotypes, imperfect black in 57 genotypes, and black in two genotypes. Seed coat colour was seen Yellow in 76 four genotypes, with the remaining 14 genotypes being yellow green and no genotype was found to be black. So, we can use these characters as an identification key. While some properties of a mature pod were discovered to be associated with the qualities of the seed, the thickness of a soybean pod held a positive correlation with the thickness of the young pod's epidermis. These research's results. Research may be taken into account when creating a new, improved variety of soybean. Similar, characterization pattern was adopted by, Ramteke et al. [14]; Malek et al. [15]; Ramteke et al. [16]; Dubey [17]; Talla et al. [18]; Bellaloui et al. [19]; Uikey et al. [4] Vandana et al. [20]; Bhakuni et al. [21]; Pawale et al. [22]; Mehra et al. [1]; Amrate et al. [2]; Dhaliwal et al. [23]; Singh et al. [24]; Banerjee et al. [7], Thakur et al. [25] taking distinguished morphological traits.

4. CLUSTER ANALYSIS

Further analysis including correlation and path coefficient can be used as an important tool for bringing appropriate cause and effects relationship between yield and some yield components Upadhyay et al. [26]. Clustering analysis shows 16 morphological traits all 90 soybean genotypes structured into one group. Major group consisted 90 genotypes. The major group was divided into two sub groups with 58 and 32 genotypes respectively. First sub group was divided into two parts. Major part contained 44 soybean genotypes and minor part had 14 genotypes, namely: DCB-137, JS24 36, SL 744, JSM-232, NRC-128, JS21-05, JS22-48, JS22-13, JS22-11, JS22-15, EC-481571, JS22-28, SL-96 and AUKS-199. Similarly, second sub group was further divided into two parts and major part consisted 30 genotypes, i.e., Cat-87, Cat-783, PS-1614, SL-710, JS22-20, JS20-105, JS24-37, JS23-08, RVS2012-19, PS-1569,JS22-36, JS22-16, JS22-55, JS22-27, NRC-137, PS-1225, JS24-35, JS21-72, JS22-54, JS22-17, JS22-53, JS23-05, PS 16-13, JS22-31, JS22-10, JS22-38, JS22-33, JS22-35, JS20-116 and JS22-26 while minor part had only two genotypes JS22-34 and JS22-47. Similarly For the most part, there was a lot of variation in the qualities evaluated. The findings demonstrated that soybean germplasm has a wide range of features and that the genotypes gathered had a lot of morphological variation, which may assist a breeder to improve the plant's genetic foundation Upadhyay et al. [10] (Fig. 4).

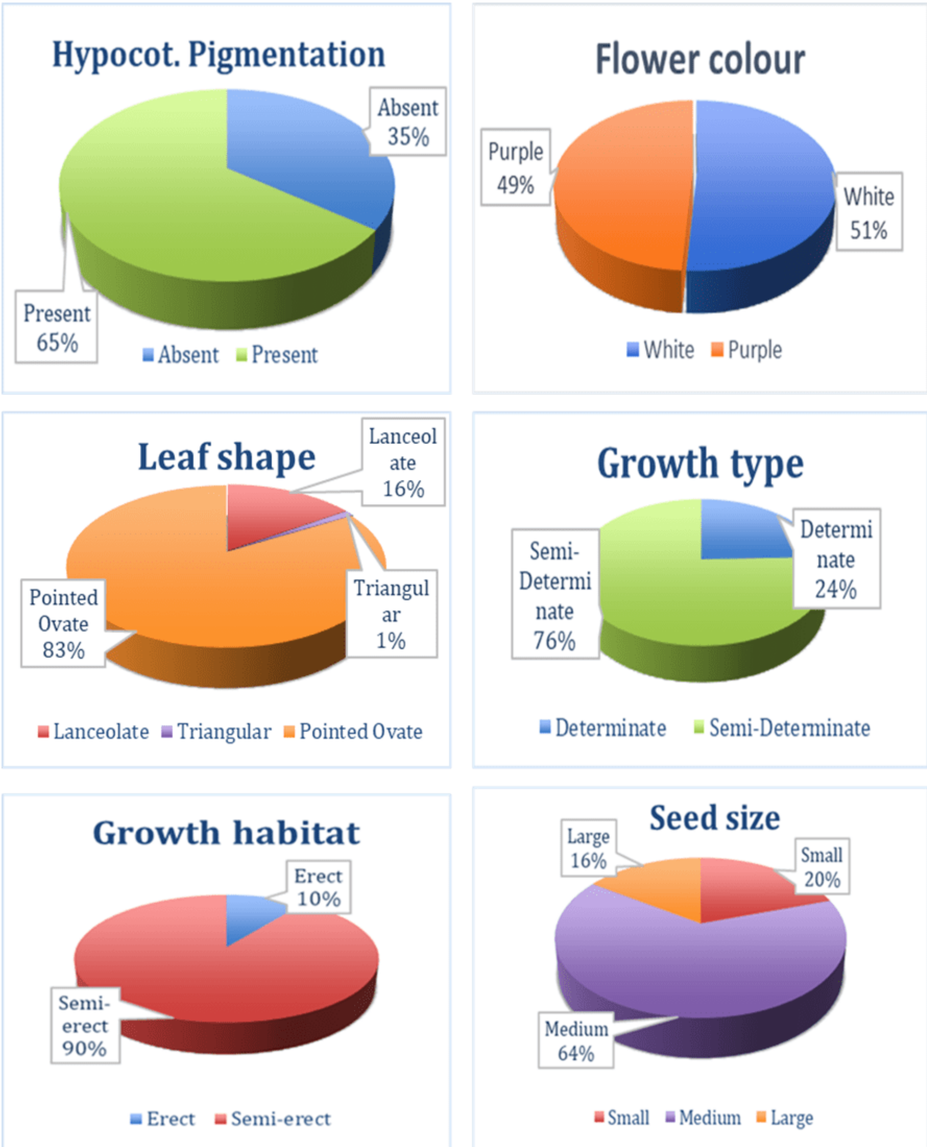

Fig. 1. Frequency distribution pie chart for different morphological traits

Table 1. Distribution of ninety genotypes based on Sixteen DUS traits of soybean

S. No.	Traits	Class	Note/ Score	Frequency	% age
1	**Hypocotyl: anthocyanin pigmentation**	Absent	1	32	35.55
		Present	9	58	65.55
2	**Growth type**	Determinate	1	22	24.44
		Semi-Determinate	5	68	75.55
3	**Growth habitat**	Erect	1	9	10
		Semi-erect	3	81	90
4	**Leaf shape**	Lanceolate	1	14	15.55
		Triangular	2	1	1.11
		Pointed Ovate	3	75	83.33
5	**Leaf size**	Small	3	2	2.22
		Medium	5	86	95.55
		Large	7	2	2.22
6	**Leaf colour**	Light Green	3	1	1.11
		Green	5	82	91.11

S. No.	Traits	Class	Note/ Score	Frequency	% age
		Dark Green	7	7	7.77
7	**Flower colour**	White	1	46	51.11
		Violet	2	44	48.89
8	**Pod hairiness**	Glabrous	0	14	15.56
		Pubescent	1	76	84.44
9	**Pod pub colour**	Absent	0	14	15.55
		Grey	1	15	16.66
		Towny Brown	2	61	67.77
10	**Pod intensity of brown colour**	Light	3	27	30
		Medium	5	52	57.77
		Dark	7	11	12.22
11	**Seed size**	Small	3	18	20
		Medium	5	58	64.44
		Large	7	14	15.55
12	**Seed shape**	Spherical	1	20	22.22
		Spherical Flattened	2	70	77.77
13	**Seed coat colour**	Yellow	1	76	84.44
		Yellow green	2	14	15.55
14	**Seed hilum colour**	Imperfect black	1	57	63.33
		Brown	3	31	34.44
		Black	5	2	2.22
15	**Seed coat Lustre**	Shiny	3	13	14.44
		Intermediate	5	70	77.77
		Dull	7	7	7.77
16	**Colour of funicle**	Brown	1	90	100
		Black	2	0	0

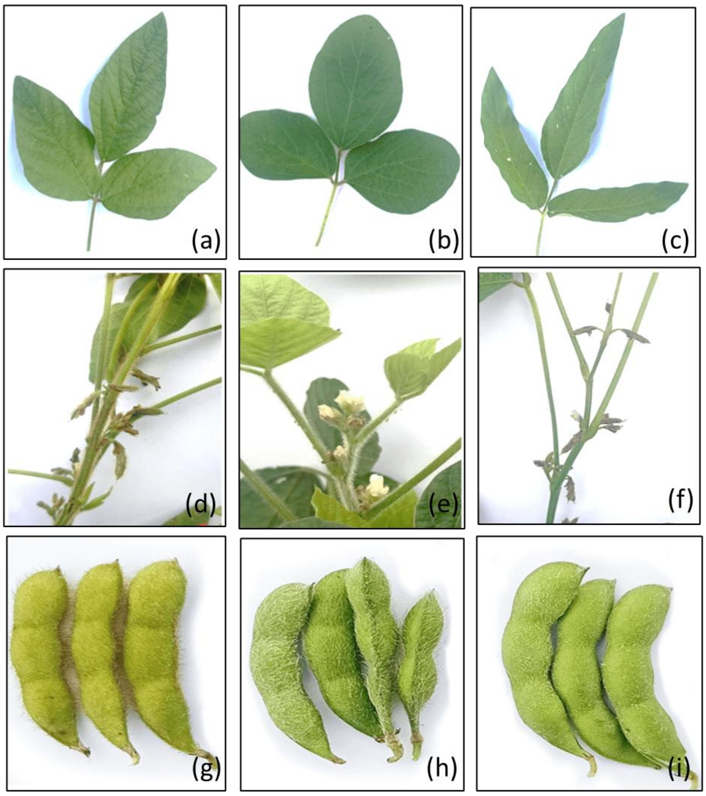

Fig. 2. Showing variation in leaf shape (a-Pointed ovate b-Ovate c-Lanceolate), Pubescence (d-Stem Pubescence e-Stem Grey f- Stem Glabrous), Pod pubescence (g-Pod Tawny Pubescence h- Grey Pubescence-Glabrous), Flower colour (j-White Flower k-Violet Flower), Foliage (l-Penta folate Leaf)

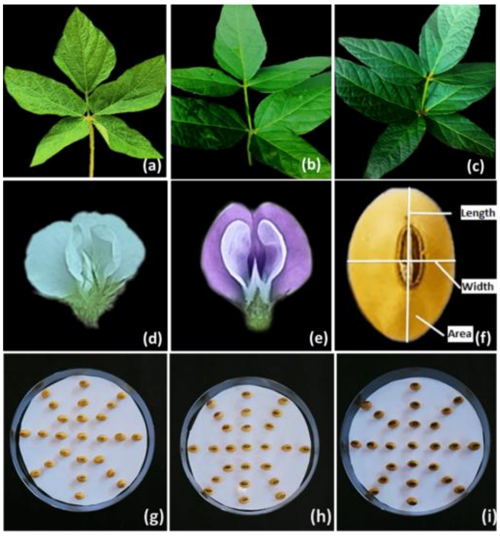

Fig. 3. Showing New trait variation in foliage (a-Penta foliate Leaf, b-Hexa foliate leaf and c-Hepta foliate leaf), Flower colour (d-White Flower e-Violet Flower) and hilum colouration (g-Brown hilum, h-Imperfect black and i-black hilum)

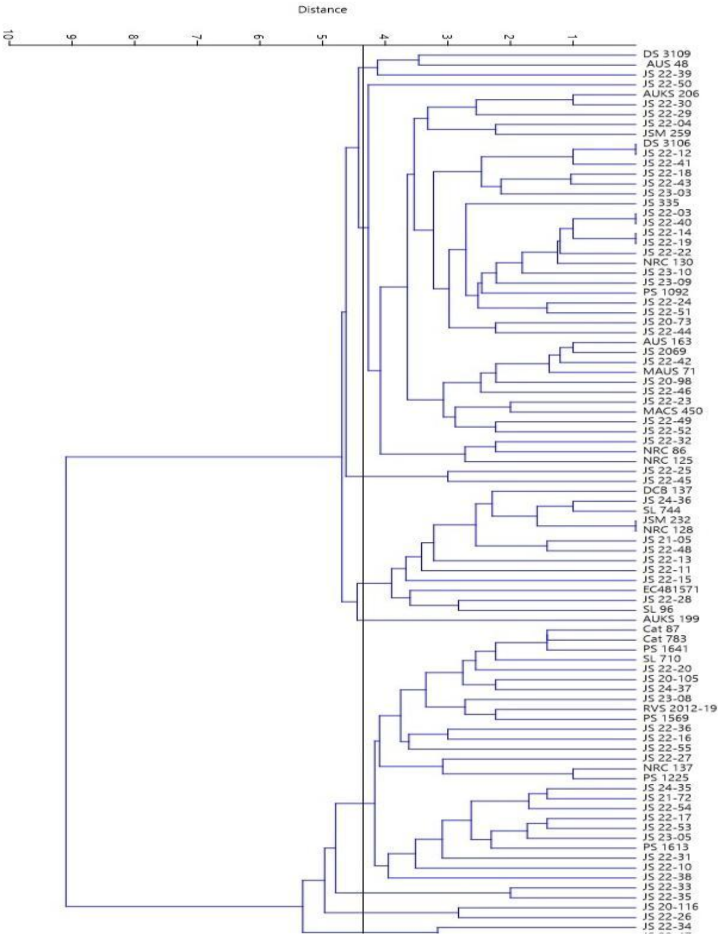

Fig. 4. Dendrogram showing relationship among soybean genotypes based on different morphological trait

5. CONCLUSIONS

Genetic resources provide the foundation for selection and improvement via breeding to fulfill the world's ever-increasing food security demands. On the other hand, systematic characterization leads to more efficient utilization of the material in the soybean development programme. The high market price and profitability for farmers are due to the large variety in seed colour inherent in the germplasm. After establishing the characteristics' stability and heritability, genotypes with this morphology can be selected as a donor in the crossing operation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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