The Pharma Innovation Journal 2022; 11(9): 1115-1121

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(9): 1115-1121

www.thepharmajournal.com
Received: 05-07-2022
Accepted: 18-08-2022

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Evaluation of qualitative trait based variability among soybean genotypes

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Abstract
Soybean is an important leguminous crop in the world with high nutritional values. Identification of diverse genotypes is a prerequisite for the development of strategies for the improvement of soybean crop. The variability may be based on morphological, biochemical or molecular traits. The present study was aimed to identify diverse soybean genotypes on the basis of five different qualitative traits under field experiment. The results reflected the similarity among the genotypes investigated based on measured qualitative variables and showed the discriminative power of the approach tracked in this research work to classify soybean genotypes. The dendrogram depicted two distinct clusters. The cluster-I consisting nineteen genotypes further bifurcated into two groups, while in cluster-II had remaining 34 genotypes and further divided into two subgroups with 9 and 25 genotypes correspondingly. Identified diverse genotypes may be employed for the detection of individual soybean genotypes in hybridization purposes for crop improvement.

Keywords: Characters, diversity, breeding, crop improvement**,** soybean

Introduction
Soybean is one of the most significant oilseed crop plants worldwide (Cunha *et al*. 2013; Tiwari *et al*., 2011; Tripathi *et al*. 2022; Mishra *et al*., 2022a; Mishra *et al*., 2022b; Upadhyay *et al*., 2022) [1, 23, 27, 10, 11, 28, 30]. A soybean seed has high nutritional value and is rich in proteins and oil with an average of 40% protein and 20% oil respectively (Tiwari and Tripathi, 2004; Zhang *et al*. 2004; Tripathi and Tiwari, 2005; Mishra *et al*. 2021a; Upadhyay *et al*. 2020a) [24, 32, 22, 12]. Development of new genotypes of soybean with high grain yield is therefore important. So far, different breeding approaches have been employed to make some genetic improvements to meet the industrial and agricultural requirements (Lu *et al*., 2017; Mishra *et al*., 2020; Upadhyay *et al*. 2020b; Mishra *et al*., 2021b; Mishra *et al*., 2021c, Mishra *et al*., 2021d; Mishra *et al*., 2021e) [8, 17, 29, 13, 14, 15, 16].
The protection of intellectual property rights on the crop varieties is an essential requirement and it is performed by registering the varieties with their distinct features. These features should also be uniform and stable. The distinction is made by a minimum margin of qualitative traits, specific to individual variety (Tripathi and Khare, 2016) [26]. The qualitative traits are also used for the analysis of variability present among genotypes (Giancola *et al*., 2002; Kachare *et al*., 2020; Sahu *et al*., 2020; Choudhary *et al*., 2021; Sharma *et al*., 2021; Rathore *et al*., 2022) [4, 33, 34, 2, 20, 18].
Diversity studies are generally based on two types of morphological data *viz.*, qualitative and quantitative traits. Qualitative traits are measures which differentiate between entities based on the deviant traits. Quantitative traits exhibit continuous variation (Mishra *et al*., 2020) [17] thus provide a simple way of measuring genetic diversity while studying performance of genotypes (Gawande *et al*., 2002; Tiwari *et al*., 2020) [3, 33]. So, the present study was conducted to evaluate soybean genotypes on the basis of different qualitative traits and analyze the variability exist among them.

Materials and Methods
A total of fifty-three soybean genotypes registered in India were grown at the experimental field, Department of Plant Molecular Biology & Biotechnology, College of Agriculture, Gwalior (M.P.) during *Kharif* and *Rabi* 2018-19. The seed sowing was carried out by hand dibbling. Thinning was done by manual laborers after 25-30 days of germination to maintain the uniform and desired plant population stand. Nitrogen, phosphorus, potassium and sulphur were applied @ 20:60:20:20, kg ha^{-1}, NPKS respectively in each plot.

The experimental material was monitored in randomized block design (RBD) with two replications. Five characters *viz*, leaf shape, leaf intensity of green color, flower colour, hairiness and pod colour intensity were employed as qualitative traits for variability analysis. Qualitative traits were described according to UPOV descriptor UPOV (1998).

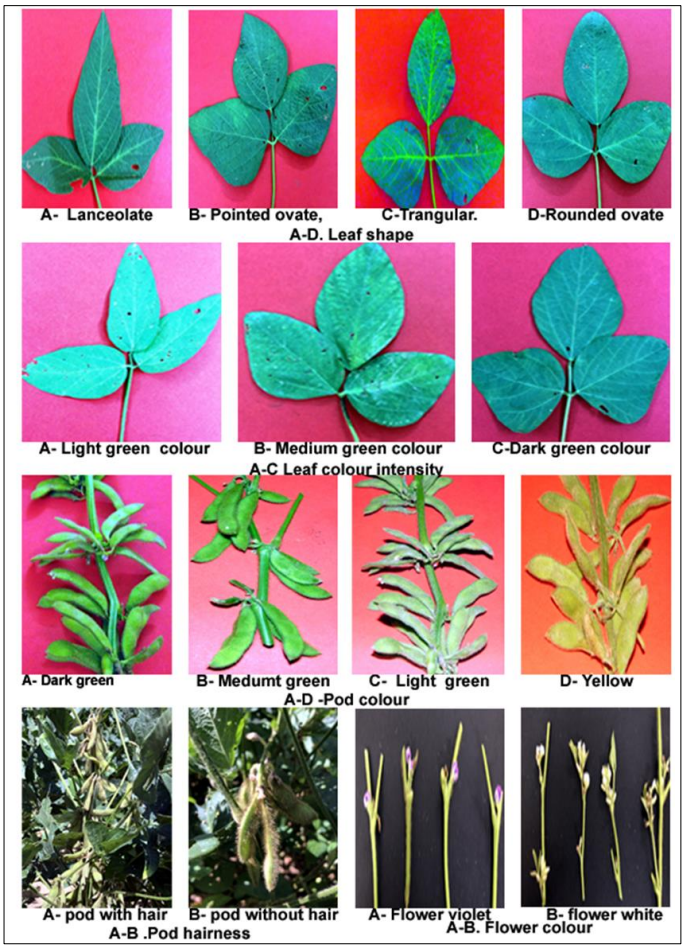

Fig 1: Different qualitative traits of soybean

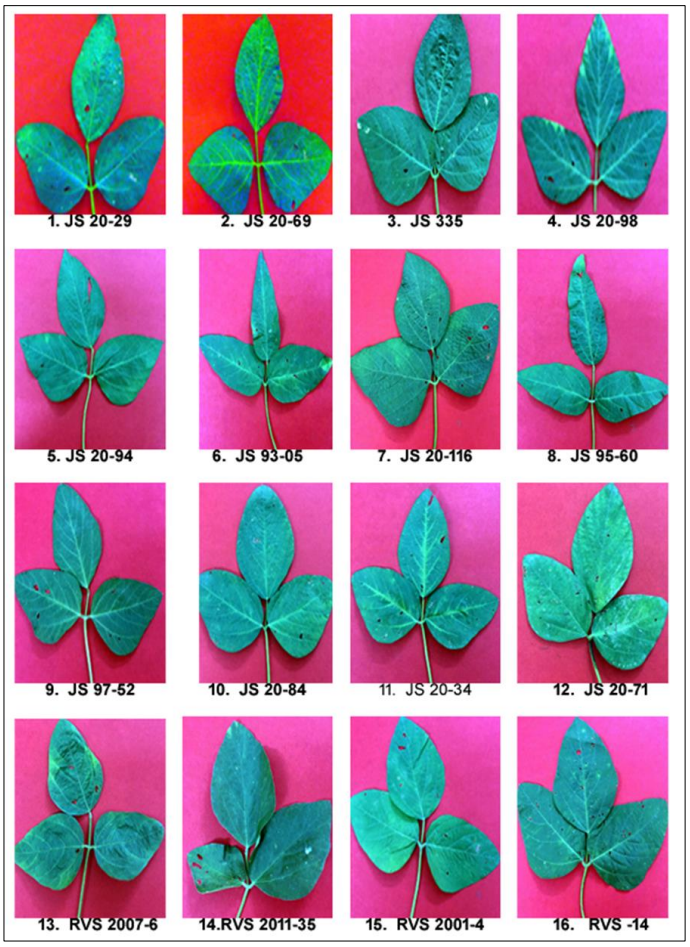

Fig 2A: Variations in leaves of soybean genotypes

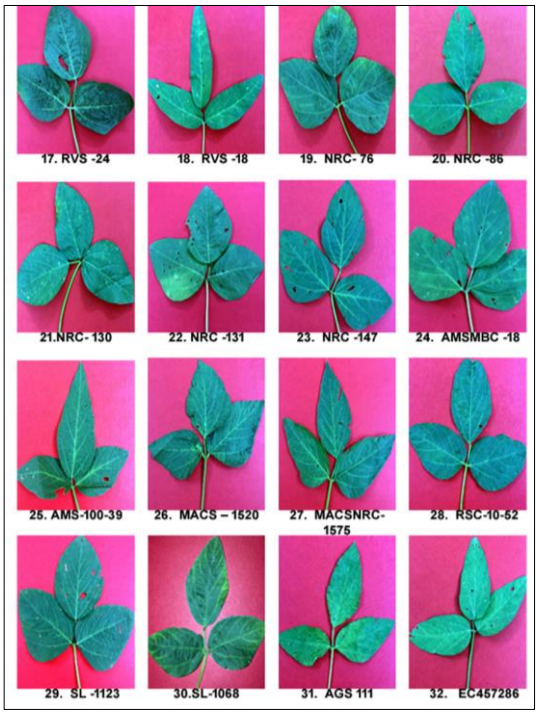

Fig 2B: Variations in leaves of soybean genotypes

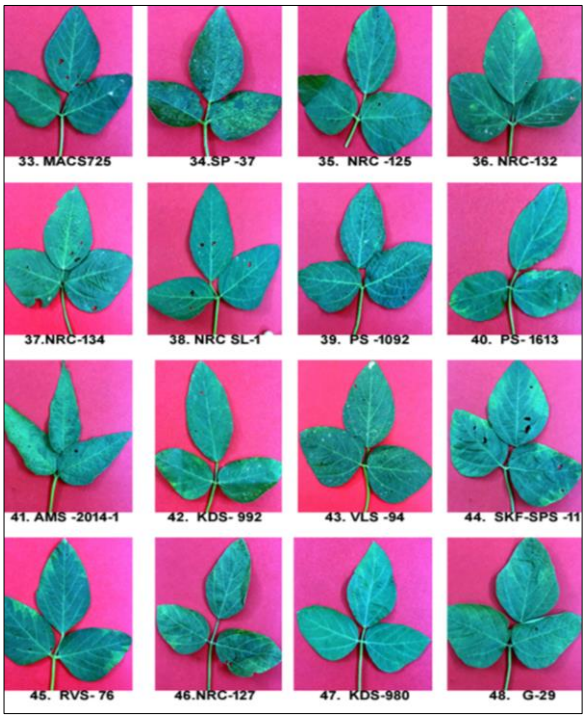

Fig 2C: Variations in leaves of soybean genotypes

Fig 2D: Variations in leaves of soybean genotypes

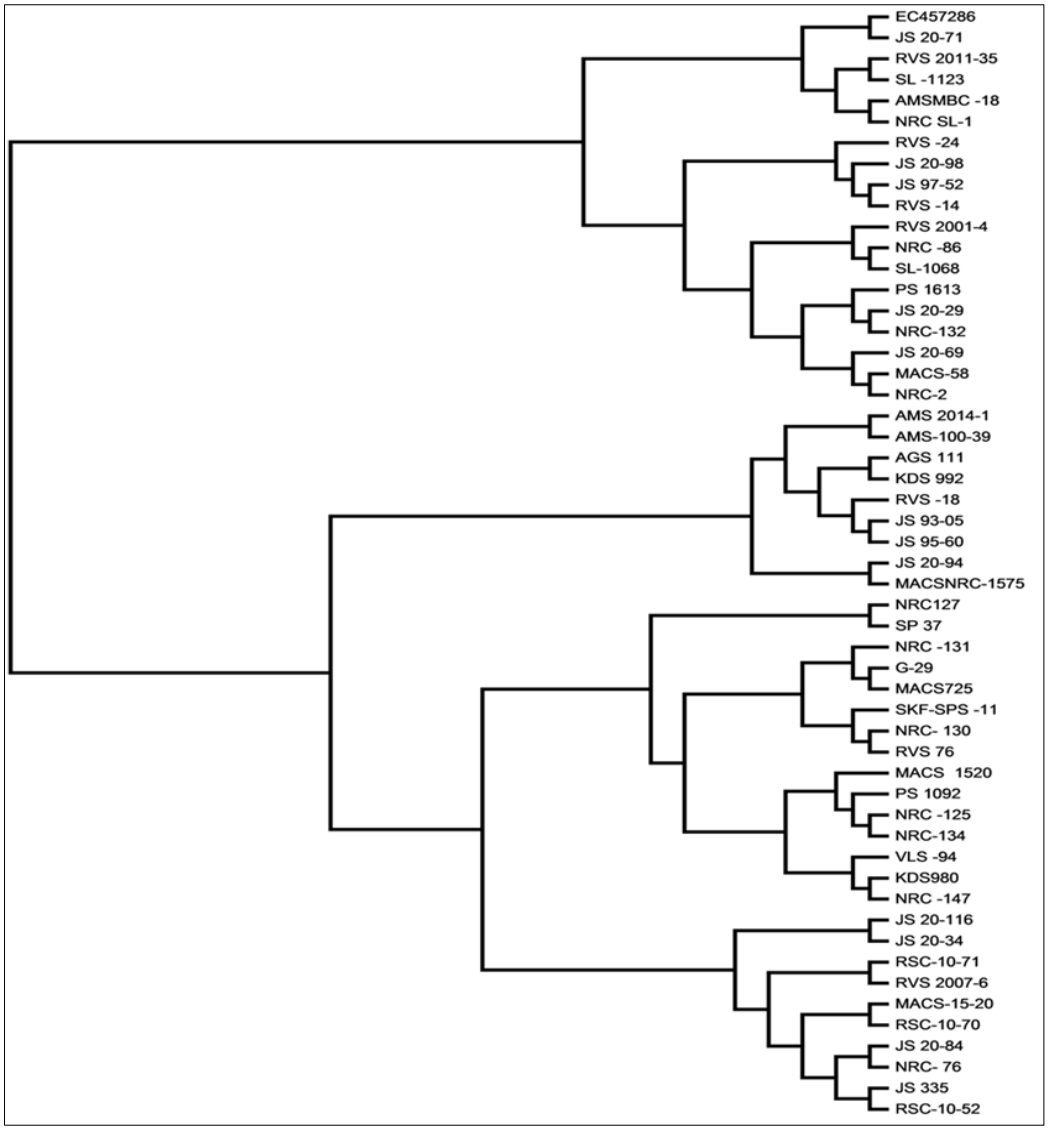

Fig 3: Dendrogram based on variability in qualitative traits 53 soybean genotypes

Table 1: Different qualitative traits of soybean genotypes

S. No.	Genotypes	Leaf types	Leaf green colour intensity	Flower colour	Pod colour	Pod hairiness
1.	JS 20-29	Pointed Ovate	Medium Green	White	Dark	Present
2.	JS 20-69	Triangular	Medium Green	White	Dark	Present
3.	JS 335	Rounded Ovate	Dark Green	Purple	Dark	Absent
4.	JS 20-98	Rounded Ovate	Dark Green	White	Medium/light green	Present
5.	JS 20-94	Triangular	Light Green	Purple	Medium	Present
6.	JS 93-05	Lanceolate	Light Green	Purple	Medium	Absent
7.	JS 20-116	Rounded Ovate	Light Green	White	Light	Absent
8.	JS 95-60	Lanceolate	Light Green	Purple	Medium	Absent
9.	JS 97-52	Rounded Ovate	Dark Green	White	Dark	Present
10.	JS 20-84	Rounded Ovate	Medium Green	White	Light	Absent
11.	JS 20-34	Rounded Ovate	Light Green	White	Dark	Absent
12.	JS 20-71	Rounded Ovate	Light Green	White	Medium	Present
13.	RVS 2007-6	Rounded Ovate	Light Green	Purple	Medium	Absent
14.	RVS 2011-35	Rounded Ovate	Medium Green	White	Medium	Present
15.	RVS 2001-4	Rounded Ovate	Light Green	White	Dark	Present
16.	RVS -14	Rounded Ovate	Dark Green	White	Dark	Present
17.	RVS -24	Rounded Ovate	Dark Green	White	Dark	Absent
18.	RVS -18	Lanceolate	Light Green	White	Medium	Absent
19.	NRC- 76	Rounded Ovate	Medium Green	Purple	Light	Absent
20.	NRC -86	Pointed Ovate	Light Green	White	Dark	Present
21.	NRC- 130	Pointed Ovate	Medium Green	Purple	Medium	Absent
22.	NRC -131	Pointed Ovate	Medium Green	Purple	Light	Absent
23.	NRC -147	Pointed Ovate	Medium Green	Purple	Light	Present
24.	AMSMBC -18	Pointed Ovate	Medium Green	White	Medium	Present
25.	AMS-100-39	Lanceolate	Medium Green	Purple	Light	Absent
26.	MACS – 1520	Pointed Ovate	Dark Green	Purple	Dark	Present
27.	MACSNRC-1575	Lanceolate	Dark Green	Purple	Medium	Present
28.	RSC-10-52	Rounded Ovate	Dark Green	Purple	Light	Absent
29.	SL -1123	Rounded Ovate	Medium Green	White	Medium	Present
30.	SL-1068	Pointed Ovate	Light Green	White	Dark	Present
31.	AGS 111	Lanceolate	Light Green	Purple	Dark	Present
32.	EC457286	Lanceolate	Light Green	White	Medium	Present
33.	MACS725	Pointed Ovate	Medium Green	Purple	Light	Absent
34.	SP 37	Pointed Ovate	Medium Green	White	Light	Absent
35.	NRC -125	Pointed Ovate	Medium Green	Purple	Dark	Present
36.	NRC-132	Pointed Ovate	Medium Green	white	Dark	Present
37.	NRC-134	Pointed Ovate	Medium Green	purple	Dark	Present
38.	NRC SL-1	Pointed Ovate	Medium Green	White	Medium	Absent
39.	PS 1092	Pointed Ovate	Medium Green	Purple	Dark	Present
40.	PS 1613	Pointed Ovate	Medium Green	White	Dark	Present
41.	AMS 2014-1	Lanceolate	Light Green	Purple	Light	Absent
42.	KDS 992	Lanceolate	Light Green	Purple	Dark	Absent
43.	VLS -94	Pointed Ovate	Medium Green	Purple	Medium	Present
44.	SKF-SPS -11	Pointed Ovate	Medium Green	purple	Medium	Absent
45.	RVS 76	Pointed Ovate	Medium Green	Purple	Medium	Absent
46.	NRC127	Pointed Ovate	Medium Green	White	Light	Present
47.	KDS980	Pointed Ovate	Medium Green	Purple	Light	Present
48.	G-29	Pointed Ovate	Medium Green	Purple	Light	Absent
49.	RSC-10-70	Rounded Ovate	Medium Green	Purple	Dark	Absent
50.	RSC-10-71	Rounded Ovate	Medium Green	Purple	Medium	Absent
51.	NRC-2	Rounded Ovate	Medium Green	White	Dark	Present
52.	MACS-15-20	Rounded Ovate	Medium Green	Purple	Dark	Present
53.	MACS-58	Rounded Ovate	Medium Green	White	Dark	Present

Table 2: Distribution of phenotypic classes among qualitative trait

Description	Category	Number of genotypes	Frequency (%)
Leaf shape	L	9	16.98
	RO	20	37.73
	PO	22	41.50
	T	2	3.77
Leaf intensity of green colour	Dark	8	15.09
	Medium	30	56.60
	Light	15	28.30
Flower colour	White	25	47.16

	Violet/purple	28	52.83
Hairiness	Absent	24	45.28
	present	29	54.71
Pod colour	Dark green	22	41.50
	Medium green	14	26.41
	Light green	17	32.07

Table 3: Shannon- Weaver diversity indices (H') of traits

Character	LT	LCI	FC	PC	PH	Avg.	SD
Shannon-H'	3.54	3.46	3.18	3.37	3.69	3.45	0.08

LT-Leaf type, LCI-Leaf green colour intensity, FC- Flower colour, PC-Pod colour, PH-Pod hairiness

Results and Discussion

Genetic diversity analysis based on qualitative traits is an important approach toward identification and improvement of soybean crop (Kumar *et al*., 2015; Mishra *et al*., 2021c; Mishra *et al*., 2021d; Mishra *et al*., 2021e) [6, 14, 15, 16]. In the present study, observations on five qualitative traits were recorded for all the 53 genotypes (Table 1; Fig.1, Fig.2 A-D). Leaf types were observed among all soybean genotypes and a total of 22 genotypes (Table 2) were found with pointed ovate leaf, 20 with rounded ovate, 9 with lanceolate and two with triangular leaf. Green colour intensity of leaf was found to be maximum (dark) in 8 genotypes, medium in 30 genotypes and light among 15 genotypes (Fig. 2 A-D). Among 53 soybean genotypes only two types of flowers colour were investigated, 25 genotypes were white and remaining 28 were purple colored (Fig. 1). A total of 18 genotypes were with medium pod colour intensity, 12 light and twenty-two were with dark pods. A total of 29 genotypes were found with pod hairiness and remaining 24 had no pod hairs (Fig. 1).

In accordance with the findings of the present investigation, Kachare *et al*. (2019) [35] investigated eleven qualitative traits for 45 genotypes and found that four groups were formed for plant growth habit *namely:* erect, semi-erect, spreading and semi-spreading. Among 45 genotypes studied, 27 genotypes were found to be semi-erect type, 14 erect, 3 spreading and one genotype was semi-spreading in nature. Maximum numbers of genotypes (31) were observed with medium leaf size of lateral leaflet, 10 genotypes with small while four genotypes were with large leaf size of lateral leaflet. Green color intensity was found to be maximum (dark) in 11 genotypes, medium in 26 genotypes and light among eight genotypes. Among the 45 genotypes, 41 had hairs and rest four were without hairs. A total of 19 genotypes were observed with sparse tawn hair color, 17 with dense tawn, 4 sparse white and only one with light tawn hair color, whereas in 4 genotypes hairs were absent. Only two types of flower color were observed, 35 genotypes were white and remaining 10 were violet colored. A total of 30 genotypes were with medium pod color intensity, 13 light and only two were with dark pods. Most genotypes possessed spherical flattened seed shape (28), whereas only 10 genotypes were spherical, six elongated flattened and one with elongated seed shape. Most of the genotypes (34) were with yellow green testa color, ten yellow and one green color. Some other reports are also available on phenotypic characterization of soybean crop (Mariela *et al*. 2011; Sepanlo *et al*., 2014; Tiwari *et al.*, 2019) [9, 21, 25].

Qualitative cluster analysis

The dendrogram, obtained from 53 soybean genotypes and 5 qualitative traits is shown in Fig. 3. It reflects the similarity among the genotypes studied based on measured qualitative variables and shows the discriminative power of the approach followed in this work to classify soybean genotypes. The dendrogram depicted two distinct clusters. The cluster-I consisting nineteen genotypes further bifurcated into two groups, while in cluster-II remaining 34 genotypes further divided into two subgroups with 9 and 25 genotypes respectively.

Shannon-Weaver diversity index (H')

Frequency distribution of diversity index was estimated using H' of five qualitative traits (Table 3). The H' of the trait hairiness was observed to be higher (3.69) among all the traits. On an average index (H') of 3.45 was observed among all the traits.

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