Quest Journals
Journal of Research in Agriculture and Animal Science
Volume 8 ~ Issue 12 (2021) pp: 09-18
ISSN(Online) : 2321-9459
www.questjournals.org

Research Paper

Preliminary evaluation for most promising accessions from procured Germplasm of Forgotten Medicinal legume Horsegram {*Macrotyloma uniflorum* (Lam.) Verdc} in Jalandhar Region of Punjab

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Abstract:
In the current preliminary screening of horsegram (Macrotyloma uniflorum) germplasm, qualitative and quantitative parameters of horsegram accessions were assessed. Initially, a total of 51 accessions were procured from different geographical regions of India. A total of 10 qualitative and 5 quantitative characters were studied for 24 purified accessions of horsegram under natural field conditions. Among the qualitative characters, a wide range of variations were recorded in seed color i.e. SBT (50%), SGT (33.3%), S (12.50%) and SBGT (4.17%). The mean of five quantitative parameters were calculated and an overall significant variation was detected. The average mean for NDF, NPPP, NSPP, TSW (g) and NDH were recorded as 49.21, 95.19, 447.3, 16.11 and 88.75.The principal components (PC1 and PC2) were accounted for 63.90% and 33.2% total variation. The average hierarchical clustering divided the 24 genotypes into three separate clusters. S44/L23, S56/L29, S8/L4, S96/L49 and S29/L14 were found to be the most promising accessions in future breeding processes of horsegram in Jalandhar region of Punjab to promote the cultivation of horsegram in terms of early flowering, early harvesting with more number of seeds.

Keywords: *Germplasm, Macrotyloma uniflorum, Qualitative, Quantitative, Early flowering*

***R**eceived 28 Nov, 2021; **R**evised 10 Dec, 2021; **A**ccepted 12 Dec, 2021 © The author(s) 2021.*
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I. Introduction

Legumes are the main component of the human diet since times **[1]; [2]; [3]; [4]** and are considered to be the most important source of food and fodder for humans as well as an animal **[5]**. Horsegram (*Macrotyloma uniflorum*) is considered as an important medicinal legume in Ayurveda with various pharmaceutical uses **[6]; [7]; [8]; [9]**. It is entirely cultivated in Karnataka, Andhra Pradesh, Odisha, Tamil Nadu, Madhya Pradesh, Chhattisgarh, Bihar, West Bengal, Jharkhand and also in foothills of Uttaranchal and Himachal Pradesh in India as forage, improvement in soil fertility [**10]**. It covers an area of about 4.00 lakh hectares with 2.47 lakh tonnes production during 2017-18 in India [**11]**. The wild members of this crop are found both in South Africa and India but still India it is considered to be the center of origin of horsegram **[12]; [13]; [14]; [15];[16]; [17].** It is highly nutritious food source among well-known legumes [**18]**. It provides dry and green fodder for animals, producing green manure which improves soil health and adds nutrients into the soil **[5];[19].** Protein-energy malnutrition is a serious problem due to the increasing population, decrease of fertile land, and degradation of natural resources **[20]; [21]**. Horsegram is one of the underutilized and unexplored food legumes **[22]; [23]** with a good source of carbohydrates, protein, and energy **[24].** It is forgotten and neglected pulse crop with little genetic and genomic information available. Beside all these useful benefits of horse gram, this food crop is being neglected by the farmers of Punjab in India due to the negative image attached to this crop as 'Poor man's food'. The main reasons for its underutilization are like forgetting its agronomic practices. The production of horsegram cultivation in India has been gradually decreasing due to unsuitability of good varieties of horsegram and agricultural practices that bear the challenging weather conditions with instant heavy rainfalls and more hot in summer of Jalandhar region of Punjab. Hence, the present investigation of evaluating horsegram germplasm accessions collected from diverse agro-ecological regions of India was conducted to identify promising accessions for utilizing them in crop improvement programs suitable in Punjab.

II. Materials and Methods

2.1 Horsegram Germplasm Procurement

The horsegram samples were procured from 51 diverse agro-ecological locations of India. The locality geographical coordinates i.e. latitute (°N), longitude (°E) and elevation in meters were recorded from Google earth **(Table 1)**. Twenty four samples of horsegram were produced in pure form from 51 diverse agro-ecological parts of various regions of India in terms of their early flowering, early maturation and more number of seeds. The three replication checks of these twenty four samples were again multiplied in a randomized block design (RBD) with spacing 60 ×30 cm during rainy season of July, 2018 at the agricultural field of DAV University, Sarmastpur, Jalandhar, Punjab under natural field conditions. The study site was located in the village Sarmastpur, Punjab (latitude: 31°25'18''N, longitude 75°37'01''E) and 244 meter above sea level. Each accession of horsegram seeds were sowed at a depth of 3 cm.

2.2 Qualitative and Quantitative characterization

A total of 10 qualitative and 5 quantitative parameters were recorded for each accession in each replication at different crop growth stages. Qualitative and Quantitative traits along with its descriptors and stage of observation have been depicted **(Table 2)**. The observations of five randomly selected plants from each block were recorded.

2.3 Experimental Design and Statistical Analysis

Randomized Complete Block Design with three replications of 24 accessions was used in this study. A mixed model analysis of variance was performed by using the PROC GLM procedure of SAS version 9.4 (SAS Institute, Cary, NC, USA) **[25]** and the means were statistically compared by least significant difference (LSD) at $p < 0.05$ **[26]**. The average hierarchial clustering and PCA component analysis was done with the help of JMP program**.**

III. Results and Discussion

Initially, a total of 51 accessions of horsegram were procured from different regions of India **(Table 1)**. These accessions were assumed to be in mixed form. So to overcome this problem, these accessions were separated on the basis of colour. Therefore, a total of 100 samples of horsegram were made and used for further study **(Figure 1).** In 2017 year, these were germinated in the field for the purification and multiplication of each sample. A total of twenty seeds of each sample of horsegram were germinated in successive rows of each accession. A total of 100 rows were used for their multiplication and purification. This plant is self-fertilizing, so there are no chances of cross pollination and each single plant will provide us the pure seeds of the particular location. The multiplication and purification of these seeds of each accession was performed in year 2017**.** Twenty four accessions of horsegram were given the good results in terms of their early flowering and more number of seeds. These accessions were used for further study to find out the most promising accessions by five quantitative parameters. Some of the accessions were not capable to bear the weather conditions of Jalandhar region of Punjab. Therefore, twenty four accessions **(Table 1)** were evaluated qualitatively and quantitatively with three replications checks using Randomised Block Design (RBD) under natural field conditions in year 2018. The recommended agronomical and plant protection practices were followed for the successful raising of this crop. A total of 10 qualitative traits, 5 quantitative traits were recorded for each character in each replication at different crop growth stages. An identification key was made for the qualitative characterization of 24 horsegram accessions **(Figure 2).** The results of frequency distribution (%) of each distinguishing traits of all qualitative parameters were recorded**.** The maximum amount (%) of each distinguishing traits were recorded against all 10 qualitative parameters in horsegram accessions **(Figure 3)**. Moderately hairy stem pubescence (95.83%), green colour stem (54.17%), moderately hairy leaf pubescence (98.83%), dark green leaf vein colour (70.83%), Light green leaf colour (62.50%), Linear leaf shape (75%), Dark yellow flower (62.50%), green pods with light purple streaks (87.50%) and straw colour seeds with black tinge (50%) were recorded. A good variation was found in leaf shape, stem colour and seed colour. There was no stem twinning was recorded by none of accessions of horsegram in the field. The seeds of horsegram have more variation in colour. Most of the accessions of horsegram were recorded as straw colour with black tinge (50%) whereas straw with green tinge (33.3%), straw with black green tinge (4.17%) and straw (12.50%) colour were recorded. The maximum diversity was observed in horsegram for leaf colour in horsegram **[27].** Similarly, maximum range of variability was also noticed in pod and seed colour of horsegram **[28]; [29]; [30]**.

The five quantitative parameters of number of days to flowering (NDF), number of days to harvesting (NDH), number of pods per plant (NPPP), number of seeds per plant (NSPP), total seed weight per plant (in gram) (TSW) were recorded. The statistical results were recorded for data comprising 24 treatments with three replications in hosrsegram **(Table 3)**. The type 1 and type 3 sum of squares were recorded for each dependent

variable. The average mean for NDF, NPPP, NSPP, TSW (g) and NDH were recorded as 49.21, 95.19, 447.3, 16.11 and 88.75. It was seen that the treatment effects were significantly different (p-value<0.0001). The treatment wise mean and standard deviation for all dependent variables were also recorded **(Table 4).** All the genotypes were separated into different groups. The means with same letter were not significantly different according to LSD at P<0.05. The significant groups i.e. 20, 18, 20, 17 and 8 were recorded for NDF, NPPP, NSPP, TSW (g) and NDH respectively. The distribution of the observations for each treatment is shown in horsegram (**Figure 4)**. The average hierarchical clustering analysis was done to the observed mean of each treatment and found three separate clusters. Cluster 1 was comprised of 20 genotypes of horsegram. All these genotypes were from different regions of Himachal Pradesh, Punjab and Utrakhand. Three accessions namely S44/L23, S56/L29 and S8/L4 were the good accessions in terms of their early flowering, early harvesting with good amount of seeds in Cluster 1. Cluster 2 was comprised of three accessions namely S53/L28, S70/L36 and S96/L49 wherein S96/L49 was the good accession and it was procured from Chhatisgarh. Cluster 3 was comprised of only one accession namely S29/L14 (Village: Bharmour, Tehsil: Brahmaur, District: Chamba, State: Himachal Pradesh) and it was the most promising accession among all the genotypes in terms of their early flowering, early harvesting with good amount of seeds (**Figure 5)**.The average means analysis for all dependent variables by average hierarchical clustering analysis were recorded **(Table 5).** The minimum average mean for NDF was found to be 35.27 and 62.11 as maximum whereas the maximum and minimum average mean for NDH was found to be 101.67 and 80 days. 50% flowering was noticed in the range from 36.58 to 38.13 days in horsegram **[31]**.The maximum amount of seeds was recorded as 1344.80 with 384.60 NSPPP. The maximum amount of total weight of seeds was recorded as 56.53g for 1344.80 seeds. The principal component analysis (PCA) was achieved by using 5 quantitative parameters. The value of the eigen values and variation explained by each of the principal component were recorded. The first principal component (PC 1) accounted for 63.90% total variation. The second principal component (PC 2) accounted for 33.2% total variation. The third principal component (PC 3) accounted for 1.85% total variation. The fourth principal component (PC 4) accounted for 0.92% total variation. The fifth principal component (PC 5) accounted for 0.16% total variation. A scatter and scree plot **(Fig 6)** drawn between PC1 and PC2 based on the factor scores obtained in clear pattern of grouping between the genotypes in the factor plane, except for few genotypes such as S53/l28, S29/L14, S96/L49, S56/L29 and S8/L4 those had high dispersion. These most promising accessions of horsegram will be further utilized in future for the varietal development. Various researchers had done for the varietal development in horsegram. Three varieties of Horse gram such as Co1 (1953), Paiyur1 (1988), Paiyur2 (1988) were released by NPRC, Vamban, Tamil Nadu, mainly for rain fed land **[32].** Two varieties of horsegram i.e. BK1 and VLG1 from Birsa Agricultural University, Kanke, Ranchi and Jharkand were developed **[33]**. PHG-1, HG-96 and PDM-1 are the commonly grown varieties in Andhra Pradesh in India **[34].** A new variety of horse gram CRIDA 18R was released that match the monsoon patterns of rainfall for South India **[35]**. Some of the procured accessions of horsegram performed very well, while others poorly in terms of early flowering, early harvesting with more number of seeds. The major factor for poor performance of these procured accessions may be due to the non-knowledge of their exact showing time of different procured accessions in Jalandhar region of Punjab. It is need to cultivate the most promising procured accessions at different locations of Punjab with different sowing time for better results and study the environmental conditions, types of soils and average rain fall of this region. Therefore, these most promising accessions i.e. S53/l28, S29/L14, S96/L49, S56/L29 and S8/L4 will be further evaluated for their yield with the available varieties of horsegram and check the response under the given climatic conditions of Punjab.

Table 1: Detail of procured horsegram accessions from different geographical regions of India

Sr. No.	Name of accession number used in year, 2017	Location	State	Samples Name	Locality Geographical Coordinates		Elevation in Meters	Name of accession number used in year, 2018
					Latitute (°N)	Longitude (°E)		
1	L1	Usnar kalan, Hamirpur	Himachal Pradesh	S1, S2	31°29'43''N	76°30'22''E	712m	-
2	L2	Kiyar, Solan	Himachal Pradesh	S3,S4	30°52'53''N	77°03'41''E	1577m	-
3	L3	Bakarti, Hamirpur-1	Himachal Pradesh	S5, S6,S7	31°38'24''N	76°30'39''E	707m	-
4	L4	Bakarti, Hamirpur-2	Himachal Pradesh	S8,S9	31°38'24''N	76°30'39''E	707m	S8/L4
5	L5	Dharmpur, Solan	Himachal Pradesh	S10, S11	30°51'35''N	77°00'07''E	1050m	-
6	L6	Roru, Shimla	Himachal Pradesh	S12, S13	31°10'47''N	77°43'20''E	1724m	-

7	L7	Nerchownk, Mandi	Himachal Pradesh	S14, S15	31°35'56''N	76°53'38''E	813m	S14/L7
8	L8	Baruhi, Una	Himachal Pradesh	S16, S17	31°35'46''N	76°10'34''E	440m	-
9	L9	Rampur, Shimla	Himachal Pradesh	S18, S19	31°26'16''N	77°39'37''E	2484m	S18/L9
10	L10	Ghandhir, Bilaspur	Himachal Pradesh	S20, S21	31°21'49''N	76°35'09''E	718m	-
11	L11	Rampur, Shimla	Himachal Pradesh	S22, S23	31°26'16''N	77°39'37''E	2484m	S23/L11
12	L12	Sarahan, Sirmour	Himachal Pradesh	S24, S25	30°43'02''N	77°08'04''E	880m	S25/L12
13	L13	Pehrwin, Bilaspur	Himachal Pradesh	S26, S27	31°22'43''N	76°44'29''E	594m	S26/L13
14	L14	Bharmour, Chamba	Himachal Pradesh	S28, S29	32°26'47''N	76°32'16''E	2046m	S29/L14
15	L15	Amb, Una	Himachal Pradesh	S30, S31	31°39'24''N	76°08'59''E	447m	-
16	L16	Village-Mairi Distt.-Una	Himachal Pradesh	S32, S33	31°42'22''N	76°11'14''E	552m	S33/L16
17	L17	Gwalpathar, Hamirpur	Himachal Pradesh	S34, S35	31°40'47''N	76°21'20''E	578m	-
18	L18	Dalhousi, Chamba	Himachal Pradesh	S36, S37	32°32'42''N	75°50'08''E	575m	-
19	L19	Baldwara, Mandi	Himachal Pradesh	S38, S39	31°33'42''N	76°45'57''E	796m	-
20	L20	Rampur, Shimla	Himachal Pradesh	S40	31°26'16''N	77°39'37''E	2484m	S40/L20
21	L21	Sandal, Shimla	Himachal Pradesh	S41	31°04'34''N	77°07'36''E	1539m	-
22	L22	Shoali, Shimla	Himachal Pradesh	S42	31°04'23''N	77°40'03''E	2813m	S42/L22
23	L23	Gondpur, Una	Himachal Pradesh	S43, S44	31°44'48''N	76°01'49''E	525m	S44/L23
24	L24	Shrog, Shimla	Himachal Pradesh	S45, S46	31°11'27''N	77°42'01''E	1942m	S45/L24
25	L25	Nauni, Solan	Himachal Pradesh	S47, S48	30°50'50''N	77°09'37''E	1158	S47/L25
26	L26	Sarahan, Sirmour	Himachal Pradesh	S49, S50	30°40'23''N	77°09'49''E	872m	S49/L26
27	L27	Sarahan, Sirmour	Himachal Pradesh	S51, S52	30°40'23''N	77°09'49''E	872m	S51/L27
28	L28	Nerchownk, Mandi	Himachal Pradesh	S53, S54, S55	31°26'16''N	77°39'37''E	2484m	S53/L28
29	L29	Pandoga, Una	Himachal Pradesh	S56, S57	31°28'30''N	76°07'58''E	469m	S56/L29
30	L30	Sarahan, Sirmour	Himachal Pradesh	S58, S59	30°40'23''N	77°09'49''E	872m	-
31	L31	Patiala-1	Punjab	S60, S61	30°26'15''N	76°14'02''E	268m	S60/L31
32	L32	Patiala-2	Punjab	S62, S63	30°26'15''N	76°14'02''E	268m	-
33	L33	Patiala-3	Punjab	S64, S65	30°26'15''N	76°14'02''E	268m	-
34	L34	Patiala-4	Punjab	S66, S67	30°26'15''N	76°14'02''E	268m	-
35.	L35	Patiala-5	Punjab	S68, S69	30°26'15''N	76°14'02''E	268m	-
36	L36	Patiala-6	Punjab	S70, S71	30°26'15''N	76°14'02''E	268m	S70/L36
37	L37	Patiala-7	Punjab	S72, S73	30°26'15''N	76°14'02''E	268m	S72/L37

38	L38	Patiala-8	Punjab	S74, S75	30°26'15''N	76°14'02''E	268m	S75/L38
39	L39	Patiala-9	Punjab	S76, S77	30°26'15''N	76°14'02''E	268m	-
40	L40	Patiala-10	Punjab	S78, S79	30°26'15''N	76°14'02''E	268m	S78/L40
41	L41	Jammu	Jammu and Kashmir	S80, S81	34°47'04''N	73°04'08''E	2098m	-
42	L42	Rajasthan-1	Rajasthan-1	S82, S83	26°45'12''N	75°05'49''E	175m	-
43	L43	Rajasthan-2	Rajasthan-2	S84, S85	26°45'12''N	75°05'49''E	175m	-
44	L44	Utrakhand	Utrakhand	S86, S87	31°08'16''N	75°48'54''E	750m	S86/L44
45	L45	Korba, Chhatisgarh-1	Chhatisgarh	S88, S89, S90	22°20'19''N	82°32'48''E	338m	-
46	L46	Chhatisgarh-2	Chhatisgarh	S91, S92	22°20'19''N	82°32'48''E	338m	-
47	L47	Chhatisgarh-3	Chhatisgarh	S91, S92	22°20'19''N	82°32'48''E	338m	-
48	L48	Chhatisgarh-4	Chhatisgarh3	S95	22°20'19''N	82°32'48''E	338m	-
49	L49	Chhatisgarh-5	Chhatisgarh	S96, S97	23°01'43''N	75°10'14''E	-191m	S96/L49
50	L50	Chhatisgarh-6	Chhatisgarh	S98, S99	22°20'19''N	82°32'48''E	338m	-
51	L51	Baraut/Bhagpur-1 (U.P)	Uttar Pradesh	S100	29°06'13''N	77°15'21''E	230m	-

Table 2: A list of qualitative and quantitative parameters with distinguishing descriptors and stage of its observation

A) Qualitative parameters			
Sr. No.	**Name**	**Distinguishing traits with descriptors**	**Stage of Observation**
1	Leaf pubescence	Slightly hairy (SH) and Moderately hairy (MH)	Before flowering
2	Leaf colour	Light green (LG), Dark green (DG)	Before flowering
3	Leaf shape	Ovate (O) and Linear (L)	Before flowering
4	Leaf vein colour	Densely green (DG), Lightly green (LG)	Before flowering
5	Stem colour	Green (G), Purple (P)	Before flowering
6	Stem pubescence	Slightly hairy (SH) and Moderately hairy (MH)	Before flowering
7	Stem twinning habit	Twinning (T) and No Twinning (NT)	After flowering
8	Flower colour	Light yellow (LY) and Dark yellow (DY)	After flowering
9	Pod colour	Green with light purple streaks (GLPS), Green with dark purple streaks: GDPS	Dried Pods
10	Seed colour	Straw (S), Straw with greenish tinge (SGT), Light straw (LS), Straw with black tinge (SBT), Straw with blackish green tinge (SBGT), Straw with orange tinge (SOT), Black (B)	30 days after harvesting
B) Quantitative parameters			
Sr. No.	**Name**		**Stage of Observation**
1	No. of days to flowering (NDF)		Days to first flowering seen in plant
2	No. of days to harvesting (NDH)		90% pods when matured and dried completely
3	No. of pods per plant (NPPP)		Dried Pods
4	No. of seeds per plant (NSPP)		30days after harvesting
5	Total seeds weight per plant in gram (TSW)		60days after harvesting

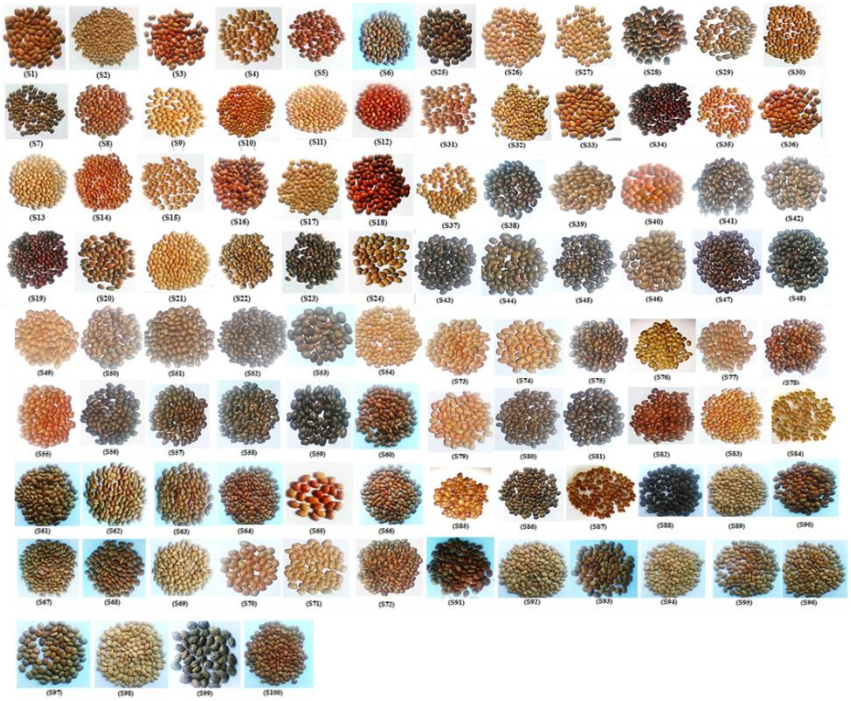

Figure 1: Separation of procured horsegram accessions on the basis of colour from 51 diverse locations of India

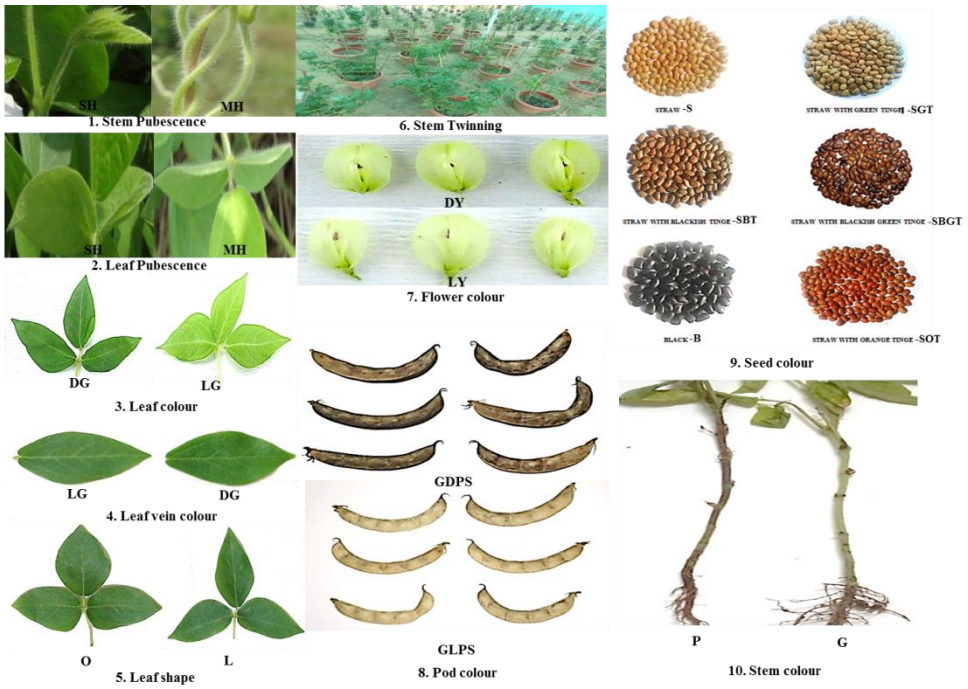

Figure 2: An identification key with distinguishing traits of ten qualitative parameters in horsegram

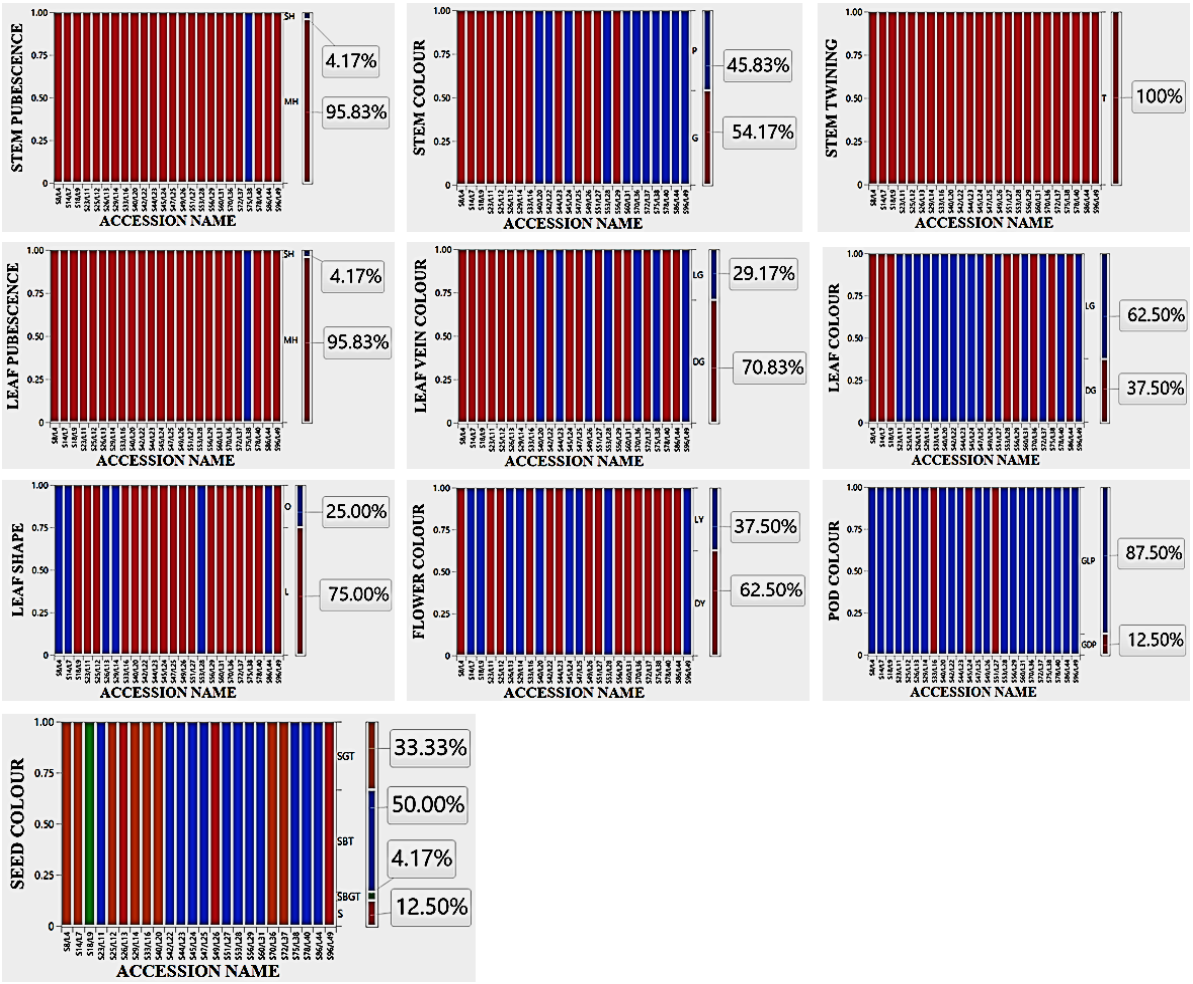

Figure 3: The frequency distribution of all contributing traits (%) in 24 accessions of horsegram by ten qualitative parameters

Table 3: The statistical results for data comprising 24 treatments with three replications in hosrsegram

Sr. No.	Dependent variable	DF	R-Square	CV	Root MSE	Mean	Type I SS	Type III SS	Mean Square	F Value	Pr > F
1	NDF	23	0.993771	2.335421	1.149416	49.21667	70391.76667	70391.76667	3060.51159	2316.54	<.0001
2	NPPP	23	0.98032	10.90508	10.38103	95.19444	1792984.922	1792984.922	77955.866	723.38	<.0001
3	NSPP	23	0.99373	5.181251	23.17574	447.3	28429564.4	28429564.4	1236068.02	2301.31	<.0001
4	TSW(g)	23	0.98747	8.339986	1.34425	16.11814	47559.63607	47559.63607	2067.81026	1144.33	<.0001
5	NDH	23	1	0	0	88.75	56437.5	56437.5	2453.80435	Infinity	<.0001

Note: DF (Degree of freedom), CV (Coefficient of variation), MSE (Mean square error), SS (Sums of squares)

Table 4: The treatment wise mean and standard deviation for all dependent variables

Name of accessions	Days to flower (NDF)	No. of pods/plant (NPPP)	No. of seeds/plant (NSP)	Days to harvest (NDH)	Total seed weight (g) TSW (g)
S14/L7	53.67±0.82^{g}	75.40±10.70^{ij}	312.47±24.88^{l}	85^{e}	8.66±1.20^{jkl}
S18/L9	62.53±0.83^{d}	36.07±6.93^{q}	141.13±19.54^{r}	95^{c}	5.16±0.98^{n}
S23/L11	59.20±1.42^{e}	95.00±8.34^{g}	386.40±20.38^{j}	95^{c}	14.47±1.34^{h}
S25/L12	47.93±0.80^{j}	71.04±7.04^{jk}	284.80±23.52^{m}	90^{d}	9.46±0.93^{j}
S26/L13	43.73±1.03^{kl}	63.47±10.22^{lmn}	250.47±20.34^{no}	85^{e}	8.75±0.78^{jk}
S29/L14	35.27±0.96^{n}	384.60±12.72^{a}	1344.80±24.43^{a}	80^{f}	56.53±3.50^{a}
S33/L16	71.80±1.32^{a}	56.47±8.48^{no}	177.13±22.93^{q}	110^{a}	6.71±0.81^{m}

S40/L20	43.07±1.44^{lm}	73.53±12.53^{ij}	525.67±26.09^{g}	85^{e}	20.21±0.89^{e}
S42/L22	35.20±1.08^{no}	52.60±9.88^{op}	224.47±22.50^{p}	80^{f}	8.97±0.82^{ik}
S44/L23	34.40±40^{o}	95.27±11.95^{g}	738.33±24.52^{d}	80^{f}	23.65±1.79^{d}
S45/L24	35.13±0.92^{no}	68.73±9.28^{jkl}	503.13±18.55^{h}	80^{f}	17.82±0.71^{fg}
S47/L25	33.33±1.18^{p}	57.40±11.36^{mno}	240.33±21.15^{op}	80^{f}	7.76±0.95^{l}
S49/L26	42.60±1.40^{m}	83.40±7.50^{h}	390.73±19.74^{j}	85^{e}	10.57±0.72^{i}
S51/L27	71.93±1.22^{a}	38.33±9.22^{q}	163.13±24.22^{q}	110^{a}	5.43±0.89^{n}
S53/L28	71.67±1.29^{a}	154.27±11.13^{c}	846.13±23.67^{c}	110^{a}	32.17±1.59^{c}
S56/L29	31.47±1.36^{q}	129.93±10.49^{e}	546.07±24.39^{f}	65^{h}	18.31±0.68^{f}
S60/L31	44.40±1.24^{k}	79.87±9.57h^{i}	453.87±26.85^{i}	75^{g}	17.22±0.62^{g}
S70/L36	65.07±1.03^{c}	103.60±14.34^{f}	534.87±23.50^{fg}	105^{b}	20.76±1.43^{e}
S72/L37	69.33±0.98^{b}	46.80±9.20^{p}	237.73±23.20^{op}	105^{b}	8.18±1.00^{kl}
S75/L38	51.07±1.39^{h}	75.87±9.74^{ij}	358.20±22.75^{k}	90^{d}	10.96±0.70^{i}
S78/L40	49.53±0.99^{i}	52.27±10.31^{op}	261.00±26.73^{n}	90^{d}	8.77±0.69^{ik}
S8/L4	23.67±1.18^{r}	139.00±10.3^{1d}	566.40±29.73^{e}	65^{h}	20.78±2.04^{e}
S86/L44	55.60±1.12^{f}	64.00±11.14^{klm}	287.87±21.53^{m}	95^{c}	10.72±0.88^{i}
S96/L49	49.60±1.18^{i}	187.73±12.30^{b}	960.07±16.82^{b}	90^{d}	34.83±2.25^{b}
LSD	0.8256	7.4565	16.647	0	0.9655

Note: Means with same letter were not significantly different for each dependent variable according to LSD at P<0.05

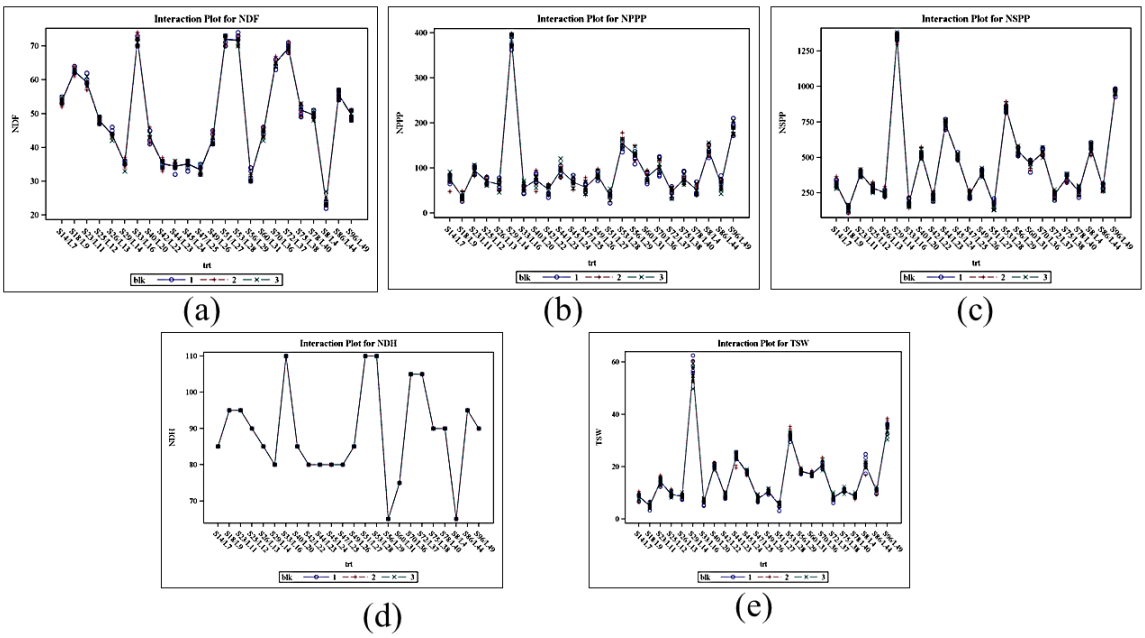

Figure 4: The graphical representation of distribution of observations for each treatment

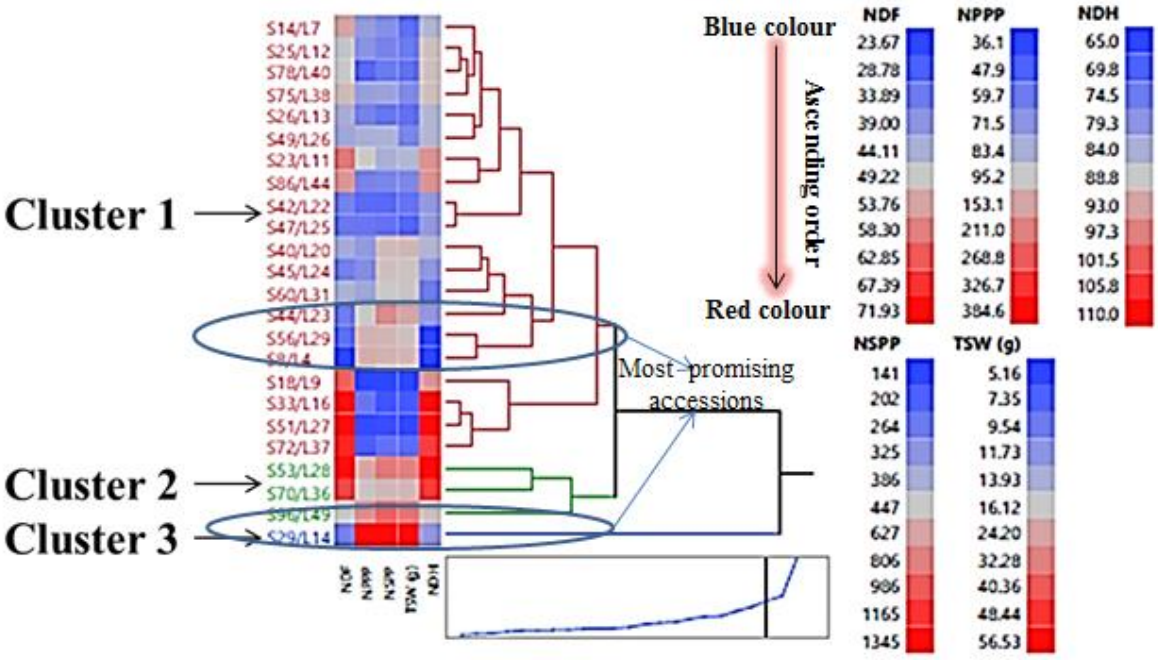

Figure 5: Dendrogram based on 5 quantitative parameters in horsegram

Table 5: Average means analysis for all dependent variables by average hierarchical clustering analysis

Cluster	Count	NDF	NPPP	NSPP	TSW (g)	NDH
1	20	47.98	72.72	352.47	12.13	87.25
2	3	62.11	148.53	780.36	29.25	101.67
3	1	35.27	384.60	1344.80	56.53	80.00

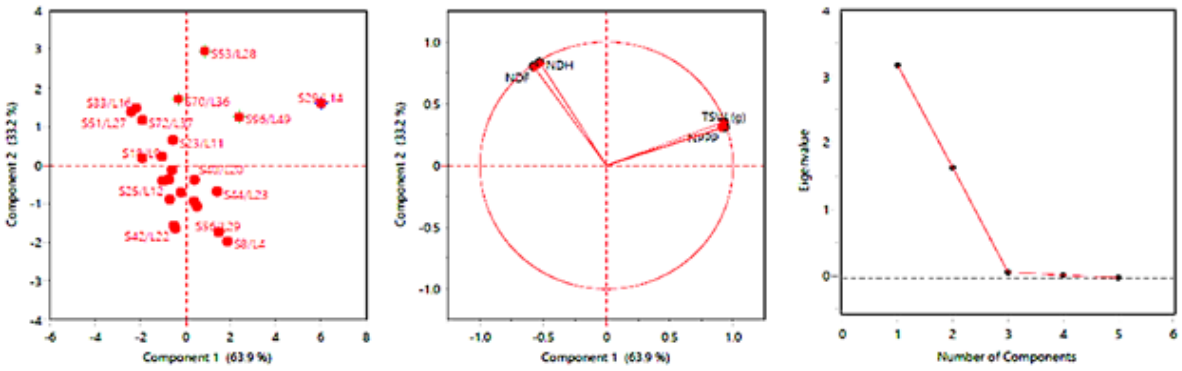

Figure 6: (a) Projection of variables and all selected 24 genotypes with PC1 and PC2 components (b) Scree plot between Eigen values and obtained principal components

IV. Conclusion

It is concluded that the phenotypic characterization provides the opportunity for selecting the designed traits. Principal component and cluster analyses of quantitative parameters of purified twenty four accessions of horsegram from different regions of India revealed the genetic diversity and relationship among the genotypes. This present research work was useful in the preliminary examination of most promising accessions namely S44/L23, S56/L29, S8/L4, S96/L49 and S29/L14 in terms of their early flowering, early harvesting with more number of seeds from procured accessions and can be useful for utilizing them in crop improvement programs suitable in Jalandhar region of Punjab. Further it is recommended to evaluate these most promising accessions for diseases, insects and pest susceptibility and fertilizer requirement. In this way we can assess the actual potential and provide exact information of these accessions to the breeder to exploit the useful genetic potential for evaluation of new varieties.

Acknowledgement

Authors acknowledge the financial assistance received from SERB-DST, GOI New Delhi with Project No. (YSS/2015/00521). Infrastructure support provided by DAV University is also acknowledged.

Conflict of interest

Authors declare that there is no conflict of interest.

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