



**GENOTYPIC AND PHENOLOGICAL PLASTICITY AMONG
VARIOUS ACCESSIONS OF *PLANTAGO OVATA* (ISABGOL)**

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ABSTRACT

Plantago ovata is the cultivated and economically important species in the monotypic genus *Plantago*. *P. ovata* is a short-stemmed annual herb, 10-45 cm tall, generally used as a laxative, emollient and demulcent, and has great commercial and economic importance as well. The present experiment was designed to explore the germplasm variability among 47 accessions of *P. ovata* obtained from IABGR and PGRC (Pakistan Agriculture Research Council, Islamabad).

Considerable variations were observed in five agro-morphological traits i.e., plant height, leaf width, length of ear, number of tillers per plant and number of seeds per ear. Among all test entries, the accession number 20555, 20671, 20666 and 20673 were found to be best in terms of all the parameters studied. These accessions may also be propagated in their original habitats to increase their productivity.

KEYWORDS: *Plantago ovata*, germplasm, morphological traits.

INTRODUCTION

Improved yield is one of the important goal of plant breeders. The stagnant yields of Isabgol may be due to the limited genetic improvement. Therefore, there is a need to understand the nature and magnitude of gene action involved in the inheritance of seed yield and associated characters.

Cholistan is the hottest desert of Pakistan where annual rainfall occurs less than 100 mm in the western area and up to 200 mm in the eastern tract. Rainfall mostly received in monsoon, in winter and spring. The minimum and maximum temperature varies from 20°C and 40°C, respectively. The soil of desert is mostly saline or saline-sodic with pH 8.2 to 9.6. Variety of environmental variations occurs within natural rangeland of Cholistan desert.

Wild plants have always been the matter of high concern to human beings^[1]. The knowledge of plants is based on trials and errors; therefore the accurate knowledge of uses of medicinal plants passes from generation to generation, after refining and additions^[2]. According to an estimate, plant species used in folk medicine, worldwide, ranged between 35,000-70,000^[3].

Genetic variability among plants shows, difference of genetic material between individuals of same species^[4]. The seed of a plant that is planted today and that is planted hundreds year ago shows a great genetic variability. Defoliation, edaphic and climatic conditions generally cause population differentiation and ecotypic variant is the result of different type of grassland management^[5].

Plantago ovata genus belongs to family Plantaginaceae. Among the latter, out of 200 species of genus, only two species namely *Plantago ovata* and *Plantago psyllium* are widely used for husk production which is a thin white covering of concave side of a seed. The husk of *Plantago ovata* is locally known as isabgol and in English it is called as Blonde psyllium. *Psyllium* is important in pharmaceutical and cosmetic industries and also used in beverages, bakery and other dietary products^[6]. Both seed and husk has the ability of retaining as well as absorbing water and thus helpful in checking diarrhea as well. It is diuretic, alleviates kidney and bladder complaints, gonorrhea, arthritis and hemorrhoids^[7]. Improved yield of Isabgol is one of the important goal of plant breeders. The stagnant yields of Isabgol may be due to the limited genetic improvement. Therefore, there is a need to understand the nature and magnitude of gene action involved in the inheritance of seed yield and associated characters.

In the present study, morpho-genetic variability and the principle component analysis (PCA) technique were used for the assessment of diversity for various morphological traits in the available 47 germplasm collections assembled from IABGR and PGRC from Islamabad, as a prelude to crop improvement.

MATERIAL & METHOD

The present work was conducted at Cholistan institute of desert studies (CIDS) located in the Baghdad-ul-Jadeed campus of Islamia University Bahawalpur, during the months of March. Germplasm of *Plantago ovata* was obtained from IABGR and PGRC, Islamabad. Sowing of *Plantago ovata* was done on November 24, 2013. The experiment was laid out according to Complete Randomized Block Design (CRBD) and a total of 47 accessions of *Plantago ovata* (isabgol) were cultivated. The distance between two rows of one accession was 50 cm, and the distance of one accession from road side and sub water-channel was about 1m.

All accessions were kept under uniform environmental conditions during the experiment; therefore the variation encountered had a genetic basis. The maximum and minimum variation shown among different morphological character may also be effected by temperature and soil. So temperature and salinity may also one of the most important characters that cause the variation among various agro-morphological characters. We have seen that some characters show positive variation while others show negative variation which may be highly effected by the temperature and salinity.

Parameters or Morphological Characters

Data were recorded on three randomly selected competitive plants from three rows of one accession to find the similarities and dissimilarities among 47 accessions of *Plantago ovata* and in five agro-morphological characters, which included the following:

Height of plant

The measurement of plant height was taken in cm with the help of measuring tape of selected plant starting from collar region up to the tip.

Length of ear

Principally larger the length of ear, large number of seed will be likely to be produced. The length of each ear was measured in mm from tip to last seed just before the start of stem.

Leaf width

Leaf width was measured in mm by taking the middle part of the leaf extended to its right and left laminar area beyond the central midrib.

Number of tillers per plant

It refers to the total number of tillers or branches present in one plant. Data was obtained by counting all the branches present on each plant.

Number of seed per ear

Plants were harvested at the time of maturity and were brought to the laboratory for further analytical processes. The data for number of seed per ear was obtained manually by counting the seeds of each ear of the individual plants.

Hundred seed weight

After the study of different morphological characters the harvested plants were placed in the laboratory in different packets along with their accession numbers. The 100 seed weight of the plant was recorded in the lab. For this purpose 100 seeds were selected three times randomly for all the packets and then weighed separately on electric balance in grams. Average of these obtained values was taken for accurate results. Hundred seed weight shows the production of seed in 47 accessions of germplasm isabgol.

Analysis of Data

The recorded data was analyzed by using SPSS-19 for windows. Principal Component Analysis (PCA) was used to know the variations among the parameters and the results were represented in the form of tables and figures.

RESULTS

The maximum average plant height was observed in accession number 20671 (i.e, 30.08cm), followed by accession number 20666 (27 cm) and accession no. 20555 (26.5cm) respectively. However, the average minimum plant height measured from six randomly selected plants from each accession was observed in accession numbers 20640, 20670 and 21291 i.e. 19.1 cm as shown in table 1. Maximum average leaf width was recorded in accession number 20676 (7.16 mm) and 20571 and 20673 (6.83 mm) whereas minimum in accession numbers 20714, 20775, 21074, 20835 and 21213 i.e. 0.3 mm respectively. Length of ear was observed maximum in accession number 20671 i.e. 4.25 mm, followed by accession numbers 20666, 20673 and 20680 (4.08 mm) and minimum in accession numbers 21162 and 21291 (2.2 mm). The number of tillers per plant were recorded maximum in accession number 20758 (14.83) and minimum in 20640 (6.83). Moreover, number of seeds per ear were observed maximum in accession number 20679 (69.33) and minimum in 20582 (16.66) respectively (table 1).

Table 1: Average values recorded from six randomly selected plants from each accession.

Sr. no.	Accessions	Morphological parameters				
		Plant height in cm (average)	Leaf Width in mm (average)	Ear length in mm (average)	No. of tillers per plant (average)	No. of seeds per ear (average)
1	20555	26.5	4.66	2.96	10	61.83
2	20556	25.5	5.83	3.5	11.6	22.83
3	20571	23.41	6.83	3.5	9.5	67.5
4	20582	20.5	6	3	10.5	16.66
5	20597	23.41	6.5	3.5	8.83	25
6	20617	23.75	5	3.16	8.66	34.16
7	20640	19.16	5.66	3	6.83	15.5
8	20658	23.83	6.16	3.83	9.66	15.5
9	20664	24.25	0.66	3.83	10	39.16
10	20665	26.08	0.53	3.86	8.33	29.16
11	20666	27	0.61	4.08	10.33	27.66
12	20668	23.16	0.53	3	7.5	36.66
13	20669	25	0.63	3	7.33	19.16
14	20670	19.14	0.7	3.23	13.16	33.33
15	20671	30.08	0.48	4.25	7.33	21.83
16	20672	27.83	5.83	3.58	8.16	50.33
17	20673	26.08	6.83	4.08	10.16	51.83
18	20674	23.66	6	3.66	11	40.66
19	20675	26.33	5.16	3.33	8.5	54.33
20	20676	27	7.16	3.41	11	38.16
21	20677	26.5	4.31	3.08	9	43.5
22	20678	24.5	0.45	3.08	8.33	52
23	20679	24.08	0.51	3.16	8.66	69.33
24	20573	23.33	0.45	2.83	10.66	53.33
25	20680	25.33	0.48	4.08	9.83	52.5
26	20681	25.75	0.5	3	9.5	32.33
27	20682	23.83	0.51	3.08	8.5	48.16
28	20683	23	0.5	3.16	9.1	31
29	20684	26.25	0.5	2.75	8.08	52
30	20685	25.41	0.91	3.58	7.01	32.5
31	20856	22	0.71	2.91	9.5	47.66
32	20709	24.25	0.4	2.91	8.16	50.16
33	20714	24.83	0.35	3.65	10.66	41.66
34	20758	24.5	0.28	3.58	14.83	19.5
35	20775	22.33	0.31	2.83	9	53.66
36	21074	25.5	0.31	3.56	8.66	54
37	20835	21.83	0.3	2.58	9.5	54
38	20897	22.5	0.41	3	9.33	53.33
39	20905	24.83	0.48	3.16	9.33	50.6
40	20972	22.5	0.63	2.66	8.66	44.16

41	20987	23.25	0.43	3.08	9.01	40.16
42	20996	20.25	2.6	2.5	8.66	62.33
43	21059	20.25	0.5	2.83	7.16	41.5
44	21125	22.5	0.43	2.5	7	37.33
45	21162	20.5	0.45	2.25	6.33	49.66
46	21291	19.16	0.51	2.28	4.33	27.5
47	21213	23.06	0.33	2.9	11.16	35.16

Communalities indicate the amount of variance in each variable that is accounted for. Data presented in table 2 shows that initial communalities for all characters are 1.0. The extraction is maximum in length of ear (>7), on the other hand the height of plant and number of seed have less variation than length of ear (= .7) while the leaf width shows medium variation (<4), and the number of tillers show minimum degree of variation than all other characters (= .2).

Table 2: Correlation for different variables recorded by communalities. (Extraction Method: Principal Component Analysis)

	Initial	Extraction
Height	1.000	.764
LW	1.000	.347
Ear Length	1.000	.810
Tiller No.	1.000	.289
Seed No.	1.000	.780

Table 3: Total variance explained by Eigenvalues, extracted components and rotated components

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.929	38.579	38.579	1.929	38.579	38.579	1.818	36.365	36.365
2	1.060	21.206	59.785	1.060	21.206	59.785	1.171	23.420	59.785
3	.877	17.533	77.318						
4	.848	16.967	94.285						
5	.286	5.715	100.000						

Legend 1 = Height of plant, Legend 2 = Leaf width, Legend 3 = Length of ear, Legend 4 = Number of tillers per plant, Legend 5 = Number of seed per ear.

Table 3 shows that in initial eigenvalue the height of the plant has highest percentage of variance (38.57%), number of seed has lowest percentage of variance (5.71%), while leaf width has less percentage of variance than height of plant but high percentage of variance than number of seed per ear and length of ear, while number of tillers per plants show medium percentage of variance. On the other hand, number of seed shows highest cumulative percentage (100%), similarly number of tillers per plants show high cumulative percentage (<100%), length of ear and leaf width show medium cumulative percentage, while height of plant show minimum cumulative percentage (>40%). In the extraction sum of square loading shows highest percentage of variance in leaf width and minimum percentage of variance in height of plant and similarly high cumulative percentage in leaf width and low cumulative percentage in height of plant. Contrary to the extraction sum of square loading the rotation sum of squared loading also shows high percentage of variance in height of plant and low percentage of variance in leaf width while cumulative percentage in leaf width and low cumulative percentage in height of plant.

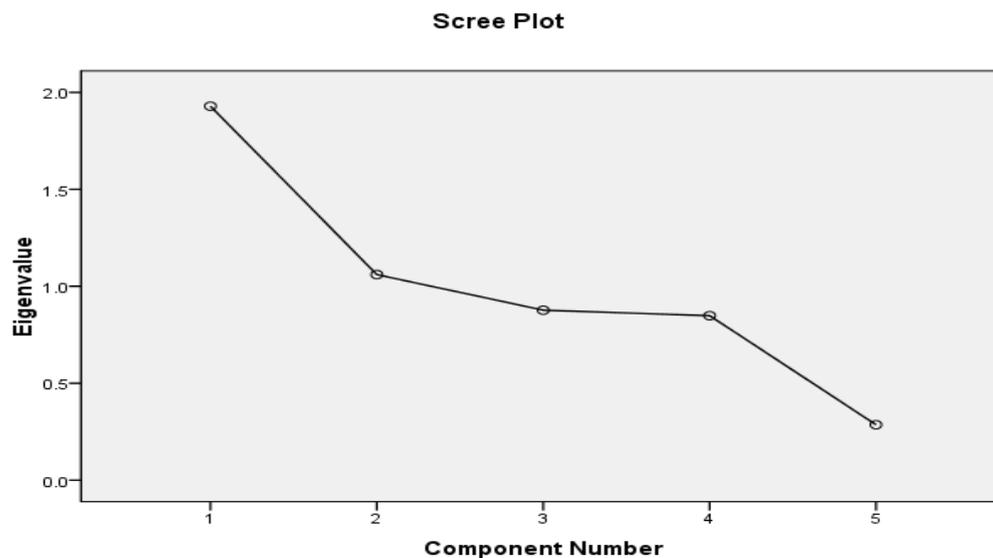


Figure 1: Scree plot between eigenvalue and components number

Scree plot helps us to determine the optimal number of components. The eigenvalues of each component in the initial solution is plotted. Generally, we want to extract the components on the steep slope. This scree plot shows that the eigenvalue of first component is 1.8; second component is 1.2, third and fourth component has 0.8 eigenvalue and fifth component has 0.2 eigenvalue respectively.

The rotated component matrix: The rotated component matrix helps us to determine what the components represent. According to this table, the second, third and fourth components are positively and negatively correlated. However, first component and fifth component show positive correlation respectively.

Table 4: Rotated component matrix

	Component	
	1	2
Height	.851	.200
L W	.340	-.481
Ear length	.859	-.267
Tiller no.	.488	-.224
Seed no.	.049	.882

Table 5: Correlation coefficient for morphological trait.

	V1	V2	V3	V4
V2	.132			
V3	.613**	.281		
V4	.131	.142	.357*	
V5	.051	-.114	-.229	-.048
** Correlation is significant at the 0.01 level (2-tailed).				
* Correlation is significant at the 0.05 level (2-tailed).				

*and**, significant at = 0.05 and 0.01 respectively.

V1 = Height of plant, V2 = Leaf width, V3 = Length of ear per plant, V4 = Number of tillers per plant, V5 = No. of seeds per ear.

Correlation coefficients for agro-morphological traits given in Table 5 showed that height of plant is positively and highly significantly ($p < 0.01$) correlated with length of ear per plant. Leaf width is negatively correlated with number of seeds per ear. Length of ear per plant is positively and significantly ($p < 0.05$) correlated with number of tillers per plant and negatively correlated with number of seeds per ear. Negative correlation is showed among number of tillers per plant and number of seeds per ear.

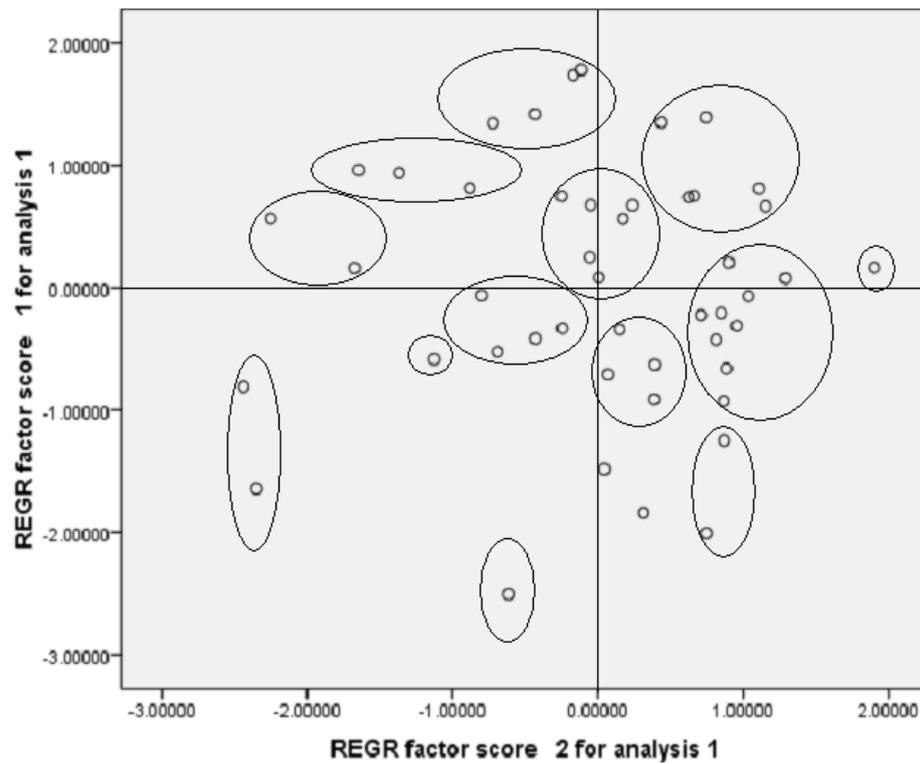


Fig 2: Plot of Principal component 1 and 2 for different accessions of *Plantago ovata*.

The data of hundred seed weight was obtained as follow:

Sample 1: 0.1462g Sample 2: 0.1634g Sample 3: 0.1305g

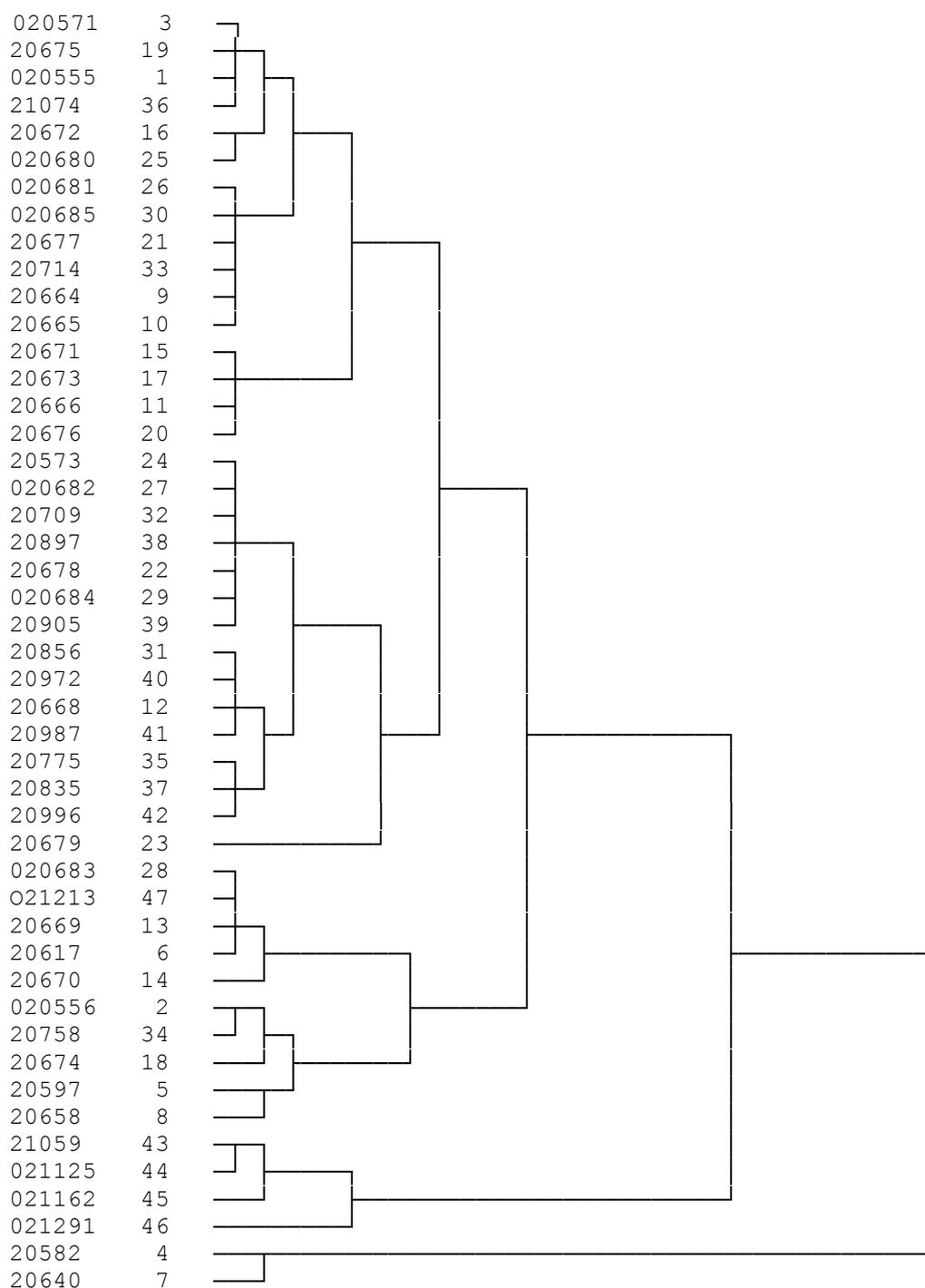
Average = $\frac{0.1462+0.1634+0.1305}{3} = 0.1467\text{g}$.

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Thus the mean hundred seed weight is 0.1467g.

Dendrogram

*****HIERARCHICAL CLUSTER ANALYSIS*****



Dendrogram describes the average linkage between groups. By the help of dendrogram we are able to find out the similarities among the different accessions. In this dendrogram all accession form a linkage group with one another. According to the dendrogram accession number 3, 19, 1, 36 form a linkage group. Similarly accession number 16 and 25 form a

linkage group with accession number 19. Another linkage is formed between accession number 26, 30, 21, 33, 9, and 10 and accession number 15, 17, 11, and 20. Accession number 30 and 26 further form a linkage group with accession number 1 and accession number 15 and 17 form a linkage group with accession number 16. Accession number 24, 27, 32, 38, 22, 29 and 39 form one linkage group and accession number 31, 40, 12 and 41 form another linkage group. Similarly 35, 37 and 42 form a linkage group and accession number 37 and 42 form a linkage group with accession number 12 and 38. Accession number 23 is linked with accession number 39 and 38. The accession number 28, 47, 13, and 6 form a linkage group and accession 14 form linkage with accession number 32. Accession number 2, 34, 18, 5, and 8 form one linkage group and accession 43, 44, 45, 46, 4, and 7 form another linkage group. Accession number 4 is further linked with accession number 6 which is linked with 41 and these accessions form linkage group with accession number 27. Similarly accession number 4 is linked with accession number 6, 41, 27, 21, 16, 1, and 19 respectively.

DISCUSSION

Plantago ovata is used as medicinal plant since ancient days. Our present study is to find out germplasm variability in different accessions of *Plantago ovata*, cultivated in experimental fields of Cholistan Institute of Desert Studies (CIDS), The Islamia University of Bahawalpur. We observed the morphological characters of *Plantago ovata* such as height of plant, number of tillers, number of ears, number of seeds and leaf width in experimental field and depicted considerable morphological variation. Every accession shows morphologically and genetically different characters than other accessions. Earlier findings also indicated that different *Plantago* species varied in amount of variation, heritability estimates and environmental stability^[8-9].

Average linkage of different groups shows that accessions of *Plantago ovata* form linkage with one another. Even the accessions which have the same origin depict large morphological variations. Different factors are responsible for these variations, some germplasms may be sensitive to available environmental conditions and others may survive well. Those survive well are our required germplasms for further propagation. Overall, the accession numbers 20555, 20671, 20666 and 20673 have shown maximum germplasm variability as compared to all other accessions selected^[10].

Plantago ovata is one of the major medicinal crops having international acceptance and industrial significance. Despite lots of effort exercised to improve the yield and quality of

Isabgol, there has been only limited success. The major bottleneck in achieving higher goals is on account of lack of genuine variability. Therefore, intensive efforts are further needed for micro-identification of variability at the molecular level. Genomics and functional genomics studies need to be undertaken to identify new genes in *P. ovata* and its wild relatives.

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