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Morphological Characterization and Diversity Analysis in Pea Germplasm

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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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ABSTRACT

An experiment was conducted to identify the diverse morphological breeding lines. A total of Fifty-two germplasm lines were characterized morphologically as per DUS guidelines, and Shannon's diversity indices (mean value=0.612) were estimated using Microsoft Excel. The results revealed that maximum variability and diversity were present in foliage color, pod intensity of green color, seed cotyledon color and plant height. Minimum variability was reported for stem anthocyanin colouration, seed testa mottling, leaf axial color and flower standard petal color. The traits of foliage waxy bloom and stipule type were present in all the genotypes. Stem anthocyanin coloration, seed testa mottling, flower standard petal color, and leaf axial color were unique traits and were reported in only a few of the genotypes. It may be concluded that these traits would be considered diverse morphological traits during the selection of lines in segregating generations for the development of pea lines /Variety.

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Keywords: Morphological characterization; pea; DUS guideline; shannon's diversity indices; segregating generations.

1. INTRODUCTION

The pea (*Pisum sativum*) is widely grown worldwide and is the second most consumed legume after chickpea. This crop belongs to the family *Fabaceae*, sub-family *Papillionaceae*, and tribe *Vicieae*, which comprises two species, *Pisum fulvum* Sibth and *Pisum sativum* L [1]. The Genetic composition of pea is about 4800 Mbp spread across 2n=2x=14 chromosomes. Peas are an important legume crop in India, after chickpeas and pigeon peas. The two types of peas are generally cultivated, i.e., one is the field pea (*Pisum sativum* (L.) var*. arvense*), and the other is garden pea (*Pisum sativum* (L.) var *hortens*). Garden pea is generally used for table purposes and is harvested in green pod conditions. In India, the major field pea-producing states are Uttar Pradesh, Madhya Pradesh, Bihar, Assam, and Orissa, contributing about 95% of the pea's total area and yield.

The morphological characteristics of plants are a result of the intricate interplay between environment and genetics, including regulatory and structural genes. The variants of these genes reveal their unique genetic regulations, and any change in phenotypic characteristics is a sign of genetic expression [2]. The morphological description has proven to be a valuable tool in plant germplasm identification and classification, breeding material selection, and genetic diversity identification [3, 4, 5 and 6]. The present study, therefore, aims to assess the level of morphological diversity within this collection of pea lines, with the ultimate goal of aiding in the selection and more efficient utilization of this germplasm in breeding programs.

2. MATERIALS AND METHODS

Experimental material consisting of fifty-two pea genotypes was received from Field Pea Improvement Project, Department of Plant Breeding and Genetics, College of Agriculture, JNKVV, Jabalpur, and All India Co-ordinated Research Project (AICRP) on MULLaRP (Mungbean, Urdbean, Lentil, Lathyrus, Rajma and Fieldpea), IIPR (Indian Institute of Pules Research) Kanpur. The material was grown in a complete randomized block design with three replications in *Rabi* season 2020. Each entry was sown at 30 cm and 10 cm between rows and plants, respectively, with two rows of 2 m length. These lines were characterized as per National Test Guidelines for the Distinctness, Uniformity and Stability (DUS) test of Pea (Table 1), given by protection of plant varieties and farmer's rights (PPVFR) Authority, Government of India, New Delhi. The Phenotypic frequencies calculated were further used to estimate Shannon's Diversity Index (H) to assess the present diversity [2]. $H= -\sum [pi \times \log pi]$ Where, pi is the portion of the total number of entries belonging to the i^{th} class.

3. RESULTS AND DISCUSSION

3.1 Morphological Characterization

In the investigation, significant variation was observed in coloration, seed, plant, pod, and stipule, which are important traits for identifying, characterization, and grouping genotypes (Table 2). All fifty-two genotypes have foliage waxy bloom and normal stipule types, and there was no variation recorded for these traits. Stem anthocyanin coloration was present only in the B-22 genotype. Purple leaf axial color was present only in four genotypes viz., DDR 54, JP 885, B22 and Gol Batra tedua, rest of the genotype has green leaf axial color. The flower's standard petal color was also purple in these four genotypes. The remaining genotypes have white standard petal color. Seed testa mottling is present only in 2 genotypes, B22 and DDR54. The purple color of the pea can also be attributed to the accumulation of anthocyanins, whereas the white pea flowers lack these pigments [7, 8, and 9]. Variation was found higher for foliage color i.e., light green in 11 genotypes, green in 20 genotypes and dark green in 21 genotypes. This finding was in consonance with the findings of [7, 10]. Pod intensity of green color was found to be light green, green, and dark green in 16, 25, and 11 genotypes, respectively. Similarly, the high variation found in flower opening (days) were two extra early (Safed Batra Gudda and Gol Batra Tendua), 13 early, 35 medium, and two late lines. A similar finding was reported by [11,12].

Pod curvature was absent in 22 genotypes, while 27 had weak and three genotypes had medium pod curvature. The plant height of 27 germplasm lines falls in long, 17 have medium while eight lines have short plant height category. The weight of 1000 seeds also showed a high degree of variation in genotypes 28 have medium seed size, 17 large seed size while seven lines

Table 1. Essential characters along with descriptor

S. No.	Characteristics	Strategies				
1.	Stem anthocyanin coloration	Absent (1)		Present (9)		
2.	Foliage colour	Light Green (3)	Green (5)	Dark Green (7)		
3.	Foliage waxy bloom	Absent (1)	Present (9)			
4.	Leaflets	Absent (1)	Present (9)			
5.	Leaf axil colour	Green (1)	Purple (2)			
6.	Stipule rabbit eared	Absent (1)	Present (9)			
7	Stipule type	Normal (1)	Vestigial (9)			
8.	Flower opening (days)	Extra early (1)	Early (2)	Medium (3)	Late (4)	
9	Flower standard petal colour	White (1)	Blue (2)	Pink (3)	Red (4)	Purple (5)
10.	Number of pod/axils	Single (1)	Double (2)	Multiple (3)		
11.	Pod curvature	Absent (1)	Weak (3)	Medium (5)	Strong (7)	
12.	Pod shape of distal part	Pointed (1)	Blunt (9)			
13.	Pod intensity of green colour	Light Green (3)	Green (5)	Dark Green (7)		
14.	Plant height	Short (3)	Medium (5)	Long (7)		
15.	Seed shape	Spherical (1)	Cylindrical (2)	Dimpled (3)		
16.	Seed surface	Smooth (1)	Wrinkled (2)			
17.	Seed cotyledon colour	Cream (3)	Green (5)	Yellow (7)		
18.	Weight of 1000 seeds	Small (3)	Medium (5)	Large (7)		
19.	Seed Testa mottling	Absent (1)	Present (9)			

Table 2. Characterization of field pea genotypes according to DUS guidelines

Germplasm	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
DDR 52	1	7	9	1	1	1	1	2	1	2	3	9	5	5	1	1	3	7	1
P 3	1	5	9	1	1	1	1	3	1	2	1	9	7	5	1	1	7	7	1
FP 14-56	1	7	9	9	1	9	1	3	1	2	1	9	3	7	1	1	5	5	1
HFP 94-13	1	5	9	1	1	1	1	3	1	2	3	9	5	5	1	1	7	5	1
FP 14-46	1	7	9	9	1	9	1	3	1	2	1	9	3	5	3	2	3	5	1
KPMR 30	1	5	9	9	1	1	1	3	1	2	1	9	5	7	1	1	7	3	1
FP 9-539	1	5	9	1	1	1	1	3	1	2	3	9	5	5	1	1	3	3	1
PP 155	1	7	9	9	1	9	1	3	1	2	1	9	7	7	1	2	3	3	1
DDR 54	1	3	9	9	2	9	1	2	5	1	3	9	5	7	1	1	3	7	9
JP 885	1	7	9	9	2	1	1	2	5	2	1	9	3	3	3	2	5	5	1
HVP 2	1	5	9	1	1	9	1	3	1	2	3	9	5	7	2	1	7	5	1
IPF 99-25	1	7	9	9	1	1	1	3	1	2	1	9	7	7	1	1	7	5	1
FP 1482	1	7	9	9	1	1	1	3	1	2	3	9	3	5	2	2	3	5	1
RP 3	1	3	9	9	1	9	1	3	1	1	1	9	7	5	1	1	5	3	1
KPMR 402	1	3	9	9	1	1	1	3	1	2	1	9	5	7	1	1	3	5	1
FP 14-27	1	3	9	1	1	1	1	3	1	2	1	9	3	7	1	1	7	5	1
FP 14-21	1	3	9	1	1	9	1	3	1	2	1	9	3	7	1	1	7	7	1
KPMR 402	1	3	9	9	1	1	1	3	1	2	1	9	5	3	1	1	3	5	1
DDR 55	1	7	9	9	1	1	1	3	1	2	1	9	7	7	2	2	7	5	1
KPMR 327	1	5	9	9	1	1	1	3	1	2	3	9	5	5	1	1	3	5	1
NDVP 4	1	3	9	9	1	1	1	3	1	2	1	9	7	5	1	1	7	5	1
KPMR 502	1	5	9	9	1	9	1	3	1	2	1	9	5	5	1	1	7	5	1
VL 3	1	3	9	9	1	9	1	3	1	2	3	9	3	7	2	2	3	3	1
FP 14-13	1	7	9	9	1	1	1	3	1	2	3	9	3	7	1	1	7	5	1
Jayanti	1	5	9	9	1	1	1	3	1	2	1	9	5	7	1	1	7	5	1
B 22	9	3	9	9	2	1	1	2	5	2	1	9	5	7	3	1	3	3	9
Rachna	1	5	9	1	1	9	1	3	1	2	5	1	3	3	1	1	7	5	1
FP 75-96	1	7	9	9	1	9	1	2	1	2	3	9	7	5	1	1	7	5	1
Choti Safed (Anju)	1	5	9	1	1	1	1	3	1	2	3	9	5	7	1	1	3	7	1
FP 18-30	1	5	9	9	1	1	1	3	1	2	3	9	3	7	1	1	7	7	1
FP 14-8	1	3	9	1	1	1	1	3	1	2	3	9	5	5	1	1	3	7	1
Matar Rangpur	1	5	9	1	1	1	1	3	1	2	3	1	7	7	1	1	3	5	1

Germplasm	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
FP 94-12	1	7	9	9	1	9	1	4	1	2	3	9	5	7	1	1	7	5	1	1
JP 180	1	7	9	9	1	9	1	2	1	2	1	9	5	7	3	2	5	3	1	1
FP14-33	1	7	9	9	1	9	1	4	1	1	3	9	5	7	1	1	7	7	1	1
VRP 5	1	3	9	9	1	9	1	3	1	2	5	1	3	3	3	2	5	7	1	1
PSM 3	1	7	9	9	1	9	1	3	1	1	3	1	5	3	3	2	5	5	1	1
Safed Batara Gudda	1	5	9	9	1	1	1	1	1	1	1	9	3	7	1	1	3	7	1	9
FP 7562	1	5	9	9	1	1	1	2	1	1	3	9	3	3	3	1	3	7	1	1
FP 1330	1	5	9	1	1	1	1	3	1	2	3	9	5	5	2	1	3	5	1	9
Gol Batra Teduaa	1	5	9	9	2	1	1	1	5	1	3	9	3	7	1	1	7	7	1	9
GS 10	1	7	9	9	1	9	1	2	1	1	3	1	7	3	3	2	5	5	1	1
Aman	1	5	9	9	1	1	1	3	1	2	1	9	7	7	1	1	7	7	1	1
FP 14 86	1	7	9	1	1	9	1	3	1	1	3	9	5	7	3	1	3	5	1	9
Arka Sampurna	1	7	9	9	1	9	1	2	1	2	3	1	5	5	1	1	7	7	1	9
Arkel	1	5	9	9	1	1	1	2	1	2	5	1	5	3	3	2	5	7	1	1
FP 14-17	1	7	9	9	1	9	1	3	1	2	3	1	5	7	1	1	7	5	1	1
JM 6	1	5	9	9	1	1	1	2	1	2	1	9	3	7	1	1	3	5	1	1
DDR 27	1	7	9	9	1	9	1	2	1	2	3	9	3	5	1	1	3	7	1	1
KPMR 585	1	5	9	9	1	1	1	3	1	2	3	9	7	7	1	1	7	7	1	1
FP 14-15	1	7	9	9	1	9	1	2	1	1	1	9	5	5	1	1	3	5	1	1
Pusa Pragati	1	7	9	9	1	1	1	3	1	2	3	1	5	5	3	2	5	5	1	1

Whereas, *1***=** *Stem anthocyanin coloration, 2=Foliage colour, 3=Foliage waxy bloom, 4=Leaflets, 5=Leaf axial colour, 6=Stipule rabbit eared, 7=Stipule type, 8=Flower opening (days), 9=Flower standard petal colour, 10=Number of pods per axil, 11=Pod curvature, 12=Pod shape of distal part, 13=Pod intensity of green colour, 14=Plant height, 15=Seed shape, 16=Seed surface, 17=Seed cotyledon colour, 18=Weight of 1000 seeds, 19=Seed testa mottling*

showed small seed size. Investigated pea lines show three types of seed shapes: spherical in 36 genotypes, cylindrical in 5 lines, and dimpled in 11 pea lines. Similarly, seed cotyledon color was also categorized as creamy in 21 lines, green in 9, and yellow in 22 genotypes. These findings were in agreement with [7,10,11,13].

Pictures of different morphological characteristics of different pea genotypes

Flower Standard Petal Colour

Purple

White

Leaf Axil Colour

Present

Absent

Leaf Leaflets

Absent

Present

Pod Curvature

Absent

Weak

Medium

Strong

Pod: Shape of Distal Part

Pointed

Blunt

Stem Anthocyanin Colouration

Seed Shape

Spherical **Dimpled** **Cylindrical**

Seed: Surface

Smooth **Wrinkled**

3.2 Shannon's Diversity Indices

The shannon's diversity indices estimated for 20 morphological traits (Table 3) ranged from 0 to 1.062 with a mean value of 0.612. The highest value of diversity index 1.062 was obtained for foliage color whereas, the lowest value of diversity index of 0 were obtained for foliage waxy bloom and stipule type as genotypes exhibited no variability for these traits. The values of indices unveiled the presence of high diversity in the morphological characters studied, particularly for the foliage color followed by pod intensity of green color, seed cotyledon color and plant height [13-16].

Table 3. Frequency distribution of morphological traits

Trait	Classes	Number of Genotypes	Percentage (%)	Shannon Weaver Diversity Index (H)
Stem anthocyanin coloration	Present	1	1.92	0.095
	Absent	51	98.08	
Foliage colour	Light green	11	21.15	1.062
	Green	20	38.46	
	Dark green	21	40.38	
Foliage waxy bloom	Present	52	100	0.000
	Absent	0	0.00	
Leaflets	Present	39	75.00	0.561
	Absent	13	25.00	
Leaf axial colour	Green	48	92.40	0.271
	Purple	4	7.60	
Stipule rabbit eared	Present	22	42.31	0.681
	Absent	30	57.69	
Stipule type	Normal	52	100.00	0.000
	Vestigial	0	0.00	
Flower opening (days)	Extra early	2	3.85	0.864
	Early	13	25.00	
	Medium	35	67.30	
	Late	2	3.85	
Flower standard petal colour	White	48	92.30	0.271
	Purple	4	7.69	
Number of pods per axil	Single	10	19.23	0.490
	Double	42	80.77	
Pod curvature	Absent	22	42.31	0.869
	Weak	27	51.92	
	Medium	3	5.76	
Pod shape of distal part	Pointed	9	17.30	0.461
	Blunt	43	82.70	
Pod intensity of green colour	Light green	16	30.76	1.043
	Green	25	48.07	
	Dark green	11	21.15	
Plant height	Short	8	15.38	0.994
	Medium	17	32.69	
	Long	27	51.92	
Seed shape	Spherical	36	69.23	0.808
	Cylindrical	5	9.61	
	Dimpled	11	21.15	
Seed surface	Smooth	40	76.92	0.540
	Wrinkled	12	23.07	
Seed cotyledon colour	Creamy	21	40.38	1.034
	Green	9	17.31	
	Yellow	22	42.31	
Weight of 1000 seeds	Small	7	13.46	0.969
	Medium	28	53.84	
	Large	17	32.69	
Seed testa mottling	Present	2	3.84	0.163
	Absent	50	96.15	

4. CONCLUSION

Based on this study, a high amount of diversity is present in the germplasm for traits such as foliage color, pod intensity of green color, seed cotyledon color, plant height and weight of 1000 seeds. Foliage color (dark green) for high photosynthetic ability and semi leaflets type for

standing plant suture. Foliage waxy bloom can be selected for drought resistance [12]. Some unique traits were reported only in a few of the genotypes, i.e. stem anthocyanin coloration, leaf axial coloration, flower standard petal color, and seed testa mottling. These unique traits must be selected in field pea breeding programmes for the development of specific varieties with distinct identification and as indicators to determine an unstable expression of the phenotype of the candidate variety. The results may offer scope for pea breeding programs aimed to generate new and improved cultivars with specific genetic identities.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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