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Assessment of morphological characterization and genetic variability of garden pea (*Pisum sativum* var. *hortense*) genotypes

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Abstract

An experiment was conducted to evaluate the extent of morphological diversity, genetic variability and heritability among genotypes of garden pea (*Pisum sativum* L. var. *hortense*). Twenty-five genotypes of garden peas were subjected to analysis with respect to their morphological attributes, which were quantified using thirteen DUS (Distinctness, Uniformity and Stability) descriptors defined by the Protection of Plant Variety and Farmers' Rights Authority. The genotypes showed significant variation in the majority of traits, especially in the attributes of the seeds, pods, foliage colour and flowering period. High variability was found among the genotypes with regard to all the characters studied, implying that sufficient genetic variability is available for effective breeding program. Remarkable observations included the afila leaf type and late flowering in NDVP-250 spherical seed shape in NDVP-23-24, KS-159 and KS-609 which distinguish them from the rest of the collection. In the present study, PCV were found higher than GCV for all the characters considered, showing that the effect of environmental factors was significant on the expression of traits. High values of GCV and PCV were observed for characters viz., Reducing sugar (32.12 and 32.16) and Plant height (20.51 and 21.51) and which indicates the presence of high genetic variation. Thus, the results revealed the role of environmental factors in limiting the expression of most of the traits. Significant phenotypic variation that can be used for upcoming breeding, selection, and variety registration is highlighted by the data. The study highlights how useful DUS descriptors are for efficiently recording genetic variation and assisting with crop improvement initiatives. The genotypes with specific characters can be utilized for hybridization programme.

Keywords: Garden pea, genetic variability, GCV, PCV, DUS, PPV&FRA

Introduction

Garden pea (*Pisum sativum* var. *hortense* L.), belonging to the family Fabaceae, is one of the most important leguminous vegetable crops cultivated worldwide due to its high nutritional and economic value. 100 grams of peas contain 7.2% protein, 14.45 grams of carbohydrates, 5.1 grams of dietary fiber, 65 µg of folic acid, 24.8 µg of vitamin K, 38 mg of vitamin A and 5.67 grams of sugar (USDA, 2023) [23]. Owing to its nutritional richness, garden pea plays a vital role in ensuring food and nutritional security, particularly in vegetarian diets. In addition, as a leguminous crop, it contributes to sustainable agriculture through its ability to fix atmospheric nitrogen and improve soil fertility. In India, peas occupy about 0.611 million hectares, yielding approximately 6.67 million tonnes. Uttar Pradesh leads both in cultivation area (0.246 million hectares) and production (3.26 million tonnes) (MoA&FW, 2024). It is also a major vegetable crop in the north-western The first step of characterizing and evaluating genetic material is an important part of crop improvement programs. There are many ways of doing this with morphological characterization being the easiest, cheapest and most common form of assessing the genetic diversity of plants. Morphological traits include the genetic differences within germplasms, which can be seen from observing the differences between plants (Srilatha *et al.*, 2022) [21]. Morphological descriptors are useful not only in testing and identifying varieties through DUS testing but also in understanding genetic diversity and phylogeny within the genotypes (Asati *et al.*, 2023) [5].

Morphological characterization is a crucial step that serves as a baseline for selecting breeding materials by allowing researchers to classify desirable genotypes based on their observable characteristics.

Guidelines on Distinctiveness, Uniformity and Stability (DUS), which were established by the Protection of Plant Varieties and Farmers' Rights Authority (PPV & FRA), have provided standard guidelines for the assessment of plant varieties. In accordance with the guidelines, it can be confirmed that the new variety is distinct from other varieties (distinctiveness), uniform in nature with respect to the expression of the desired traits (uniformity) and has remained stable during the subsequent generations in diverse environmental conditions (stability). There, must be a thorough knowledge of the existence of genetic variability, the mode of inheritance of economic characters, heritability, the kind of gene action and the relative magnitude of additive, dominance and total genotypic and phenotypic variance of the population. Considering the availability of genetic variability, there is scope of yield and quality improvement and there by develop export potential of garden peas. The current study aimed to characterize various genotypes of garden peas based on DUS descriptors in order to evaluate the magnitude of morphological variation as well as GCV and PCV of various economic traits and to measure the extent of variability and their genetic makeup in garden peas future breeding and varietal development programmes.

Materials and Methods

The present investigation was conducted during the *Rabi* season of 2024-25 at the Main Experimental Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj Ayodhya (UP). The study aimed to assess the morphological variability among 25 garden pea (*Pisum sativum* var. *hortense* L.) genotypes. The experimental material consisted of 24 diverse genotypes along with one check variety Kashi Purvi. The experiment was laid out in a Complete Randomized Block Design (CRBD) with three replications to reduce environmental effects and ensure reliable statistical analysis. Each genotype was planted at a spacing of 30 cm between rows and 10 cm between plants to provide suitable growing conditions and uniform evaluation.

Morphological characterization (DUS guidelines)

Thirteen morphological characters were evaluated for the genotypes based on the Distinctness, Uniformity and Stability (DUS) criteria recommended by the Protection of Plant Variety and Farmer's Right Authority (PPV&FRA). The observations of various characters were accurately made by visual inspection during appropriate growth periods to ensure accurate evaluation of the genotypes (Table 1). Such an exhaustive analysis provided valuable data on the morphological variation of the genotypes that is essential for future breeding programs, varietal identification and registration.

Analysis of variance

The analysis of variance was carried out for each character in accordance with design of experiment (CRBD) was carried out according to the procedure outlined by Panse and Sukhatme (2000) [17]. All Statistical analysis were done by using R software.

Estimation of coefficient of variation

The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were computed following Burton and de Vane (1953) [7].

$$GCV = \frac{\text{Genotypic standard deviation}}{\text{Mean } \bar{x}} \times 100$$

$$GCV = \frac{\sqrt{\sigma^2_g}}{\bar{x}} \times 100$$

$$PCV = \frac{\text{Phenotypic standard deviation}}{\text{Mean } \bar{x}} \times 100$$

$$PCV = \frac{\sqrt{\sigma^2_p}}{\bar{x}} \times 100$$

Results and Discussion

In this comprehensive study, 25 garden pea genotypes were evaluated for thirteen important morphological attributes, viz., foliage color, leaf leaflets, Stipule, flower opening, pod number per axil, pod curvature, pod shape of distal part, pod intensity of green color, Plant height, seed shape, seed surface, seed cotyledon color and seed weight revealing significant variation among the genotypes for most traits (Table 3 and 4).

The foliage colour varied from light to dark green. Among the 30 genotypes, 8 were observed as light green viz., NDVP-23-2, NDVP-23-7, NDVP-23-20, NDVP-24-20, KS-287, KS-609, KS-660 and Kashi Mukti. Green foliage colour was observed for 8 genotypes which included NDVP-23-12, NDVP-24-17, NDVP-250, AP-3, KS-103, KS-502, KS-684 and Kashi Purvi while NDVP-23-16 and NDVP-23-24, NDVP-24-18, NDVP-24-19, KS-110, KS-111, KS-159, Kashi Samarth, Kashi Ageti exhibited dark green foliage colour. Leaflets were present in all genotypes except for NDVP-250 which exhibited a leafless type. The leafless pea has increased standing ability due to its greater number of tendrils, it has reduced risk of lodging and the crop can be harvested more easily (Hedley & Ambrose 1981).

Rabbit eared stipule were present in NDVP-24-18, AP-3, KS-287, KS-660, Kashi Mukti and Kashi Purvi, while remaining genotypes stipule were absent. Flower opening days showed considerable variation among the evaluated genotypes indicating diverse maturity durations, Early flowering opening (40-50 days) was recorded for Kashi Purvi and Kashi Ageti. Medium flowering opening (50-70 days) was recorded for 22 genotypes and NDVP-250 was late flowering (>70 days). Early flowering genotypes are beneficial in short-season environments or for early market demands, while late flowering genotypes may be more suitable for extended growing seasons.

Pod number per axil was single recorded for 5 genotypes viz., NDVP-23-7, KS-110, KS-111, Kashi Ageti and Kashi Mukti, while the remaining 20 genotypes had double pod per axil.

Pod curvature was absent for 6 genotypes which included NDVP-23-2, NDVP-23-7, NDVP-24-17, NDVP-24-18, NDVP-24-20 and Kashi Samarth whereas weak curvature for 7 genotypes, 10 genotypes exhibited medium pod curvature and remaining 2 genotypes, NDVP-23-12 and NDVP-23-20 showed strong curvature. The shape of the distal part of the pods was recorded as blunt for 9 genotypes while pointed shape was recorded for 16 genotypes.

Pod intensity of green colour varied from light green to dark green. Among the genotypes studied, NDVP-23-7, NDVP-24-20, KS-159, KS-609, and Kashi Samarth exhibited light green colour, whereas 17 genotypes viz., NDVP-23-2, NDVP-23-12, NDVP-23-16, NDVP-23-20, NDVP-23-24, NDVP-24-17, NDVP-24-18, AP-3, KS-103, KS-110, KS-111, KS-287, KS-660, KS-684 Kashi Ageti, Kashi Mukti and Kashi Purvi were green and genotypes NDVP-24-19, NDVP-250 and KS-502 showed dark green pod colour. The plant height were recorded as small for 3 genotypes i.e. NDVP-23-20, NDVP-23-24 and KS-110, whereas 18 genotypes were medium height and genotypes NDVP-23-7, NDVP-24-20, KS-502 and KS-684 were showed long plant

height.

Seed morphology including seed shape, seed surface seed, cotyledon colour and seed weight are important traits for both varietal characterization and market preference. The seed shape and surface was spherical and smooth for NDVP-23-24, KS-159 and KS-609 while all the remaining genotypes were dimpled and wrinkled. Wrinkled seeds are typically associated with higher sugar content and are favoured for fresh consumption, while smooth seeds are generally richer in starch and better suited for dry seed storage and processing. With respect to the seed cotyledon colour, NDVP-23-20, NDVP-23-24, KS-159 and KS-609 showed creamy colour while remaining genotypes exhibited green cotyledon colour. Seed weight were recorded as medium for 14 genotypes i.e. NDVP-23-12, NDVP-23-16, NDVP-24-17, NDVP-24-18, NDVP-24-19, NDVP-250, AP-3, KS-110, KS-159, KS-502, Kashi Samarth, Kashi Ageti, Kashi Mukti and Kashi Purvi while 11 genotypes were recorded for large seed weight viz., NDVP-23-2, NDVP-23-7, NDVP-23-20, NDVP-24, NDVP-24-20, KS-103, KS-111, KS-287, KS-609, KS-660 and KS-684.

These results clearly showed marked phenotypic variation in the genotypes under study for certain crucial morphological traits, thus confirming their importance in breeding better garden pea varieties. The presence of marked phenotypic variations can serve as a strong genetic resource that can facilitate the development of better garden pea varieties having desirable characteristics suitable for various agroclimatic zones and consumers' needs. These results in favor of using DUS-based morphological characters for differentiation of pea genotypes were also documented by Dixit *et al.* (2010) [8], Singh *et al.* (2014) [30], Ardhani *et al.* (2019) [4], Kalapchieva *et al.* (2020) [12] and Rosero-Lombana and Checa-Coral (2021) [18], Srilatha *et al.* (2022) [21], Yumkhaibam *et al.* (2023) [25], Bishnoi *et al.* (2023) [6], Anand *et al.* (2024) [2], and Warriar *et al.* (2025) [24], which further validate the present results also highlighted the importance of DUS-based morphological descriptors in distinguishing garden pea genotypes, thereby supporting the relevance of the current findings.

Mean performance of genotypes

The mean performance, general means and range of 25 entries for fourteen characters had been given in Table 4.3. The days to 50% flowering ranged from 42.33 to 64.00 days with a mean of 55.84 days. The genotype Kashi Purvi showed early flowering (42.33 days) followed by Kashi Ageti (43.33 days) and while the genotype NDVP-250 showed late in flowering (64.00 days) followed by NDVP-23-24 (62.33 days) and NDVP-23-20 (61.00 days).

The mean plant height among all genotypes was 70.10 cm, with a range of 54.80 cm to 113.27 cm. Maximum plant height was recorded for the genotype KS-660 (113.27 cm) followed by NDVP-23-7 (101.47 cm) and NDVP-24-20 (98.83 cm) whereas minimum plant height was noted for the genotype KS-110 (54.80 cm) followed by NDVP-23-20 (56.33 cm) and NDVP-24-19 (60.00 cm). The mean number primary of branches per plant was 3.25, with a range of 2.93 to 4.33. The genotype with maximum number of branches per plant was NDVP-24-18 (4.33 primary branches) followed by KS-502 (4.00 Primary branches) and NDVP-23-20 (3.50 primary branches) while minimum was recorded for KS-609 (2.93 branches) followed by AP-3 (2.97 Primary branches) and NDVP-24-19, Kashi Mukti and KS-159 (3.00 primary branches).

The pod length ranged from 5.84 to 10.13 cm with a mean of 8.30 cm. The maximum length of pod was observed in NDVP-24-18 (10.13 cm) followed by KS-103 (9.65 cm) and Kashi Ageti (9.55

cm). Minimum pod length was recorded for NDVP-250 (5.84 cm) followed by NDVP-24-20 (6.13 cm) and NDVP-24-19 (6.45 cm). The number of pods per plant ranged from 8.73 to 13.43 pods with a mean of 10.82 pods. The highest number of pods were recorded for the genotypes Kashi Ageti (13.43 pods) followed by NDVP-24-18 (13.07 pods) and Kashi Purvi (12.50 pods) while minimum pods were recorded for AP-3 (8.73 pods) followed by NDVP-24-20 (8.83 pods) and Kashi Mukti (8.90 pods). The average pod weight of genotypes ranged from 2.45 g to 4.55 g with a mean of 3.50 g. Maximum pod weight was recorded for KS-110 (4.55 g) followed by KS-609 (4.54 g) and NDVP-23-16 (4.53 g) while minimum pod weight was recorded for KS-159 (2.45 g) followed by KS-287 (2.46 g) and NDVP-250 (2.47 g). The number of seeds per pod ranged from 6.37 to 9.20 seeds with a mean of 7.63 seeds per pod. Highest number of seeds was recorded for NDVP-23-20 (9.20 seeds) followed by NDVP-24-18 and KS-111 (9.10 seeds) whereas lowest number of seeds was recorded for NDVP-250 (6.37 seeds) followed by NDVP-23-2 and Kashi Mukti (6.40 seeds). The 100 seed weight mean was 19.74 and ranged from 16.43 to 23.85. Highest 100 seed weight was recorded for NDVP-23-24 (23.85 g) followed by NDVP-24-18 (22.52 g) then KS-502 and KS-684 (22.35 g) whereas lowest 100 seed weight was recorded for Kashi Mukti (16.43 g) followed by KS-159 (17.32 g) and NDVP-24-20 (17.73 g).

The total sugars content varied from 6.08 to 11.57% with a mean of 8.48%. The highest total sugars content was recorded in KS-111 (11.57%) followed by KS-287 (10.59%) and KS-609 (10.28%) while lowest was recorded in NDVP-24-18 (6.08%) followed by NDVP-23-2 (6.58%) and NDVP-24-19 (6.78%). The reducing sugar content in genotypes ranged from 1.16 to 4.32% with a mean of 2.65%. Maximum amount of reducing sugar was recorded for KS-287 (4.32%) followed by KS-111 (4.23%) and KS-609 (3.85%) whereas minimum was recorded for NDVP-23-2 (1.16%) followed by NDVP-24-18 (1.64%) and AP-3 (1.65%). The non-reducing content ranged from 4.44 to 7.34% with a mean of 5.83%. Highest amount of non-reducing sugar was recorded for KS-111 (7.34%) followed by KS-660 (7.14%) and NDVP-23-24 (7.04%). Lowest amount was reported for NDVP-24-18 (4.44%) followed by NDVP-23-12 (4.64%) and NDVP-24-19 (4.93%). The total soluble solids had a mean value of 10.17°B and varied from 8.35 to 13.47°B. Highest TSS was recorded for NDVP-23-7 (13.47°B) followed by KS-111 (13.17°B) and KS-502 (12.53°B) while lowest TSS was observed for KS-609 (8.35°B) followed by NDVP-250 (8.65°B) and NDVP-23-2 (8.86°B).

The pod yield per plant ranges from 26.61 g to 51.38 g with mean value was 37.51 g.

Maximum pod yield per plant was recorded for KS-111 (51.38 g) followed by NDVP-23-7 (49.32 g) and Kashi Purvi (49.06 g) whereas minimum pod yield per plant was recorded for KS-159 (26.61 g) followed by KS-287 (28.64 g) and AP-3 (28.75 g). The pod yield per hectare range from 85.91 to 128.07 q/ha with a mean value of 105.64 q/ha. Maximum pod yield per hectare was recorded for NDVP-24-18 (128.07 q) followed by KS-502 (127.20 q) and KS-111 (121.92 q) while minimum yield was recorded for KS-287 (85.91 q/ha) followed by AP-3 (86.24 q/ha) and NDVP-24-19 (88.53 q/ha).

The difference in genotypes due to their genetic make-up had already been observed and reported by Kumar and Kohali (2001) [26], Amjad and Anjum (2002) [27], Ankur *et al.* (2006) [28], Bhushan *et al.* (2013) [29], Sharma *et al.* (2013) [30], Mukherjee *et al.* (2013) [31], Khan *et al.* (2013) [32], Phom *et al.* (2014) [33], Anitha and Hanumantharaya (2022) [3], Neupane *et al.* (2023) [16]. Identifying key traits that exhibit consistent patterns across genotypes is valuable information for garden pea breeding

programs. It helps breeders focus their efforts on improving these specific traits to enhance overall crop performance and quality. The continuity of findings across studies contributes to the cumulative body of scientific knowledge on garden peas. This shared knowledge can benefit researchers, agronomists, and farmers working with garden peas by providing a foundation for informed decision-making and crop improvement strategies.

Anova

The mean sum of squares derived from the analysis of variance for 14 traits across 26 okra genotypes are presented in Table 5. The results revealed that the genotypic mean squares were highly significant ($p < 0.01$) for all traits. The presence of significant variation among genotypes for these traits indicates ample genetic diversity, which can be effectively exploited in breeding programs.

Coefficient of variation

The phenotypic coefficient of variation was observed lowest in days of 50% flowering (9.07%) while it was highest in reducing sugar (32.16%), followed by plant height (21.51%), average pod weight (20.92%), pod yield per plant (20.02%) and Moderate estimate of PCV was observed in total sugars (16.10%), pod length (15.97%), non-reducing sugar (14.46%) TSS (14.00%), number of pod per plant (13.56%), total pod yield (12.69%),

number of seed per plant (12.51%), primary branches per plant (10.75%), 100 seed weight (10.55%).

Genotypic coefficient of variation was recorded minimum in 100 seed weight (8.50%) followed by followed primary branches per plant (8.96%), days of 50% flowering (9.07%) whereas it was maximum in reducing sugar (32.12%), by plant height (20.51%), moderate estimate of GCV was recorded in average pod weight (19.55%), pod yield per plant (18.84%), total sugars (16.06%), non-reducing sugar (14.46%), TSS (13.93%), pod length (13.52%), number of pod per plant (11.53%), total pod yield (11.29%), number of pod per plant (11.53%). The findings at both phenotypic and genotypic coefficient (Table 6) levels provided valuable insights into the relative importance of different traits.

Similar patterns of PCV exceeding GCV in pea have been documented by Katoch *et al.* (2016) [13], Gudadinni *et al.* (2017) [9], Gupta *et al.* (2020) [10], Sharma *et al.* (2023) [19], Meena *et al.* (2025) [14]. In general, the phenotypic coefficient of variation was greater than the genotypic coefficient of variation for all the characters studied, indicating that environmental factors played a significant role in the expression of these traits. Overall, traits exhibiting moderate-to-high genetic variability particularly reducing sugar, plant height, average pod weight and pod yield per plant offer strong potential for genetic improvement through effective selection. A higher magnitude of PCV compared to GCV suggests the presence of additive gene action.

Table 1: Morphological descriptors and their stage of assessment

S. No.	Characteristics	State	Note	Stage of observation	Type of assessment
1.	Foliage: Colour	Light green Green Dark green	3 5 7	Initiation of first flower	Visual assessment by a single observation of a group of plants or parts of plants
2.	Leaf: Leaflets	Absent Present	1 9	Initiation of first flower	Visual assessment by a single observation of a group of plants or parts of plants
3.	Stipule: Rabbit eared stipule	Absent Present	1 9	Initiation of first flower	Visual assessment by a single observation of a group of plants or parts of plants
4.	Flower: Opening (days)	Extra early (<40) Early (40-50) Medium (50-70) Late (>70)	1 2 3 4	50% of the plants with at least one open flower	Visual assessment by a single observation of a group of plants or parts of plants
5.	Pod: Number/Axil	Single Double Multiple	1 2 3	Fully developed green pod	Visual assessment by observation on individual plant or parts of plants
6.	Pod: Curvature	Absent Weak Medium Strong	1 3 5 7	Fully developed green pod	Visual assessment by a single observation of a group of plants or parts of plants
7.	Pod: Shape of distal part	Pointed Blunt	1 9	Fully developed green pod	Visual assessment by observation on individual plant or parts of plants
8.	Pod: Intensity of green colour	Light green Green Dark green	3 5 7	Fully developed green pod	Visual assessment by a single observation on a group of plants or parts of plants
9.	Plant: Height	Short (<60) Medium (60-80 cm) Long (>80 cm)	3 5 7	Peak flowering	Measurement of a number of individual plants or parts of plants
10.	Seed: Shape	Spherical Cylindrical Dimpled	1 2 3	Mature seed	Visual assessment by a single observation on a group of plants or parts of plants
11.	Seed: Surface	Smooth Wrinkled	1 2	Mature seed	Visual assessment by a single observation on a group of plants or parts of plants
12.	Seed: Cotyledon colour	Creamy Green Yellow	3 5 7	Mature seed	Visual assessment by a single observation on a group of plants or parts of plants
13.	Seed: Weight of 1000 seeds	Small (<150 g) Medium (150-200 g) Large (>200 g)	3 5 7	Mature seed	Measurement by a single observation of a group of plants or parts of plants

Table 2: Morphological characterization of garden pea genotypes for thirteen characters

Genotype	Foliage colour	Leaflets	Stipule	Flower opening	Pod number per axil	Pod curvature	Pod shape of distal part	Pod intensity of green colour	Plant height	Seed shape	Seed surface	Seed cotyledon	Seed weight
NDVP-23-2	3	9	1	3	2	1	9	5	5	3	2	5	7
NDVP-23-7	3	9	1	3	1	1	9	3	7	3	2	5	7
NDVP-23-12	5	9	1	3	2	7	1	5	5	3	2	5	5
NDVP-23-16	7	9	1	3	2	3	9	5	5	3	2	5	5
NDVP-23-20	3	9	1	3	2	7	9	5	3	3	2	3	7
NDVP-23-24	7	9	1	3	2	5	1	5	3	1	1	3	7
NDVP-24-17	5	9	1	3	2	1	9	5	5	3	2	5	5
NDVP-24-18	7	9	9	3	2	1	9	5	5	3	2	5	5
NDVP-24-19	7	9	1	3	2	3	1	7	5	3	2	5	5
NDVP-24-20	3	9	1	3	2	1	9	3	7	3	2	5	7
NDVP-250	5	1	1	4	2	5	9	7	5	3	2	5	5
AP-3	5	9	9	3	2	3	1	5	5	3	2	5	5
KS-103	5	9	1	3	2	5	1	5	5	3	2	5	7
KS-110	7	9	1	3	1	5	1	5	3	3	2	5	5
KS-111	7	9	1	3	1	3	1	5	5	3	2	5	7
KS-159	7	9	1	3	2	5	1	3	5	1	1	3	5
KS-287	3	9	9	3	2	5	1	5	5	3	2	5	7
KS-502	5	9	1	3	2	5	1	7	7	3	2	5	5
KS-609	3	9	1	3	2	3	1	3	5	1	1	3	7
KS-660	3	9	9	3	2	3	9	5	7	3	2	5	7
KS-684	5	9	1	3	2	5	1	5	5	3	2	5	7
Kashi SMARTH	7	9	1	3	2	1	1	3	5	3	2	5	5
Kashi AGETI	7	9	1	2	1	5	1	5	5	3	2	5	5
Kashi MUKTI	3	9	9	3	1	3	1	5	5	3	2	5	5
Kashi PURVI (C)	5	9	9	2	2	5	1	5	5	3	2	5	5

Table 3: Morphological diversity among garden pea genotypes

S. No.	Characteristics	State	Note	No. of Genotypes	Example genotypes
1.	Foliage: Colour	Light green	3	8	NDVP-23-2, NDVP-24-20
		Green	5	8	NDVP-23-12, KS-103
		Dark green	7	9	NDVP-23-16, KS-110
2.	Leaf: Leaflets	Absent	1	1	NDVP-250
		Present	9	24	NDVP-23-2, KS-111
3.	Stipule: Rabbit eared stipule	Absent	1	6	NDVP-24-18, AP-3
		Present	9	19	NDVP-23-2, KS-159
4.	Flower: Opening (days)	Extra early (<40)	1	-	-
		Early (40-50)	2	2	Kashi Purvi, Kashi Mukti
		Medium (50-70)	3	22	NDVP-24-17, Kashi Samarth
		Late (>70)	4	1	NDVP-250
5.	Pod: Number/Axil	Single	1	5	NDVP-23-7, KS-110
		Double	2	20	NDVP-23-2, KS-287
		Multiple	3	-	
6.	Pod: Curvature	Absent	1	6	NDVP-23-2, NDVP-24-17
		Weak	3	7	AP-3, Kashi Mukti
		Medium	5	10	NDVP-23-24, NDVP-250
		Strong	7	2	NDVP-23-12, NDVP-23-20
7.	Pod: Shape of distal part	Pointed	1	16	NDVP-23-12, Kashi Purvi
		Blunt	9	9	NDVP-23-7, KS-660
8.	Pod: Intensity of green colour	Light green	3	5	NDVP-23-7, NDVP-24-20
		Green	5	17	NDVP-23-16, KS-103
		Dark green	7	3	NDVP-24-19, KS-502
9.	Plant: Height	Short (<60)	3	3	NDVP-23-20, KS-110
		Medium (60-80 cm)	5	18	NDVP-24-17, Kashi Ageti
		Long (>80 cm)	7	4	KS-502, NDVP-24-20
10.	Seed: Shape	Spherical	1	3	NDVP-23-24, KS-159
		Cylindrical	2	-	-
		Dimpled	3	22	NDVP-23-16, AP-3
11.	Seed: Surface	Smooth	1	3	NDVP-23-24, KS-159
		Wrinkled	2	22	NDVP-250, Kashi Mukti
12.	Seed: Cotyledon colour	Creamy	3	4	NDVP-23-24, KS-159
		Green	5	21	AP-3, NDVP-23-2
		Yellow	7		
13.	Seed: Weight of 1000 seeds	Small (<150 g)	3	-	-NDVP-23-16, Kashi Samarth
		Medium (150-200 g)	5	14	NDVP-23-24, KS-660
		Large (>200 g)	7	11	

Table 4: Mean performance of twenty-five genotypes for fourteen characters

S. No	Genotypes	Days of 50% flowering	Plant height (cm)	Primary branches per plant	Pod length (cm)	Number of pods per plant	Average pod weight (g)	Number of seed per pod	100 Seed weight (g)	Total sugars (%)	Reducing sugar (%)	Non-reducing sugar	TSS (°Brix)	Pod yield per plant (g)	Total pod yield (q/ha)
1	NDVP-23-2	53	67.33	3.27	6.51	9.6	3.32	6.4	18.37	6.58	1.16	5.42	8.86	30.34	93.08
2	NDVP-23-7	55.33	101.47	3.4	9.16	12.17	4.05	7.47	20.5	8.84	2.3	6.54	13.47	49.32	109.17
3	NDVP-23-12	59	66.67	3.1	6.72	9.83	2.52	6.6	18.67	6.98	2.34	4.64	9.14	32.91	98.73
4	NDVP-23-16	56	62.67	3.3	7.38	11.17	4.53	7.3	18.55	7.21	1.87	5.34	10.15	43.48	109.5
5	NDVP-23-20	61	56.33	3.5	7.41	10.27	3.61	9.2	20.33	8.96	2.13	6.83	12.33	37.69	113.06
6	NDVP-23-24	62.33	54.87	3.3	8.23	11.07	3.69	8.1	23.85	9.59	2.55	7.04	9.64	39.86	112.86
7	NDVP-24-17	53.67	60	3.17	9.47	12.03	3.23	8.37	21.38	8.07	2.33	5.74	9.33	38.89	114.07
8	NDVP-24-18	55	63.33	4.33	10.13	13.07	3.97	9.1	22.52	6.08	1.64	4.44	8.94	46.84	128.07
9	NDVP-24-19	58.67	60	3	6.45	10.47	2.72	7.2	19.25	6.78	1.85	4.93	10.14	29.51	88.53
10	NDVP-24-20	58	98.83	3.2	6.13	8.83	2.59	8.3	17.73	8.66	2.71	5.95	11.26	29.07	89.33
11	NDVP-250	64	65.47	3.1	5.84	10.43	2.47	6.37	19.3	7.58	2.53	5.05	8.65	33.13	99.38
12	AP-3	57	66.4	2.97	8.76	8.73	3.25	6.97	19.82	6.8	1.65	5.15	10.64	28.75	86.24
13	KS-103	53	67.67	3.2	9.65	11.23	3.37	7.27	20.47	8.87	3.53	5.34	10.44	37.84	113.51
14	KS-110	60.67	54.8	3.3	9.22	11.63	4.55	7.37	21.3	9.1	3.66	5.44	9.53	42.24	108.04
15	KS-111	56.33	66.7	3.13	9.15	12.3	4.17	9.1	20.24	11.57	4.23	7.34	13.17	51.38	121.92
16	KS-159	59.67	68.4	3	8.71	10.2	2.45	8.23	17.32	7.33	2.41	4.93	8.53	26.61	88.6
17	KS-287	60	67.67	3.2	8.26	9.3	2.46	7.07	18.28	10.59	4.32	6.27	9.14	28.64	85.91
18	KS-502	58	84.13	4	9.17	11.37	4.27	7.13	22.35	10.19	3.61	6.58	12.53	43.51	127.2
19	KS-609	53	65.43	2.93	8.76	9.5	4.54	7.17	18.38	10.28	3.85	6.43	8.35	43.15	106.3
20	KS-660	53	113.27	3.2	8.72	10.57	3.52	8.47	20.53	9.1	1.96	7.14	10.6	37.12	111.36
21	KS-684	59	67.4	3.03	8.2	10.2	3.29	7.23	18.38	8.89	2.14	6.75	9.95	32.22	100.45
22	Kashi Samarth	54.67	76.67	3.17	8.71	11.67	3.1	8.27	18.57	7.87	2.46	5.41	9.12	36.06	111.85
23	Kashi Ageti	43.33	63	3.17	9.55	13.43	4.33	7.5	18.67	8.64	3.37	5.28	9.67	38.23	112.89
24	Kashi Mukti	50	61	3	8.11	8.9	3.58	6.4	16.43	8.84	2.33	6.51	10.32	31.85	95.56
25	Kashi Purvi (C)	42.33	73	3.3	9.04	12.5	3.94	8.2	22.35	8.61	3.27	5.34	10.33	49.06	115.5
	Mean	55.84	70.1	3.25	8.3	10.82	3.5	7.63	19.74	8.48	2.65	5.83	10.17	37.51	105.64
	Min	42.33	54.8	2.93	5.84	8.73	2.45	6.37	16.43	6.08	1.16	4.44	8.35	26.61	85.91
	Max	64	113.27	4.33	10.13	13.43	4.55	9.2	23.85	11.57	4.32	7.34	13.47	51.38	128.07
	SE(d)±	1.47	3.72	0.16	0.58	0.63	0.21	0.43	1.01	0.07	0.04	0.07	0.12	2.08	5
	C.D. at 5%	2.97	7.5	0.32	1.16	1.27	0.43	0.87	2.03	0.15	0.07	0.15	0.24	4.2	10.08
	C.V. (%)	3.23	6.5	5.95	8.49	7.13	7.45	6.93	6.25	1.06	1.67	1.54	1.44	6.79	5.8

Table 5: Analysis of variance for fourteen character in garden pea

Source of variation	d.f.	Days of 50% flowering	Plant height (cm)	Number of primary branches per plant	Pod length (cm)	Number of pod per plant	Average pod weight (g)	Number of seed per pod	100 Seed weight (g)	Total sugars (%)	Reducing sugar (%)	Non-reducing sugar	TSS (°Brix)	Pod yield per plant (g)	Total pod yield per (q/ha)
Rep.	2	9.16	17.49	0.004	1.21	0.02	0.14	0.93	5.54	0.029	0.001	0.025	0.005	34.20	205.32
Treat	24	80.23**	640.65**	0.292**	4.27**	5.27**	1.47**	2.17**	9.97**	5.575**	2.171**	2.119**	6.039**	156.23**	464.56**
Error	48	3.26	20.74	0.037	0.50	0.59	0.07	0.28	1.52	0.008	0.002	0.008	0.021	6.49	37.48
Total	74	28.38	221.70	0.119	1.74	2.09	0.53	0.91	4.37	1.814	0.705	0.693	1.973	55.80	180.53

Table 6: Estimates of range, mean, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense of fourteen characters in garden pea genotypes

Genotypes	Mean	Range		GCV (%)	PCV (%)	Heritability (%)
		Min.	Max.			
Days of 50% flowering	55.84	42.33	64.00	9.07	9.63	88.73
Plant height (cm)	70.10	54.80	113.27	20.51	21.51	90.88
Primary branches per plant	3.25	2.93	4.33	8.96	10.75	69.44
Pod length (cm)	8.30	5.84	10.13	13.52	15.97	71.71
Number of pod per plant	10.82	8.73	13.43	11.53	13.56	72.35
Average pod weight (g)	3.50	2.45	4.55	19.55	20.92	87.32
Number of seed per pod	7.63	6.37	9.20	10.41	12.51	69.30
100 Seed weight (g)	19.74	16.43	23.85	8.50	10.55	64.88
Total sugars (%)	8.48	6.08	11.57	16.06	16.10	99.57
Reducing sugar (%)	2.65	1.16	4.32	32.12	32.16	99.73
Non-reducing sugar	5.83	4.44	7.34	14.38	14.46	98.87
TSS (°Brix)	10.17	8.35	13.47	13.93	14.00	98.95
Pod yield per plant (g)	37.51	26.61	51.38	18.84	20.02	88.49
Total pod yield (q/ha)	105.64	85.91	128.07	11.29	12.69	79.16

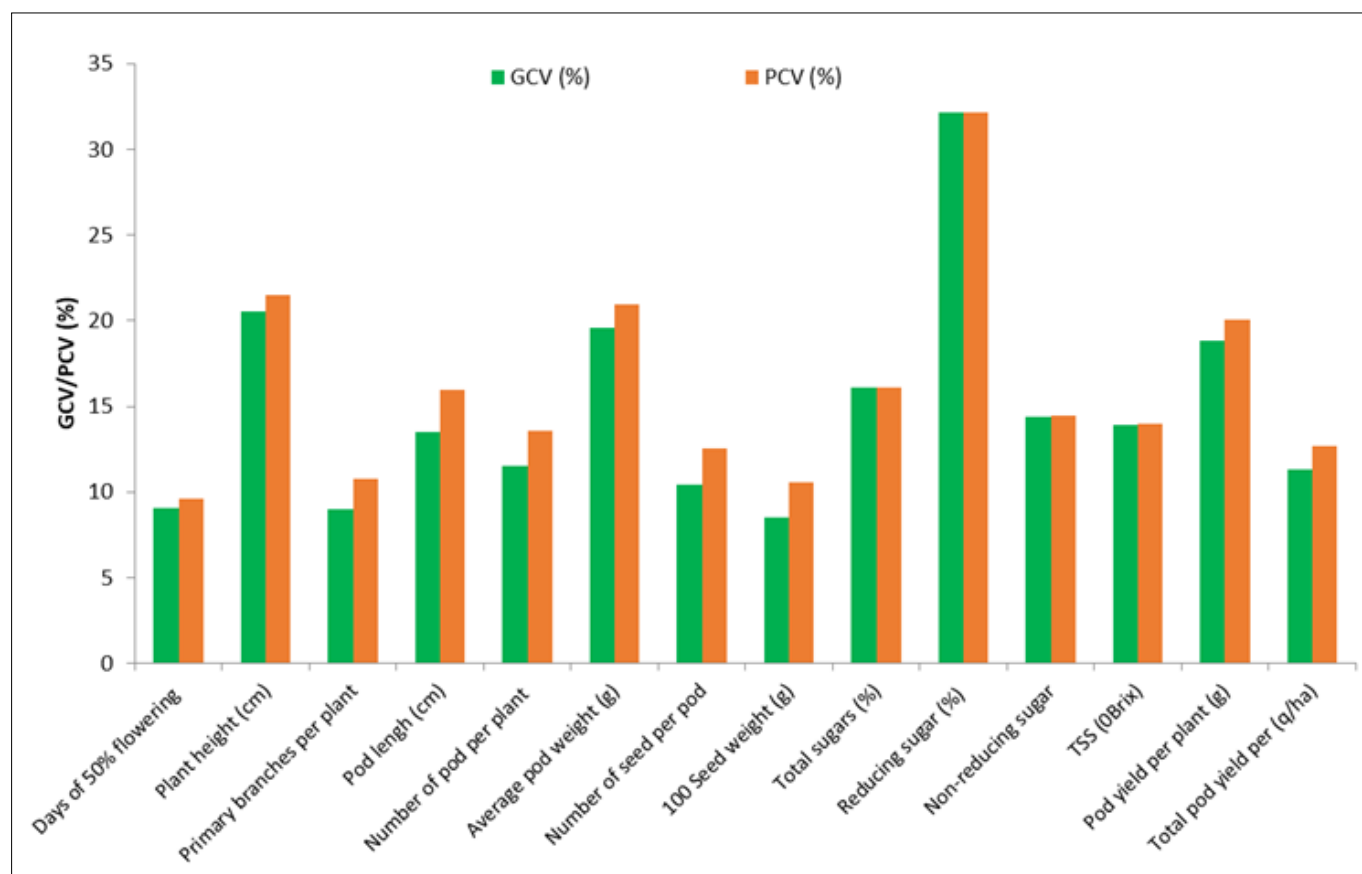


Fig 1: Effect of GCV and PCV for fourteen characters of garden pea

Conclusion

The present investigation demonstrated the existence of substantial morphological and genetic variability among the 25-garden pea (*Pisum sativum* L. var. *hortense*) genotypes evaluated under the study. Characterization based on DUS (Distinctness, Uniformity and Stability) descriptors revealed considerable diversity for important qualitative traits such as flowering duration, foliage colour, plant height, pod characteristics, and seed attributes. The wide variation observed among the genotypes confirms the presence of a broad genetic base within the germplasm and highlights the usefulness of DUS descriptors for accurate varietal identification, characterization, registration, and protection of plant varieties. Such characterization also facilitates the effective utilization of genetic resources in breeding programmes aimed at developing superior cultivars.

The analysis of yield and quality traits further indicated significant genetic variability among the evaluated genotypes, providing ample scope for selection and genetic improvement. Pod yield per hectare exhibited a wide range from 85.91 to 128.07 q ha⁻¹, demonstrating the differential performance of the genotypes under the prevailing conditions. Among the tested entries, genotype NDVP-24-18 emerged as the most promising for pod yield per hectare, while KS-111 recorded the highest pod yield per plant, indicating their potential use as valuable parental lines in future breeding programmes. The high estimates of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for reducing sugar content suggest the presence of considerable inheritable variability and indicate that effective improvement through selection is feasible for this quality trait.

Overall, the study confirms that the evaluated garden pea germplasm possesses considerable genetic diversity for economically important yield and quality attributes. The

identified superior genotypes can be effectively utilized in hybridization and selection programmes to develop high-yielding, quality-rich, and stable cultivars. Furthermore, the integration of DUS characterization with genetic variability analysis provides a comprehensive approach for germplasm evaluation, conservation, varietal development, and sustainable improvement of garden pea, thereby contributing to enhanced productivity and quality in future breeding efforts.

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