Original Research Article

Varietal Mean Performance of Garden Pea (*Pisum sativum*var. *hortense*L.) Under Subtropical Conditions of Punjab

ABSTRACT

This study on genetic variability and character association in fourteen genotypes of garden pea was conducted during the period spanning from 2022 to 2023. The research was carried out at the Agricultural Farm, School of Agriculture, Lovely Professional University, Phagwara (Punjab), India.The results obtained from this study revealed a significant variations in the mean performance among genotypes concerning various parameters, includingdays to 50% flowering, plant height, number of nodes per plant, number of primary branches, node to 1st flower appears, node to 1st pod appears, internodal length, length of pod, number of seed per pod, number of pod per plant, 100 seed weight, number of seed per 100g pods, number of pods per 100g, pod yield per plant and total soluble solids.Among these parameters, it was observed that the number of primary branches was highest(4.60) in the Tako-11 genotype, followed by GS-10 (4.46) and Samag (4.46). In terms of plant height, BKS pea recorded the highest measurement (91.28 cm), closely followed by Peas A-1 (90.85 cm). The genotypes GS-10 (104.70g) and AP-3 (102.97g) demonstrated superior performance in terms of yield parameters. Furthermore, the assessment of total soluble solids content revealed that GS-10 (19.82°B) and Nirali (18.81°B) genotypes exhibited higher sweetness levels in their pods compared to the other genotypes. An analysis of variance conducted in this study indicated substantial variance across all the traits considered under investigation. Furthermore, it revealed that there are ample opportunities exist for the selection of promising genotypes with favorable characteristics for further agricultural development and breeding programs. From the obtained results it can be concluded that a notable variation in various agronomic traits was observed and these findings would be helpful in providing valuable insights for future research and breeding efforts aimed at enhancing garden pea cultivation and productivity.

Keywords: Garden pea; genotypes; growth parameters; yield; quality parameters

1. INTRODUCTION

Garden pea, scientifically known as *Pisum sativum*var. *hortense* with a chromosome count of2n = 2x = 14, belongs to the Leguminosae family. This cool-season vegetable holds a significant place in agriculture and has a rich historical lineage, originating in regions encompassing Ethiopia, Mediterranean nations, and Central Asia [1]. The genus *Pisum* encompasses five distinct species: *P. humile, P. fulvum, P. sativum, P. abyssinicum*, and *P. elatius*, primarily distributed in the Mediterranean region and West Asia. However, only one species, *P. sativum*, is commercially cultivated [2].

Pea cultivation predominantly thrives in regions characterized by warm to mild climates. Temperature variations, whether too high or too low, are the main limiting factors for pea cultivation [3]. Peas are typically grown for their tender pods, seeds, and foliage, with substantial nutritional value. They are a rich source of protein and dietary fibre, making them a healthy choice for human consumption in various forms, including fresh, canned, frozen, and dehydrated [4,5]. Green pea pods are particularly noteworthy for their high content of folic acid, ascorbic acid (vitamin C), and vitamin K [6].

A notable characteristic of garden pea is its capacity for nitrogen fixation through root nodules, which renders it valuable for crop rotation alongside groundnut and soybean. In response to the decreasing availability and rising costs of chemical fertilizers, peas are employed as soil-building crops. Their low water requirements, approximately 300mm [7], make them a sustainable choice for cultivation. However, an arid environment can be detrimental to pea plants, especially during pod and flower development. Timing of sowing can be adjusted based on cumulative mean temperature requirements for floral initiation, which varies among cultivars [8]. Drought conditions significantly reduce yields [9]. Early cultivation and the use of seeds from cultivars with early flowering and maturation can enhance yield [10].

In India, the general pea yield falls below the global average due to a limited genetic pool and the utilization of a narrow range of varieties in cultivar development [11]. To overcome this limitation, it is imperative to introduce and evaluate germplasm for future breeding projects aimed at creating superior cultivars. The current study was designed with the objective of assessing pea genotypes for diversity and associations among various attributes. Specifically, this

investigation sought to identify the most promising genotypes in the Phagwara region of Punjab and to provide recommendations for breeding strategies to achieve high-yielding pea cultivars.

2. MATERIALS AND METHODS

This study was conducted to analyze heritability, variability, genetic advances, and correlations among various traits, with a particular focus on their impact on yield and yield-contributing characteristics. The study took place during the rabi season of year 2022-2023 at the Agricultural Farm of the School of Agriculture, Lovely Professional University, situated in Phagwara, Punjab. This region falls under a humid subtropical climate, characterized by cool winters and long, hot summers. The coordinates for this location are 75°23'03.02" East longitude and 31°22'31.81" North latitude, with an average elevation of 252 meters above sea level.

Fourteen distinct garden pea genotypes were collected from various institutes, research stations, and private seed companies. These genotypes include SATAYA-1010, Peas Vasundhara, PB-89 (check variety), Zanna +, Imported Peas OS-10, Samag, Sweet Ruby, AP-3, GS-10, Niarli, Peas A-1, Tako-10, 11 Danno Wali (tiger), and BKS peas. The experiment was meticulously organized following a Randomized Block Design (RBD) with three replications. The plot size was maintained at 4 meters by 1.5 meters. The seeds of the garden pea genotypes were sown on 2ndNovember, 2022, with a spacing of 30cm by 10cm. The initial irrigation was provided immediately after seed sowing, followed by subsequent irrigations at 15-day intervals. All recommended agricultural practices were diligently adhered to in order to cultivate a high-quality crop.The observations of different traits were recorded in five randomly chosen plants of each genotype in each replicationviz**.,** days to 50% flowering, plant height, number of nodes per plant, number of primary branches, node to 1st flower appears, node to 1st pod appears, internodal length, length of pod, number of seed per pod, number of pod per plant, 100 seed weight, number of seed per 100g pods, number of pods per 100g, pod yield per plant and total soluble solid. The mean value for the different growth, yield and quality traits were calculated.

3. RESULTS AND DISCUSSION

In this research study on garden pea, fourteen different varieties of garden pea were collected and evaluatedfor fifteen traits. The mean performance of these 14 genotypes for various growth, yield and quality characteristics are presented in Table1, which revealed that there was a

significant variation among genotypes for all the variables studied. It indicated that different pea genotypes exhibited diverse traits and have implications for better crop yield, quality, and suitability for the specified growing conditions.

3.1 Growth Parameters

3.1.1 Plant Height (cm)

Significant variations were observed in the collected data among the different genotypes. In terms of plant height, the measurements ranged from 91.28 to 61.57 cm, with a mean value of 76.53 cm. Among the genotypes, the highest plant height was recorded in BKS peas at 91.28 cm, closely followed by Peas A-1 at 90.85 cm. In contrast, the lowest plant height was observed in (check) PB-89 at 61.57 cm, with Nirali at 66.8 cm and GS-10 at 68.4 cm also showing comparatively lower heights. This extensive range of variation in plant height aligns with findings from previous studies conducted by [12,13,14], underlining the importance of genetic diversity and its influence on this particular trait.

3.1.2 Number of Nodes Per Plant

The statistical analysis revealed a significant difference among the garden pea genotypes in terms of the number of nodes per plant. This particular trait exhibited a range from 15.33 to 20.86, with a mean value of 17.46. Among the genotypes, SATAYA-1010 displayed the highest number of nodes per plant at 20.86, followed by 11 DW at 18.6 and GS-10 at 18.0. In contrast, the lowest number of nodes per plant was observed in Sweet Ruby, with a value of 15.33, followed by Peas Vasundhara at 16.20 and PB-89 (check) at 16.33. These significant variations in the number of nodes per plant highlight the genetic diversity among the garden pea genotypes and the potential influence of these variations on plant structure and development.

3.1.3 Number of Primary Branches Per Plant

The statistical analysis of the data demonstrated significant differences among the various genotypes, with a range in the number of primary branches per plant from 1.60 to 4.60 and a mean value of 3.68. The evaluation of genotype means revealed that Tako-11 exhibited the highest number of primary branches per plant at 4.60, closely followed by GS-10 and Samag, both at 4.46, and 11DW at 4.40. In contrast, Sweet Ruby had the lowest number of primary

branches per plant at 1.60. The increase in the number of primary branches can be attributed to elevated cell division, resulting in a greater number of vegetative buds on the main stem. Environmental conditions, such as moisture and temperature, also played a role in promoting vegetative growth. These findings are in line with previous studies conducted by [13-16], which have also highlighted the impact of environmental factors on pea plant development and the number of primary branches.

3.1.4 Internodal Length (cm)

The statistical analysis has highlighted significant variations in internodal length among the garden pea genotypes, with measurements ranging from 3.86 to 5.12 cm and a mean value of 4.57 cm. Among these genotypes, Samag exhibited the highest internodal length at 5.52 cm, followed by 11DW at 5.12 cm. In contrast, Nirali displayed the lowest internodal length at 3.86 cm. The increase in internodal length can be attributed to enhanced cell division, which results in the development of more vegetative buds along the main stem. This observation aligns with the findings of [17], who also noted the impact of cell division on internodal length. Additionally, [18] reported significant variations in internodal length among different pea varieties, further emphasizing the genetic diversity in this trait.

3.1.5 Days to 50% Flowering

The results of the study indicate significant differences among garden pea cultivars in terms of the number of days required for 50% flowering. This characteristic exhibited a range from 62 to 80 days, with a mean value of 73.95 days. Among the cultivars, the shortest duration to reach 50% flowering was observed in AP-3 at 62.00 days, closely followed by Zanna+ at 62.33 days. On the other hand, the longest duration was observed in BKS peas at 91.28 days, with Peas A-1 requiring 90.85 days to reach 50% flowering. This variation in the number of days to 50% flowering aligns with findings from previous studies conducted by [13, 19], further emphasizing the influence of genetic diversity and environmental conditions on this particular trait in garden pea cultivars.

3.2 Yield Parameters

3.2.1 Node to 1stFlower Appears

The data analysis has revealed significant differences among the genotypes in terms of the number of nodes to the first appearance of flowers. This trait exhibited a range from 9.13 to 11.33 nodes, with a mean value of 10.33 nodes. Peas A-1 demonstrated the earliest appearance of the first flower, occurring at 9.13 nodes, followed by Nirali at 9.33 nodes, and BKS peas at 9.93 nodes. In contrast, 11DW exhibited the latest first appearance of a flower, occurring at 11.33 nodes. These variations in the number of nodes to the first appearance of flowers can be attributed to the inherent characteristics of the different genotypes. Genetic factors likely play a role in determining the node at which early flowering occurs. This observation is in line with a similar outcome reported by [20], suggesting that genetic variation plays a key role in this specific trait among garden pea genotypes.

3.2.2 Node to 1stPod Appears

The data analysis has revealed significant variations among different genotypes in terms of the number of nodes to the first appearance of pods. This characteristic displayed a range from 10.40 to 13.62 nodes, with a mean value of 11.33 nodes. GS-10 exhibited the maximum value, with pods first appearing at 13.62 nodes, while BKS peas displayed the minimum value, with pods appearing at 10.40 nodes. These significant variations in the number of nodes to the first appearance of pods can likely be attributed to a combination of genetic factors and environmental conditions. The genetic structure of each genotype can influence when pods first appear, as can the specific environmental conditions in which they are grown. These factors contribute to the observed diversity in this trait among the different garden pea genotypes.

3.2.3 Pod Length (cm)

The analysis of pod length in the garden pea cultivars has revealed significant differences among them. Pod length ranged from 7.59 to 10.24 cm, with a mean length of 9.12 cm. Among the specific genotypes, 11DW displayed the maximum pod length at 10.24 cm, followed by GS-10 at 10.02 cm. In contrast, AP-3 had the shortest pods, measuring 7.59 cm in length. These notable variations in pod length among the different cultivars can be attributed to a combination of genetic characteristics and environmental conditions. Genetic factors are known to influence the shape, size, and number of seed pods in pea genotypes, as suggested by earlier researchers such as [21-23. The observed variation in pod length may be a resultof these underlying genetic traits,

as also noted by [24]. This variation in pod length among different genotypes was consistent with the findings reported by [25-26], underscoring the genetic diversity in this important trait.

3.2.4 Number of Seed Per Pod

The analysis of the number of seeds per pod in the garden pea cultivars has revealed significant variations among them. The number of seeds per pod ranged from 5.60 to 9.13, with a mean of 7.36. Among the specific cultivars, 11DW exhibited the highest number of seeds per pod at 9.13, followed by GS-10 with 8.73 seeds per pod. In contrast, the lowest number of seeds per pod was observed in AP-3, with 5.60 seeds per pod, followed by Sweet Ruby with 6.33 seeds per pod. These considerable variations in the number of seeds per pod among the different cultivars can be attributed to a combination of environmental and genetic factors. Environmental conditions, such as temperature and moisture, can influence seed development within the pods. Additionally, genetic traits specific to each cultivar play a role in determining the number of seeds per pod. This variability in the number of seeds per pod is consistent with findings reported by [15, 19, 25, 26], underscoring the complex interplay of genetic and environmental factors in this trait.

3.2.5 Number of Pod Per Plant

The data analysis on the number of pods per plant has revealed significant variation among the different genotypes. This characteristic displayed a range from 10.66 to 26.06 pods per plant, with a mean value of 17.08 pods per plant. GS-10 exhibited the highest number of pods per plant, with 26.06 pods, followed by AP-3 with 24.46 pods. In contrast, Peas A-1 had the lowest number of pods per plant, with 10.66 pods, followed by Sweet Ruby with 10.80 pods. This variation suggests that certain genotypes may be preferred over others based on their pod production, provided that other criteria are met at optimal levels. It's worth noting that a higher number of pods per plant may be attributed to smaller pod sizes, as smaller pods tend to require fewer nutrients than larger ones. The observed variability in this parameter can be attributed to a combination of genetic factors, soil conditions, and the local climate in the region. Similar outcomes have been reported in studies by [19, 24, 26], emphasizing the influence of genetic diversity, environmental factors, and agronomic practices on the number of pods per plant in garden peas.

3.2.6 Number of Seed Per 100g Pod

The data analysis has shown significant differences in the number of seeds per 100 grams of pods among the garden pea genotypes. This trait exhibited a range from 90.33 to 51.33 seeds per 100 grams of pods, with a mean value of 73.30 seeds per 100 grams of pods. SATAYA-1010 displayed the highest number of seeds per 100 grams of pods, with 90.33 seeds, followed by 11DW with 88.00 seeds. On the other hand, Zanna+ had the lowest number of seeds per 100 grams of pods, with 51.33 seeds. These significant variations in the number of seeds per 100 grams of pods among the different genotypes highlight the genetic diversity and potential differences in seed development and size. These variations may have important implications for crop yield and seed quality.

3.2.7 Number of Pod Per 100g

The analysis of the data has revealed significant differences among the garden pea genotypes in terms of the number of pods per 100 grams. This characteristic displayed a range from 21.33 to 12.33 pods per 100 grams, with a mean value of 16.92 pods per 100 grams. Peas A-1 exhibited the highest number of pods per 100 grams, with 21.33 pods, followed by BKS peas with 20.00 pods. In contrast, Imported Peas OS-10 had the lowest number of pods per 100 grams, with 12.33 pods. These significant variations in the number of pods per 100 grams among the different genotypes highlight the genetic diversity in this trait. The differences in pod development and size among the genotypes can have implications for crop yield and overall productivity.

3.2.8 100 Seed Weight (g)

The analysis of the data has demonstrated significant differences among the garden pea genotypes in terms of 100-seed weight. This characteristic exhibited a range from 15.96 to 36.60 grams, with a mean value of 25.09 grams. Zanna+ displayed the highest 100-seed weight, at 36.60 grams, followed by GS-10 with 36.26 grams. In contrast, Peas A-1 had the lowest 100-seed weight, at 15.96 grams. These substantial variations in 100-seed weight among the different genotypes underscore the genetic diversity in this important trait. 100-seed weight is a critical parameter as it directly influences seed yield and overall productivity in pea cultivation.

3.2.9 Pod Yield Per Plant (g)

The results clearly indicate significant variations among the cultivars in terms of pod yield per plant. Pod yield per plant ranged from 82 grams to 104.70 grams, with a mean value of 70.23 grams. GS-10 exhibited the highest pod yield per plant at 104.70 grams, followed by AP-3 with 102.97 grams. On the other hand, Sweet Ruby had the lowest pod yield per plant at 45.82 grams, followed by Peas A-1 with 46.18 grams. These significant variations in pod yield per plant among the different cultivars underscore the genetic diversity and the influence of various factors on yield in garden peas. Likewise, [25, 26, 27, 28] conducted a comparable study for the estimation of genotypes for several characters. Yield is a complex trait affected by a combination of heritable traits, soil conditions, climate, and agronomic practices[7]. The establishment of crops with robust vegetative development is crucial for achieving higher yields [22].

3.3 Quality Parameters

The analysis of the data has revealed significant differences among the garden pea genotypes in terms of total soluble solids (TSS). TSS values ranged from 12.19°B to 19.82°B, with a mean value of 16.33°B. GS-10 exhibited the highest TSS value at 19.82°B, while BKS had the lowest TSS at 12.19°B. This variation in TSS among the genotypes is consistent with findings from previous research conducted by [16, 18, 25, 26]. It underscores the genetic diversity and potential differences in sugar content or sweetness in garden pea genotypes. TSS is an important quality parameter, and variations in TSS can influence the taste and overall quality of garden peas, making it a crucial consideration for breeding and cultivation programs.

The coefficient of variation (CV) is indeed a valuable statistical measure used to assess the accuracy and reliability of research findings. In field research, the CV value serves as an indicator of the degree of variability within a dataset. Here's a breakdown of how different ranges of CV values are typically interpreted:

CV < 10%: Great Accuracy

10% ≤ CV < 20%: Fair Accuracy

20% ≤ CV < 30%: Moderate Accuracy

CV ≥ 30%: Extremely Poor Accuracy

The coefficient of variation (CV) for all the traits ranged from 3.09% to 10.54% which indicates that there was relatively low variation within the genotypes for each of the studied traits. Specifically, the CV values obtained fall within the great accuracy range (CV < 10%), suggesting that the research findings are highly reliable and that the data collected is consistent and accurate. These low CV values are indicative of the robustness of research methodology and the consistency of measurements across the different genotypes and traits studied. Researchers typically strive for low CV values as they reflect the precision and reliability of their data, enhancing the credibility of the study's findings.

The alignment of the results with previous research on various characteristics of garden pea is a positive indicator of the consistency and reliability of the findings. When different studies observe similar trends and patterns across traits, it strengthens the validity and credibility of the data and conclusions.The fact that results align with those of previous research for various characteristics viz. days to 50% flowering, plant height, internodal length, and others suggests that these traits may exhibit stable and predictable behaviour across different garden pea genotypes. The consistency in findings across different studies provides additional support for the validity and reliability of this study's results. When multiple studies produce similar results, it enhances confidence in the accuracy of the data and the robustness of the research methodology.

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.In summary, the consistency in research findings across studies underscores the reliability of the results and provides valuable insights for garden pea breeding and cultivation efforts. It demonstrates the potential for stable and predictable behavior in certain key traits, which can be leveraged for crop improvement.

4. CONCLUSION

In accordance with the mean performance of the fourteen genotypes of garden pea, BKS pea and Peas A-1 exhibited the highest plant height among the genotypes.GS-10 and AP-3 genotypes performed better than check variety (PB-89) in terms of yield parameters, indicating their potential for higher pod yields. GS-10 and Nirali genotypes had higher TSS levels, suggesting that the pods of these genotypes are sweeter in taste compared to others. Among the fourteen genotypes studied, GS-10 and AP-3 consistently showed better performance across multiple traits. Based on these findings, GS-10 and AP-3 were identified as the most promising genotypes for garden pea cultivation in the Phagwara region of Punjab. These genotypes have demonstrated superior performance in terms of yield and other important characteristics, which can contribute to better crop yields and quality in the specified region. Statistical analysis demonstratedthat the importance of research to draw reliable and meaningful results from the conducted study.Identifying and understanding these variations are crucial for making immediate and reliable decisions in agriculture, such as selecting the best-performing genotypes for a particular region or breeding program.These findings would definitely provide valuable insights for farmers and researchers in future. It's important to continue monitoring and evaluating the performance of these promising genotypes in various environmental conditions to ensure their suitability for local agricultural practices.

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Table 1. Mean performance of 14 genotypes for different growth, yield and quality characters of garden pea

S. No.	Genotypes	Traits														
		Days to 50% flowering	Plant height	Number of node per plant	Number of primary branches	Node to 1st flower appears	Node to 1st pod appears	Internodal length	Pod length	Number of seed per pod	Number of pod per plant	Number of seeds per 100g pods	Number of pods 100g	100 Seed weight	Pod Yield per plant	TSS
1	SATAYA-1010	79.00	80.38	20.86	4.26	10.86	11.46	4.32	9.16	7.20	16.66	90.33	13.66	26.30	62.28	14.76
2	Peas Vasundhara	80.00	70.81	16.20	3.60	10.13	11.20	4.71	9.43	7.80	13.26	72.00	16.66	25.50	51.05	15.72
3	PB-89	76.33	61.57	16.33	3.80	11.20	11.66	4.17	8.56	7.93	14.06	87.66	18.33	23.36	68.38	16.38
4	Zanna +	62.33	70.92	16.86	3.73	10.13	10.93	4.73	7.96	6.53	17.08	51.33	12.66	36.60	67.64	18.69
5	Imported Peas OS-10	75.66	84.22	17.93	3.66	10.00	10.53	4.25	9.66	8.06	14.73	70.00	12.33	21.33	62.18	13.58
6	Samag	82.66	75.25	17.66	4.46	10.46	11.06	5.52	8.67	6.93	17.00	60.33	19.00	23.00	73.07	18.48
7	Sweet Ruby	74.33	81.06	15.33	1.60	11.20	10.80	4.02	9.06	6.33	10.80	83.66	19.66	19.13	45.82	16.99
8	AP-3	62.00	83.11	17.20	3.53	10.33	11.86	4.66	7.59	5.60	24.46	57.66	16.00	35.26	102.97	16.78
9	GS-10	73.00	68.40	18.20	4.46	10.06	13.63	4.76	10.02	8.73	26.06	66.33	14.33	36.26	104.70	19.82
10	Niarli	72.00	66.80	17.66	4.26	9.33	11.13	3.86	9.53	7.60	18.00	67.66	18.66	28.90	78.54	18.81
11	Peas A-1	72.00	90.85	17.20	2.66	9.13	11.13	4.90	9.68	7.53	10.66	70.33	21.33	15.96	46.18	14.13

12	**Tako-10**	79.33	71.38	17.06	4.60	10.60	11.53	4.70	8.91	7.33	20.46	86.00	18.00	19.46	82.91	14.95
13	**11 D W (tiger)**	78.00	75.42	18.60	4.40	11.33	11.33	5.12	10.24	9.13	20.40	88.00	16.33	22.36	77.22	17.39
14	**BKS Pea**	68.66	91.28	17.33	2.53	9.93	10.40	4.30	9.25	6.40	15.46	75.00	20.00	17.90	60.36	12.19
	Mean	**73.95**	**76.53**	**17.46**	**3.68**	**10.33**	**11.33**	**4.57**	**9.12**	**7.36**	**17.08**	**73.30**	**16.92**	**25.09**	**70.23**	**16.33**
	CV	5.40	3.09	4.20	10.54	6.11	6.62	9.02	4.72	7.26	10.09	5.28	8.21	9.51	3.90	4.61
	S.E.	2.30	1.36	0.42	0.22	0.36	0.43	0.23	0.24	0.30	0.99	2.23	0.80	1.37	1.58	0.43
	CD 1%	6.70	3.97	1.23	0.65	1.06	1.26	0.69	0.72	0.89	2.89	6.49	2.33	4.00	4.60	1.26
	CD 5%	9.06	5.37	1.66	0.88	1.43	1.70	0.93	0.97	1.21	3.91	8.78	3.15	5.41	6.22	1.71
	Lowest Range	62.00	61.57	15.33	1.60	9.13	10.40	3.86	7.59	5.60	10.66	51.33	12.33	15.96	45.82	12.19
	Highest Range	82.66	91.28	20.86	4.60	11.33	13.63	5.52	10.24	9.13	26.06	90.33	21.33	36.60	104.70	19.82

CV = coefficient of variation; CD = critical difference; SE = standard error