RESEARCH ARTICLE

Estimation of genetic heritability and genetic advance assessment in Garden Pea (*Pisum sativum* L.)

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The crosses for the experiment were created during Rabi 2018-2019, and a field experiment was carried out at the vegetable research farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, U.P. during the 2019–2020 Rabi season. The 13 different genotypes of garden peas (10 lines and 3 testers) that were collected from Chandra Shekhar Azad University of Agriculture and Technology's vegetable research farm in Kanpur made up the experimental material. During the 2019 Rabi season, a set of thirty crosses (10 lines and 3 testers) were created. A respectable amount of crosses was tried in order to generate enough F1 seed in each cross. Using a Randomized Block Design (RBD), 13 genotypes of vegetable pea were assessed for genetic progress and genetic heritability. Notes on eleven characters, namely Days until 50% flowering plant height (cm), number of branches per plant, length between nodals, number of seeds per pod, number of pods per plant, green pod yield per plant (g), first fruiting node, and shelling percentage (%) were collected in order to conduct the assessment. Significant variations were found across the genotypes for every attribute in the ANOVA findings, suggesting a broad range of variability among the genotypes. Every character in the current study shown a high degree of heritability. With the exception of shelling percentage, days to 50% flowering, and pod width, all of the characters demonstrated high heritability and high genetic advancement; in contrast, the characters representing shelling percentage, days to 50% flowering, and pod width demonstrated moderate genetic advance and high heritability. These characters displayed the least amount of G × E interaction and were least affected by their surroundings. From a breeding standpoint, only the heritable portion of total variation matters. Therefore, in various breeding and crop improvement initiatives, these qualities should be given preference when selecting traits in order to generate high yielding and more successful varieties.

Key Words: *Genetic variability; Heritability; Genetic advance; Pea*

INTRODUCTION

There are numerous horticultural and agricultural uses for peas. Green seeds are used to create canned, frozen, and fresh vegetables. This crop has a high protein content (27%) suitable for human consumption. Green peas have the greatest protein content of any vegetable, ranging from 6 to 7% on a fresh weight basis. Peas have become increasingly useful as a food crop and as fodder in recent years. Pea protein contains all of the amino acids needed for optimum cellular activity [1]. "Pea protein is low in sulfur-containing amino acids like cysteine and methionine but high in lysine and other essential amino acids," claim Ceyhan and Avci [2]. Peas contain minerals, dietary fiber, vitamins A, B, and C, as well as antioxidant chemicals [3]. "Green peas are very important as part of a healthy diet, especially for children and the elderly, especially when eaten in their fresh, canned, or frozen form. The highest concentration of vitamins is found in green pea seeds and immature pods. Agronomically speaking, the addition of peas to crop rotation is highly significant. The pea makes an excellent forerunner to other crops because its roots contain nodule bacteria that enrich the soil and fix nitrogen, making it available to other plants [4]. For a successful breeding program, crop improvement depends upon the extent of heritability of the desirable characters and the magnitude of genetic variability [5]. The improvement of any crop, the selection of superior genotypes, and the improvement of any trait require genetic variability, heritability, and genetic advance [5]. Yield is a complicated personality that is shaped by a number of genetic variables interacting with the environment. Thus, the genetic variability that already exists in the base population and the effectiveness of selection determine the success of any breeding effort aimed at improving [6]. The percentage of phenotypic variance attributable to heritable genes is known as heritability [7]. Breeders can utilize it as a helpful guide as selection for traits with high heritability will be successful in bringing about improvement [8]. A population's genetic value can be improved by genetic advancement when compared to its original population [9]. Based on the research of heritability and genetic advancement, alternative breeding programs for the enhancement of specific features will be able to be determined [7]. Consequently, the purpose of this study was to evaluate the genetic diversity, heritability, and advancements among 20 genotypes of pea.

MATERIALS AND METHODS

The crosses for the experiment were created during Rabi 2018-2019, and the fieldwork was carried out at the Chandra Shekhar Azad University of Agriculture and Technology's vegetable research farm in Kanpur, Uttar Pradesh, during the 2019-2020 Rabi season. The 13 different genotypes of garden peas (10 lines and 3 testers) that were collected from Chandra Shekhar Azad University of Agriculture and Technology's vegetable research farm in Kanpur made up the experimental material. During the 2019 Rabi season, a set of thirty crosses (10 lines and 3 testers) were created. A respectable amount of crosses was tried in order to generate enough F1 seed in each cross. Geographically, Kanpur Nagar is located between the parallels of latitudes 25.26 and 26.58 degrees North and 79.31 and 80.34 degrees East. It is located in Central Uttar Pradesh's alluvial zone of the Indo-Gangetic plains at an elevation of 124 meters above mean sea level. Thirteen of the germplasm sets listed in Table 1 were used in the experiment, which was set up in a randomized block design with three replications. First fruiting node, Pod length, Pod breadth, Days to 50% flowering plant height (cm), and other data were recorded. Green pod yield per plant (g), number of branches per plant, length between nodes, number of seeds per pod, number of pods per plant, and shelling percentage (%). As recommended by Goulden [10], the mean values were statistically analyzed to determine an ANOVA for each character. The Lush formula [11] was used to assess heritability in the wide sense (h^2). Moreover, the Johnson et al., [12] approach was used to calculate genetic progress as a percentage of mean.

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TABLE 1
Different genotypes of garden pea and their characteristics

S. No	Genotype	Source of genotype	Characteristics' of genotypes
		Line	
1	C-18-1	C.S.A.U.A and T, Kanpur	Medium in maturity, light green pods.
2	C-18-2	C.S.A.U.A and T, Kanpur	Medium in maturity, dark green pods.
3	C-18-3	C.S.A.U.A and T, Kanpur	Early in maturity, dark green pods.
4	KS-283	C.S.A.U.A and T, Kanpur	Medium in maturity, dark green pods.
5	KS-701	C.S.A.U.A and T, Kanpur	Medium in maturity, light green pods, medium tall plant.
6	KS-702	C.S.A.U.A and T, Kanpur	Medium in maturity, light green pods, medium tall plant.
7	KS-801	C.S.A.U.A and T, Kanpur	Pod length short, tall plant and powdery mildew resistant.
8	KS-802	C.S.A.U.A and T, Kanpur	Light green pod, tall plant and powdery mildew resistant.
9	KS-601	C.S.A.U.A and T, Kanpur	Early in maturity, dwarf plant, dark green pods.
10	KS-285	C.S.A.U.A and T, Kanpur	Medium in maturity, light green pods, medium tall plant.
		Tester	
1	AP-3	C.S.A.U.A and T, Kanpur	Dwarf plant, pod slightly curved and dark green, bold and wrinkled seed, early in flowering, wider adaptability.
2	AP-1	C.S.A.U.A and T, Kanpur	Medium tall, high yielder, wrinkled seeded, Medium in maturity, powdery mildew susceptible and wider adaptability.
3	PSM-3	G.B.P.U.A and T, Pantnagar	Medium tall plant, small pod, light green in colour and powdery mildew resistant.

RESULTS AND DISCUSSION

Analysis of variance

To evaluate the importance of the various treatments, an analysis of variance was performed for each of the 11 characters. Table 2 displays the mean squares for each characteristic. The variance resulting from the parents was further divided into lines, testers, and lines versus testers. Significant variations were noted for every character across lines and testers. With the exception of days to 50% flowering, the number of branches per plant, and the first fruiting node, highly significant differences were observed between the lines and the testers for every character. Except for green pod production per plant (g), other characteristics of the hybrid and parent differ significantly. Significant diversity in the material under experimentation was reflected in it by Mehta et al., [13], Sharma et al., [14] and Kumar et al., [7] also discovered.

Mean and range

Table 3 displays the average value and range of variability for each character. With the exception of days to 50% flowering, plant height (cm), internode length (cm), and number of pods per plant, the mean of the parents was higher than the F1 for all the traits. The variability among parents was fairly high for days to 50% flowering (34.00 to 53.00 with mean of 46.33), plant height (69.67 to 104.30 with mean of 82.22), pod length (5.27 to 9.69 with mean of 8.73), pod width (1.23 to 1.75 with mean of 1.43), number of branches per plant (1.37 to 2.51 with mean of 2.04), first fruiting node (9.03 to 12.62 with mean of 10.52), internode length (2.65 to 4.53 with mean of 3.91), number of seeds per pod (4.03 to 8.62 with mean of 7.23), number of pods per plant (16.68 to 31.38 with mean of 21.65), shelling percentage (42.33 to 56.00 with mean of 47.84), green pod yield per plant (87.77 to 158.00 with mean of 126.49). The variation in F1 for days to 50% flowering (35.00 to 56.67 with mean of 48.67), plant height (68.55 to 171.67 with mean of 86.27), pod length (6.50 to 10.12 with mean of 8.35), pod width (1.23 to 1.64 with mean of 1.4), number of branches per plant (1.34 to 2.55 with mean of 1.86), first fruiting node (7.00 to 13.34 with mean of 9.57), internode length (2.84 to 10.62 with mean of 5.13), number of seeds per pod (4.34 to 10.32 with mean of 6.82), number of pods per plant (21.00 to 41.71 with mean of 24.79), shelling percentage (41.00 to 57.00 with mean of 46.63) green pod yield per plant (96.28 to 150.28 with mean of 126.12).

TABLE 2

Analysis of variance for parents and F1 for 11 yield character derived from in 10 Line × 3 Tester cross in garden pea

Characters	d.f.	Days to 50% flowering	Plant height (cm)	Pod length (cm)	Pod width (cm)	Number of branches per plant	First fruiting node	Internode length (cm)	Number of seeds per pod	Number of pods per plant	Shelling percentage	Green pod yield/plant (g)
Replication	2	0.98	22.35	0.33	0.008	0.02	0.13	0.02	0.00	0.19	1.78	3.59
Genotype	42	70.81**	1226.09**	3.94**	0.037**	0.65**	7.69**	7.02**	6.42**	65.58**	56.96**	1023.73**
Parents	12	93.39**	344.15**	4.68**	0.059**	0.68**	3.17**	1.09**	4.78**	38.87**	39.03**	1404.70**
Females (lines)	9	80.09**	376.33**	1.81**	0.063**	0.77**	2.63**	0.85**	1.72**	10.07**	47.89**	1680.71**
Males (tester)	2	197.33**	101.53**	16.90**	0.060**	0.58**	7.00**	1.37**	20.80**	58.23**	6.78**	57.93**
Line vs Tester	1	5.20	539.72**	6.13**	0.023**	0.08	0.38	2.69**	0.30**	259.38**	23.84**	1614.18**
Cross *vs* Parent	1	149.55**	447.01**	3.83**	0.030**	0.88**	24.39**	40.82**	4.60**	267.50**	41.73**	3.85
Error	84	2.10	6.70	0.33	0.001	0.01	0.08	0.04	0.05	2.04	3.66	11.29

Note: *Significant at 5% level; **Significant at 1%.

TABLE 3

Mean and range of parents and F_{1s} for 11 characters in 10 Line × 3 Tester cross in garden pea

S. No	Characters	Mean		Range			
		Parent	F1s	Parents		F_{1s}	
		Parent	F_{1s}	Minimum	Maximum	Minimum	Maximum
1	Days to 50% flowering	46.33	48.67	34	53	35	56.67
2	Plant height (cm)	82.22	86.27	69.67	104.3	68.55	171.67
3	Pod length (cm)	8.73	8.35	5.27	9.69	6.5	10.12
4	Pod width (cm)	1.43	1.4	1.23	1.75	1.23	1.64
5	Number of branches per plant	2.04	1.86	1.37	2.51	1.34	2.55
6	First fruiting node	10.52	9.57	9.03	12.62	7	13.34
7	Internode length (cm)	3.91	5.13	2.65	4.53	2.84	10.62
8	Number of seeds per pod	7.23	6.82	4.03	8.62	4.34	10.32
9	Number of pods per plant	21.65	24.79	16.68	31.38	21	41.71
10	Shelling percentage	47.84	46.63	42.33	56	41	57
11	Green pod yield/ plant (g)	126.49	126.12	87.77	158	96.28	150.28

Estimates of genetic component of variances

Table 4 displays the estimated genetic component of variances for each character. For every character, the additive genetic variances (σ^2A) were less than the dominant genetic variances (σ^2D).

Pod width and number of branches per plant did not show any additive genetic variances, but green pod yield per plant, days to 50% flowering percentage, plant height (10.95), first fruiting node (-0.02), inter-nodal length (0.07), number of seeds per pods (0.05), number of pods per plant (0.70), and shelling percentage (0.30) did.

For every character, the dominance variances (σ^2D) exceeded the additive genetic variances, indicating a predominance of non-additive gene activity.

For each of the following: Plant height (439.28), pod width (0.01), number of branches per plant (0.21), first fruiting node (3.12), inter-nodal length (2.13), number of seeds per pods (1.96), number of pods per plant (16.18), and shelling percentage (17.85), the estimated value of σ^2D was 77.83 for green pod yield per plant.

There were no pooled general combining ability variances for pod width. The parents' combined variances for green pod yield per plant was (53.54), days to 50% flowering was (5.92), plant height was 37.12, pod length was 0.72, number of branches per plant was (-0.01), first fruiting node was (0.11), inter-nodal length was (0.30), number of seeds per pod was (0.68), number of pods per pod was (2.42), and shelling percentage was (-0.31). Additionally, it was covered by Sofi et al., [15] and Singh et al., [16].

The values for green pod yield (77.83), days to 50% flowering (12.63), plant height (439.28), pod length (0.29), pod width (0.01), number of branches per plant (0.21), first fruiting node (3.12), inter-nodal length (2.13), number of seeds per pods (1.96), number of pods per plant (16.18), and shelling percentage (17.85) were all higher than the gca variances for all the characters, indicating a predominance of non-additive gene action. Both Kumar et al., [8] and Katoch et al., [9] support it.

With the exception of the number of branches per plant and the first fruiting node, all characters had average degrees of dominance greater than one. The values for green pod yield per plant were 1.78, days to 50% flowering (4.27), plant height (6.33), pod length (1.79), pod width (6.08), inter-nodal length (5.54), number of seeds per pod (6.56), number of pods per plant (4.81), and shelling percentage (7.70).

Heritability and genetic advance

Important selection criteria, such as heritability and genetic advancement, are shown in Table 5. When anticipating the gain under selection, heritability estimates combined with genetic advancement are typically more useful than heritability estimates alone. Plant breeders frequently use heritability to measure the accuracy of a single field experiment or of a set of field trials. It is defined as the percentage of individual phenotypic variance in a population that may be attributed to heritable genetic factors. Heritability is of two types: Broad sense Heritability-It is the ratio of genotypic variance to phenotypic variance. It is calculated from total genetic variance which comprises additive, dominance and epistatic variances. Compared to plant breeding, it is more beneficial in animal breeding. The ratio of additive genetic variance to phenotypic variance is known as narrow sense heritability. Plant breeders will find greater use for it. Genetic advancement is defined as an increase in the chosen plant's mean genotypic value over its parent population. In terms of inter-nodal length (65.24%), number of branches per plant (48.66%), plant height (48.44%), number of seeds per pod (42.77%), number of pods per plant (37.97%), first fruiting node (32.76%), pod length (23.62%), days to 50% flowering (19.67%), shelling percentage (16.82%), and pod width (15.02%), the character's green pod yield showed 29.49% genetic advance percent of mean. With the exception of shelling percentage, days to 50% flowering, and pod width, all of the characters demonstrated high heritability and high genetic advancement; in contrast, the characters representing shelling percentage, days to 50% flowering, and pod width demonstrated moderate genetic advance and high heritability. From a breeding standpoint, only the heritable portion of total variation matters. References Rai et al., [17], Singh et al., [18], and Sharma et al., [19] bolster this.

TABLE 4

Estimates of genetic components and related statistics for 11 characters in 10 Line × 3 Tester cross in garden pea

Genetic components	Days to 50% flowering	Plant height (cm)	Pod length (cm)	Pod width (cm)	Number of branches per plant	First fruiting node	Internode length (cm)	Number of seeds per pod	Number of pods per plant	Shelling percentage	Green pod yield/ plant (g)
$\hat{}\sigma^2A$	0.69	10.95	0.09	0	0	-0.02	0.07	0.05	0.7	0.3	24.67
$\hat{}\sigma^2D$	12.63	439.28	0.29	0.01	0.21	3.12	2.13	1.96	16.18	17.85	77.83
$\hat{}\sigma2g$ (female)	1.22	88.81	0.23	0	0.01	-0.34	0.48	-0.27	5.6	4.09	237.36
$\hat{}\sigma^2g$ (male)	7.33	21.61	0.86	0	-0.01	0.24	0.25	0.96	1.47	-1.62	-1.6
$\hat{}\sigma^2g$ (pooled)	5.92	37.12	0.72	0	-0.01	0.11	0.3	0.68	2.42	-0.31	53.54
$\hat{}\sigma^2s$ (SCA)	12.63	439.28	0.29	0.01	0.21	3.12	2.13	1.96	16.18	17.85	77.83
Average degree of dominance	4.27	6.33	1.79	6.08	-	-	5.54	6.56	4.81	7.7	1.78

TABLE 5

Heritability and genetic advance and related parameter for 11 characters in 10 Line × 3 Tester cross in garden pea

S. No.	Characters	Population mean	Heritability (%)	Genetic advance	G.A.% over mean
1	Days to 50% flowering	47.97	91.62	9.44	19.67
2	Plant height (cm)	85.05	98.38	41.19	48.44
3	Pod length (cm)	8.47	78.34	2	23.62
4	Pod width (cm)	1.41	89.27	0.21	15.02
5	Number of branches per plant	1.91	95.28	0.93	48.66
6	First fruiting node	9.86	96.94	3.23	32.76
7	Internode length (cm)	4.77	98.11	3.11	65.26
8	Number of seeds per pod	6.95	97.9	2.97	42.77
9	Number of pods per plant	23.84	91.2	9.05	37.97
10	Shelling percentage	47.01	82.93	7.91	16.82
11	Green pod yield/plant (g)	126.23	96.76	37.23	29.49

CONCLUSION

Based on the findings, it is possible to draw the conclusion that genetic gain and heritability estimates can be used to determine the heritable variation. Every character in the current study exhibited strong heritability together with high or moderate genetic advancement. High genetic progress and high heritability in the green pod yield suggested that selection may be working and that the heritability is most likely the result of additive gene action. It is desirable for the parent KS-701 and KS-283 to be included in the crossover programmed.

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