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Genetic variability, heritability and genetic advance studies in commercial varieties of garden pea (*Pisum sativum* var. hortense L.) grown under mid-hill condition of Himachal Pradesh

Lekh Raj[1*], Sandeep Kumar[2], Ritika Singh[3], Deependra Yadav[4] and Ravinder[5]
[1]M.Sc. Scholar, Department of Horticulture, School of Agriculture, Abhilashi University, Mandi, (H.P.), India.
[2]Assistant Professor, Department of Horticulture, School of Agriculture, Abhilashi University, Mandi, (H.P.), India.
[3]Assistant Professor, Department of Genetics and Plant Breeding, School of Agriculture, Abhilashi University, Mandi, (H.P.), India

(Corresponding author: Lekh Raj)*
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ABSTRACT: A field experiment was conducted on ten varieties of garden pea to determine genetic variability, heritability, and genetic advance as a percent of mean using fourteen quantitative characters. viz., count emergence of seed per plot, days to 50% flowering, days to first picking, number of flowers per plant, pod length, seeds per pod, shelling percentage, number of pickings, plant height (cm), pod setting (%), pod yield per plant (g), Pod yield per plot (kg) and pod yield per ha (q). The result of ANOVA showed significant differences among the varieties. In comparison to the corresponding genotypic coefficient of variation (GCV), the phenotypic coefficient of variation (PCV) was quite higher. High value of GCV and PCV was recorded for count plant emergence per plot (%), number of pods per plant, number of flowers per plant, pod yield per plant (g), pod yield per ha (q) and pod yield per plot (kg). All the characters except days to first picking and pod setting showed a high magnitude of heritability in the broad sense (>60%) ranging from 98.48 (count plant emergence) to 74.11 (number of pickings). Further, high heritability coupled with high genetic advance as percentage of mean (>20%) was observed for count plant emergence per plot (%), number of pods per plant, number of flowers per plant, number of pickings, pod yield per plant (g), pod yield per ha (q) and pod yield per plot (kg) suggesting that these garden pea characters are genetically controlled by additive (heritable) gene action and can be utilized for garden pea improvement through selection. The varieties that showed superior results for the objectives under study were Goldie, New- Zealand, Azad P-3 and Maxima-3636 and can be exploited for further breeding programmes of garden pea.

Keywords: GCV, Heritability, PCV, Pod yield, Variability.

INTRODUCTION

Garden Pea (*Pisum sativum* var. *hortense* L.) 2n =14 is a major leguminous vegetable crop grown under both temperate and subtropical climates. A rich source of protein (digestible) ranging from 23-33%, vitamins (A & C), minerals (Ca & P), and antioxidants, it has several health-benefiting properties. It is N fixing & soil building legume crop. It plays major role in advanced agriculture systems as it improves soil structure and maintains gap for the disease cycle. Garden pea is an annual cool-season crop grown world-wide. Depending on location, planting can take place from winter to early summer. It requires a cool, relatively humid climate for proper growth, optimum mean temperature for vegetative growth is between 13ºC and 18 ºC, growth essentially stop above 29º C and crop is frost sensitive. In the world, pea occupies the area, production, and productivity of 2.67 million ha, 20.70 million MT, 7.7 MT/ha respectively. The total area under pea in India is about 549 thousand ha with a production of 5680 thousand MT and productivity of 10.0 MT/ha respectively (Anon., 2022). In Himachal Pradesh pea occupies an area of 26 thousand ha with production and productivity of 328.80 thousand metric MT, 11.72 MT per hectare respectively (NHB, 2021-22). It is a major legume vegetable crop in the North-Western Himalayan section of India including the states of Himachal Pradesh, Jammu Kashmir (UT), and Uttrakhand. Due to diverse agro-climatic conditions in Himanchal Pradesh, the crop is grown around the year in one or another region. Plane area's consumers prefers for hill grown garden pea because of their characteristics flavour, sweetness and freshness.

Pea breeding is the fundamental goal to develop high yielding variety. Targeting varieties for a particular agro-ecological zone may be helpful. Genetic potential is best exploited in environments where some varieties have been established. Therefore, discovering new varieties with high genetic yield potential is vital for improving pea germplasm. Increasing genetic variability in garden pea remains crucial for the success of crop breeding programs. This is due to the diversity of a crop plays a significant role in determining the efficiency of selection aimed at enhancing it. When it comes to determining which character exhibits the greatest amount of variability, one cannot solely rely on the supreme variability present in different characters. Comparing the phenotypic and genotypic variation coefficients provides a consistent measure of population variability. To accurately measure variation, it is necessary to separate genetic and non-genetic factors and calculate the phenotypic and genotypic variability coefficient. The more varied the early genetic material, the greater the possibility of selecting desirable types. (Vavilov, 1959). The variability can be divided can be divided into heritable and non-heritable components in a population. Greater heritability allows for selection methods to fix characters (Sharma and Bora, 2013). Keep this in view the study was aimed to recognize garden pea varieties with unique genetic variability for further improvement.

MATERIAL AND METHODS

The present study on garden pea varieties for their variability was conducted at Research Farm of School of Agriculture, Abhilashi University Mandi (H.P.). The experimental material consists of ten varieties, and their sources of procurement are listed in Table 1. The experiment was conducted with three replications in a randomized block design during the 2021-22 *rabi* season. Seed of ten varieties were sown directly in the field with a spacing of 45 cm×10 cm was kept. In order to confirm a vigorous crop stand all the recommended cultural practices were followed. Ten randomly selected plants were selected for taking observations in each variety, and excluding unhealthy plants. Also, observations were selected for taking recorded on fifteen characters *viz*., count emergence of plant per plot (%), days to 50 per cent flowering, days to first picking, number of flowers per plant, pod length (cm), seeds per pod, shelling percentage, number of pickings, Plant height at final picking (cm), number of pods per plant, pod setting (%), pod yield per plant (g), pod yield per plot (kg) and pod yield per ha (q). The mean values underwent statistical analysis for all characters using ANOVA, as suggested by Goulden (1959). The procedure given by Bourton (1952) was used to calculate the phenotypic and genotypic coefficient of variation. Heritability in the broad sense (h2) was estimated using formula suggested by Lush (1940). Additionally, the genetic advance as a percentage of the mean was calculated using the method provided by Johnson *et al*. (1955).

Table 1: List of garden pea varieties for the present study.

Varieties	Source	Varieties	Source
GS-10	Local Market (Chail-Chowk)	AS-10	Local Market (Chail-Chowk)
Maxima-3636	Local Market (Chail-Chowk)	New Zealand	Local Market (Chail-Chowk)
Pea-10	Local Market (Chail-Chowk)	Goldie	Local Market (Chail-Chowk)
V.K-90	Local Market (Chail-Chowk)	Azad Pea-3 (Check-1)	Horticulture Collage Thunag (Mandi)
NP-11	Local Market (Chail-Chowk)	Matar Ageta-6 (Check-2)	Horticulture Collage Thunag (Mandi)

RESULTS AND DISCUSSION

Analysis of variance was directed to remove variation caused by factors other than varieties. The ANOVA (Table 2) showed highly significant variation between the varieties for all the fifteen characters under study. Thus, showing the presence of sufficient genetic variation in different varieties for different traits and enhancing the scope of better selection procedures. Sharma *et al.*, (2009), Devi *et al.*, (2010), Sharma *et al.*, (2011) and Kumar *et al.*, (2015) have also found sufficient variability in their genetic materials in their respective studies.

The data from the mean performance study (Table 3) also showed significant differences, indicating sufficient variability among the characters in all investigated varieties. The result showed that Azad P-3 took superior in ten varieties for plant emergence, days to first picking and days to 50 percent flowering. For shelling percentage Maxiama-3636 observed superior over other nine varieties. New-Zealand variety observed superior over other varieties for number of seeds per pod, number of picking and pod setting traits. Goldie variety observed superior for number of pods per plant, number of flowers per plant, plant height, pod yield per plant, pod length, pod yield per ha, pod yield per plot.

Estimation of variability is essential in any breeding programme as it provides the basis for effective selection. The chances of selecting the desirable varieties become high if the variability present in the germplasm is more. In the present study, Table 4 displays various measures of variability, such as genotypic and phenotypic coefficient of variation, broad sense heritability, and genetic gain expressed as a percentage of mean. The phenotypic coefficient of variation (PCV) exceeded the genotypic coefficient of variation (GCV) for all traits studied, indicating the impact of environmental additive gene effects on trait expression. Katoch *et al.*, (2016), Gudadinni *et al.*, (2017), Barcchiya *et al.*, (2018), Kumar *et al.*, (2018) and Yumkhaibham *et al.*, (2019) also reported the higher magnitude of GCV than PCV in their respective works. The result from the this study in this context indicated that PCV and GCV were (more than 25) high observed for pod yield per plant, pod yield per plot and pod yield per ha, plant emergence (%), number of pods per plant, number of flowers per plant, but the number of pickings observed only high PCV. Kumar *et al.,* (2013), Jaiswal *et al.,* (2015), Kumar *et al.,* (2018) and Singh *et al.,* (2019) also observed high magnitude of PCV and GCV for pod yield per plant. While moderates (10-25) PCV & GCV observed for plant height and pod length (cm), but number of picking and days to first picking observed only moderate GCV. Jaiswal *et al.,* (2015) and Singh *et al.,* (2019) also reported moderate PCV and GCV pod length. Low PCV & GCV (<10) observed for days to first picking, pod setting (%), days to 50% flowering, shelling percentage, and number of seed per pod. Jaiswal *et al.,* (2015), Kumar *et al.,* (2018a), Gudadinni *et al.,* (2017), Yumkhaibham *et al.,* (2019), Kumar *et al.,* (2019d) and Singh *et al.,* (2019) reported low PCV and GCV in his study for the parameters viz. days to 50 per cent flowering and days to first picking, number of seeds per pod & shelling percentage. In this study, the reported low, medium, and high PCV and GCV values show a varying coefficient of variability among different characteristics, indicating significant diversity in varieties.

In the present study, the heritability (broad sense) was estimated to range from 46.20 to 98.48 percent. High heritability (>70%) was observed for the traits viz. plant emergence (98.48%), days to 50% flowering (98.14%), pod yield per ha (97.41%), pod yield per plant (97.38%), number of pods per plant (96.67%), pod yield per plot (96.65%), number of flowers per plant (96.01%), number of seed per pod (93.49%), plant height (87.18%), shelling percentage (86.83), pod length (76.85%) and number of picking (74.11%). Similar findings for high heritability have also been reported earlier by Kumari *et al.* (2008) for shelling percentage and number of pods per plant, Singh *et al.* (2011) and Sharma and Bora (2013) reported high heritability for plant height, Jaiswal *et al.* (2015) for plant height and days to 50 per cent flowering, Gudadinni *et al.,* (2015) for pod yield per plant, pod length, plant height, number of seeds per pod, shelling percentage, number of pods per plant and days to 50 per cent flowering, Barcchiya *et al.,* (2018) for pod yield per plant, pod length, plant height, shelling percentage, days to 50 per cent flowering and number of pods per plant, Kumar *et al.,* (2018) for seed yield per plant, pod length, plant height, number of seeds per pod, days to 50 per cent flowering and number of pods per plant, Kumar *et al.,*(2019) for green pod yield per plant, pod length, plant height, number of seeds per pod, number of pods per axil, 100- seed weight, days to 50 per cent flowering and number of pods per plant and Singh *et al.,* (2019) for pod yield per plant, pod length, plant height, number of seeds per pod, days to 50 per cent flowering and number of pods per plant. Moderate heritability (40-70%) was observed for only pod setting (46.20%), days to first picking (64.29). While Pallavi *et al.,* (2018) and Singh and Dhall (2018) reported moderate heritability for days to first picking.

High heritability indicates that a significant portion of the character's determination is due to genetics, and it can be used to increase yield. Pod yield per plant, which exhibits high heritability, may be attributable to greater contribution from additive genetic components in the inheritance of these traits.

Genetic advance as per cent of mean was founded high (more than 30%) for pod yield per plant (99.71%), pod yield per plot (97.43%), pod yield per plot (97.30%), plant emergence (65.15%), number of pods per plant (56.99%), number of flowers per plant (54.85%) and number of picking (40.90%). Kumar *et al.,* (2016) and Singh *et al.,* (2019) in their works reported high genetic gain for pod yield per plant. Moderate (20-30%) genetic advance as per cent of mean was observed only for plant height (28.12%). Low (less than 20) genetic advance as per cent of mean was reported for pod setting (2.99%), days to 50% flowering (10.70%), days to first picking (13.72%), shelling % (13.74%), number of seed per pod (18.80%) and pod length (19.87%). Gudadinni *et al.,* (2017) reported low genetic advance as per cent of mean for shelling percentage and pod length.

In a breeding programme, though heritability (broad sense) measures the extent of variation passing to the progeny, but it alone doesn't provide the idea of effective selection among the genotypes at the genetic level because it includes both additive and non-additive gene action. Therefore, the estimation of genetic advance as percent of mean is important for effective selection along with heritability. In the current study, high heritability values coupled with high genetic advance as per cent of mean was observed for plant emergence (98.48% and 65.15), number of pods per plant (96.67% and 56.99%), number of flowers per plant (96.01% and 54.85%), number of picking (74.11% and 40.90%), pod yield per ha (97.41% and 97.30%) and pod yield per plot (96.64% and 97.43%). The results suggest that these traits are primarily controlled by additive gene action and can be improved through phenotypic selection. High heritability with moderate genetic advance as percent of mean was observed only for plant height (87.18% and 28.12%). The results suggest the importance of additive gene action in the inheritance of these traits. Improvement can be achieved through phenotypic selection. Low genetic gain values were observed for pod setting (2.99%), days to 50% flowering (10.70%), days to first picking (13.72%), shelling % (13.74%), number of seed per pod (18.80%) and pod length (19.87%) in spite of having high to moderate heritability, which means selection in these characters shall not prove to be effective for the improvement of the characters

Table 2: Analysis of variance for 15 characters of garden pea.

Source of variation	DF	CPR	DFP	DF (50%)	SP	NPP	NSP	NFP	PS	NP	PH	PY	PL	PYH	PYP
Replication	2	5.191	8.533	1.433	3.233	0.884	0.02	1.621	8.434	0.4	11.888	329.619	0.399	28.763	0.03
Treatment	9	783.887*	340.533*	98.552*	45.158*	132.243*	2.347*	131987*	17.368*	2.059*	569.486*	15037.722*	2.237*	4419.361*	1.788*
Error	18	4.017	53.2	.0619	2.173	1.5	0.053	1.805	4.856	0.215	26.622	133.507	0.204	38.872	0.02

*Significant at 1% level, CPR- Cout. plant emergence per plot, DFP- Days to first picking, DF (50%) Days to fifty percent flowering, SP- Shelling percentage, NPP- Number of pods per plant, NSP- Number of seeds per pod, NFP- Number of flowers per plant, PS- Pod setting (%), NP-Number of pickings, PH-Plant height, PY- Pod yield per plant (g), PL- Pod length (cm), PYH- Pod yield per ha (q) and PYP- Pod yield per plot (kg).

Table 3: Mean performance of ten varieties of garden pea.

Varieties	CPE	DFP	DF	SP	NPP	NSP	NFP	PS	NP	PH	PY	PL	PYH	PYP
GS-10	52.24	120.00	110.00	53.04	23.33	9.00	25.90	90.08	3.67	83.47	113.87	7.67	83.81	1.68
Maxima-3636	45.60	122.00	111.67	58.00	18.80	10.00	19.30	97.40	3.33	87.25	83.82	7.00	75.83	1.52
Pea-10	13.41	127.00	115.33	48.40	10.83	9.00	11.50	94.17	2.33	81.66	44.49	7.00	10.37	0.21
VirKrisma-90	55.75	121.00	110.33	56.00	27.37	9.00	27.67	95.52	4.00	96.45	166.47	7.43	100.85	2.02
AS-10	53.24	121.00	112.00	52.94	25.10	10.00	25.97	94.99	3.00	93.12	146.33	7.70	90.83	1.79
NP-11	58.10	120.00	109.00	55.09	28.17	8.00	28.87	97.57	4.00	103.66	202.62	8.17	109.84	2.20
New Zealand	60.04	123.00	112.67	55.07	30.00	10.6	30.67	97.84	4.67	107.29	234.60	8.57	113.35	2.28
Goldie	62.51	124.00	111.00	53.09	32.87	10.0	33.27	97.62	4.00	109.90	257.14	8.70	119.00	2.38
AzadP-3	70.00	90.00	96.33	52.50	20.80	9.00	21.30	94.09	3.00	93.45	112.56	6.57	80.17	1.60
MaterAgeta-6	35.00	110.67	101.33	44.54	17.37	8.00	18.00	96.44	2.00	63.84	75.18	6.00	14.41	0.27
Mean	50.59	117.87	108.97	52.87	23.46	9.27	24.24	95.57	3.40	92.01	143.71	7.48	79.85	1.60
CV	3.96	6.19	0.72	2.79	5.22	2.49	5.54	2.31	13.63	5.61	8.04	6.04	7.81	8.96
SEm ±	1.16	4.21	0.45	0.85	0.71	0.13	0.78	1.27	0.27	2.98	6.67	0.26	3.60	0.08
CDat5%	3.44	12.51	1.35	2.53	2.10	0.40	2.30	3.78	0.80	8.85	19.82	0.78	10.70	0.25
Minimum	13.41	90.00	96.33	44.54	10.83	8.00	11.50	90.08	2.00	63.84	44.49	6.00	10.37	0.21
Maximum	70.00	127.00	115.33	58.00	32.87	10.66	33.27	97.84	4.67	109.90	257.14	8.70	119.00	2.38

CPR- Cout. plant emergence per plot, DFP- Days to first picking, DF (50%) Days to fifty percent flowering, SP- Shelling percentage, NPP- Number of pods per plant, NSP- Number of seeds per pod, NFP- Number of flowers per plant, PS- Pod setting (%), NP-Number of pickings, PH-Plant height, PY- Pod yield per plant (g), PL- Pod length (cm), PYH- Pod yield per ha (q) and PYP- Pod yield per plot (kg).

Table 4: Coefficient of variation, heritability, genetic advance and genetic advance as % mean for 14 characters of garden pea.

Characters	*GCV*	*PCV*	*H (%)*	*GA*	GAM*(%)*
Count. Plant emergence(%)	31.87	32.12	98.48	32.96	65.15
Days to first picking	8.30	10.36	64.29	16.17	13.72
Days to 50%flowering	5.24	5.29	98.14	11.66	10.70
Shelling(%)	7.16	7.68	86.83	7.27	13.74
Number of pods per plant	28.14	28.62	96.67	13.37	56.99
Number of seeds per pod	9.44	9.76	93.49	1.74	18.80
Number of flowers per plant	27.17	27.73	96.01	13.30	54.85
Pod setting (%)	2.14	3.14	46.20	2.86	2.99
Number of pickings	23.06	26.79	74.11	1.39	40.90
Plant height(cm)	14.62	15.66	87.18	25.87	28.12
Pod yield per plant	49.05	49.70	97.38	143.29	99.71
Pod length(cm)	11.01	12.55	76.85	1.49	19.87
Pod yield per ha(q)	47.86	48.49	97.41	77.69	97.30
Pod yield per plot(kg)	48.11	48.94	96.65	1.55	97.43

GCV- Genotypic Coefficient of Variation, PCV- Phenotypic Coefficient of Variation, H- Heritability GA- Genetic Advance, GAM (%) - Genetic Advance value % means

CONCLUSIONS

The current study founded substantial variation among all varieties, with significant differences in all studied characters. The traits that exhibited high values for GCV, heritability, and genetic advance as a percentage of the mean were count of plant emergence per plot (%), number of pods per plant, number of flowers per plant, pod yield per plant (g), plot (kg), and hectare (q). Therefore, when selecting for higher yield in garden peas, it is important to consider these characteristics. The largely capable varieties that showed high values for these characteristics during the study were Goldie, New-Zealand, and Maxima-3636. These better-quality varieties can be selected and used to develop higher-yielding crops.

FUTURE SCOPE

The foundation of the evolutionary process and the emergence of new species lies in genetic variability. As climate change, there is need to develop new varieties according to climate and for high yielding varieties. Hence study of genetic variability in present and for bright future is very important and having much scope in improving varieties and genotypes according to any conditions in future.

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