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Original scientific article

UTILIZING GENETIC VARIABILITY PARAMETERS OF GARDEN PEA (*Pisum sativum* L.) GERMPLASM FOR YIELD AND QUALITY TRAITS

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Kaur H., R. Kumar Dhall, P. Sharma (2023). *Utilizing genetic variability parameters of garden pea (Pisum sativum L.) germplasm for yield and quality traits*. - Genetika, Vol 55, No.3, 869-882.
In present study, 159 diverse pea genotypes were evaluated at Vegetable Research Farm, Punjab Agricultural University, Ludhiana, Punjab, India to study genetic variability, heritability and genetic advance involving 14 morphological traits. The analysis of variance showed significant differences among genotypes for all the traits under study except node at which 1st pod appears. On the basis of mean performance, the maximum yield was observed in PB-90 which was followed by PB-89 and 2009/PMVAR-6. Highest coefficient of variation was observed for number of seeds/pod and highest genotypic and phenotypic coefficients of variation were recorded for number of pods/plant followed by plant height and total yield/plant. Very high heritability estimates were observed for plant height (99.89) followed by total yield/plant (99.71) and days to 1st picking (99.43) while genetic advance as percent of mean was observed high for number of pods/plant (65.35) followed by plant height (58.66) and total yield/plant (42.17). High heritability along with high genetic advance was found for all traits under study. High heritability estimates coupled with high genetic advance reflects the presence of additive gene action for expression of these traits.
Key words: Garden pea, genetic potential, heritability, variability, yield

INTRODUCTION

Garden pea (*Pisum sativum* L.) is a winter legume grown throughout the world for human and animal consumption. It is an important vegetable crop grown for its green succulent pods and seeds which can be used either for fresh consumption or in processed forms for off season consumption. It is nutritious vegetable rich in digestible protein (21.2-32.9%), starch (36.9-49%), soluble sugars (5.3-8.3%) (DAHL *et al*., 2012). In India, it occupies 552.0 thousand hectare with production of 55.62 lakh MT during 2019-20 (ANONYMOUS, 2020). In Punjab, it

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ranks second in area among vegetable crops after potato and occupies an area of 43.89 thousand hectares with an annual production of 467.01 thousand tons (ANONYMOUS, 2021).

Being self-pollinated crop, improvement for yield and quality is mainly effected through the selection of desirable genotypes which could be possible through variability studies. It is prerequisite to study variability for yield and its attributing traits among different genotypes to accesses the potentiality of genotypes in breeding programmes. The crop improvement largely depends upon genetic variability present among available germplasm and extent to which the desirable characters are heritable (SINGH and DHALL, 2018). Garden pea possesses a huge amount of variability for various horticultural traits but still it is not utilized for its full potential. For initiating a successful breeding programme, the evaluation of genetic stocks is pre-requisite on which the future line of action is based. For this purpose, genotypes from both indigenous and exotic sources need to be evaluated for the selection of desirable traits. Thus, identification and characterization of different genotypes must be done for yield and quality traits. Hence, the present study was conducted to evaluate the extent of variability in the available germplasm through estimates of genetic components of variation including genetic coefficients of variation, heritability and genetic advance.

MATERIALS AND METHODS

The investigation entitled, "Variability studies for yield and yield attributing traits in garden pea (*Pisum sativum* L.)" was conducted during 2018-19 and 2019-20.

Location

The present study was conducted to evaluate the pea genotypes for variability studies, at vegetable research farm, Punjab Agricultural University, Ludhiana. The experimental site is located 30° 54'' North, 75° 48'' East and 247 m above sea level. The meteorological data during experimental period is represented in Figure 1 and Figure 2 for both the years (2018-19; 2019-20).

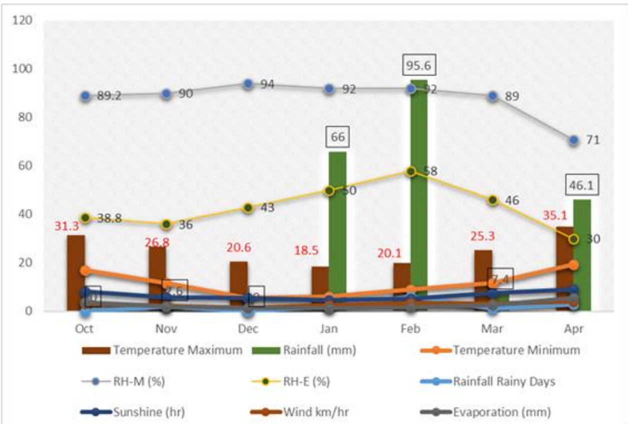

Fig. 1. Meteorological data for year 2018-19 during experimental period

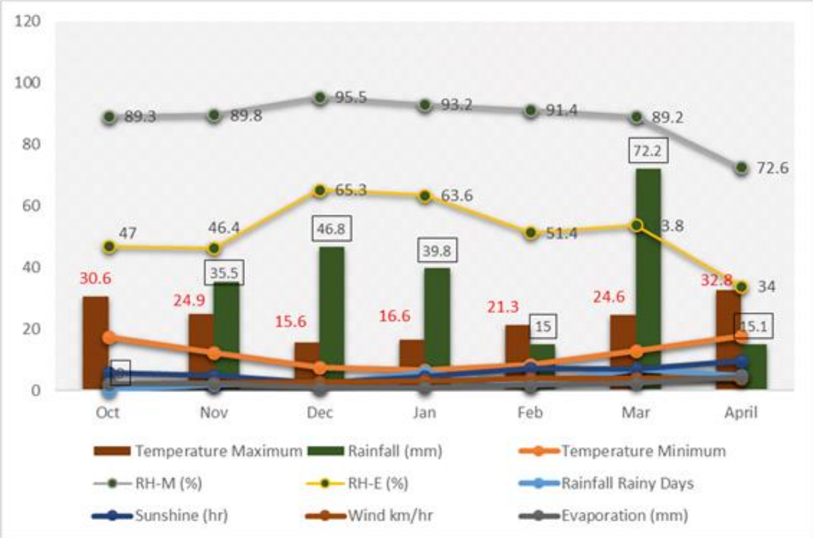

Fig. 2. Meteorological data for year 2019-20 during experimental period

Experimental material

The seeds of 159 garden pea were sown on 15-17 November 2018 and 1-7 November 2019. The sowing was done on raised beds/flat at a spacing of 30 cm × 7.5 cm. The experiment was laid out in a Complete Randomized Block Design (CRBD) with three replications. Five randomly selected plants from each replication were chosen for data collection and mean for each observation was used for statistical analysis. Crop was raised with recommended agronomic practices as mentioned in the Package of Practices of Vegetable Crops, Punjab Agricultural University, Ludhiana (ANONYMOUS, 2021).

Morphological traits studied

The observations on morphological traits viz. node at which 1st pod appears, plant height (cm), number of pods/plant, number of seeds/pod, pod weight (g), shelling percentage, pod length (cm), and total yield/plant (g) were recorded by tagging five competitive plants from each plot however, for traits viz. days to 50% flowering and days to 1st picking data was recorded on whole plot basis. Plant growth habit and plant habit was recorded at the completion of vegetative growth and ranked as 1 (sturdy), 2 (weak); 1 (spreading) and 2 (non- spreading) respectively. Seed shape was observed at seed maturity stage and ranked as 1 (round), 2 (wrinkle) and 3 (bumped) while, pod bearing habit was recorded on five selected matured plants and ranked as 1 (single), 2 (double) and 3 (mixed) following the guidelines for the conduct of test on Distinctiveness, Uniformity and Stability (DUS) on pea. The ANOVA was worked out for 159 genotypes for ten morphological traits.

Statistical analysis

Analysis of variance and error variance was worked out for homogeneity (GOMEZ and GOMEZ, 1984). The genotypic and phenotypic coefficient of variation, heritability and genetic advance were estimated according to formulae suggested by BURTON and DEVANE (1953), ALLARD (1960) and JOHNSON *et al*. (1955) respectively. The parameters of variability were estimated using following method suggested by BURTON and DEVANE (1953).

Genotypic coefficient of variation (GCV)% = $\frac{\sqrt{\sigma 2_g}}{X} \times 100$

Phenotypic coefficient of variation (PCV)% = $\frac{\sqrt{\sigma 2_p}}{X} \times 100$

Where,

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

x = Population mean of trait

Heritability estimation in broad sense was calculated as follow described by Allard (1960) for each trait.

$$H^2\ (b.s.) = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where, H^2 (b.s.) = heritability in broad sense

σ^2 g = genotypic variance

σ^2 p = phenotypic variance

The expected genetic advance from selection was obtained by ALLARD (1960).

G.A. (s) = h^2 (b) × $\sqrt{\sigma^2 p}$ × K

Where, K = 2.06 (selection differential at 5% selection intensity)

Genetic advance (% of mean) = $\frac{Genetic\ advance}{X} \times 100$

For categorizing the magnitude of different parameters, different scientists suggested the following limits. The high value of PCV and GCV was indicated by a value of >20%. The moderate and low value of PCV and GCV was indicated by a value of 10-20% and <10%, respectively as suggested by SIVASUBRAMANIAM and MENON (1973). The high amount of Heritability (H) was expressed by >60% whereas moderate value was indicated from 30-60%. The low level of heritability was expressed for a value of <30% as suggested by JOHNSON *et al*. (1955). The highest value of genetic gain was expressed by a value of >20%, moderate value by 10-20% and low level was indicated by <10% as suggested by JOHNSON *et al*. (1955).

RESULTS AND DISCUSSION

Mean performance of Genotypes

The mean performance of 159 garden pea genotypes along with range, trait mean and critical difference for studied traits is presented in Table 1.

Table 1. Mean performance of pea genotypes for various morphological traits

Genotypes	Days to 50% flowering	Node at which first pod appears	Plant height (cm)	Number of pods/ plant	Number of seeds /pod	Pod weight (cm)	Shelling %	Pod length (cm)	Days to first picking	Total yield/ plant (g)	Pod bearing habit	Plant growth	Plant habit	Seed shape
2011/ PEVAR-1	54.3	9.6	82.6	12	6.6	4.68	45.8	8.1	74.3	43.6	3	1	2	3
2012/ PEVAR-4	51.2	10.3	97.3	8.8	5.6	4.74	52.5	9.6	72.6	41.7	1	1	2	2
2014/ PEVAR-1	46.6	9.6	70	11.7	6.6	4.96	47.6	8.6	68.4	55.3	1	1	2	3
2014/ PEVAR-2	53.6	11	84	9.6	9	4.28	54.8	9.8	75.5	43.8	3	1	2	3
2014/ PEVAR-3	51.6	12.3	94.3	15.4	7.3	4.24	51.9	9.4	73.7	55.2	3	1	2	2
2014/ PEVAR-5	50	11	93.3	13.7	6.6	4.26	51.4	9	71.4	49.5	3	2	2	3
2015/ PEVAR-3	51.6	10	100.6	9.9	7.6	5.02	50.8	8.1	73.1	42.7	3	2	2	2
2015/ PEVAR-4	48.6	9.3	58.6	9.3	8.6	5.2	52.9	8.1	72.3	43.5	1	1	2	2
2015/ PEVAR-6	48	10.6	82.3	9	7.6	6.2	52.1	8.2	71.9	47.5	3	2	2	2
2016/ PEVAR-1	45.6	11.3	98.3	11.5	8.3	4.6	47	9.6	66.8	46.3	1	2	2	2
2016/ PEVAR-2	47.6	9.3	97.6	10.9	5.6	4.34	46.1	8.3	67.4	43.7	1	2	2	2
2016/ PEVAR-3	45.3	9.3	82.6	12.1	7	4.52	46.9	8.4	66.9	45.4	3	2	2	3
2016/ PEVAR-5	45.6	11	92.3	12.2	9.0	4.38	49.1	9.3	66.7	46.8	3	1	2	2
2016/ PEVAR-6	50	11.6	110.3	11.2	6.3	4.5	54.8	8.1	70.8	45.2	3	1	2	2
2017/ PEVAR-5	43.6	11.6	124.3	11.5	8	3.96	55.6	9.4	65.5	42.6	3	1	2	3
2017/ PEVAR-6	45.3	12.6	137.3	12.2	5	4.52	48.5	8.7	67.4	48.7	3	1	2	3
2017/ PEVAR-7	45.6	11.6	116.3	12.9	7.6	5.48	56.7	9.1	68.7	49.5	3	1	2	3
2018/ PEVAR-1	44	11.3	108.3	8.9	7	5.24	47.9	8.6	65.9	44.1	3	2	2	2
2018/ PEVAR-2	54.6	11	89.6	10.5	9	5.18	55.5	9.9	75.2	46.6	3	1	2	3
2018/ PEVAR-3	52.6	10.6	121.3	11.2	6.6	5.04	54.6	9.5	73.5	48.8	3	2	2	3
2011/ PEVAR-5	47	9.6	73.3	10	8.6	4.56	48.5	10	67.3	43.8	3	1	2	3
2011/ PEVAR-9	61.6	10	84.3	9	6.3	4.74	47.2	8.6	94.8	42.5	3	1	2	2
2014/ PEVAR-6	65.3	11.3	93.3	13.1	8.6	4.78	52.9	10.3	96.6	50.8	3	1	2	3
2014/ PEVAR-7	53	10	128.6	15.2	8	5.18	48.7	8	75.9	50.3	3	1	2	3
2017/ PEVAR-3	47.6	10.3	67	13.1	8.6	4.26	50.1	10.1	70.4	43.6	3	1	2	3
2018/ PEVAR-5	52.6	12.3	108.3	10.8	8.3	5.18	52.3	9.7	74.7	44.6	3	2	2	3
2015/PEVAR-5	59.4	12.3	84.6	13.1	8.3	6.32	52.7	9.9	93.9	70.8	3	1	2	2
2015/PEVAR-7	49.6	10.3	123.6	13.1	7.3	5.66	42	8.3	73.6	61.4	3	2	2	3
2016/PEVAR-4	61.6	10.3	92	17.8	6.6	4.24	48.7	8.7	95.1	62.4	3	1	2	3
2016/PEVAR-7	52.6	9.3	74.3	14	6.3	4.34	54.1	9	72.8	44.8	3	1	2	2
2016/PEVAR-8	51.4	10.3	121.6	11.9	9	4.78	55.7	9.9	71.8	47.1	3	1	2	2
Winner	30	6.4	65.4	6.5	4.5	3.08	48.2	6.1	58.4	25.8	1	2	2	2
PM-65	44.3	9.6	110.3	20.8	6.3	5.16	47	7.6	66.1	60.4	3	2	2	3
PM-69	46	10.3	110	16.1	7.6	5.34	46.9	7.3	68.9	52.4	3	2	1	1
PMR-62	69.3	14.6	98.3	25.4	8.3	4.06	47.3	8.3	97.8	65.4	3	2	1	3
PSM-3	46.6	11.6	89	14.5	6.6	4.76	56.9	8.6	69.6	50.4	3	1	2	3
MA-6	36.4	7.2	95.8	8.4	5.4	4.58	49.3	7.2	64.8	35.4	1	2	2	3
MA-7	37.5	8.4	90.4	15.1	7.2	5.46	52.7	8.1	63.5	60.5	3	2	1	3
Darl-405	41.3	7.4	81.3	14.1	5.6	3.96	49.6	7.3	67.4	51.8	3	1	1	3
DGP-207	42.3	7.6	83.6	13.8	6	3.2	55.3	5.8	68.9	42.4	3	2	2	3
NS-1202	51.5	7.6	170.6	16.7	4.3	2.66	48.4	6.1	72.8	43.5	3	1	1	2
AP-3	41.3	9.7	115	15.2	6.7	5.76	51.7	7.7	66.8	59.4	3	1	1	2
VRP-6	45.8	10.6	61	11.3	7.6	5	47.2	8.9	69.2	52.9	3	1	2	1
2014/ PMVAR-3	64	12.3	96	19.9	7.6	6.02	44.5	10.1	95.3	65.4	3	1	1	3
2016/ PMVAR-2	55.6	11.6	78.6	14.5	7.3	4.18	56.7	8.5	74.9	58.6	3	1	1	2
2016/ PMVAR-5	48	10.3	64.3	13.3	7	5.2	55.2	8.6	71.8	60.2	2	1	1	3
2012/ PMVAR-3	54	11	96.6	14.2	7.6	4.72	51.1	9.4	73.9	55.8	3	1	1	3
2012/ PMVAR-4	57	11.3	80.6	12.2	6.6	5.02	51.6	9.1	75.3	54.2	3	1	1	2
2012/ PMVAR-5	61	12	97.6	10.5	7.3	4.9	51.1	8.3	95.9	43.6	3	1	1	3
2010/PMVAR-1	61.3	12.6	127	14.5	6.6	4.98	50.9	8.9	96.1	62.2	3	1	1	1
2010/PMVAR-3	64	14.6	101	20.1	6.3	5.18	51.3	8.3	97.3	70.5	3	1	1	1
2014/ PMVAR-1	66.3	13.3	97.6	13.3	7.3	5.64	42.2	10.2	98.2	58.2	3	1	1	3
2014/ PMVAR-2	63	13.3	121.6	13.5	7.3	6.4	46.7	8.2	96.3	61.4	3	1	1	3
2014/ PMVAR-4	69	12.6	114	14.2	6.6	5.92	46.3	9.1	98.9	68.4	3	1	1	3
2014/ PMVAR-5	65	12	126	16.9	7.6	5.44	48.8	8.7	97.7	74.4	3	1	1	3
2014/ PMVAR-6	66.3	11.6	91	16.2	8.6	5.38	49.6	10.3	98.2	70.8	3	1	1	3
2016/ PMVAR-1	56	12	100.6	13.4	6.6	4.88	46.9	8.5	74.8	61.5	3	1	1	2
2016/ PMVAR-3	50.3	12	115	14.9	8.3	4.5	57.2	9.8	71.4	62.9	3	1	1	3
2016/ PMVAR-4	66	12	117.6	13.3	9.3	4.9	55.8	9	97.5	60.7	3	1	1	3
2016/ PMVAR-6	57	12.3	98	12.5	7.6	4.9	57.1	8.1	74.9	58.3	3	1	1	3
2016/ PMVAR-7	64.6	12.3	114	14.2	6.3	4.16	57.7	9.2	97.1	56.2	3	1	1	2
2016/ PMVAR-8	54.6	13	112	12	5.6	5.4	39.1	9.2	73.7	61.9	3	1	1	3
2016/ PMVAR-9	62	12.6	114.3	12.8	9.6	5.04	54.3	9.8	96.3	63.7	3	1	1	3
2017/ PMVAR-1	70	14	123.6	13.3	8.3	6.22	50.5	8.7	98.8	70.9	3	1	1	2
2017/ PMVAR-2	65	11.3	122	12.4	8	4.94	41	10.5	97.9	57.5	3	1	1	3
2017/ PMVAR-3	58.3	12	122.3	18.4	8.3	4.74	47.1	9.6	75.9	74.5	3	1	1	3
2017/ PMVAR-4	50	12.3	104	17.9	7.6	4.72	44.9	9.3	72.4	70.8	3	1	1	3

Genotypes	Days to 50% flowering	Node at which first pod appears	Plant height (cm)	Number of pods/ plant	Number of seeds /pod	Pod weight (cm)	Shelling %	Pod length (cm)	Days to first picking	Total yield/ plant (g)	Pod bearing habit	Plant growth	Plant habit	Seed shape
2017/ PMVAR-5	63.3	13	108.6	19.3	7	3.62	53.1	8.6	96.2	67.6	3	1	1	3
2017/ PMVAR-6	60.3	11.6	109.3	15.1	6.6	4.9	52.6	9.8	94.2	71.9	3	1	1	2
2017/ PMVAR-7	62.3	13.3	102.6	15.3	8	4.14	51.7	9.1	95.2	59.9	3	1	1	3
2011/PMVAR-2	61.6	12	94.3	19	6	4.92	39.4	9.1	94.9	75.9	3	1	1	3
2009/PMVAR-2	69.6	14	117.3	24.8	6.3	4.58	49.1	8.4	98.2	72.8	3	1	1	3
2009/PMVAR6	71.3	13.3	127.6	27.9	7.3	4.88	44.4	8.3	99.2	76.2	3	1	1	3
2009/PMVAR-7	67.6	12.3	121	18.1	5.6	3.42	47.2	8.2	96.3	58.9	3	1	1	3
2008/PMVAR-1	62.3	11.6	96	21.3	5.3	5.34	43	9.9	93.2	70.5	3	1	1	2
2008/PMVAR-3	72.7	14.3	103.3	22.2	5.6	5.2	46.8	8.9	99.5	74.4	3	1	1	2
2008/PMVAR-4	64	12.6	101	19.1	6	4.8	47	8.4	96.8	65.9	3	1	1	1
2008/PMVAR-5	66.6	12	113.6	16.8	7	4.68	48	8.4	94.8	58.4	3	1	1	2
Airtel	59.3	12.8	113.6	15.6	5.1	5.7	37.5	8.5	93.7	60.5	3	1	1	3
Ambassdor	66.3	13.8	125	29	5.4	3.012	45.5	8.2	97.7	62.5	3	1	1	3
Arka Sampoorna	68	13.2	77.66	22	6	5.56	33.1	7.4	98.2	60.4	3	1	1	1
Arka Ajit	66.3	11.9	97	23.7	5.3	5.1	43.8	8.1	93.1	65.9	3	1	1	2
Angoori	62.6	10.84	85.6	16.3	8.4	4.98	47.4	9.4	94.5	75.4	3	1	1	2
Arkel	44.3	11.4	122.6	37.2	6	4.94	43.5	7.4	70.4	30.4	3	1	1	2
Aryaveer	62	12.11	99	25.6	6	4.62	48.8	8.1	96.3	71.4	3	1	1	3
Buddy	62.6	13.26	111	18.7	5.4	5.28	38.7	7.7	96.9	74.5	3	1	1	2
Boogie	60	12.26	80	12.7	5.5	5.22	43.1	8.3	93.8	61.9	3	1	1	2
Bliss	61.3	11.2	93.6	26.8	6.1	3.38	53.9	9.6	95.3	44.93	3	1	1	2
Bilaspur Lincoln	69	19.53	190	11.8	5.5	5.12	47.9	7.6	98.4	32.25	3	2	1	2
Cascatia	66	14.6	145.6	14.8	4.3	4.24	22.7	6.8	94.8	61.2	3	1	1	2
CHP-1	66.6	13	104.3	20.2	7.3	5.82	37.3	8.3	95.3	72.5	3	1	1	3
CHP-2	70.1	12.6	110	20.8	4.6	3.9	47.4	8.2	99.1	74.5	3	1	1	3
C-308	65.6	10.3	100	22	8	3.96	48.2	8.9	93.7	72.5	3	1	1	2
C-400	68.3	12.3	117.6	18.6	7.6	3.8	47.2	9.7	98.2	70.8	3	1	1	2
CHPMR-2	68.3	11.6	98	19.7	6	3.64	54.6	7.9	98.8	67.8	2	1	1	1
Darl-104	68	13	103.3	11.3	6.6	4.08	46.4	7.8	97.7	42.4	3	1	1	1
Darl-404	46.6	9.6	78.6	10.1	5.6	4.34	48.3	8.4	68.4	41.4	3	1	2	3
Dwarf grey sugar	57	17.3	169.3	21.3	5.6	4.7	47.1	7.8	75.1	65.4	3	2	1	3
Espirit	62.6	12.6	104.3	18.5	6	3.58	55	7.7	96.3	62.5	2	1	2	2
GP No. 2	61.3	12.3	106	19	6	4	48.1	8	92.7	52.8	3	1	1	2
Electra	63.3	12.6	94.3	18.1	6.6	3.18	47.8	7.7	97.4	64.5	2	1	1	3
Easy Peasy	61	11.3	74	16.5	5.6	4.16	46.4	8.4	93.7	64.4	3	1	2	3
E-1	64.3	11.6	62	15.2	5.4	4.72	43.9	6.9	97.9	55.3	3	1	1	3
GP No.1	61	11	110	14.3	7.3	4.1	47.9	8.9	93.3	72.6	3	1	1	3
GP No. 3	63	10.3	76	14.9	7.3	3.76	42.5	9.1	94.2	52.8	3	1	1	2
GP No.6	61	11	83	14.2	7	4.8	46.8	10.3	92.1	57.6	3	1	1	2
Heildi	56	11.3	84.6	18.4	6.3	3.08	47.2	6.8	95.2	60.2	3	1	2	3
E-1	64.3	11.6	62	15.2	5.4	4.72	43.9	6.9	97.9	55.3	3	1	1	3
IC-36	57.6	12.6	93.3	18.4	7	3.76	46.2	8.7	74.9	39.2	3	1	1	1
Kinnouri	63.6	15	247.3	14.3	6.3	3.6	52.5	7.1	97.3	38.4	3	2	1	2
KS-20	59	12.6	143.3	10	7.3	8.24	40.8	9.1	91.9	52.4	3	1	1	1
KS-205	61.6	13	94	17.2	7.3	5.02	53.5	9.1	94.6	55.6	3	1	2	3
Marina	49.6	10.6	90.3	16.3	7.3	5.22	49.5	8.5	90.1	70.4	3	1	2	3
Mithi Phali	60	13.6	139	13.4	6	6.22	38.4	8.4	91.7	66.2	3	1	1	2
JM-1	70	11.3	101	14.8	4.3	3.24	53	7.9	98.8	45.9	3	1	1	3
JM-5	66	14	179	22.5	6	5.78	38.8	6.9	96.3	70.5	3	2	1	3
JP-19	68.3	13.3	200	25.2	6.6	3.18	54.5	7.1	98.5	45.8	3	2	1	1
JP-62	58.3	16.6	185.3	14.7	6.3	3.4	53	6.5	89.5	44.8	3	2	1	1
JP-179	62.6	14.6	196.3	31.5	6	3.82	53.6	6.7	92.3	54.8	3	2	1	3
JP-501	60.3	13.6	171.3	18.4	7.6	5.78	38.5	6.5	93.2	66.4	3	2	1	3
JP-625	58.3	14.6	158.3	27	6.6	5.24	42.7	6.4	88.7	72.9	3	2	1	1
JP-825	69.3	14.3	169.6	23.1	4	2.4	45.3	6.2	98.3	44.2	3	2	1	1
Jagatpura	71.6	12.6	102.6	20.8	6	4.68	54.4	8.4	99.6	49.5	3	1	1	3
Legacy	54.3	10.6	101.6	13.5	6.3	3.52	50.5	8.5	94.5	45.2	2	1	2	2
Larex	54.3	12.6	126.3	14.9	5.6	3.38	58.8	6.4	95.1	58.2	3	1	2	3
Little marvel	56	11.3	188.3	16.8	6.3	4.32	51.4	9	78.7	45.8	3	1	1	1
LPF-48	61.6	13	94.3	15.8	5	4.38	51	7.6	92.8	65.4	3	1	1	1
Organ Sugar Pod	66.6	15.3	119.3	15	4.6	5.14	52	8.2	96.3	65.4	3	1	1	1
Namdhari (Afila)	64.3	10	104.3	15	6.6	7.36	48.7	8.9	94.3	68.5	3	1	1	2
NDVP-8	63.3	11.6	84.3	12.2	8.3	5.98	48.1	8.6	95.4	65.4	3	1	2	2
NDVP-104	63.3	12.6	104.3	16	6.3	5.72	49.1	8.6	94.8	69.5	3	1	1	2
Nirali	60	11.3	76.3	13.6	7	4.88	50.5	9	90.6	64.8	3	1	1	2
Nepal	69	12.3	187	14.6	5.6	3.14	47.9	5.1	98.7	41.8	3	2	1	1
Sugar Daddy	64	12.6	194.6	17.7	5.3	2.74	48.8	6.3	94.3	45.8	3	1	1	1
Sugar Bon	66.6	12.3	190.3	25.6	5.3	2.72	54.8	6.3	96.5	66.2	3	1	1	1
Sugar Snappy	63.3	14.3	94.3	10.8	6.3	7.84	39.2	8.3	93.8	72.8	3	1	2	2
Seena	54	10.6	89.3	13.9	7.6	3.94	45.6	9	90.5	62.4	2	1	1	2
Sparkle	44.6	9.3	106.3	13	5.6	4.28	50.4	7.3	78.4	53.4	2	1	2	2

Genotypes	Days to 50% flowering	Node at which first pod appears	Plant height (cm)	Number of pods/ plant	Number of seeds /pod	Pod weight (cm)	Shelling %	Pod length (cm)	Days to first picking	Total yield/ plant (g)	Pod bearing habit	Plant growth	Plant habit	Seed shape
Tiger	57.3	11	91	14	7	3.6	54.7	9.5	80.5	64.3	2	1	2	2
Tarvedo Sugar II	64.3	10.3	121.6	22.2	5	3.98	39.1	8.4	94.8	45.8	3	1	1	3
Tarvedo Sugar	67.3	13.3	86.6	17.7	5.3	3.94	38.4	7.6	97.7	50.5	3	1	1	3
PB-87	59	12.6	101	27.2	7	4.38	53	8.4	90.3	74.2	3	1	1	3
PB-89	64	10.6	108.3	28	7	4.2	52.3	9.3	94.3	78.5	3	1	1	3
PB-90	64.3	11.3	117.3	30	9.3	3.64	54.3	10.4	94.8	80.9	3	1	1	2
PS-8	71.3	13.3	110	16.9	5	3.18	57.5	7.5	99.3	49.7	3	1	1	3
PS-11	72	11.6	168	23.5	7.6	3.48	55.2	7	98.9	54.5	2	2	1	1
PS-19	68	12.3	177.6	16.3	6	3.66	55.9	7.3	97.6	56.8	3	2	1	3
PS-24	64.6	10.6	117.6	24.3	5.6	4.36	55.5	7.6	97.9	55.4	3	2	1	3
Palam Priya	68	11.6	100	17	8	4.96	55.2	8.6	97.3	70.2	3	1	1	3
PEW-9	64.6	13.3	129	12.8	7.6	4.46	58.8	8.3	94.3	52.8	3	1	2	3
PMR-19	60	11.6	84	19.2	6.6	4.3	48.9	7.6	90.5	58.5	3	1	2	3
PMR-20	64.6	12.3	111.3	25.2	6	4.78	45.1	7.3	94.3	65.2	3	1	1	1
UN-53-6-W	59.3	10.3	99.3	11.9	7	3.6	54.6	8.1	90.4	40.8	3	1	2	1
Vasundra	66	12.3	79.3	13.4	7.3	5.1	49.5	8.9	96.5	65.2	3	1	1	3
PS-8	71.3	13.3	110	16.9	5	3.18	57.5	7.5	99.3	49.7	3	1	1	3
VP-434	61.6	12.6	108.6	12.4	6.3	3.66	55	8.7	91.5	43.3	3	1	2	2
VRP-7	59.6	12.3	107.3	20.5	6.6	4.84	47.5	8.7	90.8	70.4	3	1	1	1
VRP-22	63.3	12	119.3	23.8	7.6	4.66	48	8.6	93.5	65.8	3	1	2	1
VRP-233	70.3	13.6	118.3	13.5	6.3	5.02	50.3	9	98.7	60.7	3	1	1	2
Mean	59.16	11.99	111.3	16.43	6.93	4.64	50.04	8.51	87.52	57.32	-----	-----	-----	-----
Range	30.6-72.8	6.4-19.5	57.4-248.5	6.5-37.2	4.2-9.6	2.4-8.24	22.7-58.8	5.1-10.5	58.4-99.6	25.8-80.9				
CD (5%)	1.61	0.86	1.67	0.71	0.49	0.22	1.24	0.35	1.46	0.99				
CD (1%)	2.10	1.14	2.20	0.94	0.63	0.30	1.62	0.46	1.92	1.29				

Pod bearing habit: (1. single, 2. double, 3. mixed) ; Plant growth: (1. sturdy, 2. Weak); Plant habit: (1. spreading, 2. non-spreading); Seed shape: (1. round, 2. wrinkle, 3. bumped)

Days to 50% flowering

Days to 50% flowering are an indicator of earliness. Early maturing varieties are generally preferred because of price advance during early season. Secondly, it fits well in various crop rotations including rice-wheat rotation. Similarly, the late maturing varieties have also somewhat the same advantage because even at the end of season, price generally goes up. The genotype Winner took minimum days to 50% flowering followed by genotypes MA-6 (36.4) and MA-7 (37.5), while maximum days to 50% flowering were observed for genotype 2008/PMVAR-3 (72.7) followed by PS-8 (71.3) and CHP-2 (70.1).

Node at which first pod appears

Node at which first pod appears is an important trait affecting early yield. The genotypes in which the first flower appears at lower nodes generally tend to yield early than genotypes which produce flowers at relatively upper nodes. Therefore, these types of genotypes are preferred for selection keeping in view the early yield aspect. The genotype Winner (6.4) bears pod at lowest node among all genotypes followed by MA-6 (7.2) and Darl-405 (7.4). However, Bilaspur Lincoln (19.53) bears pod at highest node followed by Dwarf Grey Sugar (17.3) and JP-62 (16.6).

Plant height (cm)

Plant height has a special significance particularly for maturing groups as early maturing varieties are short in stature. Whereas, tall type varieties tend to bear pods at higher nodes and continue to bear pods at later plant growth also. The genotype 2015/PEVAR-4 (58.6 cm) had shortest height among all the genotypes, followed by VRP-6 (61 cm) and E-1 (62 cm). However, Kinnouri genotype was tallest with height of 247.3 cm followed by JP-19 (200 cm) and JP-179 (196.3 cm).

Number of pods per plant

Number of pods per plant is an important trait from yield perspective because it directly related to plant yield. The genotype Winner (6.5) had minimum number of pods per plant followed by MA-6 (8.4) and 2012/PEVAR-4 (8.8). While, maximum number of pods per plant were recorded in genotype 2018/PMVAR-4 (37.2) and followed by JP-179 (31.5) and PB-90 (30).

Number of seeds per pod

Number of seeds per pod is an important yield component and directly related to yield. The minimum number of seeds per pod was observed in genotype JP-82 (4.0) followed by JM-1 (4.3) and Cascatia (4.3). However, maximum number of seeds per pod was recorded in 2016/PMVAR-9 (9.6) followed by PB-90 (9.2) and PB-89 (9.0).

Pod weight (g)

Pod weight is an important yield component which directly influences the yield of plant**.** Therefore pod weight needs due consideration while making selection for yield. Variation for this trait was found to be quite high which might be responsible for the wide range in yield potential of different genotypes. The minimum pod weight was observed in genotype JP-825 (2.40g) followed by NS-1202 (2.66g) and Sugar Bon (2.72). The KS-20 genotype was found to have maximum pod weight (8.24g), followed by Sugar Snappy (7.84g) and Namdhari (Afila) (7.36g).

Shelling percentage

Shelling percentage is an important trait related to processing as high shelling percent varieties have high final yield of processed product. The genotype Cascatia (22.7%) had minimum shelling percentage followed by Arka Sampoorna (33.1%) as both these genotypes are edible podded types. While, the maximum shelling percentage was observed in Larex and PEW-9 (58.8%), followed by 2016/PMVAR-7 (57.7%) and PS-8 (57.5%).

Pod length (cm)

Pod length is an important trait that indirectly affects the yield. Long pods are more preferred by consumers as long contains more number of seeds. The genotype Nepal had shortest pod length (5.1cm) followed by DGP-207 (5.8 cm) and NS-1202 (6.1 cm). However, pod length was observed to be more in genotype 2017/PMVAR-2 (10.5 cm), followed by PB-90 (10.4 cm) and 2014/PEVAR-6 (10.3 cm).

Days to first picking

This trait is an important from market value because early varieties fetch more price during early season, and late varieties gives good economic advantage at the end of season. The less number of days to first picking were taken by genotype Winner (58.4) followed by MA-7 (63.5) and MA-6 (64.8). The maximum value for this trait was observed in genotype Jagatpura

(99.6) followed by 2008/PMVAR-3 (99.5) and CHP-2 (99.1).

Total yield per plant (g)

Total yield is the main breeding objective which is dependable on its attributing traits which are directly or indirectly related to yield and contributes towards it. The highest yielding genotype was PB-90 (80.9g) followed by PB-89 (78.5g) and 2009/PMVAR-6 (76.2g). However, the minimum yield was observed in Winner (25.8g) followed by 2018/PMVAR-4 (30.4g) and Bilaspur Lincoln (32.25g).

Pod bearing habit

Pod bearing habit is an important trait because double podded genotypes are preferred over single or mixed type genotypes. Out of 159 genotypes, 7 genotypes were found single pod bearing genotype, 10 double pod bearing habit and 142 mixed types. The genotypes with doubled podded habit were 2016/PMVAR-5, CHPMR-2, Espirit, Electra, Legacy, Seena, Sparkle, Tiger, Tardio and PS-11.

Plant habit (Spreading/ non-spreading)

Genotypes having plant habit as non-spreading nature are early in maturity and low yielder. However, spreading type genotypes tend to bear pods late and come in mid and late maturity group. The observed data for plant habit showed that out of 159 genotypes, 105 were found spreading while 54 genotypes were non-spreading in nature.

Plant growth (Sturdy/ Weak)

The sturdy plant growth is preferred as the plant can bear the adverse climatic conditions easily. Observed data for growth habit revealed that out of 159 genotypes, 127 were found sturdy however, 32 genotypes were weak in plant growth.

Seed shape (Round/ wrinkle/ bumped)

Seed shape (after drying) is an indicator of sweetness in the pods. It was found that out of 159 genotypes, 26 genotypes were round, 52 were wrinkle while 78 genotypes had bumped seed shape.

Variability Parameters

The mean sum of square for studied morphological traits among 159 genotypes were significant for all studied traits except for node at which first pod appears (Table 2), indicating the presence of variability in the experimental germplasm.

Apart from mean performance, genotypes under study were also evaluated for the extent of variability through genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance (GA) as percent mean (Table 3) because only rough estimates of variability can be obtained from a range of mean values. The estimation of phenotypic and genotypic coefficient of variation has wider use to determine extent of variability as compare to rough estimates from range of mean value of different genotypes for different trait.

Table 2. Analysis of variance for ten traits in pea genotypes

Traits	Mean sum of square			F-ratio	
	Replicates df=2	Genotypes df=158	Error df=316	Replicates	Genotypes
Days to 50% flowering	4.87	226.6**	1.01	4.86	226.22
Node at which 1st pod appears	0.15	9.29	0.29	0.52	32.16
Plant height	0.90	3021.5**	1.09	8.49	2929.61
Number of pods/plant	0.58	82.30**	0.20	2.96	417.93
Number of seeds/pod	1.54	3.67**	0.09	16.58	39.40
Pod weight	0.06	2.59**	0.02	2.84	138.72
Shelling %	13.86	87.62**	0.60	23.09	145.91
Pod length	0.90	3.24**	0.05	18.43	66.63
Days to 1st picking	21.73	435.5**	0.84	25.91	523.03
Total yield/plant	0.84	392.48*	0.38	21.92	1054.51

* Significant at 5% level of probability, ** Significant at 1% level of probability

In present study the GCV and PCV ranged from 10.95% and 11.06% for shelling percentage to 31.84% and 31.95% for number of pods per plant respectively (Table 3). The maximum expression of genotypic coefficient of variation was observed for number of pods per plant (31.84%) followed by plant height (28.49%), total yield per plant (20.50%) (Figure 3). Similar finding was reported for high GCV value by YUMKHAIBAM *et al*. (2019) and AFREEN *et al*. (2017). Moderate level of expression was found for pod weight (19.94%), node at which first pod appears (14.44%), number of seeds per pod (15.77%), days to 50% flowering (14.64%), days to first picking (13.75%), shelling percentage (10.95%), Pod length (12.12%). These results showed conformity with results of YUMKHAIBAM *et al*. (2019), GEORGIA *et al.* (2016) and AFREEN *et al.* (2017).

Table 3. Range, Mean, Coefficient of variations, Heritability (broad sense), Genetic advance and Genetic advance of yield and quality traits

Traits	Range		Mean	CV %		H^2 (bs)	GA	GAM
	Min	Max		PCV	GCV	%		%
Days to 50% flowering	30.6	72.8	59.16	14.74	14.64	98.68	17.73	29.97
Node at which 1st pod appears	6.4	19.5	11.99	15.12	14.44	91.22	3.41	28.42
Plant height (cm)	57.4	248.5	111.3	28.51	28.49	99.89	65.33	58.66
Number of pods/plant	6.5	37.2	16.43	31.95	31.84	99.29	10.74	65.35
Number of seeds/pod	4.2	9.6	6.93	16.37	15.77	92.75	2.17	31.29
Pod weight	2.4	8.24	4.64	20.13	19.92	97.87	1.89	40.59
Shelling %	22.7	58.8	50.04	11.06	10.95	97.97	10.98	22.33
Pod length	5.1	10.5	8.51	12.39	12.12	95.63	2.08	24.41
Days to 1st picking	58.4	99.6	87.52	14.13	14.09	99.43	25.72	28.25
Total yield/plant	25.8	80.9	57.32	20.53	20.50	99.71	24.27	42.17

The PCV values were maximum for number of pods per plant (31.95%) followed by plant height (28.51%) and total yield per plant (20.53%). Similar findings were reported by LUTHRA *et al.* (2020), RAMJAN and CHANU (2019) and KATOCH *et al.* (2016). Moderate level of expression was found for number of seeds per pod (16.37%), node at which first pod appears (15.12%), days to 50% flowering (14.74%), days to 1st picking (13.79%), pod length (12.39%), shelling percentage (11.06%). Similar findings were corroborated by YUMKHAIBAM *et al.* (2019), GUADADINNI *et al.* (2017) and AFREEN *et al.* (2017).

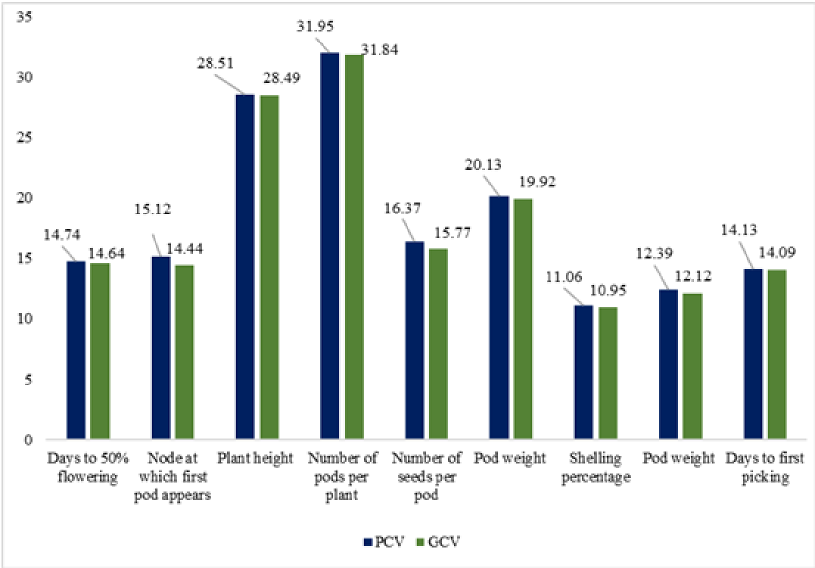

Fig. 3. Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) of yield and quality traits

In present study, the PCV values were near to GCV for studied traits indicates that high contribution of genotypic effect for phenotypic expression of such traits. Similar results were found by YUMKHAIBHAM *et al.* (2019), KATOCH *et al.* (2016) and GARIMA and LAVANYA (2012). We conclude that expression of traits was highly controlled by genetic factors than environmental factors. Thus selection could be performed on the basis of phenotypic performance.

Heritability

The idea about proportion of heritable variation in total variation can be taken from heritability estimates because GCV estimates gives information about the amount of variation present for specific traits only. Therefore, heritability estimates were calculated in present study. The results revealed that heritability estimates were high for all studied traits (Table 3). The high heritability (broad sense) estimates for all traits under studied were observed with range value from 91.22 to 99.89% (Figure 4). Similar results were observed by LUTHRA *et al.* (2020), AFREEN *et al.* (2017) and GEORGIA *et al.* (2016). High heritability estimates for studied traits revealed that selection could be effective for these traits. The environment had less influence on expression of traits, if high heritability estimates were observed for concerned traits (GANGASHETTY *et al.* 2013).

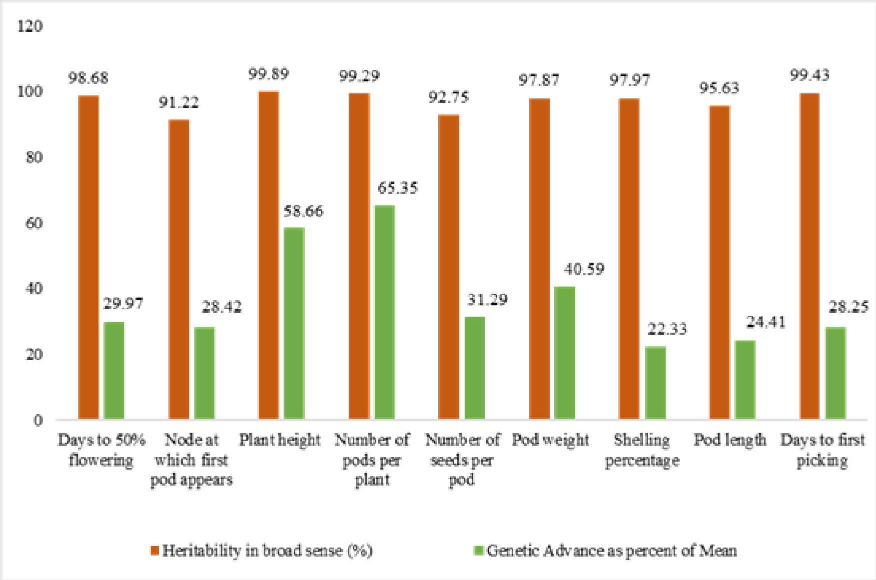

Fig. 4. Heritability (in broad sense) and genetic advance of yield and quality traits

Genetic Advance

The reliable information regarding effectiveness of selection through genetic advance as percent mean is essential to know about the genotypic value of available germplasm. There is a direct relationship between heritability and response to selection, which is referred as genetic advance (DYUGEROVA and VALCHEVA, 2014). High heritability estimates with high genetic advance offer effective selection in breeding programmes (LARIK *et al.* 2000). The results showed that genetic advance as percent mean was high for shelling percentage (66.92) followed number of pods/plant (65.35), plant height (58.66), total yield /plant (41.02), pod weight (40.59), number of seeds/pod (31.29), days to 50% flowering (29.97), node at which 1st pod appears (28.42), days to 1st picking (28.25) and pod length (24.41) (Figure 4). Similar results were found by GUDADINNI *et al.* (2017), ROSMAINA *et al.* (2016) and GEORGIA *et al.* (2016). High heritability with high genetic advance reflects the presence of additive gene action for expression of these traits.

CONCLUSION

Genetic variability study through mean, coefficient of variation, heritability and genetic was carried out for yield and yield attributing traits among 159 pea genotypes. The results revealed that high phenotypic and genotypic coefficient of variation were recorded for total yield/plant, number of pods/plant and plant height indicating better scope of phenotypic and genotypic selection to enhance total yield. Genetic advance as percent mean was observed to be high for shelling percentage followed number of pods per plant, plant height, total yield per plant, pod weight, number of seeds/pod, days to 50% flowering, node at which 1st pod appears, days to 1st picking and pod length along with high heritability which clearly indicates the expression of additive gene action and selection would be highly effective for improvement of these traits.

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KORIŠĆENJE PARAMETARA GENETIČKE VARIJABILNOSTI GERMPLAZME BAŠTENSKOG GRAŠKA (*Pisum sativum* L.) ZA OSOBINE PRINOSA I KVALITETA

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Izvod

U ovoj studiji, 159 različitih genotipova graška je procenjeno na farmi za istraživanje povrća, Poljoprivrednog univerziteta u Pendžabu, Ludijana, Pendžab, Indija da bi se proučavala genetska varijabilnost, naslednost i genetski napredak koji uključuje 14 morfoloških osobina. Analiza varijanse pokazala je značajne razlike među genotipovima za sve ispitivane osobine osim nodusa na kome se pojavljuje prva mahuna. Na osnovu srednjih performansi, maksimalni prinos je primećen kod PB-90, a zatim slede PB-89 i 2009/PMVAR-6. Najveći koeficijent varijacije zabeležen je za broj semena/mahuna, a najviši genotipski i fenotipski koeficijenti varijacije zabeleženi su za broj mahuna po biljci, zatim visinu biljke i ukupan prinos po biljci. Veoma visoke procene heritabilnosti primećene su za visinu biljke (99,89), zatim ukupni prinos po biljci (99,71) i dane do prvog branja (99,43), dok je genetski napredak kao procenat srednje vrednosti bio visok za broj mahuna po biljci (65,35), praćeno visinom biljke (58,66) i ukupnim prinosom po biljci (42,17). Visoka heritabilnost zajedno sa visokim genetskim napretkom utvđena je za sve osobine koje su proučavane. Visoke procene heritabilnosti zajedno sa visokim genetskim napretkom odražavaju prisustvo aditivnog delovanja gena za ekspresiju ovih osobina.

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