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EVALUATION OF GENETIC VARIATION IN SEGREGATING POPULATION OF PEA (*Pisum sativum* L.)

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ABSTRACT

Pea (*Pisum sativum* L.) is the most important grain legume crop grown worldwide and used as food and fodder. An experiment was undertaken to elucidate the genetic variability in five inbred parents and their 17 F_4's derivatives in pea evaluating ten characters during the winter season of 2017-2018 at the research farm, BSMRAU, Gazipur, Bangladesh. Analysis of variance explored significant differences among the genotypes for all the characters. Phenotypic coefficients of variation were close to genotypic coefficients of variation for all the characters indicating less influence on the environment and potentiality of selection. High heritability associated with high genetic advance was observed for plant height, pod per plant, hundred seed weight, and seed yield per plot. Days to 50% flowering and days to first flowering showed a highly significant positive correlation at both genotypic and phenotypic levels. Plant height showed a highly significant positive correlation with pods per plant, seeds per pod, and seed yield per plant. Pod length showed a highly significant positive correlation with pod width and hundred seeds weight. Pods per plant, pod width, and seeds per pod showed a highly positive correlation with seed yield per plant and 100-seed weight. Only days to first flowering showed a highly negative correlation with pod length and hundred seed weight. Path coefficient analysis revealed that plant height, pod per plant, and seeds per pod had a highly positive effect on yield per plant. Therefore, the yield improvement of pea is plausibly possible by associating and selecting those plant traits. Furthermore, two crosses such as Zhikargacha×IPSA Motorshuti 1 and Zhikargacha×IPSA Motorshuti 2 may be chosen for further breeding programs.

Keywords: Pea, Flower, Pod, Seed

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INTRODUCTION

Legumes are chief crops worldwide and they have major influences on agriculture, animal, the environment, and human nutrition (Graham and Vance, 2003). Among legumes, Pea (*Pisum sativum* L.) the oldest common pea is an herbaceous annual plant that belongs to the family Leguminosae. It is self-pollinated (2n=2x=14) and it is one of the earliest food crops (Praca-Fontes et al., 2014). It has originated in the Mediterranean region, primarily in the Middle East (Ellis et al., 2011). Pea is cultivated for green pods and dry seeds used as vegetables and dhal. It enriches the soil with the nodule bacteria which live in its roots and it fixes nitrogen which becomes available to other plants (Gupta et al., 2018).

It is widely used as a supplement feed, green manure, vegetables, and grains due to its amusing source of nutritional value and healing properties (Sun et al., 2014). It is a starchy vegetable with high nutritional value, high in fibers, proteins, vitamins (A, B_6, C, K), iron, zinc, phosphorus, magnesium, copper, and lutein (Hassan et al., 2009). Bangladesh is a major field pea producing country compared to other legumes (FAOSTAT, 2019) and has a high demand for quality field pea seeds. In Bangladesh, the estimated production of pea was 17538 metric tons from 7439 acres of land in 2018-2019 (BBS, 2020).

Morphological and yield characteristics are based on the explanation of separate traits of plants and are the most traditional and instinctive way to distinguish genetic variation. These features are vital in starting gene pool collections and effectual use of crop germplasm properties (Santos et al., 2012). Those characteristics are depending on the environment and genetics, including structural genes and regulatory, variants that expose their genetic foundations; a variation in phenotypic features is a sign of hereditary expression (Dean et al., 1999). To improve the higher yield through the selection of the good genetic traits verities for better results (Ranjan et al., 2005). Genetic variability has been considered an important factor that is also an essential prerequisite for crop improvement programs for obtaining high-yielding progenies (Tiwari and Lavanya, 2012). Genetic variability is important to know the source of genes for a particular trait within the available germplasm (Chakraborty and Haque, 2000). The most important tasks for pea breeding are the development of high yielding varieties with stable productivity with a high output of seeds from the total biological yield, different maturing types with a high rate of organic matter accumulation during the initial phases of growth, sufficiently high intensity of photosynthesis, increases in protein content, essential amino acids and favorable rations among them (Tiwari and Lavanya, 2012). For all of these, genetic variability is very important to select suitable types among the segregating populations. It is necessary to partition the observed variability into its heritable and non-heritable components with the help of suitable genetic parameters such as genotypic coefficient of variation (GCV), heritability estimates genetic advance, etc. It is also beneficial to make a comparative study of a few characters to select the desirable

ones in different strains as well as the study of the association of characters is to identify the role of each character towards yield (Naeem et al., 2020). This study aimed to find out the nature and magnitude of genetic variability in segregating the population of the pea for grain yield and other yield-related traits and also to evaluate selection criteria in pea breeding programs.

MATERIALS AND METHODS

Study period, site, and design

The experiment was conducted at the experimental field of Genetics and Plant Breeding Department, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during the winter season (November to February) of 2017-2018. Each plot consisted of a single row of 1.5 m long. The rows were spaced at 25 cm in which seeds were sown continuously. The experiment was laid out in RCBD with three replications.

Materials

Five inbred parents viz. IPSA Motorshuti 1, IPSA Motorshuti 2, IPSA Motorshuti 3, Natore, Zhikargacha along with seventeen F_4's viz IPSA Motorshuti 1×IPSA Motorshuti 2, IPSA Motorshuti 1×IPSA Motorshuti 3, IPSA Motorshuti 3×IPSA Motorshuti 1, IPSA Motorshuti 1×Natore, IPSA Motorshuti 1×Zhikargacha, Zhikargacha×IPSA Motorshuti 1, IPSA Motorshuti 2×IPSA Motorshuti 3, IPSA Motor shuti 3×IPSA Motorshuti 2, IPSA Motorshuti 2×Natore, IPSA Motorshuti 2×Zhikargacha, Zhikargacha×IPSA Motorshuti 2, IPSA Motorshuti 3×Natore, Natore×IPSA Motorshuti 3, IPSA Motorshuti 3×Zhikargacha, Zhikargacha×IPSA Motorshuti 3, Natore×Zhikargacha, Zhikargacha×Natore produced from crossing of the inbred parents were included in the experiment. The F4's was synthesized in the previous year of the experiment.

Data collection

Five randomly selected competitive plants from parents and 20 plants of F_4's was used for recording observations on the following parameters. The parameters were days to first flowering (DFF), days to fifty percent flowering (DFPF), days to maturity (DM), and plant height (PH).

During the harvesting period, data were collected from ten plants that were taken other than the harvesting area randomly from each plot without the border plants. The yield attributes parameters were pods per plant (PPP), pod length (PL), pod width (PW), seeds per pod (SPP), 100- seed weight (HSW), and seed yield per plant (SYPP).

Statistical analysis

The collected data were analyzed by the analysis of variance (ANOVA) technique using the computer package program MSTAT and mean differences were adjudged by the least significant difference (LSD) test at a 5% level of significance.

RESULTS AND DISCUSSION

Performance of parents and F_4 populations of pea

Days to first flowering

The lowest number of days was required for first flowering in IPSA Motorshuti 1 (27 days) and the highest was observed in Natore (46 days). In cross combinations, IPSA Motorshuti 1×IPSA Motorshuti 3 and IPSA Motorshuti 3×IPSA Motorshuti 1 showed early flowering (27 days) and followed by Zhikargacha×Natore and Natore ×Zhikargacha (Table 1).

Seed yield per plant

The highest seed yield per plant was observed in the genotype Zhikargacha×IPSA Motorshuti 2 (15.97 g) and the lowest (1.43 g) in genotype IPSA Motorshuti 1×IPSA Motorshuti 2 (Table 1). Cross combinations IPSA Motorshuti 1×Zhikargacha, IPSA Motorshuti 2×IPSA Motorshuti 3 exhibited 30 days, and IPSA Motorshuti 3×IPSA Motorshuti 1, IPSA Motorshuti 1×IPSA Motorshuti 3 revealed 27 days for first flowering. Similar findings were observed by Manoj et al. (2003) who conducted path coefficient analysis for yield and yield components in pea using 40 F_1 hybrids and 14 parents.

Days to 50% flowering

The minimum and the maximum number of days required for 50% flowering were observed in the parents IPSA Motorshuti 1 (30 days) and Zhikargacha (46 days). Three cross combinations IPSA Motorshuti 1×IPSA Motorshuti 2, IPSA Motorshuti 1×IPSA Motorshuti 3, IPSA Motorshuti 3×IPSA Motorshuti 1 revealed early 50% flowering (36 days) whereas Zhikargacha×Natore exhibited 55 days for 50% flowering (Table 1). Similar results were found by Gupta et al. (2020) in India and the results of the days 50% flowering was 28.19%.

Days to maturity

Among the parents, minimum days required for maturity in IPSA Motorshuti 1 (65 days) and maximum days were required for IPSA Motorshuti 3 (86 days) followed by Zhikargacha (85 days). In cross combinations, minimum days to maturity were required for IPSA Motorshuti 1×IPSA Motorshuti 2 (72 days). Contrariwise, Zhikargacha×Natore exhibited 48 days for first flowering but matured in 95 days (Table 1).

Plant height

The genotype IPSA Motorshuti 1 produced the shortest plant height (29.52 cm) whereas Natore exhibited the highest plant height (123.53 cm). In cross combinations, IPSA Motorshuti 1×IPSA Motorshuti 2 produced the shortest height (30.12 cm) and Zhikargacha×IPSA Motorshuti 2 manifested the tallest plant height (152.42 cm) (Table 1).

Table 1. Performance of parents and their F_4 populations of pea

Genotype	DFF	DFPF	DM (day)	PH (cm)	PPP (no.)	PL (cm)	PW (cm)	SPP (no.)	HSW (g)	SYPP (g)
IPSA 1	27g	30h	65i	29.52q	6.00m	5.66fgh	1.41c	3.52h	21.45c	4.55t
IPSA 2	29fg	34g	75g	51.55p	6.05m	7.26b	1.57a	5.05fg	25.61a	7.79m
IPSA 3	37cd	44de	86ef	112.37k	9.55k	5.73fg	1.21g	4.85g	17.24e	8.35j
Natore	46a	52b	93cd	123.53g	8.43l	5.74f	1.20g	5.81b	11.04p	5.48r
Zhikargacha	41b	46cd	85f	110.48l	12.54h	5.4ijk	1.21g	5.28cde	11.96m	7.91l
IPSA 1×IPSA 2	34de	36g	72h	30.12q	5.12n	5.28kl	1.14j	3i	9.59r	1.43u
IPSA 1×IPSA 3	27fg	36g	87e	116.4j	12.23h	6.82c	1.39d	5.46c	16.95f	11.56f
IPSA 3×IPSA 1	27fg	36g	85f	100.2o	8.58l	6.90c	1.29f	5fg	16.72g	7.11o
IPSA 1×Natore	32ef	40f	94bc	128.53f	8.21l	6.26e	1.15ij	5.21def	12.16k	5.13s
IPSA 1×Zhikargacha	30fg	40f	94bc	107.65 m	15.18e	6.26e	1.16i	5.47c	11.05p	9.47i
Zhikargacha×IPSA 1	34de	44de	93cd	130.36e	20.07b	5.51hij	1.16i	5.21def	14.52h	15.27b
IPSA 2×IPSA 3	30fg	44de	93cd	132.27d	12.55h	7.63a	1.49b	6.59a	18.13d	14.98c
IPSA 3×IPSA 2	34de	44de	92d	144.03b	14.36f	6.55d	1.41c	4.85g	21.85b	14.93d
IPSA 2×Natore	30de	39f	96a	131.68d	10.37j	6.54d	1.38de	5.10ef	14.08i	7.12o
IPSA 2×Zhikargacha	38bc	43e	92d	131.92d	11.42i	6.44d	1.36e	5.75b	14.08i	9.53h
Zhikargacha×IPSA 2	34de	45cde	93cd	152.42a	21.35a	6.55d	1.20g	5.69b	14.51h	15.97a
IPSA 3×Natore	39bc	45cde	93cd	134.8c	18.08c	5.75f	1.16ij	5.40cd	12.02l	11.61e
Natore×IPSA 3	39bc	45cde	93cd	120.27h	15.17e	5.55ghi	1.21g	5.28cde	12.77j	10.12g
IPSA 3×Zhikargacha	39bc	47c	87e	123.42g	11.53i	6.15e	1.16hi	5.28cde	11.84n	7.04f
Zhikargacha×IPSA 3	39bc	45cde	87e	118.38i	13.08g	5.09m	1.16hi	5.02fg	11.69o	7.60n
Natore×Zhikargacha	47a	53ab	96a	111.57k	12.13h	5.15lm	1.18h	4.85g	10.94q	6.84q
Zhikargacha×Natore	48a	55a	95ab	103.33n	16.29d	5.35jk	1.21g	5.29cde	9.44s	8.06k

Note: DFF=Days to First Flowering, DFPF=Days to 50% flowering, PH=Plant Height (cm), PPP=Pods per Plant (no.), PL=Pod Length (cm), PW=Pod Width (cm), SPP=Seeds per Pod (no.), DM=Days to Maturity, HSW=HundredSeed Weight (g), SYPP=Seed Yield per Plant (g)

Pods per plant

The highest and lowest number of pods per plant were produced by Zhikargacha×IPSA Motorshuti 2 (21.35 cm) with plant height (152.42 cm) besides Zhikargacha×IPSA Motorshuti 1 produced 20.07 number of pods per plant with plant height 130.36 cm and IPSA Motorshuti 1×IPSA Motorshuti 2 (5.12 cm) exhibited lowest pods per plant whose plant height was also lowest (30.12 cm) (Table 1).

Pod length

The highest and lowest pod length observed was (7.63 and 5.09 cm) in IPSA Motorshuti 2×IPSA Motorshuti 3 and Zhikargacha×IPSA Motorshuti 3 (Table 1).

Similar results also found by Khan et al., 2019 in the pulse bean crop, and the pod length was ranged from (8.12-17.33 cm) bean in Sylhet.

Pod width

The maximum and minimum pod width was observed in parents Natore (1.2 cm) and IPSA Motorshuti 3 (1.21 cm) (Table 1). IPSA Motorshuti 1×IPSA Motorshuti 2 exhibited minimum pod width (1.14 cm), and IPSA Motorshuti 2×IPSA Motorshuti 3 revealed maximum pod width (1.49 cm). Similar results were found by Luthra et al. (2029) in Idia and the pod width was varied from (1.24-1.84 cm) pea.

Seeds per pod

The highest and lowest number of seeds per pod (6.59 and 3.0) was found in IPSA Motorshuti 2×IPSA Motorshuti 3 and IPSA Motorshuti 1×IPSA Motorshuti 2 (Table 1). Pujari et al., 2021 found a similar result in field pea and the results were the high heritability coupled with low genetic advance as percent of mean it is indicated non-additive gene action in these traits viz. number of seed per pod (78.83%, 19.61%) and harvest index (74.4%, 18.31%), respectively.

100-Seed weight

The maximum and minimum 100-seed weights were found in IPSA Motorshuti 1 (21.45 g) and Natore (11.04 g) respectively. Zhikargacha×Natore exhibited 9.44 g and IPSA Motorshuti 3×IPSA Motorshuti 2 (21.85 g). Pujari et al. (2021) found a similar result in field pea and 100 seed weight (3.99, 5.38 g).

Seed yield per plant

The highest and lowest yield per plant (15.97 and 1.43 g) was observed in the genotype Zhikargacha×IPSA Motorshuti 2 and IPSA Motorshuti 1×IPSA Motorshuti 2, respectively (Table 1). IPSA Motorshuti 3×IPSA Motorshuti 1 and IPSA Motorshuti 2×Natore showed 27 and 30 days to first flowering. Similarly observed by Syed et al. (2021) in field pea in India, and the seed yield per plant ranged from (6.14-9.6 g).

Genetic component of variation for yield and yield related characters in pea

Days to first flowering

The mean of all the genotypes for this character was 35.86 days (Table 2). The phenotypic variance (39.258) was considerably higher than the genotypic variance (35.128). The genotypic (16.526) and phenotypic (17.47) coefficient of variation were close to each other indicating that, the negligible influence of the environment on this trait. Devendra et al. (2001) evaluated yield and yield components of pea and found highly significant and positive correlations in both field and vegetable peas for days to first flowering.

Days to 50% flowering

The mean of all the genotypes for this character was 42.864 days (Table 2). The phenotypic variance (39.125) was considerably higher than the genotypic variance (37.623). The genotypic (14.31) and phenotypic (14.593) coefficients of variation were close to each other indicating that the influence of environment on this trait was negligible (Table 2). Mart et al., 2021 also reported that the flowering days were ranged between (38-57) days in the trait in local pea in the Mediterranean.

Days to maturity

The mean for this character was 88.455 days. The phenotypic variance (67.242) was considerably higher than the genotypic variance (66.768). The genotypic (9.238) and phenotypic (9.27) coefficient of variation were moderate with a little difference indicating that the environment has a little effect on the expression of this character (Table 2). Chakraborty and Haque (2000) found high heritability and low genetic advance in lentils for this trait.

Plant height

The average height of the plant was 111.128 cm. The phenotypic variance (1083.843) was closely related to the genotypic variance (1083.573). The phenotypic coefficient of variation (29.625) and genotypic coefficient of variation (29.621) were close to each other indicating the negligible influence of the environment (Table 2). The high heritability and genetic advance in percent of the mean for plant height were found by Ramesh et al. (2002), and Tyagi et al. (2000).

Pods per plant

The mean of this character was 12.195 cm. The phenotypic variance (19.192) and genotypic variance (19.09) were close to each other. The genotypic (35.828) and phenotypic coefficient of variation (35.923) were close to each other indicating the negligible influence of the environment on this trait (Table 2). Yadav and Dahiya (2000) found high heritability of r this character in black gram, and it indicated that the pods per plant were an important character for selection with restriction and improvement of seed yield.

Pod length

The average value for pod length was 6.07 cm. The phenotypic variance (0.512) and the genotypic variance (0.501) were low for this trait. The genotypic (11.652) and phenotypic (11.78) coefficients of variation were close to each other indicating the negligible influence of the environment on this trait (Table 2). Ramesh et al. (2002) found moderate to high heritability coupled with high genetic advance as the percentage of the mean for pod length in cowpea.

Pod width

The mean value of this character was 1.26 cm. The phenotypic variance (0.016) and genotypic variance (0.016) were very low for this trait (Table 2). The genotypic

(9.981) and phenotypic (10.012) coefficients of variation were moderate with very little difference.

Table 2. Genetic component of variation for yield and yield related characters in pea

Traits	DFF	DFPF	DM	PH	PPP	PL	PW	SPP	HSW	YPP
V_p	39.258	39.125	67.242	1083.843	19.192	0.512	0.016	0.499	18.093	14.286
V_g	35.128	37.623	66.768	1083.573	19.09	0.501	0.016	0.482	18.092	14.286
PCV	17.47	14.593	9.270	29.625	35.923	11.78	10.012	13.795	29.274	42.011
GCV	16.526	14.310	9.238	29.621	35.828	11.652	9.981	13.558	29.273	42.010
h^2b	89.480	96.161	99.295	99.975	99.469	97.85	99.378	96.591	99.994	99.999
GA	8.858	9.503	12.865	52.003	6.885	1.106	0.199	1.078	6.72	5.972
GAPM	24.699	22.171	14.544	46.795	56.457	18.212	15.721	21.053	46.251	66.376
Mean	35.864	42.864	88.455	111.128	12.195	6.072	1.266	5.119	14.53	8.997

Note: DFF=Days to First Flowering, DFPF=Days to 50% flowering, PH=Plant Height (cm), PPP=Pods per Plant (no.), PL=Pod Length (cm), PW=Pod Width (cm), SPP=Seeds per Pod (no.), DM=Days to Maturity, HSW=Hundred Seed Weight (g), YPP=Yield per Plant (g)

Seeds per pod

The mean of all the genotypes for this character was 5.119. The phenotypic variance (0.499) and genotypic variance (0.482) were low for this trait (Table 2). The genotypic (13.558) and phenotypic (13.795) coefficients of variation were moderate with little difference. High heritability (96.591) and moderate genetic advance in percent of the mean (21.053%) were also observed for this trait. Islam et al. (1999) assessed high heritability in black gram and lentil for seeds per pod.

100-Seed weight

The mean value of this character was 14.53 g. The genotypic (18.092) and phenotypic (18.093) variance was close to each other which revealed that there was little influence on the environment (Table 2). Gupta et al. (2020) in pea, observed high heritability coupled with genetic advance as a percentage of the mean was for 100 seed weight in chickpea.

Seed yield per plant

The average value of this character was 8.997 g. The phenotypic variance (14.286) was the same as the genotypic variance (14.286) for this trait. The genotypic (42.010) and phenotypic (42.011) coefficient of variation and high heritability (99.999) along with the high genetic advance in percent mean (66.376) were estimated for this character (Table 2). Tyagi et al. (2000) in cowpea genotypes observed high heritability coupled with genetic advance as a percentage of the mean for seed yield per plant.

CONCLUSION

Based on the findings of the present investigation, it can be concluded that the highest yield per plant was observed in the genotype Zhikargacha×IPSA Motorshuti 2. High heritability associated with high genetic advance per mean was observed for plant height, pod per plant, 100-Seed weight, and seed yield per plot. Hence, yield improvement in pea could be achieved through the association and selection of these characters. Furthermore, IPSA Motorshuti 2×IPSA Motorshuti 3 and IPSA Motorshuti 3×IPSA Motorshuti 2, Zhikargacha×IPSA Motorshuti 1, and Zhikargacha×IPSA Motorshuti 2 exhibited the best performance in relation to yield and yield related parameters in this study.

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