Estimation Of Genetic Variability for Yield and Maturity Related Traits in Garden Pea (*Pisum Sativum*) Under Agro-climatic Conditions of Peshawar

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A study entitled "Estimation of genetic variability for yield and maturity related traits in garden pea (*Pisum sativum*) under agro-climatic conditions of Peshawar" was conducted in Peshawar, Pakistan, on 21st October 2021 to investigate the genetic variation among sixteen pea genotypes for yield and maturity related traits. The analysis of variance (ANOVA) revealed significant ($p \leq 0.01$) differences among most of the pea genotypes, indicating sufficient variation. The research was arranged in a Randomized Complete Block Design (RCBD) with three replications. A total of 15 pea genotypes, along with one commercial variety, "Meteor", were obtained from the National Agricultural Research Centre (NARC), Islamabad, Pakistan. The pea genotype Meteor was kept as a control, while other genotypes were maintained as a treatment. All the studied parameters were significantly affected by the pea genotypes, meteor, and the other fifteen genotypes. The pea genotype Meteor exhibited minimum days to emergence (7.5), days to first picking (60.00), and maximum pod diameter (11.62 mm). In contrast, pea genotype 29928 showed maximum green pod yield (9.48 tons ha^{-1}), hundred green pod weight (531.66 g), and pod length (8.42cm). However, the genotype 29249 produced the highest number of pods per plant (313.3). On the basis of outstanding performance for yield traits, it is concluded that genotypes 29928 and 29249 are recommended for early maturity. Genotype Meteor is advised for Peshawar growers as well as for testing across locations and onward use in the pea breeding program.

Keywords: Pisum sativum, Genetic variability, Meteor, Genotypes, Garden pea.

Introduction:

The garden pea (*Pisum sativum*), a member of the Leguminosae family, is an annual, cool-season crop known for its nitrogen-fixing ability [1]. It is self-pollinated and has a chromosome number of 2n = 2x = 14 [2]. The primary centre of origin of the garden pea is stated to be the Mediterranean, the Near East, Abyssinia, and central Asia [3]. Globally, among the most widely cultivated leguminous crops, pea ranks second in yield after the common bean (*Phaseolus vulgaris*) [4].

Peas can fix atmospheric nitrogen, thus by proper crop alternation it enhances soil productivity, although dry weather greatly reduces yield. However, their yield can be significantly reduced under dry weather conditions. To maximize productivity, early sowing and the use of high-quality seeds, particularly those that promote early flowering and vigorous growth are recommended [5]. Additionally, peas play a vital role in both human and animal nutrition due to their high content of digestible protein, ranging from 23% to 33% in the seeds [6]. Pea also contains fibre, zinc, lutein, magnesium, iron, phosphorus, copper, vitamin B6,

vitamin K, vitamin A, and vitamin C. However, an edible fresh green pea (100 g) comprises moisture 72.9%, 93 kcal energy, 7.2 g protein, 15.9 g carbohydrates, phosphorus 139 mg, 4.0 g fibre, iron 1.5 mg, and calcium 20 mg. Seeds are starchy, along with other biomolecules such as carbohydrates, vitamins, and proteins [1].

Seed germination requires optimum soil temperature, which ranges from 16 to 18 °C [7]. High soil temperatures negatively affect seed germination, plant growth, and overall yield. While pea plants can tolerate mild frost before blooming, they are highly susceptible to freezing temperatures during the flowering and pod development stages. Adequate irrigation is essential during pod development to ensure optimal yield. A regular supply of water encourages high yield, but extensive rainfall promotes root rot [8]. However, an increase in pea yield depends on the selection of genotypes for important characters, namely vine length, pod size, and seeds per pod [9]. In order to maintain yield and utilize germplasm efficiently and effectively, it is important to investigate the extent of genetic diversity it contains [10].
Several studies have been conducted to understand the genetic factors affecting pea yield and growth performance. Studies of [11] and [12] revealed the additive action of genes in controlling the inheritance of yield traits in pea. In contrast, [12] and [13] reported the importance of non-additive gene actions for controlling the expression of pea yield. The influence of non-additive gene actions for controlling the expression of seed pod^{-1} and hundred grain weight was also reported.

Additionally, [14] assessed the genetic variability of twelve pea genotypes during the pea growing season of 2011-12. Mean squares were significant for all studied characters except plant height. The highest genotypic and phenotypic coefficient of variation were noted for pod plant^{-1} (31.62, 31.99), followed by seed yield plant^{-1} (22.87, 23.65). The study indicated that priority should be given to these traits for enhancing the yield of garden pea, a conclusion that is supported by the findings of [15].

The authors in [16] and [17] reported significant genetic diversity among pea genotypes for days to first picking, plant height, pod length, pod plant$^{-1,}$ and pod yield. Similarly, [18] reported significant variation among pea genotypes for pod plant^{-1}, 100-seed weight, and average grain yield.

Furthermore, [19] assessed 140 pea genotypes for genetic variability. They reported that principal component analysis (PCA) showed significant differences among traits with 7 major principal components explaining about 90% of the variations. Branches plant^{-1}, pod plant$^{-1,}$ and yield were the traits with the highest weight, which explained 34.22% of the total variance. Similarly, [20] reported that 55 pea genotypes were best fitted into six clusters. The highest 14 and lowest 4 genotypes were grouped in cluster III and cluster IV, respectively. The result of PCA revealed that all four principal components (PC-I, PC-II, PC-III, and PC-IV) contributed 86.7% of the total variability. Therefore, to assess the suitability of various genotypes under specific environmental conditions, the present study was undertaken with the following objectives;

Objectives:

To identify genetic variation among pea genotypes for important maturity and yield traits.
To determine the best pea genotypes to be selected for the pea breeding programme.

Novelty Statement:

This study presents a comprehensive evaluation of genetic variability in garden pea for yield and maturity traits. By identifying promising genotypes with desirable genetic characteristics, the research contributes valuable insights for future breeding programs aimed at improving pea productivity and adaptability in similar environmental zones.

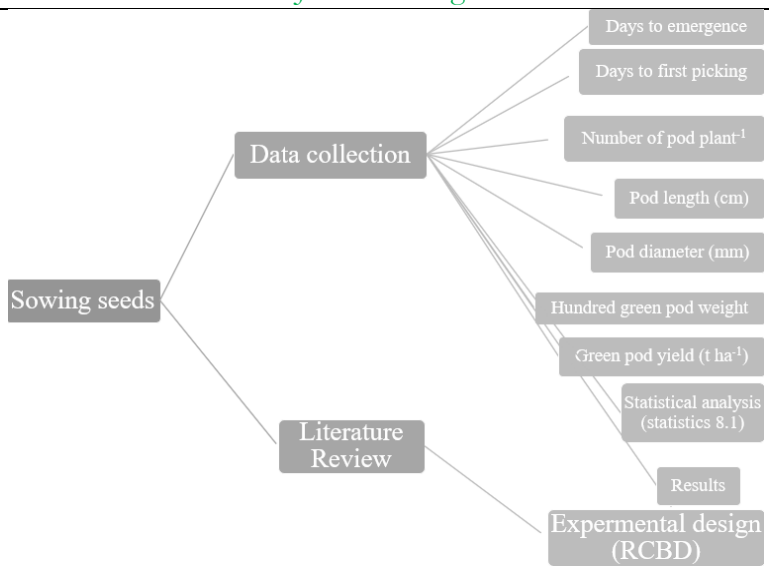

Figure 1. Flow chart of research methodology

Materials and Methods:

An experiment, was performed at the Horticulture Research Farm, University of Agriculture, Peshawar, during the pea-crop growing season in 2021. Randomized Complete Block Design (RCBD) with three replications. The treatments (pea genotypes) were randomized within and among blocks (replications).

Field Management:

The field was prepared using a rotavator at the end of October, and a basal dose of NPK fertilizer was applied to the soil one month before sowing. All the other cultural practices, like weeding, hoeing, irrigation, fertilizer application, etc., were kept constant for all plots. However, the seeds of available germplasm of garden pea were sown in a three-row plot comprising 7-8 plants per row. Ridge beds were used, maintaining a plant-plant distance of 15 cm, while row-row distance of 45 cm.

Figure 2. Map of the study site

Geographical coordinates of the study area:

Figure 2 shows the Horticulture Research Farm, University of Agriculture, Peshawar, Pakistan, located at approximately 34.0151° N, 71.5249° E, serves as the study site for this research.

Agro-climatic conditions of the field:

The temperature of the field during pea cultivation ranged from 19 to 22 °C, with rainfall approximately 250-300 mm.

Pea Germplasm:

Pea germplasm comprising 15 accessions and 1 commercial variety (Meteor) was obtained from the National Agriculture Research Centre (NARC), Islamabad, Pakistan. The germplasm was planted at the Horticulture Research Farm, University of Agriculture, Peshawar, Pakistan, and the accessions were given code numbers. The list of pea genotypes used in the experiment is given in Table 1 below;

Table 1. List of pea genotypes used in the study

Accessions	Codes	Accessions	Codes
26880	Hort-32	27003	Hort-39
26884	Hort-33	27006	Hort-40
26889	Hort-34	29249	Hort-41
26891	Hort-35	29250	Hort-42
26931	Hort-36	29256	Hort-44
Meteor	Hort-49	29260	Hort-45
26977	Hort-37	29265	Hort-46
26989	Hort-38	29928	Hort-47

Parameters Studied:

Data was collected considering various growth and yield attributes, including days to emergence, days to first picking, number of pods per plant^{-1}, pod length (cm), pod diameter (mm), hundred green pod weight (g), and Green pod yield (t ha^{-1}). Days to emergence and days to first picking were recorded from 5 randomly selected plants, and their average was calculated. Whereas, the number of pods plant^{-1} was counted for each pea genotype, and their mean was taken. While pod length and pod diameter were measured with the help of a measuring tape and Vernier calliper and the mean pod diameter and pod length were observed. The weight of a hundred green pods was calculated by using a digital electronic balance, and mean values were estimated. However, green pod yield was observed with the help of the following formula;

Green pod yield (t ha^{-1}):

The green pod yield of each pea genotype, recorded from the first to the final picking, was aggregated and subsequently converted to yield per hectare using the following formula:

$$\text{Yield tons ha}^{-1} = \frac{\text{yield per sub plot (kg)} \times 1000\text{m}^2}{\text{area of the plot (m}^2) \times 1000\text{Kg}}$$

Statistical analysis:

The ANOVA was used to analyze the data in order to find whether there were any variations among the distinct treatments. The average difference was measured using the LSD test at a 0.01 % significance level (Steel and Torrie, 1997). The STATISTIX 8.1 software was used to execute the computations for both ANOVA and LSD.

Results:

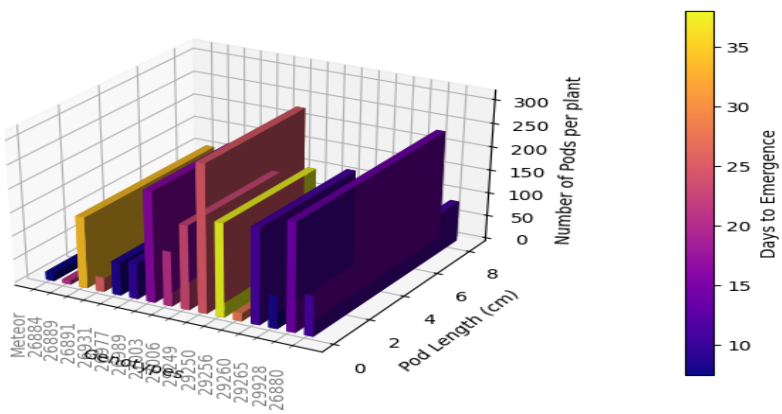

Figure 3. Days to emergence, no of pods per plant, and pod length (cm)

The data obtained from the experiment were analyzed, interpreted, and compared with findings from previous studies in this chapter. Tables 1 and 2 present the results related to the evaluated parameters. Figure 3 illustrates days to emergence, number of pods per plant, and pod length (cm).

Maximum days to emergence (38) were recorded in genotype 29250, while fewer days to emergence (7.5) were observed in pea genotype Meteor. Mean data shows that pea genotype 29265 is statistically similar to the genotype Meteor in the case of emergence. Whereas, the highest number of pods plant^{-1} (313.3) was calculated in pea genotype 29249, and the minimum number of pods plant^{-1} (8.23) was observed in pea genotype 26884. The maximum pod length (8.42 cm) was noted in pea genotypes 29928 and 26880; however, the minimum pod length (4.40 cm) was observed in pea genotype 26989.

Table 2. Days to emergence, number of pods per plant$^{-1,}$ and pod length (cm)

Genotypes	Days to emergence	Number of pods plant^{-1}	Pod length (cm)
Meteor	7.5 H	17.23 K	7.05 BC
26884	21 E	8.23 L	7.84 AB
26889	34 B	152.27 E	6.83 BC
26891	25.6 CD	30.9 J	6.33 CD
26931	8.33 GH	70.33 I	6.25 CDE
26977	9.33 GH	76.9 H	6.00 CDEF
26989	16 F	235.7 B	4.40 G
27003	20.6 E	117.3 F	6.82 BC
27006	23 DE	179.9 D	4.92 FG
29249	25 D	313.3 A	5.29 DEFG
29250	38 A	199.67 C	4.97 EFG
29256	28 C	17.83 K	8.04 AB
29260	11 G	204.00 C	5.23 DEFG
29265	8 H	70.77 I	7.21 ABC
29928	14 F	232.00 B	8.42 A
26880	11 G	86.8 G	8.42 A
LSD	2.9986	4.7632	1.3080

Table 3. Pod diameter (mm), hundred green pod weight (g), days to first picking, and Green pod yield (t ha^{-1})

Genotypes	Pod diameter (mm)	Hundred green pod weight (g)	Days to first picking	Green pod yield (t ha^{-1})
Meteor	11.62 A	486.0 C	60 I	4.50 FG
26884	11.5 AB	136.33 J	132.6 DE	3.92 GH
26889	9.63 DE	211.33 I	167 A	5.96 D
26891	9.66 CDE	207.00 I	158 B	3.25 HI
26931	8.00 F	326.66 F	125.6 FG	4.10 G
26977	8.80 EF	291.67 G	122 G	5.25 E
26989	1.73 H	506.33 B	145.5 C	7.28 C
27003	3.00 G	453.67 D	123.5 G	6.99 C
27006	2.10 GH	451.67 D	133.6 D	4.79 EF
29249	2.50 GH	231.67 H	158.4 B	5.05 EF
29250	10.4 CD	327.00 F	167.2 A	7.27 C
29256	11.7 A	513.33 B	128.3 EF	4.84 EF
29260	10.6 BC	414.33 E	115.00 H	7.36 C
29265	10.5CD	332.33 F	129.7 DEF	8.38 B
29928	10.2 CD	531.67 A	125.3 FG	9.48 A

26880	9.90 CD	111.33 K	145 C	3.13 I
LSD	0.9455	17.307	4.5805	0.6669

Figure 4 demonstrates that the maximum pod diameter (11.62 mm) was recorded for pea genotype Meteor, followed by genotype 29256 (11.7 mm). Although, minimum pod diameter (1.73 mm) was recorded for genotype 26989. A maximum of hundred green pod weight (531.67 g) was recorded for genotype 29928, followed by genotype 29256 (513.33 g). While minimum value for hundred green pod weight (111.33 g) was recorded for pea genotype 26880. Besides, maximum days to first picking (167.2) were recorded in pea genotype 29250, while minimum days to picking (60) were observed in pea genotype Meteor. Whereas Figure 5 presents, the highest green pod yield was noted in pea genotype 29928 (9.48 tons ha^{-1}), followed by the pea genotype 29265 (8.38 tons ha^{-1}). In contrast, the lowest green pod yield was recorded in pea genotype Meteor (control) (3.13 tons ha^{-1}). Mean data of pod length (cm), hundred green pod weight (g), and Green pod yield (t ha^{-1}) for genotype 29928 were recorded far more than for genotype Meteor, which is the control.

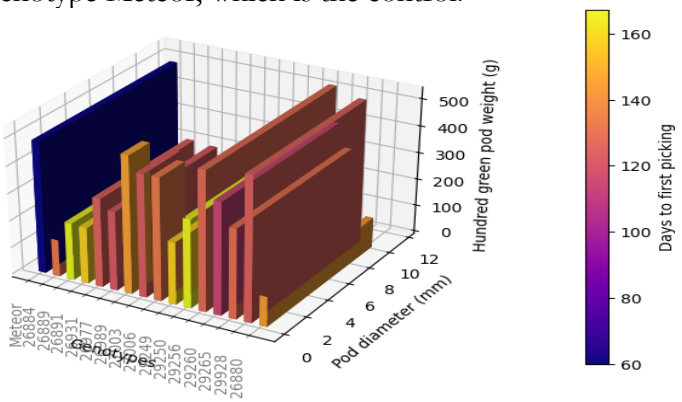

Figure 4. Days to first picking, Hundred green pod weight(g), and pod diameter (mm)

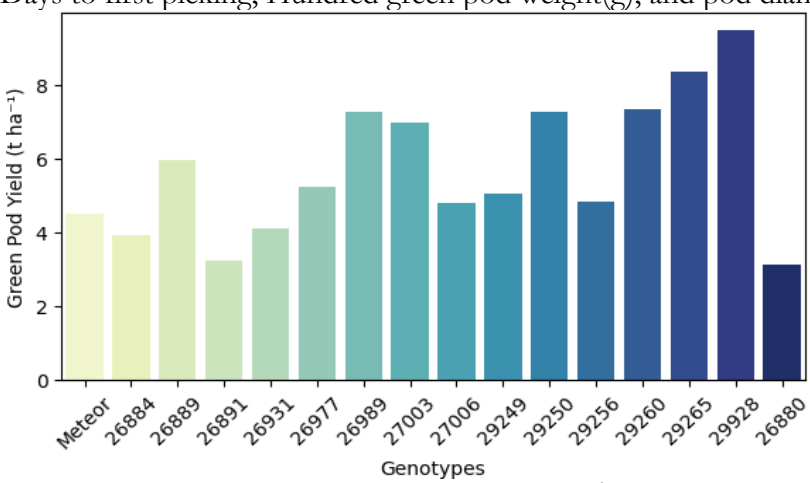

Figure 5. Green pod yield (t ha^{-1})

Discussion:

The pea variety "Meteor" exhibits early maturity due to its genetics and specific characteristics developed through breeding and selection. The genetic differences of pea genotypes were observed by [21] and [17]. They also reported a high degree of genetic diversity among pea genotypes for days to emergence. Early maturity in pea genotype is considered good; it protects the plant from both biotic and abiotic stresses and also has a positive effect on yield [22]. Also reported that crop yield is highly dependent upon biological, environmental, and genetic factors. Pea varieties exhibit a varying number of pods per plant. This is because of genetic differences, environmental factors, and their interaction with different microbes within the soil. Variation among eleven pea genotypes for pods per plant was also observed

by [20]. Additionally, factors like nutrients and water availability can impact pod development, potentially leading to larger pod length and diameter. [23] and [20] observed considerable variation among pea varieties for pod diameter and pod length. Furthermore, a larger number of pods means more sink strength for assimilates, which increases total yield. High-yielding varieties possess superior genetic potential, which contributes to traits such as increased 100-pod weight, early emergence, and maximum pod diameter. These varieties also demonstrate improved reproductive characteristics, including hundred green pod weight, maximum green pod yield, and larger pod sizes, all of which contribute to increased productivity. The adaptability of high-yielding varieties to local agro-climatic conditions, such as suitable temperature, soil type, and moisture availability, further enhances their performance. A good genetic variation among 39 genotypes of garden pea for 100-pod weight was reported by [24]. Efficient nutrient use, especially through effective symbiosis with rhizobium bacteria for biological nitrogen fixation, supports vigorous yield and growth. The studied material displayed significant variation for green pod yield. This might be due to variation in the genetic makeup of genotypes [25].

Additive gene action:

Traits like pod length, pod number, and 100 pod weight are often controlled by additive gene effects, meaning they are heritable and can be improved through selection. Meanwhile, genotype 29928 likely possesses accumulated favorable alleles for yield-related traits.

Pleiotropic and epistatic interactions:

The simultaneous development in pod size, weight, and number in genotype 29928 and 29249 might be due to epistatic gene interactions, where certain combinations of genes enhance multiple yield traits together.

High Heritability with Genetic Advance:

Traits with high heritability and high genetic advance (e.g., number of pods plant^{-1}, 100 green pod weight) indicate less environmental influence, making genotype 29928 genetically stable for high yield expression.

Conclusions:

On the basis of the experimental results, it is concluded that a significant variation was shown by different pea genotypes for yield and maturity related traits. Concerning pod yield, 29928 and 29249 gave the outstanding performance for most of the parameters that included number of pods plant^{-1}, green pod yield (tons ha^{-1}), and hundred green pod weight. The genotype Meteor was observed as early maturing, as it took a minimum of days to emergence and days to first picking.

Conflict of Interest:

All the authors declare no conflict of interest.

Authors Contributions:

N.A. Supervised the whole research, S.T. and K.T. provided technical assistance during the experiment, A.B. performed the experiment and prepared the final draft, table, graphs, and figures for the manuscript, I.H. proofread the paper.

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