**Evaluation of the Relationship between Yield and Yield Components of Garden Pea (*Pisum sativum* L. var. hortense) by Correlation and Path Analysis**

**ABSTRACT**

The garden pea (Pisum sativum L. var. hortense) is an annual herbaceous plant, with angular or roundish hollow stems covered with a waxy bloom, having growth habits ranging from bushy to climbing type. The study aims to assess the relationship between yield and yield components in garden pea using correlation and path analysis, with the ultimate goal of identifying key traits to develop new varieties with enhanced yield potential. The study was carried out during rabi season of the year 2023-2024 at Horticulture Research Farm No.1, Department of Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University, Lucknow, India. The trial was conducted in a Randomized Block Design plot with a size of 1.70 m x 1.20 m. Genetic material used in the research consists of 25 selected germplasm of pea. Five plants randomly selected and tagged before flowering from each plant to evaluate on different characters were considered. The data on seeds yield per plant showed that positive and highly significant correlation with green pod yield per plant followed by number of pods per plant, days to 50% flowering, days to first pod harvest and number of pods per cluster showed highly significant whereas seeds yield per plant showed highly and negative correlation with seed diameter followed by 100 green seed weight, pod length and weight per pod. The direct and indirect effect at both genotypic and phenotypic level elucidated that positive direct effect on seed yield per plant was exerted by reducing sugars percent followed by number of pods per plant, green pod yield per plant while negative direct effect on seed yield was exerted by total sugars percent followed by pod length, number of primary branches per plant. Regarding positive indirect effect on seed yield per plant were exhibited by days to 50 % flowering followed by node to first flower appearance, number of pods per cluster whereas the negative indirect effects on seed yield per plant were exhibited by number of pods per cluster followed by shelling percentage, node to first flower appearance.

**Keywords:** *Pea, genotype and phenotype, direct and indirect effects and correlation coefficient.*

**INTRODUCTION**

Garden pea (*Pisum sativum* L. var. hortense) is commonly known as green matar. It belongs to the family Fabaceae and it is a self-pollinated crop having diploid chromosome number 2n=14. It is an important legume vegetable grown throughout world during cool season (Taran *et al*., 2005). Pea is one of the world’s oldest domestic crops (Ambrose, 1995). Mediterranean region is the primary center of diversity and Ethiopia are the secondary centers of diversity (Blixt, 1974). It is most extensively cultivated in the temperate regions and restricted to cooler altitudes in the tropics and winter season in the sub tropics. *Pisum elatium*, a wild species is considered as the ancestor of *Pisum sativum*. There are two sub-species, namely *Pisum arvense* known as field pea with colored flowers and *Pisum sativum*, the white flowered horticultural or garden pea also known as sweet pea. The garden pea is an annual herbaceous plant, with angular or roundish hollow stems covered with a waxy bloom, having growth habits ranging from bushy to climbing type. The leaves consist of one or more pairs of opposite leaflets borne on petioles together with several pairs of tendrils, inflorescence is of raceme type. The flowers are zygomorphic and hermaphrodite. The fruit is a pod containing several seeds, flattened when young but becoming round or nearly round later and dehisce along the sides. The seeds may be round, dented or wrinkled. Seed color ranges from creamy white to brown and may be mottled (Kalloo and Bergh, 1993).

Yield is a complex character that is affected by several contributing traits and also influenced by environmental factors. Hence estimation of correlation co-efficient among the yield contributing characters is vital to understand the direction of selection. Correlation for a character may arise due to linkage, pleiotropism and also due to developmental genetic interaction. Correlation coefficient measures the mutual relationship between different plant characters and specifies the component characters on which selection can be carried out for yield improvement.

Path analysis is a standardized partial regression analysis that helps in separation of correlation coefficient into its direct and indirect effects of independent variables on dependent variable, hence it is widely used for identifying traits that have significant effect on yield in selection programmed (Basaiwala *et al*., 2013).

**MATERIALS AND METHODS**

The field experiment was carried out at the Horticulture Research Farm-1, Department of Horticulture, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya-Vihar Rae Bareli Road, Lucknow-226025 (U.P), during rabi season of 2023-24 from the November to march. Geographically it is situated 26º50 North latitude and 80º52 East longitude and an altitude of 111 meters above the mean sea level (MSL). The topography of the experimental field is plain. This region lies under Argo climate zone of Uttar Pradesh. The trial was conducted in Randomized Block Design plot size 1.70 m x 1.20 m. Spacing maintain between row to row 30 cm and plant to plant 10 cm. Genetic material used in the research consisting 25 elected germplasm of pea. To rays healthy crops all recommended agronomic practices for the region were adopted. Five plants randomly selected and tagged before flowering from each plant to investigate on different characters were considered. The statistical analysis was done by using the techniques of analysis of “Randomized Block Design”. These designs were developed by.

The basic concept of correlation was developed by Galton (1889) which was later elaborated and discussed by Searle (1961). The estimates of direct and indirect effects were calculated by the path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

**RESULTS AND DISCUSSION**

**Correlation coefficient**

The correlation coefficients among different characters were worked out in all possible of growth and yield parameters with seed yield per plant. Correlation coefficients between different morphological characters including seed yield per plant were estimated and are presented in table 1. The most important traits seed yield per plant showed highly significant and positive correlation with green pod yield per plant (0.866) followed by number of pods per plant (0.843), days to 50% flowering (0.426), days to first pod harvest (0.370) and number of pods per cluster (0.270). Whereas seeds yield per plant showed highly significant and negative association with seed diameter (-0.413) followed by 100 green seed weight (-0.249), pod length (-0.141) and weight per pod (-0.140).

Green pod yield per plant showed highly significant and positive correlation with number of pods per plant (0.790) followed by days to first pod harvest (0.343), days to 50 % flowering (0.306), number of pods per cluster (0.270) and node to first flower (0.270) appearance whereas green pod yield per plant showed highly and negative correlation with seed diameter (-0.366) followed by 100 green seed weight (-0.249), number of primary branches per plant (-0.197). Similar findings have been reported by Kashyap *et al.* (2024); Ali et al. (2021); Arya *et al.* (2004b); and Kumar *et al.* (2003).

**Path analysis**

The path coefficient analysis developed by Wright (1920) has been successfully used by many workers in different crops for partitioning the genotypic correlation coefficient into direct and indirect effects. The direct and indirect effects of different characters on seed yield have been presented in table 2. The higher magnitude of positive direct effect on seed yield per plant was exerted by reducing sugar percent followed by number of pods per plant, green pod yield per plant, weight of per pod, 100 green seed weight, days to 50 % flowering, shelling %, non-reducing sugar percent, node to first flower appearance and plant height. In contrast total sugar % followed by pod length, number of primary branches per plant, days to first pod harvest, number of pods per cluster, pod width, seed diameter, T.S.S. and number of seeds per pod contributed considerable negative direct effect on seed yield per plant. Regarding positive and higher indirect effect on seed yield per plant was exerted by days to 50 % flowering (0.866), node to first flower appearance (0.836), number of pods per cluster (0.813), number of pods per plant (0.777), shelling % (0.736) and T.S.S. (0.725) via non reducing sugar. Negative indirect effect on seed yield per plant was exerted by number of pods per cluster (-0.962) via reducing sugar, shelling % (-0.931) via total sugars, node to first flower appearance (-0.789) via non reducing sugar, non-reducing sugar (-0.747) via total sugars and days to 50 % flowering (-0.719) *via* total sugars figure 1.

Earlier, positive direct effect on seed yield has been reported by Sharma and Bala (1997); Arya *et al.* (2004a); Chaudhary and Sharma (2010) and Ghobary (2010).

**Radial Dendrogram**



###### Fig.1. Direct and indirect effects of different characters on seed yield per plant at phenotypic level in 25 garden pea genotypes shown by a dendrogram

**Table 1: Estimates of phenotypic correlation coefficient among twenty characters in garden pea genotypes**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Characters** | **Days to 50 % flowering** | **Node to first flower** | **Plant height at the time of harvesting** | **Number of primary branches per plant** | **Number of pods per cluster** | **Number of pods per plant** | **Days to first pod harvest** | **Pod length (cm)** | **Pod width (cm)** | **Number of seeds per pod** | **Seed diameter (mm)** | **100 green seed weight (g)** | **Weight of per pod (g)** | **Shelling %** | **T.S.S. (0Brix)** | **Total sugar percent** | **Reducing sugar percent** | **Non-reducing sugar percent** | **Green pod yield per plant (g)** | **Seed yield per plant (g)** |
| **Days to 50 % flowering** | 1.000 | 0.186 | 0.534  \*\* | 0.449  \*\* | 0.522  \*\* | 0.510  \*\* | 0.889  \*\* | -0.527  \*\* | -0.157 | 0.165 | -0.448  \*\* | -0.583  \*\* | -0.585  \*\* | 0.413  \*\* | 0.197 | 0.133 | -0.047 | 0.209 | 0.306  \*\* | 0.426  \*\* |
| **Node to first flower** |  |  | -0.112 | 0.168 | 0.400  \*\* | 0.290  \* | 0.167 | 0.032 | 0.004 | 0.094 | -0.178 | 0.074 | -0.182 | 0.115 | 0.118 | 0.010 | 0.312  \*\* | -0.190 | 0.234  \* | 0.270  \* |
| **Plant height at the time of harvesting** |  |  |  | 0.659  \*\* | 0.238  \* | 0.231  \* | 0.478  \*\* | -0.583  \*\* | -0.132 | -0.037 | -0.265  \* | -0.591  \*\* | -0.542  \*\* | 0.227  \* | -0.036 | 0.018 | -0.116 | 0.100 | -0.013 | 0.051 |
| **Number of primary branches per** |  |  |  |  | 0.403  \*\* | 0.184 | 0.356  \*\* | -0.712  \*\* | -0.105 | -0.350  \*\* | -0.243  \* | -0.440  \*\* | -0.653  \*\* | 0.269  \* | 0.278  \* | -0.311  \*\* | -0.193 | -0.289  \* | -0.197 | -0.123 |
| **Number of pods per cluster** |  |  |  |  |  | 0.551  \*\* | 0.473  \*\* | -0.440  \*\* | 0.106 | 0.077 | -0.392  \*\* | -0.381  \*\* | -0.483  \*\* | 0.140 | 0.064 | 0.151 | 0.048 | -0.232  \* | 0.270  \* | 0.322  \*\* |
| **Number of pods per plant** |  |  |  |  |  |  | 0.499  \*\* | -0.420  \*\* | -0.116 | 0.085 | -0.614  \*\* | -0.599  \*\* | -0.500  \*\* | 0.179 | -0.310  \*\* | 0.144 | -0.068 | -0.148 | 0.790  \*\* | 0.843  \*\* |
| **Days to first pod harvest** |  |  |  |  |  |  |  | -0.438  \*\* | -0.252  \* | 0.223 | -0.471  \*\* | -0.651  \*\* | -0.566  \*\* | 0.312  \*\* | 0.078 | 0.204 | 0.057 | 0.236  \* | 0.343  \*\* | 0.370  \*\* |
| **Pod length (cm)** |  |  |  |  |  |  |  |  | 0.391  \*\* | 0.318  \*\* | 0.434  \*\* | 0.671  \*\* | 0.835  \*\* | -0.437  \*\* | -0.339  \*\* | 0.251  \* | 0.171 | 0.224 | 0.101 | -0.141 |
| **Pod width (cm)** |  |  |  |  |  |  |  |  |  | -0.017 | 0.169 | 0.361  \*\* | 0.502  \*\* | -0.445  \*\* | -0.082 | -0.260  \* | -0.218 | -0.202 | 0.184 | -0.043 |
| **Number of seeds per pod** |  |  |  |  |  |  |  |  |  |  | -0.236  \* | -0.048 | 0.133 | 0.246  \* | -0.231  \* | 0.435  \*\* | 0.258  \* | 0.412  \*\* | 0.211 | 0.251  \* |
| **Seed diameter (mm)** |  |  |  |  |  |  |  |  |  |  |  | 0.697  **\*\*** | 0.503  \*\* | -0.194 | -0.191 | 0.212 | 0.066 | 0.240  \* | -0.366  \*\* | -0.413  \*\* |
| **100 green seed weight (g)** |  |  |  |  |  |  |  |  |  |  |  |  | 0.743  \*\* | -0.114 | 0.065 | 0.082 | 0.114 | 0.036 | -0.210 | -0.249  \* |
| **Weight of per pod (g)** |  |  |  |  |  |  |  |  |  |  |  |  |  | -0.488  \*\* | -0.240  \* | 0.111 | 0.053 | 0.114 | 0.048 | -0.140 |
| **Shelling %** |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.384  \*\* | 0.173 | 0.080 | 0.178 | -0.104 | 0.255  \* |
| **T.S.S. (0Brix)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | -0.505  \*\* | -0.476  \*\* | -0.362\*\* | 0.220 | 0.312  \*\* |
| **Total sugar %** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.692  \*\* | 0.880  \*\* | -0.045 | 0.087 |
| **Reducing sugar %** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.267  \* | -0.009 | 0.065 |
| **Non-reducing sugar %** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | -0.055 | 0.074 |
| **Green pod yield per plant (g)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 0.866  \*\* |
| **Seed yield per plant (g)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1.000 |

###### \*,\*\* significant at 5 % and 1% level respectively

###### Table 2: Direct and indirect effects of different characters on seed yield per plant at phenotypic level in garden pea germplasm.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Characters | Days to 50 % flowering | Node to first flower | Plant height at the time of harvesting | Number of primary branches per plant | Number of pods per cluster | Number of pods per plant | Days to first pod harvest | Pod length (cm) | Pod width (cm) | Number of seeds per pod | Seed diameter (mm) | 100 green seed weight (g) | Weight of per pod (g) | Shelling % | T.S.S. (0Brix) | Total sugar percent | Reducing sugar percent | Non-reducing sugar percent | Green pod yield per plant (g) | Seed yield per plant (g) |
| Days to 50 % flowering | 0.206 | 0.014 | 0.023 | -0.066 | -0.045 | 0.345 | -0.128 | 0.174 | 0.010 | -0.002 | 0.027 | -0.132 | -0.205 | 0.076 | -0.011 | -0.719 | -0.125 | 0.866 | 0.118 | 0.426\*\* |
| Node to first flower | 0.038 | 0.077 | -0.005 | -0.025 | -0.034 | 0.196 | -0.024 | -0.011 | -0.003 | -0.001 | 0.011 | 0.017 | -0.064 | 0.021 | -0.006 | -0.056 | 0.836 | -0.789 | 0.090 | 0.270\* |
| Plant height at the time of harvesting | 0.110 | -0.009 | 0.043 | -0.097 | -0.020 | 0.156 | -0.069 | 0.192 | 0.008 | 0.000 | 0.016 | -0.133 | -0.190 | 0.042 | 0.002 | -0.099 | -0.310 | 0.413 | -0.005 | 0.051 |
| Number of primary branches per | 0.093 | 0.013 | 0.028 | -0.147 | -0.035 | 0.124 | -0.051 | 0.235 | 0.006 | 0.004 | 0.015 | -0.099 | -0.229 | 0.049 | -0.015 | 0.678 | -0.518 | -0.197 | -0.076 | -0.123 |
| Number of pods per cluster | 0.108 | 0.031 | 0.010 | -0.059 | -0.086 | 0.373 | -0.068 | 0.145 | -0.007 | 0.001 | 0.024 | -0.086 | -0.170 | 0.026 | -0.003 | 0.813 | 0.129 | -0.962 | 0.104 | 0.322\*\* |
| Number of pods per plant | 0.105 | 0.022 | 0.010 | -0.027 | -0.047 | 0.677 | -0.072 | 0.139 | 0.007 | -0.001 | 0.037 | -0.135 | -0.175 | 0.033 | -0.017 | 0.777 | -0.182 | -0.612 | 0.305 | 0.843\*\* |
| Days to first pod harvest | 0.183 | 0.013 | 0.021 | -0.052 | -0.041 | 0.338 | -0.144 | 0.145 | 0.016 | -0.002 | 0.028 | -0.147 | -0.198 | 0.057 | -0.004 | -0.302 | 0.152 | 0.177 | 0.132 | 0.370\*\* |
| Pod length (cm) | -0.109 | 0.002 | -0.025 | 0.105 | 0.038 | -0.285 | 0.063 | -0.330 | -0.024 | -0.003 | -0.026 | 0.151 | 0.293 | -0.080 | 0.018 | -0.356 | 0.258 | 0.129 | 0.039 | -0.141 |
| Pod width (cm) | -0.032 | 0.003 | -0.006 | 0.015 | -0.009 | -0.079 | 0.036 | -0.129 | -0.062 | 0.000 | -0.010 | 0.081 | 0.176 | -0.082 | 0.004 | 0.401 | -0.285 | -0.139 | 0.071 | -0.043 |
| Number of seeds per pod | 0.034 | 0.007 | -0.002 | 0.052 | 0.007 | 0.058 | -0.032 | -0.105 | 0.001 | -0.010 | 0.014 | -0.011 | 0.047 | 0.045 | 0.012 | -0.348 | 0.192 | 0.209 | 0.081 | 0.251\* |
| Seed diameter (mm) | -0.092 | -0.014 | -0.011 | 0.036 | 0.034 | -0.415 | 0.068 | -0.143 | -0.010 | 0.002 | -0.060 | 0.157 | 0.177 | -0.036 | 0.010 | -0.145 | 0.177 | 0.194 | -0.341 | -0.413\*\* |
| 100 green seed weight (g) | -0.120 | 0.006 | -0.025 | 0.065 | 0.033 | -0.406 | 0.094 | -0.222 | -0.022 | 0.000 | -0.042 | 0.226 | 0.261 | -0.021 | -0.003 | -0.445 | 0.305 | 0.149 | -0.081 | -0.249\* |
| Weight of per pod (g) | -0.121 | -0.014 | -0.023 | 0.096 | 0.041 | -0.339 | 0.082 | -0.276 | -0.031 | -0.001 | -0.030 | 0.168 | 0.351 | -0.090 | 0.013 | -0.599 | 0.142 | 0.472 | 0.019 | -0.140 |
| Shelling % | 0.085 | 0.009 | 0.010 | -0.040 | -0.012 | 0.121 | -0.045 | 0.144 | 0.027 | -0.002 | 0.012 | -0.026 | -0.171 | 0.184 | -0.021 | -0.931 | 0.214 | 0.736 | -0.040 | 0.255\* |
| T.S.S. (0Brix) | 0.041 | 0.009 | -0.002 | -0.041 | -0.005 | 0.210 | -0.011 | 0.112 | 0.005 | 0.002 | 0.012 | 0.015 | -0.084 | 0.071 | -0.053 | 0.725 | -0.275 | -0.501 | 0.085 | 0.312\*\* |
| Total sugar % | 0.027 | 0.001 | 0.001 | 0.046 | 0.013 | -0.098 | -0.030 | -0.083 | 0.016 | -0.004 | -0.013 | 0.019 | 0.039 | 0.032 | 0.027 | -0.392 | 0.356 | 0.148 | -0.018 | 0.087 |
| Reducing sugar % | -0.010 | 0.024 | -0.005 | 0.028 | -0.004 | -0.046 | -0.008 | -0.056 | 0.013 | -0.003 | -0.004 | 0.026 | 0.019 | 0.015 | 0.025 | -0.733 | 0.680 | 0.107 | -0.003 | 0.065 |
| Non-reducing sugar % | 0.043 | -0.015 | 0.004 | 0.043 | 0.020 | -0.100 | -0.034 | -0.074 | 0.012 | -0.004 | -0.014 | 0.008 | 0.040 | 0.033 | 0.019 | -0.747 | 0.716 | 0.145 | -0.021 | 0.074 |
| Green pod yield per plant (g) | 0.063 | 0.018 | -0.001 | 0.029 | -0.023 | 0.535 | -0.049 | -0.033 | -0.011 | -0.002 | 0.022 | -0.048 | 0.017 | -0.019 | -0.012 | 0.245 | -0.024 | -0.226 | 0.386 | 0.866\*\* |

###### \*, \*\* significant at 5 % and 1% level respectively

**CONCLUSION**

Based on the finding of the experiment it can be concluded that the selected out of 25 genotypes, HUDP-15, Arka Priya, NPVP-5, Azad Pea-1, NPVP-2, Azad Pea-4 and Solan Nirog were found promising for green pod yield per plant and other traits and proper testing and verification through experimental trial. So higher number of pods per plant should be taken into consideration during the practice of selection. Hence these genotypes are recommended for cultivation on a large scale among the farmers and breeding future programmes.

**FUTURE SCOPE**

The current experiment would lay the ground level work for future generations and researchers who are interested in working on the diverse breeding program. The obtained elite genotypes could be used as donor parents for agronomic traits. Further it is important objective to emphasize the importance of multidisciplinary approaches that combine traditional breeding with modern biotechnological tools to achieve comprehensive improvement in pea genotypes accordingly.

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