***Original Research Article***

# Yield maximization in green gram (*Vigna radiata* L. Wilczek) through Association and path analysis studies on yield and its component traits


## ABSTRACT

The present investigation was undertaken to estimate the correlation coefficients among thirteen quantitative traits and to study the direct and indirect effects of various yield contributing traits on grain yield by path analysis. Tin ten genetically diverse genotypes of green gram (*Vigna radiata* L.) were used as parents in line x tester mating design in addition toand their twenty four $F_2$ lines at Educational and Research farm, Department of Genetics and Plant Breeding, Brahmanand P.G. College, Rath (Hamirpur), Uttar Pradesh during *zaid*, 2019 in a randomized block design with three replications each. The results of association study revealed that, grain yield per plant (g) showed highly significant and positive correlation, at both genotypic and phenotypic levels, with number of days to flowering, number of pods per cluster, number of clusters per plant, number of pods per plant and biological yield per plant (g) indicating possibility of simultaneous improvement for these traits. However,whereas yield per plant for parents showed significant negative correlation with primary branches per plant and harvest index at both genotypic and phenotypic levels in parents. In contrast, while in F2 generation only clusters per plant, pods per cluster, pods per plant, biological yield per plant, seeds per pod, seed weight per pod and 100 seed weight exhibited significant positive association in F2 generation, indicating existence of linkage. Harvest index had negative association with most of the traits at genotypic as well as phenotypic levels. Path analysis revealed that, biological yield per plant; harvest index and seeds per pod recorded the high direct effect in desirable direction. Their association with grain yield was also significant and positive except with harvest index, indicating true and perfect association between these traits at both genotypic and phenotypic levels. Therefore, direct selection for these characters would help in isolating high yielding genotypes from highly segregating population. Among the traitscharacters showing negative direct effects were days to 50% flowering, branches per plant, plant height, pods per plant and seed weight per pod, however, these traits had positive association with yield. Hence, biological yield per plant, harvest index, seeds per pod and clusters per plant may be improved to enhance seed yield per plant and hybridization followed by direct and indirect selection for these traits may be undertaken for breeding high yielding cultivars.



**Keywords:** Green gram, yield, genotypic, phenotypic, correlation coefficient, path analysis


## INTRODUCTION

Green gram (*Vigna radiata* L. Wilczek) having 2n=2x=22 chromosomes in diploid cells, is a Leguminous crop, which stands as the third most important pulse crop of Asia after chickpea

and pigeon pea. It is a widely adapted, highly versatile and drought tolerant legume crop having ability to improve soil fertility. High protein content, easy digestibility and ~~causing~~ low flatulence effect made this crop more acceptable to the people over world (Prasanna *et al.* 2013). Being rich in its nutritional profile, it is a staple~~n inseparable~~ ingredient in the diet~~s~~ of ~~vast majority of population~~a large community in the Indian sub continent. However, the average consumption of green gram in India is quite low due to the low production, which requires ~~creates need for~~ increased productivity in green gram. Seed yield is a complex character~~, and is~~ depend~~ingent~~ on number of ~~component characters~~secondary traits. Correlation coefficient is an important statistical tool, which provides the degree and direction of association between yield and its component traits at both genotypic and phenotypic levels. The study of the inter-relationships ~~among~~between yield and yield contributing traits~~characters~~ becomes more important to plant breeder for the execution of effective crop breeding~~p improvement~~ program~~me~~. But, the correlation coefficient does not always give precise information on the contribution of each trait towards dependent variable *viz*, yield. To understand the criteria~~haracters~~ effectively ~~which really~~ contribut~~ing~~e towards grain yield, the path analysis is obvious. Path-coefficient analysis is simply a standardized partial regression coefficient, which splits the correlation coefficient into ~~the measures of~~ direct and indirect effects. In green gram, several~~numbers of~~ findings based on fixed genotypes have been reported but such information are lacking for~~in~~ segregating generations. Therefore, the present investigation was undertaken to obtain information on correlation studies as well as the direct and indirect effects of twelve ~~yield contributing~~yield-contributing traits in $F_2$ segregating population along with their parent ~~population~~ in green gram.

## MATERIALS AND METHODS

The genetic ~~experimental~~ material, consisted of 24 genotypes from $F_2$ generation of mungbean (*Vigna radiata* (L.) Wilczek) along with ten parents, were grown during *zaid*, 2018-19 in a randomized block design with three replications at educational and research farm, department of Genetics and Plant Breeding, B.N.V. College Rath, dist. Hamirpur (UP). The F~~f~~2 segregating population~~genotypes~~ was~~ere~~ obtained by crossing ten parents in line x tester mating design and growing F1~~f1~~s during kharif 2018 season.

The seed of all the 34 genotypes (24 F2s and 10 parents) were sown at 0.30 ~~e~~m distance between rows~~ to row~~ and 0.10 ~~e~~m distance between plants~~nt to plant~~. Each plot had 1.2 m x 3.0 m area with four rows for each population. ~~Recommended dose of fertilizers (NPK 20:60:20 kg/ha) was applied as basal in all plots under experiment.~~ Five plants~~ each~~ from each~~ten~~ parent~~s~~ and ~~twenty four~~ genotype~~s~~ from $F_2$ generation were selected per treatment per replication for recording observations on yield and yield contributing traits *viz;* days to 50% flowering, days to maturity, number of branches per plant, plant height, number of clusters per plant, number of pods per cluster, number of pods per plant, biological yield per plant, number of grains per pod, grain weight per pod, 100 seed weight (g), harvest index, and grain yield per plant (g). All the agronomic practices were followed to maintain good crop stand. The genotypic and phenotypic co-variances were worked out as per the formulae given by Singh and Chaudhary (1977). By using this, the phenotypic and genotypic

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correlation coefficients for all the characters were ~~worked out as per procedure~~calculated based on the formula suggested by Johnson *et al.* (1955) whereas, the phenotypic as well as genotypic path coefficient analysis was done as per the method suggested by Dewey and Lu (1959). Analysis was carried out separately for parents and F2 population.

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## RESULTS AND DISCUSSION

The genotypic and phenotypic correlation coefficients were computed among all characters under study and presented in Table 1 and 2 for parents and $F_2$s respectively. In general, the genotypic correlation coefficients were comparatively higher than corresponding phenotypic correlation coefficient. Low phenotypic correlations can be explained due to masking or modifying effects of environment on genetic association between characters. Similar findings were reported by Vikas *et al.*(1999), Sirohi *et al.* (2007), Khampara *et al.* (2012) and Sneha *et al.* (2019). Seed yield per plant had significant positive correlation with days to 50% flowering, days to maturity, pods per cluster, cluster per plant, pods per plant and biological yield per plant in both genotypic and phenotypic levels in parents while it showed positive association with pods per cluster, cluster per plant, pods per plant, biological yield per plant, seeds per pod, seed weight per pod and 100 seed weight in F2s. Therefore, selection for these traits might lead to enhanced productivity. Positive correlations for one or more of these traits were reported by many earlier researchers namely by Pundhir *et al.* (1992) and Vikas *et al.* (1999) for clusters per plant and pods per plant; Reddy *et al.* (2005) for clusters per plant, Hemavathi *et al.* (2015) for number of clusters per plant and number of pods per plant, Jyothsana *et al.* (2016) [12] for number of pods per plant and Sneha *et al.* (2019) [8] for all the traits. From such positive correlation of these traits in parents~~,~~ and F2s, it was inferred that this correlation caused might be due to linkage of geneses governing these ~~traits which~~traits that is beneficial in selecetion.

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Harvest index and primary branches per plant in parents showed negative significant association with most of the traits in parents. Days to 50% flowering showed significant negative association with primary branches per plant in both parents and F2, while days to maturity showed negative association with primary branches per plant in parent and F2. Seed yield per plant had significant negative association with primary branches per plant and harvest index in parents only. This might be caused due to pleiotropy and ~~linkage which~~linkage, which may possibly be broken by breeding methods such as biparental mating or disruptive selection.

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From the estimates of direct and indirect effect of 12 characters towards seed yield per plant in parents and F2 presented in Table 3 and table 4 respectively, it may be noted that biological yield per plant and harvest index had the high positive direct effect on seed yield per plant in both parent and F2 generations while pods per cluster and cluster per plant had high negative direct effect on seed yield per plant in F2 generation. Pods per plant had the highest positive direct effect towards yield per plant in F2 at genotypic level while biological yield per plant in parent population at both genotypic and phenotypic level.~~.~~ These results are in agreement with Vikas *et al.* (1999) for biological yield and harvest index; Sirohi *et al* (2007) for harvest index and Singh *et al.* (2009) for biological yield per plant.~~,~~ The remaining characters such as pods per cluster, clusters per plant and pods per cluster, which had significant positive correlations with seed yield per plant did not exhibit considerable direct influence on seed yield per plant. ~~instead~~Instead, they contributed much indirectly via

biological yield per plant. However, few researchers reported high direct effect of these traits such as Khampara *et al.* (2012) for pods per plant, clusters per plant and pods per cluster and Hemavathy *et al* (2015) for number of pods per plant, pods per cluster, clusters per plant, and 100 seed weight. Days to 50% flowering and days to maturity also contributed through biological yield per plant. These results are in agreement with Kalpande *et al.* (1997) and Singh *et al.*(2009). Therefore, direct selection for high biological yield per plant, pods per cluster, clusters per plant, pods per plant and harvest index will result in improvement of seed yield per plant. Since, other component traits had indirect effect on seed yield per plant via biological yield per plant; correlated response in component traits will ultimately be realized.

## CONCLUSION

From ~~the analysis under~~ the present investigation, it can be concluded that number of pods per cluster, number of clusters per plant, number of pods per plant, biological yield per plant, harvest index and seed weight per pod were the major yield contributing characters which had positive and significant association with seed yield per plant in both or one of the populations and also exhibited high direct effect on grain yield per plant. Therefore, due emphasis should be given on these characters in the selection which would help in isolating high yielding genotypes from highly segregating population to enhance the productivity and yield potential of green gram cultivars.

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**Table 1: Genotypic and Phenotypic correlation coefficients among 13 characters in 10 parents in green gram (Genotypic upper diagonal and Phenotypic lower diagonal)**

| Characters | Days to 50% flowering | Days to maturity | Primary branches / plant | Plant height (cm) | Pods/ cluster | Clusters per plant | Pods per plant | Biological yield per plant | Seeds per pod | Seed weight/ pod (g) | 100-seed weight (g) | Harvest Index (%) | Seed yield/ plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% flowering | | 0.892** | -0.672** | 0.613** | 0.575** | 0.166 | 0.441* | 0.529** | 0.268 | 0.252 | 0.335 | -0.371 | 0.527** |
| Days to maturity | 0.890** | | -0.690* | 0.808** | 0.377 | 0.225 | 0.380* | 0.423* | 0.246 | -0.042 | 0.070 | -0.336 | 0.388* |
| Pr. branches / plant | -0.660** | -0.676** | | -0.527** | -0.345 | 0.022 | -0.094 | -0.232 | -0.011 | -0.211 | -0.023 | -0.078 | -0.449* |
| Plant height (cm) | 0.608** | 0.805** | -0.508* | | -0.008 | 0.252 | 0.221 | 0.218 | 0.270 | -0.492* | -0.414* | -0.140 | 0.194 |
| Pods per cluster | 0.570** | 0.372 | -0.318 | -0.006 | | 0.392* | 0.797** | 0.846** | 0.203 | 0.524** | 0.555** | -0.514* | 0.895** |
| Clusters per plant | 0.164 | 0.224 | 0.026 | 0.249 | 0.389* | | 0.819** | 0.765** | -0.256 | -0.304 | -0.147 | -0.692** | 0.586** |
| Pods per plant | 0.436* | 0.375 | -0.078 | 0.219 | 0.787** | 0.802** | | 0.955** | 0.067 | 0.052 | 0.195 | -0.759** | 0.830** |
| Biological yield (g) | 0.528** | 0.420* | -0.220 | 0.217 | 0.843** | 0.759** | 0.942** | | -0.063 | 0.241 | 0.223 | -0.802** | 0.882** |
| Seeds per pod | 0.263 | 0.244 | -0.012 | 0.268 | 0.198 | -0.253 | 0.062 | -0.061 | | -0.243 | 0.031 | 0.411* | 0.187 |
| Seed weight/ pod (g) | 0.251 | -0.040 | -0.203 | -0.479* | 0.520** | -0.304 | 0.051 | 0.240 | -0.237 | | 0.698** | -0.256 | 0.231 |
| 100-Seed weight (g) | 0.334 | 0.070 | -0.023 | -0.411 | 0.550** | -0.146 | 0.194 | 0.221 | 0.032 | 0.695** | | -0.275 | 0.163 |
| Harvest index (%) | -0.356 | -0.316 | -0.063 | -0.120 | -0.491* | -0.662** | -0.719** | -0.773** | 0.389* | -0.229 | -0.258 | | -0.427* |
| Seed yield per plant (g) | 0.521** | 0.386* | -0.428* | 0.200 | 0.882** | 0..574** | 0.811** | 0.872** | 0.185 | 0.237 | 0.162 | -0.372 | |

* Significant at 5% level, ** Significant at 1% level.

**Table 2: Genotypic and Phenotypic correlation coefficients among 13 characters in F2 generation in green gram (Genotypic upper diagonal and Phenotypic lower diagonal)**

| Characters | Days to 50% flowering | Days to maturity | Primary branches / plant | Plant height (cm) | Pods/ cluster | Clusters per plant | Pods per plant | Biological yield / plant | Seeds per pod | Seed weight/ pod (g) | 100-seed weight (g) | Harvest Index (%) | Seed yield/ plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% flowering | | 0.908** | -0.558** | 0.319* | 0.036 | 0.057 | 0.019 | 0.127 | 0.251* | -0.151 | 0.004 | 0.094 | 0.180 |
| Days to maturity | 0.902** | | -0.346** | 0.258* | 0.093 | 0.124 | 0.134 | 0.199 | 0.129 | -0.059 | 0.076 | -0.044 | 0.188 |
| Pr. branches / plant | -0.495** | -0.303* | | -0.319* | 0.084 | 0.248 | 0.241 | 0.049 | 0.072 | 0.248* | 0.396* | 0.105 | 0.097 |
| Plant height (cm) | 0.312* | 0.248* | -0.265* | | 0.010 | -0.036 | -0.069 | 0.178 | -0.118 | -0.113 | -0.056 | 0.017 | 0.205 |
| Pods/ cluster | 0.034 | 0.085 | 0.070 | 0.021 | | 0.469** | 0.855** | 0.706** | 0.246*cl | 0.550** | 0.263* | -0.125 | 0.653** |
| Clusters per plant | 0.053 | 0.116 | 0.196 | -0.027 | 0.437** | | 0.822** | 0.260* | 0.396** | 0.325* | 0.430** | 0.433* | 0.468** |
| Pods /plant | 0.018 | 0.128 | 0.201 | -0.056 | 0.798** | 0.762** | | 0.641** | 0.310* | 0.601** | 0.370** | 0.105 | 0.690** |
| Biological yield (g) | 0.128 | 0.198 | 0.028 | 0.181 | 0.684** | 0.253* | 0.604** | | 0.215 | 0.763** | 0.311* | -0.263* | 0.878** |
| Seeds/ pod | 0.225 | 0.113 | 0.071 | -0.102 | 0.217 | 0.336** | 0.275* | 0.195 | | 0.438** | 0.035 | 0.281* | 0.338** |
| Seed weight / pod (g) | -0.090 | -0.037 | 0.191 | -0.071 | 0.315** | 0.212 | 0.342** | 0.463** | 0.254* | | 0.299* | -0.096 | 0.708** |
| 100-Seed weight (g) | 0.001 | 0.073 | 0.337** | -0.055 | 0.255* | 0.401** | 0.358** | 0.302* | 0.017 | 0.173 | | 0.259* | 0.441* |
| Harvest index (%) | 0.075 | -0.044 | 0.060 | 0.004 | -0.090 | 0.398** | 0.101 | -0.243* | 0.213 | -0.068 | 0.268* | | 0.228 |
| Seed yield per plant (g) | 0.171 | 0.180 | 0.054 | 0.195 | 0.628** | 0.454** | 0.643** | 0.857** | .0293* | 0.412** | 0.440** | 0.288* | |

* Significant at 5% level, ** Significant at 1% level.

**Table 3: Path Coefficient analysis of genotypic and phenotypic correlation coefficients regarding direct and indirect effects of 12 characters towards seed yield per plant in green gram in parents (P)**

| Characters | | Days to 50% flowering | Days to maturity | Primary branches / plant | Plant height (cm) | Pods/ cluster | Clusters per plant | Pods per plant | Biological yield / plant | Seeds per pod | Seed weight/ pod (g) | 100-seed weight (g) | Harvest Index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% flower. | G | **-0.036** | -0.032 | 0.024 | -0.022 | -0.021 | -0.006 | -0.016 | -0.019 | -0.010 | -0.009 | -0.012 | 0.013 |
| | P | **-0.023** | -0.021 | 0.015 | -0.014 | -0.013 | -0.004 | -0.010 | -0.012 | -0.006 | -0.006 | -0.008 | 0.008 |
| Days to maturity | G | 0.008 | **0.009** | -0.006 | 0.007 | 0.003 | 0.002 | 0.003 | 0.004 | 0.002 | 0.000 | 0.001 | -0.003 |
| | P | -0.016 | **-0.018** | 0.012 | -0.015 | -0.007 | -0.004 | -0.007 | -0.008 | -0.005 | 0.001 | -0.001 | 0.006 |
| Primary bran. /plant | G | 0.113 | 0.116 | **-0.167** | 0.088 | 0.058 | -0.004 | 0.016 | 0.039 | 0.002 | 0.035 | 0.004 | 0.013 |
| | P | 0.122 | 0.125 | **-0.185** | 0.094 | 0.059 | -0.005 | 0.014 | 0.041 | 0.002 | 0.038 | 0.004 | 0.012 |
| Plant height (cm) | G | -0.084 | -0.111 | 0.072 | **-0.137** | 0.001 | -0.035 | -0.030 | -0.030 | -0.037 | 0.067 | 0.057 | 0.019 |
| | P | -0.072 | -0.096 | 0.061 | **-0.119** | 0.001 | -0.030 | -0.026 | -0.026 | -0.032 | 0.057 | 0.049 | 0.014 |
| Pods per cluster | G | 0.005 | 0.003 | -0.003 | 0.000 | **0.009** | 0.003 | 0.007 | 0.007 | 0.002 | 0.005 | 0.005 | -0.004 |
| | P | 0.002 | 0.001 | -0.001 | 0.000 | **0.004** | 0.002 | 0.003 | 0.003 | 0.001 | 0.002 | 0.002 | -0.002 |
| Clusters per plant | G | 0.008 | 0.011 | 0.001 | 0.012 | 0.019 | **0.048** | 0.039 | 0.036 | -0.012 | -0.014 | -0.007 | -0.033 |
| | P | 0.008 | 0.011 | 0.001 | 0.012 | 0.019 | **0.049** | 0.039 | 0.037 | -0.012 | -0.015 | -0.007 | -0.032 |
| Pods per plant | G | -0.069 | -0.059 | 0.015 | -0.034 | -0.124 | -0.127 | **-0.156** | -0.148 | -0.010 | -0.008 | -0.030 | 0.118 |
| | P | -0.024 | -0.021 | 0.004 | -0.012 | -0.043 | -0.044 | **-0.055** | -0.052 | -0.003 | -0.003 | -0.011 | 0.039 |
| Biological yield(g) | G | 0.778 | 0.621 | -0.341 | 0.319 | 1.242 | 1.123 | 1.401 | **1.468** | -0.093 | 0.354 | 0.328 | -1.177 |
| | P | 0.710 | 0.565 | -0.296 | 0.292 | 1.134 | 1.020 | 1.267 | **1.345** | -0.083 | 0.323 | 0.297 | -1.039 |
| Seeds per pod | G | 0.027 | 0.025 | -0.001 | 0.028 | 0.021 | -0.026 | 0.007 | -0.007 | **0.103** | -0.025 | 0.003 | 0.042 |
| | P | 0.027 | 0.025 | -0.001 | 0.027 | 0.020 | -0.026 | 0.006 | -0.006 | **0.102** | -0.024 | 0.003 | 0.040 |
| Seed weight / pod(g) | G | -0.004 | 0.001 | 0.003 | 0.007 | -0.008 | 0.005 | -0.001 | -0.004 | 0.004 | **-0.015** | -0.010 | 0.004 |
| | P | 0.004 | -0.001 | -0.004 | -0.008 | 0.009 | -0.005 | 0.001 | 0.004 | -0.004 | **0.017** | 0.012 | -0.004 |
| 100-Seed weight (g) | G | -0.005 | -0.001 | 0.000 | 0.006 | -0.008 | 0.002 | -0.003 | -0.003 | -0.001 | -0.010 | **-0.015** | 0.004 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | -0.010 | -0.002 | 0.001 | 0.012 | -0.016 | 0.004 | -0.006 | -0.006 | -0.001 | -0.020 | **-0.029** | 0.007 |
| Harvest index (%) | G | -0.214 | -0.194 | -0.045 | -0.081 | -0.296 | -0.399 | -0.438 | -0.462 | 0.237 | -0.148 | -0.159 | **0.577** |
| | P | -0.206 | -0.183 | -0.036 | -0.069 | -0.284 | -0.383 | -0.416 | -0.447 | 0.225 | -0.133 | -0.150 | **0.579** |
| Seed yield/ plant (g) | G | 0.527** | 0.388* | -0.448 * | 0.194 | 0.895** | 0.586** | 0.830** | 0.882** | 0.187 | 0.231 | 0.163 | -0.427* |
| | P | 0.521** | 0.386* | -0.428* | 0.200 | 0.882** | 0.574** | 0.811** | 0.872** | 0.185 | 0.237 | 0.162 | -0.372 |

Residual effect (Parents): (G) = -0.027 (P) = 0.032 **Bold** values are direct effects

**Table 4: Path Coefficient analysis of genotypic and phenotypic correlation coefficients regarding direct and indirect effects of 12 characters towards seed yield per plant in green gram in F2 generation**

| Characters | | Days to 50% flowering | Days to maturity | Primary branches / plant | Plant height (cm) | Pods/ cluster | Clusters per plant | Pods per plant | Biological yield / plant | Seeds per pod | Seed weight/ pod (g) | 100-seed weight (g) | Harvest Index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% flower | G | **-0.975** | -0.885 | 0.544 | -0.311 | -0.035 | -0.055 | -0.018 | -0.124 | -0.244 | 0.147 | -0.004 | -0.092 |
| | P | **-0.029** | -0.026 | 0.014 | -0.009 | -0.001 | -0.002 | -0.001 | -0.004 | -0.007 | 0.003 | 0.000 | -0.002 |
| Days to maturity | G | 0.373 | **0.411** | -0.142 | 0.106 | 0.038 | 0.051 | 0.055 | 0.082 | 0.053 | -0.024 | 0.031 | -0.018 |
| | P | 0.030 | **0.033** | -0.010 | 0.008 | 0.003 | 0.004 | 0.004 | 0.007 | 0.004 | -0.001 | 0.002 | -0.001 |
| Prim. Bran./ plant | G | 0.313 | 0.194 | **-0.560** | 0.179 | -0.047 | -0.139 | -0.135 | -0.028 | -0.040 | -0.139 | -0.222 | -0.059 |
| | P | 0.001 | 0.001 | **-0.003** | 0.001 | 0.000 | -0.001 | -0.001 | 0.000 | 0.000 | -0.001 | -0.001 | 0.000 |
| Plant height (cm) | G | 0.109 | 0.088 | -0.109 | **0.341** | 0.003 | -0.012 | -0.024 | 0.061 | -0.040 | -0.038 | -0.019 | 0.006 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | 0.004 | 0.003 | -0.003 | **0.013** | 0.000 | 0.000 | -0.001 | 0.002 | -0.001 | -0.001 | -0.001 | 0.000 |
| Pods per cluster | G | -0.068 | -0.178 | -0.161 | -0.018 | **-1.907** | -0.894 | -1.629 | -1.346 | -0.470 | -1.048 | -0.501 | 0.238 |
| | P | 0.001 | 0.002 | 0.002 | 0.001 | **0.022** | 0.010 | 0.018 | 0.015 | 0.005 | 0.007 | 0.006 | -0.002 |
| Clusters per plant | G | -0.144 | -0.315 | -0.631 | 0.091 | -1.191 | **-2.541** | -2.087 | -0.661 | -1.006 | -0.826 | -1.092 | -1.101 |
| | P | 0.000 | 0.001 | 0.001 | 0.000 | 0.002 | **0.004** | 0.003 | 0.001 | 0.001 | 0.001 | 0.002 | 0.002 |
| Pods per plant | G | 0.075 | 0.537 | 0.968 | -0.278 | 3.431 | 3.298 | **4.015** | 2.573 | 1.243 | 2.414 | 1.487 | 0.421 |
| | P | -0.001 | -0.004 | -0.006 | 0.002 | -0.022 | -0.021 | **-0.027** | -0.017 | -0.008 | -0.009 | -0.010 | -0.003 |
| Biological yield (g) | G | 0.093 | 0.146 | 0.036 | 0.131 | 0.518 | 0.191 | 0.470 | **0.734** | 0.158 | 0.560 | 0.229 | -0.193 |
| | P | 0.126 | 0.194 | 0.027 | 0.178 | 0.673 | 0.249 | 0.595 | **0.984** | 0.192 | 0.455 | 0.297 | -0.240 |
| Seeds per pod | G | 0.223 | 0.115 | 0.064 | -0.105 | 0.219 | 0.352 | 0.276 | 0.191 | **0.890** | 0.390 | 0.031 | 0.250 |
| | P | -0.001 | -0.001 | 0.000 | 0.001 | -0.001 | -0.002 | -0.002 | -0.001 | **-0.005** | -0.001 | 0.000 | -0.001 |
| Seed wt. per pod(g) | G | 0.130 | 0.051 | -0.214 | 0.097 | -0.474 | -0.280 | -0.518 | -0.658 | -0.378 | **-0.862** | -0.258 | 0.083 |
| | P | 0.000 | 0.000 | -0.001 | 0.000 | -0.001 | -0.001 | -0.002 | -0.002 | -0.001 | **-0.005** | -0.001 | 0.000 |
| 100-Seed weight(g) | G | 0.002 | 0.047 | 0.246 | -0.035 | 0.163 | 0.267 | 0.230 | 0.193 | 0.022 | 0.186 | **0.621** | 0.161 |
| | P | 0.000 | 0.000 | 0.001 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.001 | **0.003** | 0.001 |
| Harvest index (%) | G | 0.050 | -0.023 | 0.056 | 0.009 | -0.066 | 0.230 | 0.056 | -0.140 | 0.149 | -0.051 | 0.138 | **0.531** |
| | P | 0.040 | -0.023 | 0.032 | 0.002 | -0.048 | 0.212 | 0.054 | -0.130 | 0.114 | -0.036 | 0.143 | **0.534** |
| Seed yield/ plant(g) | G | 0.180 | 0.188 | 0.097 | 0.205 | 0.653** | 0.468** | 0.690** | 0.878** | 0.339** | 0.708** | 0.441** | 0.228 |
| | P | 0.171 | 0.180 | 0.054 | 0.195 | 0.628** | 0.454** | 0.643** | 0.857** | 0.293* | 0.412** | 0.440** | 0.288* |

Residual effect ($F_2$): (G) 0.118 (P) = 0.056 **Bold** values are direct effects