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# Relationship between Yield and Its Component Characters of Bush Bean (*Phaseolus vulgaris* L.)

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**Abstract**

Relationship between yield and its component characters of twenty seven bush bean (*Phaseolus vulgaris* L.) genotypes were studied during November 2002 to February 2003. Ten characters were studied to identify suitable traits for yield improvement of this crop. Significant variation in seed yield per plant was noticed among the genotypes and the yield difference was attributed mainly due to variation in yield components. The number of pods per plant was the highest in BB 15 followed by BB 3. The highest number of seeds per pod was found in BB 3, while BB 22 had the least. Based on the seed yield per plant, the 27 genotypes were grouped as high yielder (BB 3, BB 9 and BB 15), medium yielder (BB 10, BB 11, BB 12, BB 13, BB 14, BB 16 and BB 18) and low yielder (BB 1, BB 2, BB 4, BB 5, BB 6, BB 7, BB 8, BB 17, BB 19, BB 20, BB 21, BB 22, BB 23, BB 24, BB 25, BB 26 and BARI Bush bean-1). The differences between genotypic coefficient of variation (GCV) and the phenotypic coefficient of variation (PCV) were low for all the characters, indicated a low environmental influence over genetic factors on the characters. The GCV and PCV were generally high for pods/plant, 100-seed weight, duration of flowering, seeds/pod and seed yield/plant. High heritability coupled with high genetic advance was observed for duration of flowering, pods/plant, 100-seed weight, seed yield/plant and protein content. Days to 50% flowering, duration of flowering, plant height, pods/plant and seeds/pod had high degree of significant positive correlation with seed yield/plant. Path analysis indicated that pods/plant, days to 50% flowering, 100-seed weight, seeds/pod, plant height and pod length had positive direct effect on seed yield/plant. Those traits could, therefore, be of useful for yield improvement program of bush bean.
**Key words:** genetic variability, correlation, path coefficient, seed yield, bush bean, *Phaseolus vulgaris* L.

## Introduction

Yield is the principal factor for determining improvement of a crop. Like other legumes, seed yield in bush bean (*Phaseolus vulgaris* L.) is a quantitative character and influenced by a number of yield contributing traits. The selection of desirable types should therefore be based on yield as well as on other yield components. Infor-

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mation on mutual association between yield and yield components is necessary for efficient utilization of the genetic stock in crop improvement program of this crop.

Bush bean belongs to the family Leguminosae, is reported to be a native of Central and South America (SWAIDER *et al.* 1992). It is also referred as to French bean, common bean, snap bean, green bean, kidney bean, haricot bean and dwarf bean (GEORGE 1985). In Bangladesh it is called *Jhar seem* or *Farashi seem*. Bush bean is becoming popular for its tender pods and shelled beans. It has also high export potentiality. Few years back it was only used for making *daal* (spicy soup) mostly in the east and south-eastern parts of Bangladesh. It is now available in the big supermarkets of the capital Dhaka. The green pods and dry seeds are used in preparations with fish, meat and other vegetables as well. The dry seeds are also used in various curry preparations. Immature pods are mostly marketed as fresh. Canned pods are also imported to sale in the local market.

In a preliminary trial we noticed that bush bean showed a high variability in its yield and yield contributing characters; suggested an ample scope for yield and quality improvement of this crop. In Bangladesh only two varieties so far developed from Bangladesh Agricultural Research Institute (BARI), of which one is losing its potentiality for long time use by the farmers. Attention should therefore be paid for characterization of available bush bean genotypes. Information on association of yield related traits, and the degree and direction of association should be of helpful for identifying desirable characters for a useful breeding program on bush bean. This study was undertaken, employing 27 potential genotypes to analyze the relationship between yield components, association among desired traits and their direct and indirect contributions toward seed yield in bush bean.

## Materials and Methods

The experiment was carried out at the experimental field of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh during November 2002 to February 2003. The soil was silty clay in texture, with pH 6.5. The climate of the experimental site is subtropical in nature characterized by heavy rainfall during June to September and scanty in winter (November to March).

Twenty seven potential bush bean genotypes were the test materials. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The whole experimental area was divided into three blocks, representing three replications. Each block was further subdivided into 27 unit plots. The twenty seven genotypes were allotted to the 27 unit plots of each block. The plots were raised by 15 cm from the ground level to avoid water-logging, if occurred. The unit plot size was 4.0 m x 1.0 m, and the row - row and plant - plant spacing were 0.3 m and 0.1 m, respectively. The plot - plot and block - block distances were 0.5 m and 1.0 m, respectively. Seeds were subjected to germination test and treated with Vitavax-200 at 3g $kg^{-1}$

of seed for an hour before sowing to protect from diseases. Seeds were sown at about 3.0 cm depth. Manure and fertilizers were applied according to ISLAM and NEWAZ (2001) are shown in Table 1.

Table 1. Doses and methods of application of manure and fertilizers.

| Manure/Fertilizers | Dose (kg/ha) | Basal application | Top dressing | |
|---|---|---|---|---|
| | | | 1st installment* | 2nd installment** |
| Cowdung | 10,000 | Entire | - | - |
| N | 55 | Half | Quarter | Quarter |
| $P_2O_5$ | 100 | Entire | - | - |
| $K_2O$ | 36 | Entire | - | - |
| $ZnSO_4H_2O$ | 10 | Entire | - | - |
| $CaSO_42H_2O$ | 120 | Entire | - | - |

* 15 days after sowing ** 40 days after sowing

All necessary cultural operations were done as and when necessary during the growing period. Data collected, from 10 randomly selected plants, on days to 50% flowering, duration of flowering, plant height (cm), pod length (cm), pod breadth (mm), number of pods/plant, number of seeds/pod, 100-seed weight (g), seed yield/ plant (g) and percentage of protein content. Total protein in seeds was estimated by multiplying nitrogen content with 6.25, while total nitrogen was estimated Colorimetrically following LINDER (1944).

The data were analyzed for estimation of genotypic and phenotypic coefficients of variation following BURTON (1952). Heritability in broad sense and genetic advance were calculated according to the methods of ALLARD (1960). Simple correlation coefficients among the characters at phenotypic and genotypic levels were analyzed following HAYES *et al*. (1955), and SINGH and CHAUDHARY (1985). Path analysis at genotypic level was done following DEWAY and LU (1959).

## Results and Discussion

A large variation in yield performance was noticed among the 27 genotypes of bush bean (Table 2). Genotypes varied from 34.33 to 54.67 days to initiate 50% flowering. They differed remarkably in producing seed yield per plant, and the difference in yield was attributed mainly due to variation in yield components. The tallest genotype was BB 9, while the shortest one was BB 20. The number of pods per plant was the highest in BB 15 (22.64) followed by BB 3 (17.87), and the lowest in BB 26 (2.90). The highest number of seeds per pod was obtained from BB 3 (5.74) while BB 22 (1.84) the least.

Table 2. Mean performance of yield and yield contributing characters in 27 bush bean genotypes.

| Genotypes | Days to 50% flowering | Duration of flowering (days) | Plant height (cm) | Pod length (cm) | Pod breadth (mm) | Pods /plant (no.) | Seeds /pod (no.) | 100- seed weight (g) | Seed yield /plant (g) |
|---|---|---|---|---|---|---|---|---|---|
| BB 1 | 43.67 | 20.00 | 33.50 | 9.39 | 12.22 | 10.60 | 3.09 | 15.37 | 3.86 |
| BB 2 | 44.00 | 19.00 | 40.00 | 9.41 | 11.39 | 6.80 | 2.53 | 20.12 | 3.45 |
| BB 3 | 51.00 | 27.33 | 39.60 | 7.00 | 8.21 | 17.87 | 5.74 | 11.13 | 12.38 |
| BB 4 | 34.33 | 11.00 | 34.24 | 10.21 | 11.96 | 7.70 | 2.86 | 27.68 | 5.83 |
| BB 5 | 38.67 | 10.00 | 36.12 | 9.83 | 11.06 | 7.14 | 2.59 | 23.53 | 4.18 |
| BB 6 | 39.67 | 21.00 | 33.00 | 9.68 | 10.39 | 6.52 | 3.49 | 19.30 | 4.32 |
| BB 7 | 39.00 | 14.67 | 29.33 | 9.27 | 10.52 | 6.55 | 3.09 | 18.87 | 3.40 |
| BB 8 | 42.33 | 26.67 | 28.50 | 8.76 | 8.98 | 10.36 | 4.04 | 11.20 | 4.48 |
| BB 9 | 54.67 | 21.67 | 45.00 | 9.54 | 10.34 | 15.96 | 4.57 | 20.37 | 14.06 |
| BB 10 | 44.33 | 9.33 | 44.75 | 11.92 | 13.17 | 8.80 | 4.11 | 27.38 | 8.09 |
| BB 11 | 48.00 | 24.33 | 37.28 | 8.34 | 8.49 | 13.40 | 5.16 | 13.07 | 9.56 |
| BB 11 | 50.00 | 23.00 | 33.88 | 7.80 | 9.99 | 12.30 | 4.56 | 12.67 | 8.01 |
| BB 13 | 52.00 | 16.67 | 36.33 | 6.67 | 9.73 | 14.61 | 3.74 | 17.30 | 9.88 |
| BB 14 | 54.33 | 23.67 | 34.67 | 7.09 | 9.36 | 13.95 | 5.07 | 12.18 | 9.41 |
| BB 15 | 52.00 | 24.00 | 37.33 | 6.72 | 8.48 | 22.64 | 5.32 | 12.27 | 12.97 |
| BB 16 | 49.00 | 26.67 | 39.09 | 7.65 | 9.17 | 16.28 | 3.98 | 15.00 | 8.46 |
| BB 17 | 42.00 | 22.00 | 32.15 | 7.85 | 8.94 | 7.23 | 4.92 | 12.57 | 3.91 |
| BB 18 | 43.33 | 21.00 | 40.25 | 12.34 | 13.04 | 7.10 | 4.04 | 29.05 | 9.27 |
| BB 19 | 38.67 | 17.33 | 31.11 | 11.41 | 12.15 | 6.20 | 3.05 | 34.87 | 4.58 |
| BB 20 | 41.67 | 11.33 | 22.60 | 9.80 | 10.82 | 6.87 | 2.96 | 27.55 | 4.03 |
| BB 21 | 41.00 | 8.67 | 27.67 | 9.35 | 10.73 | 7.70 | 4.11 | 28.77 | 4.17 |
| BB 22 | 37.33 | 11.67 | 33.38 | 11.82 | 10.76 | 8.28 | 1.84 | 19.63 | 1.47 |
| BB 23 | 40.67 | 12.00 | 28.72 | 9.78 | 10.85 | 6.63 | 2.35 | 17.32 | 2.93 |
| BB 24 | 38.33 | 16.00 | 34.57 | 9.64 | 12.20 | 4.53 | 3.76 | 33.80 | 1.72 |
| BB 25 | 42.33 | 13.00 | 33.20 | 8.92 | 11.11 | 7.57 | 2.87 | 26.80 | 3.59 |
| BB 26 | 36.67 | 9.00 | 25.46 | 10.72 | 10.30 | 2.90 | 1.86 | 27.35 | 1.19 |
| BARI Bush bean-1 | 45.00 | 16.67 | 24.96 | 8.94 | 9.39 | 7.97 | 5.45 | 17.78 | 4.33 |
| F-value | ** | * | ** | ** | ** | ** | ** | * | ** |
| CV | 3.06 | 3.16 | 4.85 | 0.90 | 1.10 | 3.15 | 1.16 | 4.83 | 2.50 |
| LSD | 3.19 | 8.18 | 10.99 | 4.45 | 4.78 | 14.72 | 14.22 | 10.80 | 18.94 |

* Significant at 5% level ; ** significant at 1% level

The heaviest seeds (34.87g/100 seed) were produced by BB 19, while the lightest one (11.13g/100-seed weight) by BB 3. Based on the seed yield per plant, the 27 genotypes were grouped as i) high yielder (3 genotypes viz. BB 3, BB 9 and BB 15) which produced >12.0g seeds/plant, ii) medium yielder (7 genotypes viz. BB 10, BB 11, BB 12, BB 13, BB 14, BB 16 and BB 18) which produced >8.0g but < 12.0g seeds/plant, iii) low yielder (17 genotypes viz. BB 1, BB 2, BB 4, BB 5, BB 6, BB 7, BB 8, BB 17, BB 19, BB 20, BB 21, BB 22, BB 23, BB 24, BB 25, BB 26 and BARI Bush bean-1) which produced <8.0g seeds/plant.

Mean, genotypic and phenotypic variance, genotypic and phenotypic coefficient of variations, heritability and expected genetic advance of different yield contributing characters are given in Table 3. The differences between genotypic coefficient of variation (GCV) and the phenotypic coefficient of variation (PCV) were low for all the characters indicated a low environmental influence on the expression of these characters. The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were high for pods/plant, 100- seed weight, duration of flowering, seeds/pod and seed yield/plant. According to BURTON (1952) characters which show high GCV have the high potential for effective selection. The plant height, pod length and protein percentage had moderate genotypic and phenotypic coefficients of variation and hence, these traits provide practically average chance for selection. On the contrary days to 50% flowering (12.59 and 13.13) and pod breadth (12.83 and 13.69) had the lower phenotypic and genotypic coefficients of variation, respectively and thus, have practically less chance for selection.

The heritable fraction of the variation provides the base of the plant breeder for selection on the phenotypic performances. The heritability estimates in broad sense were the highest for protein percentage (99.78) followed by duration of flowering (94.43), pod length (93.33), days to 50% flowering (91.96), 100-seed weight (91.13), pods/plant (90.76), seed yield/plant (90.54), pod breadth (87.83), seeds/pod (79.90) and plant height (74.58). The high heritability of these parameters indicated that selection of them would be more effective than the other parameters (SINGH *et al.*, 1994). The heritability value for duration of flowering, pod length and days to 50% flowering was high, while it was low for seeds/pod which was in accordance with the findings of SAMAL *et al.* (1997) in kidney bean.

According to PANSE (1957) effective selection may be done for the characters having high heritability accompanied with high genetic advance, which is due to additive gene effect. High genetic gain along with high estimates of heritability was observed for duration of flowering, pods/plant, 100-seed weight, seed yield/plant and protein percentage in the genotypes, which in fact demonstrated the presence of additive gene effects. It would, thus, be worthwhile to select these traits for the improvement of this crop. High values for heritability and genetic advance were observed for yield/plant, pod length and pods/plant in French bean genotypes in a study of SINGH *et al.* (1994). The lowest heritability along with lower estimates of genetic advance was found in

Table 3. Estimates of genetic parameters for ten characters in bush bean.

| Characters | Mean | Variance | | Coefficient of variation | | Herit -ability (%) | Genetic advance (GA) | GA in % mean |
|---|---|---|---|---|---|---|---|---|
| | | Genotypic | Phenotypic | Genotypic | Phenotypic | | | |
| Days to 50% flowering | 43.85 | 29.58 | 32.16 | 12.59 | 13.13 | 91.96 | 10.74 | 24.87 |
| Duration of flowering (days) | 17.69 | 35.51 | 37.60 | 33.68 | 34.66 | 94.43 | 11.93 | 67.42 |
| Plant height (cm) | 34.33 | 27.40 | 36.75 | 15.25 | 17.66 | 74.58 | 9.31 | 27.12 |
| Pod length (cm) | 9.25 | 2.37 | 2.54 | 16.63 | 17.21 | 93.33 | 3.06 | 33.10 |
| Pod breadth (mm) | 10.51 | 1.82 | 2.07 | 12.83 | 13.69 | 87.83 | 2.60 | 24.77 |
| Pods/ plant (no.) | 9.80 | 20.43 | 22.51 | 46.14 | 48.43 | 90.76 | 8.87 | 90.55 |
| Seeds/ pod (no.) | 3.75 | 1.13 | 1.41 | 28.36 | 31.72 | 79.90 | 1.96 | 52.21 |
| Protein (%) | 18.45 | 9.70 | 9.72 | 16.88 | 16.90 | 99.78 | 6.41 | 34.74 |
| 100- seed weight (g) | 20.48 | 50.27 | 55.16 | 34.62 | 36.27 | 91.13 | 13.94 | 68.08 |
| Seed yield/plant (g) | 6.056 | 12.59 | 13.91 | 58.59 | 61.58 | 90.54 | 6.96 | 114.84 |

plant height (Table 3). PANSE (1957) also reported that low heritability accompanied by low genetic advance was due to non-additive gene effects for the particular character and would offer less scope for selection; because that was under the influence of environment. High heritability along with low genetic advance was recorded in days to 50% flowering, pod length and pod breadth (Table 3). Similar result was also reported by AGGARWAL and KANG (1976) for days to first flowering in horse gram (*Dolichos biflorus* L.), and argued for a minimum scope for improvement of horse gram through selection of this character.

Genotypic and phenotypic correlation coefficients between different pairs of characters are presented in Table 4. It is evident that the genotypic correlation coefficients, in majority of the cases, were higher than the corresponding phenotypic correlation coefficients, indicating an apparent association due to genetic reason. JOHNSON *et al*., (1955b), SRIVASTAVA *et al*. (1972), NANDPURI *et al*. (1973) and SINGH *et al*. (1979) also reported a higher genotypic correlation than phenotypic one, and indicated the existence of an inherent association between various characters. Seed yield/plant showed significantly positive correlations with days to 50% flowering, duration of flowering, plant height, pods/plant and seeds/pod (Table 4). Similar to the results, especially of pods/plant and seeds/pod, of this study the characters like pods/plant, pod weight, pod length and seeds/pod showed significant positive correlations with yield in pole type

French bean genotypes (MISHRA *et al*. 1996). KALIA and KALIA (1995) also observed positive significant genotypic and phenotypic association between number of pods/plant and seed yield/plant in French bean genotypes. Days to 50% flowering showed highly significant positive correlation at both genotypic and phenotypic levels with duration of flowering, plant height, pods/plant, seeds/pod and seed yield/plant, while showed significantly negative correlation with pod length and pod breadth. The character, however, showed very poor negative correlation with protein percentage. SINGH *et al*. (1987) and SINGH (1985) also reported a positive correlation between days to 50% flowering and seed yield in pea. Duration of flowering showed a similar correlation to days required for 50% flowering with all the traits studied.

Both genotypic and phenotypic correlations of plant height with all the traits were positive except pod length and 100-seed weight. However, the parameter showed a positive highly significant correlation with pods/plant and seed yield/plant. SINGH (1985) observed a positive correlation between plant height and dry seed yield in pea. Pod length and pod breadth showed significant negative correlation with pods/plant, seeds/pod as well as seed yield/plant, though they showed a highly positive significant correlation with 100-seed weight. The correlation between these two traits was also

Table 4. Genotypic (upper right) and phenotypic (lower left) correlation coefficient among ten characters in bush bean.

| Characters | Days to 50% flowering | Duration of flowering | Plant height (cm) | Pod length (cm) | Pod breadth (mm) | Pods /plant | Seeds /pod | Protein (%) | 100-seed weight (g) | Seed yield /plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% flowering | **1.000** | 0.709** | 0.616* | -0.696** | -0.537** | 0.833** | 0.709** | -0.007 | -0.659** | 0.851** |
| Duration of flowering | 0.653** | **1.000** | 0.430** | -0.596** | -0.591** | 0.669** | 0.693** | -0.090 | -0.706** | 0.593** |
| Plant height (cm) | 0.506** | 0.364** | **1.000** | -0.068 | 0.056 | 0.557** | 0.327** | 0.132 | -0.195 | 0.723** |
| Pod length (cm) | -0.666** | -0.553** | -0.034 | **1.000** | 0.817** | -0.699** | -0.616** | 0.094 | 0.738** | -0.463** |
| Pod breadth (mm) | -0.475** | -0.546** | 0.080 | 0.759** | **1.000** | -0.617** | -0.579** | 0.077 | 0.816** | -0.383** |
| Pods /plant (no.) | 0.800** | 0.628** | 0.534** | -0.647** | -0.563** | **1.000** | 0.690** | -0.094 | -0.656** | 0.870** |
| Seeds /pods (no.) | 0.645** | 0.610** | 0.208 | -0.536** | -0.510** | 0.576** | **1.000** | 0.074 | -0.536** | 0.734** |
| Protein (%) | -0.009 | -0.087 | 0.114 | 0.092 | 0.074 | -0.091 | 0.063 | **1.000** | 0.276* | 0.107 |
| 100 seed weight (g) | -0.610** | -0.639** | -0.203 | 0.672** | 0.706** | -0.609** | -0.416** | 0.265* | **1.000** | -0.408** |
| Seed yield /plant (g) | 0.781** | 0.552** | 0.634** | -0.421** | -0.338** | 0.845** | 0.647** | 0.102 | -0.408** | **1.000** |

*Significant at 5% level ; **significant at 1% level positive and highly significant. Both pod length and pod breadth was poorly correlated with protein percentage.

It was found a positive highly significant correlation between pods/plant and seeds/pod. Pods/plant and seeds/pod showed positive and highly significant association at both genotypic and phenotypic levels with seed yield/ plant, while they showed significantly negative correlation with 100-seed weight. Negative correlation was also found between pods/plant and protein percentage. The correlation between seeds/pod and protein percentage was low and positive. Protein percentage showed positive correlation at both genotypic and phenotypic levels with 100-seed weight and seed yield/ plant. A significant negative correlation was evident between 100-seed weight and seed yield/plant. A positive correlation between number of pods per plant as well as seeds per pod and seed yield was also reported earlier for legumes (SINDHU and PRASAD, 1987, SINGH *et al*. 1987, SANDHU *et al*. 1991).

Association of characters determined by correlation coefficients may not indicate properly the relative importance of direct and indirect effect of each individual yield contributing character on yield. Therefore, the direct and indirect effects were worked out using path analysis at genotypic level, which also expresses the relative importance of each character on yield. The results of path analysis as in Table 5 revealed that pods/plant (0.509) had the maximum direct effect followed by days to 50% flowering (0.335), 100-seed weight (0.306), seeds/pod (0.291), plant height (0.254), pod length (0.228) and negligible effect by protein percentage (0.006). The contribution of yield components like plant height, pods/plant, seeds/pod and 100-seed weight was relatively higher in the present study, which was in accordance with the findings of RAHMAN *et al*. (1992) on country bean.

Days to 50% flowering had higher direct positive effect (0.335) and high positive significant genotypic correlation (0.851) with seed yield (Table 5). Duration of flowering showed lower negative direct effect (-0.068), though had the significant positive genotypic correlation (0.593) with seed yield. Plant height showed moderate positive direct effect (0.254) and positive significant correlation (0.723) with seed yield. The negative indirect effects via duration of flowering (-0.029), pod length (-0.015), pod breadth (-0.011) and 100-seed weight (-0.060) were relatively low. The positive indirect effects via days to 50% flowering (0.206), pods/plant (0.284), seeds/pod (0.095) and protein percentage (0.001) can minimize the total negative effects. High positive direct effect (0.509) and correlation coefficients (0.870) with seed yield was exhibited by pods/plant. Indirect effect via days to 50% flowering (0.295), plant height (0.141), pod breadth (0.131) and seeds/pod (0.201) were positive though other characters showed negative indirect effect on seed yield, which can not influence the total effect. Considering high positive direct effect and significant correlation with seed yield, the pods/plant is the main important character which can help to select better plant type. SINGH and RAM (1988) also reported a high direct effect of pods per plant on seed yield in garden pea.

Direct positive effect of seeds/pod (0.291) is one of the important contributors to

Table 5. Path coefficient (genotypic) showing direct (bold) and indirect effects of different characters contributing towards seed yield in bush bean.

| Character | Days to 50% flowering | Duration of flowering | Plant height (cm) | Pod length (cm) | Pod breadth (mm) | Pods /plant (no.) | Seeds /pod (no.) | Protein (%) | 100-seed weight (g) | Seed yield/plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% flowering | **0.335** | -0.048 | 0.156 | -0.159 | 0.113 | 0.450 | 0.206 | -0.000 | -0.202 | 0.851** |
| Duration of flowering | 0.238 | **-0.068** | 0.109 | -0.136 | 0.125 | 0.341 | 0.202 | -0.001 | -0.217 | 0.593** |
| Plant height (cm) | 0.206 | -0.029 | **0.254** | -0.015 | -0.011 | 0.284 | 0.095 | 0.001 | -0.060 | 0.723** |
| Pod length (cm) | -0.233 | 0.041 | -0.017 | **0.228** | -0.173 | -0.356 | -0.179 | 0.001 | 0.227 | -0.463** |
| Pod breadth (mm) | -0.179 | 0.040 | 0.014 | 0.186 | **-0.212** | -0.314 | -0.168 | 0.001 | 0.251 | -0.383** |
| Pods /plant (no.) | 0.295 | -0.045 | 0.141 | -0.159 | 0.131 | **0.509** | 0.201 | -0.001 | -0.201 | 0.870** |
| Seeds/pod (no.) | 0.238 | -0.047 | 0.083 | -0.140 | 0.123 | 0.351 | **0.291** | 0.001 | -0.165 | 0.734** |
| Protein (%) | 0.002 | 0.006 | 0.034 | 0.021 | -0.016 | -0.048 | 0.022 | **0.006** | 0.085 | 0.107 |
| 100-seed weight (g) | -0.221 | 0.048 | -0.050 | 0.168 | -0.173 | -0.334 | -0.156 | 0.002 | **0.306** | -0.408** |

Residual effect = 0.251 ;**Significant at 1% level ; The bold values indicate direct effects

seed yield. Positive indirect effect of seeds/pod via days to 50% flowering (0.238), plant height (0.083), pod breadth (0.123) and pods/plant (0.351) might be due to the significant positive correlation (0.734) with seed yield/plant (Table 5). Strong direct effect of seeds/pod on seed yield was also reported by NAYAK and BAISAKH (1990) and SINGH and RAM (1988). Though pod length (0.228) showed positive direct effect on seed yield, its indirect effect via days to 50% flowering (-0.233), plant height (-0.017), pod breadth (-0.173), pods/plant (-0.356) and seeds/pod (-0.179) were negative, which consequently reduced the correlation of this character with seed yield. This suggested that a restricted simultaneous selection model could be followed to nullify the undesirable indirect effects to make proper use to the direct effects (SHAH *et al*. 1996). Negative direct effect exhibited in pod breadth with seed yield/plant was also negative and was mainly due to negative indirect effects via days to 50% flowering (-0.179), pods/plant (-0.314) and seeds/pod (-0.168). Hundred seed weight (0.306) showed a positive direct effect on seed yield per plant, though a significant negative correlation was found between them (-0.408). Similar result was also reported for mungbean by ALI and SHAIKH (1986).

The estimated residual effect was low (0.251), which indicated that about 75% of the variability in seed yield was contributed by the plant characters studied. This residual effect towards seed yield in the present study might be due to other characters or environmental factors and, or sampling errors (SENGUPTA and KATARIA 1971). On the basis of estimates of path analysis it is suggested that pods/plant, seeds/pod, plant height as well as days to 50% flowering are the main contributors to seed yield, and thus, emphasis should be given in selecting plants with these characters for its yield improvement program.

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