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CORRELATION AND PATH COEFFICIENT ANALYSIS OF DIFFERENT GROWTH AND YIELD COMPONENTS OF KIDNEY BEAN (*Phaseolus vulgaris* L.)

R. Fatema†, B. N. Shompa†, and J. Rahman*

Department of Genetics and Plant Breeding, Faculty of Agriculture, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh

Abstract

An investigation was undertaken to determine the major yield contributing traits based on their direct and indirect effects on yield through the correlation and path coefficient analysis. The research of kidney bean germplasm was based on the evaluation of germplasm collected from Sylhet, Bandarban hilly regions and Bangladesh Agricultural Research Institute, considering 17 yield and its contributing characters. The study unraveled that yield per plant had highly significant positive correlation with number of leaves (0.83, 0.78), number of pods per plant (0.78, 0.73), pod length (0.86, 0.76), dry weight of pod (0.97, 0.90), number of seeds per pod (0.79, 0.72) at both genotypic and phenotypic correlation levels. It showed significant and negative association with pod diameter (-0.67) at the genotypic level. In path coefficient analysis high positive direct effect was found in seed yield towards yield per hectare. While, it was observed negligible positive indirect effect towards yield per hectare via, days to first flowering, days to maturity, plant height, number of pods per plant, petiole length, pod diameter, and number of seeds per pod. The overall results suggest that the yield contributing traits such as number of leaves, number of pods per plant, pod length, dry weight of pod, and number of seeds per pod should be considered as selection index for yield improvement of kidney bean.

Keywords: Correlation, Germplasm, Kidney bean, Path coefficient

Introduction

Kidney bean *(Phaseolus vulgaris* L.) is cultivated widely due to its high nutritional composition, especially good source of protein in dry seed, and higher content of fiber in fresh pod. The bean is usually consumed either as fresh pod or dry bean (pulse). This pulse has different names such as Bush bean, French bean, Haricot bean, Snap bean, Navy bean, Pinto bean, Rajma, Green bean, while in Bangladesh it is known as '*Forshisheem* or *Jarsheem*'. The crop is very popular among the ethnic people, especially in the hilly areas of Sylhet, Bandarban, Rangamati and Khagrachari districts, where the bean is consumed as the main sources of protein (Fatema *et al.,* 2019). Besides

*Corresponding author: jamilur@sau.edu.bd
† Equally contributed

the hilly areas, the crop is being also cultivated in Jashore, Rangpur, Cumilla, Cox's Bazar, etc., districts. Being a short duration crop kidney bean fits well in three and four crop-based cropping patterns both in hills and plains areas of Bangladesh. Recently, BRAC and Hortex Foundation are trying to extend the cultivation area of the kidney bean because the crop is an exportable vegetable now and has a huge demand in the foreign countries (FAOSTAT, 2021). Thus, the popularity of kidney bean cultivation is increasing in Bangladesh due to its high demand as an export product. Yield is an important quantitative character that is greatly depended on several attributing characters. Some characters affect directly, while some affect indirectly to the yield. For the improvement of yield and other important characters, a knowledge of the extents of variation in the available germplasm, the correlation of associated characters with yield, degrees of environmental influences on these traits and the heritability of the characters is necessary (Saifullah and Rabbani, 2009). Generally, correlation coefficient shows association among yield related characters (Toker and Cagirgan, 2004). However, correlation studies provide the relative effects to the yield on the other hand, path analysis is used as a supplementary component of correlation coefficients. Thus, path analysis allows partitioning of components as their direct and indirect effects and it uses a standard partial regression co-efficient (Shabana *et al.*, 1990). The path analysis method gives the clear idea about the effects of every distinct characteristic on yield (Onder and Babaoglu, 2001). Path analysis has been used by the breeders to recognize the traits that are useful selection criteria to improve crop yield (Shompa *et al*., 2020).

Kidney bean is getting popularity in Bangladesh due to its high nutritional values and export values, however, till date only three varieties of kidney bean have been so far released in Bangladesh (Rahman *et al*., 2022), hence the scope of genetic improvement of the bean is very ample. The literature survey indicates that scanty researches have been carried out on kidney bean improvement in Bangladesh. Therefore, the present investigation was undertaken to determine the major of yield contributing traits of kidney bean. and their direct and indirect effects on yield to select the highly correlated. Thus, the breeders can use those characters as a selection index to improve the yield.

Materials and Methods

Location of experimental site and soil

The present investigation was carried out at the experimental field of Sher-e-Bangla Agricultural University, Dhaka. The area situated at 23°46'16" N latitude and 90°22'46" E longitude at an altitude of 4 meter above the sea level with sub-tropical climate. Soil of the experimental site belongs to the general soil type, Shallow red brown terrace soils under Tejgaon Series. Topsoil is clay loam in texture, the pH ranged from 6.0- 6.6 and had organic matter 0.84%. The experimental area was flat which facilitated irrigation and drainage system easily. Soil samples from 0-15 cm depths were collected from experimental field. The soil analyses were done by Soil Resource and Development Institute (SRDI), Dhaka. The experimental field belongs to Agrological Zone Madhupur Tract (AEZ 28) having soil properties as 6.62 pH; 0.84 organic matter; 0.046 % total N; 21 ppm available P and 0.41 cmolc kg^{-1} exchangeable K (Roy *et al.*, 2019).

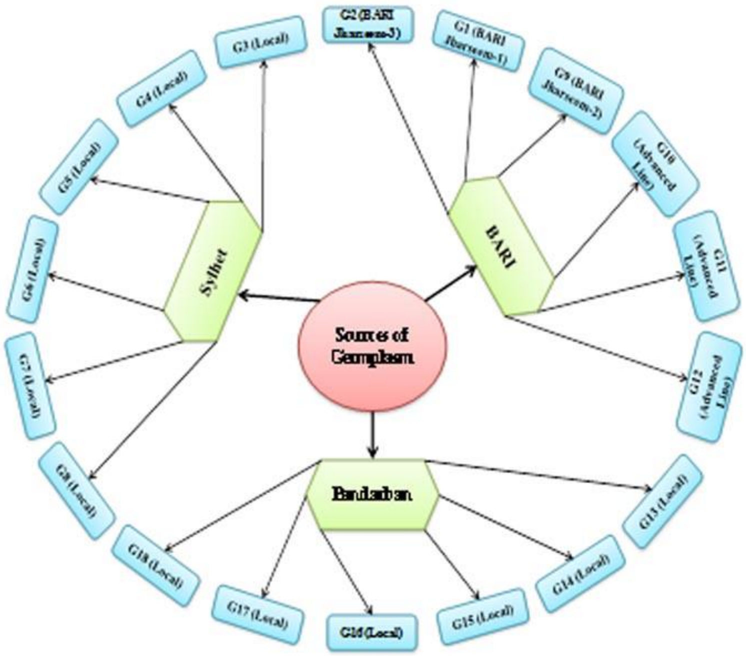

Fig. 1. Different sources of 18 germplasms of kidney bean

Plant materials

Total 18 genotypes of kidney beans were collected from hilly areas of Sylhet and Bandarban districts. Three advanced lines and three released varieties were collected from Bangladesh Agricultural Research Institute (BARI). The sources of the collected Kidney bean germplasm are shown in Fig. 1.

Land preparation, seed sowing and crop raising

The land was prepared through ploughing and it was leveled to avoid water logging condition. The field experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The experimental field was irrigated to have optimum level of moisture condition. Recommended doses of fertilizers were applied (Azad *et al.*, 2020). The seeds were treated with Vitavax 200 and water priming for 12 hours to get good field emergence before sowing. The seed was sowing on 16 November 2016. Total land area was 210 m^2 where each genotype occupied three rows. Plant to plant and row to row distance followed were 25 cm and 50 cm, respectively. Staking was done using bamboo sticks to keep the plants erect. The experimental plot was irrigated during the cropping period with light irrigation.

Recording of growth and yield contributing parameters

Five individual plants of each treatment from each replication were selected randomly at the time of recording the data on various characters. Mean data of five plants for each replication was used for statistical analysis. The observations were recorded on Days to 5-leaves stages, Days to 1stflowering, Days to 50% flowering, Days to pod maturity, Days to 1st pod setting, Plant height (cm), Number of leaves plant^{-1}, Number of pods plant^{-1}, Leaf area (cm^2), Petiole length (cm), Pod length (cm), (Fig. 2), Pod diameter (cm), Dry weight of pod (g), Number of seeds pod^{-1}, 1000 seed weight (g), Seed weight (g/plant) and Seed yield (t/ha). For each parameter data recording methods were described in Table 1.

Table 1. Name of parameters and data recording methods

Sl No	Traits/Parameters	Method of data recording
1.	Days to 5-leaves stages	Whole plot basis
2.	Days to 1st flowering	Whole plot basis
3.	Days to 50% flowering	Whole plot basis
4.	Days to pod maturity	Whole plot basis
5.	Days to 1st pod setting	Whole plot basis
6.	Plant height(cm)	5-plant basis
7.	Number of leaves plant^{-1}	5-plant basis
8.	Number of pods plant^{-1}	5-plant basis
9.	Leaf area (cm^2)	5-plant basis by using leaf area meter
10.	Petiole length (cm)	5-plant basis
11.	Pod length (cm)	5-pod basis
12.	Pod diameter(cm)	5-pod basis
13.	Dry weight of pod (g),	5-pod basis
14.	Number of seeds pod^{-1}	5-pod basis
15.	1000-seed weight(g)	Total of 1000 dry seed
16.	Seed weight plant^{-1} (g/plant)	5-pod from each genotype
17.	Seed yield hectare^{-1} (t/ha)	Seed yield plot-1 is converted to seed yield hectare^{-1} (t/ha)

Statistical analysis

The mean values of each trait from all the genotypes were subjected to statistical analysis. The correlation coefficients were estimated to determine the degree of association of characters with yield and also among the yield components; Both genotypic and phenotypic coefficients of correlation between two characters were determined by using the variance and covariance components as suggested by Al-Jibouri *et al.*, (1958). Path coefficient analysis was carried out using phenotypic correlation values of yield components on yield as suggested by Wright (1921) and Dewey and Lu (1959). Standard path coefficients which are the standardized partial regression coefficients were obtained using statistical software packages OPSTAT (Pal *et al*., 2017)

Results and Discussion

Phenotypic correlation analysis

The phenotypic correlation between yield and its contributing traits of available kidney germplasm found in Bangladesh are presented in the Table 2. Seed yield per plant was highly significant and positively correlated with number of leaves (0.781), leaf area (0.440), petiole length (0.474), number of pod per plant (0.776), pod length (0.772), pod dry weight (0.909), number of seed per pod (0.719), 1000 seed weight (0.677) (Table 3). While the negative phenotypic correlations were found with plant height (-0.128), days to 5 leaves stages (-0.502), days to 1st flowering (-0.179), days to maturity (-0.401), days to 50% flowering (-0.049), days to 1st pod setting (-0.106), pod diameter (-0.404) (Table. 2). The correlation of days to first pod setting with days to 1st flowering (0.902), days to 50% flowering (0.940), days to maturity (0.728), plant height (0.498) and pod length (0.611) was positive and highly significant at the phenotypic levels (Table 2).

Number of pods per plant displayed high significant and positive correlation with number of leaves (0.821), pod length (0.732), dry weight of pod (0.769), number of seeds per pod (0.845), seed yield (0.734) and yield (0.735) at phenotypic levels (Table 3). Pod length is one of the main yield components in Kidney bean. Pod length showed similar association at phenotypic levels. It was recorded that pod length had positive and high significant correlation with number of leaves (0.827), dry weight of pod (0.759), number of pods per plant (0.732), number of seeds per plant (0.682), seed yield (0.767) and yield (0.76) (Table 2). Number of seeds per pod was found positive association with number of leaves (0.84), Number of pods per plant (0.845), pod length (0.682), dry weight of pods (0.804), seed yield (0.720) and yield (0.720). This also had significant and positive correlation with leaf area (0.520). All these associations were observed at phenotypic levels (Table 2).

Genotypic correlation analysis

The seed yield per plant was positively correlated number of leaves (0.837), number of pod per plant (0.793), leaf area (0.391), petiole length (0.371), pod length (0.861), pod dry weight (0.976), number of seed per pod (0.799),1000 grains weight (0.463). While the seed yield was negatively correlated with days to 5 leaves stages (-0.559), days to 1st flowering (-0.217), days to 50% flowering (-0.142), days to maturity (-0.462), days to 1st pod setting (-0.176), plant height (-0.186), pod diameter (-0.677) (Table 3). The correlation of days to first pod setting with days to 1st flowering (0.952), days to 50% flowering (0.990), days to maturity (0.791), plant height (0.557) and pod length (0.635) was positive and highly significant at the genotypic levels (Table 3). Number of pods per plant displayed high significant and positive correlation with number of leaves (0.855), pod length (0.795), dry weight of pod (0.802), and number of seeds per pod (0.903), seed yield (0.793) and yield (0.785) at genotypic levels (Table 3). But it showed negatively significant association with pod diameter (-0.676) at genotypic level. Pod length is one of the main yield components in kidney bean. Pod length showed similar association in case of genotypic levels. Results also showed that pod length had

Fig. 2. Green pod length variation of different genotypes of kidney bean

positive and high significant correlation with number of leaves (0.909), dry weight of pod (0.816), number of pods per plant (0.795), number of seeds per plant (0.742), seed yield (0.861) and yield (0.861) (Table 3). The number of seeds per pod was found in significant and positive association with number of leaves (0.885), Number of pods per plant (0.903), pod length (0.742), dry weight of pods (0.816), seed yield (0.799) and yield (0.798). This also had a significant and positive correlation with leaf area (0.537). All these associations were observed at genotypic level (Table 3).

Several correlation studies were conducted in kidney bean and found similar trends of results. A group of scientists found that number of pods per plant and number of seeds per pod were positively associated with seed yield in kidney bean (Atuahene-Amankwa and Michaels, 1997; Chand, 1999; Coimbra *et al.,* 1998; Coyne, 1968; Duarte and Adams, 1972; Nienhuis and Singh, 1986; Samal *et al*., 1995; Immaculee, 2011; Murry *et al*., 2022. Again, in case of first pod setting, similar result also observed by Aggarwal *et al*., 1973; Chand (1999), Coimbra *et al*., 1998. The positive and significant association of pod per plant with seeds per pod has also been reported by Mishra *et al*., (1996), Singh (2000) and Prasad (1995). Singh (2000) reported pod length showed significant and positive association with plant height, number of pods per plant. Apart from that, Alemu *et al.* (2017) reported that there was negative and significant association between green pod width and green pod length. However, pod length was negatively associated with seed yield observed by Immaculee (2011) in kidney bean, Venkatkrishnakishore *et al.* (2002) and Mittal and Singh (2005) in Mungbean. Pod length had non-significant correlation with days to maturity in the investigation confirmed by Narsinghani and Saxena (1991). Seeds per pod were recorded significant and positive association with pod length in accordance with Sharma *et al.*(1998) and Basavaraja *et al.* (2021). Similarly, the significant association of seeds per plant with pod length was reported by Singh *et al*., 1994; Kumara *et al*., 1997; in Rice bean and Chauhan *et al*., 2003; in cowpea.

Path coefficient analysis

Correlation coefficients show relationships among independent variables and the linear relationship between these variables. However, it is not sufficient to describe these relationships when the causal relationship among variables is needed. Yield components have either a direct or an indirect effect on seed yield, or both. Therefore, we calculated the direct and indirect effects of yield components on seed yield through the other components in Kidney bean germplasm. A high positive direct effect was found in seed yield (1.00) towards yield per hectare. It was recorded as the highest positive effect on yield per hectare. However, Immaculee (2011) found pods per plant having the highest direct effect on yield per hectare. Further, it was recorded negligible positive indirect effect towards yield per hectare via days to first flowering (0.01), days to maturity (0.01), plant height (0.015), number or pods per plant (0.012), petiole length (0.005), pod diameter (0.017), number of seeds per pod (0.026). It also reported negligible negative indirect effect towards yield per hectare via days to 5- leaves stage (-0.009), days to 50% flowering (-0.013), days to 1st pod setting (-0.017), number of leaves (-0.019), leaf area (-0.016), pod length (-0.002), dry weight pod (-0.019), 1000 seed weight (-0.012) (Table 5). The genotypic correlation (1) with yield was positive and significant. Karasu and Oz

Table 2. Phenotypic correlation coefficient for 17 characters of kidney bean germplasm

	FF	50%F	M	FPS	PH	NLP	NPP	LA	PL	PdL	PdD	DWP	NSP	1000SW	SY	Y
LS	0.410	0.267	0.165	0.379	0.059	-0.495*	-0.330	-0.018	-0.119	-0.494*	0.378	-0.407	-0.423	0.050	-0.504*	-0.504*
FF		0.956**	0.628**	0.902**	0.531*	-0.244	-0.095	0.267	0.481*	-0.177	0.273	-0.109	-0.164	-0.077	-0.196	-0.196
50%F			0.674**	0.940**	0.584*	-0.052	0.057	0.399	0.614**	-0.064	0.203	0.027	0.031	-0.130	-0.096	-0.096
M				0.728**	0.571*	-0.287	-0.279	0.205	0.419	-0.486*	0.273	-0.200	-0.228	-0.383	-0.376	-0.376
FPS					0.498*	-0.105	-0.071	0.367	0.611**	-0.201	0.232	-0.015	-0.070	-0.041	-0.139	-0.139
PH						0.072	0.144	0.572*	0.676**	0.102	0.107	0.082	-0.049	-0.407	-0.156	-0.155
NLP							0.821**	0.451	0.468	0.827**	-0.266	0.825**	0.844**	0.195	0.781**	0.781**
NPP								0.462	0.419	0.732**	-0.361	0.769**	0.845**	-0.065	0.734**	0.735**
LA									0.810**	0.499*	-0.008	0.604**	0.520*	0.024	0.366	0.367
PL										0.423	0.024	0.551*	0.429	0.081	0.349	0.349
PdL											-0.236	0.759**	0.682**	0.300	0.767**	0.767**
PdD												-0.322	-0.344	0.133	-0.411	-0.411
DWP													0.804**	0.288	0.902**	0.902**
NSP														0.074	0.720**	0.720**
1000SW															0.348	0.348
SY																1.000**

** = Significant at 1% ; * = Significant at 5% ; LS= Days to 5 leaves stage ; FF=Days to 1st Flowering 50% ; F=Days to 50% flowering; M=Days to Maturity; FPS=Days to 1st Pod Setting; PH=Plant Height (cm); NLP=No of Leaves/plant; NPP=No of Pod/Plant; LA=Leaf A;rea (cm²); PL=Petiole Length (cm); PdL=Pod Length (cm); PdD=Pod Diameter (cm); DWP=Dry Weight of Pod; NSP=No of Seeds/Pod; 1000SW=1000 Seed Weight; SY=Seed Yield (g/Plant); Y=Seed Yield (g/Plant)

Table 3. Genotypic correlation coefficient for seventeen characters of kidney bean germplasm

	FF	50%F	M	FPS	PH	NLP	NPP	LA	PL	PdL	PdD	DWP	NSP	1000SW	SY	Y
LS	0.423	0.275	0.176	0.385	0.066	-0.515*	-0.337	-0.017	-0.126	-0.532*	0.678**	-0.417	-0.456	0.087	-0.559*	-0.560*
FF		0.988**	0.699**	0.952**	0.556*	-0.257	-0.112	0.273	0.495*	-0.193	0.435	-0.105	-0.163	-0.139	-0.217	-0.217
50%F			0.773**	0.990**	0.607**	-0.068	0.048	0.417	0.640**	-0.072	0.309	0.023	0.038	-0.202	-0.142	-0.142
M				0.791**	0.703**	-0.288	-0.324	0.227	0.460	-0.559*	0.370	-0.204	-0.247	-0.580*	-0.462	-0.462
FPS					0.557*	-0.127	-0.085	0.386	0.635**	-0.213	0.331	-0.011	-0.067	-0.076	-0.176	-0.172
PH						0.077	0.148	0.601**	0.721**	0.112	0.283	0.090	-0.028	-0.506*	-0.186	-0.185
NLP							0.855**	0.469*	0.483*	0.909**	-0.523*	0.848**	0.885**	0.253	0.837**	0.831**
NPP								0.471*	0.428	0.795**	-0.676**	0.802**	0.903**	-0.125	0.793**	0.785**
LA									0.821**	0.536*	0.029	0.616**	0.537*	0.033	0.391	0.391
PL										0.447	0.044	0.559*	0.441	0.093	0.371	0.372
PdL											-0.408	0.816**	0.742**	0.359	0.861**	0.861**
PdD												-0.554*	-0.631**	-0.092	-0.677**	-0.677**
DWP													0.816**	0.352	0.976**	0.976**
NSP														0.083	0.799**	0.798**
1000SW															0.463	0.462
SY																1.000**

** = Significant at 1% ; * = Significant at 5%; LS =Days to 5 leaves stage ; FF = Days to 1st Flowering 50% ; F=Days to 50% flowering; M=Days to Maturity; FPS=Days to 1st Pod Setting; PH =Plant Height (cm); NLP=No of Leaves/plant ; NPP=No of Pod/Plant; LA=Leaf Area (cm^2); PL=Petiole Length (cm); PdL=Pod Length (cm); PdD =Pod Diameter (cm);DWP=Dry Weight of Pod; NSP=No of Seeds/Pod; 1000SW=1000 Seed Weight; SY=Seed Yield (g/Plant); Y=Seed Yield (t/ha)

(2010) found high positive direct effect of seed yield per plant with yield per hectare. He also found positive significant correlation between the traits. Acharya (2013) reported seed weight had negligible positive direct effect on toward the yield, and he also reported high positive indirect effects towards pod yield per hectare via pod weight. Seeds per plant (0.442) exhibited the highest positive direct effect on seed yield found by Mehra *et al.*, (2016) and kalauni (2020). Previous studies indicated that seed yield per hectare in the bean was positively correlated with number of pods per plant, number of seeds per pod and seed yield per plant (Duarte and Adams, 1972; Westerman and Crothers, 1977; Prakash and Ram, 1981. From the investigation, it can be concluded that seed yield per plant and number of seeds per pod can be considered the vital traits in selection of desirable genotypes of kidney bean for their genetic improvement.

The days to 1st pod setting recorded negligible positive direct effect (0.004) towards yield per hectare. Further, it was recorded negligible positive indirect effect towards yield per hectare via days to first flowering (0.020), days to maturity (0.013), plant height (0.011), number of pod per plant (0.011), pod diameter (0.008) and number of seeds per plant (0.008) (Table 5). However, it was recorded negligible negative indirect effect towards yield per hectare via days to 5 leaves stage (-0.026), days to 50% flowering (-0.037), number of leaves (-0.019), leaf area (-0.020), petiole length (-0.001), pod length (-0.026), dry weight of pod (-0.020), 1000 seed weight (-0.019), seed yield per plant (-0.080). These results are in agreement with results of Fisher (1918), Pande *et al.*, (1975), Shinde and Dumbre (2001), and Tamilselvan *et al.*, 1994. The number of pods per plant recorded negligible positive direct effect (0.020) towards yield per hectare. On the other hand, Kumar *et al.*, 2014; found number of pods per plant showed high positive indirect effect through number of seeds per pod. Mishra *et al*., 1996; reported high positive direct effect of pods per plant on seed yield which was an indication of improvement of high pod yield through selection of these characters.

Further, it was recorded negligible positive indirect effect towards yield per hectare via. days to 1st flowering (0.022), days to maturity (0.023), plant height (0.027), petiole length (0.016), pod length (0.008), pod diameter (0.028), number of seeds per pod (0.041) and significant, high, positive indirect effect toward seed yield per plant (0.641) (Table 4). Number of pods per plant did not have any significant effect on yield per hectare through days to 5- leaves stage. However, it was found negligible negative indirect effect towards yield per hectare via, days to 50% flowering (-0.003), days to 1st pod setting (-0.010), number of leaves (-0.010), leaf area (-0.006), dry weight pod (-0.009) and 1000 seed weight (-0.004). The correlation of number of leaves was highly significant (0.785) with yield per hectare. Highly positive indirect effect of pod per plant was recorded through seed per pod whereas indirect effects of seeds per pod through other character were negligible (Immaculee, 2011). Pod length observed negligible positive direct effect (0.031) towards yield per hectare. However, Ulukan *et al.*, (2003) and Sharifa (2014) found that pod length had high positive direct effect on seed yield per plot in broad bean. It was also recorded negligible negative indirect effects to yield per hectare via days to days to 1st pod setting (-0.006), number of leaves (-0.004), leaf area (-0.001), dry weight pod (-0.004) (Table 4). On the other hand, it was found negligible positive indirect effect toward yield per hectare via days to 5- leaves stage (0.006), days

Table 4. Path coefficient analysis showing direct and indirect effects of different characters on the yield of kidney bean

Characters	Direct effect	Indirect effect																Genotypic correlation with yield
		LS	FF	50%F	M	FPS	PH	NLP	NPP	LA	PL	PdL	PdD	DWP	NSP	1000SW	SY	
LS	-0.036		0.015	-0.029	0.009	-0.011	0.007	-0.019	0.010	-0.022	0.011	-0.032	0.006	-0.020	0.001	-0.022	-0.429	-0.560*
FF	0.031	-0.020		-0.032	0.019	0.004	0.019	-0.012	0.018	-0.014	0.010	-0.020	0.015	-0.013	0.013	-0.013	-0.222	-0.217
50%F	-0.040	-0.022	0.025		0.015	0.001	0.018	-0.017	0.013	-0.018	0.003	-0.021	0.012	-0.017	0.013	-0.018	-0.087	-0.142
M	0.016	-0.023	0.015	-0.030		-0.009	0.010	-0.019	0.011	-0.021	0.006	-0.031	0.008	-0.019	0.005	-0.023	-0.358	-0.462
FPS	0.004	-0.026	0.020	-0.037	0.013		0.011	-0.019	0.011	-0.020	-0.001	-0.026	0.008	-0.020	0.008	-0.019	-0.080	-0.172
PH	0.026	-0.028	0.003	-0.033	0.002	-0.027		-0.029	0.001	-0.029	-0.009	-0.024	0.000	-0.029	0.000	-0.030	0.021	-0.185
NLP	-0.010	0.003	0.023	-0.003	0.025	-0.006	0.030		0.023	-0.004	0.013	0.011	0.028	-0.007	0.043	-0.002	0.663**	0.831**
NPP	0.020	0.000	0.022	-0.003	0.023	-0.010	0.027	-0.010		-0.006	0.016	0.008	0.028	-0.009	0.041	-0.004	0.641**	0.785**
LA	-0.016	-0.013	0.016	-0.018	0.015	-0.011	0.025	-0.017	0.013		-0.003	-0.005	0.017	-0.018	0.027	-0.013	0.393	0.391
PL	-0.012	-0.014	0.017	-0.024	0.015	-0.006	0.024	-0.020	0.012	-0.018		-0.008	0.014	-0.019	0.024	-0.014	0.401	0.372
PdL	0.021	0.006	0.026	0.003	0.027	-0.006	0.035	-0.004	0.027	-0.001	0.019		0.031	-0.004	0.041	0.002	0.636**	0.861**
PdD	-0.037	-0.052	-0.019	-0.051	-0.020	-0.047	-0.018	-0.050	-0.020	-0.050	-0.020	-0.052		-0.050	-0.023	-0.047	-0.120	-0.677**
DWP	-0.005	0.006	0.028	0.001	0.029	-0.001	0.032	-0.005	0.027	-0.001	0.015	0.014	0.033		0.046	0.003	0.756**	0.976**
NSP	0.053	0.007	0.030	0.001	0.031	0.000	0.030	-0.003	0.028	0.001	0.020	0.013	0.035	-0.002		0.003	0.549*	0.798**
1000SW	0.003	-0.006	0.024	-0.005	0.022	-0.004	0.018	-0.008	0.023	-0.007	0.019	-0.002	0.018	-0.008	0.024		0.351	0.462
SY	1.000	-0.009	0.011	-0.013	0.013	-0.017	0.015	-0.019	0.012	-0.016	0.005	-0.002	0.017	-0.019	0.026	-0.012		1.000**

Residual Effect= 0.11597014; ** = Significant at 1% * = Significant at 5% ; LS=Days to 5 leaves stage; FF=Days to 1st Flowering; 50%F=Days to 50% flowering; M=Days to Maturity; FPS=Days to 1st Pod Setting; PH=Plant Height (cm); NLP=No of Leaves/plant; NPP =No of Pod/Plant; LA =Leaf Area (cm²); PL=Petiole Length (cm); PdL=Pod Length (cm); PdD =Pod Diameter (cm); DWP = Dry Weight of Pod; NSP =No of Seeds/Pod; 1000SW =1000 Seed Weight; SY = Seed Yield (g/Plant); Y=Seed Yield (g/Plant) to 1st flowering (0.026), days to 50% flowering (0.003), days to maturity (0.027), plant height (0.035), number of pods per plant (0.027), petiole length (0.019), pod diameter (0.021), number of seeds per pod (0.041) 1000 seed weight (0.002) and high positive indirect effect of seed yield per plant (0.636). The genotypic correlation of leaf area (0.861) with yield per hectare was positive and significant. Pod length recorded low positive indirect effects towards pod yield per hectare via pod weight (Acharya, 2013).

Number of seeds per pod showed negligible positive direct effect (0.053) towards yield per hectare. In previous studies, it was reported that seed number per pod had highest and positive direct effect on seed yield (Amini *et al*., 2002; Dursun, 2007). Shinde and Dumbre (2001) also found it on consonance. Further, it was recorded negligible positive indirect effect towards yield per hectare via, days to 5- leaves stage (0.007), days to first flowering (0.030), days to 50% flowering (0.001), days to maturity (0.031), plant height (0.030), number or pods per plant (0.028), leaf area (0.001), petiole length (0.020), pod length (0.013), pod diameter (0.035), 1000 seed weight (0.003) and high positive indirect effect of seed yield per plant (0.549) (Table 4). It also found negligible negative indirect effect towards yield per hectare via, number of leaves (-0.003) and dry weight pod (-0.002). It had significant and positive genotypic correlation (0.79) with yield per hectare. Dursun (2007) found that number of seeds per pod showed the highest indirect effect on yield via wet pod weight. Number of seed per pod exhibited high positive indirect effects towards pod yield per hectare via pod weight and moderate negative indirect effect number of pods per plant observed by Acharya (2013).

Conclusion

The genotypic correlation coefficients were higher than their corresponding phenotypic correlation coefficients for all the characters under study. The association of the characters showed that seed yield per hectare was highly significant and positive with number of leaves, number of pods per plant, pod length, dry weight of pod, number of seeds per pod and seed yield per plant at both genotypic and phenotypic levels. The path co-efficient analysis for seed yield per hectare revealed that seed yield per plant exerted direct effect on seed yield, number of seeds per pods. Thus the results suggest that number of leaves, number of pods per plant, pod length, dry weight of pod, number of seeds per pod and seed yield per plant can be used as selection index to maximize the yield of kidney bean in Bangladesh.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

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