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Correlation and Path Coefficient Analysis for Yield and Yield Components of Soybean Genotypes Under Different Planting Density

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ABSTRACT

Two field experiments were conducted during 2010 and 2011 seasons in at the Research and Experimental Center of the Faculty of Agriculture at Moshtohor, Benha University, Egypt, to evaluate 5 soybean genotypes i.e., Clark, Crawford, Giza22, Giza35 and Giza83 under three planting densities i.e., 70000, 140000 and 210000 plants fed^{-1} and estimate the relationships between seed yield and its components. The results could be summarized from the combined analysis of the two seasons which indicated that Giza83 genotype significantly exceeded other genotypes in plant height, number of pods plant^{-1}, weight of pods plant^{-1}, weight of seeds plant^{-1}, 100-seed weight, straw yield fed^{-1} and seed yield fed^{-1}. Also, the genotypes Giza83 and Giza22 genotypes were superior in number of branches plant^{-1} and number of seeds pod^{-1} over others soybean genotypes. Decreasing planting density to 70000 plants fed^{-1} was increased significantly number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, weight of pods plant^{-1}, weight of seeds plant^{-1}, shelling percentage and 100-seed weight. However, increasing plant density form 70000 up to 210000 plants fed^{-1} increased significantly plant height, biological, straw and seed yields fed^{-1}. A significant interaction effect between soybean genotypes and planting density was detected for plant height, number of branches plant^{-1}, number of pods plant^{-1}, 100 seed weight and seed yield fed^{-1}. The highest number of branches plant^{-1}, number of pods plant^{-1}, 100-seed weight were obtained from Giza83 at 70000 plants fed^{-1}, while plant height and seed yield fed^{-1} were obtained from Giza83 at 210000 plants fed^{-1}. Significant positive phenotypic correlation values were detected between seed yield plant^{-1} and each of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1} and 100-seed weight. According to path analysis, No. of pods plant^{-1} through 100-seed weight proved to have the highest indirect effect to seed yield plant^{-1} (26.47%) followed by direct effect 100-seed weight (15.51%) and direct effect No. of pods plant^{-1} (14.04%).

Key words: Soybean, genotypes, planting density, correlation, path coefficient, yield, yield components

INTRODUCTION

Soybean (*Glycine max* L. *Merr.*) is one of the most important world legume crops for feed and food. Its seed protein is the best nutritional available plant protein sources, because it contains all essential amino acids. The pharmaceutical industry widely uses soybean in the manufacture of antibiotics. Soybean crop is one a good green manure crops for sandy soils. Using good soybean cultivars or genotypes and different planting density are necessary for the production of economical soybean yield. Soybean breeders try to explain the relations between seed yield and agronomic traits using simple correlation. Also, path coefficient is very important to determine traits that directly and indirectly affect seed yield. Direct selection for soybean seed yield seems to be rather complex, it might be more desirable to select for some easily identified characteristics provide to be closely correlated with seed yield. Several investigators performed simple correlation and path coefficient for soybean yield and yield components (Hamed, 2003; Mehasen and Saeed, 2005; Barbaro *et al*., 2006; Sedghi and Amanpour-Balaneji, 2010).

Several researches stated that the differences among soybean cultivars or genotypes were significant in plant height, number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, weight of pods plant^{-1}, weight of seeds plant^{-1}, shilling%, 100-seed of weight, biological, straw and seed yields fed^{-1} (El-Hefni *et al*., 1994; Hassanein *et al*., 1996; El-Metwally, 1999; Hamed, 2003; Khalil, 2003; Hafiz, 2005; Mehasen and Saeed, 2005; Soliman *et al*., 2007; Cho and Kim, 2010; Rahman *et al*., 2011).

With respect to the effect of plant population density on soybean crop, Shafshak *et al*. (1997) studied the effect of plant population densities 35, 70, 105, 140 and 175 thousand plants fed^{-1} on soybean. They revealed that plant height and seed yield fed^{-1} were significantly increased with increasing plant densities, while number of branches and pods plant^{-1}, seed weight plant^{-1} and seed index were significantly decreased with increasing plant densities. El-Din *et al*. (1997), Salem *et al*. (2000), Hafiz (2005), Cho and Kim (2010) and Rahman *et al*. (2011) reported that increasing plant density from 93333 up to 280000 plants fed^{-1} significantly increased plant height, biological, straw and seed yields fed^{-1} whereas, number of branches and pods plant^{-1}, pods and seed weight plant^{-1} and 100-seed weight were reduced.

The aim of this study was to evaluate the five soybean genotypes under three planting densities and estimate the relationships between seed yield and its components.

MATERIALS AND METHODS

Two field experiments were carried out in the Agricultural Research and Experimental Center, Faculty of Agriculture Moshtohor, Benha Univ. during 2010 and 2011 seasons to study the effect of three planting densities (D) i.e., 70000, 140000 and 210000 plants fed^{-1} and estimate the relationships between seed yield and its components for 5 soybean genotypes (G) namely Clark, Crawford, Giza22, Giza35 and Giza83. The descriptions of those genotypes presented in Table 1. The soil of the experimental site was clay loam with pH of value of 7.8 and 7.9 and organic matter content of 1.90 and 1.85% in the first and second seasons, respectively. The preceding winter crop was wheat in both seasons.

The treatments were arranged in a split-plot design with four replicates, in which soybean cultivars were allocated in the main plots, while the sub-plots were devoted for planting densities. The sub plot area was 1/400 fed, 10.5 m^2 (3×3.5 m) with 5 ridges which were 60 cm width and 3.5 m long.

Table 1: The descriptions of soybean genotypes used in this study

Genotype	Maturity group	Country origin	Growth habit	Pedigree
Clark	IV	USA	Indeterminate	Lincoln (2)×Richland
Crawford	IV	USA	Indeterminate	Williams×Columbus
Giza22	IV	Egypt	Indeterminate	Crawford×Forrest
Giza35	IV	Egypt	Indeterminate	Crawford×Celest
Giza83	IV	Egypt	Indeterminate	Union×L76-0038

Soybean seeds were inoculated with the specific *Bradyrhizobium japonicum* strain just before sowing. Soybean seeds were planted on May 25 and 27th in 2010 and 2011 seasons, respectively. The distance between hills was 10 cm apart and soybean plants were thinned to one, two and three plants per hill. Calcium super phosphate (16% P_2O_2) was applied at a rate of 200 kg fed^{-1} during seed bed preparation. Agronomic practices were followed according to the standard recommendation for soybean in the region.

At harvest, ten guarded plants from each experimental unit were chosen randomly and the following traits were estimated plant height (cm), number of branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1}, weight of pods $plant^{-1}$ (g), weight of seeds $plant^{-1}$ (g), shilling (%) and 100-seed of weight (g). The biological, straw and seed yields fed^{-1} were determined from the whole subplot of the four replications.

Statistical analysis: Data were statistically analyzed according to Steel and Torrie (1987). Combined analysis for the data of the two growing seasons, simple correlation and path coefficient were carried out according to procedures outlined by Gomez and Gomez (1983). L.S.D. test at 0.05 level was used for comparison between treatments means.

RESULTS AND DISCUSSION

Analyses of variances for all traits in each season as well as the combined analysis are presented in Table 2. Test of homogeneity revealed that the error variance for the two seasons were homogenous, therefore combined analysis was processed. Year's mean squares were highly significant for all the studied traits except number of branches $plant^{-1}$, number of seeds pod^{-1}, shilling (%), biological yield fed^{-1} and straw yield fed^{-1} were not significant. Soybean genotypes mean squares were significant for all traits in both seasons as well as the combined data except number of seeds pod^{-1}, shelling percentage and biological yield in the first season, number of branches $plant^{-1}$, number of seeds pod^{-1}, shelling percentage and straw yield in the second season and shelling percentage and biological yield in the combined analysis. Planting densities mean squares were highly significant for all traits in both seasons as well as the combined data. The interaction between years (Y) and soybean genotypes (G) mean squares was not significant for all of the studied characters except No. of pods $plant^{-1}$. The interaction between years (Y) and planting densities (D) mean squares was not significant for all of the studied characters except No. of pods $plant^{-1}$. The interaction between years, soybean genotypes and planting densities mean squares were not significant for all of the studied characters except seed yield fed^{-1}.

A: Effect of growing seasons: Results in Table 3 show that the seasonal mean affect was significant for all of the traits under study except number of branches $plant^{-1}$, number of seeds $plant^{-1}$, shilling (%), biological yield fed^{-} ^{1}and straw yield fed^{-} ,^{1}the highest mean values for all character were detected in the first season except plant height. It could be concluded that the increase of seed yield in the first season may be due to the significant increase in number of pods $plant^{-1}$, weight of pods and seeds $plant^{-1}$ and 100-seed weight.

B: Varietal differences: Results in Table 4 indicated clearly that there were significant differences between soybean genotypes in plant height, number of branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1}, weight of pods $plant^{-1}$, weight of seeds $plant^{-1}$, 100-seed weight, straw yield fed^{-1} and seed yield fed^{-1} in combined analysis. However, differences in shelling percentage

Table 2: Mean squares values and significance for yield and its attributes of soybean genotypes in 2010, 2011 seasons and their combined analysis

SOV	df	Plant height (cm)	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	Pods weight plant^{-1} (g)	Seed weight plant^{-1} (g)	Shelling (%)	100-seed weight (g)	Biological yield fed^{-1} (kg)	Straw yield fed^{-1} (kg)	Seed yield fed^{-1} (kg)
2010 season												
R	2	4.867	0.165	5.489	0.068*	13.1**	2.917**	4.462	0.067	278718	968**	1350*
G	4	66.0**	1.066*	28.3**	0.033	37.94**	11.79**	0.937	8.92**	103097	32572**	15300**
Error (a)	8	1.700	0.246	1.933	0.015	0.144	0.250	3.420	0.789	211397	98.189	281.156
D	2	843.2**	5.049**	500.8**	0.198**	240.3**	126.3**	73.60**	74.8**	18526990**	11123177**	1064360**
G×D	8	8.5**	0.313	3.183	0.007	0.578	0.142	2.064	0.506	197604	3233**	1069*
Error (b)	20	1.100	0.200	1.711	0.028	1.033	0.258	2.904	0.244	216105	220.322	334.922
CV (%)		1.10	12.71	2.72	5.27	3.70	3.24	2.99	3.04	14.68	0.73	1.51
2011 season												
R	2	14.0*	0.014	9.600	0.018	18.2*	6.406**	3.935	1.867	19456**	8317	8602**
G	4	74.1**	0.0111	94.39**	0.061	57.48**	19.27**	3.200	12.2**	111449**	36706	20855**
Error (a)	8	1.828	0.031	2.989	0.038	2.144	0.239	8.570	0.506	469.678	18663.5	503.167
D	2	861.7**	4.98**	382.5**	0.038	209.1**	119.0**	85.5**	74.8**	18628620**	11010832**	1083160**
G×D	8	7.144**	0.105**	8.106**	0.011	1.511	0.339	1.754	0.589	4341**	18196	1048*
Error (b)	20	0.800	0.013	0.578	0.038	1.056	0.447	3.446	0.311	498.700	19724.289	294.611
CV (%)		0.95	3.20	1.62	6.10	3.55	4.03	3.24	3.32	0.68	6.93	1.38
Combined analysis												
Y	1	24.5**	0.196	23.5**	0.011	49.9**	18.68**	2.611	6.4**	342990	1137	15628**
R×Y	4	9.44**	0.089	7.544*	0.043	15.6**	4.661**	4.199	0.967	149087	4642	4976**
G	4	134.8**	1.306**	112.2**	0.090*	93.63**	30.53**	3.109	20.8**	91984	58477**	35862**
Y×G	4	5.267	0.117	10.511*	0.003	1.794	0.532	1.028	0.317	122561	10801	293
Error (a)	16	1.764	0.138	2.461	0.027	1.144	0.244	5.995	0.647	105933.59	9380.85	392.161
D	2	1703**	10.03**	879.2**	0.192**	448.7**	245.2**	158.4**	149.7**	37027014**	22131620**	2146864**
Y×D	2	1.878	0.0001	4.044*	0.044	0.711	0.136	0.763	0.0001	128596	2390	656
G×D	8	14.0**	0.280*	10.04**	0.011	1.378	0.376	1.740	1.053**	82988	9398	1409**
Y×G×D	8	1.6	0.138	1.253	0.007	0.711	0.105	2.077	0.042	118956	12031	708*
Error (b)	40	0.950	0.106	1.144	0.033	1.044	0.353	3.175	0.278	108301.917	9972.306	314.767
CV (%)		1.03	9.16	2.25	5.70	3.63	3.68	3.12	3.19	10.20	4.93	1.44

* and **Significant at $p<0.05$ and 0.01, respectively, R: Reproduction, G: Genotype, D: Planting density, Y: Years

Table 3: Seasonal mean effect on seed yield and its attributes of soybean genotypes

Traits	Growing seasons 2010	2011	F-test
Plant height (cm).	93.9	95.0	**
No. of branches plant^{-1}	3.6	3.5	ns
No. of pods plant^{-1}	48.0	47.0	**
No. of seeds pod^{-1}	3.17	3.15	ns
Pods weight plant^{-1} (g)	28.9	27.4	**
Seed weight plant^{-1} (g)	16.5	15.6	**
Shelling (%)	57.3	56.9	ns
100-seed weight (g)	16.8	16.2	**
Biological yield fed^{-1} (kg)	3289	3165	ns
Straw yield fed^{-1} (kg)	2027	2020	ns
Seed yield fed^{-1} (kg)	1241	1215	**

* and **Significant at $p<0.05$ and 0.01, respectively, ns: Non significant

Table 4: Seed yield and its attributes for five soybean genotypes as affected by the three planting densities, combined analysis over two seasons

Treatments	Plant height (cm)	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	Pods weight plant^{-1} (g)	Seed weight plant^{-1} (g)	Shelling (%)	100-seed weight (g)	Biological yield fed^{-1} (kg)	Straw yield fed^{-1} (kg)	Seed yield fed^{-1} (kg)
Genotypes											
Clark	95.3	3.27	44.3	3.11	26.6	15.1	57.4	14.9	3137	1963	1174
Crawford	95.3	3.46	46.1	3.11	25.9	14.9	57.0	16.5	3193	1995	1198
Giza22	89.6	3.82	48.1	3.17	27.2	15.8	57.7	17.0	3249	2019	1230
Giza35	95.5	3.37	48.1	3.14	29.7	16.9	56.6	16.4	3280	2026	1254
Giza83	96.5	3.87	50.9	3.28	31.3	17.9	57.1	17.8	3402	2115	1287
LSD at 5%	0.94	0.26	1.11	0.12	0.76	0.35	ns	0.57	ns	68	14
Y×G	ns	ns	*	ns	ns	ns	ns	ns	ns	ns	ns
Densities (Plant fed^{-1})											
70000	86.3	4.17	53.1	3.25	32.1	19.0	59.2	18.7	2104	1179	925
140000	95.9	3.49	47.1	3.16	28.1	16.1	57.5	16.6	3253	1997	1332
210000	101.2	3.02	42.3	3.08	24.4	13.3	54.7	14.3	4325	2896	1429
LSD at 5%	0.51	0.17	0.56	0.09	0.53	0.31	0.93	0.27	172	52	9
Y×D	ns	ns	*	ns	ns	ns	ns	ns	ns	ns	ns

*Significant at $p<0.05$; ns: Non significant, Y: Years, G: Genotype, D: planting density

and biological yield fed^{-1} were not significantly different. Moreover, combined data cleared that Giza83 genotype significantly exceeded other genotypes in plant height, number of pods plant^{-1}, weight of pods plant^{-1}, weight of seeds plant^{-1}, 100-seed weight, straw yield fed^{-1} and seed yield fed^{-1}. The superiority of Giza83 and Giza22 genotypes in number of branches plant^{-1} and number of seeds pod^{-1} over others genotypes of soybean. The superiority of Giza83 genotype over others genotypes of soybean in seed yield fed^{-1} may be attributed to the increase in number of branches plant^{-1}, number of pods plant^{-1}, pods weight plant^{-1}, seed weight plant^{-1} and 100-seed weight. Similar variations among soybean cultivars were obtained by El-Hefni *et al.* (1994), Hassanein *et al.* (1996), Hamed (2003), Mehasen and Saeed (2005), Cho and Kim (2010) and Rahman *et al.* (2011).

C: Effect of planting population density: As shown in Table 4 all the studied traits of yield and yield components were significantly decreased with increasing planting density except plant height in the combined analysis. Decreasing planting density to 70000 plants fed^{-1} increased significantly number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, weight of pods plant^{-1}, weight of seeds plant^{-1}, shelling percentage and 100-seed weight. However, increasing plant density form 70000 plants fed^{-1} up to 210000 plants fed^{-1} increase significantly plant height, biological, straw and seed yields fed^{-1} in combined analysis. The result showed that seed yield plant^{-1} for 70000, 140000 and 210000 plants fed^{-1} treatments amounted to 19.0, 16.1 and 13.3 g in the combined analysis, respectively. The increases in biological yield fed^{-1} were about 105.56 and 54.61%, in straw yield fed^{-1} were about 145.63 and 69.38% and in seed yield fed^{-1} were about 54.49 and 44.00% in the combined analysis for 210000 and 140000 plants fed^{-1} compared with 70000 plants fed^{-1}, respectively.

It could be concluded that decreasing plant density resulted in an increase in the yield components due to the lower intraspecific competition for the edaphic and above ground environmental resources especially light. This in turn resulted in an increase in photosynthesis and dry matter production, number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, weight of pods plant^{-1}, weight of seeds plant^{-1}, shelling percentage and 100-seed weight. All these criteria resulted finally in producing more seed yield fed^{-1}. These results are in agreement with those obtained by Shafshak *et al*. (1997) studied the effect of plant population densities 35, 70, 105, 140 and 175 thousand plants fed^{-1} on soybean. They revealed that plant height and seed yield fed^{-1} were significantly increased with increasing plant densities, while number of branches and pods plant^{-1}, seed weight plant^{-1} and seed index were significantly decreased with increasing plant densities. El-Din *et al*. (1997), Salem *et al*. (2000), Hafiz (2005), Cho and Kim (2010) and Rahman *et al*. (2011) reported that increasing plant density from 93333 up to 280000 plants fed^{-1} significantly increased plant height, biological, straw and seed yields fed^{-1} whereas, number of branches and pods plant^{-1}, pods and seed weight plant^{-1} and 100-seed weight were reduced.

D: Interaction effects: Table 4 shows that the effect of interaction between soybean genotypes and seasons was statistically insignificant for all the studied characters except No. of pods plant^{-1}. This result indicates that the performance of genotypes was almost the same from one season to another. For the exceptional case of this character, significant effect of this interaction was detected, revealing that the tested genotypes ranked differently from season to season. Giza83 had the highest value for this character in the combined analysis.

Also, the effect of the interaction between plant density and seasons was not significant for all growth characters except No. of pods plant^{-1}, revealing that the effect of plant density treatments was stable from one season to another (Table 4). Insignificant effect of interaction between soybean genotypes and plant density treatments was obtained for yield and yield components except plant height, number of branches plant^{-1}, number of pods plant^{-1}, 100-seed weight and seed yield fed^{-1} in the combined analysis (Table 5). This result indicates that the genotypes responded similarly to the different planting densities. For 5 exceptional traits, significant interaction indicates that factors were not independent in their effect, the simple effects of a factor differ and the magnitude of any simple effect depends upon the level of the other factor of the interaction term. Where factors interact, a single factor experiment will lead to disconnect and possibly misleading information. With regard to number of branches plant^{-1}, number of pods plant^{-1} and 100 seed weight Giza83 gave the highest values followed by Giza22 at 70000 plant fed^{-1}. While, for plant height and seed yield fed^{-1} Giza83 gave the highest values at 70000 plant fed^{-1}. The significance of this interaction may be due to the different responses of each genotype to the different planting population densities (Table 5).

E: Correlation study: The simple correlation coefficients between some possible pairs of the studied soybean traits of the combined analysis are presented in Table 6. Seed yield plant^{-1} was highly positively significant correlated with number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1} and 100-seed weight except plant height. Therefore, these traits may be more attributed for higher yielding soybean. Also, significant positive phenotypic correlations were observed between 100-seed weight and each of branches plant^{-1}, number of pods plant^{-1}and number of seeds pod^{-1}. These results might indicate that selection for high values of the characters is more effective for increasing seed yield plant^{-1}. The phenotypic correlation coefficient provides important information about inter-relationships between two or more of yield attributes by which the breeder can design a successful program to improve the yield capacity of soybean. These results

Table 5: Effect of the interaction between soybean genotypes and planting densities on seed yield and its attributes, combined analysis over two seasons

	Genotypes				
Densities	Clark	Crawford	Giza22	Giza35	Giza83
Plant height (cm)					
70000	88.50	88.00	83.00	85.50	86.60
140000	96.00	96.50	91.10	97.50	98.30
210000	101.50	101.50	94.80	103.50	104.60
LSD at 5%	1.14				
No. of branches plant^{-1}					
70000	3.65	3.98	4.68	3.82	4.72
140000	3.27	3.33	3.75	3.38	3.72
210000	2.90	3.08	3.15	2.92	3.05
LSD at 5%	0.38				
No. of pods plant^{-1}					
70000	48.80	50.10	54.80	54.00	57.80
140000	43.50	46.00	47.80	48.00	50.00
210000	40.50	42.10	41.50	42.50	45.50
LSD at 5%	1.25				
100-seed weight (g)					
70000	16.50	18.50	19.50	19.00	20.20
140000	15.00	16.50	16.80	19.00	18.20
210000	13.20	14.50	14.70	13.80	15.20
LSD at 5%	0.62				
Seed yield fed^{-1} (kg)					
70000	862.00	896.00	907.00	968.00	991.00
140000	1288.00	1283.00	1347.00	1350.00	1391.00
210000	1372.00	1414.00	1435.00	1445.00	1479.00
LSD at 5%			21.00		

Table 6: Simple correlation coefficients among seed yield plant^{-1} and its related characters in soybean, combined over both seasons

Characters	X_1	X_2	X_3	X_4	X_5	Y
Plant height (X_1)	1.000					
No. of branches plant^{-1} (X_2)	-0.751**	1.000				
No. of pods plant^{-1} (X_3)	-0.726**	0.759**	1.000			
No. of seeds pod^{-1} (X_4)	-0.265*	0.213*	0.254*	1.000		
100-seed weight (X_5)	-0.774**	0.792**	0.897**	0.254*	1.000	
Seed yield plant^{-1} (Y)	-0.736**	0.715**	0.852**	0.329**	0.860**	1.000

*, **Significant at $p<0.05$ and 0.01, respectively

were supported by the results of Hamed (2003) and Mehasen and Saeed (2005). Sedghi and Amanpour-Balaneji (2010) found that correlation coefficient analysis grain yield had significant positive and negative association with No. of pods plant^{-1} and plant height, respectively.

F-Path coefficient analysis: Direct, indirect effects, coefficient of determination and relative importance of each variable to seed yield plant^{-1} are presented in Table 7. From Table 7, it could be concluded that the most important sources of variation in seed yield plant^{-1} were the indirect effect of No. of pods plant^{-1} through 100-seed weight followed by direct effect of 100-seed weight followed by direct effect No. of pods plant^{-1} followed by indirect effect of plant height through

Table 7: Direct and indirect effects of some yield attributes to yield plant^{-1} of soybean over two seasons

Source of variation	Effects	CD	RI (%)
Direct effect of Plant height	**-0.1324**	**0.0175**	**1.6994**
Indirect effect via No. of branches plant^{-1}	0.0081	-0.0025	0.2085
Indirect effect via No. of pods plant^{-1}	-0.2762	0.0731	7.0914
Indirect effect via No. of seeds pod^{-1}	-0.0260	0.0069	0.6667
Indirect effect via 100-seed weight	-0.3095	0.0820	7.9464
Total direct and indirect effects of plant height			17.6124
Direct effect of No. of branches plant^{-1}	**-0.0108**	**0.0001**	**0.01134**
Indirect effect via No. of pods plant^{-1}	0.2888	-0.0062	0.6056
Indirect effect via No. of seeds pod^{-1}	0.0209	-0.0005	0.0438
Indirect effect via 100-seed weight	0.3167	-0.0069	0.6642
Total direct and indirect effects of No. of branches plant^{-1}			1.32494
Direct effect of No. of pods plant^{-1}	**0.3805**	**0.1448**	**14.0356**
Indirect effect via No. of seeds pod^{-1}	0.0249	0.0189	1.8365
Indirect effect via 100-seed weight	0.3587	0.2730	26.4662
Total direct and indirect effects of No. of pods plant^{-1}			42.3383
Direct effect of No. of seeds pod^{-1}	**0.0980**	**0.0096**	**0.9312**
Indirect effect via 100-seed weight	0.1016	0.0199	1.9303
Total direct and indirect effects of No. of seeds pod^{-1}			2.8642
Direct effect of 100-seed weight	**0.3999**	**0.1599**	**15.5063**
Residual		0.2100	20.3567

Multiple coefficient of determination = 79.6433, CD: Coefficient of determination, RI%: Relative importance

100-seed weight followed by indirect effect plant height through No. of pods plant^{-1} at the combined analysis. These effects account for approximately 71.06% of seed yield plant^{-1} variation. No. of pods plant^{-1} through 100-seed weight proved to have the highest indirect effect to seed yield plant^{-1} (26.47%) followed by direct effect 100-seed weight (15.51%), direct effect No. of pods plant^{-1} (14.04%), indirect effect of plant height through 100-seed weight (7.95%) and indirect effect plant height through No. of pods plant^{-1}(7.09%).

Although, 100-seed weight and No. of pods plant^{-1} have the highest simples correlation (0.860**) and (0.852**), respectively with seed yield plant^{-1} Table 6. The results indicated that No. of pods plant^{-1}, 100-seed weight and plant height affected seed yield plant^{-1} and it was concluded that these characters should considered as selection criteria in soybean breeding for yield Table 7. Table 7 shows that the total direct and indirect effects were 17.61, 1.32, 42.34, 2.86 and 15.51% for plant height, No. of branches plant^{-1}, No. of pods plant^{-1}, No. of seeds pod^{-1} and 100-seed weight, respectively. Barbaro *et al.* (2006) found that number of pods, plant height and number of reproductive nodes are important criteria for evaluating of different soybean varieties and suggested that pod number plant^{-1} as the best selection criterion. Ball *et al.* (2001) and Sedghi and Amanpour-Balaneji (2010) also demonstrated that pod number plant^{-1} is the most important variable for grain yield in soybean at constant densities.

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