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GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS IN SOYBEAN

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ABSTRACT

The present investigation was carried out at the experimental farm of Sakha Research Station, Kafr El-Sheikh, during 2009 and 2010 seasons to study the performance of 15 soybean genotypes for yield and its related traits. A combined analysis of variance and covariance were computed over the two seasons to estimate genotypic and phenotypic variances using the pertinent mean square expectations which help also in estimating broad sense heritability (h^2) and genetic advance expressed as % of general mean. In addition, correlation and path analyses were computed between seed weight/plant and its components being days to flowering, days to maturity, plant height, number of branches/plant, number of pods/plant and 100-seed weight. Results showed significant differences among soybean genotypes for all studied traits. Genotypes H32, H2L12 and DR101 recorded the highest values of seed yield and seed weight/plant over the two seasons, indicating that these genotypes are promising and could be recommended for release. On the other hand, the highest values of genotypic and genotypic coefficient of variation were obtained with number of branches/plant, seed yield, number of pods/plant, seed weight/plant and plant height indicating a wide range of variation which provided a good opportunity for yield improvement. Also, large proportions of heritability coupled with high values of genetic advance (% of mean) were recorded for seed yield, number of branches/plant and number of pods/plant, explaining that these traits have more chance for soybean yield development among the tested genotypes. Highly significant and positive correlation coefficients were detected between seed weight/plant and each of number of pods/plant, number of branches/plant, plant height and days to maturity while only significant positive relation was observed between seed weight/plant and days to flowering. Regarding 100-seed weight, it had negative and insignificant association with seed weight/plant. Path analysis showed that the traits of number of pods/plant, number of branches/plant and plant height were the most directly contributed traits to seed weight/plant. As a result, the three mentioned traits could be used as selection criteria in the present soybean breeding program, where they were the most important traits in determining seed weight/plant.

Key words: ***Soybean, Genotypic variance, Direct effect, Relative importance.***

INTRODUCTION

Soybean (*Glycine max* L.) is an important source of high quality, inexpensive protein and oil. Soybean has the highest protein content (30-45%) of all food crops and also contains a considerable oil content (15-24%) comprising high percent of unsaturated fatty acids. So, it is highly desirable in the human diet.

High yielding soybean cultivars could be achieved by introducing well adapted varieties or through hybridization and selection for one or more of major yield components. Therefore, sufficient genetic information regarding the yield traits of soybean is essential and an important step to get progress in soybean breeding programs. Besides, heritability is a measure of phenotypic variance attributable to genetic causes; it is also a basic component of calculating the genetic advance which indicates the degree of gain in a character obtained under particular selection intensity.

On the other hand, the study of correlation along with path analysis provides a better understanding of the association between yield and its related traits. Path coefficient analysis separates the direct from the indirect effects through other related traits by partitioning the correlation coefficient.

Several investigators took interest in evaluating soybean genotypes and estimated the corresponding genetic parameters, such as Eisa *et al* (1998), Hassan *et al* (2001) and (2002), and Mohamed and Morsy (2005) who found that soybean genotypes differed significantly for most studied traits. Also, Hamdi *et al* (2008) evaluated most the studied genotypes for agronomic and seed technology characters. They found variability among genotypes for most studied characters.

The genetic parameters of soybean traits were estimated by many researches among them, Mohamed *et al* (2000), Ganesamurthy and Seshadri (2004), Malik *et al* (2006), Muhammad *et al* (2006) and Muhammad *et al* (2007) who emphasized that heritability alone is not enough to make sufficient improvement through selection, especially in advanced generations, unless accompanied by substantial amount of genetic advance.

The study of casual relationship between yield and its related characters occupied a large area of research in soybean (Pandey and Torrie 1973, Akhter and Sneller 1996, Shukla *et al* 1998, Board *et al* 1999, Ball *et al* 2001 and Oz *et al* 2009).

The present study was planned to investigate the yielding ability and to estimate the genetic parameters, correlation and path analysis to identify the best genotypes that may be exploited in the future by soybean breeders.

MATERIALS AND METHODS

A field experiment was carried out at the experimentalfarm of Sakha Research Station, Kafr El-Sheikh, during 2009 and 2010 summer seasons to study the performance of 15 soybean genotypes for yield and its components. The experimental design was a randomized complete block (RCBD) with three replications. The pedigree, maturity group, flower color and origin of the tested genotypes were presented in Table (1).

Table 1. The pedigree, maturity group, flower color and origin of tested soybean genotypes.

No.	Genotype	Pedigree	Maturity group	Flower color	Origin
1	H 113	Giza 21 x Major	III	Purple	FCRI *
2	H 117	D 89-8940 x Giza 111	III	White	FCRI *
3	H 127	D 89-8940 x Giza 82	IV	White	FCRI *
4	H 129	D 76-8070 x Giza 35	IV	White	FCRI *
5	H 132	Giza 35 x Giza 83	IV	Purple	FCRI *
6	H 30	Crawford x L 62-1686	III	Purple	FCRI *
7	H 32	Giza 21 x 186 k-73	IV	White	FCRI *
8	H 2 L 12	Crawford x Celest	IV	Purple	FCRI *
9	H15 L 5	Crawford x D 79-10426	IV	Purple	FCRI *
10	Toano	Ware x Essex	V	Purple	AES, USA **
11	Holladay	N 77-179 x Johnston	V	Purple	AES, USA **
12	DR 101	Introduction	V	Purple	USA ***
13	Giza 21	Crawford (L7) x Celest	IV	Purple	FCRI *
14	Giza 111	Crawford (L7) x Celest	IV	Purple	FCRI *
15	Crawford	Williams x Columbus	IV	Purple	USA ***

* FCRI = Field Crops Research Institute, Giza, Egypt.
** AES, USA = Agricultural Experiment Station, USA.
*** USA = U. S. Regional Soybean Laboratory at Urbana, Illinois, and Stoneville, Mississipi.

Each plot consisted of six ridges, 70 cm apart and four m long. Seeds of all genotypes were inoculated by specific *rhizobia* and then hand planted at density of 20 plants per a meter of a linear ridge on 20 May 2009 and 27 May 2010. All other agricultural practices were conducted as recommended for Sakha location.

The data of days to flowering, days to maturity, were recorded on plot basis. Ten guarded plants were randomly taken from each plot to measure plant height (cm), number of branches/plant, number of pods/plant, 100-seed weight (g) and seed weight/plant (g). Also, data of seed yield was determined from the central area (8.4 m^2) in each plot, then transformed to ton/fed.

A combined analysis of variance and covariance were computed over the two seasons to estimate the genotypic and phenotypic variances using the pertinent mean square expectations which help also in estimating genotypic and phenotypic coefficients of variation. The analysis of variance was done according to Snedecor and Cochran (1980) while the genetic parameters were estimated according to the method suggested by Johnson *et al* (1955). The broad sense heritability (h^2) and genetic advance in terms of percentage of means (with 5 % selection intensity) were estimated as described by Allard (1999). On the other hand, Levene test (1960) was used to satisfy the assumption of homogeneity of variances before running the combined analysis.

The methodology proposed by Dewey and Lu (1959) was used in running path analysis for seed weight/plant and its components keeping seed weight/plant as resultant variable and its components as casual variables.

RESULTS AND DISCUSSION

Mean performance

The results of Levene test confirmed the homogeneity of variances for all studied characters which allowed applying the combined analysis. Accordingly, mean performance of soybean genotypes for seed weight/plant and its related traits over the two seasons 2009 and 2010 was presented in Table (2). The results revealed significant differences among the tested genotypes for all studied characteristics. Genotypes; Toano, Holladay, and DR101 were the latest in flowering and maturity recording (48 and 138), (51 and 137), and (48 and 139 days) over the two seasons, respectively.

On the other hand, H132 was the earliest in flowering (38 days) while H2L12 was errlier in flowering and maturity recording averages of 39 and 119 days over both seasons, respectively. The current results are in harmony with those obtained by Mohamed and Morsy (2005) and Hamdi *et al* (2008).

H129 had the tallest plants (113.7 cm) while Holladay was the shortest (62.1 cm) per plant. Genotypes: Toano, Holladay and Giza 111 gave the highest number of branches/plant being (3.3, 3.2 and 3.1), respectively, with no significant differences among them over both seasons. Similar results were obtained by Eisa *et al* (1998) and Hassan *et al* (2001 and 2002).

Regarding number of pods/plant, Crawford, DR 101 and H32 genotypes produced the largest number of pods/plant being 85.8, 83.7 and 82.9, respectively compared with H113 which recorded the lowest number of pods/plant (43.6). However, the heaviest weight of 100-seeds (17.2 g) was produced by DR 101 genotype compared to genotype H129 that gave the lightest weight of 100-seeds (13.73 g).

The results showed that H32, H2L12 and DR101 genotypes surpassed the other tested genotypes for both seed weight/plant and seed yield recording 27.9, 27.6 and 25.6 g/plant, and 1.96, 1.74 and 1.74

Table 2. Mean performance of some yield traits for the tested soybean genotypes (combined over 2009 and 2010 seasons).

Genotype	DF @	DM	PH (cm)	NB/P	NP/P	100-SW (g)	SW/P (g)	SY (ton/fed)
H 113	41	124	83.5	1.8	43.6	16.6	17.3	1.16
H 117	45	130	95.5	1.8	64.9	15.6	21.6	1.19
H 127	42	126	86.4	2.2	68.1	15.1	16.8	1.10
H 129	49	129	113. 7	2.6	71.4	13.7	24.4	1.68
H 132	38	125	93.6	1.8	66.1	16.2	21.3	1.32
H 30	39	132	93.3	1.7	64.6	16.4	23.6	1.57
H 32	45	137	108.9	2.9	82.9	15.7	27.9	1.96
H 2 L 12	39	119	106.7	2.4	79.1	14.9	27.6	1.74
H15 L 5	40	127	96.9	2.6	61.4	15.5	21.4	1.25
Toano	47	138	85.2	3.3	71.7	15.7	24.8	1.69
Holladay	51	137	62.0	3.2	74.3	16.0	24.4	1.69
DR 101	48	139	80.9	3.1	83.7	17.2	25.6	1.74
Giza 21	39	127	103.3	2.2	72.2	16.8	22.8	1.56
Giza 111	39	125	105. 7	3.1	79.0	16.3	25.1	1.72
Crawford	40	121	100.3	2.3	85.8	16.5	24.0	1.63
$LSD_{0.05}$	1.12	6.52	9.25	0.22	11.44	0.63	3.49	0.21

@ DF = days to flowering, DM= days to maturity, PH = plant height, NB/P = no. of branches/plant, NP/P = no. pods/plant, 100-SW = 100 – seed weight, SW/P = seed weight/plant and SY = seed yield (ton/fed).

(ton/fed), respectively while H127 and H113 genotypes were inferior to the mentioned genotypes recording 16.8 and 17.3 g / plant, and 1.10 and 1.16 ton/fed, respectively.

This finding is in agreement with those reported by Hassan *et al* (2001 and 2002), Mohamed and Morsy (2005), and Hamdi *et al* (2008).

Genetic parameters

Genotypic and phenotypic variances, genotypic and phenotypic coefficients of variation (GCV and PCV), broad sense of heritability (h^2), and genetic advance expressed as percent of mean for the studied traits are shown in Table (3).

Because the variance as a measure of variability (phenotypic or genotypic) is affected by the measure unit of traits, it is seldom to be used in comparisons. Accordingly, the comparison among yield traits concerning the degree of variability was made using the magnitude of coefficient of variation which is an absolute measure of variability.

Table 3. Estimates of genetic parameters for some yield traits in soybean.

Character	Variances		Coefficient of variation		Heritability (h^2)	Genetic advance (GA)	Expected GA (% of mean)
	Genotypic	Phenotypic	Genotypic (GCV)	Phenotypic (PCV)			
Plant height (cm)	117.48	160.9	11.48	13.44	73.02	19.08	20.22
No. of branches/plant	0.25	0.30	20.38	22.38	82.90	0.94	38.23
No. of pods/plant	100.50	115.85	14.07	15.10	86.75	19.24	26.99
100 - seed weight (g)	0.60	0.72	4.88	5.35	83.34	1.46	9.18
Days to flowering	13.25	16.90	8.47	9.57	78.40	6.64	15.46
Days to maturity	29.09	37.85	4.18	4.77	76.86	9.74	7.55
Seed weight/plant (g)	7.52	9.80	11.82	13.50	78.71	4.95	21.32
Seed yield (ton/fed)	0.057	0.066	15.59	16.77	86.47	45.81	29.87

The estimate of (GCV) was only high for number of branches/plant (20.38) while moderate values of (GCV) were recorded with seed yield (15.59), number of pods/plant (14.07), seed weight/plant (11.82), plant height (11.48), and days to flowering (8.47). The remaining two traits showed low estimates of (GCV).

On the other hand, the values of (PCV) were slightly higher than the values of (GCV) for all traits which reflect somewhat influence of environment on the expression of traits. In accordance, the selection would be effective to improve these traits among the studied genotypes. Similar findings were reported by Mohamed and Morsy (2005), Malik *et al* (2006) and Muhammad *et al* (2007).

It has to emphasize that, without considering genetic advance, the heritability values (h^2) would not be practically important in selection based on phenotypic appearance. Johnson *et al* (1955) confirmed that heritability estimates along with genetic advance would give a more reliable index of selection value.

In the present investigation, high values of heritability coupled with high values of genetic advance (as % of mean) were recorded for seed yield, number of branches/plant, number of pods/plant, plant height and seed weight/plant indicating the importance of the additive gene effects, so, selection would be effective in early generations for these traits.

High values of heritability accompanied with low genetic advance for 100-seed weight, days to flowering and days to maturity are indicative of non-additive gene effects. Therefore, limited scope for improvement of these traits is expected under the tested genotypes. The current conclusions are supported by Muhammed *et al* (2006) and Muhammed *et al* (2007) who confirmed that plant breeders can safely make their selection when they take in consideration high values of heritability and genetic advance.

Correlation matrix

The correlation coefficients among all pairs of studied characters of soybean over the two seasons are given in Table (4).

The results showed that there was a highly significant positive correlation between seed weight/plant and each of number of pods/plant (0.783), number of branches/plant (0.598), plant height (0.353) and days to maturity (0.309). Days to flowering had only significant positive association with seed weight/plant. It is suggested that seed weight/plant of soybean may be raised through selection for lateness, tallness, more pods and branches per plant, which is evident in the present study. However, insignificant association between 100-seed weight and seed weight/plant (-0.062) was also observed, indicating that the two traits may be independent in their genetic behavior under the tested genotypes.

Table 4. Correlation matrix for some yield – related traits in soybean.

Character	PH	NB/P	NP/P	100-SW	DF	DM	SW/P
Plant height (PH)	1	-0.18	0.254*	-0.417**	-0.492**	-0.479**	0.353**
No. of branches/plant (NB/P)		1	0.598**	-0.072	0.609**	0.539**	0.598**
No. of pods/plant (NB/P)			1	0.018	0.179	0.183	0.783**
100-Seed weight				1	-0.277**	0.166	-0.062
Days to flowering (DF)					1	0.798**	0.228*
Days to maturity (DM)						1	0.309**
Seed weight/plant (SW/P)							1

* and ** : Significant and highly Significant at probability levels 0.05 and 0.01, respectivel

The yield components exhibited various trends of association among themselves. However, highly significant negative correlations of plant height with each of 100-seed weight, days to flowering and days to maturity were observed reporting that most of short genotypes (such as Toano and Holladay) were late maturing and had light weight of 100-seeds but they produced more pods per plant according to the significant positive association between plant height and number of pods/plant (Table 4).

Number of branches/plant had highly significant positive correlation with number of pods/plant, days to flowering and days to maturity explaining that late maturity genotypes produced more branches and pods per plant.

It is important to note that the large sample size (n=30) of data may be the reason of the significance of some correlation coefficients although of small magnitudes.

These results concur with those reported by Pandey and Torrie (1973), Akhter and Sneller (1996), Ball *et al* (2001), Mohamed and Morsy (2005), Muhammad *et al* (2006), Muhammad *et al* (2007) and Hamdi *et al* (2008).

Path analysis

Information obtained from correlation coefficients can be augmented by partitioning the correlation coefficients into direct and indirect effects for a given set of causal interrelationships. In such situations, the correlation coefficients may be confounded with indirect effects due to common association inherent in trait interrelationships. So, path coefficient analysis has proven useful in providing additional information that describes the casual relationships such as yield and its components.

In the present investigation, the resultant variable was seed weight/plant while the remaining characters represented the casual variables. The matrix of direct and joint effects for the six yield – related traits on seed weight/plant are shown in Table (5).

Table 5. Path coefficients (direct and joint effects) of seed weight/plant and its related traits in soybean.

Character	PH	NB/P	NP/P	100-SW	DF	DM	SW/P
PH	***0.537***	-0.045	0.109	-0.076	-0.078	-0.095	0.353**
NB/P	-0.097	***0.247***	0.258	-0.013	0.096	0.107	0.598**
NP/P	0.136	0.148	***0.431***	0.003	0.028	0.036	0.783**
100-SW	-0.224	-0.018	0.008	***0.183***	-0.044	0.033	-0.062
DF	-0.264	0.15	0.077	-0.051	***0.158***	0.158	0.228*
DM	-0.257	0.133	0.079	0.03	0.126	***0.197***	0.309**
Residual effect = 0.489.							

The direct effects occupied the diagonal cells.

It is worthy to note that all the direct effects (diagonal values) were positive and below one, suggesting that inflation due to multicolinearity was minimal (Gravois and Helms 1992). The maximum direct effect was observed for plant height (0.537) followed by number of pods/plant (0.431) and number of branches/plant (0.247). The high positive direct effects of the previous mentioned traits in addition to their highly significant correlation coefficient with seed weight/plant indicated that the direct selection through these traits would be effective for soybean improvement. Similar results were obtained by .Oz *et al* (2009). On the other hand, the direct effects of 100-seed weight, days to flowering and days to maturity were positive and of secondary importance recording 0.183, 0.158 and 0.197, respectively.

In fact, the usefulness of path-coefficient analysis is apparent here. The discussion of present results at only simple correlation coefficient level, revealed that the relation between 100-seed weight and seed weight/plant was not significantly different from zero (-0.062). When the indirect effects are separated from simple correlation coefficient by path analysis, however, the direct effect revealed a positive and moderate relationship between 100-seed weight and seed weight/plant (0.183). The current results were in parallel line with those obtained by Muhammad *et al* (2006) and Muhammad *et al* (2007).

The indirect effect of plant height on seed weight/plant via number of pods/plant was positive and low (0.109) while its indirect effects via the other characters were negative and negligible. Only one considerable component of indirect effect was recorded for number of branches/plant via number of pods/plant being 0.258. Also, it is noticed that the indirect effects of number of pods/plant on seed weight/plant through their association with number of branches/plant and plant height were small and almost counterbalance being 0.148 and 0.136, respectively. Trivial components of indirect effects were obtained for number of pods/plant via the remaining traits.

Generally, it could be reported that the indirect effects for plant height, number of pod/plant and number of branches/plant were less important compared to their direct effects.

The importance of indirect selection could be considered in the absence or negligible values of direct effects. The current results were in harmony with those obtained by Akhter *et al* (1996), Shukla *et al* (1998), Board *et al* (1999), Ball *et al* (2001) and Oz *et al* (2009) who indicated the importance of path analysis when deciding upon selection criteria using yield components.

The component of indirect effects was more important than the part of direct effect considering the traits of 100-seed weight, days to flowering and days to maturity. The marked parts of their joint effects on seed weight/plant were especially those via plant height recording -0.224 for 100-seed weight, -0.264 for days to flowering and -0.257 for days to maturity. Thus, simultaneous selection which takes into account these pairs of characters would be effective for improvement of seed yield in soybean.

The coefficient of determination and relative importance according to path analysis for seed weight/plant and its related characters are shown in Table (6). The results revealed that the greatest parts of seed weight/plant variation were accounted for by the direct effects of plant height (17.22), number of pods/plant (11.1) and number of branches/plant (3.65). The great contribution of these characters on seed weight/plant plus the facility of visually selecting them supported their importance as selection criteria in soybean selection program.

Table 6. The coefficient of determination (CD) and relative importance (RI %) according to path analysis of seed weight/plant and its components in soybean.

Characters		CD	RI %
Direct effects			
Plant height (X1)		0.288	17.22
No. branches/plant (X2)		0.061	3.65
No. pods/plant (X3)		0.186	11.10
100 – seed weight (X4)		0.033	2.00
Days to flowering (X5)		0.025	1.49
Days to maturity (X6)		0.039	2.33
Total (direct)		0.632	37.79
Indirect effects			
X1 via	X2	-0.048	2.85
	X3	0.117	7.00
	X4	-0.082	4.89
	X5	-0.084	4.99
	X6	-0.102	6.06
X2 via	X3	0.128	7.61
	X4	-0.007	0.39
	X5	0.048	2.84
	X6	0.053	3.14
X3 via	X4	0.003	0.17
	X5	0.024	1.45
	X6	0.031	1.86
X4 via	X5	-0.016	0.96
	X6	0.012	0.72
X5 via	X6	0.050	2.98
Indirect total (absolute)		0.803	47.94
Total (direct + indirect)		1.435	85.73
Residuals		0.2391	14.27
Absolute total		1.675	100

Regarding the relative importance for the components of joint effects, it appeared that the highest value was observed for the indirect effect of number of branches/plant on seed weight/plant through its association with number of pods/plant (7.61 %) followed by the joint effect of plant height via number of pods/plant (7.0 %).

Also, considerable values of relative importance were listed for the joint effects of plant height via days to maturity, days to flowering and 100-seed weight (6.06 %, 4.99 % and 4.89 %, respectively). Small values of relative importance ranging from 0.17 % to 3.14 % were obtained by the other direct and indirect effects.

Totally, the studied characters explained 85.73 % of seed weight/plant variation. Accordingly, the residual component (14.27 %) may be attributed to unknown variation (random error), human errors during measuring characters and/or some other traits that were not under consideration in the present investigation.

In fact, path coefficient analysis gave somewhat a different picture than correlation coefficient did.

On the basis of obtained results of the present investigation, among the components of seed weight/plant, number of pods/plant, number of branches/plant and plant height are the most reliable yield components as selection criteria. These traits have a considerable value of genotypic coefficient of variation and also secured large degree of heritability coupled with the highest values of genetic advance (% of mean). Furthermore, they reflect highly significant positive correlation with seed weight/plant and their direct effects on yield formation process is also positive and the highest over the other yield attributes.

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الاختلافات الوراثية والارتباط و معامل المرور فى فول الصويا

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أجرى هذا البحث فى محطة بحوث سخا بكفر الشيخ خلال موسمى ٢٠٠٩ و ٢٠١٠ لدراسة وتقييم ١٥ تركيب وراثى من فول الصويا تمت زراعتها فى تصميم القطاعات الكاملة العشوائية بهدف تقدير التصنيفات الوراثية و المظهرية وذلك باستخدام مكونات التباين المتوقع من جداول التحليل الضام لكل صفة خلال الموسمين. كما تم دراسة العلاقات المتداخلة بين محصول بذور النبات و مكوناته و ذلك باستخدام تحليل معامل المرور. وتتلخص اهم النتائج المتحصل عليها فيما يلى :

١- أظهرت النتائج وجود فروق معنوية بين التراكيب الوراثية تحت الدراسة لجميع الصفات المدروسة حيث اعطت التراكيب الوراثية H32 ، H2L12 ، DR101 اعلى قيم لوزن بذور النبات بالجرام و كذا محصول البذور (طن/فدان) مع عدم وجود فروق معنوية بينهم مما يشير الى تفوقها وكونها من التراكيب الوراثية المبشرة التى يوصى بالتوسع فى استخدامها فى برامج التربية فى فول الصويا.

٢- أعطت صفات عدد أفرع النبات ، عدد قرون النبات ، وزن بذور النبات و كذا طول النبات اعلى قيم لمعامل الاختلاف الوراثى والمظهرى مما يعطى فرصة اكبر للانتخاب من خلال هذه الصفات.

٣- اشارت الدراسة الى اهمية الجمع بين نتائج درجة التوريث بمعناها الواسع و بين التحسن الوراثى المتوقع (% من المتوسط) فى الحكم على امكانية الانتخاب للصفات المختلفة بناء علـى الشـكل المظهـرى. و قـد اظهرت الدراسة ان اعلى قيم من درجة التوريث و كذا من التحسن الوراثى المتوقع تم الحصول عليها لصفات عدد أفرع النبات وعدد قرون النبات وكذا محصول البذور (طن/فدان).

٤- أظهرت النتائج وجود علاقة ارتباط موجب عالية المعنوية بين محصول بذور النبات وبين صفات عدد قرون النبات ، عدد أفرع النبات ، طول النبات ، عدد الايام حتى النضج بينما كانت العلاقة معنوية فقط بالنسبة لصفة عدد الايام حتى التزهير. اما بالنسبة لصفة وزن الـ ١٠٠ بذرة فقد كانت ذات علاقة ارتباط سالب وغير معنوى مع صفة وزن بذور النبات.

٥- أشارت نتائج تحليل معامل المرور ان صفات عدد قرون النبات ، عدد أفرع النبات ، و كذا طول النبات كانت هى الاكثر اسهاما فى محصول بذور النبات سواء عن طريق التأثير المباشر او غير المباشر مما يشير الى اهمية وضع هذه الصفات فى الاعتبار من قبل المربى عند تنفيذ برامج التربية واجراء الانتخاب لتحسين انتاجية محصول فول الصويا.

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