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Interrelationships of Agronomical Characteristics in Soybean (*Glycine max*) Grown in Different Environments

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ABSTRACT

This study was conducted to determine the correlations between seed yield and certain yield components and direct and indirect effects of these characters on seed yield in soybean [*Glycine max* (L.) Merrill]. Eight cultivars were evaluated in two locations (Mustafakemalpaşa & Gorukle) of Southern Marmara region, Turkey during two years (2000 & 2001) to determine correlations and path coefficients. Certain agronomical traits such as plant height, first pod height, number of pods per plant, number of seeds per plant, number of seeds per pod, 1000 seed weight and seed yield. Combined data over the years and locations indicated that seed yield had significant correlations with number of pods per plant ($r = 0.458$; $P<0.01$), number of seeds per plant ($r = 0.329$; $P<0.01$) and number of seeds per pod ($r = 0.491$; $P<0.01$). Positive associations only between seed yield and number of pods per plant were stable over the years and locations. Path coefficient analysis indicated that the number of seeds per pod gave the greatest direct positive effect (0.4728) on seed yield, followed by number of pods per plant (0.3988). Direct effects on seed yield were 57.0% and 50.4% for number of seeds per pod and number of pods per plant, respectively. Direct positive effect of number of pods per plant were seen stable over the years and locations. As a result, the number of seeds per pod and the number of pods per plant could be used as a selection criterion in breeding, because they were the most important factors in determining seed yield.

Key Words: Soybean; Path coefficient analysis; Seed Yield; Correlation

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is the most imported oilseed crop in Turkey. It is grown on about 23,000 ha with a seed production of 74-75 thousand tons annually. Annual imported is 900,000 tons to meet the increasing demand of oil for a long time. Soybean seed needs to be increased to decrease the import. Higher production may be achieved by using modern cultural practices and plant breeding programmes. Higher yield depends on succesfull results in plant breeding studies. Knowledge of relationship among yield and the other agronomic traits is important in plant breeding, especially for the plant selection. Thus breeding program should be planned to increase seed yield having lower heritabilities and have good associations between certain agronomical characters and seed yield. Correlation of particular character with other characters contributing to seed yield is of great importance for indirect selection of genotypes for higher seed yield.

Many of previous studies indicated that there were positive associations between number of pods per plant, number of seeds per plant and seed yield in soybean (Jadhav *et al*., 1995; Shinde *et al*., 1996; Malik *et al*., 2006; Taware *et al*., 1997; Ramgiry *et al*., 1998; Haliloglu *et al*., 2007). Path coefficient analysis helps for partitioning the correlation coefficient into its direct and indirect effects (Dewey & Lu, 1959; Salem *et al*., 1997). Path analyses have been identified as important yield components and direct and indirect influences of these components on seed yield in soybean (Pandey & Torrie, 1973; Jadhav *et al*., 1995; Shinde *et al*., 1996; Mehetre *et al*., 1997; Board *et al*., 1997). Many reports show a close positive effect of number of pods per plant, number of seeds per pod and 100 seed weight (Pandey & Torrie, 1973; Mridula *et al*., 1988; Dobhal & Gautam, 1995; Shinde *et al*., 1996; Taware *et al*., 1997; Dogney *et al*., 1998; Gaikwad *et al*., 2007).

The objective of this research was to estimate the simple correlations and to determine direct and indirect contributions of certain traits to seed yield in soybean grown at different locations and years.

MATERIALS AND METHODS

Eight soybean genotypes, "Ataem-1", "Ataem-2", "A-3127", "Corsoy", "Etae-8", "Hogdson-78", "Mitchell" and "Sa-88" were grown at two locations in Mustafakemalpasa (MKP) and Gorukle. Field experiments were conducted in a randomized complete block design with three replications. Each plot with 13 m^2 size consisted of four rows 6.0 m long

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with 0.65 cm distance between the rows. The seeding rate was 33 seeds m^{-1}. Plot size was 13 m^2 at harvest. Sixty kg each of nitrogen (N) and phosphorus (P) per hectare as fertilizer (20-20-0) were applied prior to sowing. A further 60 kg N ha^{-1} was added when the plants were at reproductive stages (V). After emergence, Fusilade was sprayed at a rate of 0.20 mL m^{-2} for weed control. Plants were irrigated three times at different growth periods such as vegetative stage (V_2), beginning of flovering (R_2) and full pod (R_4). Hand hoeing was done after irrigations. Plots were harvested by hand and then threshed to determine seed yield and yield components.

Seven agronomical traits such as plant height (cm), first pod height (cm), number of pods per plant, number of seeds per plant, number of seeds per pod, 1000 seed weight (g) and seed yield per hectar (kg ha^{-1}). Plant height, first pod height, number of pods per plant, number of seeds per plant, number of seeds per pod were measured on twenty plants selected randomly from all plots at each location and year. The seed yield was measured as mature seed harvested and threshed from 5 m lengths of the four rows. Seed weight was recorded as weight of 1000 randomly selected seeds from a bulk at each plot. An analysis of variance was made for each trait combined over years and locations. Simple correlation coefficients were obtained between all possible combinations of traits related to seed yield. Significance of correlation coefficients were tested at $P<0.05$ and $P<0.01$. These correlations were further analyzed using path coefficients as described by Li (1968) for each location and year.

For path coefficient analysis seed yield was selected as the dependent variable and the other traits as the independent variables. Coefficients of correlation and path coefficients analysis of the results were done using software "TARPOPGEN" (Fig. 1). Relationships between dependent variable, seed yield (X_6) and the five independent variables, plant height (X_1), first pod height (X_2), number of pods per plant (X_3), number of seeds per plant (X_4), number of seeds per pod (X_5) and 1000 seed weight (X_6) were estimated in that model.

Path coefficients are represented by P_{17}, P_{27}, P_{37}, P_{47}, P_{57} and P_{67} corresponding to direct effects on yield from plant height, first pod height, number of pods per plant, number of seeds per plant, number of seeds per pod and 1000 seed weight, respectively (Fig. 1). The direct effect of each yield component on yield is the path coefficient from this component to yield. The indirect effect of one component through a second component is the product of the path coefficient from the second component and the correlation between the two components (Dewey & Lu, 1959).

RESULTS

Combined correlation coefficients over the years and locations were positive between seed yield and number of pods per plant ($r = 0.458$; $P<0.01$), number of seeds per plant ($r = 0.329$; $P<0.01$) and number of seeds per pod ($r = 0.491$; $P<0.01$). Seed yield was positively associated with all the traits studied except first pod height and 1000 seed weight in only 2000 at Gorukle location from individual environments. Positive association between seed yield and number of pods per plant were only stable over years and locations in this study. Correlations between seed yield and the other traits were unstable over individual environments (Table I).

Plant height was positively and significantly associated with first pods height from ground ($r = 0.565$; $P<0.01$), but negatively with number of seeds per pod and 1000 seed weight ($r = -0.236$; $P<0.05$) and -0.239; $P<0.05$, respectively). There were positive associations between number of pods per plant and number of seeds per pod ($r = 0.413$; $P<0.01$) and number of seeds per plant ($r = 0.806$; $P<0.01$). Correlation between number of seeds per plant and number of seeds per pod was positive and significant ($r = 0.496$; $P<0.01$). Contrarily, number of seeds per plant was negatively associated $r = -0.338$; $P<0.01$) with 1000 seed weight.

The results of path coefficient analysis revealed that number of seeds per pod exerted maximum direct positive effect on seed yield followed by number of pods per plant (Table II), which were stable over the years and locations. The direct effect of number of seeds per pod was 57% with a positive correlation between number of seeds per pod and seed yield ($r = 0.491$; $P<0.01$). Number of seeds per plant exhibited negative direct effect, while plant height and 1000 seed weight had positive direct effect on seed yield. Associations between seed yield and plant height were non-significant. However, number of seeds per plant had the highest positive indirect effects through number of pods per plant (32.9%) and number of seeds per pod (28.6%) on seed yield. Positive association of seed yield and number of pods per plant ($r = 0.458$; $P<0.01$) occurred from direct effect of 50.4%. Also, number of pods per plant had positive indirect effect of 24.7% over number of seeds per pod but negative indirect effect of 16.9% over number of seeds per plant on seed yield (Table II).

Results of analysis indicated great negative direct and indirect effects between seed yield and plant height, first pod height from ground and 1000 seed weight. Plant height had total negative indirect effect (48.2%), while 1000 seed weight showed negative indirect effect (39.6%) on seed yield. First pod height from ground had negative direct effect (44.0%) first pod height and seed yield.

DISCUSSION

Description of associations between technological traits of plants is very important in breeding programmes. There were close positive associations between seed yield and number of pods per plant, number of seeds per plant and number of seeds per pod. In this study, only positive

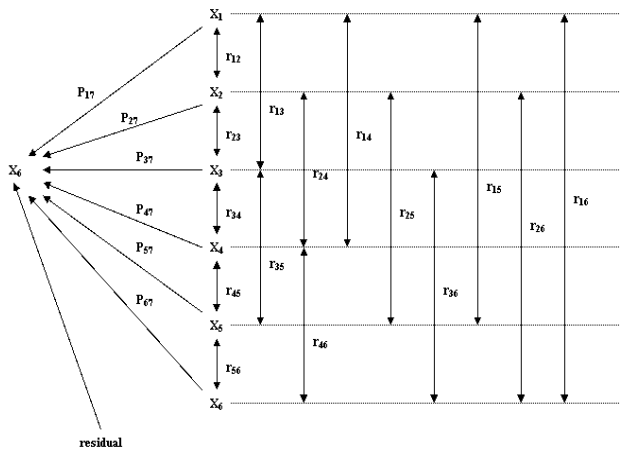
Table I. Correlation coefficients among seven characters of soybean cultivars grown under different environment conditions+

Traits	Site and year	Traits					
		Plant height	First pod height from ground	No. of pods plant^{-1}	No. of seeds plant^{-1}	No. of seeds pod^{-1}	1000 seed weight
Seed yield	MKP 99	-0.050	0.236	0.246	0.269	-0.144	0.282
	MKP 00	0.456*	0.454*	0.296	-0.086	0.341	0.395
	GOR 00	0.628**	-0.160	0.706**	0.592**	0.814**	0.183
	GOR 01	0.022	0.304	0.367	0.272	0.141	0.246
	Combined	0.018	-0.095	0.458**	0.329**	0.491**	0.096
Plant height	MKP 99		0.757**	0.005	-0.099	-0.093	0.387
	MKP 00		0.654**	-0.052	-0.347	0.145	0.078
	GOR 00		-0.042	0.511*	0.275	0.369	0.129
	GOR 01		0.689**	0.008	-0.325	-0.185	0.247
	Combined		0.565**	0.128	-0.019	-0.236*	-0.239*
First pod height from ground	MKP 99			0.001	0.068	-0.148	0.410*
	MKP 00			-0.146	-0.393	0.261	0.306
	GOR 00			-0.073	-0.014	-0.017	0.135
	GOR 01			0.272	-0.103	0.022	0.213
	Combined			-0.009	-0.108	-0.135	-0.009
No. of pods plant^{-1}	MKP 99				0.687**	0.309	0.429*
	MKP 00				0.726**	0.011	0.098
	GOR 00				0.893**	0.473*	0.448*
	GOR 01				0.681**	0.453*	0.063
	Combined				0.806**	0.413**	-0.146
No. of seeds plant^{-1}	MKP 99					0.385	0.461*
	MKP 00					0.144	-0.107
	GOR 00					0.462*	0.543**
	GOR 01					0.345	-0.179
	Combined					0.496**	-0.338**
No. of seeds plant^{-1}	MKP 99						0.393
	MKP 00						-0.078
	GOR 00						0.211
	GOR 01						0.129
	Combined						-0.151

*, ** : Significant at P=0.05 and P= 0.01 probability levels, respectively

+ : Correlation coefficients are values in 1999 and 2000 at Mutafakemalpasa (MKP 99 and MKP 00), in 2000 and 2001 at Gorukle (GOR 00 and GOR 01) and combined over sites and years, respectively

Fig. 1. Path diagram belong to direct and indirect effects of the independent variables on the pendent variable (from Ball *et al*., 2001)



associations between seed yield and number of pods per plant were stable over years and locations. Correlations between seed yield and the other traits were unstable, because of significant genotype × year or genotype × location interactions (Table I). These data are in agreement with those reported by Jadhav *et al.* (1995), Shinde *et al*. (1996), Ramgiry *et al*. (1998) and Taware *et al*. (1997), Nag *et al*. (2007) and Malik *et al*. (2007). On the other hand, associations between number of pods per plant and number of seeds per plant were the highest and the most stable. Correlations among all the other traits were unstable over years and locations. Therefore, these correlations were not considered as significant linear associations. However, it was reported in earlier studies that there were positive correlations between number of pods per plant and 1000 seed weight (Whigham, 1976); plant height and first pod height (Martin & Wilcox, 1973; Isler *et al*., 1997), while the associations between plant height and 1000 seed weight were negative and significant (Atakisi, 1978).

In our study, number of seeds per pod and number of pods per plant had the highest direct positive effect on seed yield (Table II). Previous reports indicated that number of seeds per yod exerted maximum direct positive effect on seed yield (Pandey & Torrie, 1973; Mridula *et al*., 1988; Shinde *et al*., 1996; Dogney *et al*., 1998; Sirohi *et al*., 2007). On the other hand, masking functions of negative direct and indirect effect reduced correlations between seed yield and

plant height, first pod height from ground and 1000 seed weight. Thus, direct effect of 1000 seed weight was non significant. Similarly, direct effects of plant height and first pod height from ground on seed yield were positive and negative, respectively and both were non significant (Table II). Rajanna *et al*. (2000) found that 1000 seed weight and number of pods per plant had highly positive direct effects on seed yield.

In conclusion, both number of seeds per pod and number of pods per plant were the most important factors in determining seed yield. These results releaved that number of seeds and number of pods per plant could be used as selection criteria in breeding for high yield.

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