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Determining the Relationship between SPAD Values and Common Bean Seed (*Phaseolus vulgaris* L.) Yield by Correlation and Path Coefficient Analysis Method by using Different Organic Fertilizer

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ABSTRACT

Path coefficient analysis provides a much better understanding of the correlation coefficient values. Spad values give information about the state of the leaf. In the study, path coefficient analysis was performed, especially SPAD values in beans. The study was carried out Kahramanmaraş Sutcu Imam University, treatment area in 2021 year. Mispir cultivar and Aydintepe local common bean genotype were used, leonardite and chicken litter and their mixture were used, various doses (3,6,9 t ha^{-1} and conventional fertilizer (25 kg ha^{-1} N / 64 kg ha^{-1} P_2O_5) and control application) were added to the soil. Leaf chlorophyll content was measured in three periods: early leaf (1st SPAD), flowering stage (2nd SPAD), post-flowering (3rd SPAD). In addition, seed yield and biomass yield values were determined. Chicken Manure 3 t ha^{-1} organic fertilizer application showed the best performance among all applications in terms of seed yield. And the Aydintepe local genotype showed higher performance than the Mispir cultivar for the most of the properties examined.

Key words: Chlorophyll, Common bean, Organic fertilizers, Seed yield, SPAD.

Organic, ecological and biological farming identified as a natural farming system (Lammerts Van Bueren *et al*. 2002). The rule in organic agriculture is that no synthetic substance is used during production (such as chemical fertilizers, chemical pesticides). These synthetic substances have negative effects on human health and food safety (Anonymous, 2021).

Common bean (*Phaseolus vulgaris* L.) also known as field bean, dry bean, french bean, kidney bean and green bean which is an important legume around the world (Camara *et al.* 2013; Swegarden *et al.* 2016; Jannat *et al.* 2019).

Relations of the common bean spad values and biomass yield are important for high yield. But yield parameters are changes due to the different interactions of various factors (Khan and Dar, 2010).

Correlation coefficient analysis examines the relationship between variables and path coefficient analysis enables the correlation coefficient values to be separated according to the variables and analyzed in more detail. Path coefficient analysis gives information on the common bean yield criteria relations (Ekinci *et al*. 2010).

Correlation and path coefficient analyzes of seed yield and bean components have been studied by many researchers (Agsakalli and Olgun, 2001; Peksen and Gulumser, 2005; Ghobary and Abdallah, 2010; Karasu and Oz, 2010; Salehi *et al*., 2010; Sadeghi *et al*., 2011; Cokkizgin *et al*., 2013; Prakash *et al*., 2014; Akhshi *et al*., 2015; Ejara *et al*., 2017; Panchbhaiya *et al*., 2017; Kalauni and Dhakal, 2020). However, little study has been done on the effect of spad values on yield. In addition, researching the subject with organic fertilizers is rarely studied.

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This bean study investigated the SPAD-seed yield relationship that was not addressed in other studies. In the study, it was tried to determine the relationship of the spad values measured at three different times to seed yield and biomass yield to seed yield *via* correlation and path coefficient analysis.

This study was conducted to Kahramanmaraş Sutcu Imam University, Faculty of Agriculture, Department of Field Crops treatment area (37°35′38.3″N 36°48′46.2″E) in 2021 year from 04 April to 28 July.

Two bean genotypes, one local genotype (Aydintepe) and the other registered variety (Mispir), were used in the

Table 1: Analysis of variance summary of 1st SPAD, 2nd SPAD and 3rd SPAD features.

Variation source	Df	1st SPAD		2nd SPAD		3rd SPAD	
		MS	F val.	MS	F val.	MS	F val.
Rep.	2	8.170	2.21	82.612	3.25*	53.917	6.04**
Fertilizer	10	4.294	1.16	30.147	1.19*	6.941	0.78
Genotype	1	31.409	8.48**	339.048	13.35**	2.138	0.24
Fer. × Gen. interaction	10	2.513	0.68	33.021	1.30	4.008	0.45
Error	42	3.703		25.405		8.925	
Total	65						
Coeff var. (%)		4.854		13.473		9.203	

Table 2: The obtained values of 1st SPAD, 2nd SPAD and 3rd SPAD and their Duncan statistical groups in terms of fertilizer applications.

Application	1st SPAD	2nd SPAD	3rd SPAD
Control (No fertilizer)	40.445	43.883 A	33.927
Control (Chemical fertilizer)	39.682	36.690 B	33.033
Leonardite 3 t ha^{-1}	40.535	37.535 B	32.908
Leonardite 6 t ha^{-1}	38.573	36.440 B	33.397
Leonardite 9 t ha^{-1}	39.708	37.233 B	33.863
Leonardite/chicken manure mix. 3 t ha^{-1}	38.405	35.947 B	30.610
Leonardite/chicken manure mix. 6 t ha^{-1}	38.860	36.338 B	31.938
Leonardite/chicken manure mix. 9 t ha^{-1}	40.927	37.082 B	32.120
Chicken manure 3 t ha^{-1}	39.910	35.593 B	32.333
Chicken manure 6 t ha^{-1}	38.953	37.125 B	31.813
Chicken manure 9 t ha^{-1}	40.120	37.645 B	31.120
Mean	39.647	37.41015	32.46030

study. In the field treatment, leonardite and chicken litter and their mixture were used and their various doses (3,6,9 t ha^{-1}) were added to the soil. The common bean conventional production method (25 kg ha^{-1} N and 64 kg ha^{-1} P_2O_5) and the application with no fertilizer were used for control.

The plots were 10 square meters, with 4 rows and the row length was 5 meters. On the other hand, the experiment was established with three replications. Sowing was done on 4th of April and harvesting on 28th of July 2021. During the growing period, irrigation and weed control were carried out at regular intervals. Organic farming principles were followed during these processes.

Leaf chlorophyll content (SPAD) values, biomass yield and seed yield were measured in the study (Estrada and Rodriguez-Gonzalez, 2017; Cokkizgin *etal.* 2018; Girgel and Cokkizgin, 2019; Girgel *et al.*, 2019; Ahmadi and Arain, 2021; Amarapalli, 2022). Leaf chlorophyll content was measured in three periods: early leaf stage (SPAD I, 10.May.2021), flowering stage (SPAD II, 31.May.2021), post-flowering stage (SPAD III, 29. June. 2021).

Collected data were subjected to analysis of variance (ANOVA), using SAS 9.1 statistical analysis system (SAS, 2004). Duncan's multiple range test (DMRT) was used to compare the means (Duncan, 1955). Correlation coefficients between all possible combinations of variables were worked out according to Snedecor (1957). Path coefficient technique (in other words multiple regression analysis) was performed according to the method of Wright (1934). On the other hand, correlation and path coefficients were determined using Totemstat, the Windows compatible version of the Tarist statistical analysis program (Acikgoz *et al.* 1993).

Table 3: According to the genotypes, the obtained values of 1st SPAD, 2nd SPAD and 3rd SPAD and their Duncan statistical groups.

Cultivars	1st SPAD	2nd SPAD	3rd SPAD
Aydintepe	40.3370 A	39.677 A	32.280
Mispir	38.9573 B	35.144 B	32.640
Mean	39.647	37.41015	32.460

1st SPAD measurement (Early leaf stage)

According to the results obtained, the difference between the cultivars was found to be statistically significant (Table 1). Aydýntepe genotype has a higher spad value (40.337) than the Mispir variety (38.957). On the other hand, the Fertilizer×Genotype interaction and the differences in organic fertilizer applications were statistically insignificant. It was found to be statistically insignificant, but leonardite/chicken manure mix. 9 t ha^{-1} application had the highest spad value (40.927) among organic fertilizers (Table 2-3).

2nd SPAD measurement (Flowering stage)

The statistical difference between cultivars was also found significant in the second spad measurement. It was determined that the spad value (43.883) of the application without fertilizer was higher than all other applications.

Table 4: Analysis of variance summary of biomass yield and seed yield features.

Variation source	Df	Biomass yield		Seed yield	
		MS	F val.	MS	F val.
Rep.	2	12278.503	0.52	41.69604	0.07
Fertilizer	10	9017.001	0.38	1868.573	3.36**
Genotype	1	43119.720	1.83	24284.949	43.66**
Fer. × Gen. interaction	10	39048.557	1.66	229.089	0.41
Error	42	23585.226		556.267	
Total	65				
Coeff var. (%)		32.995		26.981	

Table 5: The obtained values of biomass yield and seed yield their Duncan statistical groups in terms of fertilizer applications.

Application	Biomass yield	Seed yield
Control (No fertilizer)	445.55 A	66.50 DE
Control (Chemical fertilizer)	520.70 A	100.94 A-C
Leonardite 3 t ha^{-1}	520.78 A	70.67 C-E
Leonardite 6 t ha^{-1}	465.19 A	72.48 B-E
Leonardite 9 t ha^{-1}	418.62 A	65.45 E
Leonardite/chicken manure mix. 3 t ha^{-1}	446.38 A	85.00 B-E
Leonardite/chicken manure mix. 6 t ha^{-1}	505.51 A	97.33 A-D
Leonardite/chicken manure mix. 9 t ha^{-1}	399.83 A	102.83 AB
Chicken manure 3 t ha^{-1}	467.58 A	118.79 A
Chicken manure 6 t ha^{-1}	460.06 A	99.70 A-C
Chicken manure 9 t ha^{-1}	469.66 A	81.85 B-E
Mean	465.4415	87.41

Table 6: According to the genotypes, the obtained values of biomass yield and seed yield and their duncan statistical groups.

Cultivars	Biomass yield	Seed yield
Aydintepe	491.00 A	106.59 B
Mispir	439.88 A	68.23 A
Mean	465.44	87.41

In the first spad measurement, Fer × Gen. interaction was statistically insignificant. Also, Aydintepe genotype also had a high value (39.677) in the second spad measurement; Mispir variety had lower value (35.144)..

3rd SPAD measurement (Post-flowering stage)

In the third spad measurement, all factors were found to be statistically insignificant. However, Mispir cultivar (32.640) had high value between genotypes and among the fertilizers, control (no fertilizer) got the highest spad value (33.927).

Biomass yield (kg da^{-1})

All sources of variation in biomass yield were found to be insignificant (Table 4). However, Aydintepe genotype produced more biomass (491.00 kg da^{-1}) than Mispir cultivar (439.88 kg da^{-1}). Leonardite 3t ha^{-1} application (520.78 kg da^{-1}) was also the fertilizer application in which the most biomass was obtained (Table 5-6). Properties such as biomass yield and yield are highly affected by the environment, climate and soil conditions. Similar views were also reported by Karavidas *et al*. (2022). On the other hand, it was reported that there was a strong influence of environmental influences on yield (Swegarden *et al*., 2016).

Seed yield (kg da^{-1})

In terms of seed yield, both the difference between genotypes and the difference between fertilizer applications were found to be statistically significant (Table 4). Between the genotypes, Aydintepe genotype (106.59 kg da^{-1}) had higher yield compared to Mispir cultivar (68.23 kg da^{-1}). Considering the fertilizer issue; Chicken Manure 3 t ha^{-1} organic fertilizer application (118.79 kg da^{-1}) was the application with the highest seed yield. However, the following were also included in the same statistical group: Leonardite/Chicken Manure Mix. 9 t ha^{-1} (102.83 kg da^{-1}), Control (Chemical fertilizer) (100.94 kg da^{-1}), Chicken Manure 6 t ha^{-1} (99.70 kg da^{-1}) and Leonardite/Chicken Manure Mix. 6 t ha^{-1} (97.33 kg da^{-1}) respectively (Table 5-6). The formation of the phenotype; It occurs as a result of genetic factors, environmental factors and the interaction of genetic and environmental factors (Falconer and Mackay 1996). For this reason, the amount of product we obtained varied according to the region and organic fertilizer. It was reported that the yield of bean varies according to the bean genotypes, fertilizer and fertilization (Karavidas *et al*., 2022). It has been reported that environmental factors have a great effect on yield (Swegarden *et al*. 2016).

Correlation and path coefficient analysis

Path coefficient analysis is used to examine the correlation coefficient in more detail. And the aim of the path coefficient analysis is the direct and indirect effects of the independent variables on the dependent variable (Wright, 1918; Wright, 1920; Wright, 1921; Wright, 1934).

When the relationships between the examined features are considered; A positive and significant correlation coefficient was determined between 1st SPAD and 2nd SPAD measurement (r=0.523). All correlation coefficients that could be calculated among other features were found to be insignificant. In this study the results obtained were different

Table 7: Matrix of correlation coefficients for all measurement parameters.

Parameters	Seed yield	1st SPAD	2nd SPAD	3rd SPAD	Biomass yield
Seed yield	1.000				
1st SPAD	0.394ns	1.000			
2nd SPAD	0.214ns	0.523*	1.000		
3rd SPAD	-0.414ns	0.261ns	0.189ns	1.000	
Biomass yield	0.146ns	0.191ns	-0.010ns	0.307ns	1.000

Table 8: Path coefficients for direct and indirect effects of variables.

Parameters	Direct effect	Indirect effect			
		1st SPAD	2nd SPAD	3rd SPAD	Biomass yield
1st SPAD	0.4612		0.2411	0.1204	0.0883
2nd SPAD	0.0944	0.0493		0.0179	-0.0010
3rd SPAD	-0.6297	-0.1644	-0.1192		-0.1932
Biomass yield	0.2522	0.0483	-0.0026	0.0774	

Table 9: Path ratios for direct and indirect effects of variables.

Parameters	Direct effect	Indirect effect			
		1st SPAD	2nd SPAD	3rd SPAD	Biomass yield
1st SPAD	%63.7681		%52.7227	%14.2479	%16.5083
2nd SPAD	%20.6367	%6.8228		%2.1136	%0.1845
3rd SPAD	%74.4852	%22.7370	%26.0644		%36.1404
Biomass yield	%47.1668	%6.6721	%0.5762	%9.1532	

from other studies due to both genetic and environmental effects (Table 7).

3rd SPAD had a direct and great negative effect on seed yield and the percentage of effect was 74.4852% (-0.6297). The 1st SPAD value had the greatest positive direct effect on seed yield and the effect percentage was 63.7681% (p=0.4612). Other direct effects were found positive and the biomass yield was 47.1668% (p=0.2522) and 2nd SPAD 20.6367% (p=0.0944), respectively (Table 8-9).

Falconer and Mackay (1996) reported that genetic and environmental variations inluences physiological mechanisms. Therefore, the the relationships between these studied parameters have changed. For this reason, it is considered as the relationships between the features we examine to change.

CONCLUSION

As a result of spad measurements, it was determined that the Aydintepe genotype produced more chlorophyll. Spad values were found to be statistically insignificant among fertilizer applications, as they were generally similar.

In most of the traits examined, the Aydintepe local genotype showed higher performance than the Mispir cultivar.

Chicken Manure 3 t ha^{-1} organic fertilizer application showed the best performance among all applications in terms of seed yield. However, positive effects of Leonardite/Chicken Manure Mix. 9 t ha^{-1}, Control (Chemical fertilizer), Chicken Manure 6 t ha^{-1} and Leonardite/Chicken Manure Mix. 6 t ha^{-1} applications were determined in terms of seed yield.

Considering the correlation and path coefficients, the effect of spad values on seed yield should also be considered.

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Authors' contribution

The authors declared that they contributed equally at all stages of the study/writing of the manuscript.

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