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SOYBEAN YIELD ANALYSIS WITH POTASSIUM AND ZINC FERTILIZERS APPLICATION

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ABSTRACT

Our objective was to evaluation of regression relationships between yield and its components in soybean when that potassium and zinc fertilizers are used. Therefore, an experiment was conducted in a factorial experiment based on Randomized Complete Block with three replicates in Kermanshah province, Iran at 2011. In this research, treatments included Usage amounts of fertilizers potassium (0, 50 and 100 kg K ha^{-1}), and zinc (0, 15 and 30 kg Zn ha^{-1}) as soil application. The results were showed that the effect of potassium and zinc application on seed yield was significant at 1% and 5% levels, respectively. There are significantly positive correlation between seed yield and seed dry weight ($r=0.754^{**}$), seed/plant ($r=0.742^{**}$), pod/plant ($r=0.710^{**}$) at 1% level. The results of stepwise regression analysis indicated that seed dry weight as the first variable that entered in model and explaining 56.9 percent of total variation and recognized as the most effective role on grain yield. Pod/plant and seed weight are the second and third variables that entered to model and explaining 16.4 and 7.7 percent of yield variance, respectively.

Keyword: Path Analysis, Potassium, Regression Analysis, Soybean, Zinc

INTRODUCTION

Improving the uptake of minerals from the soil and enhancing their transfer to seed and bioavailability in the edible parts of the plant will provide benefits for animal and human nutrition. According to **[1]** studies Nutrient requirements of crops depended on expected of yield, crop species, climatic conditions, soil type, and biology. Indeed, soil, plant, and climatic conditions are the main factors for determine of the plant nutrients requirement. Potassium is an essential element for soybean plant. According to **[2]** studies, 21 percent of Asian land is faced with potassium deficient. Based on previous studies 25 percent of soils in tropics and subtropics **[3]**, and many soils of the tropical and temperate regions **[4]** have deficient potassium. In developing countries that diets are cereal based, zinc deficiency in human widespread **[5]**. Nutrient concentrations in shoot plants reflect the interactions effects between elements. **[6]** Reported that symptoms of zinc deficiency in plant first appear on the younger leaves. There is positive correlation between essential macro and micro element accumulation and improvement of quality and quantity characteristics of soybean plant. **[7, 8]** stated that grain harvest index improved in dry bean by potassium application. They also reported that there is positive correlation between grain harvest index and yield of dry bean. Soybean yield is determined by yield components, which are number of pod per plant, number of seed per pod, and seed weight **[9]**. It is very important to understand the formation of yield components and management practices that can be influenced yield components and consequently final yield. Hence, the main objective of this study is to evaluation relationships between yield and its components in soybean when that potassium and zinc fertilizers were used.

MATERIALS AND METHODS

The experiment was done at the research field of the Islamic Azad University of Kermanshah province, Iran ($34^0 26^{'}$ N, $46^0 81^{'}$ E; 1363 m elevation) in 2011. The experimental design was a 3×3 factorial experiment based on Randomized Complete Block with three replicates. Soil samples were collected from experimental area at 0-30 cm depth. The results of soil analysis were shown in **Table 1**.

Table 1: The Results of Soil Test (0-30) cm

Soil Properties	Value
Soil texture	Silty clay
Organic matter (%)	1.8
pH	7.3
Electrical conductivity (dsm^{-1})	1.23
N (%)	0.11
P (ppm)	6.2
K (ppm)	206
zinc (mg/kg)	0.34

Before planting of soybean, fertilizers were used as follows: 16.5 kg P_2O_5 and 4.5 kg N and mixed with soil and land was ploughed once and harrowed twice. Seeds were inoculated with Brady*Rhizobium japonicum* and sown at a high-planting rate in field plots. Potassium and zinc fertilizers 0, 50, 100 and 0, 15, 30 $kg.ha^{-1}$ were applied, respectively. When the unifoliate leaves were expanded, the plots were hand-thinned to obtain a uniform plant population of 33 plants per m^2. The plots were irrigated when necessary to avoid water deficits. At the end of growth season, ten plants were selected randomly from each plot and number of pod/plant, seed/plant, and seed/pod and 100-seed weight were determined. To calculate final yield, a 1-m^2 area from each plot were completely harvested considering the sides. Weight 13% deduction of moisture, grain dry weight was calculated and considered as economic yield. To determine biological yield, total plant dry weight was employed as biological yield, Harvest index was obtained by dividing economic yield by biological yield multiplied by 100. Data for evaluated traits were statistically analyzed using a standard analysis of Variance technique for the factorial experiment in randomized complete block design using the statistical software MSTATC. Means were separated by the Duncan's Multiple Range Test at 5 percent probability level. Regression analysis and path analysis were conducted by using SPSS software.

RESULTS AND DISCUSSION

Diagnosis of interrelationships between yield components is necessary to obtained high-yielding cultivars. Direct and indirect effects of these components on yield can be determined by standardized partial regression coefficients in path analysis technique. The results of this experiment were showed that the effect of potassium application on seed yield, total dry weight, number of sub branch, and number of pod and seed per plant was significant at 1% levels. **[10, 11]** emphasized that any deficit of K during the late vegetative and reproductive stages is going to reflect on yield of soybean. K-uptake in soybean has been estimated at about 101-120 kg/ha potassium. Also, seed yield, pod dry weight and number of sub branch affected by zinc application at 5% level. In addition zinc fertilizer had significantly effects on total dry weight, pod and seed number per plant ($P<0.01$). In contrast, the effects of potassium and zinc on seed weight were not significant. **[12]** Indicated that seed number per plant increased by zinc fertilizer application compared with check treatment. The highest of seed yield was achieved with 50 kg/ha and 30 kg/ha potassium and zinc fertilizers application, respectively **(Table 3)**. In previous studies **[13, 14]** demonstrated that nutrition unbalanced is one of the important reasons of low productivity. These results agree with **[15]**. Correlation coefficients calculated among examined characteristics are shown in **Table 4**. Correlation analysis showed that seed yield had significantly positive correlation with seed dry weight ($r=0.754^{**}$), number of seed per plant ($r=0.742^{**}$), number of pod per plant ($r=0.710^{**}$), number of sub branch ($r=0.613^{**}$) and total dry weight ($r=0.567^{**}$) at 1% level and with pod dry weight ($r=0.382^{*}$) at 5% level. The results of stepwise regression analysis **(Table 5)** indicated that seed dry weight as the first variable that entered in model and explaining 56.9 percent of total variation and recognized as the most effective role on grain yield **(Table 6)**. Pod/plant and seed weight are the second and third variables that entered to model and explaining 16.4 and 7.7 percent of yield variance, respectively. The results of path analysis for interrelationships of yield and yield components **(Table 7)** indicated that number of pod per plant had the most direct effect on seed yield (0.418). Indirect effect of pod/plant on seed yield on seed yield via seed/plant recorded (0.286). Evaluation of final yield and yield components for selection of high yielding cultivars is necessary and path analysis has been used to identify important yield components in soybean **[16-19]**. The results of principal components presented in **Table 8**. The principal components analysis to reduce the number of primary variables, Characteristics grouped according to their interrelations and Contribution; and as a supplement to the stepwise regression can be used **[20]**.

Eigen value is equal to the total variance of the data and the share of the variance component of the total variance shows. In this experiment analysis was conducted based on eight traits. Among principal components, three components collectively 67.71% of the total variation are explained. The largest coefficient factor in seed yield, seed dry weight, number of sub branch, total dry weight, and pod/plant were observed that belonged to first components. Therefore, this component named yield factor. This component explaining 54.07% of data variation, so any increase in this component can lead to an increase in the seed yield. In second component, seed weight had the largest factor coefficient and named remobilization. This component is explaining 13.63% of data variation. Furthermore, selected based on the first component causing to increase in seed yield. These relationships are shown in **Table 8** and **Figure 3**. Effects of potassium and zinc fertilizer application are shown in **Figure 1 and 2**. Based on results seed yield affected by both potassium and zinc fertilizers application. The best equations regressions in potassium and zinc application are:

Eq 1: Potassium application

$$SY=-369.5X^2+1843.5X+756 \quad r^2=1.00$$

Eq 2: Zinc application

$$SY=-72X^2+415X+2225 \quad r^2=1.00$$

Whereas SY and X are seed yield potassium and zinc application, respectively **(Figure 1 and 2)**. Indeed, potassium had more effect on seed yield compared zinc fertilizer application.

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Table 2: Analysis of Variance of Soybean Yield and Yield Components

					Ms				
Source of variation	d.f	SY	DWPP	DWSP	TDW	NSS	NPP	NSP	SWP
Block	2	57920.4	0.01	0.19	2.82	0.03	0.93	3.00	0.75
Potassium (K)	2	1611176.34^{**}	0.18^{ns}	6.23^{*}	11.02^{**}	2.50^{**}	8.82^{**}	627.52^{**}	0.44^{ns}
Zinc (Zn)	2	160569.33^{*}	0.51^{*}	4.51^{ns}	9.33^{**}	0.82^{*}	7.37^{**}	291.37^{**}	0.17^{ns}
Potassium×Zinc (K)× (Zn)	4	46664.35^{ns}	0.01^{ns}	1.14^{ns}	1.27^{ns}	0.07^{ns}	0.83^{ns}	33.99^{**}	0.28^{ns}
Error	16	27121.45	0.11	1.36	0.99	0.18	1.01	5.62	1.21
Coefficient of variation (%)	-	8.96	8.29	9.02	6.12	10.23	7.19	8.63	7.97

NOTE: -ns, * and **: non-significant, significant at 5% and 1% levels of probability, respectively; -SY: Seed yield, DWPP: Pod dry weight, DWSP: Seed dry weight, TDW: Total dry weight, NSS: Number of sub branch; NPP: Number of pod per plant, NSP: Number of seed per plant, SWP: 100-see weight

Table 3: Means Comparison of Yield and Yield Components of Soybean at Different Fertilizer Treatments

Treatment	SY	DWPP	DWSP	TDW	NSS	NPP	NSP	SWP
Potassium (K)								
K_0	2230 b	2.96 a	6.89 b	15.07 b	2.8 b	12.9 b	26.3 c	13.6 a
K_{50}	2965 a	3.23 a	8.29 a	16.57 a	3.5 a	14.8 a	43.0 a	13.7 a
K_{100}	2961 a	3.05 a	8.36 a	17.23 a	3.8 a	14.3 a	34.8 b	14.0 a
Zinc (Zn)								
Zn_0	2568 b	2.83 b	7.07 b	15.11 b	3.1 b	12.9 b	28.3 c	13.9 a
Zn_{15}	2767 a	3.11 ab	8.01 ab	16.90 a	3.5 a	14.5 a	36.5 b	13.8 a
Zn_{30}	2822 a	3.30 a	8.46 a	16.85 a	3.6 a	14.6 a	39.3 a	13.6 a
LSD value (P<0.05)	164.6	0.339	1.165	0.997	0.427	1.007	2.369	1.099
Interaction effects (K)×(Zn)								
K_0Zn_0	2052 d	2.73 b	6.35 b	14.76 c	2.4 d	11.2 b	23.7 d	13.5 a
K_0Zn_{15}	2383 c	2.96 ab	7.20 b	15.25 c	3.0 cd	13.9 a	27.2 d	13.7 a
K_0Zn_{30}	2256 cd	3.18 ab	7.11 b	15.20 c	3.0 bcd	13.6 a	28.1 d	13.6 a
$K_{50}Zn_0$	2725 b	2.97 ab	6.89 b	14.97 c	3.1 abc	14.2 a	33.4 c	14.1 a
$K_{50}Zn_{15}$	2982 ab	3.25 ab	8.32 ab	17.35 ab	3.5 abc	15.0 a	47.2 a	13.9 a
$K_{50}Zn_{30}$	3189 a	3.48 a	9.67 a	17.38 ab	3.9 ab	15.2 a	48.5 a	13.2 a
$K_{100}Zn_0$	2927 ab	2.79 b	7.97 ab	15.61 bc	3.6 abc	13.5 a	27.9 d	14.1 a
$K_{100}Zn_{15}$	2935 ab	3.12 ab	8.52 ab	18.11 a	4.0 a	14.6 a	35.2 c	13.9 a
$K_{100}Zn_{30}$	3021 ab	3.25 ab	8.59 ab	17.97 a	3.9 ab	14.9 a	41.2 b	14.1 a
LSD value (P<0.05)	285.1	0.587	2.018	1.727	0.741	1.743	4.010	1.903

NOTE: In each column with similar letter(s) are not significantly different at the 5% level of probability; SY: Seed yield, DWPP: Pod dry weight, DWSP: Seed dry weight, TDW: Total dry weight, NSS: Number of sub branch, NPP: Number of pod per plant, NSP: Number of seed per plant, SWP: 100-see weight

Table 4: Correlation Coefficient Between Yield and Yield Components in Soybean at Different Fertilizer Treatments

	SY	DWPP	DWSP	TDW	NSS	NPP	NSP	SWP
EY	1.00							
DWPP	0.382^{*}	1.00						
DWSP	0.754^{**}	0.438^{*}	1.00					
TDW	0.567^{**}	0.287^{ns}	0.694^{**}	1.00				
NSS	0.613^{**}	0.519^{**}	0.532^{**}	0.565^{**}	1.00			
NPP	0.710^{**}	0.308^{ns}	0.466^{*}	0.436^{*}	0.427^{*}	1.00		
NSP	0.742^{**}	0.594^{**}	0.570^{**}	0.606^{**}	0.580^{**}	0.685^{**}	1.00	
SWP	0.098^{ns}	-0.011^{ns}	-0.196^{ns}	-0.086^{ns}	-0.034^{ns}	-0.146^{ns}	0.056^{ns}	1.00

NOTE: ns, * and **: non-significant, significant at 5% and 1% levels of probability, respectively
-SY: Seed yield, DWPP: Pod dry weight, DWSP: Seed dry weight, TDW: Total dry weight, NSS: Number of sub branch, NPP: Number of pod per plant, NSP: Number of seed per plant, SWP: 100-see weight

Table 5: Stepwise Regression Analysis ANOVA for Soybean Yield [d] (as a Dependent Variable) at Different Fertilizer Treatments

Model	df	Sum of Squares	Mean Square	F	Sig.
1 Regression	1	2435294.458	2435294.458	33.005	0.000[a]
Residual	25	1844638.208	73785.528		
Total	26	4279932.667			
2 Regression	2	3137906.166	1568953.083	32.972	0.000[b]
Residual	24	1142026.500	47584.438		
Total	26	4279932.667			
3 Regression	3	3466288.727	1155429.576	32.662	0.000[c]
Residual	23	813643.939	35375.823		
Total	26	4279932.667			

NOTE: a) Predictors: (Constant), DWSP; b) Predictors: (Constant), DWSP, NPP; c) Predictors: (Constant), DWSP, NPP, SWP; d) Dependent Variable: SY; SY: Seed yield, DWSP: Seed dry weight, NPP: Number of pod per plant, SWP: 100-see weight

Table 6: The results of Stepwise Regression Analysis for Soybean Yield [d] (as a Dependent Variable) at Different Fertilizer Treatments

Traits Entered to Model	Regression Coefficient	Standard Error	R^2	T	Sig.
1 Constant	954.694	311.501		3.065	0.005
DWSP	224.834	39.136	0.569	5.745	0.000
2 Constant	-355.381	422.863		-0.840	0.409
DWSP	161.188	35.526		4.537	0.000
NPP	129.146	33.609	0.733	3.843	0.001
3 Constant	-2217.67	711.722		-3.116	0.005
DWSP	174.924	30.961		5.650	0.000
NPP	134.754	29.037		4.641	0.000
SWP	121.543	39.893	0.810	3.047	0.006

NOTE: Dependent Variable: SY; SY: Seed yield, DWSP: Seed dry weight, NPP: Number of pod per plant, SWP: 100- seed weight

Table 7: Path Analysis for soybean Yield at Different Fertilizer Treatments

		Indirect effects			
	Direct effect	Number of sub branch	Number of pod per plant	Number of seed per plant	100-seed weight
Number of sub branch	0.271[ns]	-	0.115	0.157	-0.092
Number of pod per plant	0.418[*]	0.178	-	0.286	-0.061
Number of seed per plant	0.290[ns]	-0.099	0.199	-	0.017
100-seed weight	0.158[ns]	-0.052	-0.022	0.008	-
Residual	0.0565				

NOTE: ns, and *: Non-Significant, and Significant at 5%, Respectively

Table 8: The Results of Principal Components on Soybean at Different Fertilizer Treatments

Traits	components	
	1	2
Number of sub branch	0.771	0.007
Number of pod per plant	0.735	-0.141
Number of seed per plant	0.882	0.118
100-seed weight	-0.007	0.971
Pod dry weight	0.629	0.117
Seed dry weight	0.806	-0.272
Total dry weight	0.753	-0.183
Seed yield	0.888	0.085
Eigenvalue	4.326	1.091
Relative variance (%)	54.075	13.636
Cumulative variance (%)	54.075	67.711

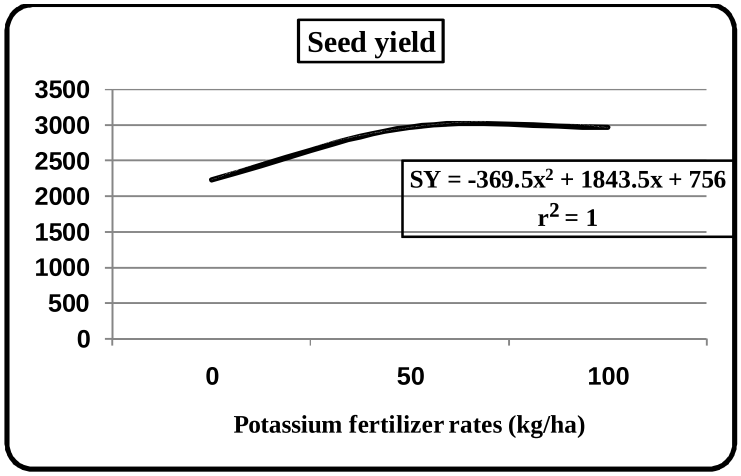

Figure 1: Effect of Different Levels of Potassium Application on Seed Yield of Soybean

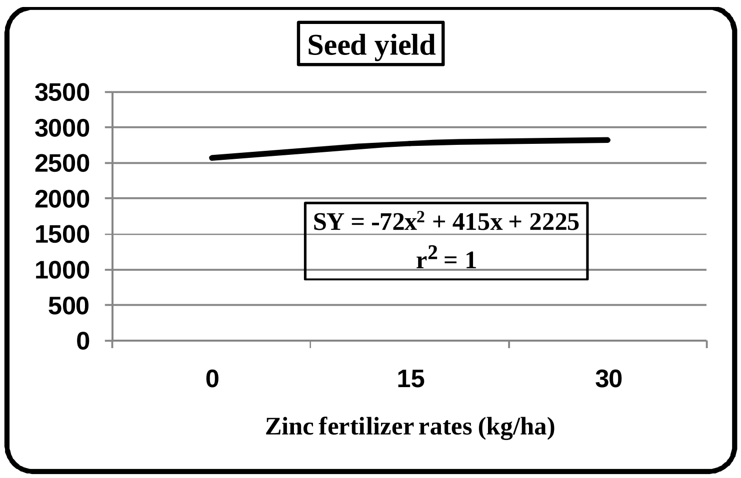

Figure 2: Effect of Different Levels of Zinc Application on Seed Yield of Soybean

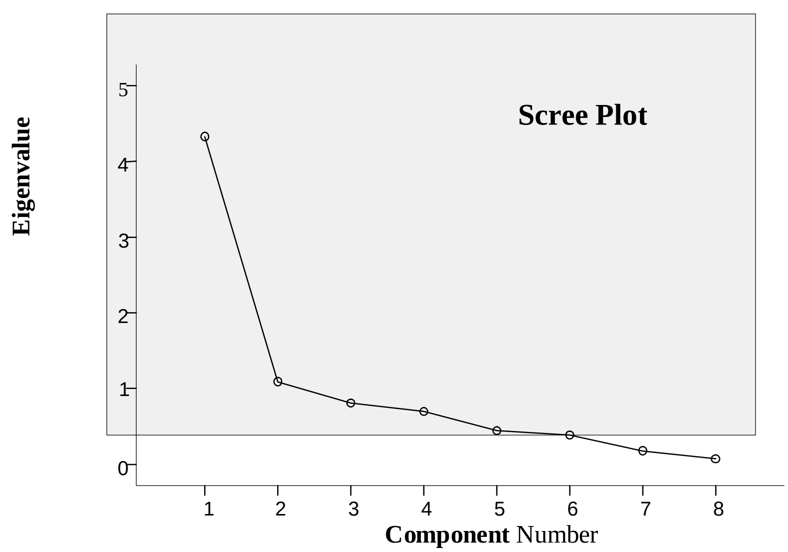

Figure 3: Scree Plot Based on Principal Components Analysis