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The Effects of Zinc Fertilization on Yield and Some Yield Components of Dry Bean (*Phaseolus vulgaris* L.)

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Abstract: This study was conducted to investigate the effects of six zinc doses (0, 15, 20, 25, 30 and 35 kg ha⁻¹) on yield and some yield components of dry bean (*Phaseolus vulgaris* L.) Cv. Şeker in eastern Turkey in the 2001 and 2002 growing seasons. Plant height, number of pods per plant, number of seeds per plant, number of branches per plant, biological yield, grain yield per area, grain yield per plant, harvest index and 1000 seed weight were measured. The highest grain yield per area was obtained with 25 kg ha⁻¹ (3607.0 kg ha⁻¹) and 30 kg ha⁻¹ (2172.0 kg ha⁻¹) zinc application in 2001 and 2002, respectively. On the average of two years, grain yield per area was 2766 kg ha⁻¹ in the plots that received 25 kg ha⁻¹ zinc compared with control (1485 kg ha⁻¹) and other zinc doses. Zinc application of 25 kg ha⁻¹ gave an increase of 1281 kg ha⁻¹ (86.3%) in grain yield per area over the control. It may be concluded that zinc fertilizer should be applied in zinc-deficient soils in order to obtain high grain yield per area from dry bean.

Key words: *Phaseolus vulgaris*, zinc, yield and yield components

INTRODUCTION

Dry bean is one of the most important protein crops in Turkey. It is grown on 175.000 ha and production exceeds 236.000 tones^[1]. However, national yields have been stagnant at 1349 kg ha⁻¹ on average.

Seeds of pulses are the most important protein and mineral food crops in the world, especially developing countries^[2].

Among other production techniques, fertilization with macro and trace nutrition elements is important in order to increase dry bean yield. Of the trace elements, zinc is of the great significance in that it constitutes building blocks of the plant growth hormones responsible for various enzymes and shoots generation. Zinc deficiency in crop plant leads to decreasing tryptophan content and protein synthesis and to accumulation of free aminoacids, consequently resulting in low yields^[3]. One of excessively available essential metal, zinc affects bean growth^[4-6] by alternation of several physiological processes^[7-9]. The high of zinc level singly applied, significantly reduced yield of bean roots^[10].

Studies show that 30% of the arable areas in the world and 50% of the agricultural soils in Turkey suffer from zinc deficiency^[11]. The Van region is among the most severely affected^[12-15]. Zinc deficiency can be alleviated by soil or foliar application. Foliar application may last 4-5 years^[16]. This study was undertaken to investigate the

effects of zinc application on yield and some yield components of dry bean in the Van region in eastern Turkey.

MATERIALS AND METHODS

The effects of six doses of zinc (0, 15, 20, 25, 30 and 35 kg ha⁻¹) on yield and some yield components of dry bean (*Phaseolus vulgaris* L.) Cv. Şeker in eastern Turkey in the 2001-2002 growing seasons. This study was conducted Completely Randomized Block Design with three replications. Sowing was done on lines on 15 May in 2001 and 30 May in 2002 by hand in 2.5x4 m plots (10 m²) in rows, 50 cm apart. The dry bean variety "Şeker" was sown at a rate of 200 kg ha⁻¹. At the sowing, 150 kg ha⁻¹ diamonium phosphate (18% N, 46% P₂O₅) and zinc (Zn₂SO₄ · 7H₂O) (Merc.) were applied. When plants need, permanently irrigated and weed controlled. Harvest was done on 25 September 2001 and 4 October 2002, excluding one row from both sides of each plot and 50 cm from both ends (1.5x3 m = 4.5 m²). Data on grain and biological yields were recorded from the whole plot, but the yield components data were recorded from randomly selected plants in each plot.

Soil samples were analyzed at the laboratories of Erzurum Village Affairs Research Institute (Table 1). The experimental soil was slightly alkaline with zinc content being below the critical level (0.7 ppm)^[17]. Monthly rainfall

Table 1: Chemical and physical analysis of the experimental soils

Soil property	2001	2002
Texture	Sandy-loamy-clay	Sandy-loamy
Organic matter content (%)	2.130	1.410
N (%)	0.020	0.020
Phosphorus content (ppm)	7.640	7.210
Lime content (%)	21.900	20.070
Salt (%)	0.084	0.091
pH	7.710	7.760
Zinc (ppm) *	0.480	0.340

* Available Zn extracted with DTPA^[17]

and maximum, minimum and average temperatures are shown on Table 2^[18].

Data on investigated characters were subjected to analysis of variance and means were separated according to LSD Multiple Range Test at $p < 0.01$.

RESULTS AND DISCUSSION

The analysis of variance showed that zinc application significantly affected all the characters investigated except 1000-seed weight ($p < 0.01$). Year and zinc application interaction was also statistically significant for all studied characters except harvest index and 1000-seed weight.

The highest plant height was obtained from 35 kg ha⁻¹ zinc application as 130 cm in the first year and from 30 kg ha⁻¹ zinc application as 132.3 cm in the second year. The lowest plant height was obtained from control plots in both years. On the average of two years, plant height was higher with 30 kg ha⁻¹ zinc application than in the other doses (Table 3). In some studies it was concluded that the low zinc application caused reductions of internodes length^[19].

Zinc application also significantly affected the number of pods per plant. The highest number of pods per plant was obtained with 25 kg ha⁻¹ zinc fertilization in 2001 (37.9 pods/plant) and 35 kg ha⁻¹ zinc fertilization in 2002 (55.1 pods/plant). On the average of two years, the highest number of pods per plant was obtained from 25 kg ha⁻¹ zinc levels (43.7 pods/plant). But there were non-significant differences between 25 kg ha⁻¹ and 30 (43.1 pods/plant) and 35 kg ha⁻¹ (42.2 pods/plant) zinc levels. MacDonald *et al.*^[20] reported similar results about the number of pods per plant.

The highest average number of seeds per plant was recorded from 30 kg ha⁻¹ zinc level as 138.9 seeds/plant and it is significantly higher than the other zinc levels. Since the number of seeds/plant related to the number of pods/plant, the plots have higher number of pods per plant, which gave the higher seeds/plant (Table 3). It is inevitable and natural results. The average number of branches per plant changed between 3.5 and 5.3 (Table 3). While the highest branches were obtained from 25 kg ha⁻¹

zinc application, control plots gave the lowest number of branches.

The lowest biological yield per unit area was obtained from control plots as 4000 kg ha⁻¹ in 2001. 15 kg ha⁻¹ zinc application increased biological yield approximately 30% compared with control plots (Table 3). The other doses increased biological yield per unit area but this increase didn't occur 15 kg ha⁻¹ Zn application. The highest biological yield per unit area was obtained with 25 kg ha⁻¹ zinc application as 7439 kg ha⁻¹ in 2001. 30 and 35 kg ha⁻¹ zinc application caused reduction in biological yield per unit area. Second year of the study, 25 and 30 kg ha⁻¹ zinc applications significantly increased biological yield but there weren't significantly in differences between control plots and 15- 20 kg ha⁻¹ zinc doses. On the average of two years biological yield per unit area increased with zinc application, clearly. The lowest biological yield per unit area was in recorded control plots as 3980 kg ha⁻¹. The highest biological yield per unit area was obtained with 25 kg ha⁻¹ zinc application as 5890 kg ha⁻¹. According to Karaman *et al.*^[21] 25 kg ha⁻¹ zinc fertilization increased the biological yield of bean. Besides, if the soil had enough zinc level, zinc fertilization didn't effect on the biological yield^[22-24]. There is a difference between the years. It might be due to meteorological changes (Table 2).

Grain yield per area and grain yield per plant were found similar biological yield per unit area. Zinc application increased grain yield per area as compared with control plots in both years. While the highest grain yield per area was obtained from 25 kg ha⁻¹ zinc application in the first year, it was the highest with 30 kg ha⁻¹ zinc application in the second year. It might be due to low zinc content soils of the second year (Table 1). On the average of two years the lowest grain yield per unit area and grain yield per plant were obtained from control plots as 1485 kg ha⁻¹ and 31.5 g, respectively. The highest grain yield per unit area and grain yield per plant were obtained with 25 kg ha⁻¹ zinc application (7666 kg ha⁻¹ and 53.9 g/plant), respectively. On the contrary, the following doses decreased grain yield per unit area and grain yield per plant decreased (Table 3). In other studies, zinc application significantly increased the dry matter yield of bean plant as compared to control treatment and 25 kg ha⁻¹ zinc application increased seed yield and haulm yield^[21,22]. However in some studies, 0-5 kg ha⁻¹ zinc application didn't effect yield of dry bean^[23]. McKenzie *et al.*^[24] concluded that if the soil had enough zinc level, zinc fertilization had not an effect on dry bean yield.

Zinc application also increased harvest index. The average harvest index changed between 37.0 and 49.5%. The highest harvest index was obtained from 30 kg ha⁻¹

Table 2: Meteorological data at the experimental site including vegetation period

Months	2001					2002				
	Max. Temp. (°C)	Min. Temp. (°C)	Average Temp. (°C)	Relative humidity (%)	Rainfall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Average Temp. (°C)	Relative humidity (%)	Rainfall (mm)
March	6.8	-0.7	2.6	51.8	43.5	6.5	-1.7	1.9	60.9	60.7
April	14.1	9.2	4.2	54.2	48.7	10.6	6.6	3.0	63.8	127.8
May	16.4	6.6	11.9	55.7	44.1	17.1	5.8	11.7	54.2	92.1
June	23.4	11.9	9.9	42.6	13.2	24.5	16.8	18.2	47.5	15.7
July	27.8	14.8	13.6	44.5	8.2	28.1	20.7	21.8	48.8	5.6
August	27.2	15.4	13.5	39.5	-	29.1	20.2	22.5	48.3	1.3
September	24.1	11.2	10.4	42.3	1.8	24.8	16.6	19.0	49.5	10.0
October	18.0	5.9	7.3	49.7	70.2	16.8	11.9	11.0	60.5	34.0
November	10.2	1.7	-1.2	49.7	53.8	8.3	2.7	3.7	65.8	42.9
Average/Total	18.2	10.9	11.1	45.4	326.4	18.8	15.3	17.4	58.9	390.1

Source: <http://www.fao.org>Table 3: The effect of zinc ($ZnSO_4 \cdot 7H_2O$) application on yield and some yield components of dry bean in Turkey

Zinc doses (kg ha ⁻¹)	Plant height (cm)	Number of pods/plant	Number of Seeds/plant	Number of branches/plant	Biological yield (kg ha ⁻¹)	Grain yield (kg ha ⁻¹)	Grain yield /plant (g)	Harvest index (%)	1000-seed weight (g)
2001									
0	104.0	26.0	73.5	2.8	4000	1393	28.2	34.9	391.5
15	101.6	26.5	79.7	3.8	6039	2733	32.6	46.2	399.7
20	118.5	35.8	137.3	3.8	6650	3167	55.8	47.6	391.8
25	112.4	37.9	126.7	4.6	7439	3607	66.2	48.5	395.2
30	129.1	31.2	125.9	3.8	5775	2961	44.4	51.3	389.6
35	130.0	36.3	122.2	4.0	6183	2863	46.4	46.6	401.6
LSD (0.01)	10.3	5.2	14.0	0.6	768	88	10.8	6.4	NS
2002									
0	104.8	36.3	89.6	4.1	3960	1577	34.8	39.2	395.0
15	111.9	39.6	100.4	4.6	3764	1642	33.9	43.7	397.7
20	121.3	43.7	118.6	5.2	3892	1738	38.6	44.3	398.3
25	126.8	49.4	129.4	6.0	4340	1925	41.5	45.0	401.6
30	132.3	55.1	151.8	6.2	4759	2172	45.2	47.7	400.0
35	123.8	48.0	119.6	5.4	4363	1899	42.9	43.7	400.3
LSD (0.01)	12.3	5.5	16.5	0.7	583	186	5.1	4.4	NS
Mean (2001-2002)									
0	104.4	31.1	81.5	3.5	3980	1485	31.5	37.0	393.3
15	106.8	33.1	90.1	4.2	4901	2212	33.2	44.9	398.7
20	119.9	39.8	128.0	4.5	5271	2453	47.2	46.0	395.1
25	119.6	43.7	128.0	5.3	5890	2766	53.9	46.8	398.4
30	130.7	43.1	138.9	5.0	5267	2566	44.8	49.5	394.8
35	126.9	42.2	120.9	4.7	5273	2381	44.6	45.1	400.8
LSD (0.01)	6.9	3.2	9.7	0.5	420	91	5.6	3.3	NS
2001	115.9	32.3	110.9	3.8	6014	2796	45.6	45.9	394.9
2002	120.2	45.4	118.2	5.3	4180	1825	39.5	43.9	398.8
LSD (0.01)	4.0	1.9	5.6	0.3	242	53	3.3	1.9	NS

zinc fertilization but significantly differed from between 20 kg ha⁻¹ (46%) and 25 kg ha⁻¹ (46.8%) zinc applications. The lowest harvest index was obtained from control plots with 37% (Table 3).

1000-seed weight not affected by zinc application, changed between 393.3 and 400.8 g (Table 3). While the highest average 1000-seed weight was obtained from 35 kg ha⁻¹ zinc application, there was non-significant differences between other zinc doses. Singh *et al.*^[23] found similar results.

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