THE EFFECT OF PHOSPHORUS AND ZINC DOSES ON YIELD AND YIELD COMPONENTS OF BEANS (*PHASEOLUS VULGARIS* L.) IN VAN-GEVAŞ, TURKEY

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Abstract. This research was carried out in Van-Gevaş in 2015 and 2016 with three replications according to the Divided Parcel Trial Design that was divided into random blocks. The experiment involved 2 bean varieties (Aras-98 and Seker-90) x 4 phosphorus dose (0.0, 40.0, 60.0 and 80.0 kg ha^{-1}) x 4 zinc dose (0.0, 10.0, 25.0 and 50.0 kg ha^{-1}) x 3 repetition = 72 parcels were planned and examined. In the experiment, 4 different phosphorus (P) doses were applied to the subparcels as TSP (P2O5) fertilizer. and to gold sub-parcels 4 different zinc (Zn) doses were applied as zinc sulfate (ZnS04.7H20) fertilizer. Two bean varieties used in the study on the effect of phosphorus and zinc doses on plant height (cm), the number of pods per plant (units of $plant^{-1}$), number of branches ($plant^{-1}$), seed yield (kg ha^{-1}), harvest index (%) and the effect of protein (%) on grain was also investigated. According to the results obtained in 2015 and 2016, the highest grain yield was obtained from Sugar-90 beans. In the first year, the highest grain yield was obtained from 3380.00 kg ha^{-1} and 40.0 kg ha^{-1} phosphorus and 10.0 kg ha^{-1} zinc, while in the second year 4250.70 kg ha^{-1} was obtained in the same phosphorus and zinc dose. As a result, it has been determined that due to degradation in the phosphorus balance in soil, the efficiency of utilization of zinc in plants affects the yield and quality characteristics.
Keywords: *bean, number pods, interaction, grain yield*

Introduction

For many thousands of years, legume grains have had a very important place in human nutrition. In cases where animal proteins cannot be provided in suffiecient amount, the deficiencies are met from these plants (Adak, 2014). These plants are rich in vitamins and also minerals such as iron, phosphorus, calcium and potassium, as well as dietary fibers (Pekşen and Artık, 2005). It form in nutrition programs together with cereals a very good group (McPhee and Muehlbauer, 2002). Especially together with high lysin content, cholesterol rates are very low. In human nutrition, edible grain legumes contain 22% of proteins and 7% of carbohydrates. 18-31.6% of the leguminous protein is an important and inexpensive source for solving nutritional problems in the body (Adak et al., 2010; Altunkaynak, 2018). In terms of cultivation and production in the world, this is an important genus in the family of beans. Dry and fresh consumption is common. Around 29 million hectares of land is cultivated in the world. The total production amount is 23 million tons and the yield per hectare is 8000.00 kg (FAO, 2015). In our country, bean cultivation area is 848 thousand ha, 220 thousand tons production and 2590.00 kg ha^{-1} yield is obtained (TÜİK, 2018).

Cultivation, irrigation, fertilization and harvesting are very important in bean production. Fertilization has an important place in these cultural applications. The fact that they fix the free nitrogen of air due to the rhizobium bacteria found in the roots of

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legumes reduces their need for nitrogenous fertilizers. In this case, in the case of deficiencies such as phosphorus and zinc, it increases the importance of the nutritional elements affecting other yield parameters, in particular efficiency. In terms of legumes, phosphorus is an important macro element. This need must be eliminated by fertilization with sowing (Togay and Anlarsal, 2008). The greatest benefit of phosphorous fertilizers is the increase in the quality of the grain and the availability of nitrogen by increasing nodulation and nitrogenase activity (Arıoğlu, 1989).

Another important plant nutrient is zinc, while various enzymes operating in the plant are the building blocks of some hormones in tissue development, the deficiency of zinc leads to the decrease of tryptophan hormone level and protein synthesis is disrupted. In addition, free amino acid accumulation in plants adversely affects grain quality (Yalçın and Usta, 1990).

The height of elements such as phosphorus and zinc in the soil does not always mean that they will be taken and used by plants. In soil, pH, salinity and the amount of other elements are important factors affecting plants. As a result, deficiencies in plants cause significant reductions in yield and quality (Togay and Anlarsal, 2008).

With this study, it was aimed to determine the effect of phosphorus and zinc fertilizers on yield and yield components of beans grown in our region, and as well as to investigate the interactions between P and Zn micronutrients.

Materials and Methods

The research was conducted in Van-Gevaş District (38.2978° N, 43.1055° E) between the years of 2015-2016 (*Figure 1*). In the experiment, two bean varieties (Aras-98 and Şeker-90) were used as plant material. The varieties are registered at the East Anatolian Agricultural Research Institute are white and coarse in color (Şehriali, 1988). Climate data for the years of research and the average for many years are given in *Table 1*.

Figure 1. *Place of trial (Van-Gevaş)*

The total amount of precipitation during the period from May to September in 2015, when the experiment was conducted, was 43.6 mm. In 2016, it was observed that this amount was more than 2015 with 73.3 mm. The average temperature was 18.5°C in the

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first year. This value was measured as 17.9°C in the second year of the experiment. The average humidity was lower in the first year (42.4%) than in the second year (50.5%).

Table 1. *Experimental climate data**

	2015 year					2016 year				
Months	Temperature (°C)			Cover. Moisture (%)	Rains (mm)	Temperature (°C)			Cover. Moisture (%)	Rains (mm)
	Min	Max	Avg.			Min	Max	Ave.		
May	8.6	27.5	14.4	54.7	31.6	6.5	24.3	13.6	62.3	48.7
June	13.0	34.1	18.1	39.0	11.2	12.0	34.5	18.0	56.0	15.0
July	18.0	37.9	21.7	39.2	-	17.3	37.2	20.7	46.7	3.2
August	17.1	36.4	21.5	38.7	0.8	17.5	35.9	21.1	42.0	1.8
September	13.8	32.0	16.9	40.4	-	13.4	30.4	16.2	45.3	4.6
Average	14.1	33.6	18.5	42.4	-	13.3	32.5	17.9	50.5	-
Total					43.6					73.3

* Van Regional Directorate of Meteorology Records, 2017

Soil samples were taken from the 0-20 cm depth of the soils belonging to the experimental site and analyzed physically and chemically (*Table 2*).

Table 2. *Some chemical properties of experimental soils at a depth of 0-30 cm**

Years	Texture	Total Salt	pH	Calcanty	Available K (K_2O)	Available P (P_2O_5)	Organic matter	Available Zn
		(%)		(%)	(kg da^{-1})	(kg da^{-1})	(%)	(kg da^{-1})
2015	Sandy-Loam-Clay	0.044	7.6	8.06	51.3	2.76	2.32	0.286(Poor)
2016	Sandy-Loam-Clay	0.039	7.5	8.72	42.0	3.58	2.57	0.311(Poor)

*Van Commodity Exchange was conducted in soil analysis laboratories, 2015

The experimental soils are slightly alkaline and the organic matter levels are moderate. It was found that the soil was low in lime, poor in phosphorus and zinc and rich in potassium.

The research was established according to the experimental design of Divided Parcels Divided into Randomized Blocks with 3 replications. The trial area, which was driven deeply in the last spring, was completed in April with a second surface version and disc harrow. Seed planting was carried out in the first week of May, in 5 rows per parcel. The distance between the rows in the parcels was 40 cm. The area of a parcel was 2.0 m x 4.0 m = 8 m². In the study, the varieties in the main parcels were Aras-98 and Seker-90, phosphorus (18-19% P_2O_5) doses in sub-parcels and zinc (Zn) sulphate doses ($ZnS0_4.7H_20$) were applied to the six parcels in the same test design. The amount of seed to be taken into the parcel was determined to be 45 seeds per m^2 21% Ammonium Sulphate $(NH4)_2SO_4$ fertilizer was placed in the soil with 20.00 kg of pure nitrogen per hectare evenly to each parcel. Trial parcels; 1 The first foliation period, 2 with branching, 1 before flowering, 1 flowering period, and 1 bean binding period in including was irrigated 6 times in total. (Engin, 1989). In this study, the effect of increasing Zinc (Zn) and Phosphorus (P) doses on plant height, number of pods per plant, grain yield, harvest index (Harvest index = Grain / Plant stalk ratio), thousand seed weight and protein ratio in two bean varieties were investigated. In the study, two bean varieties were treated in 4 different doses (0.0, 10.0, 25.0, 50.0 kg ha^{-1}) in the form of Zinc $ZnSO_4.7H_2O$ and in 4 different doses (0.0 (control), 40.0, 60.0, 80.0, kg ha^{-1}) in the form of phosphorus P_2O_5. Each row of 5 parcels on each side of each row and 50 cm within the row of plants in the row

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as the edge of the effect was excluded from the observation (Ceylan and Sepetoğlu, 1979). All observations were made on an area of 1.2 m x 3 m = 3.6 m². The data obtained after trial in terms of yield and yield components were used in determining the differences of split parcel design with the variance analysis method. In the determination of different groups Duncan (5%) multiple comparison test was utilized with Costata and Mstatc software (Düzgüneş et al., 1987).

Results

Plant Height (cm)

According to the data obtained at the end of the research in 2015, the interactions of year, variety, phosphorus, zinc doses, variety x phosphorus, variety x zinc, variety x phosphorus and variety x phosphorus x zinc doses were significant and phosphorus x zinc interactions were not statistically significant. In 2016, other differences between plant height averages were significant (*Table 3*).

Table 3. *Bean varieties in the groups and averages related to the height of the plant**

		2015 Zn Doses						2016 Zn Doses					
Variety	P Dose	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.
Ç1	P0	42.90qr	47.13l	41.68s	49.12ij	45.20D		61.29	65.89	63.05	67.24	64.36A	
	P1	43.78pq	45.00no	52.04g	47.27kl	47.02C		60.56	66.12	66.47	65.74	64.71A	
	P2	45.90mn	55.50bc	52.79fg	44.78op	49.74B	46.68B	70.96	76.93	64.47	69.76	70.53A	65.12A
	P3	42.02rs	46.64lm	45.40no	45.02no	44.77D		60.40	57.80	63.69	61.58	60.86B	
ÇxZn Ave.		43.65B	48.57A	47.98A	46.54A			63.30AB	66.68A	64.42A	66.08A		
	P Dose	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.
Ç2	P0	53.10ef	58.28a	54.05de	50.88h	50.07B		55.57	57.24	53.08	58.77	56.16B	
	P1	48.85j	50.97h	48.32jk	50.03jk	49.54B		52.86	54.95	58.88	59.94	56.66B	
	P2	52.45fg	54.86cd	56.22b	54.98cd	54.62A	50.93A	66.46	65.70	62.33	65.95	65.11A	60.04B
	P3	52.90fg	52.17fg	42.87qr	50.02hi	49.49B		69.72	54.53	59.94	64.79	62.24AB	
ÇxZn Ave.		51.82B	54.07A	50.36C	51.48B			61.15B	58.10B	58.56B	62.36A		
Zn Ave.		47.73B	51.32A	49.17A	49.01A			60.26C	60.69BC	62.05B	67.82A		
Yıl Ave.		48.80B						62.58A					
	P Dose	Zn0	Zn1	Zn2	Zn3	P Ave.		Zn0	Zn1	Zn2	Zn3	P Ave.	
P x Zn	P0	48.00	52.70	47.86	50.00	49.64A		58.43j	61.56gh	58.06j	63.00e	60.26B	
	P1	46.31	47.98	50.18	48.65	48.28B		56.71k	60.53i	62.67ef	62.84e	60.68B	
	P2	49.17	55.18	54.50	49.88	52.18A		68.71b	71.31a	63.40e	67.85bc	67.81A	
	P3	47.46	49.40	44.13	47.52	47.12B		65.06d	56.16k	61.81fg	63.18e	61.55B	
C.V (%)		5.29						4.14					

*The difference between the averages indicated with the same letters is not significant at 5%; C.V- Coefficient of variation. Zn- Zinc Dose; Ç1- Aras-98; Ç2-Sugar-90; P-Phosphorus doses; Ave.- Average; Z x Zn- Variety x Zinc Dose Interaction; P x Zn- Phosphorus x Zinc Doses Interaction

According to the data obtained at the end of the experiment; In 2015 and 2016, the average plant height was 46.68-65.12 cm with Aras-98 cultivar, while the Sugar-90 variety was higher with 50.93- 60.04 cm. The plant height values obtained from the Seker-90 variety in both years of the experiment were found to be higher than that of the Aras-98 variety (*Table 3*).

According to the data obtained, average plant height values obtained from different phosphorus doses ranged from 54.62-44.77 cm in 2015 and from 70.53-56.16 cm in 2016. In

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the first year of the experiment, the highest plant height (54.62 cm) was obtained in Sugar-90 from 60 kg ha^{-1} phosphorus dose. The lowest plant height value was determined at a dose of 0 (control) applied to Aras-98 cultivar with 45.20 cm. In 2016, the plant height average values ranged from 56.16 to 70.53 cm. The highest plant height values (70.53 cm) were obtained from 60.00 kg ha^{-1} phosphorus dose applied to Aras-98 cultivar, 56.16 cm with the lowest value was obtained from parcels belonging to sugar-90 cultivar of not phosphorous.

As shown in *Table 2*, plant height average values obtained from different zinc doses changed between 51.32-47.73 cm in 2015 and 67.82-60.26 cm in 2016. In the first year of the experiment, the highest plant height value was obtained from Sugar-90 varieties with 54.07 cm and 25.00 kg ha^{-1} zinc. The lowest value was determined in Aras-98 cultivar, which does not apply zinc dose, which is measured as 43.65 cm.

The highest plant height (56.22 cm) value in the first year in terms of zinc x phosphorus doses applied in the research; It was obtained from 25.00 kg ha^{-1} zinc x 60.00 kg ha^{-1} phosphorus dose applied to Sugar-90 bean variety, and the lowest value was obtained from the P3 phosphorus dose and non-zinc parcels with 42.02 cm (*Table 3*).

Number of Pods (number / plant)

As seen in *Table 4*, there were differences in the number of pods in the experiment. In the first year of the experiment on the average number of pods; Interactions between year, variety, zinc doses, type x phosphorus and phosphorus x zinc dose interactions were significant, some x phosphorus x zinc doses were considered statistically insignificant. In the second year of the experiment, cultivar, zinc, phosphorus, Zn x P, Ç x Zn and Ç x Zn x P interactions were found statistically significant.

Table 4. *Averages and formed groups on number of pods in bean varieties**

		2015 Zn Doses						2016 Zn Doses					
Variety	P Dose	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.
Ç1	P0	7.38	9.31	10.30	10.64	9.40BC		10.46o	12.53klm	13.18ijk	14.04gh	12.55	
	P1	9.20	10.85	11.22	11.70	10.74A		12.66jkl	15.21de	13.34hij	12.00lmn	13.30	
	P2	9.11	10.75	12.87	10.48	10.80A	10.23A	15.61cd	16.58b	16.02bc	15.55cd	15.94	14.35A
	P3	8.18	12.19	10.27	9.26	9.97AB		13.88ghi	15.19de	18.04a	15.45cde	15.64	
ÇxZn Ave.		8.46	10.77	11.16	10.52			13.15D	14.87AB	15.14A	14.26BC		
	P Dose	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.	Zn0	Zn1	Zn2	Zn3	Ç x P.Ave.	Ç. Ave.
Ç2	P0	7.28	9.32	8.81	7.94	8.11D		9.37p	8.09q	10.45o	10.33o	9.56	
	P1	7.75	9.59	10.39	10.19	9.48BC		11.77n	10.70o	14.36fg	12.64jkl	12.36	
	P2	8.16	11.11	8.66	8.30	9.05CD	8.75B	11.64n	14.83ef	15.25de	11.80mn	13.38	12.48B
	P3	6.94	10.57	7.06	7.88	8.15D		11.85mn	16.31b	15.42cde	14.96def	14.63	
ÇxZn Ave.		7.53	10.14	8.73	8.57			11.15E	12.48E	13.87C	12.43D		
Zn Ave.		7.99C	10.45A	9.94A	9.54B			12.15C	13.67B	14.50A	13.34B		
Yıl Ave.		9.48B						13.41A					
	P Dose	Zn0	Zn1	Zn2	Zn3	P Ave.		Zn0	Zn1	Zn2	Zn3	P Ave.	
P x Zn	P0	7.33g	9.31cd	9.55bc	9.29cd	8.87B		9.91h	10.31h	11.81g	12.18fg	11.05C	
	P1	8.47def	10.22ab	11.05a	10.94a	10.17A		12.21efg	12.95de	13.85c	12.32efg	12.83B	
	P2	8.63def	10.93a	10.76a	9.39bcd	9.92AB		13.62cd	15.70b	15.63b	13.67c	14.65A	
	P3	7.70fg	10.45a	8.66cde	8.57def	8.84B		12.86f	15.75b	16.73a	15.20b	15.13A	
C.V (%)		10.36						6.93					

*The difference between the averages indicated with the same letters is not significant at 5%; C.V- Coefficient of variation. Zn- Zinc Dose; Ç1- Aras-98; Ç2-Sugar-90; P-Phosphorus doses; Ave.- Average; Z x Zn- Variety x Zinc Dose Interaction; P x Zn- Phosphorus x Zinc Doses Interaction

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The average number of pods obtained at the end of the study was 9.48 in the first year and 13.41 in the second year. According to the results, the average number of pods per year was determined to be 10.21-14.35 in Seker-98 cultivar and 8.75-12.45 in Sugar-90 cultivar, respectively (*Table 4*). According to the data obtained, the interaction of the first year varieties x phosphorus doses on the average number of pods was statistically significant and the second year was insignificant. The highest number of pods was obtained from Aras-98 bean varieties with 10.8 pieces at 60.0 kg ha^{-1} phosphorus dose, while the lowest value was obtained from 00.0 kg ha^{-1} phosphorus dose in Sugar-90 cultivar with 8.11 pieces. According to these results, it was seen that increased phosphorus doses increased the number of pods in the plant up to a certain point. According to the data obtained at the end of the study, it was observed that the correlation was statistically significant on the average number of pods per day. The highest number of pods was obtained from 10.00 kg ha^{-1} zinc and 40.00 kg ha^{-1} phosphorus application per decare with 11.05 pcs in the first year. The lowest value was obtained with 0.33 doses of both fertilizer doses. The highest number of pods obtained in the second year of the experiment was obtained from 16.73 number pods of 60.00 kg ha^{-1} phosphorus and 10.00 kg ha^{-1} zinc dose. The lowest value was found in 9 doses with 9.91 pieces (*Table 4*). According to the data obtained in the second year of the experiment, the interactions between the number of phosphorus x zinc doses considering the average number of pods were statistically significant and the first year was insignificant. The highest average number of pods was 18.04 and was obtained from 60.00 kg ha^{-1} phosphorus and 10.00 kg ha^{-1} zinc dose applied to Aras-98 bean cultivar. The lowest value was measured in the control parcel with Sugar-90 cultivar with 9.37 units (*Table 4*).

Number of Branches (pieces / plant)

In the study carried out in 2015-16 years, year, variety, phosphorus doses, variety x phosphorus doses and phosphorus x zinc doses interactions were found statistically significant considering the average number of branches in bean varieties in the first year. In the second year of the experiment, the effect of varieties on the average number of pods was found statistically significant (*Table 5*).

According to the results obtained in the experiment, the average number of branches in the first year was 4.33 and in the second year it was 5.24. The number of branches among the varieties were obtained from Aras-98 variety with 4.78-5.78 units, respectively. Sugar-90 varieties (3.88-4.70) branching was detected in a lower number (*Table 5*).

According to the results obtained, the first year on the number of branches was statistically significant and the second year was insignificant. According to the results obtained from the experiment, the highest average number of branches was obtained from the 40.00 kg ha^{-1} phosphorus dose applied to the Aras-98 variety. The lowest value was obtained from the control (0 dose) of Sugar-90 variety with 3.59.

As seen in *Table 5*, the effect of P x Zn interaction on the average number of branches was found significant ($p<0.01$). The highest average number of branches was obtained from 4.67 pieces and 40.00 kg ha^{-1} phosphorus x10.00 kg ha^{-1} zinc dose. The lowest value (3.89) was measured in the application of 60.00 kg ha^{-1} phosphorus x 25.00 kg ha^{-1} zinc dose.

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Table 5. *Groups and averages of the number of branches in bean varieties**

		2015 Zn Doses						2016 Zn Doses					
Variety	P Dose	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.
Ç1	P0	4.41	4.58	4.74	4.54	4.56B		5.77	5.53	5.76	5.41	5.62	
	P1	4.59	4.87	4.76	4.43	4.66AB	4.78A	5.45	5.67	5.94	5.65	5.67	
	P2	4.89	5.20	4.98	4.66	4.93A		6.06	5.77	5.79	5.72	5.83	5.78A
	P3	4.78	4.98	5.12	4.40	4.82AB		6.03	6.03	6.23	5.82	6.02	
ÇxZn Ave.		4.66	4.90	4.90	4.50			5.81	5.75	5.93	5.65		
	P Dose	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.
Ç2	P0	3.66	3.29	3.95	3.48	3.59D		4.55	4.06	4.56	4.49	4.41	
	P1	3.93	3.64	3.74	3.74	3.76CD		4.70	4.98	4.88	4.60	4.79	
	P2	4.08	4.15	3.98	3.92	4.03B	3.88B	4.84	5.11	5.06	4.73	4.93	4.70B
	P3	3.70	3.74	3.96	3.39	3.70CD		4.60	4.58	5.01	4.56	4.68	
ÇxZn Ave.		3.84	3.70	3.90	3.63			4.67	4.68	4.87	4.59		
Zn Ave.		4.25	4.30	4.40	4.06			5.24	5.21	5.40	5.12		
Yıl Ave.		4.33B						5.24 A					
	P Dose	Zn0	Zn1	Zn2	Zn3	P Ave.		Zn0	Zn1	Zn2	Zn3	P Ave.	
P x Zn	P0	4.03defg	3.93fg	4.34bcd	4.01efg	4.07B		5.16	4.79	5.16	4.95	5.01	
	P1	4.26bcde	4.25bcdef	4.25bcdef	4.08cdef	4.21AB		5.07	5.32	5.41	5.12	5.23	
	P2	4.48ab	4.67a	4.48ab	4.29bcde	4.48A		5.45	5.44	5.42	5.22	5.38	
	P3	4.24bcdef	4.36bc	4.51ab	3.89g	4.25AB		5.31	5.30	5.62	5.19	5.35	
C.V (%)		5.36						6.42					

*The difference between the averages indicated with the same letters is not significant at 5%; C.V- Coefficient of variation. Zn- Zinc Dose; Ç1- Aras-98; Ç2-Sugar-90; P-Phosphorus doses; Ave.- Average; Z x Zn- Variety x Zinc Dose Interaction; P x Zn- Phosphorus x Zinc Doses Interaction

Harvest Index (%)

In the study conducted between 2015-16 years; It was statistically determined that other factors other than the varieties on the harvest index of zinc x phosphorus fertilizer application were insignificant (*Table 6*).

According to the results obtained in the study, the harvest index was found to be 41.89-41.91% in the Aras-98 variety and 45.67-46.18 % in the Ç2 (Şeker-90). In this study; phosphorus and zinc fertilizer doses were not found to be very effective on the harvest index. Harvest index = Grain / Plant stalk ratio is calculated with the formula.

Grain Yield (kg ha^{-1})

In 2015 and 2016, the effect on average grain yield of different phosphorus and zinc doses in dry bean varieties year, variety, phosphorus, zinc, variety x phosphorus, variety x zinc, phosphorus x zinc and cultivar x phosphorus x zinc interactions were found statistically significant (*Table 7*). The mean grain yields obtained at the end of the experiment were 2320.71 kg ha^{-1} in the first year and 2518.90 kg ha^{-1} in the second year.

According to the data, the average grain yield of Aras-98 bean varieties was 1449.80-2174.40 kg ha^{-1} in years, and in Sugar-90 variety 2308.70-2863.00 kg ha^{-1} (Das et al., 2005) in the study carried out in Erzurum. The yield of Yakutiye-98 and Aras-98 varieties were determined as 1842.00 and 1944.00 kg ha^{-1}, respectively. The effect of

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phosphorous fertilizer on average grain yield in beans was found statistically significant. The highest grain yield in both years of the experiment was obtained from a dose of 60.00 kg ha^{-1} phosphorus in Sugar-90 cultivar with 2465.10-3468.50 kg ha^{-1}, respectively. The lowest value is determined as 1209.80-2000.00 kg ha^{-1} in parcels with no fertilizer (*Table 7*). In parallel with the increasing phosphorus doses, the average grain yield of the varieties was increased up to 60.00 kg ha^{-1} phosphorus dose and the yields of grain decreased.

Table 6. *Groups and averages of harvest index in bean varieties**

		2015 Zn Doses						2016 Zn Doses					
Variety	P Dose	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.	Zn0	Zn1	Zn2	Zn3	Ç x P.Ave.	Ç. Ave.
Ç1	P0	40.56	43.06	42.11	41.81	42.17		39.38	38.38	41.89	41.80	40.36	
	P1	41.64	43.16	44.84	40.39	42.74		38.96	44.49	41.55	41.73	41.68	
	P2	42.49	40.24	41.92	39.17	42.55	41.89B	40.18	43.15	40.37	41.08	41.19	41.19B
	P3	43.98	44.50	41.34	39.42	40.20		40.41	41.25	40.63	42.66	41.23	
ÇxZn Ave.		42.17	42.74	42.55	40.20			39.73	41.81	41.11	41.81		
	P Dose	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.	Zn0	Zn1	Zn2	Zn3	Ç x P.Ave.	Ç. Ave.
Ç2	P0	41.42	46.17	48.01	47.31	43.12		44.71	45.87	47.47	43.81	45.46	
	P1	43.31	48.18	47.73	48.39	47.43		44.88	46.40	49.69	45.23	46.55	
	P2	48.34	47.63	44.78	42.30	46.47	45.67A	42.92	47.87	48.27	49.45	47.20	46.18A
	P3	47.74	45.34	47.02	43.25	45.31		45.45	45.89	45.16	45.88	45.59	
ÇxZn Ave.		45.20	46.83	46.89	45.31			44.49	46.50	47.65	46.09		
Zn Ave.		43.68	44.78	44.72	42.75			42.11	41.16	44.37	43.95		
Yıl Ave.		43.79						43.65					
	P Dose	Zn0	Zn1	Zn2	Zn3	P Ave.		Zn0	Zn1	Zn2	Zn3	P Ave.	
P x Zn	P0	40.99	44.62	45.06	44.56	43.80		42.04	42.12	44.68	42.80	43.91	
	P1	42.48	45.67	46.29	44.39	44.70		41.92	45.44	45.62	43.48	44.11	
	P2	45.42	43.94	43.35	40.74	43.36		41.55	45.51	44.32	45.26	44.16	
	P3	45.86	44.92	44.18	41.34	44.07		42.93	43.57	42.89	44.27	43.41	
C.V (%)		5.32						4.91					

*The difference between the averages indicated with the same letters is not significant at 5%. ; C.V- Coefficient of variation. Zn- Zinc Dose; Ç1- Aras-98; Ç2-Sugar-90; P-Phosphorus doses; Ave.- Average; Z x Zn- Variety x Zinc Dose Interaction; P x Zn- Phosphorus x Zinc Doses Interaction

As shown in *Table 7*, the effect of zinc doses on average grain yields in bean varieties was found significant. The highest grain yields obtained from the experiment were obtained from the application of 2340.00-4416.60 kg ha^{-1} and 25.00 kg ha^{-1} zinc dose in Sugar-90 bean cultivar by years. The highest grain yields obtained from the experiment were obtained from the application of 2340.00-4416.60 kg ha^{-1} and 25.00 kg ha^{-1} zinc dose in Sugar-90 bean cultivar by years.

The effect of phosphorus and zinc on the average grain yield in beans was found significant ($p<0.01$). The highest average grain yield was obtained in 2548.80-3304.80 kg ha^{-1} and 60 kg ha^{-1} phosphorus and 25.00 kg ha^{-1} zinc in both years of the experiment. The lowest value was obtained from the fertilizer-free parcels with 1425.50 kg ha^{-1} in the first year and from the parcel applied 40.00 kg ha^{-1} phosphorus in the second year (*Table 7*).

The effect of phosphorus and zinc fertilizer doses on mean grain evolution was found statistically significant. The highest average grain yield was obtained from the Sugar-90

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cultivar in both years of the experiment with 3380.00-4257.00 kg ha^{-1} and 40.00 kg ha-1 phosphorus (P2) x 10.00 kg ha^{-1} zinc (Zn) respectively, the lowest values were 1014.50-1484.70 kg ha^{-1} Aras-98 cultivars were obtained from fertilizer applications (*Table 7*).

Table 7. *Groups and averages of grain yield in bean varieties**

		2015						2016					
		Zn Doses						Zn Doses					
Variety	P Dose	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.
Ç1	P0	101.45w	127.49j	128.00j	127.00j	120.98E		148.47z	229.98s	167.22z	255.70n	200.34CD	
	P1	138.34s	145.76h	146.76gh	147.76gh	144.65CD		203.70x	242.42p	215.04v	222.68u	220.96C	
	P2	148.22qh	167.50e	171.77n	169.70e	164.31C	144.98B	212.70v	229.30st	235.26r	193.96y	217.80C	217.44B
	P3	139.33i	151.20f	156.40f	153.00f	149.98CD		251.66o	227.06t	238.32q	206.34w	230.84BC	
Ç x Zn Ave.		131.84C	147.98B	150.73A	149.38B			204.13E	232.19 D	213.96D	219.67D		
	P Dose	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.
Ç2	P0	127.49j	127.20j	318.58c	318.20c	222.86B		286.59k	305.47h	352.90c	239.62q	221.14BC	
	P1	146.76gh	146.00h	336.48a	336.40a	241.60A		192.63y	320.40e	326.07d	278.23m	279.33B	
	P2	150.25fg	169.77e	338.00a	328.03b	246.51A	230.87A	307.63g	370.79b	425.70a	283.30l	346.85A	286.30A
	P3	135.20i	151.20f	282.75d	281.00d	212.53B		284.14l	314.06f	301.97i	291.39j	297.89AB	
Ç x Zn Ave.		139.92B	148.54B	318.95A	315.90A			267.74C	327.68B	351.66A	273.13C		
Zn Ave.		135.88C	148.26B	234.84A	232.64A			235.93C	279.93A	282.81A	246.40B		
Year Ave.		232.71 B						251.89 A					
	P Dose	Zn0	Zn1	Zn2	Zn3	P Ave.		Zn0	Zn1	Zn2	Zn3	P Ave.	
P x Zn	P0	114.47m	127.34l	223.29d	222.60de	171.92C		217.53j	267.72e	260.06e	247.66h	248.24B	
	P1	142.55j	145.88ij	241.62c	242.08c	193.03A		198.16k	281.41c	270.55d	250.45g	250.14B	
	P2	149.23hi	168.63g	254.88a	248.86b	205.40A		260.16f	300.04b	330.48a	238.63i	282.32A	
	P3	137.26k	151.20h	219.57ef	217.00f	181.25B		267.90e	270.56d	270.14d	248.86gh	264.36B	
C.V (%)		7.01						4.83					

*The difference between the averages indicated with the same letters is not significant at 5%; C.V- Coefficient of variation. Zn- Zinc Dose; Ç1- Aras-98; Ç2-Sugar-90; P-Phosphorus doses; Ave.- Average; Z x Zn- Variety x Zinc Dose Interaction; P x Zn- Phosphorus x Zinc Doses Interaction

Crude Protein Content (%)

At the end of the study, it was found that the effects of type x zinc and phosphorus x zinc doses on the crude protein content were statistically significant. As of years, the protein ratio was obtained from Seker-90 variety with 22.48-12.08%, respectively. Lower crude protein ratios were obtained from Aras-98 variety (22.45-22.04%) (*Table 8*).

The effect of different zinc doses on average crude protein ratios was found statistically significant in every two years when seen in *Table 8*. The highest crude protein content (24.20-23.96%) was obtained from Sugar-90 bean cultivars of 25.00 kg ha^{-1} zinc fertilizer while the lowest values (20.95-21.79%) were obtained from the fertilizer application of the same type.

The effect of phosphorus doses on the average crude protein ratio was found significant ($p < 0.01$). The highest values were obtained from 23.56 to 23.26% crude protein ratios and 60.00 kg ha^{-1} phosphorus dose in 2015-2016. The lowest value was

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found in the first year without fertilizer with a rate of 21.23% and with a rate of 80.00 kg ha^{-1} phosphorus with 21.98% in the second year (*Table 8*).

Table 8. *Groups and averages of crude protein ratios in bean varieties**

		2015 Zn Doses						2016 Zn Doses					
Variety	P Dose	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.
Ç1	P0	21.05	20.33	21.75	20.74	20.97		21.22	21.77	21.66	21.22	21.46	
	P1	21.92	23.00	23.55	21.70	22.54		22.92	23.43	24.24	23.23	23.45	
	P2	23.10	24.19	24.71	23.47	23.86	22.45A	22.14	22.24	22.98	22.06	22.35	22.04B
	P3	21.89	22.47	23.45	22.45	22.56		20.90	21.77	21.10	19.84	20.90	
Ç x Zn Ave.		21.99C	22.49B	23.36A	22.09B			21.79B	22.30B	22.49B	21.58BC		
	P Dose	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.	Zn0	Zn1	Zn2	Zn3	Ç x P. Ave.	Ç. Ave.
Ç2	P0	20.07	20.99	23.66	21.32	21.51		20.85	23.93	24.62	23.38	23.19	
	P1	20.94	21.87	24.54	22.20	22.38		20.80	23.55	24.57	23.37	23.07	
	P2	21.32	23.25	24.93	23.25	23.18	22.48	20.59	23.33	24.35	23.75	23.00	23.08A
	P3	21.48	23.40	23.67	22.81	22.84		22.91	23.60	22.33	23.45	23.07	
Ç x Zn Ave..		20.95C	22.37B	24.20A	22.39B			21.28C	23.60AB	23.96A	23.48B		
Zn Ave.		21.47	22.43	23.78	22.42			21.53BC	22.95AB	23.22A	22.53C		
Year Ave.		22.46						22.56					
	P Dose	Zn0	Zn1	Zn2	Zn3	P Ave.		Zn0	Zn1	Zn2	Zn3	P Ave.	
P x Zn	P0	20.56	20.66	22.70	21.03	21.23B		21.03	22.85	23.14	22.30	22.33B	
	P1	21.43	22.43	24.04	21.95	22.46AB		21.86	23.49	24.40	23.30	23.26A	
	P2	22.21	23.72	24.82	23.36	23.52A		21.36	22.78	23.66	22.90	22.67B	
	P3	21.68	22.93	23.56	22.63	22.70A		21.90	22.68	21.71	21.64	21.98C	
C.V (%)		5.43						5.16					

*The difference between the averages indicated with the same letters is not significant at 5%; C.V- Coefficient of variation. Zn- Zinc Dose; Ç1- Aras-98; Ç2-Sugar-90; P-Phosphorus doses; Ave.- Average; Z x Zn- Variety x Zinc Dose Interaction; P x Zn- Phosphorus x Zinc Doses Interaction

Discussion

These results of plant height values in the second year were significantly higher than the first year. In the first trial year, due to lack of precipitation, the decrease in the plant output and the decrease in the time between the output and the maturation caused the plant height values to decrease. This difference is thought to be caused by the climate in terms of plant height values (Elkoca and Kantar, 2003). This difference between years is thought to be due to the effect of climate factors as well as phosphorus fertilizer applied. It is stated that phosphorus, like nitrogen, increases the root, stem length, seed production, seed quality and resistance to diseases (Marschner, 1995; Hussein and Alva, 2014). Many research studies (Shrotriya, 1998; Bokhtiar and Sakurai, 2005; Pholsen and Sormsungnoen, 2005; Bayu et al., 2006; Barros et al., 2007; Alatürk, 2012) on fertilization obtained similar results as this study. In similar studies, increased fertilization of leguminous crops indicated that zinc fertilization increased plant height (Sing and Saxena, 1986; Togay and Anlarsal, 2008). In the second year of the experiment, the interaction effect between doses was statistically insignificant. In similar studies Tisdale and Nelson (1966), reported that phosphorous fertilizers added to phosphorous-rich soils make it difficult for the plants to uptake other nutrients, especially zinc, resulting in zinc deficiency in the plants grown in these parcels.

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Similarly, Bayraktar (1966) also stated that when excess phosphorus is present in the soil or when more phosphorus is supplied to the plant, excess phosphorus prevents the extraction of 67 micro elements such as zinc and iron.

In a similar study conducted by Elkoca and Kantar (2004), the number of pods ranged from 3.5-4.2, indicating that this feature showed a wide variation according to the types and lines. Legumes in plants are the most effective group of phosphorus in the soil (Altın et al., 2005; Batıca et al., 2017). Turunko and Mohammed (2014), in Ethiopia's Arbe Minch agricultural enterprise using Red Wolaita varieties; 5 different doses of phosphorus (00.00, 10.00, 20.00, 30.00, 40.00 kg ha^{-1}) growth, dry matter and yield components were investigated. As a result, the most suitable phosphorus fertilizer dose was 20.00 kg ha^{-1}. In another similar study, it was noted that the leaf area of beans increased significantly with the increase of phosphorus dose from 25.00 kg ha-^{1} to 75.00 kg ha^{-1} (Veeresh, 2003). According to these results, increasing doses of phosphorus in low zinc doses caused increases in the number of pods up to a certain point. Lonergan et al. (1982) obtained higher yields than plants in low Zn and high P conditions. In contrast, an antagonist effect also occured, resulting in reduced yields (Ozanne, 1980). As the reason for these results; Besides to the environment and genotype, high doses of phosphorous fertilizers are thought to result in yield losses due to reduced zinc uptake (Ozanne, 1980).

Unlike nitrogenous fertilizers, the effect of phosphorus fertilizers remains limited on the number of branches depending on the environment and genetic structure. It is thought that this difference in average number of branches due to years is due to insufficient quantity and distribution of rainfall in the first year as well as genetic factors (Elkoca and Kantar, 2003). Like the number of pods, the number of branches also show a very wide variation depending on the variety and lines (Elkoca and Kantar, 2004). In spite of increasing doses of phosphorus, it is thought that zinc use efficiency and number of branches decrease (Ozanne, 1980).

In the studies conducted by some researchers, it has been observed that these effects vary widely. It is thought that this difference is caused by environment, genotype and cultural practices. Gangwar and Singh (1986) showed in their study, that the rate of harvest index of zinc fertilizers increased the maximum rate of foliar applied fertilizers. Azad et al. (1993), reported that zinc fertilizers increased the rate of harvest index up to a certain dose and then decreased. In this study, it is observed that zinc fertilizer increased the ratio of harvest index by 15.00 and 30.00 kg ha^{-1} and then it started to decrease.

Climate factors are undoubtedly the most important factors in determining the fate of agricultural production. It is thought that this difference between years is mainly due to the fact that the precipitation amount (43.6 mm) and distribution in the first year is lower and insufficient compared to the second year (73.33 mm) (*Table 1*). The balance of soil water in beans is very sensitive to flowering period. Fluctuations in this period are reported to cause 20% yield losses in yields (Elkoca and Kantar, 2003). In the second year fertilizer doses were used more effectively with rainfall in the development periods of the plant. In the first year, the average temperature were recorded higher than in the second year, especially in flowering and pollination periods of the plant in other developmental according to the periods.

The grain yield in beans is dependent on other genetic-based variations, particularly earliness in various environmental conditions (Dreyer and Wielpütz, 1998). Similar studies have shown that phosphorus promotes flowering and pod formation in the plant

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(Araújo et al., 2000). In the experiment, it can be said that the difference between the first year and the second year zinc doses was due to the fact that the phosphorus in the first year inhibited the uptake of zinc more than in the second year. In the second year, it is thought that the climate is more suitable and fertilizers may be taken more uniformly (Toğay and Anlarsal, 2007). In many studies, it has been reported that phosphorus and zinc fertilizers are used together and that the efficiency of phosphorus zinc decreases the efficiency and quality decreases (Ozanne, 1980; Lonergan et al., 1982). In a similar study, it was reported that environmental and genetic factors were effective on the average grain yield in lentils (Islam et al., 1989).

Many previous studies have shown that the protein content of beans varies between 17.40% and 28.00%. It has been reported that bacterial applications, especially nitrogen fertilization, increase this rate (Tajini et al., 2012; Bulut, 2013; Özturan and Akman, 2017). The effect of zinc fertilizer on crude protein content was found to be important due to environmental and genotypic factors. Similar results were obtained in other studies conducted on legumes (Toğay and Anlarsal, 2008). Zinc is an active element in biochemical events and has a biological interaction. When used in combination with phosphorus, a decrease in the uptake by plants occurs. The most important element limiting the use efficiency of zinc by plants is phosphorus. Especially in the case of phosphorus poor soils, where the need for excess phosphorus is met, the use of zinc decreases. Disruptions in phosphorus and zinc balance in the plant cause disruptions in the cell and some parts of the cell (Das et al., 2005; Khorgamy and Farnis, 2009; Salimpour et al., 2010).

Conclusion

In this study carried out in Van-Gevaş, the effect of different phosphorus and zinc doses on the yield and yield components of dry bean varieties were investigated. Although these factors have changed over the years, they have provided important information about yield and yield components. The results of the decrease in zinc utilization efficiency in high phosphorus doses have emerged in yield and quality parameters. Especially in our city where zinc deficiency is seen too much, and especially before planting other plants, soil analysis should be conducted before planting. In view of these results, phosphorus fertilization should be done between 10.00-30.00 kg ha^{-1} zinc and 20.00-80.00 kg ha^{-1}. The grain yield which is close to Turkey's on average or above on a yearly basis may be interrelated with zinc and phosphorus deficiency in the soil, which is thought to reduce the yield and quality losses.

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