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EFFECTS OF VARIOUS NITROGEN SOURCES ON IRON AND ZINC CONTENTS OF SPRING SPINACH

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ABSTRACT

This study was conducted to determine the effects of nitrogen using increasing doses (0, 10, 20, 40 and 60 kg N/da ammonium nitrate, ammonium sulphate, urea and 0, 1000, 2000, 4000 and 6000 kg/da barnyard manure) on Fe and Zn contents in spring spinach plant leaf and leaf stem grown under greenhouse conditions with no heating in clay loam and sandy loam soils. The effects of soil texture, fertilizer and dose on Fe and Zn contents of spinach plant were found statistically significant at 1 % level. Fe content of spinach plant grown in clay loamy soil was higher than sandy loamy soil, however Zn content of spinach plant was opposite of this. Mineral fertilization improved Fe and Zn contents of the leaf and leaf stem. Nitrogen doses differently affected these improvings. For all treatments, Fe content of plant were higher than Zn contents. Fe content (58.89 ppm) of the leaf was smaller than leaf stem (66.85 ppm), and Zn content (49.65 ppm) of the leaf was higher than leaf stem (36.00 ppm). Kind of the fertilizer and their doses affected significantly Fe and Zn content and quality of spinach plant.

Key Words: Iron, zinc, nitrogen, soil texture, spinach.

ÖZET

YAZLIK ISPANAĞIN DEMİR VE ÇİNKO İÇERİKLERİ ÜZERİNE DEĞİŞİK AZOT KAYNAKLARININ ETKİLERİ

Bu araştırma, farklı dozlarda uygulanan (0, 10, 20, 40 ve 60 kg N/da) amonyum nitrat, amonyum sülfat ve üre gübresi ile ahır gübresinin (0, 1000, 2000, 4000 ve 6000 kg/da) sera şartlarında yazlık olarak, killi tın ve kumlu tın tekstüre sahip topraklarda yetiştirilen ıspanak bitkisinin (*Spinacia oleracea* L.) yaprak ve yaprak saplarının Fe ve Zn kapsamlarına olan etkilerini belirlemek amacıyla yapılmıştır. Toprak tekstürü, gübre çeşidi ve gübre dozlarının bitkinin Fe ve Zn kapsamı üzerine etkileri istatistiki olarak % 1 seviyesinde önemli bulunmuştur. Demir için killi tın, çinko için ise kumlu tın toprağın etkisi daha yüksek olmuştur. Yaprak ve yaprak sapının Fe ile Zn kapsamı üzerine inorganik gübreler daha yüksek etkide bulunmuşlardır. Artan azot dozları bitkinin Fe ve Zn kapsamları üzerinde değişken etki göstermişlerdir. Yaprağın ortalama Fe kapsamı (58.89 ppm) yaprak sapından (66.85 ppm) daha düşük, yaprağın ortalama Zn kapsamı (49.65 ppm) ise yaprak sapından (36.00 ppm) daha yüksek elde bulunmuştur.

Anahtar Kelimeler: Demir, çinko, azot, toprak tekstürü, ıspanak,.

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INTRODUCTION

Spinach is largely consumed as a winter and spring vegetable in Turkey. 100 g fresh spinach contains 10 000 IU A, 0.17 mg B_1, 0.25 mg B_2, 10 mg B_6, 55 mg C vitamin, 1.8 mg protein, 0.2 g fat, 1.4 g carbohydrate, 93 g water, 130 mg Ca, 51 mg P, 500 mg K, 71 mg Na, 4 mg Fe, 26 kcal energy, 0.7 g fibre and 1.5 g ash (Anonymous, 1991; Souci et al., 1989/90). 1000 kg spinach contain also 50 kg nitrogen, 5 kg phosphorus, 28 kg potassium and 20 kg calcium. Therefore, 9-12 kg N/da, 10 kg P_2O_5/da and 15-20 kg K_2O/da for fertilization are suggested (Günay, 1983).

The Fe and Zn contents of spinach plant were affected by nitrogenous fertilization (Yoltaş et al., 1992; Çil and Katkat, 1995; Güneş and Aktaş, 1996). The highest Fe and Zn contents of spinach plant were determined by treatments of ammonium sulphate and ammonium nitrate, respectively (Çil and Katkat, 1995). Spinach plants grown in pots contained 3.5 kg soil fertilised with ammonium nitrate 0.15, 0.30 and 0.60 g N/pot, and increasing nitrogen rates increased the Zn content in all parts of plant, and effects on Fe content were different, and high nitrogen doses decreased Fe/Zn and P/Zn rates (Jurkowska et al., 1990). Fe and Zn contents of spinach plant were increased by ammonium nitrate, ammonium sulphate and urea given 6 kg N/da (Kheir et al., 1991). Low doses of nitrogen given to spinach plant in sand culture increased Zn content of root and decreased Zn content of leaf (Ahmed, 1991). Fe contents of spinach plant was found between 1.43 and 2.22 mg/100 g (fresh matter) (Miskovic et al., 1992). Fe contents of spinach plant grown in field were determined as around 3.9 mg/100 g (fresh matter) (Khan and Nusrat, 1992). It was expressed that Zn contents of spinach plant were 0.95-5.50 mg/kg (fresh matter) (Ellen et al., 1990) and 11.70-12.60 mg/100 g (dry matter) (Yadaw and Salil, 1995) and average 10.77 mg/100 g (Souci et al., 1989/90).

In this study, the effects of different nitrogen sources and theirs doses on iron and zinc contents of spinach plant leaf and stems grown in various textured soils, were investigated.

MATERIALS AND METHODS

The clay loamy and sandy loamy textured soils were weighed by two kg as oven dry weight (105 °C, 24 h) and filled into plastic pots. The soil samples were passed by 5 mm sieve. They were mixed with ammonium nitrate (AN), ammonium sulphate (AS) and urea (U) as 0, 10, 20, 40 60 kg N/da doses and barnyard manure as 0, 1000, 2000, 4000 6000 kg/da doses. 200 000 kg soil was calculated per 1000 m^2. The study was carried out in greenhouse condition with no heating and the Matador variety of spinach was grown.

The some physical and chemical properties of clay loamy and sandy loamy soil samples were given in Table 1.

This investigation was established according to randomised parcels factors experience model (2 x 4 x 5 x 3; texture x fertiliser x dose x replicate), and in 4 April. Seven spinach seeds were sown to each pot, and phosphorus has been supplied 10 kg P_2O_5/da rate as basal fertiliser from triple super phosphates. Germination occurred in 10

days after sowing. The plants were rarefied after being four leafs and left three plants each pot. Distilled water was given as irrigation water to each pot 4600 ml (278.79 mm = 278.79 ton/da) along vegetation period. The plants reached to harvest maturity in 62 days. Greenhouse atmosphere conditions along growing period: mean relative humidity 55 %, mean temperature 26.33 °C and mean day length 14.21 hours. The spinach plants were harvested with stainless steel knife from soil surface and leaf and leaf stems were separeted after washing with water, 0.1 M HCl solution and distilled water, respectively. Plant samples were kept in plastic boxes as ground after dried in oven at 70 °C for 48 hours. Fe and Zn contents of plant samples after treated with H_2SO_4 and H_2O_2 was determined by atomic absorption spectrophotometer (Kacar, 1972). Statistical analyses of results were done by Minitab packet programs (Minitab, 1995).

Table 1. Some Physical and Chemical Properties of Investigation Soils

Properties	Clay Loam	Sandy Loam	Analysis Methods
Clay (%) (< 0.002 mm)	39	19	Ellen, 1990
Silt (%) (0.002-0.05 mm)	32	29	Ellen, 1990
Sand (%) (0.005-2 mm)	29	52	Ellen, 1990
pH (1:2.5 soil:distilled water)	8.00	7.30	Yadaw, 1995
$ECx10^6$ (1:2.5 soil:distilled water)	93	297	Yadaw, 1995
Organic matter (%) (w/100g)	0.80	1.36	Bouyoucos, 1951
Lime (%) (w/100 g)	20.6	37.0	Bayraklı, 1987
CEC (me/100 g)	28.5	24.0	Jackson, 1966
Field capacity (%) (w/w)	30.0	22.7	Hızalan, 1966
Total nitrogen (ppm)	266.6	250.0	Chapman, 1965
Phosphorus (ppm)	11.1	8.44	Peters, 1965
Potassium (ppm)	267.3	129.0	Bremner, 1965
Iron (ppm)	294.0	180.0	Olsen, 1954
Zinc (ppm)	18.0	11.0	Olsen, 1954

RESULTS AND DISCUSSION

Iron and Zinc Contents of Leaf

The soil texture, fertiliser kind, fertiliser dose and their interactions affected significantly ($p<0.01$) Fe content of leaf (Table 2). Fe content (85.86 ppm) of spinach leaf grown in the clay loamy soil was found higher than that of spinach (31.93 ppm) in the sandy loamy soil. The first reason of this may be difference of total and available iron contents of the soils. The other factors probably are airing capacity and reduction or oxidation conditions of the soils. Generally, clay soils have lower airing capacity than sandy soils. After irrigation, reduction conditions in clay soils go on longer time than in sandy soils. Therefore, in the soils having high airing capacity, Fe^{3+} form is converted to Fe^{2+} form. Thus, this iron form is readly took up by plants. Various investigations supported that this express were carried out about availability of iron in different soils (Mandal, 1961; Güzel, 1983; Kacar, 1984).

Fertilization increased iron content (76.20 ppm) of leaf in comparison with the control. With the AS, U and BM treatments, iron contents of the leaf were 76.20 ppm, 45.30 ppm and 45.10 ppm, respectively. The nitrogen doses (20, 40 and 60 kg N/da) increased Fe contents of leaf in regard to the control treatment. Texture x fertilizer interaction affected significantly ($p<0.01$) the iron content of leaf. The highest iron contents (112.13 and 119.87 ppm) were determined in clay loamy soil AN and AS fertilizers treatments, respectively. The lowest iron contents (25.87-32.53 ppm) were found in sandy loamy soil AN, AS and U fertilizers treatments, respectively. The texture x dose interaction

Table 2. Variance Analysis Results of Fe and Zn Contents of Spinach Leafs Grown in Clay Loamy and Sandy Loamy Soil Using Varied Doses of Nitrogenous Fertilisers

	Degree of Freedom		Sum of Squares		Mean of Squares	
Variation Sources	Fe	Zn	Fe	Zn	Fe	Zn
Texture	1	1	87264.1	357.08	87264.1**	357.08*
Fertilizer	3	3	23301.0	516.29	7767.0**	172.10
Dose	4	4	42936.5	1137.53	10734.1**	284.83**
Texture x Fertilizer	3	3	36412.5	891.62	12137.5**	297.21*
Texture x Dose	4	4	28273.9	48.97	7068.5**	12.24
Fertilizer x Dose	12	12	12361.7	2842.00	1030.1**	236.83**
Texture x Fertilizer x Dose	11	11	13309.9	1086.83	1109.2**	90.57
Error	78	78	12143.3	6080.67	151.8	76.01
Total	116	116	256002.8	12960.99		

*: $p < 0.05$, **: $p < 0.01$

affected significantly ($p<0.01$) the iron content of leaf. The highest Fe content in clay loamy soil 20 kg N/da dose, the lowest Fe contents in clay loamy soil control and in sandy loamy soil control, 10 and 20 kg N/da doses, were determined. The fertilizer x dose interaction affected significantly ($p<0.01$) Fe content of leaf. The highest Fe contents (88.33-103.17 ppm) were measured in the 20 and 60 kg N/da doses of AN and the dose 20 kg N/da of AS, respectively. The lowest Fe content (23.00 ppm) was also determined in the control. The texture x fertilizer x dose interaction affected significantly ($p<0.01$) the iron contents of the leaf. The highest Fe content (174.33 ppm) was found in clay loamy soil AS 20 kg N/da. The lowest Fe contents (18.33-33.33 ppm) were determined in clay and sandy loamy soils control treatments, in sandy loamy soil AN and AS 10, 20 and 40 and U 10, 20, 40 and 60 kg N/da doses. Mean Fe content of leaf was 58.89 ppm. On the other hand, increasing fertilizer doses changed Fe content of leaf as increasing and decreasing (Table 3). Some researchers also determined similar results (Yoltaş et al., 1992; Çil and Katkat, 1995; Güneş and Aktaş, 1996; Jurkowska et al., 1990; Kheir et al., 1991; Ahmed, 1991; Miskovic et al., 1992; Khan and Nusrat, 1992; Ellen et al., 1990; Yadaw and Salil, 1995).

Soil texture and texture x fertilizer interaction affected significantly ($p<0.05$), dose and fertilizer x dose interaction affected also significantly Zn content of leaf by statistically ($p<0.05$) (Table 2). Zn content (51.38 ppm) of spinach leaf grown in clay loamy soil was determined higher than Zn content (47.93 ppm) of spinach leaf grown in sandy loamy soil.

The effects of 20 and 40 kg N/da doses were found higher than 0, 10, and 60 kg N/da doses. Soil texture x fertilizer interaction affected significantly ($p<0.05$) Zn content of the leaf. The highest Zn contents (48.86-55.26 ppm) were measured in clay loamy soil AS and BM. The lowest Zn contents (42.93-51.80 ppm) were determined in clay loamy soil AN, AS, U, and in sandy loamy soil U fertilizers. Interaction of fertilizer x dose affected significantly ($p<0.05$) Zn content of the leaf and the highest Zn contents (53.66-64.16 ppm) were found AN 40 and 60, AS 10 and 20 kg N/da and BM 2000 kg/da doses. Lowest Zn contents (41.00-53.66 ppm) were measured AN 10 and 20, AS 10, 40 and 60 kg N/da, U all doses and BM 4000 and 6000 kg/da doses. Mean Zn content of leaf was 49.65 ppm. However, increasing doses of fertilizers affected differently Zn content of spinach leaves (Table 3). The similar results were reported by the other researcher (Yoltaş et al., 1992; Çil and Katkat, 1995; Ellen et al., 1990; Yadaw and Salil, 1995).

Table 3. Effects of Fertilizers and Theirs Doses on Fe and Zn Contents (ppm) of Spinach Leafs Grown in Clay Loamy and Sandy Loamy Soils* and Comparison of Means with Duncan Test**

		Clay Loam		Sandy Loam		Means	
Fertil.	Doses	Fe	Zn	Fe	Zn	Fe	Zn
Contr.	0	21.00 no	43.66	25.00 mno	45.00	23.00 f	44.33 cde
	10	84.00 e	34.66	18.33 o	47.33	51.17 e	41.00 e
	20	154.33 b	36.00	22.33 mno	52.00	88.33 abcd	44.00 cde
AN	40	144.00 bc	45.33	27.00 lmno	67.66	85.50 bcd	56.50 abc
	60	157.33 b	55.00	36.67 ıjklmn	64.33	97.00 ab	59.66 ab
	Mean	112.13 A	42.93 C	25.87 D	55.26 A	69.00 B	49.10
	10	133.33 cd	51.00	29.67 klmno	56.33	81.50 cd	53.66 abcde
	20	174.33 a	47.00	32.00 jklmno	61.33	103.17 a	54.16 abcd
AS	40	124.67 d	51.66	32.67 jklmno	49.66	78.67 d	50.66 bcde
	60	146.00 bc	51.00	43.33 ıjkl	46.66	94.67 abc	48.83 bcde
	Mean	119.87 A	48.86 ABC	32.53 D	51.80 AB	76.20 A	50.33
	10	73.67 ef	50.66	22.33 mno	44.66	48.00 e	47.66 cde
	20	73.00 ef	50.66	25.00 mno	49.00	49.00 e	49.83 bcde
U	40	66.33 fg	51.33	33.33 jklmno	50.33	49.83 e	50.83 bcde
	60	86.00 e	35.33	27.33 lmno	46.66	56.67 f	41.00 e
	Mean	64.00 B	46.33 BC	26.60 D	47.13 BC	45.30 C	46.73
	1000	48.67 hıj	54.00	46.67 hıj	58.00	47.67 e	56.00 abc
	2000	67.33 fg	69.33	44.33 ıjk	59.00	55.83 e	64.16 a
BM	4000	61.00 fgh	51.66	52.33 ghı	51.00	56.67 e	51.33 bcde
	6000	39.33 ıjklm	49.33	45.33 ıjk	43.66	42.33 e	46.50 cde
	Mean	47.47 C	53.60 AB	42.73C	51.33 AB	45.10 C	52.46
	Mean	85.86 A	47.93 B	31.93 B	51.38 A	58.89	49.65

*: Mean of three replicates.

**: No difference among means displayed the same letter.

AN: Ammonium nitrate AS: Ammonium sulphate U: Urea BM: Barnyard manure

Iron and Zinc Contents of Leaf Stem

Soil texture, kind of fertilizer, dose of fertilizer and their interactions affected significantly ($p<0.05$) Fe content of leaf stem (Table 4). Fe content (78.25 ppm) of spinach leaf stem grown in clay loamy soil was found higher than that (55.33 ppm) of spinach leaf stem grown in sandy loamy soil. The highest Fe contents (72.00 and 74.06 ppm) in U and BM, the lowest Fe contents (59.16 and 62.33 ppm) were determined in AN and AS treatments, respectively. The highest Fe content in 10 kg N/da and the lowest Fe content in 0, 40 and 60 kg N/da doses were determined. The texture x fertilizer interaction affected significantly ($p<0.05$), and the the lowest Fe contents (43.73 and 48.87 ppm) in clay loamy soil AN and sandy loamy soil BM treatments, respectively. The texture x dose interaction affected significantly ($p<0.05$) Fe content of leaf stem and the highest Fe content was found in clay loamy soil 10, 20 and 60 kg N/da and in sandy loamy soil control plot, the lowest Fe content in clay loamy soil control plot and in sandy loamy soil 40 kg N/da doses. The fertilizer x dose interaction affected significantly ($p<0.05$) Fe content of leaf stem and the highest Fe contents (85.33-96.16 ppm) were measured with AN 10, U 60 kg /da and BM 4000 kg/da doses, the lowest Fe contents (48.00-60.16 ppm) AN 20 and 60, AS 10 and 60 and U 40 kg N/da doses. The texture x fertilizer x dose interaction affected significantly ($p<0.05$) Fe content of leaf stem, and the highest Fe contents (129.00-142.00 ppm) were determined in clay loamy soil U 10 and 60 kg N/da and BM-2000 and 4000 kg/da doses, the lowest Fe contents (18.67-36.33 ppm) in clay loamy soil control dose, in sandy loamy soil AN 40, AS 20, U 10 kg N/da and BM 2000, 4000 and 6000 kg/da doses. Mean Fe content of leaf stem was 66.89 ppm. On the other hand, increasing fertilizer doses changed Fe content of leaf stem as increasing or decreasing (Table 5). Some researchers also determined similar results (Yoltaş et al., 1992; Çil and Katkat, 1995; Güneş and Aktaş, 1996; Jurkowska et al., 1990; Kheir et al., 1991; Ahmed, 1991; Miskovic et al., 1992; Khan and Nusrat, 1992).

Table 4. Variance Analysis Results of Fe and Zn Contents of Spinach Leaf Stem Grown in Clay Loamy and Sandy Loamy Soil Using Varied Doses of Nitrogenous Fertilizers

	Degree of Freedom		Sum of Squares		Mean of Squares	
Variation Sources	**Fe**	**Zn**	**Fe**	**Zn**	**Fe**	**Zn**
Texture	1	1	16031.4	102.68	16031.4**	102.68
Fertiliser	3	3	4740.9	1415.69	1580.3**	471.90**
Dose	4	4	4736.1	1084.12	1184.0**	271.03**
Texture x Fertilizer	3	3	25510.5	2774.49	8503.5**	924.83**
Texture x Dose	4	4	57767.5	2790.28	14441.9**	697.57**
Fertilizer x Dose	12	12	20159.7	3374.35	1680.0**	281.20**
Texture x Fertilizer x Dose	11	11	23416.8	2856.72	1951.4**	238.06**
Error	78	78	8876.7	2946.67	111.0	36.83
Total	116	116	161239.6	17344.99		

*: $p < 0.05$, **: $p < 0.01$

Table 5. Effects of Fertilizers and Theirs Doses on Fe and Zn Contents (ppm) of Spinach Leaf Stems Grown in Clay Loamy and Sandy Loamy Soils* and Comparison of Means with Duncan Test**

		Clay Loam		Sandy Loam		Means	
Fertil.	Doses	Fe	Zn	Fe	Zn	Fe	Zn
Contr.	0	28.33 jkl	21.00 jkl	92.00 de	41.66 bcdefg	60.16 efg	31.33 fghı
	10	74.33 ef	12.66 l	108.67 cd	47.33 abcd	91.50 ab	30.00 ghı
	20	41.33 hıjk	50.66 abc	63.33 fg	48.33 abcd	52.33 fg	49.50 ab
AN	40	45.33 ghıj	37.00 defgh	26.00 jkl	52.66 ab	35.66 h	44.83 abc
	60	55.00 fghı	50.00 abc	57.33 fgh	55.00 a	56.16 fg	52.50 a
	Mean	48.87 DE	34.26 CDE	69.47 C	49.00 A	59.16 B	41.63 A
	10	60.33 fgh	37.33 defgh	44.33 ghıjk	42.00 bcdefg	52.33 fg	39.66 cdef
	20	115.00 bc	35.00 efghı	36.33 ıjkl	29.66 ghıjk	75.66 cd	32.33 fghı
AS	40	104.67 cd	37.00 defgh	42.67 hıjk	44.33 abcde	73.66 cde	40.66 cde
	60	55.00 fghı	30.66 fghıj	44.67 ghıjk	40.66 bcdefg	49.83 fg	35.66 defgh
	Mean	72.67 C	32.20 DEF	52.00 D	39.66 B	62.33 B	35.93 B
	10	135.00 a	50.33 abc	30.67 jkl	18.00 kl	82.83 bc	34.16 efghı
	20	94.67 d	30.33 fghıj	51.00 ghı	25.66 ıjk	72.83 cde	28.00 hı
U	40	52.33 ghı	34.66 efghı	43.67 ghıjk	26.66 hıjk	48.00 g	30.66 fghı
	60	129.00 ab	47.66 abcd	63.33 fg	39.00 cdefg	96.16 a	43.33 bcd
	Mean	87.87 B	36.80 BCD	56.13 D	30.20 EF	72.00 A	33.50 B
	1000	108.00 cd	48.66 abcd	55.00 fghı	26.66 hıjk	81.50 bc	37.66 cdefg
	2000	134.67 a	42.66 bcdef	24.33 kl	34.00 efghı	79.50 bc	38.33 cdefg
BM	4000	142.00 a	31.66 fghıj	28.67 jkl	21.00 jkl	85.33 abc	26.33 ı
	6000	109.00 cd	41.33 bcdefg	18.67 l	21.00 jkl	63.83 def	31.16 fghı
	Mean	104.40 A	37.06 BC	43.73 E	28.86 F	74.06 A	32.96 B
	Mean	78.45 A	35.08	55.33 B	36.93	66.89	36.00

*: Means of three replicates.

**: No difference among means displayed the same letter.

AN: Ammonium nitrate AS: Ammonium sulphate U: Urea BM: Barnyard manure

The kind of fertilizer, dose of fertiliser and their interactions affected significantly Zn content of leaf stem by statistical in 1 % level (Table 4). The textures did not affect differently Zn contents of the leaf stem. The highest Zn concentration (41.63 ppm) was found with the AN, the lowest Zn concentrations (32.96-35.93 ppm) with AS, U and BM in regard to control treatment. Highest Zn content was determined in 20 and 60 kg N/da doses, the lowest Zn contents in control treatment. The texture x fertilizer interaction affected significantly ($p<0.05$) Zn content of leaf stem, and the highest Zn content (49.00 ppm) was measured in sandy loamy soil-AN, the lowest Zn contents (28.86-32.20 ppm) in sandy loamy soil-U and BM, in clay loamy soil-AS fertilizer. Soil texture x fertilizer dose interaction affected significantly ($p<0.05$) Zn content of leaf stem, and the highest Zn content was found in clay loamy soil-10, 20 and 60 kg N/da and in sandy loamy soil-0 and 60 kg N/da, the lowest Zn content in clay loamy soil-control dose. Fertilizer x dose interaction affected significantly ($p<0.05$) Zn content of leaf stem, and the highest Zn

contents (44.83-52.53 ppm) were determined in the AN 20, 40 and 60 kg N/da, the lowest Zn contents (26.33-34.16 ppm) in the control dose, AN 10, AS 20, U 10, 20 and 40 kg N/da and BM 4000 and 6000 kg/da doses. The texture x fertilizer x dose interaction affected significantly ($p<0.05$) Zn content of leaf stem, and the highest Zn contents (44.33-55.00 ppm) were found in clay loamy soil AN 20 and 60 kg N/da, U 10 and 60 kg N/da and BM 1000 kg/da and in sandy loamy soil AN all doses, AS 40 kg N/da, the lowest Zn contents (12.66-21.00 ppm) in clay loamy soil control doses, AN 10 kg N/da and in sandy loamy soil U 10 kg N/da and BM 4000 and 6000 kg/da doses. Mean Zn content of leaf stem was 36.00 ppm (Table 5). Similar results were expressed also by some researchers (Yoltaş et al., 1992; Çil and Katkat, 1995; Ellen et al., 1990; Yadaw and Salil, 1995).

As the result, it was determined that the iron accumulated the more in the leaf stem, the zinc accumulated the more in the leaf. The iron was found higher than zinc for all treatments. High iron contents was determined in clay loamy soil and mineral fertilisation, and the high zinc in clay loamy soil and organic fertilization. Increasing nitrogen doses affected variously the iron and zinc contents of the spinach plant.

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