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Mineral Nutrient Content of Sweet Corn under Deficit Irrigation

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ABSTRACT

The present study was conducted to determine the effects of deficit irrigation (I) ($I_{100:}$ full irrigation; I_{85}: 15% deficit; I_{70}: 30% deficit; I_{55}: 45% deficit and I_{40}: 60% deficit) on mineral nutrient contents of fresh sweet corn (*Zea mays saccharata*) grain in two vegetation seasons, years of 2011 and 2012, in Isparta ecological conditions. The experiment was set up according to the Randomized Complete-Block Design with three replicates. The species of Lumina F_1 was used as the sweet corn cultivar. The results revealed statistically significant effects of water deficit on mineral nutrient contents of fresh sweet corn grain. The highest nitrogen content (2.29% in 2011 and 2.32% in 2012), the highest phosphorus content (0.332% in 2011 and 0.331% in 2012), the highest potassium content (0.855% in 2011 and 0.837% in 2012), the highest calcium content (0.031% in 2011 and 0.029% in 2012), the highest magnesium content (0.123% in 2011 and 0.132% in 2012), the highest iron amount (27.27 mg kg^{-1} in 2011 and 26.12 mg kg^{-1} in 2012), the highest copper amount (3.99 mg kg^{-1} in 2011 and 4.12 mg kg^{-1} in 2012) and the highest manganese amount (10.92 mg kg^{-1} in 2011 and 11.68 mg kg^{-1} in 2012) were obtained from the "I_{70}" irrigation level. The highest zinc amount (34.77 mg kg^{-1} in 2011 and 30.14 mg kg^{-1} in 2012) and the highest boron amount (5.389 mg kg^{-1} in 2011 and 5.306 mg kg^{-1} in 2012) were determined in I_{85} and I_{40} irrigation levels, respectively. Generally, the mineral nutrient contents were increased with water deficit up to a certain level "I_{70}" and he lower irrigation levels (I_{55} and I_{40}) than "I_{70}" resulted in decreased mineral nutrient contents, except for B, of sweet corn in both years.

Keywords: Sweet corn; Irrigation; Macro nutrient; Micro nutrient

Kısıntılı Sulamada Şeker Mısırın Mineral Besin İçeriği

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ÖZET

Çalışma; 2011 ve 2012 vejetasyon döneminde taze şeker mısır (*Zea mays saccharata*) tanesinin mineral besin içeriğine kısıntılı sulamanın (S) (S_{100}: tam sulama; S_{85}: % 15 kısıntı; S_{70}: % 30 kısıntı; S_{55}: % 45 kısıntı ve S_{40}: % 60 kısıntı) etkisini belirlemek amacıyla Isparta ekolojik koşullarında yürütülmüştür. Deneme tesadüf blokları deneme desenine göre üç tekerrürlü olarak kurulmuştur. Şeker mısır çeşidi olarak Lumina F1 kullanılmıştır. Sonuçlar kısıntılı sulamanın taze şeker mısır tanesinin mineral besin içeriğine etkisinin istatistiksel olarak önemli olduğunu göstermiştir. En yüksek azot oranı (2011'de % 2.29 ve 2012'de % 2.32), fosfor oranı (2011'de % 0.332 ve 2012'de % 0.331), potasyum oranı (2011'de % 0.855 ve 2012'de % 0.837), kalsiyum oranı (2011'de % 0.031 ve 2012'de % 0.029), magnezyum oranı (2011'de % 0.123 ve 2012'de % 0.132), demir miktarı (2011'de 27.27 mg kg^{-1} ve 2012'de 26.12 mg kg^{-1}), bakır miktarı (2011'de 3.99 mg kg^{-1} ve 2012'de 4.12 mg kg^{-1}) ve mangan miktarı (2011'de 10.92 mg kg^{-1} ve 2012'de 11.68 mg kg^{-1}) "S_{70}" sulama seviyesinden elde edilmiştir. En yüksek çinko miktarı (2011'de 34.77 mg kg^{-1} ve 2012'de 30.14 mg kg^{-1}) ve bor miktarı (2011'de 5.389 mg kg^{-1} ve 2012'de 5.306 mg kg^{-1}) sırasıyla I_{85} ve I_{40} sulama seviyesinde belirlenmiştir. Genellikle her iki yılda da S_{70} sulama seviyesine kadar su kısıtlamasıyla şeker mısırın besin içeriği artmıştır ve S_{70} den daha düşük sulama seviyelerde (S_{55} ve S_{40}) bor hariç tanenin mineral besin içeriği azalmıştır.

Anahtar Kelimeler: Şeker mısır; Sulama; Makro besin; Mikro besin

1. Introduction

Sweet corn is used as a fresh or processed vegetable. Sweet corn contains higher kernel protein, oil, starch, sugar contents and many other nutrients than the other maize types. Sweet corn is favorable for fresh consumption because of its delicious taste, delicate crust and soft and sugary texture compared to other corn varieties. The human body needs nutritious food to stay healthy. The foods come from plants, fruit, vegetables, grains, legumes, nuts, seeds and animals, diary food, eggs and meat. To maintain good health, we need macronutrients, micronutrients, vitamins and minerals. Macronutrients are our main source of energy. Vitamins and minerals are essential for the body's many biochemical processes. Both vitamins and minerals are needed to maintain optimal health. Minerals assist the body in energy production and other biochemical processes. Minerals are critically important to the maintenance of human health. Because the human body cannot manufacture minerals, deficiencies are common. Minerals supports healthy immune system, is necessary to synthesize DNA, is essential for wound healing, supports healthy grow and development of body during adolescence, childhood and pregnancy (John & Jeanne 2012).

Sweet corn requires some specific environmental and cultural conditions such as an irrigation, which must be respected for the high productive and marketable yields. Corn grown mostly under irrigated conditions in Turkey. Mineral nutrient contents of grain is direct related to the available nutrient in the root zone in growing period. Available water in root zone is a significant factor in nutrient uptake of plants. Eryüce & Kılıc (2001) determined that inadequate irrigation result in low nutrient uptake in maize. According to the researches, to produce 1 kg of corn's dry matter, 368 liters of water is needed (House 1985). Water supply has a significant effect in the grain filling period (Adrienn & Janos 2012). Drought during this period usually leads to smaller grains, and the amount of dry matter accumulation decreases (Andrade et al 2005). During the seed filling period due to transfer of food to the seeds, an increase in growth intercepting hormones, an increase in ratio of abscisic acid to cytokinins in leaves, a decrease in leaf strength, an increase in the death of plant tissues, the falling of lower bush leaves, increasing respiration speed due to shadowing and reducing light, decreasing the accumulation of dry matter, and increasing the retransfer in plant are observed (Yin et al 2000; Murchie et al 2002). Szirtes et al (1977) stated that the grain nutrient content was significantly determined by the weather. The most influential factors on protein and the other mineral nutrient content are heat units and the quantity and distribution of precipitation in growing period (Asghari & Hanson 1984). Barber & Jessop (1987) found that wheat grain protein content decreased by irrigation. Andrade et al (2005) stated that unfavorable water supply decreased dry matter accumulation in corn. Many factors influence the quality of crop products which serve as a basis for food, the most important of which are the variety, climatic factors and the production technology (Nagy 2009). Grain quality parameters have come to be more greatly preferred in recent years, making it necessary to know the effects of agro-technical factors on grain quality (Adrienn & Janos 2012). The aim of this research was to evaluate the effects of different irrigation levels on mineral nutrient content of fresh sweet corn.

2. Material and Methods

2.1. Experimental conditions

The study was conducted in the Isparta ecological conditions of Turkey during the 2011 and 2012 growing seasons. In the study, Lumina F_1 hybrid cultivar was used as the sweet corn variety.

Isparta has a territorial climate (cold winters and dry hot summers) with an annual mean rainfall of 524.4 mm. The long-term average temperature from April to end of August is 18.5 °C. The vegetative periods (from April to end of August) in 2011 and 2012 had average temperatures of 18.5 and 19.2 °C, total precipitation of 162.4 and 214.1 mm respectively (Table 1). Some physical and chemical characteristics of the experimental soil were presented in Table 2.

Seeds were sown at 5-6 cm depths using a dibbler in 70x20 cm row space on 9th and 5th May in 2011 and 2012 years, respectively. Each plot area was 25.2 m^2 and consisted of 6 rows. The experiments were arranged according to a randomized complete block design with three replicates.

Table 1- Climatic data of the experimental area*

*Çizelge 1- Deneme alanının iklim verileri**

Climatic factors	*Years*	*Months*					*Total or average*
		April	*May*	*June*	*July*	*August*	
Precipitation (mm)	2011	54.7	43.1	62.2	1.8	0.6	162.4
	2012	53.2	107.4	18.1	0.8	34.6	214.1
	Long term	56.6	50.8	28.4	18.4	0.8	155.0
Average Temperature (^{0}C)	2011	10.2	14.1	19.5	24.7	24.0	18.5
	2012	10.8	14.5	22.5	25.4	22.8	19.2
	Long term	10.8	15.6	20.1	22.3	23.9	18.5
Relative humudity (%)	2011	70.0	68.0	59.0	44.0	40.0	56.2
	2012	57.0	66.0	46.0	42.0	43.0	50.8
	Long term	64.2	50.3	53.0	45.8	44.5	51.5

*, records of the Isparta Meteorology Station

Table 2- Some physical and chemical characteristics of the experimental soil

Çizelge 2- Deneme toprağının bazı fiziksel ve kimyasal özellikleri

Depth cm	ρ_b *g cm^{-3}*	*FC* θ_{fc}	*WP* θ_{pwp}	*pH*	*EC dS m^{-1}*	$CaCO_3$ *g kg^{-1}*	*OM g kg^{-1}*	*K cmol kg^{-1}*	*Texture*
0-30	1.12	23.9	13.5	7.8	0.378	292	16.9	1.48	CL
30-60	1.18	24.7	14.6	7.8	0.381	221	12.8	1.13	CL
60-90	1.20	26.8	15.6	7.9	0.404	309	14.3	0.70	SiCL

ρ_b, soil bulk density; FC, field capacity; WP, wilting point; OM, organic matter; SiCL, silty-clay loam; CL, clay-loam

200 kg ha^{-1} N, 100 kg ha^{-1} P and 100 kg ha^{-1} K were applied to the rows in the form of ammonium sulphate, triple super phosphate and potassium chloride, respectively. The total quantity of phosphorus and potassium was applied at the time of sowing and nitrogen was applied in three equal amounts at the time of sowing, 10 cm seedling height and 35-40 cm height stages.

2.2. Irrigation

The irrigations were made on 29 June and 11 August in the 2011, and for 2012 year were made on 13 June and 9 August. The plants had been watered 7 and 8 times with 7 day intervals, respectively in both 2011 and 2012 (Table 3).

The 16 mm diameter lateral pipes with carrying 2 L h^{-1} of water had inline drippers located at 33 cm intervals. Soil water contents were measured by the gravimetric method in 30 cm increments to a depth of 90 cm in each plot at planting, before irrigations, and at the final harvesting date.

After sowing, the irrigation was watered using a sprinkler irrigation system at the beginning for uniform plant establishment. In this stage, irrigation was carried out two times. After the emergence of maize seedlings, subsequent irrigations were applied according to the prescribed irrigation rates. In study, irrigation treatments were consisted to according to five different deficit rates of available soil water before irrigation (1- $I_{100:}$ full irrigation and K_1: 1.00, 2- I_{85}: 85% of full irrigation and K_2: 0.85, 3- I_{70}: 70% of full irrigation and K_3: 0.70, 4- I_{55}: 55% of full irrigation and K_4: 0. 55 and 5- I_{40}: 40% of full irrigation and K_5: 0.40). Levels of irrigation water for treatments were computed using Equation 1.

$$I_r = W_{sd} \times K \quad (1)$$

Where; I_r, the irrigation water (mm); W_{sd}, soil water deficit in the irrigation before (mm); and K, the rate of water cuts.

The plant water consumption (*Et*) was estimated using Equation 2 (James 1988).

$$E_t = I_r + P + C_r - D_p - R_f \pm \Delta s \quad (2)$$

Where; E_t, plant water consumption (mm); I_r, irrigation water (mm); P, the precipitation (mm); C_r, the capillary rise (mm); D_p, the deep percolation losses (mm); R_f, the runoff losses (mm); and Δs, the moisture storage in soil profile (mm).

2.3. Analysis of mineral nutrient contents

When the kernel moisture was about 72% (Olsen et al 1990), five ears in the center of each plot were harvested manually. The cobs were immediately frozen by liquid nitrogen to prevent changing from sugar to starch. Later, grains were removed from ear by using cutter, and the samples were dried in an air-forced oven at 70 ^{0}C until became stable weight. Then dried samples were ground to pass through a 1-mm screen. Mineral nutrient contents including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), manganese (Mn), zinc (Zn) and boron (B) were determined. N content was determined by using Kjeldahl method. Phosphorus content

Table 3- Seasonal irrigation water, rainfall, total water and evapotranspiration (ET) of sweet corn under different irrigation levels

Çizelge 3- Farklı sulama seviyelerinde şeker mısırın sulama suyu, yağış, toplam su ve buharlaşma miktarları

Irrigation levels (mm)	*Applied irrigation water (mm)*		*Rainfall (mm)*		*Total water (mm)*		*ET (mm)*	
	2011	*2012*	*2011*	*2012*	*2011*	*2012*	*2011*	*2012*
I_{40}	151.93	181.34	102.30	160.70	254.23	342.04	239.79	406.12
I_{55}	180.78	223.50	102.30	160.70	283.08	384.20	261.50	426.12
I_{70}	209.63	265.67	102.30	160.70	311.93	426.37	290.35	447.91
I_{85}	238.48	307.65	102.30	160.70	340.78	468.35	319.20	476.06
I_{100}	267.33	350.00	102.30	160.70	369.63	510.70	348.04	504.01

was determined according to the Molibdovanado-Phosphoric Acid Method (Kacar & İnal 2008). K content was measured by Flame Emission Spectrophotetry. Ca, Mg, Fe, Cu, Mn, Zn and B contents were measured with an Atomic Absorbtion Spectrofotometer.

2.4. Statistical analysis

All the data were analyzed according to the analysis of variance (ANOVA) using SAS Statistical Package Program; the significant differences between the group means were separated using the LSD (Least Significant Difference) test.

3. Results and Discussion

The effects of the different irrigation levels on the mineral nutrient contents, except for Ca and Mg in 2011, of sweet corn were found to be significant ($P<0.05$ and $P<0.01$) for both years. No significant differences between the two subsequent years in all mineral nutrient contents were found (Table 4).

Table 4- Effect on mineral nutrient contents of sweet corn of deficit irrigation

Çizelge 4- Kısıtlı sulamanın şeker mısırın mineral besin içeriğine etkisi

Irrigation levels (mm)	*N (%)*		*P (%)*		*K (%)*		*Ca (%)*	
	2011	*2012*	*2011*	*2012*	*2011*	*2012*	*2011*	*2012*
I_{40}	1.90 c	1.93 c	0.220 c	0.217 c	0.689 b	0.688 b	0.024	0.023 b
I_{55}	2.05 b	2.06 b	0.247 bc	0.265 b	0.744 ab	0.768 a	0.026	0.028 a
I_{70}	2.29 a	2.32 a	0.332 a	0.331 a	0.855 a	0.837 a	0.031	0.029 a
I_{85}	1.88 c	1.89 c	0.284 ab	0.287 b	0.823 ab	0.816 a	0.029	0.028 a
I_{100}	1.81 c	1.80 d	0.271 bc	0.273 b	0.814 ab	0.818 a	0.027	0.026 ab
Years	1.98	1.99	0.272	0.274	0.785	0.786	0.028	0.027
Lsd	0.118	0.057	0.055	0.027	0.150	0.075	ns	0.004
CV (%)	5.160	5.048	7.476	3.688	6.988	3.506	13.097	6.473
F value	57.42	84.01	13.00	49.75	4.50	14.34	1.85	6.65
P value	0.001	0.001	0.004	0.001	0.033	0.001	0.213	0.011

Irrigation levels (mm)	*Mg (%)*		*Fe (mg kg⁻¹)*		*Cu (mg kg⁻¹)*		*Mn (mg kg⁻¹)*	
	2011	*2012*	*2011*	*2012*	*2011*	*2012*	*2011*	*2012*
I_{40}	0.104	0.103 b	20.95 b	20.88 b	3.10 b	3.09 c	6.57 b	6.65 c
I_{55}	0.117	0.117 ab	21.01 b	21.49 b	3.61 ab	3.68 b	7.38 b	7.36 c
I_{70}	0.123	0.132 a	27.27 a	26.12 a	3.99 a	4.12 a	10.92 a	11.68 a
I_{85}	0.118	0.119 ab	25.14 ab	25.78 a	3.89 ab	3.80 ab	10.86 a	10.59 a
I_{100}	0.120	0.121 ab	23.66 ab	23.98 ab	3.80 ab	3.73 ab	8.90 ab	9.06 b
Years	0.117	0.118	23.57	23.65	3.68	3.69	8.93	9.07
Lsd	ns	0.017	6.233	3.115	0.813	0.407	2.576	1.284
CV (%)	10.581	5.278	9.652	4.808	8.064	4.030	10.530	5.168
F value	1.05	8.04	4.08	13.37	4.17	19.12	13.28	61.05
P value	0.439	0.006	0.043	0.001	0.040	0.001	0.001	0.001

Irrigation levels (mm)	*Zn (mg kg⁻¹)*		*B (mg kg⁻¹)*	
	2011	*2012*	*2011*	*2012*
I_{40}	24.19 c	24.46 b	5.389 a	5.306 a
I_{55}	25.27 c	26.99 ab	3.761 b	3.528 b
I_{70}	29.70 b	28.55 ab	3.543 b	3.527 b
I_{85}	34.77 a	30.14 a	3.223 bc	3.126 c
I_{100}	28.39 bc	28.45 ab	2.483 c	2.267 d
Years	28.5	27.7	3.680	3.551
Lsd	4.344	4.122	0.741	0.370
CV (%)	5.570	5.427	7.351	3.808
F value	20.80	6.04	47.00	201.32
P value	0.003	0.015	0.001	0.001

Means in the same columns followed by the same letters are not significantly different at the 0.05 and 0.01 level as statistically. I_{100}, full irrigation; I_{85}, 85% of full irrigation; I_{70}, 70% of full irrigation; I_{55}, 55% of full irrigation and I_{40}, 40% of full irrigation

In both subsequent years (2011 and 2012) the "I_{70}" irrigation level resulted in the highest N content (2.29 and 2.32%, respectively), the highest P content (0.332 and 0.331%, respectively), the highest K content (0.855 and 0.837%, respectively), the highest Ca content (0.031 and 0.029%, respectively), the highest Mg content (0.123 and 0.132%, respectively), the highest Fe amount (27.27 and 26.12 mg kg^{-1}, respectively), the highest Cu amount (3.99 and 4.12 mg kg^{-1}, respectively) and the highest Mn amount (10.92 and 11.68 mg kg^{-1}, respectively) (Table 4). The highest Zn amount (34.77 and 30.14 mg kg^{-1}, respectively) and the highest B amount (5.389 and 5.306 mg kg^{-1}, respectively) were obtained from I_{85} and I_{40} irrigation levels, respectively, in both years (Table 4).

While the lowest N content (1.81 and 1.80%, respectively) and the lowest B content (2.483 and 2.267 mg kg^{-1}, respectively) were obtained from I_{100} irrigation level in both years, the others mineral nutrient contents of sweet corn decreased in the lowest irrigation level in both 2011 and 2012: the lowest P content (0.220 and 0.217%, respectively), the lowest K content (0.689 and 0.688%, respectively), the lowest Ca content (0.024 and 0.023%, respectively), the lowest Mg content (0.104 and 0.103%, respectively), the lowest Fe amount (20.95 and 20.88 mg kg^{-1}, respectively), the lowest Cu amount (3.10 and 3.09 mg kg^{-1}, respectively), the lowest Mn amount (6.57 and 6.65 mg kg^{-1}, respectively) and the lowest Zn amount (24.19 and 24.46 mg kg^{-1}, respectively) were obtained from the "I_{40}" irrigation level (Table 4).

N content was significantly increased with the water deficit up to "I_{70}". N content was decreased in the lower water levels (I_{55} and I_{40}) than "I_{70}", however the lowest N content was determined in "I_{100}" irrigation level in both 2011 and 2012. This can be explained by nitrogen decrease in the root zone due to nitrogen washing at the high irrigation levels (I_{85} and I_{100}). On the other hand, plants can not sufficiently benefit from nitrogen in the upper soil layers due to low water at the lower irrigation levels (I_{55} and I_{40}). Adrienn & Janos (2012) reported that irrigation up to a certain level significantly increased the nitrogen content of maize hybrids. Asghari & Hanson (1984) determined that the nitrogen content of corn was affected from the quantity and distribution of precipitation-irrigation-in growing period. Barber & Jessop (1987) found that increasing the number of irrigations up to three reduced grain nitrogen content. Oury et al (2003) stated that there is a negative effect of irrigation on grain nitrogen concentration. This can be explained by the strong association between the amount of minerals transported by the water flow in the plant, and transpiration (Misra et al 2006).

Water deficit up to "I_{70}" irrigation resulted in increased P, K, Ca, Mg, Fe, Cu and Mn content. These minerals in the "I_{100}" and "I_{85}" irrigation levels were higher than "I_{55}" and "I_{40}". Drought stress caused the concentration of P, K, Ca, Mg, Fe, Cu and Mn decreases in sweet corn grain. The lowest mineral contents (P, K, Ca, Mg, Fe, Cu and Mn) were obtained from the "I_{40}" irrigation level, the lowest irrigation level in both 2011 and 2012. Zn content was increased with the increasing irrigation water up to "I_{85}". The lowest Zn content was obtained from the "I_{40}" irrigation level, the lowest irrigation level in both 2011 and 2012. Yazar et al (2002) also reported the highest average corn grain yield from the full irrigation treatment with 6-day irrigation interval. Yıldırım & Kodal (1998) were stated that applications of excessive water were not increased grain yields at the important level. Limited water supply during the growing season results in soil and plant water deficits and reduces maize yields (Patel et al 2006). Water deficit delays physiological processes of corn, tasseling initiation and silking, and reduces plant height and vegetation growth of maize as a result decrease grain yields (Singh et al 2007; Payero et al 2009).

Especially, in the dripping irrigation system, salts in root zone and the irrigation water accumulate at edge of wetted front (Ertek & Kanber 2002). Therefore, in the higher irrigation levels (I_{100} and I_{85}) than "I_{70}" might be decreased to nutrient uptake of maize due to edge of wetted front by washed of plant nutrient elements. On the other hand, in the lower irrigation levels (I_{55}

and I_{40}) than "I_{70}" might be fall to nutrient uptake of maize due to insufficient dissolution of plant nutrients. Under water stress macro-micronutrients decrease due to increased remobilization of stored assimilates. Rezaei et al (2012) found that the Zn concentration of grains increased with decreasing water availability, and micronutrients such as Fe, Zn and Cu in shoots decreased as water supply limited but Mn concentration of grain and straw was not or only little affected by water stress. Andrade et al (2005) found that unfavorable water supply of corn, the speed and duration of dry matter accumulation decrease. Rouphael et al (2008) reported that under water stress conditions, higher concentration of K and Mg were observed. Some researchers stated that the high irrigation levels resulted in decreased mineral nutrient contents (Simonne et al 1998; Kirnak et al 2001; Kaya et al 2003; Rouphael et al 2008). B content was decreased with the increasing irrigation water (I_{55}, I_{70}, I_{85} and I_{100}). The highest B content was determined in "I_{40}" irrigation level, the lowest irrigation level; the lowest B content was obtained from "I_{100}" level, the highest irrigation level in both 2011 and 2012. There is close relationship between boron uptake of plants and its transport at different plant organs with water intake of plant (Marschner 1976). Therefore, it is possible to say that B content of sweet corn increased with lower irrigation levels. Zubaidi et al (1999) reported that plants were marginally deficient in N P and Zn, but boron concentration was high under drought stress condition.

4. Conclusions

The results obtained from present study indicated that irrigation levels (I_{40}, I_{55}, I_{70}, I_{85} and I_{100}) had significant effects on mineral nutrient contents (N, P, K, Ca, Mg, Fe, Zn, Mn, Zn and B) of sweet corn. The mineral nutrient contents were increased with water deficit up to a certain level "I_{70}". The lower irrigation levels (I_{55} and I_{40}) than "I_{70}" resulted in decreased mineral nutrient contents, except for B, of sweet corn. Based on the results of the research, it is possible to say that mineral nutrient contents of sweet corn increased with water deficit up to "I_{70}". "I_{70}" irrigation application for sweet corn can be accepted as the optimum water level due to higher nutrient content.

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This study is a part of research belonging to effects on performance of sweet corn of deficit irrigation.

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