



Effects of Foliar Application of Micronutrients on Agronomic Traits of Beet Cv. Sonja under Dsa (Hot Summer Continental) Climatic conditions of Naqadeh Iran

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<p><i>Research Article</i></p> <p>Received : 24/06/2018 Accepted : 15/08/2018</p> <p>Keywords: Micronutrients Sugar beet Foliar spray Yield Hot summer continental climate</p>	<p>Plants need different macro and micro nutrient elements to grow and reproduce. Their malnutrition results in unhealthy growth. The soils of Naqadeh area, Iran are deficient in micronutrient elements. The aim of the study was to evaluate the effects of micronutrients application on some qualitative and quantitative parameters of economically important monogerm sugar beet cv. Sonja. The plants were foliar sprayed with iron, boron, zinc, and manganese. The studied traits were potassium, sodium, nitrogen, extraction coefficient, sugar percent, recoverable sugar, alkalinity, molasses, root yield, and white sugar recovery yield. The effect of micronutrients was significant on all studied traits. The highest extraction coefficient of 89.31 was related to the foliar application of iron (Fe) and the highest recoverable sugar percent (16.91%) was obtained from Zn application. Also, the highest mean root yield (74.120 t ha⁻¹) and white sugar yield (12.137 t ha⁻¹) were noted after foliar treatments of boron (B) and Fe, respectively.</p>

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Mikrobesin Maddelerin Şeker Pancarın Sonja Çeşidinde Yapraktan Uygulamasının Tarımsal Özellikleri Üzerine Etkileri

MAKALE BİLGİSİ	ÖZ
<p><i>Araştırma Makalesi</i></p> <p>Geliş : 24/06/2018 Kabul : 15/08/2018</p> <p>Anahtar Kelimeler: Mikro besinler Şeker pancarı Yaprak spreyi Verim Sıcak yaz iklimi</p>	<p>Bitkiler, büyüme ve gelişimleri için farklı makro ve mikro besin elementlerine ihtiyaç duymaktadırlar. Yetersiz beslenme durumları sağlıklı büyümeleri ile sonuçlanmaktadır. İran'ın Nekede bölgesinin toprakları, mikro besin elementleri bakımından yetersiz olmaktadır. Bu çalışmada, Sonja çeşidinde mikro besin maddelerinin yapraktan uygulanması sonucunda kalitatif ve verim özellikleri üzerine etkisi incelenmiştir. Bitki yapraklarına demir, bor, çinko ve manganez püskürtülmüştür. Potasyum, sodyum, azot, ekstraksiyon katsayısı, şeker yüzdesi, arınabilen şeker yüzdesi, alkalinite, melas, kök verimi ve beyaz şeker verimi parametreleri incelenmiştir. Çalışılan tüm özelliklerde, mikro besin maddelerinin etkisi önemli bulunmuştur. En yüksek ekstraksiyon katsayısı 89,31 ile demir (Fe) uygulamasından ve en yüksek elde edilen şeker yüzdesi (%16,91) çinko (Zn) uygulamasından elde edilmiştir. Ayrıca en yüksek ortalama kök (74,120 ton ha⁻¹) ve beyaz şeker verimleri (12,137 ± ha⁻¹) ise sırasıyla bor ve demirin yapraklara uygulanması sonucunda elde edilmiştir.</p>

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Introduction

Sugar beet (*Beta vulgaris* L.) is a biennial, diploid ($2n=18$) plant which is the main source of sucrose and income for farmers and has a considerable role in gross domestic production (GDP) of Iran. Over 30% of world soils suffer from the deficiency of one or more micronutrients, a trend which is deteriorating (Sillanpaa, 1982), with the passage of time. The share of micronutrients in total fertilizer consumption is about 2-4% in developed countries (Masri and Hamza, 2015). There are numerous reports about the role of micronutrients in enzymatic responses, plant metabolism and assimilation of carbon, nitrogen and different compounds, sugar translocation, cellular division, water regulation, conductivity, and consequently, higher photosynthetic capacity and productivity of the plants (Shiemshi, 2007). The best approach to realize this objective and also, earn foreign exchange is to increase production per unit area and improve crop quality (Run and Johnson, 1999; Masri and Hamza, 2015). Plants require some nutrients for optimum growth, among which trace elements like Fe, B, boron (B), iron (Fe), manganese (Mn), magnezium (Mg) and molibden (Mo) are needed (Fajrya, 1998); but, their deficiencies in soil can affect the performance of macronutrients (Xue et al., 2014).

Deficiency is widely common in sugar beet growing regions throughout the world and its symptoms are almost similar in all countries. The symptoms of this deficiency are usually visible on plants growing on soils with B content of less than 0.5 mg kg⁻¹ (Armin and Asgharipour, 2012). B, Copper (Cu), Mg, Mn, and zinc (Zn) are important nutrient elements for the growth and development of sugar beet. Micronutrient elements such as B, Cu, Mn, and Zn have important role in development and yield improvement of crop plants (Ziaean and Malakouti, 2001) however, foliar applications of micro nutrient fertilizers are considered more appropriate (Kristek et al., 2006; Çelik et al., 2010).

Foliar spray of crops can supplement soil application of nutrients. Micronutrients application in case of their deficiencies, especially by spray, can improve the yield and yield components of safflower and other crop plants (Lewis and McFarlane, 1986; Arnon, 2001; Fernandez et al., 2004). According to Erdal et al. (2004), Fe spray increased growth and metabolism of strawberries. Teixeira et al. (2004), reported that foliar application of Zn and Mn increased dry matter by 18 and 32% as compared to control, treatments respectively. Lin (1996), reported that soybean grain yield was sharply increased with foliar spray and soil application of Mn and that foliar application was more effective than soil application. Masri and Hamza (2015) sprayed sugar beet zinc (Zn) + Manganese (Mn) + Iron (Fe) + Boron (B) and noted positive effect of foliar application on sugar beet root yield.

There is no previous study reporting about the effect of micronutrients on some properties of sugar beet in the region. The study aimed to evaluate the effects of micronutrients (Fe, Zn, B, and Mn) spray on some qualitative and quantitative parameters of sugar beet (cv. Sonja) under Naqadeh condition (Elevation: 4298 feet, Latitude: 36 57N, Longitude: 045 23E).

Materials and Methods

The study was carried out in experimental farm of Naqadeh Sugar Factory "Dsa". (Hot Summer Continental Climate) of Naqadeh Elevation: 4298 feet, Latitude: 36 57N, Longitude: 045 23E. Soil physico-chemical properties were measured on soil samples taken at the depth of 0-30 cm. The experimental treatments included foliar spray of trace elements –B, Fe, Mn, and Zn – at five levels and no trace element application as control. The experimental plots consisted of 4 × 4 m² composed of eight sugar beet sowing rows on ridges with inter-row spacing of 50 cm and inter-plant spacing of 20 cm. After preparation, the plots were manually sown by wet planting in rows on April 3, 2012. The seeds were provided by the Naqadeh Sugar beet factory with 98% viability and 99% purity. The plots were thinned and weeded twice at 4-6-leaf stage and 6-8-leaf stage. Agronomic operations like weeds control, crust breaking, irrigation, etc. were performed manually. The plots were sprayed with micronutrients in two stages using a fog machine, for which spray was dissolved in water at 2-weeks interval during vegetative period in early hours of the day when it was cool and there was no wind. The micronutrient fertilizers Fe, Zn, B, and Mn at the rates of 1, 1, 2, and 3 l ha⁻¹ respectively were procured from a Company in Mashhad and applied according to producer recommendation. At harvest time, all plants were harvested after eliminating two marginal rows at 0.5 m from both ends of the plots. The sugar content and impurities of sugar beets including Na, K and amino-N were estimated by flame photometry in Sugar Technology Laboratory of Sugar beet Seed Institute, Karaj to estimate the differences among harvest periods in sugar percentage, N percentage, K and Na. The detached roots from the shoot were rinsed and turned into root pulp by sampling device. Then, their qualitative parameters were determined by betalyser (model D-3016) and flame photometer. Sugar percent and impurities of roots (amino N, K and Na contents) were measured by betalyser and flame photometer (Kunz, 2004). Molasses percent was calculated by Equation (1) (Dutton and Bowler, 1984).

$$MS(\%)=0.343(K+Na)+0.094(\alpha\text{-amino-N})-0.29 \quad (1)$$

Where, MS represents molasses, and K, Na, and amino N are expressed in meq 100 g⁻¹ sugar beet root.

White sugar percent or recoverable sugar percent was estimated as the difference in sugar percent and molasses percent using Equation (2) (Shoae et al., 2014).

$$ESC(\%)=SC(\%)-MS(\%) \quad (2)$$

Where, WSC represents recoverable sugar content, SC represents sugar percent, and MS represents molasses percent.

Sugar percent, or sugar content, includes recoverable sugar percent plus sugar percent of molasses. The sucrose content was measured by polarimetry method. The method is based on the deviation percent of polarized light. To measure qualitative parameters of the root, root pulp and lead acetate were mixed with the ratio of 26 g pulp and 177.7 cm³ lead acetate by automatic mixers.

Then, it was infiltrated by filter paper No. 42 and the extract was taken. Afterwards, sugar percent was determined by polarimetry method (Kunz, 2004).

Alkalinity shows that the juice is base and is of crucial importance in carbonation in terms of juice buffering capacity, CO₂ uptake, and Ca removal, so that the juice pH should not be less than a specific limit after dilute juice stage; otherwise, acidic inversion happens and sucrose turn into invert sugar. Alkalinity of the studied samples was calculated by Equation (3) (Aazam et al., 2016).

$$\text{Alkalinity} = \text{Na} + \text{K} / \text{N} \quad (3)$$

K and Na content of root pulp extract was measured in terms of meq per 100 g root pulp by flame photometer which compares the emission spectrum of the sample with that of lithium. Amino-N percent was estimated by betalyser. The device mixes the extract and copper reagent with equal ratios and monitors the color change, comparing it with the standards. It expresses amino-N percent in terms of meq per 100 g root pulp (Kunz, 2004).

The soil characteristics of the experimental area are given in Table 1. The results show that the soil had 9.1, kg/da P₂O₅, 0.70% organic matter, 0.06% Total N, 23.0% TNV, 55% SP, electrical conductivity of 0.721 dS/m, 39% clay, 43% silt, 18% sand, oH of 7.81, Fe of 8.71 mg kg⁻¹, Zn of 1.1 mg kg⁻¹, B of 0.33 mg kg⁻¹ and Mn of 11.65 mg kg⁻¹ (Table 1).

Table 1 Results of soil analysis

Nutrient and soil characteristics	Results
P ₂ O ₅ (kg/da)	9.1
K ₂ O (kg/da)	379
Organic matter (%)	0.70
Total N (%)	0.06
TNV (%)	23.0
SP (%)	55
EC (dS/m)	0.721
Clay (%)	39
Silt (%)	43
Sand (%)	18
pH	7.81
Fe (mg kg ⁻¹)	8.17
Zn (mg kg ⁻¹)	1.1
B (mg kg ⁻¹)	0.33
Mn (mg kg ⁻¹)	11.65

Results and Discussion

Results of analysis of variance (Table 2) showed significant differences among micronutrients application and control in extraction coefficient, sugar percent, sodium, nitrogen, recoverable sugar percent, alkalinity, molasses, potassium, and root yield (P<0.01) and white sugar yield at the 5% probability level.

Sugar Percent

Foliar application of micronutrients significantly influenced sugar percent (P<0.01-Table 2). Means comparison revealed that the highest sugar percent of

18.94% was related to Zn application, but the lowest one (18.11%) was observed in B treatment (Table 3).

Extraction Coefficient

Extraction coefficient was significantly influenced by the foliar application of micronutrients (P<0.01-Table 2). According to means comparison, Fe application resulted in the highest extraction coefficient of 89.31%, whilst the lowest coefficient (86.53%) was observed in control. No significant differences were observed among Fe, B and Zn treatments, but it showed significant differences with control and Mn application (Table 3). Foliar application of Fe improved growth and production of sugar beets (Fernandez et al. 2004). As well, it has been reported that Zn application improved sugar beet root yield significantly (Masri and Hamza 2015).

Recoverable Sugar Percent

It was observed that the application of different micronutrients caused significant differences in recoverable sugar percent (P<0.01-Table 2), sugar percent of 16.91% related to the treatment of Zn and the lowest one (16.16%) to the treatment of Mn (Table 3).

Molasses Percent

Molasses percent was significantly impacted by the application of micronutrients (P<0.01-Table 2). The highest and lowest molasses percents were obtained from control and B application (2.56 and 1.92%), respectively. There were no significant differences among Fe, B and Zn treatments (Table 3).

Potassium

The impact of micronutrients was significant on sugar beet potassium content (P<0.01-Table 2). Control exhibited the highest K content of 4.26 mg kg⁻¹ and B treatment showed the lowest one of 3.64 mg kg⁻¹ (Table 3).

Sodium

Micronutrients changed sugar beet sodium content significantly (P<0.01-Table 2). The highest and lowest Na contents were observed in control (1.77 mg kg⁻¹) and Fe treatment (0.83 mg kg⁻¹), respectively (Table 3).

Nitrogen

The effect of micronutrients was significant (P<0.01) on sugar beet nitrogen content (Table 2). Control and B treatment showed the highest and lowest N content (2.24 and 1.01 mg kg⁻¹), respectively (Table 3).

Alkalinity

Alkalinity was significantly (P<0.01-Table 2) influenced by micronutrients B treatment and control were associated with the highest and lowest alkalinity (4.5 and 2.66), respectively (Table 3).

Root and White Sugar Yield

The effect of micronutrients was significant on root yield (P<0.01) and white sugar yield (P<0.05-Table 2). The highest mean root yield (74.120 t ha⁻¹) and white sugar yield (12.137 t ha⁻¹) were observed in B and Fe treatments, respectively (Table 3).

Table 2 Analysis of variance for the effect of different elements on qualitative and quantitative traits of sugar beet cv. Sonja under Dsa (Hot Summer Continental) Climatic conditions of Naqadeh Iran

SOV	Df	Means of squares										
		K	Na	N	Al	S	EC	RS	M	RY	SY	WSY
Block	3	0.001	0.006	0.02	0.01 ^{ns}	0.08	0.18*	0.08 ^{ns}	0.002 ^{ns}	19.099	0.544	0.390
Micronutrie	4	ns	ns	ns	1.79**	ns	5.59**	0.43**		**	**	ns
Nts	1	0.25	0.58	0.96	0.05	0.49	0.04	0.04	0.28**	8.460	0.021	0.14
Experiment	2	**	**	**		**			0.002	**	ns	0*
Al error		0.005	0.003	0.03		0.04				1.062	0.071	0.068
C.V. (%)		1.94	5.29	12.51	6.3	1.11	0.24	1.32	2.13	1.42	1.98	2.19

SOV: Source of variation; Df: Degree of freedom; Al: Alkalinity; S: Sugar (%); EC: Extraction coefficient; RS: Recoverable sugar (%); M: Molasses (%); RY: Root yield; SY: Sugar yield; WSY: White sugar yield; ns, * and ** represent non-significance and significance at the 5 and 1% levels, respectively.

Table 3 Means comparison for the effect of different elements on qualitative and quantitative traits of sugar beet cv. Sonja under Dsa (Hot Summer Continental) Climatic conditions of Naqadeh Iran

T	K	Na	N	Al	S	EC	RS	M	RY	SY	WSY
	ppm	ppm	ppm	-	%	%	%	%	t ha ⁻¹	t ha ⁻¹	t ha ⁻¹
Control	4.26 ^a	1.77 ^a	2.24 ^a	2.66 ^c	18.88 ^{ab}	86.53 ^c	16.26 ^{bc}	2.56 ^a	71.472 ^b	13.495 ^a	11.630 ^b
Zinc	3.73 ^c	0.94 ^c	1.2 ^{bc}	3.9 ^b	18.94 ^a	89.25 ^a	16.91 ^a	1.98 ^c	70.915 ^b	13.430 ^a	11.995 ^{ab}
Iron	3.71 ^c	0.83 ^d	1.16 ^{bc}	3.92 ^b	18.56 ^{bc}	89.31 ^a	16.6 ^{ab}	1.93 ^c	73.097 ^a	13.572 ^a	12.137 ^a
Manganese	3.95 ^b	1.1 ^b	1.4 ^b	3.66 ^b	18.32 ^{cd}	88.12 ^b	16.16 ^c	2.1 ^b	73.963 ^a	13.565 ^a	11.952 ^{ab}
Boron	3.64 ^c	0.9 ^{cd}	1.01 ^c	4.5 ^a	18.11 ^d	89.11 ^a	16.17 ^c	1.92 ^c	74.120 ^a	13.420 ^a	11.982 ^{ab}

T: Treatment; Al: Alkalinity; S: Sugar (%); EC: Extraction coefficient; RS: Recoverable sugar (%); M: Molasses (%); RY: Root yield; SY: Sugar yield; WSY: White sugar yield; Means followed with similar letter(s) in each column had no significant differences (P<0.05) according to Duncan Test.

Discussion

Micronutrients have a significant effect on the extraction coefficient and the recoverable sugar percentage. It seems that the better availability of micronutrient elements leads to more effective absorption and greater availability of the nutrients and elements (Marschner, 1995). Fertilizer and physiological growth stages of a plant has significant positive interactions (Mandal et al., 2007). In similar studies, foliar application of micronutrients in different ontogenetic stages of plant growth were significant for important traits including plant yield (Sultana et al., 2016). Therefore, it is very important to optimize fertilizer efficiency for appropriate growth of a plant.

Micronutrients increase the yield and essential oil through the effect of manganese on photosynthesis and assimilates (Ziaei and Malakouti, 2001). Also, plant yield is affected by application of micro nutrients (Mandal et al., 2007). Enhancing non-sugar compounds in the sugar beet root extract prevents the sugar crystallization process in sugar beet factories and leads to an increase in the percentage of molasses sugar, which is in fact is an indicator for determining the decline in sugar production. The results revealed that the effect of drought stress in this cultivars on the given trait were not significant. The findings of the current study confirms that drought stress at the end of the growth period of sugar beet increased the amount of impurities of the root compounds and thus reduced the extraction efficiency.

Conclusion

The application of micronutrients influenced all studied traits significantly. The highest extraction coefficient was related to Fe foliar spray and the highest recoverable sugar percent was related to Zn application.

Root yield and white sugar yield were found highest in the treatments of B and Fe, respectively. Thus, the application of micronutrients may improve photosynthesis efficiency and leaf area duration of sugar beets and also, increase metabolic activities resulting in yield or sugar percent gain.

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