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Araştırma Makalesi (Research Article)

The Effects of Sugar Beet Molasses Applications on Root Yield and Sugar Content of Sugar Beet (*Beta vulgaris* L.)

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Abstract

The present study was carried out to determine effects of molasses obtained from sugar beet on yield and quality of sugar beet in Isparta, Turkey during 2011 and 2012 crop seasons. Different concentrations of molasses were applied to soil and to plant leaves at different doses (0, 25, 50, 75 and 100 kg/ha) 3 times during the vegetation period. The experiment was setup as factorial design with randomized complete block design with three replications. Molasses applications significantly increased root yield and quality compared to the control. Soil applications were more effective than foliar applications for all parameters studied. Molasses applications at more than 50 kg/ha for soil and foliar applications negatively affected plant and root growth and their effects was more pronounced in the foliar application. Molasses increased root yield by 20.4% in soil applications and by 9.6% in foliar applications compared to control. The highest root yield was obtained in the soil applications at 50 and 75 kg/ha (72.3 and 72.0 t/ha, respectively) and in the foliar applications at the same dose (66.1 t/ha). Sugar content and gross sugar yield significantly increased with molasses treatments by 1.2 % and 2.9 t/ha, respectively compared to control. It was concluded that sugar beet molasses can be used effectively in order to increase sugar beet yield and quality.

Anahtar Kelimeler: Molasses, sugar content, root yield, sugar beet

Melas Uygulamalarının Şeker Pancarında (*Beta vulgaris* L.) Kök Verimi ve Şeker Oranı Üzerine Etkilerinin Belirlenmesi

Öz

Bu araştırma şeker pancarı yan ürünü olarak üretilen melasın şeker pancarında kök verimi ve kalitesi üzerine etkilerini belirlemek amacıyla 2011-2012 yıllarında Isparta ekolojik koşullarında yürütülmüştür. Melasın farklı konsantrasyonları (0, 25, 50, 75 ve100 kg/ha) vejetasyon dönemi boyunca 3 kez toprağa ve bitki yapraklarına uygulanmıştır. Çalışma Tesadüf Blokları Deneme Planında Faktöriyel Düzenlemeye göre 3 tekerrürlü olarak kurulmuştur. Melas uygulamaları şeker pancarında kök verimi ve kalitesini kontrole göre önemli derecede arttırmıştır. Araştırmada incelenen tüm parametrelerde de melasın topraktan uygulanması yaprak uygulamalarına göre daha etkili bulunmuştur. 50 kg/ha'dan daha yüksek dozlarda yapılan melas uygulamaları bitki ve kök gelişimini olumsuz yönde etkilemiş, bu etki yaprak uygulamalarında daha belirgin olmuştur. Kontrol ile karşılaştırıldığında şeker pancarında kök verimi topraktan yapılan uygulamalarda % 20.4, yapraktan yapılan uygulamalarda ise % 9.6 daha yüksek olmuştur. Araştırmada en yüksek kök verimi topraktan yapılan melas uygulamalarında 50 ve 75 kg/ha (sırası ile 72.3 ve 72.0 t/ha) dozlarında, yapraktan yapılan uygulamalarda ise 50 kg/ha (66.1 t/ha) dozundan elde edilmiştir. Kontrol ile karşılaştırıldığında polar şeker oranı (% 1.2) ve polar şeker verimi (2.9 t/ha) melas uygulamaları ile birlikte önemli seviyede artış göstermiştir. Çalışmada melasın şeker pancarında kök verimi ve kalitenin arttırılmasında etkili bir şekilde kullanılabileceği sonucuna varılmıştır.

Keywords: Kök verimi, melas, şeker oranı, şeker pancarı

Introduction

Molasses is the residual syrup from the processing of sugar beet and sugar cane (Honma et al. 2012). Molasses is produced annually in large amounts and were used in different industries including animal feeding, alcohol and fertilizers. The use of sugar beet molasses in agriculture stimulates nutrient elements uptake efficiency and soil biological activity (Samatav and Samatav 2014). Numerous studies have shown that the molasses, organic acids, amino acids, humic and Fulvic acids have significant effects on plant growth. Sugar beet molasses contains different amounts of humic, fulvic and amino acids (Samatav and Samatav 2014). Humic substances are the major components of soil organic matter, and they are used in various areas of agriculture such as soil chemistry, fertility, plant physiology, as well as environmental sciences, because of multiple ways in which these materials can greatly benefit plant growth (Lobartini et al. 1997). Pujar (1995) reported that foliar application of molasses increased uptake of Zn, Cu, Fe and Mn in corn and wheat. Chandraju et al. (2008) reported that the use of a diluted solution of molasses will increase nutrient uptake and yield of leafy vegetables. Mohammadi Torkashv and Brimvandi (2008), reported that use of molasses increased total nitrogen and potassium and decreased available phosphorus in soil. The purpose of this study was to investigate the effects of soil and leaf application of sugar beet molasses on sugar beet root yield and sugar content.

Material and Method

The study was conducted at the research farms of Suleyman Demirel University, Isparta (37^{O} 45' N, 30^{O} 33' E, altitude 1035 m), during 2011 and 2012 crop seasons. Soil type of the experimental area was loam with a pH of 8.2. Nutrient content of the experimental area was determined for the entire location and it was divided two parts and each part was used to grow sugar beet during first and second year of the study separately. Total nitrogen content of the entire location was 0.18% (micro Kjelhdal method), extractable P and K contents were 18.5 mg/kg (Olsen method) and 166 mg/kg, respectively. Organic matter content of soil was 1.4% (Walcley-Black method). Total precipitation between April and October was 226 mm and 201 mm for the first and second years of the experiment, respectively, and for the same period the long term average rain fall was 188 mm. Average daily temperature was 19.7 ^{O}C and 18.8 ^{O}C, for 2011 and 2012 crop seasons, respectively. Long term average daily temperature between April and October was 18.1 ^{O}C. The experiment was setup as factorial design with two factors in a randomized complete block design with three replications. The molasses used in the present study was obtained from the Sugar Beet Industry, Burdur. Sugar beet seeds (cv. Esperanza) were purchased from KWS. Some chemical and physical properties of molasses used in the study: TSS: 79.5%, TS: 51%, pH: 5.8, Ash: 9.2%, N: 2.12%, P: 0.34%, K: 3.9%, Ca: 0.9%, Mg: 0.5%, S: 0.7%

Sowing was performed on 6-8th and 12-13th April in 2011 and 2012, respectively. Sowing rates were 8 kg/ha. Each plot was 6 m in length and consisted of 4 rows. Row spacing was 50 cm and intra-row spacing was 20-25 cm after thinning. Different concentrations of molasses were applied to soil and to plant leaves (0, 25, 50, 75 and 100 kg/ha) 3 times during the vegetation period. Molasses was applied to the soil (12 m^2) with drip irrigation systems on three different times (30, 60 and 90 days after completion). In addition, molasses were sprayed to leaves (12 m^2 of field) at the same time with a pulverizator. N-P-K (120-80-100 kg/ha) were incorporated into soil prior to sowing. Irrigation was performed with drip irrigation system when available soil moisture dropped below 50% in soil. Weed control was done with hand two to three times depending on weed density. Plants were harvested at 15-17th October and 22-24th October in 2011 and 2012, respectively. Average root weight and sugar content of roots were determined from middle row of each plot using 20 plants. Fresh root yield and biological yield were determined from rest of the plants within the same two rows. Data was subjected to the analysis of variance (ANOVA) procedure with SAS statistical program (SAS 2009). Means were separated using Duncan's multiple range tests at the 0.05 significance level.

Results and Discussion

According to ANOVA results, application method (A) and dose (D) effects were significant for all examined traits at 1% level of significance. Differences between years were significantly important for all examined traits at 1% level of significance except that sugar content. A x D interaction was important for all examined traits at 1% level of significance except that sugar content (5% level). No statistically significant interactions were detected between Y x A, Y x D and Y x D x C interactions (Table 1).

Average root weight was significantly increased by molasses application. Average root weight increased by 25% at the rate of 50 kg/ha molasses application compared to control. Average root weight in soil application (1202 g) was higher than foliar application (1103 g). The maximum average root weight was obtained in soil application at 50 kg/ha (1293 g) and higher doses and foliar application at 50 kg/ha (1250 g). Foliar application of molasses at a rate of more than 50 kg/ha resulted in significantly decreased average root weight (Table 2).

Molasses applications significantly increased root yield (Table 2). Differences between soil and foliar applications were significant for root yield. Mean root yield was higher in molasses soil applications (67.8 t/ha) than the foliar applications (61.5 t/ha). 50 kg/ha molasses applications increased the average root yield by 20% and 9.6% at soil and foliar applications, respectively. Foliar application of molasses at the rate of 100 kg/ha caused decrease in root yield by 9.8% compared to control (Table 2).

Molasses application significantly affected the biological yield. 50 kg/ha molasses application increased the biological yield by 17.6% compared to control. The maximum biological yield was obtained at 50 kg/ha (93.4 t/ha) and 75 kg/ha (91.7 t/ha) for soil applications and 50 kg/ha (88.6 t/ha) for foliar applications (Table 2). Foliar applications of molasses at higher doses decreased biological yield.

Molasses application methods had significant effect on polar sugar content. Soil applications of molasses were more effective than the foliar applications. The highest polar sugar content was obtained from 75 kg/ha (20.5%) and 50 kg/ha (20.3%) molasses soil applications (Table 2). 100 kg/ha foliar application of molasses and control produced the lowest sugar content (19.4%).

Both soil (24.4%) and foliar (12.8%) applications of molasses at the rate of 50 kg/ha increased gross sugar yield significantly. The differences of molasses doses between 50 kg/ha and higher concentrations was not significant for soil applications, while foliar applications at the rate of 100 kg/ha resulted significantly decreased gross sugar yield compared to control (Table 2).

Average root weight, root yield, biological yield and sugar yield were lover at the first year of the research than the second year. Mean weather temperature was higher at first year. High daytime temperatures could also lower root yield and yield reduction was attributed to stomatal closure by reducing photosynthesis and increasing respiration (Cooke and Scott 1995). Warmer temperatures accelerate development and early growth but have a negative effect on final biomass, due to canopy senescence and increase in maintenance respiration (Demmers-Derks et al. 1998). Molasses is used primarily as a source of K. It also contains secondary elements in small quantities such as P, S, Ca, Mg and numerous trace elements. Molasses also contains different amounts of humic and fulvic acids and amino acids exhibiting hormone-like activity (Samavat and Samavat, 2014; Leventoğlu and Erdal, 2014). The above described characteristics of the molasses might explain the yield increases of sugar beet root at the present research. Cleasby (1957), reported that the molasses application indicated a potential yield response of between 9-20% for sugar cane. Makela et al. (1998) stated that the Glycinebetaine, product from sugar beet, is

Table 1. Results of analyses variance (ANOVA) for the traits measured in the study

Çizelge 1. Araştırmada incelenen karakterlere ilişkin varyans analiz (ANOVA) sonuçları

Source of Variation	Df	Average root weight (g)	Root yield (t/ha)	Biological yield (t/ha)	Sugar content (%)	Gross sugar yield (t/ha)
Year (Y)	1	**	**	**	ns	**
Blok (Year)	4	*	*	ns	ns	*
Appl. (A)	1	**	**	**	**	**
Y x A	1	ns	ns	ns	ns	ns
Doses (D)	4	**	**	**	**	**
Y x D	4	ns	ns	ns	ns	ns
A x D	4	**	**	**	*	**
Y x A x D	4	ns	ns	ns	ns	ns
Error	36					
CV		5.6	4.3	3.6	0.95	4.5

Df: Degrees of freedom. ns: non significant. * P<0.05; ** P<0.01

Df: Serbestlik derecesi. ns: önemli değil. * P<0.05; ** P<0.01

purified from molasses during sugar processing, increased the yield and the number of tomato fruits and increased the rate of net photosynthesis of tomato plants. Molasses contains high levels of sugar and its fermentation causes productions of CO_2 (Mweresa et al. 2014). Releasing of CO_2 from fermentation of molasses creates an additional carbon source to the plant (Quan et al. 2005) and thus, photorespiration rate of the plants reduced and net photosynthesis increase (Nonomura and Benson 1992).

Soil application of molasses on sugar beet growth was more effective than foliar applications. Apart from supplying nutrients, some of the other beneficial effects of molasses reported by researchers included a physical improvement in soil structure and an increase in the biological activity of beneficial micro-organisms such as soil fungi, following partial sterilization of the soil (Wynne and Meyer 2002). On the other hand, molasses contains large quantities of fermentable sugars that can temporarily immobilize or tie up plant

Table 2. Effects molasses applications on average root weight, root yield, biological yield, polar sugar content and polar sugar yield of sugar beet

Çizelge 2. Melas uygulamalarının şeker pancarında ortalama kök ağırlığı, kök verimi, biyolojik verim, polar şeker oranı ve polar şeker verimine etkileri

Doses (kg/ha)	2011			2012			Mean		
	Soil	Foliar	Mean	Soil	Foliar	Mean	Soil	Foliar	Mean
				Average Root Weight (g)					
0	924	923	923	1127	1095	1111	1025	1008	1017C
25	1130	1018	1077	1300	1198	1253	1215	1108	1165B
50	1209	1143	1176	1377	1358	1368	1293	1250	1272A
75	1165	1041	1103	1303	1207	1255	1234	1124	1179B
100	1171	912	1042	1296	1132	1214	1233	1022	1128B
Mean	1121	1007	1064b	1282	1198	1240a	1202a	1103b	
							Lsd $_{Dose\ x\ Appl.}$: 75.9		
				Root Yield (t/ha)					
0	59.1	59.5	59.3	61.5	61.1	61.3	60.3	60.3	60.3C
25	62.3	62.8	62.5	65.5	64.2	64.8	63.9	63.5	63.7B
50	70.6	65.9	68.2	73.9	66.3	70.1	72.3	66.1	69.2A
75	69.7	62.3	66.0	74.2	64.1	69.2	72.0	63.2	67.6A
100	68.6	52.9	60.7	72.9	56.0	64.5	70.8	54.4	62.6B
Mean	66.0	60.7	63.4b	69.6	62.3	66.0a	67.8a	61.5b	
							Lsd $_{Dose\ x\ Appl.}$: 3.2		
				Biological Yield (t/ha)					
0	75.9	76.8	76.4	78.5	78.4	78.4	77.2	77.6	77.4D
25	80.6	82.1	81.4	84.5	85.2	84.9	82.6	83.7	83.1C
50	90.3	86.4	88.4	96.5	90.8	93.7	93.4	88.6	91.0A
75	88.4	81.1	84.8	94.9	83.4	89.2	91.7	82.3	87.0B
100	84.7	68.9	76.8	86.6	73.4	80.0	85.7	71.2	78.4D
Mean	84.0	79.1	81.5b	88.2	82.2	85.2a	86.1a	80.7b	
								Lsd $_{Dose\ x\ Appl.}$: 3.5	
				Sugar Content (%)					
0	19.6	19.5	19.5	19.7	19.3	19.5	19.7	19.4	19.5C
25	19.8	19.7	19.8	19.9	19.6	19.8	19.9	19.7	19.8B
50	20.3	20.0	20.2	20.2	20.0	20.1	20.3	20.0	20.1A
75	20.6	19.8	20.2	20.4	19.9	20.2	20.5	19.8	20.2A
100	20.0	19.4	19.7	19.9	19.4	19.6	19.9	19.4	19.7BC
Mean	20.1	19.7	19.9a	20.0	19.6	19.8a	20.0a	19.7b	
								Lsd $_{Dose\ x\ Appl.}$: 0.22	
				Gross Sugar Yield (t/ha)					
0	11.6	11.6	11.6	12.1	11.8	12.0	11.9	11.7	11.8C
25	12.4	12.4	12.4	13.0	12.6	12.8	12.7	12.5	12.6B
50	14.3	13.1	13.7	15.0	13.2	14.1	14.7	13.2	13.9A
75	14.4	12.3	13.4	15.2	12.7	14.0	14.8	12.5	13.7A
100	13.7	10.3	12.0	14.5	10.9	12.7	14.1	10.6	12.3B
Mean	13.3	11.9	12.6b	14.0	12.2	13.1a	13.6a	12.1b	
								Lsd $_{Dose\ x\ Appl.}$: 0.68	

*,**; There is no significant difference between the groups with the same letters at 5% level.

,; Aynı harf grubuna girenler arasında %5 seviyesinde önemli farklılıklar yoktur.*

available nitrogen in organic form, causing leaf yellowing due to transient N deficiency (Wynne and Meyer, 2002). Foliar application of molasses at high doses showed negative effects on sugar beet growth. Due to the adhesive properties of the molasses, airborne dust and particles readily adhere to the leaves and could decrease stomatal conductance. In addition, high doses molasses applications at 90 days after emergence caused leaf deformations (leaves have a hard and brittle structure) and fragmentation due to the high temperatures during the applications period (August). This situation could cause a reduction of leaf photosynthesis area in plants at high doses. De Kreij and Basar (1995), reported that, high doses of humic acid applications could cause creation of complex compounds in the soil and in leaves resulting decreased nutrient uptake by roots and leaves. Similarly, it was reported that application of high doses of organic compounds had no or negative effects on plant growth (Tan and Nopamonbodi 1979; Leventoğlu and Erdal 2014).

Based on the present study, it was concluded that root and polar sugar yield can be increased (more than 20%) with molasses applications and 50 kg/ha molasses application to soil gave the best results. Further research is required in diverse planting environments to determine economically feasible application level of molasses while comparing it with other manures and organic fertilizer sources.

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