Effect of Treated Filter Cake on Yield and its Components of Sugar Beet under Saline Soil Condition

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Abstract

Sugar beet, the first sugar crop in Egypt, is one of the most salt tolerant crops. Tremendous amounts of sugar beet industrial byproducts, including filter cake, are annually produced from beet sugar factories causing environmental problems. A field experiment was conducted at the Research Farm of Delta Sugar Company, Kafr El-Sheikh during the two successive seasons of 2017/2018 and 2018/2019 aiming to the response of sugar beet to application of sulphuric and phosphoric acids-treated filter cake under saline soil condition in terms of growth, yield and quality.
Application of 1 ton/fed. of treated filter cake significantly enhanced root length, diameter and leaf area in both growing seasons. The highest values of root length and diameter, leaf area, root and top yields were obtained from the application of either 1 or 2 tons/fed. of treated filter cake. Molasses application led to significant enhancement of root length and diameter and leaf area as well. Application of molasses at the rate of 50 L/fed. significantly increased root and top yields.

Keywords: Sugar beet; Soil amendments; Filter cake; Molasses; Soil salinity.

Introduction

Sugar beet (*Beta vulgaris* L) is the is ranked as the first sugar crop in Egypt (www.fao.org). The importance of the crop comes not only from its ability to grow in the newly reclaimed soils, but from its ability to produce a higher sugar content in short growing season. Water scarcity, steady population growth and decreasing sugarcane harvested area necessitate the expansion in sugar beet cultivation to overcome the gap between sugar production and consumption in Egypt ***(Abo-Elwafa et al. 2006; Abou-Elwafa 2010; Abo-Elwafa et al. 2013).*** Sugar beet is one of the most salt tolerant crops, however it is less tolerant during seed germination and seedling establishment. Increasing of EC level above 6 dSm^{-1} drastically reduces seedling emergence rate and dry weight ***(Kaffka and Kurt 2004).*** In addition, increasing soil salinity level significantly reduces germination%, germination rate, seedling length, seedling fresh weight and seedling vigor of all sugar beet varieties under investigation to different extents ***(Abd El-Hady et al. 2014).*** Furthermore, soil salinity resulted in osmotic and oxidative stress, ion toxicity, nutritional imbalances, decreasing cell division and changes in metabolic processes such as photosynthesis, respiration, and disruption of plant membranes disorganization of ***(Hasanuzzaman et al. 2014).***

In Egypt, tremendous amount of sugar beet industrial byproducts are produced from beet sugar factories. These industrial byproducts are increasing annually causing environmental pollution. Filter cake, a byproduct of using the lime stones in juice clarification, is an important byproduct which contains organic matter and have relatively high CEC values. Thus, a beneficial utilization of the large quantity of lime wastes (filter cake) produced annually is a great challenge ***(Ippolito et al. 2013).*** Superphosphate (Delta Superphosphate) was produced from filter cake, which is mainly composed of calcium carbonate, when it was mixed with a 1:1 diluted phosphoric acid after using different portions and mixing for a definite time, and sulphuric acid (98%) in different proportions for a definite time ***(Abd El-Samea 2009).***Beside, some chemical

properties of the soil was greatly improved when a mixture of byproducts including filter cake treated with commercial H_2SO_4 was applied ***(Amer 2015).*** Application of phosphogypsum (PG) which has been traditionally applied as Ca-amendment in saline soils increased sugar beet yield ***(Rymar' et al. 2003; Abril et al. 2009).***

Humic acid, which is major components of soil organic matter, have multiple roles in plant growth and in various areas of agriculture, such as soil chemistry, soil fertility and plant physiology ***(Ouni et al. 2014).*** Foliar application of Humic acid at rates of 15, 20 and 25 g/ L significantly improved sugar beet growth parameters, i.e., root length, diameter and size, number of leaves, root and leaves fresh weight, root and leaves dry weight and root yield ***(EL-Gamal et al. 2016).*** Furthermore, soil physical and chemical properties and nutrient dynamics were substantially improved in response to application of the natural material Potassium humate ***(K-humate) (Abd-All et al. 2017).*** Application of sugar beet molasses mitigates the negative effects of salinity on tomato growth ***(El-Tokhy et al. 2019).***

The objective of the present study is to investigate effect of filter cake treated with sulphoric and phosphoric acids and some other amendments on growth and yield of sugar beet.

1. Material and methods

1.1. Plant material and evaluation

A field experiment was conducted at the Delta Sugar Company Research Farm, El-Hamool, Kafr El- Sheikh, Egypt during the two successive growing seasons of 2017/2018 and 2018/2019. The sugar beet cultivars Top and Bleno was grown in the first and second growing seasons, respectively.

Table 1: Basic physical and chemical properties of experimental soil.

Parameters	2017/2018	2018/2019
Silt %	23.6	24.7
Sand %	29.1	28.3
Clay %	47.3	47.0
Texture grade	Clayey loam	Clayey loam
$CaCO_3$%	3.8	4.7
pH	7.97	8.20
EC dSm^{-1}	8.67	7.50
Soluble cations, meq L^{-1}		
Ca^{2+}	32.70	26.22
Mg^{2+}	20.35	20,75
Na^{+}	32,32	27.26
K^{+}	1.40	1.54
Soluble anions, meq L^{-1}		
Cl^{-}	52.00	42.55
HCO_3^{-}	4.00	5.16
SO_4^{2-}	30.78	28.06
Available nutrients ppm		
N	30	28
P	7.5	7.6
K	366.6	460

Plants were grown on October 22, 2017 and 2018 and harvested on May 15, 2018 and 2019 in the first and second growing seasons, respectively. Seeds were hand sown at 15-20 cm spaces in a 15 m^2 plot consists of 5 rows of 5 m length, with a distance of 60 cm between rows. Recommended doses of N, P and K and all other cultural practices were performed according to locally recommended practices for sugar beet production. The main soil properties (0-20 cm depth) are described in Table 1. Analysis of the physical and chemical properties of the soil was performed according to ***Bao (2005).***

At harvest, root length and diameter (cm), leaf area (cm^2), root yield (t/fed.) and shoot fresh weight (top yield; t/fed.) were determined.

1.2. Soil amendments and filter cake treatment

Four soil amendments, i.e., Phosphogypsum (PG) which is a byproduct of the processing of phosphate rock in plants producing phosphate fertilizers such as superphosphate and phosphoric acid, Desal which is a desalination commercial product, Humic acid and treated filter cake. To convert the filter cake (lime cake) from deleterious material to useful material, the filter cake produced from Delta Sugar Company stored from the previous years was treated with a mixture of sulphoric and phosphoric acids (1.5:1) (18+12 cm^3/100g). The final product contains a mixture of gypsum and monocalcium phosphate beside a portion of calcium carbonate. All four types of soil amendments were sprayed on the soil surface before sowing.

1.3. Experimental design and statistical analysis

Experiments arrangement were designed in a four-replicates randomized complete block design (RCBD) in a split plot design. The main plots were assigned to six soil amendment treatments, i.e., control treatment (without amendments), 1ton/fed. of treated filter cake, 2 tons/fed. of treated filter cake, 1ton/fed. of phosphogypsum (PG), 4 l/fed. of Desal (desalinization), sprayed on the soil surface before sowing and 4 l/fed. of Humic acid sprayed on the soil surface before sowing. The sub-plots were assigned to three molasses treatments, i.e., control treatment (without molasses application), 25 L/fed. of molasses sprayed on the soil surface before sowing and 50 L/fed. of molasses sprayed on the soil surface before sowing. The Proc Mixed of SAS 130 package version 9.2 was used to perform analysis of variance (ANOVA), Fisher's least significant difference (LSD), of significantly differed treatments was calculated**.**

2. Results and discussion

2.1. Application of treated filter cake and molasses enhances sugar beet growth

Application of 1 ton/fed. of treated filter cake significantly enhanced root length, diameter and leaf area in both growing seasons (Table 2). The highest values of root length in both growing seasons (26.48 and 25.68 in the first season and 25.29, and 25.14 in the second season) were obtained from the application of 1 and 2 tons/fed. of treated filter cake, respectively. No significant difference between the application of either 1 or 2 ton/fed. of treated filter cake was observed in root length. Likewise, the application of 1 and 2 ton/fed. of treated filter cake resulted in the highest root diameter in both growing season , however the differences between the application of either 1, 2 ton/fed. of treated filter cake, Desal (12.02cm) or humic acid were insignificant (Table 2). The largest leaf area (168.42 cm^2) was obtained from the application of 1 ton/fed. of treated filter cake in the first growing season. Meanwhile, in the second growing season the highest leaf area (238.75 cm^2) resulted from the application of Desal, however it was not significantly different from that resulted from the application of 1 ton/fed. of treated filter cake (Table 2). The action of treated filter cake in enhancing root length, diameter and leaf area could be attributed to its high calcium content that dramatically improves soil properties and hence enhances sugar beet growth. The difference pattern observed in the leaf area between the two growing seasons could due to the cultivation of a different cultivars. The application of 25L of molasses/fed. resulted in the highest root diameter in the first season, while in the second season the application of molasses at 50 L/fed. produced the highest leaf area without significant difference between either application rates.

The interaction between soil amendments and molasses exhibited significant effects on root length, diameter and leaf area in

the first growing season, while in the second growing season the s[illegible] ficant effects were only observed on leaf area (Table 2). The highest root length and leaf area values in the first growing season (27.50 cm and 181.75 cm^2) were obtained from the application of 1 ton/fed of treated filter cake and 25L molasses/fed. Meanwhile, the application of Desal in combination with either 25L or 50L of molasses per feddan resulted in the highest root diameter in the first reason (12.65 cm), and leaf area in the second season (248.75).

2.2. Soil amendments improve root and top yields

Soil amendments revealed highly significant effects on root, top yields and sugar content. The highest root yields (26.11 and 29.43 tons/fed.) in the first and second growing seasons, respectively, were obtained from the application of 1 ton/fed of treated filter cake. The highest top yield (7.66 and 15.75 tons/fed.) were obtained from the application of Desal in the first growing season and 1 ton/fed of treated filter cake in the second growing season (Table 3).

Table 2: Effect of soil amendments and molasses application on root length and diameter as well as leaf area in the two growing seasons 2017/2018 and 2018/2019.

Soil amendments	Molasses	Root Length (cm)	Root diameter (cm)	Leaf area (cm^2)	Root Length (cm)	Root diameter (cm)	Leaf area (cm^2)
Control	Control	18.45 d	9.27 e	124.00 de	22.77	12.92	139.50 f
	25L Molasses	20.32 cd	10.33 cde	157.75 abc	23.67	13.30	159.50 ef
	50L Molasses	20.22 cd	9.95 de	146.50be	23.80	13.70	168.00 def
Mean		19.66c	9.85b	140.88c	23.41b	13.31b	155.67d
Filter cake (1 t/fed.)	Control	27.25 a	12.02 ab	172.75 ab	25.38	15.20	235.50 ab
	25L Molasses	27.50 a	11.97 ab	181.75 a	25.20	14.72	224.00 abc
	50L Molasses	24.68 b	11.92 ab	150.75 bcd	25.30	14.47	233.00 abc
Mean		26.48	11.97a	168.42a	25.29a	14.80a	230.83a
Filter cake (2 t/fed.)	Control	27.00 a	12.60 ab	173.75 ab	24.90	13.77	198.50 cd
	25L Molasses	24.77 b	11.95 ab	156.25 abc	25.15	14.32	205.00 bc
	50L Molasses	25.27 b	12.20 ab	158.25 abc	25.37	14.65	209.00 bc
Mean		25.68a	12.25a	162.75a	25.14a	14.25b	204.17b
Phosphogypsum	Control	21.12 c	10.00 de	139.50cde	23.80	13.25	166.75 def
	25L Molasses	18.57 d	9.77 de	120.25 e	24.57	13.47	232.25 abc
	50L Molasses	21.08 c	9.90 de	141.75 cde	24.67	14.05	238.50 ab
Mean		20.26c	9.89b	133.83d	24.35ab	13.59b	212.50b
Desal	Control	21.10 c	11.20 bc	140.00cde	24.85	14.07	239.25 ab
	25L Molasses	23.82 b	12.65 a	156.50 abc	24.92	14.10	228.25 abc
	50L Molasses	24.00 b	12.20 ab	153.25 abc	25.12	14.32	248.75 a
Mean		22.97b	12.02a	149.92bc	24.96a	14.16ab	238.75a
Humic acid	Control	21.15 c	10.70 cd	142.00 cde	23.80	13.30	166.75
	25L Molasses	21.90 c	12.57 ab	152.75 abc	23.87	13.35	171.75 def
	50L Molasses	24.65 b	12.35 ab	163.25 abc	24.65	13.90	175.75 de
Mean		22.57b	11.87a	152.67b	24.11ab	13.52c	171.42b

The highest sugar contents (19.91 and 19.38%) in the first and second growing seasons, respectively, resulted from the control treatment. This may be due to the presence of high calcium content ions in the treated filter cake which is antagonized with sodium ions and enhance soil aggregation which improves soil properties, plant growth and yield. Sugar percentage was decreased as increasing root yield by the dilution effect (Mohamedin et al 2012; Shaheen et al. 2017).

Table 3: Effect of soil amendments and molasses application on root and top yields in the two growing seasons 2017/2018 and 2018/2019.

Growing season		2017/2018		2018/2019	
Soil amendments	Molasses	Root Yield (t/fed.)	Top yield (t/fed.)	Root Yield (t/fed.)	Top yield (t/fed.)
Control	Control	18.13 gh	4.16 de	21.70 g	8.18 i
	25L Molasses	20.30 efg	4.25 de	23.05 f	9.48 ghi
	50L Molasses	19.39 fgh	4.57 d	23.83 ef	9.95 gh
Mean		19.27e	4.33d	22.86d	9.20e
Filter cake (1 t/fed.)	Control	26.03 a	5.02	31.05 a	16.50 a
	25L Molasses	27.20 a	4.79 d	28.40 bc	16.35 a
	50L Molasses	25.10 ab	4.17 de	28.85 b	14.40 b
Mean		26.11a	4.66d	29.43a	15.75a
Filter cake (2 t/fed.)	Control	25.92 ab	7.01 b	26.25	12.15 de
	25L Molasses	24.87 abc	5.72 c	26.95 cd	11.85 de
	50L Molasses	25.22 ab	4.79 d	28.43 bc	12.30 de
Mean		25.34b	5.84c	27.21b	12.10c
Phosphogypsum	Control	20.90 ef	6.89 b	23.70 ef	9.10 ghi
	25L Molasses	17.28 h	2.68 f	25.50 de	9.80 gh
	50L Molasses	19.39 fgh	3.50 e	26.10 d	11.17 ef
Mean		19.19e	4.36d	25.10c	10.02d
Desal	Control	21.95 de	6.89 b	26.75 d	13.60 bc
	25L Molasses	23.35 bcd	9.46 a	25.45 de	12.45 de
	50L Molasses	23.35 bcd	6.65 b	26.85 cd	13.05 cd
Mean		22.88d	7.67a	26.35b	13.03b
Humic acid	Control	22.48 cde	6.73 b	23.70 ef	9.00 hi
	25L Molasses	23.50 bcd	6.34 b	23.55 ef	9.43ghi
	50L Molasses	24.69abc	7.22 b	25.95 d	10.50 fg
Mean		23.56c	6.76b	24.40d	9.64e

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الملخص العربي

تأثير إضافة الطينة الصفراء المعالجة على محصول بنجر السكر ومكوناته تحت ظروف الاراضى الملحية

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1) **أجريت تجربة حقلية بالمزرعة البحثية لشركة الدلتا للسكر، مصنع الحامول – محافظه كفرالشيخ خلال الموسمين2017/2018و2018/2019باستخدم تصميم القطاعات كاملة العشوائية بترتيب القطع المنشقة في أربعة مكررات. كان الهدف من هذه الدراسة هو تقييم بعض المحسنات الارضية مثل الطينة الصفراء المعالجة بخليط من حمضي الكبريتيك والفسفوريك وفوسفوجيبسيم وحمض الهيوميك وكذلك مركب ديسال(مركب تجاري)علي محصول بنجر السكر ومكوناته تحت ظروف الأراضي الملحية. شغلت القطع الرئيسية بستة محسنات تربة: تم استخدام الطينة الصفراء المعالجة بمعدل1و2 طن للفدان ، فوسفوجيبسيم، بمعدل 1 طن للفدان، دي سال 4 بمعدل لتر للفدان، حمض الهيومك بمعدل 4 لتر للفدان. و شغلت القطع المنشقة بثلاثة معدلات للمولاس هي بدون مولاس، 25 لتر مولاس للفدان، 50 لتر مولاس للفدان.**

2) **يمكن تلخيص أهم النتائج المتحصل عليها في الآتي: أدى استخدام المحسنات الارضية الى زيادة معنوية في نمو محصول بنجر السكر تحت ظروف الاراضي الملحية وكان لاستخدام الطينة الصفراء المعالجة بخليط من حمضي الكبريتيك والفسفوريك الأثر الأكبر مقارنة بالمحسنات الاخرى، حيث ادت اضافة الطينة الصفراء المعالجة بمعدل1 طن للفدان سواء منفردة اومع اضافة المولاس إلي اعلي قيم لطول وقطر الجذر ومساحة الاوراق ومحصول الجذور في كلا موسمي النمو. في حين كانت اقل قيم للصفات المدروسة مع معامله الكنترول.**

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