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Productivity and Quality of Some Sugar Beet Varieties As Affected By Bacterial Inoculation and Inducing Materials in Saline Soil

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Abstract

Two field experiments were carried out during the winter seasons of 2020/2021 and 2021/2022 at Ras–Sudr experimental station, Desert Research Center, Western Sinai Peninsula, Egypt. The main objective of this study was to evaluate yield and yield components as well as juice quality of three sugar beet varieties (Raspoly, Halawa and Melodia) as affected by six combinations between bacterial inoculation and inducing material treatments under saline soil conditions. Results showed that the Halawa variety gave the highest values and highly significance for sucrose% and purity%. While the Melodia variety gave the highest values and highly significance for sugar yield. While, Raspoly variety gave the highest values and highly significance for root length over the combined analysis. Yield, its components, and juice quality of sugar beet, i.e., root length, root diameter, sugar yield, sucrose%, purity%, Na%, K% and proline were highly significantly as affected by the combinations between bacterial inoculation and inducing material treatments in the combined analysis. A significant impact of the interaction between sugar beet varieties and the combinations between bacterial inoculation and inducing material treatments was gained for root length, root diameter, sugar yield, sucrose% and purity% in the combined data. It could be complemented that under the conditions of the experiment, planting Raspoly or Halawa or Melodia variety with the combinations between bacterial inoculation and foliar application with proline treatment under saline soil conditions is recommended.

Keywords: *Sugar beet varieties, Saline soil, Bacterial inoculation, Inducing materials, Yield and its components*.

Introduction

Sugar beet is the most important industrial sugar crop that can be cultivated under a wide range of climatic conditions. Egypt suffers from a gap between the consumed and produced sugar which reaches nearly one million ton. Wherefore, many studies are being performed to decrease the gap between the production and consumption through horizontal and vertical expansion of sugar beet production. It is difficult to increase the horizontal expansion in the Nile valley and delta areas. Therefore, the researchers turned to try to cultivate this crop in the newly reclaimed lands which are mainly saline soil. Salinity is one of the major environmental factors that severely limit the growth and yield of crop plants because most of crop plants are sensitive to salinity caused by high concentrations of salts in the soil (**Kronzucker and Britto 2011**). Many different approaches and practices may need to be combined to increase plants tolerance to salinity.

Yield, its components, and juice quality of sugar beet have been reported to be significantly affected by varieties (**Safina and Abdel Fatah 2011, Ahmad *et al* 2012, Wu *et al* 2013, Zaki *et al* 2014, Mehanna *et al* 2017, Abu-Ellail *et al* 2019, Kaloi *et al* 2020 and El-Kady *et al* 2021**).

The application of plant growth promoting rhizobacteria (PGPRs), like N_2 fixing bacteria, has been highlighted as a feasible way to help plants to tolerate environmental stresses as it is relatively cost-efficient and easy to used. Several reports showed that the inoculation of plants with N_2 fixing bacteria with mineral fertilizers improved the yield, yield components and root quality of sugar beet plants **(Mahmoud *et al*, 2014, Rashed *et al* 2016, Karagöz *et al* 2018, Gomaa *et al* 2019 and Sarhan and El-Zeny 2020)**. Inducing materials such as salicylic acid (SA) and proline have been widely applied to enhance the growth and development of plants. Foliar application of inducing materials led to improving plant growth characteristics and enhanced the tolerance capacity of plants under abiotic stresses as well as it protects the plant from oxidative stress by increasing antioxidant enzymes activity, and finally improving traits of sugar beet crop (**Merwad 2015, Merwad 2016, Khalil *et al* 2020, AlKahtani *et al* 2021 and El-Gamal *et al* 2021**).

Therefore, the present investigation was designed to study the performance and productivity of three sugar beet varieties with six combinations between two bacterial inoculation and three inducing materials treatments under saline soil conditions, in Ras–Sudr region, Western Sinai Peninsula, Egypt.

Materials and Methods

The present study was carried out during the winter seasons 2020/2021 and 2021/2022 at Ras–Sudr experimental station, Desert Research Center, Western Sinai Peninsula, Egypt, to study the effect of six combinations between bacterial inoculation and inducing material treatments i.e. None-inoculation+foliar application with water (Control), None-inoculation+foliar with salicylic acid 200 g fed^{-1}, 2-None-inoculation+foliar with proline 100 g fed^{-1}, Inoculation with biogene+foliar application with water, Inoculation with biogene+foliar application with salicylic acid 200 g fed^{-1} and Inoculation with biogene+foliar application with proline 100 g fed^{-1} on yield and yield components as well as juice quality of three sugar beet varieties (Raspoly, Halawa and Melodia) under saline soil conditions.

The soil was sandy loam in texture, pH value, organic carbon content%, CaCO3 (g kg^{-1}) and EC (dSm^{-1}) were 8.12, 0.15%, 58.15 g kg^{-1} and 7.6 average of the first and second growing seasons.

The treatments were designed in split-plot in a randomized complete block design (RCBD) with three replications. Sugar beet varieties were allocated to the main plots while, the combinations between bacterial inoculation and inducing material treatments occupied the sub-plots. The sub-plot area was 10.5 m^2.

Varieties of sugar beet were sown on 30th September in the first and second growing seasons. P fertilizer with the average of 30 kg P_2O_5 fed^{-1} was one similar dose as calcium super phosphate form (15.5% P_2O_5) applied at soil preparation. The nitrogen fertilization was applied in the form of urea (46% N) at a rate of 75 kg fed^{-1} as well as potassium sulfate fertilizer (48% K_2O) at a rate of 48 Kg K_2O fed^{-1} were added as liquid fertilizer. The common cultural pursuits were carried out as locally recommended for sugar beet cultivation.

At harvest, five plants were randomly selected from each sub-plot to determine root length (cm) and diameter (cm). Sugar yield (ton fed^{-1}) was calculated according to the following equation = Root yield (ton fed^{-1}) × sucrose %. Purity% was calculated according to **Carruthers *et al.* (1962)**. Proline concentration was measured in fresh leaves according to **Bates *et al.* (1973)**. For Na% and K% a sample of 100g of roots was randomly taken from each treatment and digested, then determined using flame photometer according to **Brown and Lilliland (1964).**

Analysis of difference was done for the data of every season individually and a combined analysis was performed for the data over the first and second seasons as stated by **Snedecor and Cochran (1980)** treatment means were compared using the least significant difference test at 0.05 level of significance. Using the MSTAT-C Statistical Software package **(Michigan State University, 1983)**.

Results And Discussion

Analysis of variances for the all treatments in each growing season moreover the combined analysis is shown in Table 1. Test of homogeneity detected that the error difference for the first and second growing seasons were homogenous, therefore the combined analysis was performed. Year's mean squares were significant only for root diameter. Sugar beet varieties mean squares were significant for root length and sucrose% in first and second growing seasons as well as the combined data, for sugar yield in the second growing season and the combined data and for purity% in the first growing season and the combined data. The combinations between bacterial inoculation and inducing material treatments mean squares were highly significant for all studied characteristics in the first and second growing seasons as well as the combined data. The interaction between years and sugar beet varieties mean squares was not significant for all studied characteristics. The interaction between years and the combinations between bacterial inoculation and inducing material treatments mean squares was insignificant for all of the studied characteristics. The interaction between sugar beet varieties and the combinations between bacterial inoculation and inducing material treatments mean squares was not significant for all studied characteristics except for root length which was highly significant in the second growing season as well as in the combined data, root diameter was significant in the first growing season and the combined data, sugar yield and sucrose% were highly significant or significant in both growing seasons and the combined data, purity% was highly significant in first growing season and the combined data, K% was highly significant only in the first growing season. The interactions between years, sugar beet varieties and the combinations between bacterial inoculation with inducing material treatments mean squares were not significant for all studied traits.

Effect of varieties.

The outcomes indicated in Table 2 clearly showed that, there were highly significant variances between varieties in root length, sugar yield, sucrose% and purity% in the combined analysis. The variety Halawa gave the greatest values of sucrose% (20.63%) and purity% (87.74%) under saline soil. While the variety Melodia produced the highest values of sugar yield (5.30 ton fed^{-1}) under saline soil. However, the greatest value of root length (26.68 cm) was obtained from the variety Raspoly under saline soil.

It could be complemented that varietal variations among sugar beet varieties may be because genetic makeup. The results were obtained by **Safina and Abdel Fatah (2011), Ahmad *et al.* (2012), Wu *et al.* (2013), Zaki *et al.* (2014), Mehanna *et al.* (2017), Abu-Ellail *et al.* (2019), Kaloi *et al.* (2020) and El-Kady *et al.* (2021)** indicated marked differences among sugar beet varieties in yield, yield components and juice quality .

Table 1. Mean square values and significance for yield, its components and chemical analyses of sugar beet in 2020/2021, 2021/2022 growing seasons and their combined analysis

SOV	df	Root length (cm)	Root diameter (cm)	Sugar yield (ton fed^{-1})	Sucrose %	Purity %	Na %	K %	Proline (mmol g^{-1})
					2020/21 season				
Rep	**2**	0.474	0.522	0.009	0.000	0.229	0.086	0.000	0.013
Var.	**2**	36.20**	0.288	0.038	0.02*	0.62*	0.072	0.001	0.009
Err.(a)	**4**	1.126	0.141	0.010	0.002	0.054	0.021	0.001	0.005
I.	**5**	9.02**	11.49**	5.09**	1.44**	47.84**	0.33**	0.32**	9.50**
VxI	**10**	0.438	0.43*	0.04*	0.01**	0.69**	0.016	0.002**	0.003
Err.(b)	**30**	0.211	0.193	0.015	0.004	0.162	0.028	0.000	0.009
					2021/22 season				
Rep	**2**	0.998	0.051	0.004	0.002	0.014	0.004	0.002	0.000
Var.	**2**	32.95*	0.025	0.03*	0.03*	0.099	0.011	0.006	0.001
Err.(a)	**4**	2.846	0.063	0.002	0.003	0.059	0.010	0.003	0.007
I.	**5**	11.39**	11.01**	4.94**	1.42**	50.05**	0.33**	0.31**	9.94**
VxI	**10**	0.89**	0.073	0.01**	0.01**	0.25**	0.006	0.006	0.001
Err.(b)	**30**	0.246	0.100	0.002	0.004	0.064	0.006	0.005	0.003
					Combined analysis				
Years	**1**	0.992	0.82*	0.001	0.001	0.000	0.014	0.007	0.001
R(Y)	**4**	0.736	0.287	0.006	0.001	0.122	0.045	0.001	0.007
Var.	**2**	69.1**	0.179	0.06**	0.05**	0.61**	0.059	0.005	0.006
V(Y)	**2**	0.040	0.134	0.006	0.003	0.114	0.024	0.002	0.003
Err.(a)	**8**	1.986	0.102	0.006	0.002	0.057	0.016	0.002	0.006
I.	**5**	20.3**	22.45**	10.02**	2.86**	97.69**	0.63**	0.63**	19.43**
I(Y)	**5**	0.110	0.045	0.006	0.004	0.192	0.029	0.003	0.006
VxI	**10**	1.23**	0.31*	0.05**	0.02**	0.84**	0.014	0.004	0.001
VxIxY	**10**	0.099	0.196	0.008	0.005	0.109	0.008	0.004	0.002
Err.(b)	**60**	0.229	0.147	0.009	0.004	0.113	0.017	0.003	0.006

* and ** significant at 5% and 1% level of probability, respectively

Combinations between bacterial inoculation and inducing material treatments effect.

Results in Table 2 showed that, yield, its components and juice quality of sugar beet, i.e., root length, root diameter, sugar yield, sucrose%, purity%, Na%, K% and proline content were highly significant as affected by the combinations between bacterial inoculation and inducing material treatments under saline soil in the combined analysis. Compared with other treatments, it is obvious that the significant greatest values of root diameter (9.72 cm), sugar yield (5.97 ton fed^{-1}), sucrose% (20.89%), purity% (89.59%) and Na% (3.42%) under saline soil resulted from the combination of bacterial inoculation +foliar application with Proline (Inoc +Prol.). Otherwise, the combination of None-inoculation+ foliar application with water treatment (control) produced the heights values of K% (5.19%) and proline (5.30 mmol g^{-1}) under saline soil. The greatest value of root length (26.53 cm) was obtained from the combination of bacterial inoculation +foliar application with salicylic (Inoc +SA). **The interaction effects**

Significant influences of the interaction between sugar beet varieties and the combinations between bacterial inoculation and inducing material treatments was observed for root length, root diameter, sugar yield, sucrose% and purity% under saline soil in the combined data (Table 3). The variety Melodia under the combination of bacterial inoculation+foliar application with Proline (Inoc+Prol.) treatment afford the highest values of sugar yield (5.99 ton fed^{-1}), sucrose% (20.92%) and purity% (89.69%). Meanwhile, the variety Melodia under the combination of bacterial inoculation +foliar application with salicylic (Inoc +SA) treatment gave the highest value of root diameter (9.87 cm). On the other hand, the variety Raspoly under the combination of bacterial inoculation+foliar application with salicylic (Inoc+SA) treatment gave the highest value of root length (28.56 cm). Whereas the variety Raspoly under the combination of None-inoculation+ foliar application with water treatment (control) gave the lowest values of sucrose% (19.68%) and purity% (82.50%) in the combined data. The variety Melodia under the combination of None-inoculation+ foliar application with water treatment (control) gave the lowest values of root diameter (6.88 cm) and sugar yield (4.00 ton fed^{-1}) in the combined data. Finally, the lowest value of root length (22.61 cm) was obtained from the variety Halawa under the combination of None-inoculation+ foliar application with water treatment (control).

Table 2. Yield, its components and chemical analyses of sugar beet varieties as affected by the combinations between bacterial inoculation and inducing material (over the two growing seasons)

Treatments	Root length (cm)	Root diameter (cm)	Sugar yield (ton fed^{-1})	Sucrose %	Purity %	Na %	K %	Proline (mmol g^{-1})
Varieties								
Raspoly	26.68	8.25	5.23	20.56	87.56	3.16	4.84	4.16
Halawa	24.04	8.32	5.29	20.63	87.74	3.19	4.83	4.18
Melodia	24.64	8.39	5.30	20.58	87.49	3.11	4.86	4.18
LSD at 5%	**0.76**	**NS**	**0.04**	**0.02**	**0.12**	**NS**	**NS**	**NS**
Inocu. &Inducing Materials								
Control	23.52	6.90	4.05	19.81	83.16	3.10	5.19	5.30
None+SA	25.47	7.74	4.93	20.62	87.50	2.86	4.73	3.70
None+Prol	24.51	7.94	5.05	20.63	87.76	3.25	4.79	4.95
Inoc+Water	24.84	8.00	5.71	20.72	88.24	3.12	4.91	3.65
Inoc+SA	26.53	9.62	5.94	20.87	89.34	3.17	4.71	2.58
Inoc+Prol	25.85	9.72	5.97	20.89	89.59	3.42	4.73	4.85
LSD at 5%	**0.31**	**0.25**	**0.06**	**0.04**	**0.22**	**0.08**	**0.03**	**0.05**

NS= None significant

Table 3. Effect of the interaction between varieties and the combinations between bacterial inoculation and inducing material on some traits of sugar beet (over the two growing seasons)

Varieties	Inocu.& Inducing Materials	Root length (cm)	Root diameter (cm)	Sugar yield (ton fed^{-1})	Sucrose %	Purity %
Raspoly	**Control**	24.75	6.90	4.05	19.68	82.50
	None+SA	26.51	8.05	4.85	20.63	87.53
	None+Prol	25.97	7.79	4.86	20.61	87.81
	Inoc+Water	26.49	7.71	5.70	20.74	88.41
	Inoc+SA	28.56	9.35	5.95	20.84	89.55
	Inoc+Prol	27.82	9.72	5.97	20.85	89.57
Halawa	**Control**	22.61	6.93	4.10	19.97	84.03
	None+SA	24.77	7.36	5.03	20.66	87.61
	None+Prol	23.83	8.05	5.05	20.66	88.02
	Inoc+Water	23.18	8.25	5.70	20.70	88.17
	Inoc+SA	25.16	9.62	5.90	20.90	89.10
	Inoc+Prol	24.69	9.71	5.97	20.89	89.52
Melodia	**Control**	23.21	6.88	4.00	19.78	82.95
	None+SA	25.14	7.81	4.91	20.58	87.36
	None+Prol	23.74	8.00	5.24	20.62	87.45
	Inoc+Water	24.85	8.06	5.72	20.72	88.14
	Inoc+SA	25.87	9.87	5.96	20.87	89.36
	Inoc+Prol	25.05	9.74	5.99	20.92	89.69
LSD at 5%		**0.55**	**0.44**	**0.10**	**0.07**	**0.38**

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إنتاجية وجودة بعض أصناف بنجر السكر تحت تأثير التلقيح البكتيري والمواد المستحثه في الأراضي الملحية

ميادة صبحي عبدالصادق نايل ، حسن رمضان أحمد الديبة ، محمد إسماعيل محمد سلوع ، صديق عبدالعزيز صديق محيسن
قسم المحاصيل - كلية الزراعة بمشتهر- جامعة بنها

نفذت تجربتان حقليتان خلال الموسمين الشتويين 2021/2020 و2022/2021م في مزرعة محطة بحوث راس سدر التابعة لمركز بحوث الصحراء، غرب شبه جزيرة سيناء، مصر. كان الهدف من هذه الدراسة هو تقييم المحصول وبعض مكوناته والجودة لثلاثة أصناف بنجر سكر (راس بولى و حلاوه وميلوديا) تحت ظروف التربة الملحية باستخدام ستة معاملات من التلقيح البكتيرى والمواد المستحثه (عدم التلقيح البكتيرى+ الرش الورقي بالماء، عدم التلقيح البكتيري+ الرش الورقي بالسلسيك ، عدم التلقيح البكتيرى+ الرش الورقى بالبرولين، التلقيح البكتيرى+ الرش الورقي بالماء، التلقيح البكتيري+ الرش الورقي بالسلسيك ، التلقيح البكتيرى+ الرش الورقى بالبرولين).

أظهرت النتائج تفوق عالي المعنوية للصنف حلاوة لصفات نسبة السكروز (%) و نسبة النقاوة (%). بينما أظهر الصنف ميلوديا تفوق عالي المعنوية لصفة محصول السكر (طن فدان$^{-1}$) في حين أن الصنف راس بولى أعطى تفوق عالي المعنوية لصفة طول الجذر (سم) تحت ظروف التربة الملحية للتحليل التجميعي لموسمي الزراعة.

أعطت معاملة التلقيح البكتيري+ الرش الورقي بالبرولين زيادة معنوية لصفات قطر الجذر (سم) و محصول السكر (طن فدان$^{-1}$) و نسبة السكروز (%) و نسبة النقاوة (%) ونسبة الصوديوم (%) . بينما سجلت معاملة عدم التلقيح البكتيري+ الرش الورق تفوق عالي المعنوية لصفات نسبة البوتاسيوم (%) و البرولين (مللي مول جم$^{-1}$). وأعطت معاملة التلقيح البكتيري+ الرش الورقي بالسلسيك تفوق عالي المعنوية لصفة طول الجذر (سم) تحت ظروف التربة الملحية للتحليل التجميعي لموسمي الزراعة.

أظهر التفاعل بين أصناف بنجر السكر والخليط بين التلقيح البكتيري والمواد المستحثه فروق معنوية لصفات طول الجذر، قطر الجذر، محصول السكر، نسبة السكروز ونسبة النقاوة تحت ظروف التربة الملحية لتحليل الضم لموسمي الزراعة.

توصي هذه الدراسة بزراعة صنف راس بولى أو حلاوة أو ميلوديا مع معاملة التلقيح البكتيري+ الرش الورقي بالبرولين تحت ظروف هذه التجربة.