Minufiya J. Agric. Res. Vol.39 No. 1(1): 181 - 189 (2014) "http://www.mujar.net"

SUGAR BEET PRODUCTIVITY AND QUALITY AS AFFECTED BY NITROGEN FERTILIZER LEVEL AND IRRIGATION WITHHOLDING DATE

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(Received : Dec. 22 , 2013)

ABSTRACT: *Two field experiments were carried out at El-Manyal Village, Talkha Center, Dakahlia Governorate during 2010/2011 and 2011/2012 seasons to evaluate the response of productivity and quality of sugar beet "variety Maribo" to four nitrogen fertilizer levels ,i.e., (70, 90, 110 and 130 kg N/fad) and four irrigation withholding dates ,i.e.,(15, 30, 45 and 60 days before harvesting). A split-plot design with four replicates was used during the two seasons. The main obtained results could be summarized as follows:*

1- Increasing nitrogen fertilizer levels from 70 to 130 kg N/fad.,significantly increased root fresh weight, root length and diameter, root yield (t/fad) and TSS % in both seasons, but it significantly decreased both sucrose and purity percentages in both seasons.
2- Increasing the period from the last irrigation until harvesting date from 15 to 60 days significantly decreased root fresh weight (g/plant), root length and diameter (cm), root yield (t/fad) and juice purity (%) in both seasons, but it significantly increased total soluble solids (TSS). The highest root yield/fad. Was obtained when the last irrigation was done at 30 days before harvesting date.

Application of nitrogen at the rate of 130 kg N/fad and giving the last irrigation at 30 days before harvesting date could be recommended to obtain suitable root yield and the highest sugar yield under the environmental conditions of Dakahlia Governorate.

Key words: *Sugar beet, Beta vulgaris L., nitrogen fertilizer level, last irrigation date, withholding date, yield, quality.*

INTRODUCTION

All researchers working on sugar crops aiming to increase sugar productivity to maximize the usefulness of every unit cultivated area and to minimize the gap between consumption and production of sugar. So, most of them studied the effects of nitrogen fertilizer and others studied the effects of the irrigation treatments as follows:

Nitrogen fertilizer has a pronounced effect on the growth, physiological and chemical characteristics of the crop.It causes desirable effect on sugar beet growth. In this concern, El-Geddawy *et al.* (2006) found that increasing nitrogen doses from 60 up to 100 kg/fad significantly increased root length and diameter as well as root and top yields/fad. While, sucrose and purity percentages were significantly decreased. Seadh *et al.* (2007) found that increasing nitrogen fertilizer levels from 50 up to 125 kg N/fad significantly increased root and foliage fresh weights, root length and diameter, root/top ratio, root, top and sugar yields/fad as well as TSS, sucrose and purity percentages in both seasons. Seadh (2008) showed that application the highest level of nitrogen fertilizer (150 kg N/fad) produced the highest values of root and top yields and its components in both seasons. While, fertilizing beet plants with 125 kg N/fad came in the second rank with respect to these characters and resulted in the highest values of sugar yield in both seasons. Optimum means of sucrose and purity percentages were obtained from using 75 kg N/fad in both seasons. Shewate *et al.* (2008) found that application of 180 kg N/ha gave significantly maximum root weight, root length and root yield. Siuliauskas *et al.* (2008) reported that under moderate fertilizer rate (80-120 kg N/ha), the root yield was higher than that in the control. Under optimum fertilizer rate (120 kg N /ha), sugar

beet sucrose content reached 17.19-18.02 %. The highest rate of nitrogen fertilizers marked reduced the sucrose level in sugar beet. Abdel-Motagally and Attia (2009) observed that increasing nitrogen significantly increased root fresh weight and sugar yield (t/ha) of sugar beet. Abdou *et al*. (2009) stated that increasing nitrogen levels from 80 to 100 and 120 kg/fad significantly increased root weight (g/plant), root length and diameter as well as both root and sugar yields/fad in both seasons. On the other hand, it significantly decreased TSS, and purity percentages in the two seasons and sucrose in the first season. El-Sarag (2009) concluded that increasing nitrogen fertilizer rates from 60 to 120 kg N/fad substantially improved most of the studied growth criteria and root yield. Meanwhile, adding 100 kg N/fad gave the optimum sugar yield. The highest sucrose and purity percentages were gained with the lowest nitrogen fertilizer rate (60 kg N/fad). Sarhan *et al*. (2012) reported that fertilizing sugar beet plants with 80 kg N/fad significantly increased root and sugar yields and its components as well as TSS % and markedly recorded the highest values of these characters. Nitrogen fertilizer at the level of 60 kg N/fad produced the highest values of sucrose and apparent juice purity percentages. Seadh (2012) showed that increasing NPK levels from 50 up to 100 % of the recommended dose (NPK 80 kg N + 30 kg P_2O_5 + 48 kg K_2O/fad)significantly affected root fresh weight, root length and diameter, TSS, sucrose and apparent purity percentages, root, top and sugar yields. Application 100 % of the recommended dose was the most effective treatment on these traits. Sharaf (2012) concluded that maximum values of all growth, yield components, quality and yields were resulted from using the highest rate of nitrogen fertilizer (120 kg N/fad) as compared with other rates (80 and 100 kg N/fad). Seadh *et al*. (2013) noticed that nitrogen fertilizer levels significantly affected yield components, root, top and sugar yields/fad. Raising nitrogen levels markedly accompanied with obvious increase in all studied characters. Application of 100 kg N/fad significantly resulted in the highest values of all studied characters. Application of 80 kg N/fad produced the best results after aforementioned level in both seasons.

All crops need adequate water supply to harvest maximum economic yield. Khajehpoor (1991) stated that irrigation management and its cutting off in a short period prior to harvest have to be based on decreasing growth and at the same time with maintaining the size of photosynthetic machinery. Kaffka *et al*. (1997) showed that water deficit near the end of growth periods may have less effect on sugar beet yield and result in saving irrigation water. Jaggard *et al*. (1998) reported that water supply is often regarded as one of the major factor affecting sugar beet (*Beta vulgaris* L.) growth and yield. Abdollahian–Noghabi (1999) found that water deficiency during the early growing season is the main cause of potential yield loss in sugar beet production. Kirda *et al*. (1999) showed that withholding water application during ripening stage saved nearly 22% water without any significant loss in sugar yield. Sohrabi and Heidari (2008) evaluate the effects of irrigation withholding (10, 20 30 and 40 days before harvest) on yield and quality of sugar beet. They showed that irrigation withholding significantly affected the root and sugar yields. Increase in length of irrigation cutoff date from 10 to 40 days before harvest reduced root yield, but increased total and white sugar content. The highest sugar and white sugar yield were achieved at the last harvest time (200 days after sowing) and irrigation cutoff date of 10 days before harvest, that had no significant difference with irrigation cutoff dates of 20, 30 and 40 days before the last harvest time. They concluded that reduction of sugar beet irrigation during late growth season could decrease irrigation amounts and it is important for areas with water deficit in harvest period.

Therefore, this study aimed to determine the effect of irrigation withholding date and nitrogen fertilizer level on productivity and quality of sugar beet under the environmental conditions of Dakahlia Governorate.

MATERIALS AND METHODS

This study was conducted at El-Manyal Village, Talkha Center, Dakahlia Governorate during the two successive winter seasons of 2010/2011 and 2011/2012 to study the effect of nitrogen fertilizer levels and irrigation withholding dates on sugar beet productivity and quality of variety Maribo.

A split-plot design with four replicates was used during the two seasons. The main plots were occupied with four irrigation withholding dates (15, 30, 45 and 60 days before harvesting date).

The sub-plots were devoted at random with the four nitrogen fertilizer levels (70, 90, 110 and 130 kg N/fad). Nitrogen in the form of urea (46.5%) was applied as formerly mentioned levels in two equal doses at the first and second irrigations after thinning.

Each experimental basic unit (sub-plot) included five ridges, each 3.5 m length and 60 cm apart, which resulted in an area of 10.5 m^2 (1/400 fad). The previous crop was maize (*Zea mays,* L.) in both seasons. Soil samples were taken at random from the experimental field area at a depth of 0-30 cm from soil surface and prepared for both mechanical and chemical analysis. The physical and chemical properties of the experimental soil are presented in Table (1).

The experimental field well prepared through three ploughings, leveling, compaction and then divided to the experimental units. Calcium super phosphate (15.5 % P_2O_5) was applied during soil preparation at the rate of 31 kg P_2O_5/fad. Potassium sulphate (48 % K_2O) at the rate of 24 kg k_2O/fad. was applied before ridgin

Table 1: Mechanical and chemical soil properties at the experimental site during the two growing seasons.

Soil analysis		2010/2011 season	2011/2012 season
A: Mechanical properties:			
Fine sand (%)		9.20	19.00
Coarse sand (%)		5.20	4.40
Silt (%)		36.00	27.00
Clay (%)		49.60	49.60
Texture		Clayey	Clayey loam
B: Chemical analysis			
Soil reaction pH		7.40	7.60
Available N (ppm)		42.50	47.30
Available P (ppm)		12.00	12.00
Exchangeable K (ppm)		150.00	120.00
Fe (ppm)		5.10	6.50
Mn (ppm)		0.80	1.50
Zn (ppm)		1.60	2.20
Cu (ppm)		0.80	0.70
Soluble cations meq/100 g soil	Ca^{++}	0.22	0.44
	Mg^{++}	0.36	0.33
	Na^{+}	0.07	0.02
	K^{+}	0.07	0.06
Soluble anions meq/100 gsoil	CO_3^{--}	0.00	0.00
	HCO_3^{-}	0.40	0.60
	Cl^{-}	0.28	0.24
	SO_4^{--}	0.03	0.01

Sugar beet balls were sown using dry sowing method in the second week of September in both seasons. Irrigation was applied after sowing immediately. Plants were thinned to one plant/hill at the age of 30 days. Plants were kept free from weeds, by hand hoeing for three times. All normal agricultural practices with the exception of the studied factors were conducted as usually done for growing sugar beet according to the recommendations of Ministry of Agriculture.

At harvesting time, ten guarded plants were chosen randomly from the three inner ridges of each sub-plot to determine yield attributes and quality characters as follows:

1. Root fresh weight (g/plant).
2. Root length (cm).
3. Root diameter (cm).
4. Total soluble solids (TSS %) in roots. It was measured in juice of fresh roots by using Hand Refractometer.
5. Sucrose percentage (%). It was determined Polarimetrically on lead acetate extract of fresh macerated roots according to the method of Carruthers and OldField (1960).
6. Apparent purity percentage (%). It was determined as a ratio between sucrose % and TSS % of roots (Carruthers and OldField, 1960).

At harvest time, plants that produced from the three inner ridges of each sub-plot were collected and cleaned. Roots and tops were separated and weighed in kilograms, then converted to estimate:

7. Root yield (t/fad.).
8. Sugar yield (t/fad.). It was calculated by multiplying root yield by sucrose percentage.

All obtained data were statistically analyzed according to the of analysis of variance technique (ANOVA) for the split-plot design as outlined by Gomez and Gomez (1984) by using means of "MSTAT-C" computer software package. Least Significant Difference (LSD) method was used to compare the differences between treatment means at 5% level of probability as described by Waller and Duncan (1969).

RESULTS AND DISCUSSION

1- Effect of nitrogen fertilizer levels:

Results presented in Table (2) cleared that increasing nitrogen fertilizer levels from 70 to 130 kg N/fad resulted in gradual significant increase in root fresh weight /plant, root length and diameter (cm) as well as root and sugar yields (t/fad) in both seasons. On the other hand, the same trend caused gradual significant decreases in sucrose and purity percentages in both seasons. The increase in root fresh weight /plant, root length and diameter (cm), root and sugar yields/fad., might be due to the role of nitrogen in encouragement of canopy growth that produced more photosynthesis products translocated to roots. This mean good photosynthesis and more dry matter production. These results are in agreement with those stated by El-Geddawy *et al.* (2006), Seadh *et al.* (2007), Shewate *et al.* (2008), Abdou *et al.* (2009), El-Sarag (2009), Sarhan *et al.* (2012), Seadh (2012) and Seadh *et al.* (2013).

2- Effect of irrigation withholding date:

Results listed in Table (2) show that increasing the last irrigation withholding date from 15 to 60 days before harvesting significantly affected all studied characters in both seasons. It caused gradual decreases in root fresh weight /plant, root length and diameter (cm), purity % as well as root and sugar yields (t/fad) in both seasons. On the other hand, the same treatment gradually increased total soluble solids percentage in both seasons. The highest values of sucrose % (18.37 and 18.32) and sugar yield (6.461 and 6.369 t/ fad) were obtained from sugar beet plants, which irrigated the last irrigation at 30 days before harvesting date. The increase in root fresh weight (g/plant), root length and diameter (cm), sucrose %, root and sugar yields (t/fad) associated with decreasing last irrigation period before harvesting date might be due to the roles of water in plant tissues in increasing cells size and dimensions and keeping suitable heat

TABLE 2

for plants, as well as, the fact that water shortage in some plant tissues increased respiration rate, dissolution the accumulation starch, carbohydrates and sucrose to simple sugars (glucose and fructose). Above all, water shortage raising plant heat that also increased respiration rate. These results are in agreement with those obtained by Jaggard *et al.* (1998), Abdollahian–Noghabi (1999), Kirda *et al.* (1999) and Sohrabi and Heidari (2008).

3- Effect of interaction:

Results presented in Table (3) show that root fresh weight as well as root and sugar yields (t/fad) were significantly affected by the interaction between irrigation withholding date and nitrogen fertilizer level during the two seasons. The highest values of root fresh weight (1150.0 and 1130.0 g/plant), root yield (40.491 and 39.548 t/fad) were obtained from sugar beet plants, which irrigated the last irrigation at 15 days before harvesting date and fertilized with 130 kg N/fad. in the first and second seasons, respectively. While, the highest values of sugar yield (7.101 and 6.879 t/ fad) were resulted from sugar beet plants fertilized with 130 kg N/fad and irrigated the last irrigation at 30 days before harvesting date in the first and second seasons, respectively.

Table (3): Root fresh weight (g/plant), root and sugar yields (t/fad.) as affected by the interaction between irrigation withholding date (days before harvesting date) and nitrogen fertilizer levels during 2010/2011 and 2011/2012 seasons.

Characters / Treatments		Root fresh weight (g/plant)		Root yield (t/fad.)		Sugar yield (t/fad.)	
		2010/2011	2011/2012	2010/2011	2011/2012	2010/2011	2011/2012
70 kg N/fad	15 days	850.0	880.0	29.670	30.884	5.280	5.405
	30 days	835.0	860.0	29.139	30.192	5.621	5.855
	45 days	815.0	835.0	28.770	29.380	5.409	5.438
	60 days	780.0	800.0	27.635	28.163	4.969	5.011
90 kg N/fad	15 days	990.0	970.0	34.843	33.954	5.991	5.770
	30 days	970.0	960.0	34.048	33.596	6.334	6.214
	45 days	945.0	940.0	33.364	33.180	6.107	5.972
	60 days	915.0	910.0	32.117	32.127	5.686	5.652
110 kg N/fad	15 days	1090.0	1050.0	38.039	36.538	6.387	6.065
	30 days	1075.0	1040.0	37.730	36.503	6.790	6.529
	45 days	1050.0	1025.0	36.959	36.077	6.471	6.276
	60 days	1025.0	990.0	35.986	34.834	6.113	5.855
130 kg N/fad	15 days	1150.0	1130.0	40.491	39.548	6.595	6.488
	30 days	1140.0	1120.0	40.351	39.314	7.101	6.879
	45 days	1125.0	1110.0	39.376	38.958	6.691	6.617
	60 days	1100.0	1070.0	38.616	37.765	6.331	6.119
LSD (5 %)		21.3	24.4	1.593	1.767	0.268	0.371

CONCLUSION

In this study, we could summarize current knowledge regarding the importance of four irrigation withholding dates and four nitrogen fertilizer levels on sugar beet growth, productivity and quality. We summarize four take-home messages:

- Sugar beet need adequate water supply to harvest maximum economic yield. Water deficit near the end of growth periods may have less effect on sugar beet yield and resulted in saving irrigation water, which is important for areas with water deficit in harvest period.
- The N fertilizer supply is often inadequate due to economic reasons, unavailability of fertilizers or limited knowledge. Fertilizer application techniques may be still better adjusted to the prevailing crop and growth conditions. Especially, because the demand of N is expected to increase significantly, in particular in developing regions of the world.
- Irrigation until harvesting date (from 15 to 60 days) significantly decreased root fresh weight, root length and diameter, root yield (t/fad.) and juice purity (%), while it significantly increased total soluble solids (TSS) during the two seasons. On the other hand, increasing nitrogen fertilizer levels significantly increased root fresh weight, root length and diameter, root yield (t/fad.) and TSS %. While, it significantly decreased both sucrose and purity percentages in both seasons.
- The optimum root and sugar yields could be obtained by giving the last irrigation at 30 days before harvesting date and fertilizing sugar beet with 130 kg N/fad.

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تأثر إنتاجية وجودة بنجر السكر بمستويات السماد الأزوتى وتاريخ الرية الأخيرة

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الملخص العربى

أقيمت تجربتان حقليتان بقرية المنيل – مركز طلخا – محافظة الدقهلية خلال موسمى 2011/2010 و2012/2011 م لدراسة تأثير أربعة مواعيد للرية الأخيرة قبل الحصاد (15 ، 30 ، 45 و60 يوماً قبل الحصاد) وكذلك أربع مستويات من التسميد النيتروجينى (70 ، 90 ، 110 و130 كجم نيتروجين/ فدان) على إنتاجية وجودة بنجر السكر (صنف ماريبو). نفذت التجارب فى القطع المنشقة مرة واحدة فى أربع مكررات. وأوضحت النتائج المتحصل عليها ما يلى:

1- أدت زيادة مستويات السماد النيتروجينى من 70 إلى 130 كجم نيتروجين/فدان إلى زيادة معنوية لكل من الوزن الغض للجذر بالجرام / نبات ، طول وقطر الجذر (سم) وكذلك محصولى الجذور والسكر بالطن/فدان وكذلك النسبة المئوية لكل من المواد الصلبة الذائبة الكلية بالجذور فى كلا الموسمين ، ولكنها أدت إلى نقص معنوى فى النسبة المئوية للسكروز والنقاوة فى الجذور خلال الموسمين.

2- أدت زيادة الفترة بين الرية الأخيرة لبنجر السكر وميعاد الحصاد من 15 إلى 60 يوما حتى الحصاد إلى نقص معنوى لصفات الوزن الغض للجذر بالجرام / نبات ، طول وقطر الجذر وكذلك محصولى الجذور والسكر بالطن/فدان ونقاوة العصير فى كلا الموسمين. ولكنها أدت إلى زيادة معنوية فى محتوى الجذور من المواد الصلبة الذائبة الكلية . وقد أمكن الحصول على أعلى محصول من السكر عندما كانت الرية الأخيرة عند 30 يوماً قبل الحصاد.

3- أظهرت النتائج المتحصل عليها وجود تفاعل معنوى بين ميعاد الرية الأخيرة قبل الحصاد و مستويات السماد النيتروجيني على صفات الوزن الغض للجذر بالجرام / نبات ومحصولى الجذور والسكر بالطن/فدان فى كلا موسمى الزراعة.

من هذه الدراسة يمكن أن نوصى بتسميد بنجر السكر بمعدل 130 كجم نيتروجين للفدان و أن تكون الرية الأخيرة عند 30 يوماً قبل الحصاد للحصول على محصول مناسب من الجذور وأعلى محصول من السكر تحت ظروف منطقة الدراسة بمحافظة الدقهلية.

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Table (2): Root fresh weight (g/plant), root length and diameter (cm), total soluble solids (TSS), sucrose and purity percentages as well as root and sugar yields(t/fad) as affected by irrigation withholding date and nitrogen fertilizer level as well as their interaction during 2010/2011 and 2011/2012 seasons.

Characters / Treatments	Root fresh weight (g/plant)		Root length (cm)		Root diameter (cm)		TSS (%)		Sucrose (%)		Purity (%)		Root yield (t/fad)		Sugar yield (t/fad)	
	2010/ 2011	2011/ 2012	2010/ 2011	2011/ 2012	2010/ 2011	2011/ 2012	2010/ 2011	2011/ 2012	2010/ 2011	2011/ 2012	2010/ 2011	2011/ 2012	2010/ 2011	2011/2 012	2010/ 2011	2011/ 2012
A- Last irrigation date (days before harvesting):																
15	1020.0	1007.5	32.10	32.12	13.42	13.42	22.36	21.58	17.02	16.87	76.17	78.21	35.761	35.231	6.063	5.932
30	1005.0	995.0	31.75	31.87	13.15	13.15	24.39	24.50	18.37	18.32	75.34	74.81	35.317	34.901	6.461	6.369
45	983.7	977.5	31.15	31.42	12.72	12.80	24.46	24.57	17.90	17.72	73.22	72.14	34.617	34.399	6.169	6.076
60	955.0	942.5	30.85	30.90	12.05	12.32	24.62	24.70	17.27	17.10	70.18	69.26	33.588	33.222	5.774	5.659
F. test	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5 %	20.3	21.2	0.41	0.53	0.32	0.40	0.37	0.36	0.39	0.36	1.96	2.02	0.668	0.712	0.184	0.145
B- Nitrogen fertilizer level (kg N/fad):																
70	820.0	843.7	29.55	29.07	11.42	11.05	23.89	23.57	18.47	18.30	77.41	77.77	28.803	29.655	5.320	5.427
90	955.0	945.0	31.55	31.37	12.15	12.37	23.88	23.83	17.95	17.77	75.22	74.75	33.593	33.214	6.029	5.902
110	1060.0	1026.2	31.72	32.22	13.45	13.50	23.97	23.92	17.32	17.17	72.33	71.94	37.179	35.988	6.440	6.181
130	1128.7	1107.5	33.02	33.65	14.32	14.77	24.08	24.03	16.82	16.77	69.94	69.95	39.708	38.896	6.679	6.526
F. test	*	*	*	*	*	*	NS	NS	*	*	*	*	*	*	*	*
LSD at 5 %	28.9	21.8	0.52	0.44	0.55	0.47	-	-	0.31	0.35	1.92	1.70	1.182	0.688	0.202	0.146
C- Interaction:																
A X B	*	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	*	*	*