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Yield and Technological Characteristics of Sugar Beet as Affected by Sowing Date, Nitrogen Level and Harvesting Age

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ABSTRACT

In order to investigate the effect of nitrogen fertilizer levels, sowing date and harvesting age on growth yield and root quality of sugar beet. Four field experiments were conducted at Mallawi Research Station, El-Minia Governorate during 2015/2016 and 2016/2017 seasons. Sugar beet sown at two dates (the 1st of September and October) fertilized with three nitrogen levels (80, 100 and 120 kg N/fed.) and harvested at three ages (180, 195 and 210 days after sowing). The results showed that all studied traits of sugar beet were significantly affected by sowing date in both seasons. The highest values of root length, diameter, root fresh weight, as well as α-amino N, Na, K, sugar lost to molasses, root and corrected sugar yields were obtained by delaying sowing date from September 1st to October 1st. On the contrary, an higher sucrose, quality and corrected sugar percentages were detected in beets sown earlier in September. Raising nitrogen fertilization level from 80 to 100 and 120 kg N/fed. resulted in a gradual and significant increases in root fresh weight, root length and diameter, root yield, sugar lost to molasses and corrected sugar yield in both seasons. While, alkalinity coefficient and quality percentages were decreased. The highest sucrose and corrected sugar percentages were recorded by applying 100 kg N/fed. The studied traits were markedly influenced by plant age at harvesting in both seasons. Root length and diameter, root fresh weight and yield/fed, sucrose, quality, corrected sugar percentages and corrected sugar yield/fed. were increased gradually with increasing plant age at harvest from 180, 195 to 210 days, in both seasons, while Na, sugar lost to molasses and alkalinity coefficient were decreased. Under these conditions of the present work, sowing sugar beet on October 1st, with nitrogen fertilization at rate of 120 kg N/fed. and harvested at 210 days from sowing could be recommended to obtain the highest root yield/fed., while harvesting it after 195 or 210 days to get the highest sugar yield/fed.

Keywords: Nitrogen fertilization levels, Sowing date, Harvesting age, Sugar beet, Root quality.

INTRODUCTION

Among the important environmental variables that determine the beginning of sugar beet growing season are temperature, light perception and soil moisture (Petkeviciene, 2009). Sowing date has an active role on growth, yield and quality characteristics of sugar beet. Under the environmental conditions of Egypt, there is a general agreement that early planting of sugar beet during September-October results in the highest sucrose % as well as root and sugar yields per unit area (Lielah *et al* 2005, Nasr and Abd El-Razek 2008 and Safina *et al* (2012) obtained higher root and sugar yields from sugar beet sown on October 10th compared to that planted on November 10th. Other studies found that planting sugar beet through October markedly increased weight of roots, sugar content as well as root and sugar yields, compared with beets sown in November Ghareeb *et al* 2013, Mahdi *et al* 2013, Ntwanai and Tuwana (2013), El-Mansuob and Mohamed (2014) and Hossain *et al* (2015) mentioned that sowing sugar beet on 15th October significantly increased sucrose, Na, K, alpha amino-N, sugar lost to molasses and extractability %, purity% as well as top and root yields. Aly and Khalil (2017) found that sugar beet planted on October 1st had higher values of root fresh weigh/plant, root and sugar yields/fed as well as the percentages of sucrose, corrected sugar, quality index and lower significant impurities compared with that sown on November 1st. Pavlui *et al* (2017) mentioned that root yield was significantly higher in the earlier drilled plots. On average, prolongation of the vegetation period in spring by 13 days increased root yield by 10.9%. Therefore, each day by which drilling is postponed represents a 0.7-0.8% loss in yield. As to sugar content, no statistically significant benefit of vegetation period prolongation by early drilling was found.

Sugar beet greatly responds to the applied nutrients, particularly the major-elements, which affect yield and quality of the harvested roots. Abdel-Motagally and Attia (2009) illustrated that increasing nitrogen fertilization level from 143 to 214 and 285 kg N/ha increased root and foliage fresh and sugar yield/ha of sugar beet. Increasing N level up to 285 kg N/ha significantly increased impurities (Na, K and α-amino-N) and sugar loss percentage as well as improved root yield, quality and nutritional status of sugar beet. Mohamed *et al* (2012) and Omar and Mohamed (2013) found that applying nitrogen fertilizer at 80 kg N/fed significantly affected on root diameter, root fresh weight as well as root, top and sugar yields/fed. At the mean time, increasing nitrogen levels from 50 up to 125 kg N/fed caused a significant increase in root dimensions, root and top fresh weight/plant, Na%, K %, sugar lost to molasses% and root yield/fed. Top and recoverable sugar yields positively responded only to 100 kg N/fed. The highest sucrose, purity and extractable sugar percentages were produced with using low nitrogen levels (50 or 75 kg N/fed). Abdou and Badawy (2014) and El-Geddawy and Makhlouf (2015) reported that increasing nitrogen levels from 70 to 90 and 110 to 130 kg N/fed significantly increased root fresh weight, root dimensions, and root and sugar yields/fed. They added that adequate N application is needed to obtain maximum sugar beet vegetative growth early in the growing season. However, adjusted N supply is required at low levels by midseason to maximize sugar production. High N availability late in the season increases foliage growth and impurities in the beets. Mentioned that root length, diameter and fresh weight/plant, K and Na concentrations in roots as well as yields of root and tops significantly increased by increasing nitrogen levels from 80 to 120 kg N/fed. The highest sucrose% was recorded with 100 kg N/fed, whereas sugar yield was the highest with 120 kg N/fed.

Masri *et al* (2015) and Wael *et al* (2017) concluded that increasing N rate up to 120 kg N/fed significantly increased individual root weight and impurities percentage as well as root yield/fed and white sugar yield/fed. They added that excessive N application decreased quality in terms of sucrose, purity and extractable sugar percentages. At the same trend, increased shoot and root fresh weight. Badr (2016) and Makhlouf and Abd El-All (2017) found that applying 110 kg N/fed resulted in the highest values of fresh root/plant and top yields/fed. They found insignificant differences among N levels in their effect on fresh root yield/fed. Moreover, they showed that adding 70 kg N/fed produced the maximum sucrose %, extractable white sugar% and purity %. Sugar yield/fed. significantly increased by increasing nitrogen level up to 90 kg N/fed. They recommended the application of 90 kg N/fed produced the highest yield and quality of sugar beet. DeBruyn (2017) harvested sugar beet early-mid September, late October and early November with the application of N fertilizer in a 5-by-5 cm band during sugar beet planting. Application of 157 kg N/ha optimized root yield but only 120 kg N/ha optimized recoverable white sucrose yield at either harvest age.

Many workers found that late harvesting of sugar beet crop increased growth traits, quality%, yields/fed and decreased impurities, regarding N, Na and K in roots. Abou El-Maged *et al* (2003), Aly (2006), Azzazy *et al* (2007), El-Sheikh *et al* (2009) and Mahmoud *et al* (2008) in Egypt found significant increase in root length, diameter, root fresh weight/plant, sucrose%, as well as root and sugar yields/fed and significant decrease in root impurities (Na, K and alpha amino-N). Abd El-Razek and Ghonema (2016) obtained a gradual and significant increase in sucrose% and purity% as beet age at harvesting was increased from 170, 190 and to 210 days. They also found that delaying harvest age increased root and sugar yields. At late harvesting ages, impurities illustrated the highest values, while earlier harvesting resulted in the lowest values of impurities in roots. DeBruyn (2017) mentioned that the effect of harvest age and N fertilizer placement were not influential on nitrogen use efficiency and the studied traits.

The main objective of this study was to find out the appropriate sowing date, nitrogen fertilization levels and crop age at harvesting to obtain the best growth, yield and technological quality characteristics of sugar beet plant grown under conditions of El-Menia Governorate, Middle Egypt.

MATERIALS AND METHODS

Four field experiments were conducted at Mallawi Research Station, El-Minia Governorate (latitude of 28.1003° N and longitude of 30.7582° E, and 49 m above sea level) in 2015/2016 and 2016/2017 seasons to study the response of some growth, yield and technological quality traits of sugar beet to sown at two dates (the 1st of September and October) fertilized with three nitrogen levels (80, 100 and 120 kg N/fed) and harvested at three ages (180, 195 and 210 days after sowing). Each sowing date was performed in a separate experiment in split-plot design with three replications. The main plots were occupied with nitrogen levels, while the sub-plots were devoted for harvesting ages. Nitrogen fertilizer was added as urea (46% N) in two equal doses; after thinning and three weeks later. The area of each experimental basic unit (sub-plot) was 15 m^2, including five ridges of 0.60 m apart and 5.0 m in length. The preceding summer crop was maize in both seasons. Calcium super phosphate (15.0% P_2O_5) was applied during seed bed preparation at the rate of 200 kg/fed. Potassium sulfate (48% K_2O) was applied at the rate of 50 kg/fed with the second nitrogen dose before canopy closer. Soil samples were taken before sowing at random from every location at 0-30 cm depth for mechanical and chemical analyses according to the method of Piper (1955) as shown in Table 1. The monthly temperature (°C) from every season was done in average soil physical and chemical properties of the experimental sites are illustrated Table 2.

Table 1. Soil physical and chemical properties of the experimental site in the two growing seasons

Season	Particle size distribution			Textural Class	Available Nutrients (ppm)			E.C dSm^{-1}	O.M%	pH
	Sand %	Silt %	Clay %		N	P	K			
2015/2016	9.63	61.87	28.50	Clay loam	31.12	2.62	106.1	2.11	1.99	7.65
2016/2017	7.52	62.13	30.35		34.26	2.97	125.2	2.08	1.80	7.45

Table 2. Averages of temperature degrees and relative humidity percentages during the two growing seasons at Mallwi

season	2015/2016				2016/2017			
Months	Temperature (°C)			Relative humidity%	Temperature (°C)			Relative humidity%
	Max	Min	Avg.		Max	Min	Avg.	
September	37.9	23.0	30.5	32.0	35.3	20.6	27.9	37.3
October	32.7	19.8	26.2	45.2	31.7	17.7	24.7	46.5
November	25.9	13.5	19.7	54.3	26.1	13.3	19.7	48.9
December	20.3	8.1	14.2	61.5	18.8	6.5	12.6	57.5
January	18.5	5.5	12.0	54.1	18.1	5.0	11.6	52.5
February	23.9	8.5	16.2	42.1	20.5	5.6	13.0	48.0
March	26.8	12.3	19.5	32.2	25.3	9.8	17.6	36.7
April	33.9	15.8	24.8	24.3	30.8	13.8	22.3	29.2
May	35.4	19.0	27.2	25.2	35.4	18.6	27.0	26.2

Source: Agro-meteorological station, Agric. Res. Center, Giza, Egypt

The recorded measurements:

At harvest, 10 plants from the three guarded rows were uprooted, topped and weighed to determine:

1. Root length (cm).
2. Root diameter (cm).
3. Root and top fresh weight/plant (g).
4. Impurities of juice, *i.e.* Na and K (meq/100 g beet) were determined in the lead acetate extract of fresh macerated root tissue using "Flame photometry" method as described by Browen and Lilliand (1964), while Alpha amino-nitrogen (meq/100 g beet) was determined using "ninhydrin hydrindantin" method according to the method of Cooke and Scott (1993).
5. Sucrose % (pol%) was polarimaterically determined according to the methods of Le-Docte, (1927).
6. Corrected sugar % = Pol % - 0.343 (K + Na) - α-amino N (0.0939) - 0.29, according to the equation of Dexter, *et al.* (1967).
7. Sugar lost to molasses (SLM %) = Plo%- corrected sugar%-0.6, according to the equation of Devillers (1988).
8. Quality index (Qz) = extracted sugar % x 100/Pol%.
9. Alkalinity Coefficient (AC) was determined from the major non sugars K, Na and α-amino N as follows equation of Devillers (1988):

Alkalinity Coefficient = (K% + Na%)/ α-amino N%

10. Sugar beet roots per plot were weight in kg and converted root yield/fed (ton).
11. Corrected sugar yield/fed (ton), which was calculated according to the following equation:

Corrected sugar yield/fed (ton) = root yield/fed (ton) x corrected sugar%.

12. Top yield/fed (ton).

Statistical analysis:

The obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) was done as published by Gomez and Gomez (1984) for the split-split plot design, where sowing dates were distributed in the main plots, sub plots were occupied with nitrogen levels, while the sub-sub plots were devoted for harvesting age. Least significant differences (LSD) method was used to test the differences between treatment means at 5% level of probability as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1. Yield and its attributes:

The results in Table 3 point to significant increases in root length and diameter amounted to (1.88 and 1.69 cm) and (1.97 and 1.00 cm), which resulted in marked increases in root fresh of (0.286 and 0.265 g) and ultimately participated in increasing root yield substantially by (3.07 and 2.71 tons/fed), in the 1st and 2nd season, respectively by delaying sowing date from September 1st to October 1st. These results may be due to favorable meteorological factors for optimal germination, emergence and plant establishment, especially in the early stage of growth (Table 2). These results are in accordance with those reported by Aly and Khali (2017) and Pavlui *et al.* (2017).

Table 3. Root length and diameter (cm), root fresh weight (kg) and root yield (t/fed.) of sugar beet as affected by sowing date, nitrogen level and harvest age in 2015/2016 and 2016/2017 seasons

Treatment	Root length (cm)		Root diameter (cm)		Root fresh weight (g)		Root yield (t/fed.)	
Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Sowing date								
September 1st	29.05	30.19	13.84	14.53	0.917	0.949	21.04	21.89
October 1st	30.93	31.88	15.81	15.53	1.203	1.214	24.11	24.60
LSD at 5%	1.04	0.82	0.33	0.26	0.029	0.020	0.49	0.25
Nitrogen fertilization level								
80 kg N/fed	28.77	29.72	14.09	14.33	0.976	0.991	20.82	21.30
100 kg N/fed	29.97	31.14	14.89	14.83	1.053	1.092	22.28	23.30
120 kg N/fed	31.23	32.24	15.51	15.93	1.151	1.161	24.62	25.13
LSD at 5%	1.27	0.98	0.42	0.29	0.036	0.024	0.60	0.31
Harvest age								
180 days	27.48	28.43	14.03	14.05	0.964	0.974	20.33	21.50
195 days	29.91	31.31	14.94	15.14	1.062	1.094	23.08	23.37
210 days	32.58	33.37	15.52	15.89	1.154	1.176	24.32	24.86
LSD at 5%	1.52	0.93	0.70	0.55	0.034	0.020	0.48	0.43

The results showed that root length, diameter and fresh weight as well as root yield/fed were appreciably affected by the applied nitrogen levels in both seasons. Raising nitrogen fertilization level to 100 and 120 kg N/fed given to sugar beet resulted in a gradual increase in root fresh weight amounted to (0.077 and 0.175 g) and (0.101 and 1.170 g) compared to that supplied with 80 kg N/fed, successively. Similar trend was observed concerning root length and diameter. Likewise, root yield increased by 1.46 and 3.80 tons/fed, in the 1st season, corresponding to 2.00 and 3.83 tons/fed, in the 2nd one, as N-fertilization level was raised to 100 and 120 kg N/fed, in comparison to beets fertilized with 80 kg N/fed, respectively. These results are probably referred to the role of nitrogen as an essential structural element in building plant organs and enhancing its growth, and hence increased root fresh weight per plant and the harvested root yield per feddan. These results are in agreement with those found by Masri, *et al.* (2015), Badr (2016), DeBruyn (2017) and Makhlouf and Abd El-All (2017).

Root length, diameter and fresh weight as well as root yield/fed of sugar beet were significantly affected by plant age at harvesting (Table 3). It was found that increasing age of beets from 180, 195 and to 210 days led to a gradual increase in root length and diameter in both seasons, which increased root fresh weight by 0.098 and

0.190 g, in the 1st season, being 0.120 and 0.202 g, in the 2nd one, respectively, where root yield was finally increased by 2.75 and 3.99 tons/fed, in the 1st season, and by 1.87 and 3.36 tons/fed, in the 2nd season, successively. Theses results were due to prolonging the period of photosynthesis and dry matter accumulation before harvesting. These results are in agreement with those stated by Badr (2016), Abd El-Razek and Ghonema (2016) and DeBruyn (2017).

2. Root quality:

The results in Table 4 clear that sugar beet root contents of sucrose% and impurities, in terms of alpha amino N, Na and K were significantly affected by sowing dates in both seasons. Higher sucrose percentage were detected in beets sown earlier in September, while higher contents of impurities were recorded in beets planted later in October. Theses results may be attributed to relatively better conditions, *i.e.* lower temperature before harvest in case of early sowing, which guaranteed more sugar accumulation and lower contents of impurities. These results are in agreement with those mentioned by El-Mansuob and Mohamed (2014) and Aly and Khalil (2017).

Table 4. Sucrose% and impurities (alpha amino N, Na and K meq/100 g beet) of sugar beet as affected by sowing date, nitrogen level and harvest age in 2015/2016 and 2016/2017 seasons

Treatment	Sucrose %		Impurities (meq/100 g beet)					
			A-amino-N		Na		K	
Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Sowing date								
September 1st	18.62	18.06	0.75	0.75	1.66	1.62	3.53	2.95
October 1st	17.36	17.21	0.88	0.83	1.72	1.65	4.03	3.68
LSD at 5%	0.60	0.32	0.07	0.08	0.12	0.06	0.09	0.09
Nitrogen fertilization level								
80 kg N/fed	17.81	17.30	0.77	0.74	1.63	1.55	3.77	3.23
100 kg N/fed	18.45	18.07	0.82	0.78	1.71	1.64	3.78	3.36
120 kg N/fed	17.71	17.53	0.86	0.86	1.73	1.71	3.79	3.36
LSD at 5%	0.74	0.40	0.09	0.10	0.15	0.08	0.11	0.12
Harvest age								
180 days	17.16	16.99	0.79	0.78	1.70	1.66	4.01	3.56
195 days	18.34	17.83	0.86	0.82	1.67	1.62	3.75	3.34
210 days	18.47	18.07	0.81	0.78	1.70	1.61	3.58	3.04
LSD at 5%	0.57	0.33	0.07	0.06	0.10	0.06	0.12	0.09

Root sucrose% and impurities were markedly influenced by the applied N-fertilizer levels in both seasons (Table 4). The results showed that raising N-fertilization level from 80 to 100 kg N/fed led to increasing sucrose %. However, a reduction in sucrose % was noticed when N level was increase to 120 kg N/fed. These results may prove that adding 100 kg N/fed was required for the construction of an optimal foliage size able to play its functional role in photosynthesis and accumulation of sugars in roots. However, applying 120 kg N/fed directed beets to produce more foliage rather than sugar translocation and storage in roots. These results are in agreement with those mentioned by Masri, *et al*. (2015), Badr (2016) and DeBruyn (2017). Meanwhile, it was found that increasing N-dose from 80 to 100 and 120 kg N/fed was associated with a gradual increase in root impurities (alpha amino N, Na and K), which may be due to the fact that raising the amount of the applied nitrogen enhances plants to absorb more solutes involved in the soil solution. These results are in agreement with those mentioned by Badr (2016), DeBruyn (2017) and Makhlouf and Abd El-All (2017).

Root sucrose % and impurities were significantly affected by plant age at harvesting in both seasons. The results indicated that prolonging sugar beet age at which it was harvested from 180 to 195 and up to 210 days resulted in an ascendant trend for sucrose % and descendant tendency for impurities (α-amino-N, Na and K). Theses results referred to extending the duration sugar accumulation before harvesting. These results coincided with those stated by Aly (2006) and Abd El-Razek and Ghonema (2016).

3. Alkalinity coefficient, quality%, sugar lost to molasses%, corrected sugar% and corrected sugar yield:

Alkalinity coefficient, quality%, sugar lost to molasses%, corrected sugar% and corrected sugar yield/fed of sugar beet were markedly affected by sowing dates (Table 5). Higher values of quality, corrected sugar and lower sugar lost to molasses percentages were recorded in beets sown earlier in September in both seasons, probably due to higher values of sucrose % and lower impurities as α-amino-N, Na and K in roots (Table 4). However, sugar beet sown in October out-yielded that planted September. These results are coincided with those found by El-Mansuob and Mohamed (2014) and Aly and Khalil (2017). **No clear cut trend was noticed concerning alkalinity coefficient as affected by sowing date.**

The applied N-fertilizer levels had a significant influence on alkalinity coefficient, quality%, sugar lost to molasses%, corrected sugar% and corrected sugar yield/fed (Table 5). Raising N level from 80 up to 120 kg N/fed resulted in a reduction in alkalinity coefficient, while sugar lost to molasses increased. Both quality and corrected sugar percentages recorded the highest values with the application of 100 kg N/fed, thereafter decreased with the highest N-fertilizer level (120 kg N/fed). This was the same tendency of sucrose %

(Table 4). These results are in line with those stated by Masri, *et al.* (2015), Badr (2016) and DeBruyn (2017).

Increasing N level up to 100 and 120 kg N was accompanied with an increase in corrected sugar yield amounted to 0.36 and 0.55 in the 1st season, being 0.46 and 0.61 ton/fed in the 2nd one, compared to beets fertilized with 80 kg N/fed, successively. These results may be referred to the increase in all of root fresh weight/plant and root yield/fed (Table 3). These results are in accordance with those reported by Masri, *et al.* (2015); Badr (2016); DeBruyn (2017) and Makhlouf and Abd El-All (2017).

Plant age at harvesting significantly affected alkalinity coefficient, quality%, sugar lost to molasses%, corrected sugar% and corrected sugar yield/fed, in both seasons (Table 5). A reduction in alkalinity coefficient was recorded as harvesting of sugar beet was delayed from 180 up to 210 days from sowing. Both quality and sugar lost to molasses percentages increased gradually as the period from sowing to harvest was prolonged from 180 to 195 and 210 days, while sugar lost to molasses decreased.

Increasing beet age at harvest to 195 and 210 days raised the corrected sugar yield by 0.70 and 0.93 ton/fed in the 1st season, corresponding to 0.50 and 0.82, over that harvested at age of 180 days. These results are in agreement with those mentioned by Aly (2006) and Abd El-Razek and Ghonema (2016).

Table 5. Alkalinity coefficient, quality%, sugar lost to molasses%, corrected sugar% and corrected sugar yield/fed (ton) of sugar beet as affected by sowing date, nitrogen level and harvesting age in 2015/2016 and 2016/2017 seasons

Treatment	Alkalinity coefficient		Quality%		Sugar lost to molasses%		Corrected sugar%		Corrected sugar yield (t/fed)	
Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
					Sowing date					
September 1st	6.49	5.66	88.46	89.30	1.54	1.33	16.48	16.13	3.47	3.54
October 1st	6.34	6.10	86.43	87.20	1.75	1.60	15.02	15.01	3.63	3.70
LSD at 5%	0.08	0.18	0.48	0.44	0.09	0.12	0.48	0.44	0.11	0.08
					Nitrogen fertilization level					
80 kg N/fed	6.68	5.96	87.44	88.38	1.62	1.40	15.60	15.31	3.25	3.26
100 kg N/fed	6.38	6.01	87.71	88.43	1.65	1.48	16.20	15.99	3.61	3.72
120 kg N/fed	6.18	5.67	87.18	87.94	1.66	1.51	15.45	15.42	3.80	3.87
LSD at 5%	0.13	0.14	0.18	0.20	0.02	0.06	0.38	0.35	0.14	0.10
					Harvest age					
180 days	6.91	6.31	86.41	87.26	1.72	1.56	14.84	14.84	3.01	3.18
195 days	6.09	5.75	87.78	88.37	1.63	1.47	16.11	15.76	3.71	3.68
210 days	6.24	5.58	88.13	89.13	1.58	1.36	16.30	16.11	3.94	4.00
LSD at 5%	0.10	0.09	0.43	0.34	0.10	0.13	0.49	0.46	0.16	0.12

Significant interactions between the studied factors:

The results in Table 6 point to a significant interaction effect between sowing dates and N-levels on root diameter and fresh weight, in both seasons and root yield/fed in the 2nd one.

It was found that the difference between 100 and 120 kg N/fed in their effect on root diameter was insignificant, when sugar beet was sown in October, while the application of 120 kg N/fed caused a significant increase in root diameter compared with 100 kg N/fed in September, in the 1st season. In the 2nd one, the application of 80 and/or 100 kg N/fed had insignificant difference in this trait in October, with higher and significant increase in root diameter with the application of 100 kg N/fed over that recorded by 80 kg N/fed, in September.

Table 6. Effect of the interactions between sowing date and nitrogen level on root diameter (cm), root fresh weight (kg) and root yield (t/fed.) of sugar beet in 2015/2016 and 2016/2017 seasons

Treatment		Root diameter (cm)		Root fresh weight (kg)		Root yield (t/fed.)
Season		1st	2nd	1st	2nd	2nd
Sept. 1st	80 kg N/fed	12.99	13.82	0.824	0.831	20.57
	100 kg N/fed	13.58	14.57	0.889	0.958	21.60
	120 kg N/fed	14.97	15.21	1.036	1.058	23.50
Oct. 1st	80 kg N/fed	15.19	14.84	1.127	1.152	22.03
	100 kg N/fed	16.20	15.09	1.218	1.226	25.00
	120 kg N/fed	16.04	16.64	1.265	1.263	26.76
LSD at 5%		0.59	0.42	0.051	0.034	0.43

The results in the same table manifested that the difference between 100 and 120 kg N/fed in their effect on root fresh weight was insignificant in beets sown in October, with a significant increase in this trait resulted from the applying 120 kg N/fed over that of 100 kg N/fed, in September, in the 1st season. In the 2nd one, applying 120 kg N/fed led to more distinguished significant increase in root fresh weight (0.227 kg/plant) over that obtained by applying 80 kg N/fed in September, compared to that recorded in October (0.111 kg/plant).

Applying 120 kg N/fed. resulted in more distinguished significant increase in root yield (4.73 tons/fed.) higher than that produced by applying 80 kg N/fed in October, compared to that recorded in September (2.93 tons/fed), in the 2nd season.

The results in the same table manifested that the difference between 100 and 120 kg N/fed in their effect on root fresh weight was insignificant in beets sown in October, with a significant increase in this trait resulted from the applying 120 kg N/fed over that of 100 kg N/fed, in September, in the 1st season. In the 2nd one, applying 120 kg N/fed led to more distinguished significant increase in root fresh weight (0.227 kg/plant) over that obtained by applying 80 kg N/fed in September, compared to that recorded in October (0.111 kg/plant).

Applying 120 kg N/fed. resulted in more distinguished significant increase in root yield (4.73 tons/fed.) higher than that produced by applying 80 kg N/fed in October, compared to that recorded in September (2.93 tons/fed), in the 2nd season.

The results in Table 7 indicate that Na, quality % and corrected sugar yield were significantly influenced by the interaction of sowing date x N fertilization levels in the 2nd season.

Higher and significant increase in root Na% was detected with the application of 100 kg N/fed over that recorded by 80 kg N/fed, in September, without significant difference in this trait in October, in case of applying 80 or 100 kg N/fed. Likewise, higher and significant increase in root quality% was found, when beet were supplied with 120 kg N/fed compared with those given 100 kg N/fed, in September, without significant difference in this trait in October between the two N fertilizer levels.

Applying 120 kg N/fed led to more distinguished and significant increase in corrected sugar yield (0.83 ton/fed) higher than that produced by applying 80 kg N/fed in October, compared to that obtained in September (0.39 ton/fed).

Table 7. Effect of the interactions between sowing date and nitrogen level on Na (meq/100 g beet), quality% and corrected sugar yield (t/fed.) of sugar beet in 2015/2016 and 2016/2017 seasons

Treatment		Na (meq/100 g beet)	Quality %	Corrected sugar yield (t/fed)
Season		2nd	2nd	2nd
Sept. 1st	80 kg N/fed	1.47	89.64	3.32
	100 kg N/fed	1.64	89.52	3.58
	120 kg N/fed	1.74	88.74	3.71
Oct. 1st	80 kg N/fed	1.62	87.12	3.21
	100 kg N/fed	1.65	87.34	3.87
	120 kg N/fed	1.67	87.14	4.04
LSD at 5%		0.11	0.38	0.14

The results in Table 8 elucidate that root fresh weight (in both seasons), sucrose and quality percentages (in the 2nd season) were significantly affected by the interaction of sowing date and plant age at harvesting.

The results cleared exhibited higher and distinguished increase in root fresh weight of beets harvested at age of 210 days than those harvested at 195 dayes, when sugar beet was sown earlier in September compared to that planted one month later, in the 1st and 2nd seasons.

Sucrose% was significantly higher in beets harvested at age of 210 days than that recorded in beets harvested at 195 days, when sugar beet was sown in September, without significant variance between the two harvesting ages, in case of sowing sugar beet in October, in the 2nd season.

Table 8. Effect of the interactions between sowing date and harvest age on root fresh weight (kg), sucrose% and quality% of sugar beet in 2015/2016 and 2016/2017 seasons

Treatment		Root fresh weight (kg)		Sucrose%	Quality%
Season		1st	2nd	2nd	2nd
Sept. 1st	180 days	0.833	0.864	17.51	88.61
	195 days	0.891	0.936	17.96	89.37
	210 days	1.025	1.047	18.71	89.91
Oct. 1st	180 days	1.094	1.085	16.48	85.90
	195 days	1.233	1.251	17.70	87.37
	210 days	1.283	1.305	17.44	88.34
LSD at 5%		0.048	0.028	0.47	0.48

Quality% was significantly and noticeably higher in beets harvested at age of 195 days than that recorded in beets harvested at 180 days, when sugar beet was sown in October, compared to that planted in September, in the 2nd season.

The results in Table 9 reveal that the interactions between sowing date and harvest age had a significant effect on Na, alkalinity coefficient and sugar lost to molasses% (in the 2nd season) as well as K (in both seasons).

The results cleared that the difference in K % and sugar lost to molasses was insignificant whether beets were harvested at 195 and 210 days in September, with a significant variance between these two harvest ages in October.

Alkalinity coefficient was insignificantly influenced in case of harvesting beets at 180 or 195 days from sowing in October, with a significant difference between the two harvest ages in September.

Insignificant variance of the interaction of sowing date x harvest age on Na% was recorded, when beets were harvested either 195 or 210 days in October, with a significant difference between the two harvest ages in September.

Table 9. Effect of the interactions between sowing date and harvest age of Na, K (meq/100 g beet) K (meq/100 g beet), alkalinity coefficient and sugar lost to molasses% in 2015/2016 and 2016/2017 seasons

Treatment		Na (meq/100 g beet)	K (meq/100 g beet)		Alkalinity coefficient	Sugar lost to molasses %
Season		2nd	1st	2nd	2nd	2nd
Sept. 1st	180 days	1.46	3.88	3.30	6.11	1.39
	195 days	1.73	3.41	2.77	5.27	1.31
	210 days	1.66	3.30	2.79	5.60	1.29
Oct. 1st	180 days	1.87	4.14	3.82	6.51	1.72
	195 days	1.52	4.09	3.92	6.23	1.63
	210 days	1.56	3.87	3.29	5.56	1.43
LSD at 5%		0.08	0.18	0.13	0.50	0.06

The results in Table 10 show that corrected sugar % and root yield (in the 2nd season) as well as corrected sugar yield (in both seasons) were significantly affected by the interaction of sowing date x harvest age.

Table 10. Effect of the interactions between sowing date and harvest age of Corrected sugar%, Corrected sugar yield (t/fed.) and Root yield/fed (ton) in 2015/2016 and 2016/2017 seasons

Treatment		Corrected sugar%	Root yield (t/fed.)	Corrected sugar yield (t/fed.)	
Season		2nd	2nd	1st	2nd
Sept. 1st	180 days	15.52	19.89	2.95	3.08
	195 days	16.05	21.96	3.53	3.52
	210 days	16.82	23.81	3.94	4.00
Oct. 1st	180 days	14.16	23.10	3.07	3.28
	195 days	15.46	24.78	3.89	3.84
	210 days	15.41	25.91	3.94	3.99
LSD at 5%		0.47	0.60	0.60	0.14

Higher and significant increase in corrected sugar% was noticed in beets harvested after 210 days from sowing over that recorded after 210 days, in September, without significant difference in this trait in October, in case of harvesting beets at these two ages , in the 2nd season.

Distinguished and significant increase in root yield amounted to 3.92 tons/fed was obtained in beets harvested after 210 days from sowing more than those harvested after 180 days, in September (2.81 tons/fed), without significant difference in this trait in October, in case of harvesting beets at these two ages, in the 2nd season.

Noticeable and significant increase in corrected sugar yield/fed was recorded in beets harvested at age of 210 days higher than those harvested after 180 days, in September compared to those harvested at the same ages in October, in the 1st and 2nd seasons.

CONCLUSION

Under conditions of the present work, sowing sugar beet on October 1st and fertilized with 120 kg N/fed. and harvested at age of 210 days from sowing can be recommended to obtain the highest root yield/fed, while harvesting it after 195 or 210 days to get the highest sugar yield/fed.

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تأثُّر الصفات التكنولوجية وحاصل جذور بنجر السُكَّر بميعاد الزراعة ومستوى النتروجين وعمر الحصاد

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أُجريت أربع تجارب حقلية في محطة بحوث ملوى بمحافظة المنيا خلال الموسمين 2016/2015 و 2017/2016 لدراسة تأثير ميعادين زراعة (الأول من سبتمبر والأول من أكتوبر) وثلاثة مستويات من النيتروجين (80 و100 و120 كيلوجرام نيتروجين/فدان) وثلاثة أعمار حصاد (180 و195 و210 يوماً من الزراعة) على نمو وخصائص الجودة وحاصل بنجر السكر. تم تنفيذ كل ميعاد زراعة فى تجربة منفصلة فى تصميم قطع منشقة مرة واحدة فى ثلاث مكررات ، حيث وضعت مستويات النيتروجين فى القطع الرئيسية ، في حين خصصت القطع الفرعية لأعمار الحصاد. وفيما يلي ملخص لأهم النتائج. أظهرت النتائج أن كل صفات بنجر السكر المدروسة تأثرت معنوياً بميعاد الزراعة فى الموسمين. إزداد كلاً من طول وقطر ووزن الجذر وحاصل الجذور/فدان وكذلك الألفا أمينو نيتروجين والصوديوم والبوتاسيوم وحاصلى الجذور والسكر المُصحح بتأخير ميعاد الزراعة من أول سبتمبر إلى أول أكتوبر. على العكس من ذلك ، فقد سُجلت قيماً أعلى لنسب السكروز والسكر المُصحح والجودة بتبكير الزراعة فى أول سبتمبر. أوضحت النتائج على أن كل صفات بنجر السكر المدروسة تأثرت معنوياً بمستوى السماد النيتروجينى فى الموسمين. أدى رفع مستوى التسميد النيتروجيني من 80 إلى 100 و 120 كجم نيتروجين/فدان إلى زيادة تدريجية في طول وقطر ووزن الجذر ونسبة السكر المفقود فى المولاس وحاصلى الجذور والسكر/فدان فى كلا الموسمين - في حين إنخفضت نسبة الجودة ومعامل القلوية. سُجلت أعلى قيم لنسبة السكروز والسكر المُصحح بإضافة 100 كجم نيتروجين/فدان. أشارت النتائج إلى تأثُّر كل صفات بنجر السكر المدروسة معنوياً بعمر النبات عند الحصاد فى الموسمين فقد زاد كلاً من طول وقطر ووزن الجذر ونسبة السكر المفقود فى المولاس وحاصلى الجذور والسكر/فدان وكذلك النسبة المئوية للسكروز والنقاوة تدريجياً بزيادة عمر النبات عند الحصاد من 180 و195 إلى 210 يوماً – بينما إنخفضت نسبة الصوديوم والسكر المفقود فى المولاس ومعامل القلوية في كلا الموسمين. توصي الدراسة بزراعة بنجر السكر في الأول من أكتوبر والتسميد النيتروجيني بمعدل 120 كجم نيتروجين للفدان والحصاد عند عمر 210 يوماً من الزراعة للحصول على أعلى حاصل جذور/فدان أو حصاده بعد 195 أو 210 يوماً للحصول على أعلى حاصل سكر/فدان.