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COMPONENTS OF SUGAR BEET, YIELD GROWTH CRITERIA, AND JUICE QUALITY UNDER VARYING PLANT DENSITIES AND NITROGEN FERTILIZATION

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ABSTRACT

Two field experiments were conducted throughout two seasons in 20/2021 and 21/2022 in Sannource village Elfayoum Governorate to study the effect of three hill spaces i. e. 13,15 and 18 cm and four nitrogen fertilization i.e. 60, 80, 100, and 120 kg. N/ fed. and their interaction on yield and quality of sugar beet crop. Sugar beet variety viz Bts mono germ variety was sown in the 1st week of September in the two studied seasons. Significant response in root dimensions with the increase in hill distances, positive and significant response in root dimensions in both seasons due to the extra applications in nitrogen fertilization, yield root fresh weight fed.-1 showed statistical differences at $P \leq 0.05$ between hill spaces, in the respect to their effect on fresh weight of sugar beet yield fed.-1. an irreversible relationship between hill spaces and root yield/fed. was found with the increase in hill spaces, positive increase in root yield of sugar beet with the increase in the farther doses of nitrogen. Neither hill spaces nor nitrogen fertilizer levels and their interaction influenced sugar beet juice purity percentages in the two seasons. neither hill spaces nor nitrogen fertilizer levels appeared a significant influence on K % and Na %.

Key Words: sugar beet, plant densities, nitrogen fertilizer

INTRODUCTION

Under the limited sources whether from the cultivated areas and/ or the scarce water needed**,** the policy decision maker and the agricultural investors investigators make a continuous attempt to increase vertically the productivity and the quality of the cultivated unit area to face the continuous demands on the strategy commodities such as sugar, wheat, rice and oil. Plant population of unit area and/ or the suitable quantity of the applied fertilization will hardly contribute in the improving of yield and quality of crops.

El-Geddawy and Makhlouf (2015) reported that the increase in hill spaces from 15 to 25 cm. significantly increased root diameter, root length, root fresh weight, nitrogen and potassium concentration of the root as well as root and top yield of sugar beet. The Hughes and significant values of sucrose and sugar yield/fed. were obtained with a distance of 20 cm., meanwhile purity % was reduced with 15 cm between hills. **Leilah *et al*., (2017)** exhibited that sawing beet seeds at 35 cm. distance between hills on both sides of mastaba 80 cm width (30000 plant/ fed.) resulting significant increase in number of leaves/plant, foliage fresh weight/plant & root weight, sucrose, total soluble solids and purity percentages. **Sarhan, and El-Zeny (2020)** showed that sowing sugar beet in both sides terraces, 90 cm apart, at 20 cm between hills attained the highest values of yield components, most of root juice quality parameters and-yield, followed by sowing in one side of ridges, 60cm apart, at 15 cm between hulls.

El-Shafai (2000) showed that increasing nitrogen –level up to 92 Kg. - N/ fed. significantly increased root fresh weight, root and sugar yields, while sugar sucrose % decreased. However , purity % was not significantly affected by the applied nitrogen level. **Tawfic *et al.*, (2012)** cleared that the studied nitrogen levels (65, 80 and 95 kg N/Fed.) insignificantly effected on growth criteria in terms of root dimension, root fresh weight, quality as well as quality traits (TSS %, sucrose % purity %) , yield of tops, roots, and sugar/Fed. **Osman *et al*., (2010)** reported that increasing nitrogen level up to 120 Kg. N/Fed. significantly increased root length. Diameter and root fresh weight as well as root yield. **Badr (2016)** showed that feeding sugar beet plants grown in a sandy soil with 70 kg. N /fed. produced the maximum sucrose percentage, extractable white sugar, purity %. Sugar yield tons/fed. was significantly increased by increasing nitrogen level up to 90 kg. N/fed. **Leilah *et al.*, (2017)** found that increasing nitrogen levels from 69 to 92 and 115 kg. N/fed. significantly increased root weight, root diameter, root length, number of leaves, foliage fresh weight/plant and plant weight. While it significantly deceased sucrose and TSS and purity percentage. **Makhlouf and Abd El-All (2017)** indicated that root length and diameter, impurities content s,leaf area index, top, root and sugar yields of sugar beet were significantly increased when raising nitrogen levels from 80 to 120 kg.N/fed. Whereas adding 100 kg. N/fed. gave the highest significant values of sucrose and extractable sugar percentages. **Sarhan, and El-Zeny (2020)** cleared that the highest values of yield components, most of root juice quality parameters and yields were produced from fertilizing beet plant with 110 kg. N/fed. However, application of 90 kg. N/fed. induced the highest value of sugar yield and the second best value for each of yield component, root juice quality parameters, top and root yields values significant differences between them in most cases. **Makhlouf *et al.*, (2021)** showed that addition of 60 kg. N/fed.to sugar beet plants along with a mixture of *Azospirillum* *barasiliense* and *Bacillus polymyxa* as a soil drench at 5 kg. / fed. twice, significantly decreased K and α- amino nitrogen contents, as well as sugar lost to molasses %. Meanwhile there were no significant differences in sucrose %, extracted sugar %, quality index and root and sugar yields/fed.as compared to that given with 80 kg. N/fed.

MATERIALS AND METHODS

Two field experiment**s** were carried out in two successive seasons in 20/2021 and 21/2022 in Sannource village Fayoum Governorate to study the influence of plant densities in terms of three hill spaces i. e. 13, - 15 and 18 cm. and four nitrogen fertilization levels. 60 - 80, 100 & 120 kg. N/ fed. , their interaction**s** on yield and quality of sugar beet crop. Sugar beet variety viz Bts mono germ variety from Sugar Crops Research Institute (SCRI) was sown at the 1st week of September in the two studied seasons.

Experiment site description

The examined treatment**s** were allocated in sub plot design in three replicates, where the hill spaces were distributed in the main plots. Whereas nitrogen levels were done in the sub plots. Nitrogen fertilizer levels were added in two equal doses, the 1st one after 25 days and the 2nd one month later.Potassium fertilization was added once at 48 Kg. K_2O/Fed. with the 1st application of nitrogen. Whereas phosphorus fertilization was applied once at land preparation at 30 kg. P_2O_5/ fed. as recommended. Growth criteria, roots and sugar yields in addition to technological traits were studied.

Data collected were statistically analyzed according to the technique of analysis of variance (ANOVA) according to **Snedecor and Cochran (1980).**

RESULTS AND DISCUSSION

Data presented in Table (1 &2) showed significant response at $P \leq 0.05$ in root dimensions with the increase in hill distances. However, this increase was limited in root length in the 1st season and continuously in the 2nd season for root length and in both seasons in root diameter. These finding indicate that the wider the hill space, the higher the root diameter. This observation was accepted because the wider space between plants allow to increasing in root girth. This result is in agreement with that reported by **El-Geddawy and Makhlouf (2015)**.

It can figure out from Tables (1 & 2) that there was a positive significant response at $P \leq 0.05$ in root dimensions in both seasons due to the further nitrogen fertilization application This result was achieved under the various hill spaces. This finding is in line with that found by **Makhlouf and Abd El-All (2017).** Data in Table (1 & 2) revealed that in spite of the significant response at P ≤ 0.05 for the interaction between hill spaces and nitrogen levels on root dimensions did not reach to the level of significance in both growing seasons.

Table (1): Root length of sugar beet as affected by Hill space, nitrogen fertilizer and their interaction over two studied seasons in 20/2022 and 22/2023.

20/2022 season					
Hill space (H)	Nitrogen fertilizer Kg. N/fed. (N)				Mean
	60	80	100	120	
13	35.33	37.33	39.0	41.33	38.25
15	36.00	39.33	41.67	42.33	39.83
18	36.67	40.0	41.0	41.67	39.83
Mean	36.0	38.89	40.56	41.78	
L:SD at 0.05 level of significance H 1.10 N 0.71 HxN, NS					
22/2023 season					
13	34.66	35.33	36.66	37.66	36.07
15	35.33	36.33	37.0	38.66	36.91
18	37.33	37.66	39.65	40.66	38.83
Mean	35.77	36.55	37.77	38.99	

L:SD at 0.05 level of significance
H 0.499
N 0.653
HxN NS

Table (2): Root diameter of sugar beet as affected by Hill space, nitrogen fertilizer and their interaction over two studied seasons in 20/2022 and 22/2023.

202022 season					
Hill space (H)	Nitrogen fertilizer Kg. N/fed. (N)				Mean
	60	80	100	120	
13	11.67	12.67	14.65	15.07	13.07
15	12.67	14.00	15.33	17.33	14.83
18	14.67	15.67	17.0	17.33	16.17
Mean	13.00	14.11	15.67	16.78	14.89
L:SD at 0.05 level of significance H 1.05 N 0.07 HxN NS					
22/23 season					
13	10.66	11.33	12.66	13.0	11.91
15	11.0	12.66	13.66	14.66	12.99
18	14.66	15.33	16.33	16.33	15.66
Mean	12.11	13.11	14.22	14.66	

L:SD at 0.05 level of significance
H 0.59
N 0.65
HxN NS

Data illustrated in Table (3) pointed out that increasing hill spaces tended to significant at P ≤ 0.05 increase in the values of root fresh weight in both growing studied seasons.The highest values of root fresh weight were recorded with 18 cm between hills. This result may be due to the fact that the wider hill space, the bigger area which allow more growth in root girth consequently more growth in root weight. This result is in accordance with **Leilah *et al.*, (2017).** Table (3) cleared that there is a positive increase in the values of root fresh weight plant^{-1} due to the increased in nitrogen levels from 60 to 120 Kg. N/fed.

Table (3): Root fresh weight plant^{-1} of sugar beet as affected by Hill space, nitrogen fertilizer and their interaction over two studied seasons in 20/2022 and 22/2023.

20/2022 season					
Hill space (H)	Nitrogen fertilizer Kg. N/fed. (N)				Mean
	60	80	100	120	
13	1066	1300	1566	1733	1416
15	1300	1466	1666	2033	1616
18	1533	17.33	2066	2233	1891
Mean	1300	1500	1766	2000	
LSD at P ≤ 0.05 level of significance H 86.57 N 55.56 HxN NS					
22/2023					
13	1016	1233	1466	1485	1300
15	1166	1416	1633	1733	1487
18	1533	1766	1966	2133	1850
Mean	1238	1472	1688	1783	

LSD at P ≤ 0.05 level of significance
H 47.69
N 48.12
HxN NS

Additionally, results obtained in Table (4) cleared that yield of root fresh weight /fed. showed statistical differences at P ≤ 0.05 between hill spaces in respect to their effect on fresh weight of root yield fed.$^{-1}$ This finding was completely obtained in both seasons. This observation was consistent with that reported by **Sarhan, and El-Zeny (2020)**. However, it could be noted that an irreversible relationship between hill spaces and root yield fed.$^{-1}$, In spite of this relationship was positively related to root fresh weight plant^{-1}. This observation could be explaining that under wider hill space (18 cm) root fresh weight plant^{-1} increased.However with narrow hill space (13 cm.) the number of root yield /fed. which compensated the decrease in root fresh weigh/plant consequently increased root fresh weight/fed.

It's reasonable that the positive increase in root yield of sugar beet with increasing in the additional doses of nitrogen. Raising the applied dose of nitrogen from 60 to 120 kg. fed^{-1}. increased root yield by 117 % and 23 % in the 1st and 2nd season respectively. The obtained results are in accordance with those reported by **Makhlouf and Abd El-All (2017).** The differences between the two seasons may be due to environmental conditions.

The results in Table (4) illustrated that the interaction between hill spaces and nitrogen fertilizer levels significantly at $P \leq 0.05$ influenced root fresh weight yield in both growing seasons. It could be observed that increasing applied doses of nitrogen under the various hill spaces increased root yield. The highest root yield was recorded with the combination between 120 Kg. N/fed. and hill space of 13 cm.

Table (4): Root yield Tons Fed^{-1} of sugar beet as affected by Hill space, nitrogen fertilizer and their interaction effect over two studied seasons in 20/2022 and 22/2023.

20/2022 season					
Hill space (H)	Nitrogen fertilizer Kg. N/fed. (N)				Mean
	60	80	100	120	
13	35.3	49.67	58.00	63.66	51.66
15	25.33	41.33	46.66	59.66	43.25
18	21..00	35.33	48.0	54.66	39.74
Mean	27.32	42.11	50.88	59.33	
L:SD at 0.05 level of significance H 0.92 N 0.61 HxN 1.05					
22/2023					
13	48.30	51.3	60.33	60.33	55.08
15	46.66	48.66	51.33	52.66	49.83
18	37.00	42.66	44.33	49.66	43.41
Mean	44.00	47.55	52.0	54.22	

L:SD at 0.05 level of significance
H 3.04
N 2.06
HxN 3.57

3- Juice quality:

a- Juice quality (QZ %): This parameter used in sugar factory to indicate to juice purity. Data obtained in Table (5) indicated to neither hill spaces nor nitrogen fertilizer levels and their interaction influenced on sugar beet juice purity percentages in the two seasons.

Table (5): Juice quality as affected by Hill space, nitrogen fertilizer and their interaction over two studied seasons in 20/2022 and 22/2023.

20/2022 season					
Hill space (H)	Nitrogen fertilizer Kg. N/fed. (N)				Mean
	60	80	100	120	
13	85.27	77.95	82.80	87.3	84.58
15	87.03	85.93	86.90	86.63	86.65
18	86.63	86.20	85.63	86.27	86.74
Mean	86.26	83.36	86.78	86.74	
L:SD at 0.05 level- of significance H NS N NS H × N NS					
22/2023					
13	87.97	87.26	87.0	87.7	87.68
15	88.13	88.23	88.17	86.9	87.86
18	86.5	86.6	86.9	87.07	86.77
Mean	87.53	87.37	87.62	87.22	

L:SD at 0.05 levelof significance
H NS
N NS
HxN NS

Table (6) cleared that increasing hill spaces was accompanying with increasing in α-amino nitrogen in both studied seasons.However**,** the influence of nitrogen level and /or the interaction between hill spaces and nitrogen levels did not reach to the level of significance at $P \leq 0.05$ in their effect on α-amino nitrogen**.** These result**s** may be indicating that the applied dose of nitrogen in addition to the content of nitrogen in the experimental soil (Table 7) was not enough to occur the differences between levels.

Table (6): α-amino nitrogen of sugar beet as affected by Hill space, nitrogen fertilizer and their interaction over two studied seasons in 20/2022 and 22/2023.

20/2022 season					
Hill space (H)	Nitrogen fertilizer Kg. N/fed. (N)				Mean
	60	80	100	120	
13	1.97	1.85	1.93	1.90	1.91
15	1.83	2.02	2.19	2.01	2.01
18	2.08	2.74	2.26	2.28	2.19
Mean	1.96	2.01	2.13	2.06	
L:SD at 0.05 level of significance H 015 N NS HxN NS					
22/2023					
13	2.15	2.14	1.92	2.03	2.06
15	1.97	1.94	1.91	2.05	1.97
18	2.20	2.31	2.15	2.15	2.20
Mean	2.11	2.13	1.99	2.07	

L:SD at 0.05 level-of significance
H 0.09
N NS
HxN NS

Table (7): Physical and chemical properties of the experimental soil According to Piper,(1950)

Sand	Silt	Clay		N	P	K	pH		Ec
22.8	34.3	42.9	Clay	58.6	7.33	175.6	7.9		3.13
22.4	33.8	43.8	Clay	61.4	7.92	181.3	8.0		3.33
Cation				Anion					
K+	Na+	Mg++	Ca++	SO4--	HCO3-	Cl-			
1.3	15.6	5.6	8.8	7.9	4.1	19.3			
1.5	15.9	5.3	10.4	8.4	4.5	20.2			

Concerning the effect of hill spaces and /or nitrogen levels on K % in sugar beet roots, the available data in Table (8) appeared neither hill spaces nor nitrogen fertilizer levels exhibited a significant influence at P ≤ 0.05 on K % in the two growing seasons. However, the interaction between hill spaces and the applied levels of nitrogen tended to be significant effect on K % of sugar beet roots. It obviously shows that increasing hill space under the various level of nitrogen almost be likely to raise the K % values. This finding may be indicate to the values of K % is related to root criteria in terms of size and weight of sugar beet roots. Data in Table (9) pointed out that the values of Na % in sugar beet juice did not appeared any response to the effect of hill spaces and nitrogen application and /or their interaction on the values of Na % in both studied growing seasons.

Table (8): K % of sugar beet as affected by Hill space, nitrogen fertilizer and their interaction over two studied seasons in 20/2022 and 22/2023.

20/2022 season					
Hill space (H)	Nitrogen fertilizer Kg. N/fed. (N)				Mean
	60	80	100	120	
13	3.6	3.09	3.65	3.93	3.43
15	3.70	3.76	3.65	3.40	3.63
18	3.51	3.55	3.60	3.66	3.58
Mean	3.60	6.46	6.63	3.48	
L:SD at 0.05 levelof significance H NS N NS HxN 0.24					
22/2023					
13	2.93	3.03	3.13	3.14	3.06
15	3.50	3.43	3.58	3.60	3.53
18	3.53	3.70	3.44	3.10	3.44
Mean	3.32	3.39	3.38	3.28	

LSD at 0.05 level-of significance
H NS
N NS
HxN 0.22

Table (9): Na % of sugar beet as affected by Hill space, nitrogen fertilizer and their interaction over two studied seasons in 20/2022 and 22/2023.

202022 season					
Hill space (H)	Nitrogen fertilizer Kg. N/fed. (N)				Mean
	60	80	100	120	
13	5.65	5.43	5.37	5.24	5.42
15	5.27	5.31	5.43	5.63	5.41
18	6.00	5.67	5.68	5.64	5.72
Mean	5.64	4.44	5.49	5.51	
LSD at 0.05 level of significance H NS N NS HxN NS					
13	5.00	5.10	5.08	5.04	5.05
15	4.97	4.97	5.06	5.41	5.10
18	5.38	5.55	5.44	5.31	5.42
Mean	5.11	5.21	5.19	5.25	

LSD at 0.05 level of significance
H NS
N NS
HxN NS

Once more, the presented data in Table (10) showed that sugar yield ton fed.$^{-1}$ statistically affected by hill spaces, increasing the distance between hill from 13 up to 18 cm tended to appear a negative response in the values of sugar yield ton fed.$^{-1}$. This finding almost attributes by the increase in root size and root weight plant^{-1}, as it is higher, the root weight gets higher, the root yield consequently sugar yield became higher. Moreover, it could be noted that increasing applied levels of nitrogen was completely correlated with the increasing in the values of sugar yield ton fed.$^{-1}$ in both studied seasons. This finding are in agreement with those found by **Makhlouf and Abd El-All (2017)**.

Table (10): Sugar yield ton fed.$^{-1}$ as affected by Hill space, nitrogen fertilizer and their interaction over two studied seasons in 20/2022 and 22/2023.

20/2022 season					
Hill space (H)	Nitrogen fertilizer Kg. N/fed. (N)				Mean
	60	80	100	120	
13	3.02	3.87	4.8	5.55	4.35
15	2.2	3.53	4.05	5.16	4.74
18	1.0	3.04	4.11	4.73	3.23
Mean	2.07	3.51	4.41	5.12	
L:SD at 0.05 levelof significance H 0.92 N 0.61 HxN 1.05					
22/2023					
13	4.24	4.47	5.24	5.29	4.82
15	4.11	4.29	4.52	4.57	4.37
18	3.2	3.69	3.85	4.32	3.7
Mean	3.85	4.15	4.55	4.72	

L:SD at 0.05 levelof significance
H 0.85
N 0.75
HxN 0.83

CONCLUSION

So, it could be concluded that application of 120 kg N/ fed under 13 cm hill appears and achieve the highest root and sugar yield / fed under the experimental conditions.

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مكونات بنجر السكر ومعايير نمو المحصول ونوعية العصير تحت كثافات نباتية مختلفة والتسميد النتروجيني

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قسم بحوث المعالات الزراعية– معد بحوث المحاصيل السكريه– مركز البحوث الزراعية– الجيزة–مصر

أقيمت تجربتان حقليتان خلال موسمين 2021/20 و 2022/21 بقرية منشأه سنورس محافظة الفيوم لدراسة تأثير ثلاث مسافات زراعه. 15,13 و 18 سم. وأربعة تسميد نيتروجيني 60 و80 و100 و120 كجم. ن/ ف وكان التصميم المستخدم قطع منشقة مرة واحده حيث كانت مسافات الزراعه فى القطع الرئيسية بينما وزعت معدلات النيتروجين بشكل عشوائى فى القطع الشقية . وتفاعلها في إنتاجية وجودة محصول بنجر السكر. تم زراعة صنف بنجر السكر وهو الصنف BTS وحيد الأجنه في الأسبوع الأول من شهر سبتمبر في الموسمين المدروسين. استجابة معنوية في طول الجذور مع زيادة مسافات الزراعه، استجابة معنوية في طول الجذور في كلا الموسمين بزيادة معدلات التسميد النتروجيني، وكذلك زيادة معنوية فى الوزن الطازج للجذور.-1 أظهرت فروق ذات دلالة إحصائية عند $P \geq 0.05$ بين مساحات الزراعه، زيادة معنوية فى الوزن الطازج للجذور -1.اثرت مسافات الزراعه معنوياعلى محصول الجذور / فدان وكانت مسافه الزراعه 13 سم اعلى فى محصول الجذور عن باقى المسافات وكذلك زاد محصول الجذور عند مسافه زراعه 13 سم بزياده معدلات النيتروجين. لم تؤثر مساحات الزراعه ولا مستويات السماد النتروجيني وتفاعلهما على نسب نقاوة عصير بنجر السكر في الموسمين. وكان لا يوجد تأثير معنوى لمساحات الزراعه أو مستويات الأسمدة النيتروجينية لها تأثير كبير على نسبة البوتاسيوم و الصوديوم.