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Effect of Varietal Differences and Seed Type on Sugar Beet Yield and Quality in Sandy Soil

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Abstract: Two Field experiments were conducted in the Experimental Farm of the National Research Centre, El-Behaira Governorate. The experiments were conducted in 2016/17 and 2018/19 winter seasons and included the evaluation of 10 sugar beet varieties in the first season, which were five monogerm seed varieties *i.e*., Francesca, Karem, AS 0082, Ravel and MK 4114 used and another five polygerm seed varieties Samba, Rizobel, MK 4016, SV 1841 and Amina. used in production areas in 16/2017. In 2018/19 season Karem, AS 0082, Ravel were evaluated as well as Rizobel, MK 4016, SV 1841 and Amina as monogerm and polygerm varieties, respectively. Generally, it seems that the monogerm seeds produced stronger sugar beet plants under sandy soil conditions compared with plants produced from the polygerm seeds. The plants produced from the monogerm seeds have longer and wider beets and possessed greater roots and shoot yields per plant and per feddan. The results showed significant differences among the tested varieties in mean root length and diameter, root and top weight per plant as well as root and top weight per feddan. The data show that Ravel variety significantly surpassed the other varieties in root and top yields per plant and per feddan and possessed reasonable criteria for root length and diameter. However, the varieties SV 1841 and Amina gave the lowest studied parameters in root length and diameter as well as root and top yields per plant and per feddan. The tested varieties could be arranged according to sugar yield per feddan in 2016/17 season in the following order Rizobel > Francesca > MK4016 > Ravel > AS 0082 > SV 1841 > Amina. While in 2018/19 season they were Rizobel > Francesca > MK4016 > Ravel > AS 0082 > SV 1841 > Amina. The data of the extractable sugar indicated similar tendency for the gross sugar yield per feddan Gross sugar yield per feddan ranged between 2.925 and 5.076 with an average of 3.856 ton fed^{-1} in 2016/17 season while the corresponding values for 2018/19 season were 3.358 and8.186 for the minimum and maximum yields with an average of 5.403 ton fed^{-1}. It is worthy to note that the lowest sugar beet varieties in yield contained the extractable and gross sugar yields per feddan whereas the variety SV 1841 could compensate the lower production ability as occurred by the higher sugar % in 2016/17 season. Moreover, it can be noticed that the high purity percentage expressed as (Qz%) shared in the partial compensation of the extractable for some tested varieties. It could be concluded from this study that sugar beet seed type may affect yield and quality and the monogerm seed type is favored in sandy soil conditions to produce higher sugar beet yield with good quality. Due to the instability of sugar beet varieties performance in yield and quality, it is recommended to continue varietal evaluation under such conditions.

Key words: Sugar beet · Variety · Seed type · Yield · Quality · Sandy soil

INTRODUCTION

Sugar beet (*Beta vulgaris var. saccharifera* L.) ranks as the second important sugar crops after sugar cane, producing annually about 40 % of sugar production all over the world. In Egypt, it has been a large importance where there are wide newly reclaimed sandy soils at the northern and southern parts of Egypt, that could be cultivated with sugar beet without competition with other winter crops due to its tolerance to salinity and ability to produce high sugar yield under saline conditions and limited water requirements in comparison to the other traditional winter crops. Moreover, in Egypt, there was a gap between sugar consumption and production due to

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steady increases in the country population and average consumption of sugar beside limited cultivated area. Increasing sugar crops cultivated area and sugar production per unit area are considered the important national target to minimize the gap between sugar consumption and production. The total sugar beet cultivated area reached about 559744 feddan with an average of 20 ton fed^{-1} (Agricultural Economics of Egypt, 2016). Recently, sugar beet has an important position in winter crops not only in the fertile soils, but also in poor, saline, alkaline and calcareous soils.

Sugar beet varieties in Egypt are imported and regular evaluation for these imported varieties is essential in order to get stability of root and sugar yields as well as farmer confidence in these varieties. As large number of sugar beet cultivars are available all over the world and most of them are grown under temperate conditions. Hence, there is need to evaluate the performance of these varieties under subtropical conditions for their suitability [1]. Osman *et al*. [2] found significant differences among the sugar beet varieties Gloria, Toro and Pamela in root length, diameter, fresh weight, root and sugar yield (ton fed^{-1}), as well as sucrose and purity%. Azzazy [3] and Abd El-Aal and Amal [4] showed that sugar beet varieties varied significantly for root fresh weight $plant^{-1}$, root and sugar yields fed^{-1}, while root length and diameter as well as sucrose and purity% did not differ significantly and sugar beet variety KWS-9422 gave the highest root and sugar yields fed^{-1}. El-Bakary [5] and Ismail *et al*. [6] found that sugar beet genotypes differed significantly in growthparameters, i.e. root length, diameter and root fresh weight as well as top, root and sugar yields fed^{-1}. Also, impurities%, Na, K and N% in sugar beet roots and quality sucrose and purity% in both seasonsincreased except impurities Na and K% in both seasons. Farida and Gazella genotypes gave the highest values, while, Samba and LPII contained the highest impurities.

Several investigators and many studies confirmed that sugar beet varieties differed significantly in most studied traits [7-14]. Meanwhile, different studies either in Egypt or other countries reported the importance of selected or/and evaluated varieties for increasing sugar productivity as well as showed the differences between sugar beet varieties in yield and quality in many environmental conditions *i.e.,* location and sowing dates. Hozayn *et al*. [15] cleared that individual variability of different varieties might be attributed to their genetic constituents and their capacity to benefit from the environmental factors, which enable them to acclimatize and attain better yield and quality parameters. Ntwanai and Tuwana [16] stated that planting date x varieties and location x varieties interactions had a significant effect on sugarand root yields and sugar content as well as impurities of sugar beet cultivars. Ghareeb *et al*. [17] found that Pleno, Samba, Sultan and Farida sugar beet genotypes had the highest root and sugar yields at early sowing dates in October than that in November. Brar *et al*. [1] stated that for successful production of sugarbeet under subtropical environmental conditions there is need to evaluate the performance of different varieties under subtropical Indian conditions. Erciyes *et al*. [18] determined yield and quality parameters of 22 different sugar beet genotypesand found that there were variability in root yields, sugarratios, pure sugar ratios and pure sugar yields of the tested genotypes.

Sugar beet seed type monogerm or polygerm may affect sugar beet germination and plant health during growth stages as well as sugar beet yield and quality. El-Kammash *et al*. [19] found that root yield per feddan of mono-germ cultivars exceeded that of multigerm cultivars significantly. They found that, the monogerm cultivars Lp 16 and BTS 899 were the most promising ones under the experimental conditions. While the multigerm cultivars Monte Bianco and Capel produced maximum root yield. Aly *et al*. [20] tested The sugar beet varieties Cesira, Univeres, Esperanza and Yaman as monogerm seeds as well as Carola, Oscar poly, Panther and Farida as multigerm seeds Oscar poly variety significantly surpassed of root fresh weigh $plant^{-1}$ and root yield fed^{-1}, while Cesira variety surpassed of corrected sugar yield, sucrose%, corrected sugar % and quality index%. They concluded that Oscar Poly, Panther and Farida varieties were the most high and stable root yield-type.

In Egypt sugar beet varieties are imported and therefore, regular evaluation for these imported varieties is essential in order to get stability of root and sugar yields as well as farmer confidence in these varieties in the newly reclaimed or sandy soils conditions Therefore, the aim of this work is to evaluate the effect of sugar beet varieties differ in their seed type on yield and quality under sandy soil conditions.

MATERIALS AND METHODS

Two field experiments were conducted in the experimental Farm of the National Research Centre (latitude of 30.87°N and longitude of 31.17°E and mean altitude 21 m above sea level), El-Behaira Governorate. The experiments were conducted in 2016/17 and 2018/19

Table 1: Mechanical and chemical analysis of experimental soil.

Sand %	Silt %	Clay %	pH	Organic matter, %	$CaCo_3$ %	E.C. dS/m	Soluble N, ppm	Available P, ppm	Exchangeable K, ppm
91.2	3.7	5.1	7.3	0.3	1.4	0.3	8.1	3.2	20

winter seasons and included the evaluation of 10 sugar beet varieties in the first season, which were five monogerm seed varieties i.e., Francesca, Karem, AS 0082, Ravel and MK 4114 used and another five Polygerm seed varieties Samba, Rizobel, MK 4016, SV 1841 and Amina. Used in production areas in 16/2017 while in 2018/19 season Karem, AS 0082, Ravel were evaluated as monogerm varieties as well as Rizobel, MK 4016, SV 1841 and Amina were evaluated as monogerm and polygerm varieties, respectively. The experimental soil was sandy. The mechanical and chemical analysis of the soil are presented in Table 1.

Seeds of sugar beet were sown in 21^{th} and 29^{th} November in 2016/17 and 2018 /19seasons, respectively. The experimental design was Complete Randomized Block Design (CRBD) Since two varieties failed to germinate in 2016/17 season the experiments included 8 and 7 treatments which were the evaluated varieties in 2016/17and 2018/19, respectively. During soil preparation, the recommended dose of phosphorus fertilizer was applied at a level of 200 kg calcium super phosphate fed^{-1} (15.5% P_2O_5). Nitrogen fertilizer (as ammonium nitrate 33.5% N) at the rate of 100 kg fed^{-1} was applied in four equal portions, the first was applied after thinning and 15 days between the others. Potassium fertilizer (as potassium sulfate 48% K_2O) at the rate of 36 kg fed^{-1} was applied with nitrogen fertilizer after thinning. Then the experimental area was ridged and divided into plots (3.5 m width x 7m length). Sugar beet cultivars were sown in hills 25 cm apart at rate of 2 kg fed^{-1} by hand in rows. After 35 days from sowing, plants were thinned twice and later one was left to ensure one plant $hill^{-1}$. Other agricultural practices were kept the same as normally practiced in growing sugar beet fields.

Data Recorded: At harvest, plants in the four inner ridges of each plot were collected and cleaned, therefore harvest was done at early April. Root and shoot yields fed^{-1} were determined from a central area of 10.5 m^2.

Studied Characters: Plant samples were taken from 3 replicates and 10 plants were taken from each variety to estimate root characters: root length (cm), root diameter (cm), root weight (g) and top weight perplant (g).

Yield per Feddan: Number of plants in the experimental unit wascounted and top and rootweights of 3x3.5 m were determined, thentotal yield was calculated fed^{-1} (ton).

Chemical Determinations:

Chemical Composition of the Roots: A sample of 5 kg of each variety was taken from the rootsfor analysis done by the sugar factory in El-Nubaria to determine:

- Gross sugar %: Juice sugar content, which was determined by means of an Automatic Sugar Polarimetric according to [21].
- Extractable white sugar %: Corrected sugar content (white sugar) of beets was calculated bylinking the beet non-sugar K, Na and α-amino (expressed as a meq/100 g of beet) according to Harvey and Dutton [22] as follows:

$$ZB = pol-[0.343(K+Na) + 0.094\ AmN + 0.29]$$

where:

ZB = Corrected sugar content (% per beet) or extractable white sugar

Pol = Gross sugar %

AmN = α-amino-N determined by the "blue number method".

- Loss sugar% = Gross sugar % - white sugar %
- Juice purity percentage: Juice purity % (Qz) = ZB/ Pol x100

Soluble Non-Sugar Content: The soluble non-sugars (potassium, sodium and α-amino nitrogen in meq/100 g of beet) in roots were determined by means of an Automatic Sugar Polari metric system. The results of these quality parameters were automatically calculated through the analyzer and the final results were tabulated and sugar yield fed^{-1} was calculated.

Statistical Analysis: The analysis of variance of the complete Randomized Block Design was carried out using MSTAT-C Computer Software [23]. To differentiate between monogerm and polygerm sugar beet seed types T-test was employed. Means of the different treatments were compared using the least significant difference (LSD) test at $P<0.05$.

Table 2: Effect of sugar beet seed type on root characters and yield.

Sugar beet seed type	Root length (cm)	Root diameter (cm)	Root yield plant^{-1} (g)	Shoot yield plant^{-1} (g)	Root yield (ton)	Shoot yield (ton)
			2016/17			
Monogerm	42.0	13.33	1561.1	731.1	30.59	14.30
Polygerm	40.9	10.13	1287.7	526.0	25.25	10.30
T-test	ns	*	ns	*	***	***
			2018/19			
Monogerm	26.5	9.21	518.3	266.4	17.58	6.51
Polygerm	27.8	8.50	606.3	140.9	28.35	10.38
T-test	ns	ns	*	***	***	***

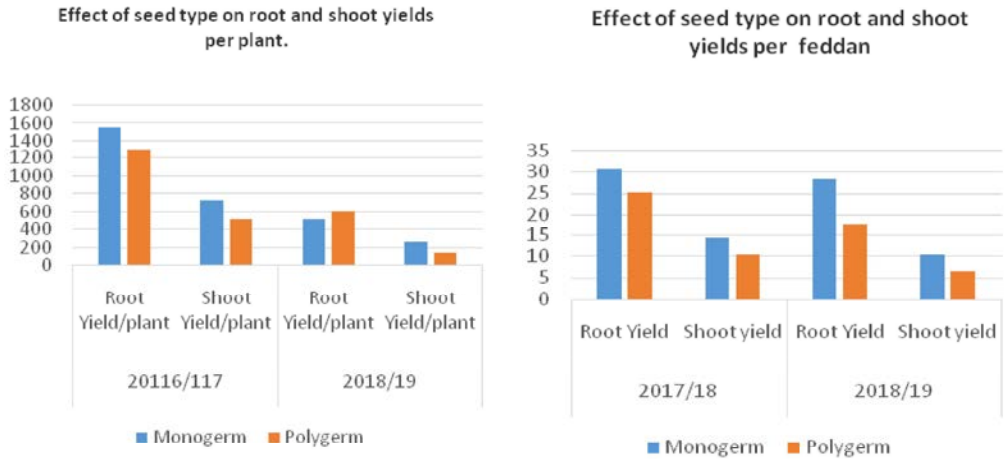

Fig. 1: Effect of seed type on root and shoot yields per plant and per feddan.

RESULTS AND DISCUSSION

Effect of Seed Type on Sugarbeet Characters: Data presented in Table (2) show the effect of mono or polygerm seeds when sown in new lands. Two monogerm varieties did not succeed in germination namely Francesca and MK 4114 in 2016/17 season. Generally, it seems that the monogerm seeds produced stronger sugar beet plants under sandy soil conditions compared with plants produced from the polygerm seeds. The plants produced from the monogerm seeds have longer and wider beets and possessed greater roots and shoot yields per plant and per feddan (Fig. 1). However, such superiority in root length and root yields per plant and per feddan was not evident for theplants produced from polygerm seed varieties. The greatest yield was obtained from the monogerm variety Ravel (Table 2) in 2016/17 season. Data in the second season 2018/19 reveal similar attitude for sugar beer seed type effect on yield characters. In other words, it can be said that the monogerm types are favored under such sandy soil conditions, these results are confirmed by those obtained by El-Kammash *et al.* [19]. They found slight yield increase for the monogerm cultivars than the multigerm cultivars without significant differences. Also, they concluded that seed type of sugar beet cultivars had no significant effect on sugar recovery per feddan. The three monogerm cultivars Lagon, Lp15, Lp16 and two multigerm cultivars Monte Bianco, Capel gave maximum yield from sugar recovery per feddan under the experimental conditions. They added that the three cultivars Lagon, Lp15 and Lp 16 (monogerm) and Monte Bianco, Capel (multigerm) could be evaluated under different environments for stability before recommending them for cultivation. Aly*et al*. [20] tested The sugar beet varieties Cesira, Univeres, Esperanza and Yaman as monogerm seeds as well as Carola, Oscar Poly, Panther and Farida as multigerm seeds Oscar poly variety significantly surpassed of root fresh weigh plant^{-1} and root yield fed^{-1}, while Cesira variety surpassed of corrected sugar yield, sucrose%, corrected sugar% and quality index%. They concluded that Oscar Poly, Panther and Farida varieties were the most high and stable root yield-type.

Effect of Varietal Difference on Sugar Beet Yield Characteristics: Data presented in Table (3) and Fig. (2) show significant differences among the tested sugar beet varieties. It is important to mention that 10 varieties (with 5 monogerm seeds and another 5 polygerm) were sown in the experiment and two varieties from the

Table 3: Effect of Sugar beet varietal differences on root characters and yield.

Varieties	Root length (cm)	Root diameter (cm)	Root weight plant^{-1} (g)	Shoot weight plant^{-1} (g)	Root yield fed^{-1} (ton)	Shoot yield fed^{-1} (ton)
			2016/17			
Karem	43.0	14.0	1400.0	726.7	27.44	14.24
AS 0082	36.3	12.7	1433.3	633.3	28.09	12.41
Ravel	46.7	13.3	1850.0	833.3	36.26	16.33
Samba	43.3	12.0	1416.7	663.3	27.77	13.00
Rizobel	40.7	11.0	1335.0	643.3	26.17	12.61
MK 4016	40.7	9.0	1306.7	543.3	25.61	10.65
SV 1841	45.0	9.3	1306.7	426.7	25.61	8.36
Amina	35.0	9.3	1073.3	353.3	21.04	6.93
LSD at 0.05	10.7	3.8	67.81	26.83	8.13	5.26
			2018/19			
Francesca	31.0	9.3	657.1	350.0	39.43	21.00
AS 0082	30.7	10.8	384.2	192.1	23.05	11.53
Ravel	22.3	7.8	398.6	164.3	23.94	9.86
Rizobel	29.7	8.2	763.0	463.9	45.73	27.84
MK 4016	34.0	10.0	602.1	254.5	36.13	15.27
SV 1841	26.0	9.7	335.1	252.7	20.11	15.16
Amina	31.7	7.7	325.0	138.2	19.50	8.29
LSD at 0.05	6.86	2.45	38.6	75.2	1.17	1.73

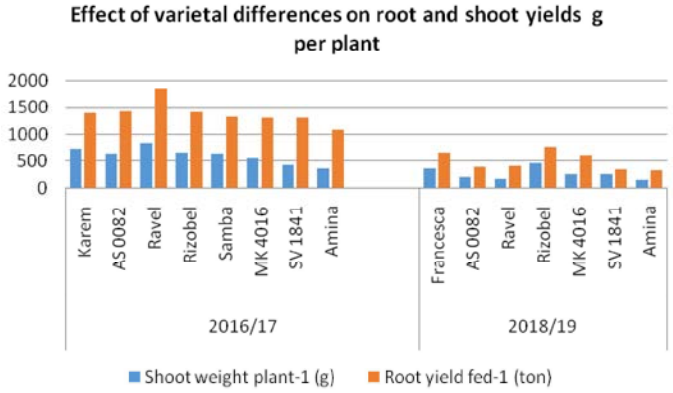

Fig. 2: Effect of varietal differences on root and shoot yields per plant 2016/17 and 2018/19.

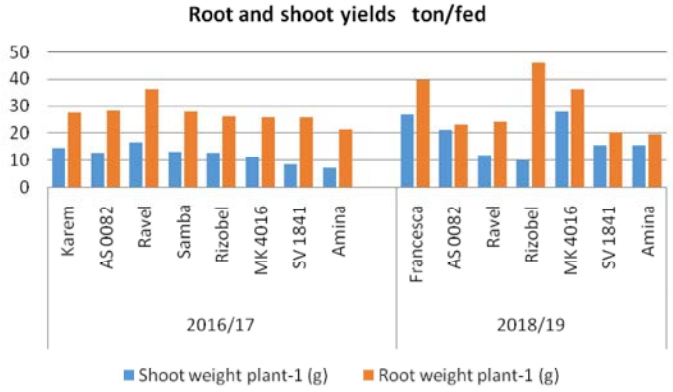

Fig. 3: Effect of Sugar beet varietal differences on root and shoot yields per fed.

monogerm seeds sown (Francesca and MK 4114) did not germinate in 2016/17. So, the presented data are related to the remainder of the tested varieties (8 varieties). Significant differences among the tested varieties in mean root length and diameter, root and top weight per plant (Table 3 and Fig. 2) as well as root and top weight per feddan (Table 3 and Fig. 3) were reported in both seasons of study. The data show that Ravielvariety significantly surpassed the other varieties in root and top yields per plant and per feddan and

possessed reasonable criteria for root length and diameter. The most superior variety in root and top yields per feddan in 2018/19 season was reported by Rizobel followed by Francesca although it had severe problems in germination in the 1st season 2016/17. However, the varieties SV 1841 and Amina gave the lowest studied parameters in root length and diameter in the 1stseason as well as root and top yields per plant and per feddan in both seasons of study. The tested varieties could be arranged according to root yield fed^{-1} in 2016/17 season in the following order Ravel > Karem > SV 1841 > AS 0082 > Rizobel >MK 4016 > Amina. While in 2018/19 season they were Rizobel > Francesca > MK4016 > Ravel > AS 0082 > SV 1841>Amina. These results indicate that there were not clear tendency for the performance of sugar beet varieties even under the same soiltype or the same district indicating the need for concentrating evaluation over repeated seasons to give the confidence to sugarbeet growers and producers for specific region. These results were similar to those obtainedby Aly [7] and El-Sheikh *et al*. [9] they found that the examined sugar beet varieties varied significantly for root fresh weight plant^{-1}, as well as, root and sugar yields fed^{-1}, while, root length and diameter, as well as, sucrose% and purity% were insignificant differences. Enan *et al*. [10] in Egypt, showed that sugar beet varieties differed significantly in root length, diameter, fresh weightplant^{-1}. Shalaby *et al*. [14] reported that sugar beet varieties showed insignificant differences in root length in two seasons. While, root diameter was affected significantly in the 2nd season and gave the highest value (15 cm). Also, root fresh weight was significantly superior to the other varieties in both seasons were it produced (1300 and 1250 g plant^{-1}) obtained from Lola variety. Hozayn *et al*. [15] cleared the individual variability of different varieties might be attributed to their genetic constituents and their capacity to benefit from the environmental factors, which enable them to acclimatize and attain better yield Also, Aly *et al*. [20] tested the sugar beet varieties Cesira, Univeres, Esperanza and Yaman as monogerm seeds as well as Carola, Oscar Poly, Panther and Farida as multigerm seeds Oscar Poly variety significantly surpassed of root fresh weigh plant^{-1} and root yield fed^{-1}.

Effect of Varietal Differences on Sugar Beet Quality: Data presented in Table (4) and Fig. (4) show that sugar beet varieties exhibited clear differences in quality parameters which affected sugar extraction parameters. Data in Table (4) show that the minimum sugar % in beet roots expressed as polarity % ranged between 12.9 and 15.7 % with an average of 14.2% while it ranged between 17.2 and 19.1 with an average of 18.1 % in 2018/19 season. Sugar yield ranged between 2.925 and 5.076 ton fed^{-1} with an average of 3.856 ton fed^{-1} in 2016/17 season while the corresponding values for 2018/19 season were 3.358 and 8.186 ton fed^{-1} for the minimum and maximum yields with an average of 5.403 ton fed^{-1}. It is worthy to note that the lowest sugar beet varieties in yield contained the sugar yield per feddan whereas the variety SV 1841 could compensate the lower production ability as occurred by the higher sugar % in 1916/17 season. The data of the extractable sugar indicated similar tendency for the gross sugar yield per feddanit seems that α-Amino-N the component is related to sugar detracting where as it is lower the juice purity (Qz%) parameter increase.The tested

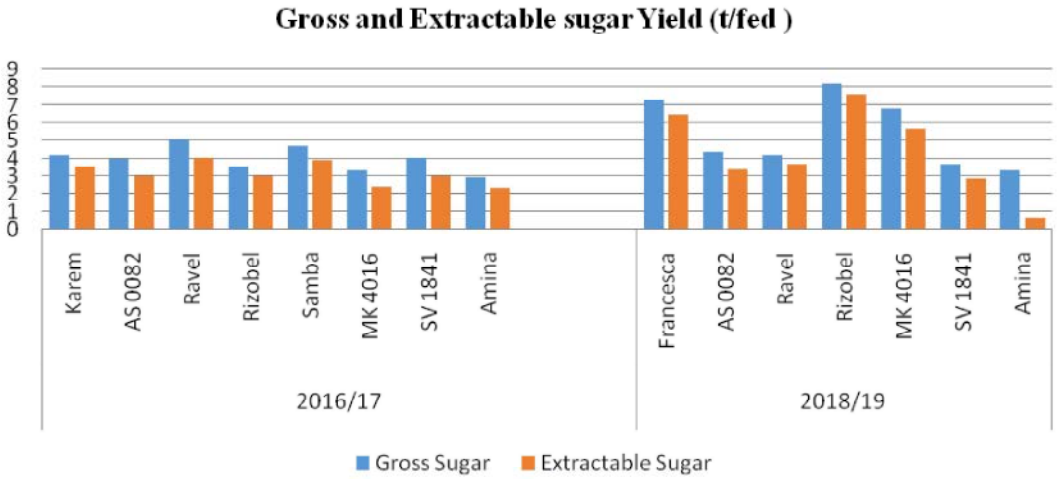

Fig. 4: Effect of sugar beet varietal differences on gross and extractable sugar yield.

Table 4: Effect of sugar beet varietal differences in chemical composition of roots.

Variety	Sugar %	Na %	K %	α-Amino-N %	Juice purity (Qz) %	Sugar yield fed^{-1} (ton)
2016/17						
Karem	15.1	2.4	2.8	1.3	85.74	4.143
AS 0082	14.2	2.5	6.5	2.3	75.07	3.989
Ravel	14.0	3.5	4.6	1.8	80.07	5.076
Rizobel	13.5	3.2	5.3	1.7	80.88	3.533
Samba	16.9	2.2	4.1	2.0	88.64	4.679
MK 4016	12.9	3.7	6.2	2.5	72.89	3.304
SV 1841	15.7	2.6	5.8	2.3	75.27	4.021
Amina	13.9	3.8	6.9	1.8	79.47	2.925
Mean	14.2	3.1	5.4	2.0	78.48	3.856
Min.	12.9	2.4	2.8	1.3	72.89	2.925
Max.	15.7	3.8	6.9	2.5	85.74	5.076
CV%	6.90	19.9	26.5	22.4	5.78	18.64
2018/19						
Francesca	18.5	1.9	3.7	1.6	87.39	7.294
AS 0082	19.1	2.1	4.5	1.9	85.59	4.399
Ravel	17.3	2.5	4.1	1.1	84.70	4.147
Rizobel	17.9	2.0	4.0	2.1	85.87	8.186
MK 4016	18.9	1.0	3.9	2.2	88.31	6.814
SV 1841	18.0	1.4	3.8	2.4	87.14	3.623
Amina	17.2	2.1	4.8	1.6	83.76	3.358
Mean	18.1	1.9	4.1	1.8	86.11	5.403
Min.	17.2	1.0	3.7	1.1	83.76	3.358
Max.	19.1	2.5	4.8	2.4	88.31	8.186
CV%	4.11	27.4	10.12	25.6	1.92	37.7

varieties could be arranged according to sugar yield fed^{-1} in the following order Ravel > Karem > SV 1841 > AS 0082 > Rizobel > MK 4016 > Amina in 2016/17 season while it was in the order: Rizobel > Francesca > MK 4016 > AS 0082 > Ravel > SV 1841 > Amina. It is worthy to note that the lowest sugar beet varieties in yield contained the extractable and gross sugar yields per feddan whereas the variety SV 1841 could compensate the lower production ability as occurred by the higher sugar % in 2016/17 season. The obtained results are in accordance with those obtained by Jassem [24] who reported that monogerm sugar beet varieties had lower sugar beet content. He found that monogerm varieties are higher yielding than multigerm varieties. Also, Khan *et al*. [25] reported that varieties differed significantly for yield and sugar contents in districts of southern KPK, Pakistan. The average beet yield remained 36.0 to 72.8 t ha^{-1}. It has been reported from three years of sugar beet varietal trials that in different parts of Punjab sugar beet varieties performed differently with respect to germination, yield and sugar recovery. El-Kammash *et al*. [19] pointed out that sugar beet cultivars had no significant effect on sugar recovery per feddan.

CONCLUSION

It could be concluded under the circumstances of this study that sugar beet seed type may affect yield and quality and the monogerm seed type is favored in sandy soil conditions to produce higher sugar beet yield with good quality. Due to the instability of sugar beet varieties performance in yield and quality, it is recommended to continue varietal evaluation under such conditions.

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