Effect of Harvest Dates on Yield and Quality of Sugar Beet Varieties

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Abstract: Two field experiments were carried out at Malawi Agriculture Research Station, Minia Governorate in 2009/2010 and 2010/2011 seasons to investigate the effects of the harvest dates on sugar beet of root yield and quality of three sugar beet varieties. Split plot design with three replicates was used in both season, where harvest dates were arranged in main plots. The tested sugar beet varieties were Pamella, H poly 1 and Top poly. Harvested dates were at three different times 180, 195 and 210 days (after emergence). The obtained results indicated significant difference between sugar beet varieties for studied traits, except total soluble solids %, Na content, α-amino N content and sugar lost to molasses. Late harvesting (210 days after sowing) resulted in greater yield of root and sugar content with or without sugar beet varieties interactions than earlier harvesting.

Key words: INTRODUCTION

After introducing Sugar beet (Beta vulgaris, L.) to Egypt and its high adaptability under different environmental factors from Northern to Middle Egypt, it become the second source for sugar production with 40%.

Investigators showed the effect of harvest dates on the yield and quality characteristics of sugar beet varieties. The root of this crop contains 13–22% sugar content (Cattanach et al., 1991). Sugar beet yield include biomass, root and sugar yield, but economic characters are storable root and percentage of sugar (Koocheki et al., 1996). In fact sugar yield is a portion of root dry matter and higher yield of sugar is obtained when higher amount of dry matter is produced in root (Lauer, 1995). Sugar yield comprises two aspects: total sugar yield that is obtained from root yield multiple by total sugar content and white sugar yield that is obtained from root yield multiple by white sugar content. White sugar yield is important to sugar industry (Koocheki et al., 1996). Sugar beet in primary growth stages needs warm and sunny climate and optimum water supply for optimal photosynthesis and photoassimilate partitioning (Fortune et al., 1999).

Time of harvest is one of the factors that affect on yield and quality of sugar beet crop. Delay in harvest enhanced root yield, sugar and extractable sugar content (Er and Inan, 1989; Marlander 1992; Lauer, 1995). Brown (1997) reported that a delay in sugar beet harvest till the end of autumn leads to decrease in sugar beet root and sugar yield and sucrose percentage and white sugar content. Jaggard and Scott (1999) and Burcky and Winner (1986) suggested that later harvest dates for sugar beet result in greater sugar yield under no rainfall and cold weather. Kerr and Leaman (1997) in a two year experiment showed that the yield was increased from the first till the last harvest. The effect of planting date on harvest date is not understood (Jaggard et al., 1983). One hypothesis is that early planted sugar beets mature early and should be harvested early, while late planted sugar beets should be harvested later, after the field has undergone a more complete maturing process (Draycott et al., 1973). An other hypothesis is that early planted sugar beets have greater yield and quality potential and should be harvested after later planted sugar beets of lower production potential (Holmes and Adams, 1966). Finally, Hull and Webb (1970) and Scott et al. (1973) concluded that yield increases at the same amount during fall harvest, regardless of planting date.

Some of sugar beet genotypes have been promoted as high sugar content genotypes adapted for early harvest. Large genotype differences in crown tissue production (Halvorson et al., 1978; Halvorson and Hartman, 1980) and development rate may cause quality differences between genotypes and thus require different harvesting strategies. Most plant breeders would agree that genotype × harvest date interactions should exist for sugar beet performance; i.e., specific genotypes should perform better early in the harvest season, while other genotypes would perform better later in the harvest season.

The objective of this experiment was to describe the relationships of sugar beet yield and quality response to harvest date, with emphasis on the management effects of varieties.

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MATERIALS AND METHODS

This experiment was carried out at Malawi Agriculture Research Station, Minia Governorate in 2009/2010 and 2010/2011 seasons to investigate the effects of the harvest dates on sugar beet of root yield and quality of three sugar beet varieties. The experiment was conducted using a split plot design arranged in randomized complete block design with three replications to study the effect of harvest dates on root yield and quality of sugar beet plant grown on a clay soil. Three varieties of sugar beet (Pamella, Top Poly and H Poly 1) were allocated to the main plots and three harvesting dates (180, 195 & 210 day after sowing) were placed in subplots. Plot size was of 3 x 7 m. Seeds were sown on 7 and 12 October during 2009/2010 and 2010/2011, respectively at 4 cm depth. All recommended agronomic practices were carried out. The first harvest was carried out 180 days after emergence and the subsequent harvests were carried at intervals of 15 days till the last harvest.

The following data was recorded after harvest as follows:
1. Root Yield (RY) ton/fadd.
2. Total Soluble Solids (TSS %) which was determined according to Simon et al., (1980).
3. Sugar Content (SC).
4. Potassium content (K content).
5. Sodium content (Na content).
6. α-amino N content (N content).
7. Extractable Sugar Content (EESC) or crystal sugar was calculated according to the following formula:
   EESC(%) = SC - [0.343(Na+k)+0.094*α-amino N+0.29] according to (Reinefeld et al., 1974)
8. Recoverable Sugar Yield (RSY) was calculated according to the following formula:
   RSY(t/fadd.) = (EESC/100) x root yield (t/fadd.) according to (Reinefeld et al., 1974)
9. Sugar lost to Molasses (MS) was calculated according to the following formula:
   MS = 0.343 * (K + Na) + 0.094*α-amino-N - 0.31. according to (Reinefeld et al., 1974).
10. Purity percentage was calculated according to the following formula:
    apparent purity % = sucrose% / TSS % X 100. According to Poschenok (1976).

Statistical Analysis:
The data were subjected to the combined analysis of variance over years and LSD test was used for means separation by using the Mstat-C statistical package software. The chi-square test (Gomez and Gomez, 1984) was used to verify homogeneity of variance before combined data.

RESULTS AND DISCUSSION

I-Effects of Varieties on Yield and Quality:
Data in Table (1) indicated that, there was significant differences between varieties for root yield, sugar content, potassium content, EESC%, RSY% and Purity %, while there were no significant differences between varieties for TSS%, Na content, N content and MS %.

Sugar beet variety Pamella recorded the highest values of root yield and RSY % followed by H-poly 1 in the combined data. While, the highest values of sugar content, potassium content, EESC% and purity % were obtained with sugar beet variety Top poly. On other hand, Flipovic, et al., 2011, obtained that, the genotypes of sugar beet recorded no significant different for sucrose content, potassium content, sodium content, Nitrogen content and recoverable sugar content.

Laure (1994) found that, on the Garland clay loam, ACH 164 and HH 30 had similar sucrose contents throughout harvest, except on harvest date 279 when HH 30 had greater sucrose content.

Some of sugar beet genotypes have been promoted as high sugar content genotypes adapted for early harvest. Large genotype differences in crown tissue production (Halvorson et al., 1978; Halvorson and Hartman, 1980) and development rate may cause quality differences between genotypes and thus require different harvesting strategies.

II-Efetcts of Havest Date on Yield and Quality:
Harvest date effects were highly significant for all traits studied, except, Na content which was no significant difference between all harvest dates in the combined data as shown in Table 1.

The highest root yield was obtained in the third harvest (210 days after sowing), which increased the root yield about 33.36% than the first harvest date. On the other hand, Abou-Salama (2000), found that, root yield was not significantly affected by harvesting date. Also, TSS %, SC and K content were increased from the first harvest till the last harvest in combined data. This enhancement can be related to increased root dry weight, which contained sucrose as a major portion (Koocheki, 1996). In relation to harvesting date effect on sugar yield, Jaggard and Scott (1999) and Burcky and Winner (1986) have suggested that at later harvest dates
produced more sugar yield under no rainfall and cold weather. Kerr and Leaman (1997) also showed that yield was increased from the first harvest till the last harvest in both years.

Laure (1994) found that, root yield and sucrose content are currently the most important parameters used in calculating grower payments for most factory districts of the western U.S. Root yield and sucrose content were affected by harvest date.

Delaying harvest dates up to 210 days significantly increased root weight, TSS%, sugar content, K content, N content, EESC%, RSY% and MS %. The same results were found by Laure (1994) he found that, root yield and sucrose content increased in a linear or sometimes quadratic fashion with later harvest date.

Aly (2006), found that, root weight, sucrose %, alpha amino nitrogen %, sucrose loss to molasses %, extractable sugar %, root yield and sugar yield per feddan were increased with the later harvest date 210 days, while early harvest date at 170 gave the highest mean values of sodium % and potassium %

Delaying harvest would often decrease sucrose loss to molasses, but wheater events such as frost or cold temperatures can also influence losses to molasses (Lauer 1997).

The highest values of purity % was recorded from the harvest at 190 days, the same results found with, Aly (2006).

Zielke (1973) found that, delaying harvest from mid-september to late of october increased root and crown yield, sucrose content and juice purity.

Cakmakci (2002), recorded that, the later harvest date resulted in greater RY, SC, and RSC, while impurities decreased.

Crystal sugar, which is the most important economic indicator in sugar beet production, was increased during grow season from the first up to the last harvest during both the years. This increase was due to increase in root yield and white sugar content during this period. Laure (1995) showed that the later harvesting dates produce more root yield, sucrose percentage and white sugar content, because of extended growth period under no rainfall and cold weather.

### III-Effects of the Interaction Between Harvest Dates and Sugar Beet Varieties on Yield and Quality:

Root yield were significantly different within the harvest date x sugar beet varieties as shown as in Table (1), the same results was found by Zielke (1973).

**Table 1:** Mean sugar yield and quality as affected by varieties, harvest date and their interactions.

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Root yield</th>
<th>TSS%</th>
<th>SC</th>
<th>K content</th>
<th>Na content</th>
<th>N content</th>
<th>EESC%</th>
<th>RSY%</th>
<th>MS</th>
<th>Purity %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pamella</td>
<td>31.24 a</td>
<td>19.35 b</td>
<td>16.95 b</td>
<td>5.48 b</td>
<td>1.64</td>
<td>1.87 b</td>
<td>14.04 b</td>
<td>3.63 c</td>
<td>2.31</td>
<td>87.63 b</td>
</tr>
<tr>
<td>Top Poly</td>
<td>28.63 b</td>
<td>20.13 a</td>
<td>18.13 ab</td>
<td>5.74 a</td>
<td>1.61</td>
<td>1.92 a</td>
<td>15.14 a</td>
<td>4.33 b</td>
<td>2.39</td>
<td>90.05 a</td>
</tr>
<tr>
<td>H Poly</td>
<td>30.86 ab</td>
<td>20.19 a</td>
<td>17.31 ab</td>
<td>5.71 ab</td>
<td>1.63</td>
<td>1.83 a</td>
<td>14.33 b</td>
<td>4.42 b</td>
<td>2.38</td>
<td>85.74 b</td>
</tr>
<tr>
<td>F-test</td>
<td>** ns</td>
<td>* *</td>
<td>*</td>
<td>ns</td>
<td>ns</td>
<td>*</td>
<td>*</td>
<td>* ns</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>LSD0.05</td>
<td>0.75</td>
<td>0.75</td>
<td>0.2</td>
<td>-</td>
<td>-</td>
<td>0.73</td>
<td>0.97</td>
<td>0.04</td>
<td>1.14</td>
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</tr>
<tr>
<td>LSD0.01</td>
<td>2.55</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.66</td>
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</tr>
</tbody>
</table>

Harvest dates (days after sowing)

| 180 days after sowing | 25.85 c | 19.35 ab | 16.95 b | 5.48 b | 1.64 | 1.87 b | 14.04 b | 3.63 c | 2.31 | 87.63 b |
| 195 days after sowing | 30.52 b | 20.05 ab | 17.99 a | 5.54 b | 1.64 | 1.83 b | 15.07 a | 4.60 b | 2.33 | 89.74 a |
| 210 days after sowing | 34.36 a | 20.93 ab | 18.29 a | 5.96 a | 1.66 | 1.94 a | 15.20 a | 5.22 a | 2.48 | 87.38 b |

**F-test**

| ** ns | * * | ** ns | **ns | ** | ** |
| LSD0.05 | 0.76 | 0.88 | 0.61 | 0.35 | - | 0.04 | 0.97 | 0.04 | 0.14 | 1.252 |
| LSD0.01 | 1.02 | 1.2 | 0.82 | 0.35 | - | 0.04 | 0.97 | 0.04 | 0.14 | 1.697 |

Interaction between harvest date x sugar beet varieties
The highest root yield recorded with Pamela and H-poly 1 x later harvest date (210 days after sowing). While, the lowest value of root yield recorded with Top poly x early harvest date (180 days after sowing). Also, the highest values of TSS% and sugarcane content were obtained with sugar beet pamelle with the later harvest date (210 days after sowing), while the lowest values of TSS% and sugarcane content were obtained with pamella x early harvest date (180 days after sowing) and H-poly 1 x early harvest date (180 days after sowing), resp.

Data in Table (1) showed that, potassium % and MS % were increased with H-poly 1 x later harvest date (210 days after sowing), on the other hand, interaction between Pamella and 195 days after sowing recorded the highest values of Na content in the combined data. While, the highest N content was obtained with the interaction between Top poly with both harvest dates 180 and 210 days after sowing and H-poly 1 with 210 days after sowing.

There was no significant difference between all treatments on EESC%, except H-poly 1 and early harvest date (180 days after sowing) which recorded the lowest significant value, while the highest EESC% was obtained with pamella and the later harvest date, also Top poly with the interaction with 195 and 210 days after sowing as shown as in Table (1).

Abou-Salama (2000), found that, sugar quality was higher with early sowing and late harvesting, and varied significantly between cultivars.

The interaction between pamella and H-poly 1 with 210 days after sowing recorded the highest significantly values of RSY% and MS as shown as in Table (1). On the other hand, the purity % was highest with the interaction between Pamells, Top poly and 195 days after sowing.

Conclusion:
A delay at the time of harvest increased root yield and root sugar content due to extending the growth period, sunny days and cool nights of autumn, which are the best conditions for sugar producing and reserving in sugar beet. This results obtained that, the highest yield of roots was obtained with Pamella and 210 days after sowing, while sugar content was highest with Pamella, Top poly and 210 days after sowing.

REFERENCES


<table>
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<tr>
<th>H-Poly 1 x 210 days</th>
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<th>LSD0.01</th>
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* and ** are significant at 0.05 and 0.01 levels of probability, respectively.