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Full Length Research Paper

Effect of Sowing Dates and Length of Storage on Storability in Sugar Beets (*Beta vulgaris* L.) Piles

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Many agronomic practices may need to be adjusted to maximize yield and quality of sugar beet. Thus, agronomic package must be always modified. The present study was conducted in split-split plot design at the Agricultural Research Center of Al Ghab, General Commission for Scientific Agricultural Research (GCSAR), Syria. The objective was to evaluate the effect of planting dates, and length of storage on the sugar losses reduction, and some quality traits in 2014/2015 season. Tow sowing dates were settled, (15th of October, and January) (factor T). The second factor (D) was the storage durations of 6 days, and tow varieties (Factor V) were arranged as split split plot design with four replications. The varieties one of them was monogerm (Vico), while the other was multigerm (Reda). Weight percent loss and quality of beet samples such as sugar content, total soluble solids (TSS%), and purity% were determined throughout storage period. Prolonging storage period of the harvested roots leads to high and gradual increment in the total soluble solids (brix %), sucrose%, and root weight loss% (23.5, 11.3, and 9.6%), respectively. Also the results clarified low juice purity % with a percent of 9.6% at the end of storage period as compared with the first day, for the all varieties and sowing dates. The variance analysis showed that the most effective factor for the all studied traits was the storage period (factor D), followed by the sowing dates (factor T), then varieties, in a very low percent (factor V), so it can be concluded that it is very urgent to send the harvested roots immediately to the factories to be processed within 24 hours, and to grow beet mainly in autumn (1st of November).

Key words: Sowing dates, Sugar losses, Storage duration, and Sugar beet.

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is the second important sugar crop after sugar cane; produce about 30 % of total world production and have readily adaptable to different environmental factors including climate (El Hag Mohammad *et al*., 2015). The suitable date for sugar beet planting depends on many factors such as previous crop, climatic conditions, cultivar, etc. (Kandil *et al*., 2004). The composition of sugar beet is affected by cultivation methods such as nitrogen application, variety, planting date and population density (Sogut and Aroglu, 2004). Sugar beet is the main and only source of sugar in Syria (AL Jbawi *et al*., 2015a). The main area for growing sugar beet in Syria is Al Ghab that yields 50% of the total root yield nationally (Al Jbawi *et al*., 2011). The total area is about 6 thousand hectares (217 hectares in winter time, and 6179 hectares in autumn time), which produced 316855 tons of roots, while the yield is 49.5 ton ha^{-1} (Ministry of Agriculture and Agrarian Reform, 2013). Sugar beet is sown from mid October onwards mid November, and from mid January to mid February, and the operation is normally completed by September. The harvesting period, takes place between late June and late September, when the amount of sugar in the beet is at its highest. As late season growth declines, the pace of harvesting quickens to ensure the crop is safely gathered in before the onset of damaging summer high temperatures.

After harvest, most of the beets is stored in piles, during which respiration, rotting, and physical deterioration decrease extractable sucrose (Campbell and Klotz, 2006; Campbell *et al*., 2008; Al-Abdallah *et al*., 2010, Al Jbawi *et al*., 2015b). Storage conditions are

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Table 1: The source of sugar beet varieties.

Genotype	Germity	Source
Vico	monogerm	Belgium
Reda	multigerm	Belgium

Source: Sugar Beet Department (GCSAR)

important factors affecting the losses of technological value of beets (Miyamoto *et al*., 1989; Bzowska-Bakalarz, 1991; Al-Abdalla, 2010; Al Jbawi *et al*., 2015b). Sugar loss represents a substantial decrease in revenue for the sugar industry, and even small reductions in storage losses can have significant economic impact, when multiplied over the volume of roots processed and the time in storage. Because of that the ultimate goal of the sugar industry constantly strives to attain is to store sugar beets for long periods of time with a minimum of weight and sugar loss. Under European conditions, long-term storage is only reasonable at low temperature with beets which are protected against frost (Jaggard *et al*., 1997; Kenter and Hoffmann, 2006; Kenter *et al*., 2006). At low temperature, changes in beet quality could be kept to a minimum. Nevertheless, amino N, invert sugar and raffinose accumulated in the beet, which increases the costs of sugar manufacturing.

Many studies confirmed that chemical treatments is a good solution to reduce the loss in sugar content and root loss throughout spraying beet roots with calcium hydroxide Ca(OH)2 (5%) (Gibriel *et al*., 2003), or a mixture of calcium hydroxide (5%) and calcium chloride (2%) (Yousif and Abou El-Magd, 2004). These chemicals increased root hardness, and reflects sunlight because of its white color, so thus reduces the temperature.

Learning about the effect of those factors shall enable to define the optimum conditions for harvesting and storage of the tested varieties. The aim of the present study was to quantify changes in the quality of beet roots during storage outdoors in piles, in order to investigate whether the chemical treatment is an appropriate to prolong the processing campaign, and to improve the storability of sugar beet roots.

MATERIALS AND METHODS

The experiment was carried out at Agricultural Research Center, (GCSAR), Al Ghab, Syria, during 2014/2015 season. The study included two varieties, the source of those genotypes were clarified in Table (1). Two sowing dates, 15th November, and 15th January, and storage durations of 6 days.

The trail was planted in a density of 100 000 plant.ha^{-1} (50 X 20) (Al Jbawi *et al*., 2009), on 15th November, and 15th January for autumn and winter sowings. Plots were eight rows wide, (50-cm row spacing), and 20 cm within plants in each row, and 8 m long. The plot size was 32 m^2. The soil classifies as sandy clayed, low content of organic matters, high nitrogen and phosphorous contents, and good content of potassium, because of that no nitrogen, potassium, and phosphorous fertilizers addition. The previous crop was wheat. The crop was harvested after 240, and 210 days after autumn and winter sowings, respectively. The temperatures during September at harvest reached 41°C (Table 2).

During the 2014/2015 storage period, temperatures began 38.5, 41.6 °C and attained after 7 days in storage 33, 32.4°C in autumn and winter, respectively (Table 2). The temperature remained above 34°C for the remainder of the storage period in both seasons.

Root samples

The center six rows were manually harvested on 1 September for autumn sowing, and on 16th September for winter sowing, and topped. Six beet sugar samples per plot were collected for sugar analysis during harvest. At the same time, a sample per plot for each chemical treatment was collected and placed in a nylon mesh onion bag in natural conditions, at the average temperature of 33^{o}C (Table 2). However, temperature changes in the piles are not predictable and vary considerably at different depths of the pile (Jaggard *et al*., 1997). The storage period from harvest to the final measurement was 6 days.

Studied traits

Sucrose was determined polarimetrically (McGinnis, 1982). Juice purity was calculated using the procedures described by Dexter *et al*., (1967). Sucrose concentrations for the samples obtained were expressed on a fresh weight basis. Subsample of brie 50 g dried in a vacuum oven at 85°C to constant weight to calculate water content. Prior to placing the storage samples in the pile, each sample was weighed. The samples were reweighed when retrieved from the storage pile. These weights were used to determine reduction in root weight.

Statistical analysis

Data was analyzed using Genstat 12 for analysis of variance (ANOVA) and Fisher's test was used to

Table 2: Temperatures during 2014/2015 storage period.

Season	2014/2015				
Autumn	**Max. Temperature ℃**	**Min. Temperature ℃**	**Winter**	**Max. Temperature ℃**	**Min. Temperature ℃**
1/9/2015	38.5	22.6	**15/9/2015**	41.0	22.0
2/9/2015	39.0	21.0	**16/9/2015**	34.6	22.5
3/9/2015	40.0	19.5	**17/9/2015**	36.5	21.0
5/9/2015	39.0	24.0	**19/9/2015**	36.5	21.0
6/9/2015	37.0	20.5	**20/9/2015**	37.0	18.8
7/9/2015	41.0	20.5	**21/9/2015**	36.6	19.0
8/9/2015	33.0	24.5	**22/9/2015**	32.4	18.0

Source: Meteorology Station in Al Ghab

Table 3. Variance combined analysis (ANOVA) of TSS (Brix)%

Source of variance	df	MS	Variance%	P
Replications	**3**	8.959	0.94	**-**
Sowing date (T)	**1**	245.664	25.89	0.015
Residual	**3**	9.488	2.09	-
Varieties (V)	**1**	47.954	10.54	0.018
T * V	**1**	0.079	0.02	0.900
Residual	**6**	4.548	0.87	**-**
Day (D)	**5**	161.119	30.91	<.001
T * D	**5**	4.910	0.94	0.461
V * D	**5**	19.919	3.82	0.005
T * V * D	**5**	10.578	2.03	0.087

df : Degree of freedom = n – 1, MS : Mean Square = SS / DF, SS : Sum of Squares
Variance % = (MS Factor / MS Total) * 100, P : Probability 0.05.

Table 4: The effect sowing dates and postharvest on brix% of two sugar beet varieties during 2014/2015 season.

Day (D)	15th November (T)			15th January (T)			Combined		
	Dita (V) (mono)	Reda (V) (multi)	Mean	Dita (V) (mono)	Reda (V) (multi)	Mean	Dita (V) (mono)	Reda (V) (multi)	Mean
1	24.3	24.4	24.3^{d}	26.9	28.4	27.7^{d}	25.6	26.4	26.0^{d}
2	24.4	24.3	24.4^{d}	28.1	30.4	29.3^{d}	26.3	27.4	26.9^{cd}
3	25.7	27.6	26.7^{c}	28.2	30.8	29.5^{cd}	27.0	29.2	28.1^{c}
4	29.5	30.8	30.1^{b}	31.1	33.5	32.3^{bc}	30.3	32.2	31.3^{b}
5	30.1	33.8	32.0^{a}	32.8	37.9	35.4^{ab}	31.5	35.9	33.7^{a}
6	30.6	31.4	31.0^{ab}	35.9	30.1	33.0^{a}	33.3	30.8	32.1^{b}
Mean	27.4	28.7	28.1	30.5	31.9	31.2	29.0	30.3	29.7
$L.S.D_{0.05}$	V=0.95*, D=1.64*, V*D=2.32			V=1.63, D=2.83*, V*D=4.00			T=2.00*, V=1.07*, D=1.62*, T*V=1.88, T*D=2.48, V*D=2.26*, T*V*D=3.33		
CV%	5.8			8.9			7.7		

determine least significance differences (LSD) at p<0.05.

RESULTS AND DISCUSSION

The effect of sowing dates and postharvest on the Total Soluble Solids % (Brix%):

The combined analysis showed a significant effect of sowing date (p<0.05) on brix% (Table 3). High brix% was achieved in beets planted in Mid January (31.3%) (Table 4). Though a significant difference was found between the varieties, Reda variety gave the highest brix% value (30.3), compared to Vico (29.0) over all studied factors (D and C). So thus the monogerm variety was deteriorated less compared to multigerm variety according to this trait, it gave less value. The statistical analysis shows that prolonging postharvest period of beet roots in the fields

Table 5. Variance combined analysis (ANOVA) of sucrose%.

Source of variance	df	MS	Variance%	P
Replications	3	7.0738	0.93	-
Sowing date (T)	1	0.0345	0.46	0.545
Residual	3	0.0745	0.03	--
Varieties (V)	1	17.0691	7.54	0.033
T * V	1	6.6571	2.94	0.137
Residual	6	2.2633	3.30	-
Day (D)	5	45.9846	67.05	<.001
T * D	5	5.4574	7.96	<.001
V * D	5	2.7549	4.02	0.003
T * V * D	5	0.4825	0.70	0.623

df : Degree of freedom = n – 1, MS : Mean Square = SS / DF, SS : Sum of Squares
Variance % = (MS Factor / MS Total) * 100, P : Probability 0.05

Table 6: The effect of sowing dates and postharvest on sucrose% of two sugar beet varieties during 2014/2015 season

Day (D)	15th November (T)			15th January (T)			Combined		
	Dita (V) (mono)	Reda (V) (multi)	Mean	Dita (V) (mono)	Reda (V) (multi)	Mean	Dita (V) (mono)	Reda (V) (multi)	Mean
1	16.6	17.4	17.0^{c}	18.4	18.3	18.3^{d}	17.5	17.9	17.7^{d}
2	17.7	17.7	17.7^{c}	19.5	18.7	19.1^{cd}	18.6	18.2	18.4^{c}
3	19.6	21.4	20.5^{b}	19.0	19.8	19.4^{c}	19.3	20.6	20.0^{b}
4	21.3	23.2	22.2^{a}	20.5	21.3	20.9^{b}	20.9	22.3	21.6^{a}
5	20.4	23.4	21.9^{a}	21.7	22.3	22.0^{a}	21.1	22.9	22.0^{a}
6	19.3	20.1	19.7^{b}	19.3	19.8	19.5^{c}	19.3	20.0	19.7^{b}
Mean	19.2	20.5	19.8	19.7	20.0	19.9	19.4	20.3	19.9
L.S.D $_{0.05}$	V=0.60*, D=1.04*, V*D=1.48			V=0.46, D=0.79*, V*D=1.12			T=0.18, V=0.75*, D=0.59*, T*V=0.75, T*D=0.76*, V*D=0.99*, T*V*D=1.24		
CV%	5.2			3.9			4.2		

leads to an increase in brix% significantly; this result is accompany with Kenter and Hoffmann, (2008) who stated that storage conditions in piles had negative consequences of accumulation of non sucrose substances. The highest values were achieved in the last days of storage 33.7%, and 32.1% for the fifth and sixth days, respectively (Table, 4). The loss percentage was 23.5%, the results are in a link with Smith and Ruppel, 1971; Bugbee, 1993; Wiltshire and Cobb, 2000, who concluded that the environment affect subsequent storage losses. The Variance% confirmed that the most effective factors on brix% were the storage period and sowing dates 30.91, and 25.89%, respectively (Table 3).

The effect of sowing dates and postharvest on sucrose %:

Irrespective of sowing dates and varieties, the sucrose % gradually increased and attained the peak at the fifth day of storage (Table 6). This increase was due to the reduction in water content as a result of high temperature during storage period (Table 2). Because of that, this increment is not a good indicator, this reduction in water content of the roots make them lose their refreshment and affect negatively sugar extraction during manufacturing in sugar factories. Similar trend was also reported by (Jaggard *et al*., 1997, Al Jbawi *et al*., 2015b). The increment in clamp temperature improve the respiratory losses thereby root damage (Wiltshire and Cobb, 2000). The high temperatures hydrolyses sucrose to give the reducing sugars, glucose and fructose, which are then used in respiration (Wiltshire and Cobb, 2000). Respiration rate is highly and predictably correlated with sucrose loss (Youssif, and Abou El-Magd, 2004; Kenter and Hoffmann, 2008).

The results in Table (5) clarified that the storage period had the effect (67.05%) on sucrose % compared to the other main factors.

The effect of sowing dates and postharvest on purity %:

Sowing dates showed a marked influence on purity% (Table 7). In both varieties the purity% decreased progressively over storage period significantly (P≤0.05). This decrease in purity% resulted by the increase in brix%, because the correlation between those two traits is

Table 7. Variance combined analysis (ANOVA) of purity%

Source of variance	df	MS	Variance%	P
Replications	3	28.77	0.84	-
Sowing date (T)	1	1463.64	42.72	0.007
Residual	3	34.26	2.28	-
Varieties (V)	1	117.04	7.78	0.032
T * V	1	362.33	24.08	0.003
Residual	6	15.05	0.63	-
Day (D)	5	222.94	9.29	<.001
T * D	5	68.88	2.87	0.022
V * D	5	39.46	1.64	0.162
T * V * D	5	65.93	2.75	0.027

df : Degree of freedom = n – 1, MS : Mean Square = SS / DF, SS : Sum of Squares
Variance % = (MS Factor / MS Total) * 100, P : Probability 0.05.

Table 8: The effect of sowing dates and postharvest on purity% of two sugar beet varieties during 2014/2015 season.

Day (D)	15th November (T)			15th January (T)			Combined		
	Dita (V) (mono)	Reda (V) (multi)	Mean	Dita (V) (mono)	Reda (V) (multi)	Mean	Dita (V) (mono)	Reda (V) (multi)	Mean
1	81.6	84.7	83.2^{ab}	81.8	75.2	78.5^{ab}	81.7	80.0	80.9^{ab}
2	82.2	86.6	84.4^{a}	83.4	73.9	78.7^{ab}	82.8	80.3	81.6^{a}
3	86.8	85.9	86.3^{a}	86.3	74.3	80.3^{a}	86.6	80.1	83.4^{a}
4	78.9	81.8	80.3^{bc}	77.2	70.2	73.7^{bc}	78.1	76.0	77.1^{c}
5	84.9	86.7	85.8^{a}	74.3	65.3	69.8^{c}	79.6	76.0	77.8^{bc}
6	77.5	76.3	76.9^{c}	65.5	72.8	69.1^{c}	71.5	74.6	73.1^{d}
Mean	82.0	83.7	82.8	78.1	72.0	75.0	80.0	77.8	78.9
L.S.D $_{0.05}$	V=2.06, D=3.57*, V*D=5.05			V=3.43*, D=5.94*, V*D=8.40			T=3.80*, V=1.94*, D=3.47*, T*V=3.56*, T*D=5.13*, V*D=4.74, T*V*D=6.95*		
CV%	4.2			7.8			6.2		

Table 9. Variance combined analysis (ANOVA) of root weight loss%

Source of variance	df	MS	Variance%	P
Replications	3	5.571	0.42	-
Sowing date (T)	1	413.050	31.43	0.011
Residual	3	13.141	2.81	-
Varieties (V)	1	0.399	0.09	0.780
T * V	1	282.323	60.32	<.001
Residual	6	4.681	2.14	-
Day (D)	5	301.492	137.55	<.001
T * D	5	10.785	4.92	<.001
V * D	5	3.601	1.64	0.163
T * V * D	5	4.528	2.07	0.082

df : Degree of freedom = n – 1, MS : Mean Square = SS / DF, SS : Sum of Squares
Variance % = (MS Factor / MS Total) * 100, P : Probability 0.05.

negative (Al Jbawi *et al*., 2015b). The reduction percentage was 8.67% (Table 8).

The effect of sowing dates and postharvest on root weight loss:

Loss of moisture increases the degree of wilting and changes processing properties of the crop (Vukov, 1977; Trzebinski, 1984). The results in Table (9) shows that the differences between varieties were not significant (P=0.78). There were significant differences between the sowing dates (P<0.05). Sowing on 15th of January attained the highest value (19.4%), while sowing on 15th November gave the lowest loss in root weight (15.2%).

Table 10: The effect of sowing dates and postharvest on root weight loss % of two sugar beet varieties during 2014/2015 season.

Day (D)	15th November (T)			15th January (T)			Combined		
	Dita (V) (mono)	Reda (V) (multi)	Mean	Dita (V) (mono)	Reda (V) (multi)	Mean	Dita (V) (mono)	Reda (V) (multi)	Mean
1	12.7	9.1	10.9^{d}	10.9	15.9	13.4^{ab}	11.8	12.5	12.2^{f}
2	14.9	10.4	12.6^{c}	13.6	18.1	15.9^{ab}	14.3	14.3	14.3^{e}
3	14.6	11.1	12.9^{c}	15.8	20.2	18.0^{a}	15.2	15.7	15.5^{d}
4	16.0	12.2	14.1^{c}	19.3	21.8	20.6^{bc}	17.7	17.0	17.4^{c}
5	20.7	15.9	18.3^{b}	22.7	24.0	23.3^{c}	21.7	20.0	20.9^{b}
6	23.1	22.1	22.6^{a}	23.9	26.2	25.1^{c}	23.5	24.2	23.9^{a}
Mean	17.0	13.4	15.2	17.7	21.0	19.4	17.4	17.3	17.3
L.S.D $_{0.05}$	V=0.94*, D=1.63*, V*D=2.31			V=3.43*, D=5.94*, V*D=8.40*			T=2.36*, V=1.08, D=1.05*, T*V=2.19*, T*D=2.24*, V*D=1.63, T*V*D=2.66		
CV%	10.5			7.8			8.6		

The statistical analysis shows that prolonging postharvest period of beet roots leads to increment in root weight loss significantly (P≤0.05). The increase percentage was 9.6% (Table 10), this decrease in root weight loss% because of high temperature during storage period (Table 2). Kenter and Hoffmann (2008) and Al Jbawi *et al*., (2015b) confirmed that the storage duration and temperature have large significant on the changes of beet quality and water content.

CONCLUSION

Prolonging storage period of the harvested roots leads to high and gradual increment in the total soluble solids (brix %), sucrose%, and root weight loss% (23.5, 11.3, and 9.6%), respectively, from the first day to the last day of the studied period. Also the results clarified low juice purity % at the end of storage period as compared with the first day. The percent of reduction in purity% was 9.6 % for the all varieties and sowing dates.

The percentage of variance confirmed that the most effective factor for the all studied traits was the storage period (factor D), followed by the sowing dates (factor T), then varieties, in a very low percent (factor V), because of that it is very urgent to send the harvested roots immediately to the factories to be processed within 24 hours, and to grow beet mainly in autumn (1^{5th} of November).

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