

INFLUENCE OF PLOUGHING DEPTH, PHOSPHORUS FERTILIZER LEVEL AND THINNING DATE ON SUGAR BEET PRODUCTIVITY AND QUALITY

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ABSTRACT

This investigation was conducted at El-Manyal Village, Talkha District, Dakahlia Governorate, during 2012/2013 and 2013/2014 seasons to study the effect of ploughing depth (0.0, 10, 20 and 30 cm), phosphorus fertilizer levels (0.0, 15.5 and 31.0 kg P₂O₅/fad) and thinning dates (at 20, 30 and 40 days after sowing) on productivity and quality of sugar beet "variety Kawemira". A split-plot design with four replicates was used for each ploughing depth during the two seasons (each ploughing depth was considered as a separate experiment). The main results of this investigation could be summarized as follows:

- 1- Increasing ploughing depths from 0.0 up to 30 cm significantly increased root fresh weight, root length, total soluble solids percentage (TSS %) as well as root and sugar yields/faddan. On the other hand, it significantly decreased root juice purity percentage in both seasons.
- 2- Increasing phosphorus fertilizer levels from 0.0 to 15.5 and 31.0 kg P₂O₅/fad, significantly increased all studied characters in both seasons.
- 3- Delaying thinning dates from 20 to 30 and 40 days after sowing markedly decreased all studied characters, except root diameter in both seasons.
- 4- The interactions among studied factors showed insignificant effects, except for the effect of the interaction between ploughing depth and phosphorus fertilizer levels on root length in the first season and sugar yield/fad in the second season.

Increasing ploughing depth to be 30 cm, adding 31.0 kg P₂O₅/fad and thinning at the age of 20 days was the suitable recommendation to maximize sugar beet root yield and quality under the environmental conditions of Dakahlia Governorate.

Keywords: Sugar beet, *Beta vulgaris L.*, ploughing depth, phosphorus fertilizer levels, thinning dates, yield, quality.

INTRODUCTION

During last years some of sugar beet producers tended to sow beet plants on the ridges of the previous crops (without ploughing). Others plough only one or two times to save time or ploughing costs with carelessness of ploughing depth. Some researchers studied the effects ploughing depth such as Korany and Khalifa (1998) in Egypt, who stated that increasing tillage depth improved root yield of sugar beet because of root size (length and diameter) was increased. Butorac *et al.* (2000) stated that deep plowing had positive effects on sugar beet root and sugar yields. Khalifa *et al.* (2000) stated that plowing is the oldest and most common practice used for achievement the primary goals of early seedbed preparation. Soil aeration is the most limiting factor in the development of an extensive root system particularly of tuber crops. Agami (2005) studied the effect of three plowing depth (30, 40 and 50 cm) and found that the highest values of root diameter as well as the percentages of total soluble solids and root sucrose were obtained from sugar beet plants planted in plots plowed until 30 cm depth. On the other side, increasing plowing depth up to 50 cm recorded the highest

values of root length. Kanany *et al.* (2005) revealed that seed bed preparation is one of the major factors affecting crop production. They added that tillage is the first step to prepare suitable conditions for seed germination. It improves soil aeration, maintains, improves soil fertility and soil moisture and creates favourable conditions for activity of useful micro organisms. Abdou *et al.* (2008) found that increasing number of ploughings from zero (without plough) up to three times significantly increased root weight by 22.96 and 21.31 %, root length by 22.82 and 18.25 %, root yield (t./fad) by 23.19 and 21.03 % and sugar yield (t./fad) by 21.23 and 16.60 % in the first and second seasons, respectively. Enan *et al.* (2008) found that increasing plowing depth from 25 up to 40 cm, significantly increased root dimensions and root sucrose percentage in both seasons and total soluble solids in the second season. While, increasing plowing depth from 20 up to 40 cm, significantly increased root and sugar yields/fad, in both seasons. On the other side, plowing depth had no significant effect on root juice apparent purity percentage in both seasons. Maghraby, Samia *et al.* (2008) stated that mechanical practices significantly increased root length of sugar beet. The highest averages were observed at 150 days after sowing. Laser leveling + deep plowing significantly produced longer roots. Shallow plowing significantly produced the shortest roots.

Concerning phosphorus fertilizer effects on sugar beet, Draycott (1993) revealed that phosphorus is an essential nutrient to raise sugar beet production. Sims and Smith (2001) reported that root yield significantly less in the control treatment (0.0 kg P₂O₅/ha.) compared to the other applications (15, 30 and 45 kg P₂O₅/ha). Ismail and Abo El-Ghait (2004) found that sucrose % was appreciably influenced by the studied levels of phosphorus (0.0, 15 and 30 kg P₂O₅/fad) in the second season of study. They added that the highest value of sucrose % was obtained with the addition of 15 kg P₂O₅/fad in the second season under the experimental conditions. Abdou *et al.* (2008) stated that increasing phosphorus fertilizer levels from 0.0 up to 30 kg P₂O₅/fad, markedly increased root weight by 10.80 and 10.82 %, root yield (t./fad) by 17.56 and 17.72 % and sugar yield (t./fad) by 29.31 and 29.52 % in the first and second seasons, respectively. Marinković *et al.* (2008) showed that increasing phosphorus from 50 to 100 and 150 kg/ha resulted in marked increases in root and sugar yields/ha. Seadh (2012) stated that application of 30 kg P₂O₅/fad, produced the highest values of growth characters and the highest values of root, top and sugar yields/fad, in both seasons.

Thinning crop plants is a very serious agricultural practice so that much of field crops such as sugar beet can't grow well giving economic yield without this operation. But, most of the investigators don't look after it. Concerning this subject, Robbins (1928) stated that beets thinned when they had two to four leaves yielded 1.75 tons more per acre than beets thinned when they had eight to ten true leaves; and 3.50 tons more per acre than beets thinned when they had twelve to fourteen true leaves. Beets blocked and thinned when 16 days old produced 1596 pounds beets and 167 pounds sugar more per acre than beets blocked and thinned when 31 days old (delay of 15 days). Beets blocked and thinned when 25 days old produced 845

pounds beets and 91 pounds sugar more per acre than beets blocked and thinned when 32 days old (delay of 7 days). A delay of 14 days reduced the yield 2744 pounds beets and 645 pounds sugar per acre. Thinning beets is an operation which should be started promptly, and pushed to as conclusion quick as possible while soil and weather conditions are favorable. Too frequently, because of delay, the beets in a part of the field become so large that they suffer from the thinning. Kamel et al. (1975) found that sugar content was not affected by time of thinning. While, delaying thinning at the 8-leaf stage reduced root and sugar yields in both seasons. Mahmoud (1979) stated that sucrose content was not affected by time of thinning. Delaying thinning up to 8-leaf stage significantly decreased root yield. Kamel et al. (1989) found that earliest thinning time (4-leaf stage) produced the highest dry matter production, root weight/plant, root and sugar yields and root juice apparent purity in both seasons and root sucrose percentage in the second season.

So, this investigation aimed to study the effect of plough depth besides phosphorus fertilizer levels and thinning dates that play major roles to overcome the bad effects that may be happen in case of sowing without plough or undeepl plough.

MATERIALS AND METHODS

Two field experiments were carried out at El-Manyal Village, Talkha District, Dakahlia Governorate during the two successive winter seasons of 2012/2013 and 2013/2014 to study the effects of ploughing depth, phosphorus fertilizer levels and thinning dates on sugar beet "variety Kawemira" productivity and quality.

Each ploughing depth (without ploughing "zero depth", 10, 20 and 30 cm depth) was performed as a separate experiment. Each experiment of ploughing depth was performed in a split plot design with four replicates in both seasons. The main plots were occupied at random with three phosphorus fertilizer levels; 0.0, 15.5 and 31.0 kg P₂O₅/fad, which were added in the form of calcium superphosphate (15.5 % P₂O₅) after ridging and division the field into plots. While, the sub-plots were devoted to thinning dates (20, 30 and 40 days after sowing to let one plant/hill) which were randomly distributed. Nitrogen in the form of urea (46.5%) was applied at the rate of 80 kg N/fad, in two equal doses, at the first and second irrigations after thinning. Potassium sulphate (48.0% K₂O) at the rate of 24 kg K₂O/fad, was added before the last plowing.

Each experimental basic unit included five ridges, each of 60 cm width and 3.5 m length, comprising an area of 10.5 m.² (1/400 fad). The previous crop was maize (*Zea mays* L.) in both seasons. Soil samples were taken at random from the experimental field area at a depth of 0-30 cm from soil surface and prepared for both physical and chemical analysis. The mechanical (physical) and chemical properties of the experimental soil are presented in Table 1.

Sowing of dry sugar beet balls took place in dry soil (2-3 seed balls/hill) during the first week of September in both seasons. The experimental field

area was immediately irrigated after sowing. Plants were kept free from weeds, by hand hoeing for three times. All normal agricultural practices, with the exception of the studied factors, were conducted as usually done for growing sugar beet according to the recommendations of Ministry of Agriculture and Land Reclamation.

Table 1: Mechanical and chemical soil properties at the experimental site area during the two growing seasons of 2012/2013 (I) and 2013/2014 (II).

Soil analysis	(I)	(II)
<i>A: Mechanical properties:</i>		
Fine sand (%)	9.60	10.20
Coarse sand (%)	5.30	4.90
Silt (%)	32.10	30.80
Clay (%)	52.90	54.00
Texture	Clayey	Clayey
<i>B: Chemical analysis</i>		
Soil reaction pH	7.60	7.70
Available N (ppm)	48.40	49.30
Available P (ppm)	11.50	12.00
Exchangeable K (ppm)	140.00	130.00

STUDIED CHARACTERS:

At harvest time (210 days after sowing), ten plants were randomly chosen from the three inner ridges of each sub-plot to estimate yield attributes and quality parameters as follows:

1. Root fresh weight (g/plant).
2. Root length (cm).
3. Root diameter (cm).
4. Total soluble solids percentage (TSS %) in roots. It was measured in juice of fresh roots by using Hand Refractometer.
5. Sucrose percentage. It was determined Polarimetrically on a lead acetate extract of fresh macerated roots according to the method of Carruthers and OldField (1960).
6. Apparent Purity percentage. It was calculated as a ratio between sucrose % and TSS % of roots according to Carruthers and OldField (1960).
7. Root yield/fad: At harvest, all plants that produced from the three inner ridges of each sub-plot were collected and cleaned. Roots and tops were carefully separated and weighed in kilograms, then converted to estimate tons/fad.
8. Sugar yield (t/fad). It was calculated by multiplying root yield by sucrose percentage.

All obtained data were statistically analyzed according to the technique of analysis of variance (AOV) for split plot design of each experiment (ploughing depth), then the combined analysis was carried out as it was outlined by Gomez and Gomez (1984) by using means of "MSTAT-C" computer software package. Least Significant Difference test (LSD) method was used to test the differences between treatment means at 5% level of probability was reported as described by Waller and Duncan (1969).

RESULTS AND DISCUSSION

1- Effect of ploughing depth:

Results listed in Table 2 clear that ploughing depth had significant effects on all studied characters over both seasons. Increasing ploughing depths from 0.0 up to 30 cm resulted in gradual increases in root fresh weight, root length as well as root and sugar yields/fad in both seasons and total soluble solids in the second season. On the other side, it resulted in gradual significant decrease in root juice apparent purity in both seasons. Moreover, the highest values of root diameter (11.98 and 12.40 cm) and root juice purity percentage (79.28 and 80.15) in the first and second seasons, respectively were obtained from plants planted in plots without plough. Increasing ploughing depths from 0.0 to 10 cm recorded the highest values of sucrose percentage (18.11 and 18.05) in the first and second seasons, respectively. While, increasing ploughing depth up to 20 cm came in the second rank, where it decreased sucrose % to be 18.06 and 17.85 in the first and second seasons, respectively. Moreover, the highest values of TSS % (23.21 and 22.87) in the first and second seasons, respectively were obtained when the ploughing depth increased up to 20 cm in the first season and 30 cm in the second season, respectively. The increase in root yield and its attributes may be due to the facts that were mentioned by Kanany *et al.* (2005) who stated that seed bed preparation is one of the major factors affecting crop production. Tillage is the first step to prepare suitable conditions for seed germination. It improves soil aeration, soil fertility and soil moisture and creates favourable conditions for activity of useful micro organisms. These results are similar to those stated by Korany and Khalifa (1998) and Abdou *et al.* (2008).

2- Effect of phosphorus fertilizer level:

Results presented in Table 2 show that increasing phosphorus fertilizer levels from 0.0 up to 31.0 kg P₂O₅/fad, significantly affected all studied characters in both seasons, except root diameter (cm) in the second season and root juice purity percentage over both seasons. There were positive relations between phosphorus levels and all studied characters. This means that each increase in phosphorus fertilizer level was associated with an increase in each one of the estimated characters over both seasons. The highest values of root fresh weight (999.1 and 986.6 g.), root length (26.96 and 27.11 cm), root yield (30.879 and 30.444 t/fad), sugar yield (5.628 and 5.542 t/fad), total soluble solids percentage (23.20 and 22.10%) and sucrose percentage (18.21 and 18.20%) in the first and second seasons, respectively and the highest value of root diameter (11.91 cm) in the first season were obtained with the addition of 31.0 kg P₂O₅/fad. The increase in these studied characters with increasing phosphorus fertilizer levels from 0.0 up to 31.0 kg P₂O₅/fad, may be due to the following: A) Phosphorus shares in the bioactivities inside plants, B) It increases the creation of carbohydrates as starch and sugars, C) It helps in the divisions of plant cells, D) It shares in forming adenosin tri phosphate (ATP) that it is necessary to form sucrose, E) It helps roots to be strong and to go down and F) It plays role in decreasing soil solution pH and hence it helps in facilitation of nutrients absorption by plants. These results are in agreement with those stated by Ismail and Abo EL- Ghait (2004) Abdou *et al.* (2008), Marinković *et al.* (2008) and Seadh (2012).

3- Effect of thinning date:

Results exposed in Table 2 clear that thinning dates had significant effects on all studied characters in both seasons, except root juice purity percentage. Delaying thinning dates from 20 to 30 and 40 days after sowing resulted in gradual decreases in root fresh weight, root length as well as root and sugar yields/fad and the percentages of total soluble solids (TSS), sucrose and apparent root juice purity in both seasons. On the other side, it increased root diameter over both seasons. The decrease which happened in all studied characters because of delaying thinning of plants from 20 to 30 and 40 days after sowing may be due to the fact that delaying thinning save competition among roots and also among complete plants during the early stages of its life. While increasing root diameter which happened because of delaying plant thinning may be due to the fact that delaying thinning don't help roots to go down so that the upper parts of roots tended to grow more. These results are similar to those stated by Robbins (1928), Kamel et al. (1975), Mahmoud (1979) and Kamel et al. (1989).

4- Effect of interaction:

Results in Table 2 show that all studied characters were not significantly affected by the interaction among studied factors, except for the effect of ploughing depth and phosphors fertilizer levels on root length in the first season and sugar yield/fad in the second season. Results in Table 3 show that increasing ploughing depth up to 30 cm and adding 31.0 kg P₂O₅/fad, recorded the highest value of root length (30.7 cm) in the first season and the highest value of sugar yield (6.178 t/fad) in the second season.

Conclusion:

In general, it could be concluded that increasing ploughing depth up to 30 cm, adding 31.0 kg P₂O₅/fad and thinning at the age of 20 days is the suitable recommendation to maximize sugar beet yield and quality under the environmental conditions of Dakahlia Governorate.

Table 3: Root length in the first season and sugar yield in the second season as affected by the interaction between ploughing depths and phosphorus fertilizer levels.

Characters	Root length (cm)			Sugar yield (t/fad)		
	Phosphorus fertilizer levels (P ₂ O ₅ /fad)					
	0.0 kg	15.5 kg	31.0 kg	0.0 kg	15.5 kg	31.0 kg
Treatments						
Ploughing depth						
0.0 cm	22.4	23.0	24.0	4.460	4.702	5.013
10 cm	24.4	24.4	24.9	4.806	5.272	5.402
20 cm	27.2	28.0	28.3	5.209	5.508	5.575
30 cm	28.6	29.5	30.7	5.482	5.748	6.178
F. test	*			*		
LSD at 5 %	0.70			0.197		

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تأثير عمق الحرث ومستويات السماد الفوسفاتي ومواعيد الخف على إنتاجية وجودة بنجر السكر

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أقيمت تجربتان حقليةتان بقرية المنيل - مركز طلخا - محافظة الدقهلية خلال موسمي ٢٠١٢/٢٠١٣ و ٢٠١٣/٢٠١٤ م - لدراسة تأثير عمق الحرث (بدون حرث ، عمق ١٠ ، ٢٠ و ٣٠ سم) وثلاث مستويات من السماد الفوسفاتي (صفر ، ١٥,٥ و ٣١,٠ كجم فو.أه/فدان) وكذلك ثلاثة مواعيد للخف (عند ٢٠ ، ٣٠ و ٤٠ يوماً من الزراعة) على إنتاجية وجودة بنجر السكر "صنف كواميرا المتعدد الاجنة". تم تنفيذ كل عمق حرث كتجربة مستقلة وتم تنفيذ التجارب بنظام القطع المنشقة مرة واحدة في أربع مكررات ، حيث وزعت مستويات السماد الفوسفاتي على القطع الرئيسية ووزعت معاملات الخف عشوائياً على القطع الشقية. ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلي:

- ١- أدت زيادة عمق الحرث من صفر حتى ٣٠ سم إلى زيادة معنوية تدريجية في صفات الوزن الغض للجزر ، طول الجذر ومحصولي الجذور والسكر (طن / فدان) خلال موسمي الدراسة وكذلك النسبة المئوية للمواد الصلبة الذائبة الكلية بالجذور خلال الموسم الثاني. وعلى النقيض من ذلك فقد أدت هذه المعاملة إلى نقص معنوي في قطر الجذور والنسبة المئوية للسكر ونقاوة العصير خلال الموسمين.
 - ٢- أدت زيادة مستويات السماد الفوسفاتي من صفر و ١٥,٥ إلى ٣١,٠ كجم فو.أه/فدان إلى زيادة معنوية في جميع الصفات المدروسة في الموسمين فيما عدا قطر الجذر في الموسم الثاني حيث أن الزيادة لم تكن معنوية.
 - ٣- أدى تأخير خف نباتات بنجر السكر من ٢٠ إلى ٣٠ ثم ٤٠ يوماً من الزراعة إلى زيادة معنوية في قطر الجذر خلال الموسمين - بينما أدت نفس المعاملة إلى نقص معنوي في كل من الوزن الغض للجزر وطول الجذر ومحصولي الجذور والسكر بالطن/فدان وكذلك النسبة المئوية لكل من السكر و المواد الصلبة الذائبة الكلية بالجذور خلال الموسمين.
 - ٤- أظهرت النتائج المتحصل عليها وجود تأثيراً معنوياً للتفاعل بين عمق الحرث ومستويات السماد الفوسفاتي لصفتي طول الجذر في الموسم الأول ومحصول السكر/فدان في الموسم الثاني.
- توصى هذه الدراسة بضرورة زيادة عمق الحرث حتى ٣٠ سم والتسميد الفوسفاتي بمعدل ٣١,٠ كجم فو.أه/ فدان وكذلك الخف عند عمر ٢٠ يوماً للحصول على أعلى إنتاجية وجودة لمحصول بنجر السكر تحت ظروف محافظة الدقهلية.

