Asian Journal of Advances in Agricultural Research

7(4): 1-9, 2018; Article no.AJAAR.43632
ISSN: 2456-8864

Application of Tillage Implements in Different Depths of Soil on Sugar Beet (*Beta vulgaris* L.) Yield and Some Soil Properties

Mohammad Ali Behaeen[1*]

[1]Department of Agricultural Engineering Research, Fars Research and Education Center for Agriculture and Natural Resources, Agricultural Research, Education and Extension (AREEO), P.O.Box: 71555-617, Shiraz, Iran.

Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJAAR/2018/43632
Editor(s):
(1) Dr. Tancredo Souza, Department of Life Sciences, Centre for Functional Ecology, University of Coimbra, Portugal.
Reviewers:
(1) Fábio Henrique Portella Corrêa de Oliveira, Universidade Federal Rural de Pernambuco, Brazil.
(2) Subrata Kumar Mandal, CSIR-Central Mechanical Engineering Research Institute, India.
(3) M. H. Ali, BINA, Bangladesh.
Complete Peer review History: http://prh.sdiarticle3.com/review-history/26212

Original Research Article

Received 25 June 2018
Accepted 01 September 2018
Published 14 September 2018

ABSTRACT

Aim: This study was carried out to identify the optimal seedbed preparation with different tillage implements and their impacts on sugar beet yield and some soil properties in monogerm seeds.
Place and Duration of Study: The research was carried out in Darab Research Station of Fars province, Iran.
Study Design: A randomised complete block design (RCBD) with three replications was used to conduct the experiment.
Methodology: Use of monogerm seeds of sugar beet has increased among farmers due to reducing thinning costs. So, research on suitable tillage methods to prepare seedbed preparation for this type of seed is necessary. An experiment was conducted in Darab Research station of Fars province, Iran with six treatments in a loamy soil. Treatments were ploughing with moldboard plow at a depth of 35-30 cm + disc harrow (T_1); plowing with moldboard plow at a depth of 35-30 cm + rototiller (T_2); plowing with chisel plow at a depth of 35-30 cm + disc harrow (T_3); plowing with chisel plow at a depth of 35-30 cm + rototiller (T_4), subsoiler at a depth of 30-35 cm + moldboard plow to a depth of 25-30 + disc harrow (T_5); subsoiler at a depth of 30-35 cm + moldboard plow to

**Corresponding author: Email: ali_behaeen@yahoo.com;*

a depth of 25-30 + rototiller (T_6). Parameters such as soil bulk density, soil cone index, percentage of seed emergence, seed emergence rate, root yield and qualitative yield were measured. After conducting the experiments, collected data were analysed using SAS statistical software, and Duncan's multiple range test was used for comparing the treatments.

Results: Results demonstrated that the greatest and the lowest reduction in soil bulk density was observed in treatment T_6 and T_4, respectively. The trend of enhancement and reduction of the soil cone index was consistent with the soil bulk density. Also, analysis of data showed that the type of tillage implement and the depth of tillage operation are important for seed emergence and seed emergence rate. The highest and the lowest value of these two parameters were in treatments T_2 and T_3, respectively. The maximum amount of yield obtained from treatment T_6 and there was no significant difference between treatments T_5 and T_2.

Conclusion: The following conclusions are deduced from this research:

1. For preparing seedbed of sugar beet, two points are important; first the tillage implements and then the depth of tillage operation.
2. To prepare a suitable seedbed for sugar beet with monogerm seed, moldboard plow in the depth of 30-35 cm and rototiller suggests instead of chisel plow and disk harrow.
3. By using moldboard plow and rototiller, soil bulk density and soil cone index are reduced, and seed emergence and seed emergence rate are enhanced and eventually, sugar beet yield increased.

Keywords: Soil bulk density; soil cone index; seed emergence rate; monogerm seed.

1. INTRODUCTION

Seedbed preparation for sugar beet is important for producing a high yield. The surface soil should be fine, slightly dense and smooth. In this condition, the germination of seed achieves fast and uniform. The physical properties of the soil, especially in heavy soils, is very important. No ventilation, inappropriate drainage and excessive soil compaction are very harmful to sugar beet growth**.** Root form plays an important role in the process of sugar extraction and depends on the deep soil. Breeders have produced seeds that are simple and single-seeded or monogerms. This type of seeds have some advantages such as reducing the cost of thinning, decreasing the amount of seed up to 3-5 kilograms per hectare. But the use of monogerm seed requires a suitable seedbed, optimum moisture, and weed control [1]. The low seed quality and adverse conditions of the seedbed delay the emergence of seed and slow the rate of seed emergence and finally reduced the establishment of plants. The tillage methods are different in terms of the type of tillage, time and numbers of tillage operations [2]. Therefore, research on different seedbed preparation methods is necessary. Principally, selecting suitable tillage implements and seedbed preparation operations for sugar beet sowing is important like seed selection. Koch et al. [3] reported that decreasing depth in tillage operation caused penetration resistance and dry bulk density and minimum tillage decreased sugar beet yield. They recommended that for producing high yield, the soil should be loosened down to 0.15-0.20 m depth. Results of research by Laufer and Koch [4] showed that strip tillage than reduced tillage could increase high yield in sugar beet. Also, penetration resistance and root length density have no relation to differences in yield. Arvidsson et al. [5] stated that with ploughless tillage in sugar beet, soil bulk density may be too high for optimal growth. In another experiment, chisel plow lowered yield compared with moldboard plowing. Soil bulk density decreased with tillage operations (conventional tillage) and reducing soil bulk density created good soil conditions for root growth and development [6]. Results of research by Koch et al. [7] indicated that due to repeated wheeling, negatively affected penetration resistance on sugar beet yield. They recommended that reduction of tillage depth to 0.1 m is not good for high yielding sugar beet crops. Research on some crops like spring cereals, oilseed, potatoes and sugar beet showed that crop yield in shallow tillage was 1.8% lower than for moldboard plowing. For sugar beet alone, reduction in yield was 5-10% in shallow tillage. Also, in no-tillage, needs to improve to secure plant establishment and crop yield [8]. Primary tillage and the nature of the soil is important for high yield in sugar beet and obtaining acceptable mean saturated hydraulic conductivity. Also, management in topsoil is necessary for tillage operation [9]. An experiment based on meta-analysis showed that on average, deep tillage slightly increased yield (+6%). At sites with hardpan and root-restricting, crop yield response to deep tillage 20% more than the sites without a hardpan. The final results suggested that deep tillage prepare nutrients for the plant in subsoil [10]. Crittenden et al. [11] reported that non-inversion tillage could apply for producing the sugar beet yield. In this method of tillage operation, there are high penetration resistance and low field-saturated hydraulic conductivity. However, they recommended that non-inversion tillage in sugar beer as a viable alternative for farms. Sugarbeet is a sensitive crop to soil compaction. Eleven sugarbeet genotypes were examined about the performance under different soil compaction levels. The compaction levels were up to 400 kPa. Results showed that low compaction pressure (less than 200 kPa) seems harmless for sugar beet and causes more crop yield [12]. Comparison of two tillage operations (conventional tillage and zero tillage) indicated that zero tillage systems offer financial benefits than the conventional tillage, but the crop yield in zero tillage was low about 0-14.2% across all crops [13]. In a two-year experiment (2006-2007) on sandy soil in Germany, ridge and flat cultivation compared. Results demonstrated that yield was higher in ridge cultivation and white sugar yield was increased by 8.4% compared to flat cultivation [14]. Direct drilling and using moldboard plow were tested on sugar beet yield. After six years of experimentation, the use of moldboard plow and disk harrow produced a higher yield than direct drilling [15]. Datsenko et al. [16] reported that the depth of ploughing had a positive effect on seed emergence in sugar beet. Also, tillage on sugar beet rows had no significant difference compared to conventional tillage in sugar beet yield. The effect of moldboard plow on sugar beet yield after 5 years of the experiment showed no significant difference than the no-tillage systems. Of course, a slight reduction was observed during the first two years of the experiment [17]. Hao et al. [18] stated that mean weight diameter (MWD) in conventional tillage (3.81 mm) was less than reduced tillage (6.52 mm) and the yield of sugar beet in conventional tillage was 25% more. Bialsic et al. [19] stated that moldboard plough and rotavator caused the low soil penetration resistance than direct drilling in sugar beet. That was a reason for obtaining high yield and in shape for sugar beet crop. The main aim of this study was to determine the effects of using different types of tillage implements in different depths of a loamy soil on soil physical properties and quantitative and qualitative yield of sugar beet in monogerm seeds.

2. MATERIALS AND METHODS

The research was carried out in Darab Research Station of Fars province (250 KM south-east of Shiraz, Latitude 28°47′ N, 57°17′ E, and 1120 m above sea level with semi-arid climate condition), Iran. A randomised complete block design (RCBD) with three replications was used to conduct the experiment in a loamy soil with six treatments including ploughing with moldboard plow at a depth of 35-30 cm + disc harrow (T_1); plowing with moldboard plow at a depth of 35-30 cm + rototiller (T_2); plowing with chisel plow at a depth of 35-30 cm + disc harrow (T_3); plowing with chisel plow at a depth of 35-30 cm + rototiller (T_4); subsoiler at a depth of 30-35 cm + moldboard plow to a depth of 25-30 + disc harrow (T_5); subsoiler at a depth of 30-35 cm + moldboard plow to a depth of 25-30 + rototiller (T_6). Dimensions of each plot were (20 m × 10 m) and at a distance of 6 m from each other in each replication and the distance between replications were considered 10 m for better traffic of tractor. Each experimental plot consisted 20 rows at a space of 0.5 m. Fertilizers based on soil analysis were added to the soil. Table 1 shows the soil characteristics of the tested farm.

The genotype of Rasoul cultivar was planted (4 units ha^{-1}) with pneumatic planter and spaced at 5 cm from each other. Furrow Irrigation system was used for plots. Measurable parameters were: soil bulk density, soil cone index, the percentage of seed emergence, seed emergence rate, root yield and qualitative yield. Bulk density in each plot was measured using the core sampler method. Intact soil core samples with a 5.4 cm diameter and 4 cm height were taken using a core sampler [20]. The samples were dried at 105 degrees centigrade for 24 hours in the oven. The following equation was used to calculate the soil bulk density:

$$BD = \frac{W_d}{V} \tag{1}$$

Where:

BD = soil bulk density (Mg m^{-3}),
W_d = sample dry weight (Mg), and
V = Sample total volume (m^3).

Table 1. Soil specifications of the field used for the study

Soil depth (cm)	Sand (%)	Clay (%)	Silt (%)	O.C (%)	pH	EC (dS m^{-1})	Soil texture
0-15	36.5	19.1	42.8	0.74	7.9	0.51	Loam
0-30	37.9	19.3	41.4	0.73	8.1	0.54	Loam

Cone penetration resistance (PR) was measured using a digital cone penetrometer (Model Rimik CP20, Agridry Rimik Ltd, Queensland, Australia). Penetration resistance was measured for the soil depth of up to 35 cm with the distance interval of one centimetre before and after tillage operation. The number of plants at full emergence was determined by counting the number of seedlings in two rows with the length of 1 m in each plot. Percentage of seeds emerged was calculated by the following equation:

$$SE = \frac{PPSM}{(SPSM)(P)(G)} \times 100 \tag{2}$$

Where *SE* is seed emergence (%), *PPSM* is the number of emerged seed in 1 m^2 of each plot, *SPSM* is the number of planted seeds in 1 m^2 of each plot, *P* is seed purity, and *G* is the viability of seeds. Data collected from this study were analysed using SAS software, [21], and Duncan's multiple range tests were used to compare the treatments means. Plant establishment is often considered as an evaluation of the performance of tillage and planting equipment. To determine the percentage of seed emergence, the number of emerged seed per day was counted from within the frames with the area (1 m × 1m) in the middle of each plot. Then the seed emergence rate was calculated from the following equation:

$$ERI = \sum_{i=F}^{L} \frac{[\%D - \%(D-1)]}{D} \tag{3}$$

Where ERI is seed emergence rate (%), D is percentage of emerged seed in day of D, D-1, is percentage of emerged seed in the day of D-1, F is the number of days after planting, which is the first seed was developed (the first day of counting) and L is the number of days after planting when the seed emergence is completed (the last day of counting). At the end of the planting season, root yield per area unit was harvested and Weighed for all treatments in different plots.

3. RESULTS AND DISCUSSION

3.1 Bulk Density and Penetration Resistance

Comparison of means for using the tillage implements on soil bulk density and percent reduction in soil cone index are presented in Table 2.

Table 2. Soil bulk density and cone index reduction in different treatments

Treatments	BD reduction (%)	Cone index reduction (%)
T_1	3.95 ^{e}	10.83 ^{d}
T_2	4.53 ^{b}	11.08 ^{c}
T_3	3.52 ^{e}	10.80 ^{d}
T_4	2.88 ^{d}	10.74 ^{d}
T_5	4.73 ^{b}	11.12 ^{c}
T_6	5.91 ^{a}	12.71 ^{a}

Averages with different letters were statistically different at the confidence level of 95%.
T_1= Moldboard plow (30-35) + disk harrow.
T_2= Moldboard plow (30-35) + rototiller.
T_3= Chisel plow (30-35) + disk harrow.
T_4= Chisel plow (30-35) + rototiller.
T_5= Subsoiler (30-35) + Moldboard plow (25-30) + disk harrow.
T_6= Subsoiler (30-35) + Moldboard plow (25-30) + rototiller

According to Table 2, the greatest reduction in soil bulk density was observed in the use of subsoiler along with moldboard plow and rototiller (T_6) with 5.91%. This treatment showed a significant difference at 5% level with treatment T_5. With regard to the fact that in these two treatments the subsoiler and moldboard plow are the same, a further reduction in soil bulk density in treatment T_6 is related to the use of rototiller. The use of rototiller than the tandem disk harrow causes more porosity in the soil, and due to increasing of soil volume, the bulk density reduces in the soil. The use of moldboard plow reduces soil bulk density and penetration resistance at a depth of 10-15 cm [3]. The soil porosity enhancement (soil bulk density reduction) by using rotavator has been also reported by Alvarenga et al. [22]. The lowest amount of soil bulk density is found in the chisel plow**.** This implement did not completely inverse the soil and increasing the volume of soil. So, in the constant volume of the soil, bulk density enhances in comparison with the moldboard plow. These results have been stated in the other research for mixing the residue in the soil [23]. There was no significant difference between treatments T_2 and T_5 at 5% level in percentage of soil bulk density. So, the use of secondary tillage equipment is also important. The trend of decreasing or increasing the percentage of the soil cone index is consistent with the soil bulk density. Koch et al. [3] reported that changes in soil bulk density up to 25 cm depth were consistent with variations in soil resistance. Because of increasing soil porosity, the amount of penetration increases and cone index decreases in the soil.

3.2 Seed Emergence and Seed Emergence Rate

As shown in Table 3, the highest percentage of seed emergence was in the use of moldboard plow at a depth of 35-30 cm and rototiller with 92.81% (T_2). This treatment did not show a significant difference at 5% level with the treatment of subsoiler with moldboard plow and rototiller (T_6). Laufer and Koch [4] reported that field emergence was 84-93% in sugar beet and there was no significant difference in tillage systems. Seed emergence in treatments T_1, T_4 and T_5 were 88.55%, 85.23% and 84.18%, respectively. The lowest emergence of sugar beet seeds observed in chisel plow along with disk harrow (T_3) with the amount of 83.79%. Regarding the percentage of seed emergence, two points are important: type of tillage implement and the depth of tillage operation**.** As can be deduced from the data in Table 3, the moldboard plow with rototiller (T_2) has the highest seed emergence. This treatment does not show a significant difference in the treatment of subsoiler with moldboard plough and rototiller (T_6). The percentage of seed emergence is a parameter that is considered at the beginning of plant growth and depends on the depth of planting. Sowing depth of seeds and seedbed preparation are important on the emergence of sugar beet seeds. No significant difference between the two treatments (T_2 and T_6) and using moldboard plow in different depth (25-30 and 30-35) indicated that rototiller as secondary tillage implement is considerable for preparing the suitable seedbed, especially in the surface soil. In addition to the creation of a uniform seedbed from clod size in rototiller, this implement acts as a leveller due to having a cap. The results of research showed that uneven seedbed preparation slows sugar beet seed emergence [4]. The rapid and uniform emergence of sugar beet is a prerequisite for the development of a canopy of the plant leaf and increase the product yield [24]. As already stated, the emergence rate index can be used as a parameter for plant establishment and evaluating the performance of tillage implements**.** The highest value of this index was 4.42 and 4.35 in the use of treatments T_6 and T_5 with no significant difference at 5% level. These two treatments did not show any significant difference with the treatment T_2. The emergence rate index, like the percentage of seed emergence, is related to the optimal seedbed preparation, the beginning of plant growth and surface soil**.** In addition, treatments T_2, T_5 and T_6 had the highest reduction in soil bulk density. Based on an experiment, root growth is controlled by soil resistance and moisture content [25,26,27]. Romaneckas et al. [28] found that the reduction in soil bulk density in the range of 1-1.1 g cm^{-3} leads to rapid seed emergence and increase the sugar beet yield.

Table 3. Seed emergence rate and seed emergence in different treatments

Treatments	Seed emergence rate (%)	Seed emergence (%)
T_1	4.15 ^{b}	88.55 ^{b}
T_2	4.33 ^{a}	92.81 ^{a}
T_3	3.40 ^{d}	83.79 ^{e}
T_4	3.58 ^{c}	85.23 ^{d}
T_5	4.35 ^{a}	84.18 ^{e}
T_6	4.42 ^{a}	91.95 ^{a}

Averages with different letters were statistically different at the confidence level of 95%.
T_1= Moldboard plow (30-35) + disk harrow.
T_2= Moldboard plow (30-35) + rototiller.
T_3= Chisel plow (30-35) + disk harrow.
T_4= Chisel plow (30-35) + rototiller.
T_5= Subsoiler (30-35) + Moldboard plow (25-30) + disk harrow;
T_6= Subsoiler (30-35) + Moldboard plow (25-30) + rototiller

3.3 Root Yield

According to Fig. 1, there is a significant difference between using subsoiler along with moldboard plow and rototiller (T_6) with 71.50 t ha^{-1} in comparison with the other treatments. The highest amount of seed emergence rate and soil bulk density was obtained in T_6. This treatment also produced the highest yield. Romaneckas et al. [28] reported that reduction in soil bulk density enhanced seed emergence rate and sugar beet yield, which is consistent with the results of this research. The results of a study showed that the use of subsoiler along with rototiller increased the wheat yield by 8.5%. In this experiment, soil penetration resistance was 1 and 1.5 MPa in the use of the subsoiler + rototiller and moldboard plow, respectively [29]. After that, there are two treatments T_2 and T_5 with 67.75 and 66.49 t ha^{-1} and no significant difference. One of the remarkable points about using the monogerm seed of sugar beet is suitable for seedbed preparation. Sugar beet requires a high-quality seedbed and is sensitive to the soil compaction in the surface layer [24]. Using moldboard plow produces the smaller clods and better soil inversion. According to Sperlingsson [30] the seedbed surface in sugar beet should be flat, and 80% clods should be less than 50%. These happen in more depth (30-35 cm) than the depth of 20-25 cm. Also, the depth of tillage operations is also important in the production of yield [24]. Therefore, the yield of sugar beet is more in the usage of this implement. Reduction in bulk density and soil cone index led to an increase in sugar beet yield in T_6. Ehler and Goss [25] and Ubelhor et al. [27] stated that the development of root in soil is associated with a decrease in soil penetration resistance. Arvidsson et al. [5] also reported a negative correlation between soil bulk density and increase in sugar beet yield. Many researchers believe that tillage in the depths of 19-43 cm has a positive and significant effect on increasing sugar beet production [31,7,3]. The chisel plow with disk harrow and rototiller (T_3 and T_4) produced the lowest amount of yield with 48.75 and 54.12, respectively. Based on the comparison of treatments, the performance of moldboard plow and rototiller were better than chisel plow and disk harrow in the production of sugar beet root yield. In chisel plow, due to increasing soil bulk density and penetration resistance, reduction in crop yield is observed. According to Table 2, the lowest amount of soil bulk density and cone index were related to T_3 and T_4. The results of Jaggard's [32] experiments showed a final reduction of sugar beet yield by increasing the soil bulk density. An increase in penetration resistance and bulk density of soil at a depth of 0-30 cm, is related to the reduction of the sugar beet yield [3]. The amount of yield was 12 and 14 Mg ha^{-1} at 10 and 20 cm depths in the use of chisel plow. However, the amount of yield was 15 Mg ha^{-1} in using if the moldboard plow [5].

3.4 Quantitative and Qualitative Yield of Sugar Beet

Regarding the performance of white sugar yield, treatments showed significant differences at 5% level. The highest yield of white sugar yield (9.6 t ha^{-1}) was related to the use of subsoiler and moldboard plow along with rototiller. The reason for increasing white sugar yield in this treatment can be attributed to the highest root yield. As previously stated, this treatment had the highest reduction in soil bulk density, cone index, seed emergence and seed emergence rate.

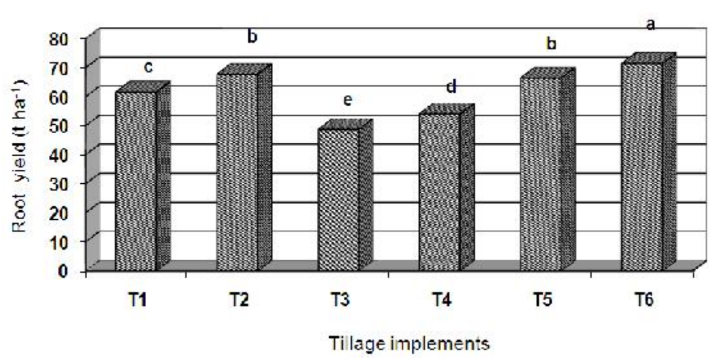

Fig. 1. Sugar beet yield in different treatments

Averages with different letters were statistically different at the confidence level of 95%.
T_1= Moldboard plow (30-35) + disk harrow; T_2= Moldboard plow (30-35) + rototiller; T_3= Chisel plow (30-35) + disk harrow; T_4= Chisel plow (30-35) + rototiller; T_5= Subsoiler (30-35) + Moldboard plow (25-30) + disk harrow. T_6= Subsoiler (30-35) + Moldboard plow (25-30) + rototiller

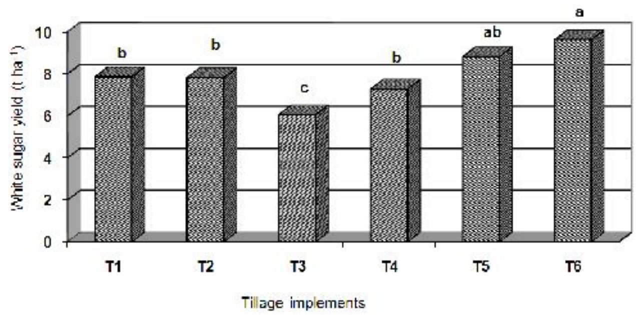

Fig. 2. White sugar yield in different treatments

Averages with different letters were statistically different at the confidence level of 95%.
T_1= Moldboard plow (30-35) + disk harrow; T_2= Moldboard plow (30-35) + rototiller.
T_3= Chisel plow (30-35) + disk harrow; T_4= Chisel plow (30-35) + rototiller.
T_5= Subsoiler (30-35) + Moldboard plow (25-30) + disk harrow.
T_6= Subsoiler (30-35) + Moldboard plow (25-30) + rototiller

The performance of white sugar in the treatment of using subsoiler with moldboard plow and disk harrow (T_5) was 8.82 t ha^{-1}. There was no significant difference in this treatment and subsoiler (30-35) + moldboard plow (25-30) + rototiller (Fig. 2). Also, treatments T_2 and T_5 did not show any significant difference. Tillage implement and the depth of operation is important. Comparison of these two treatments (T_2 and T_5) showed the superiority of rototiller to disc harrow.

So, usage of moldboard plow and rototiller affected on preparing the suitable seedbed and root growth of sugar beet. The other researcher also reported on this subject [24]. In all treatments, relative superiority was observed in the application of moldboard plow than chisel plow and rototiller than tandem disk harrow. There was no significant difference at 5% level in treatments from the point of view sugar content, white sugar content, molasses sugar, purity raw juice and impurities (Na, P and Amino nitrogen) (Table 4). In different treatments, there was no significant difference in molasses of root sugar, and thus the amounts of white sugar content had not significantly different (Table 4). Proper tillage led to that the crown of sugar beet roots had completely established in the soil and roots were not multi-branch. So, sugar content increased in sugar beet roots (treatments T_5 and T_6). This subject has also been reported by the other researcher [33]. The highest amount of purity raw juice was related to applying moldboard plow and rototiller (79.61%). The reduction of molasses sugar in this treatment increased the purity of raw juice. Sugar content and impurities (Na, K and Amino nitrogen) of sugar beet roots affected on purity raw juice. As shown in table 4, by reducing the impurities in the roots of sugar beet, the purity raw juice increased.

Table 4. Qualitative technological analysis of sugar beet

Treatments	Molasses sugar (%)	Impurities (meq.100 g beet^{-1})			Purity raw juice (%)	White sugar content	Sugar content
		Amino nitrogen	P	Na			
T1	2.98 ^{a}	1.42 ^{a}	7.14 ^{a}	2.16 ^{a}	77.86 ^{a}	12.76 ^{a}	16.31 ^{a}
T2	2.69 ^{a}	1.34 ^{a}	6.86 ^{a}	1.86 ^{a}	79.61 ^{a}	11.54 ^{a}	16.48 ^{a}
T3	2.89 ^{a}	1.49 ^{a}	7.16 ^{a}	1.99 ^{a}	77.76 ^{a}	12.45 ^{a}	16.85 ^{a}
T4	2.89 ^{a}	1.44 ^{a}	6.96 ^{a}	1.87 ^{a}	79.04 ^{a}	13.47 ^{a}	16.89 ^{a}
T5	2.98 ^{a}	1.63 ^{a}	6.99 ^{a}	2.12 ^{a}	78.44 ^{a}	13.27 ^{a}	16.84 ^{a}
T6	2.83 ^{a}	1.66 ^{a}	7.22 ^{a}	1.86 ^{a}	79.27 ^{a}	13.45 ^{a}	16.87 ^{a}

Averages with different letters were statistically different at the confidence level of 95%.
T_1= Moldboard plow (30-35) + disk harrow; T_2= Moldboard plow (30-35) + rototiller.
T_3= Chisel plow (30-35) + disk harrow; T_4= Chisel plow (30-35) + rototiller;
T_5= Subsoiler (30-35) + Moldboard plow (25-30) + disk harrow.
T_6= Subsoiler (30-35) + Moldboard plow (25-30) + rototiller

4. CONCLUSIONS

The following conclusions are deduced from this research:

1. To prepare a suitable seedbed for sugar beet with monogerm seed, moldboard plow in the depth of 30-35 cm and rototiller are suggested instead of chisel plow and disk harrow.
2. By using moldboard plow and rototiller, soil bulk density and soil cone index are reduced, and seed emergence and seed emergence rate are enhanced, and eventually, sugar beet yield increased.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Khodabandeh N. Industrial crops culture. 1st ed. Sepehr Pub; 2006. Persian.
2. Shafiee SA. Tillage machinery. 5th ed. University Publication Center, Iran; 2016. Persian.
3. Koch HJ, Dieckmann J, Buchse A, Marlander B. Yield decrease in sugar beet caused by reduced tillage and direct drilling. European Journal of Agronomy. 2009;30(2):101-109.
4. Laufer D, Koch HJ. Growth and yield formation of sugar beet under strip tillage compared to full width tillage on silt loam soil in Centeral Europe. European Journal of Agronomy. 2017;82:182-189.
5. Arvidsson J, Bolenius E, Cavalieri KMV. Effects of compaction during drilling on yield of sugar beet (*Beta vulgaris* L.). European Journal of Agronomy. 2012;39: 44-51.
6. Oshunsanyaya SO, Yu H, Li Y. Soil loss due to root crop harvesting increase with tillage operations. Soil & Tillage Research. 2018;181:93-101.
7. Koch HJ, Heuer H, Tomanova O, Marlander B. Cumulative effect of annually repeated passes of heavy agricultural machinery on soil structural properties and sugar beet yield under two tillage systems. Soil & Tillage Research. 2008;101(1-2): 69-77.
8. Arvidsson J, Etana A, Rydberg T. Crop yield in Swedish experiments with shallow tillage and no-tillage 1983-2012. European Journal of Agronomy. 2014;52:307-315.
9. Hanse B, Vermeulen GD, Tijink FGJ, Koch HJ, Marlander B. Analysis of soil characteristics, soil management and sugar yield on top and averagely managed farms growing sugar beet (*Beta vulgaris* L.) in the Netherlands. Soil & Tillage Research. 2011;117:61-68.
10. Schneider F, Don A, Hennings I, Schmttmann O, Seidel SJ. The effect of deep tillage on crop yield - What do we really know? Soil & Tillage Research. 2017;74:193-204.
11. Crittendes SJ, Poot N, Heinen M, Van-Balen DMJ, Pullemon. Soil physical quality in contrasting tillage systems in organic and conventional farming. 2015;154:136-144.
12. Gemtos TA, Goulas C, Lellis T. Sugar beet genotypes response to soil compaction. European Journal of Agronomy. 2000; 12(3-4):201-209.
13. Townsend TBYJ, Ramsden SJ, Wilson P. Analysing reduced tillage practices within a bioeconomic modeling framework. Agricultural Systems. 2016;146:91-102.
14. Krouse U, Koch HJ, Merlaender BW. Soil properties effecting yield formation in sugar beet under ridge and flat cultivation. European Journal of Agronomy. 2009; 31(1):20-28.
15. Kordas L, Zimny L. The effects of long-term using of no-tillage method in sugar beet production on soil structure indices. Biuletyn-instytutu-Hodowli-i- Aklimatyzacji-Roslin. 2002;222:263-270.
16. Dotsenko IM, Chmeleva LE, Borodin AA. Tillage of inter rows in sugar beet cultivation. Sakharanaya-Svekla. 2002;6: 18-19.
17. Reinhard H, Chervet A, Sturny WG. No-tillage in field crops. I. Effect on yields. Revue-Suisse-d Agriculture. 2001;33(1): 70-130.
18. Hao XY, Change C, Larney FJ, Nitschelm J, Regitnig P. Effect of minimum tillage and crop sequence on physical properties of irrigated soil in southern Alberta. Soil & Tillage Research. 2000;57(1-2):53-60.
19. Bialczyk W, Czarnecki J, Kordas L, Pieczarka K, Michalek R. Changes in physical and mechanical properties of soil in different technoligies of tillage. Conference on Machines- Soil-Plants, April 12-14, Inzynieria-Rolnicza, Poland. 2000;6: 47-54.

20. Blake GR, Hartage KH. Bulk density in methods of soil analysis. Agronomic. Monograph. 1986;9:363-375.
21. SAS Institute. SAS/SAT User's Guide, Version 6, 4th Edition. SAS Institute, Cary, NC. 1990;2.
22. Alvarenga RC, Fernandes B, Silva TCA. Effect of different methods of soil preparation and maize residue management on bulk density, total porosity and pore-size distribution in ared latosol. Revista Ceres. 1987;34(196):569-577.
23. Behaeen MA, Afzalinia S. Impact of crop residue management on soil properties and crop yield, in irrigated corn-wheat cropping system. International Journal of Plant & Soil Science. 2018;23(1):1-9.
24. Hakansson I, Henriksson L, Blomquist JE. Soil tillage and crop establishment. Sugar Beet. Blackwalls, Oxford, UK. 2006;114-168.
25. Ehlers W, Goss M. Water dynamics in plant production. CABI, Wallingford, UK; 2003.
26. Bengough AG, Young IM. Root elongation of seedling peas through layered soil of different penetration resistance. Plant Soil. 1993;149:129-139.
27. Ubelhor A, Witte I, Billen N, Gruber S, Hernann W, Morhard J, Claupein W. Feasibility of strip-tillage for field grown vegetables. Journal of Cultivated Plants. 2014;66:365-377.
28. Romaneckas R, Pilipavicius V, Sarauskis E. Impact of seedbed density on sugar beet (*Beta vulgaris* L.) seed germination, yield and quality of roots. Journal of Food Agricultural Environment. 2010;81:599-601.
29. Afzali SMJ, Javaheri E. Effects of tillage methods on soil tillage resistance, technical indices and wheat yield. Journal of Agricultural Machinery. 2013;3(1):24-31.
30. Sperlingsson C. The influence of the seedbed soil physical environment on seedling growth and establishment. In: Proceedings of the 44th IIRB Congress Brussels 1981. IIRB, 1981;59-77.
31. Bollman SL, Sprague CL. Effects of tillage and soil applied herbicides with micro-rate herbicide programs on weed control and sugar beet growth. Weed Technology. 2009;23:264-269.
32. Jaggard KW. Effects of soil density on yield and fertilizer requirement of sugar beet. Annals Applied Biology. 1977;86: 301-312.
33. Gutmanski I, Pikulik R. Possibility of modification of soil cultivation for sugar beet. Biuletyn Instytutu Hodowli Aklimatyzacji Rosl. 1994;190:83-91.

Peer-review history:
The peer review history for this paper can be accessed here:
http://prh.sdiarticle3.com/review-history/26212