

Effect of Different Tillage Methods on Yield and Quality of Sugar Beet

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Abstract: Field experiments were carried out to study the effect of different tillage methods on yield and quality of sugar beet. Tillage treatments were moldboard plow + two passes of disk harrow (MDD) and moldboard plow + one pass of rotavator (MR) as conventional tillage methods; chisel plow + one pass of rotavator (CR) and two passes of disk harrow (DD) as reduced tillage methods; one pass of rotavator (R) and one pass of tine cultivator (C) as minimum tillage methods and no-tillage (NT). The root yield and quality characteristics of sugar beet *viz.*, sugar content, K, Na, alpha-amino nitrogen and molasses were measured for different tillage treatments. Results of the study indicated that different tillage methods significantly ($P=0.05$) affected K, but no significant differences were found in root yield, sugar content, Na, alpha-amino nitrogen and molasses. Although there was no significant difference in most studied traits, tillage operations were useful in improving the root yield and quality characteristics of sugar beet.

Key words: Sugar beet • Tillage method • Root yield • Quality characteristics • Iran

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is one of the most important crops in a wide variety of temperature climates [1-3]. It is a hardly biennial plant with large (1-2 kg) storage root and great amount of sucrose (15-20%). Sugar beet accounts for 30% of the world's sugar production [4]. The top ten sugar beet producer countries are France, Germany, United States, Russia, Ukraine, Turkey, Italy, Poland, United Kingdom and Spain with 29, 25, 25, 22, 16, 14, 12, 11, 8 and 7 million tons, respectively. Also, the European Union and Ukraine are major exporters of sugar from beets. Besides, the United States harvested 406,500 hectares of sugar beets in 2008 alone [5]. On the other hand, the average cultivated area and national production of sugar beet in Iran for the last three years was about 178,000 hectares and 5.9 million tons, respectively [6]. Although the use of better varieties, mechanical planting, chemical fertilizers, herbicides application and mechanized harvesting have increased sugar beet production to a great extent, the complete potential of sugar beet production has not yet been attained as compared to the top ten sugar beet producers.

Tillage is one of the most essential crop production factors that influence soil properties [7, 8] and

consequently crop yield [9-14]. Appropriate tillage operations can enhance soil properties, while excessive, inappropriate and unnecessary tillage operations may result in a range of undesirable processes [15-20]. Although for most situations, conventional tillage methods have been the main tillage methods for establishing sugar beet since the first part of the 20th century, they are now expensive operations in terms of work rate and fuel consumption [21]. The costs, as well as the environmental concerns have leaded farmers and researchers to adopt alternative tillage methods [22]. For these reasons, there is a considerable attention and significant emphasis on moving towards the conservation tillage methods, i.e. reduced tillage, minimum tillage and no-tillage methods [7, 8, 10-15, 20, 23-27]. Conservation tillage methods may be used for sugar beet [28-31]. However, the results of these methods may be contrary [20]. Conservation tillage operations may reduce yield of sugar beet [4]. Conversely, decrease of soil tillage practices may have no significant effect on the yield of other crops [25-27, 32, 33]. Conservation tillage methods may also lead to raised diversity of weed species and population [33, 34] and have a harmful effect on crop yield [35]. But, other studies have confirmed the opposite [36].

In Iran, most of the cultivated area is under conventional tillage methods and conservation tillage methods have not been studied enough. For this reason, information on response of sugar beet to different tillage methods is meager. Therefore, this study was carried out to study the effect of different tillage methods on root yield and quality characteristics of sugar beet.

MATERIALS AND METHODS

Research Site: This study was conducted at the Research Site of Hamedan Province, Iran for two successive growing seasons (2008 and 2009). The research site is located at latitude of 34° 52' N, longitude of 48° 21' E and altitude of 1730 m in semi-arid climate (298 mm rainfall annually) in the west of Iran. Mean temperature and monthly rainfall of the experimental site from sowing to harvest during study years (2008 and 2009) are indicated in Fig. 1.

Soil Sampling and Analysis: A composite soil sample (from 21 points) was collected from 0-30 cm depth during the study years and was analyzed in the laboratory for their pH, EC, OC, N, P, K, Fe, Zn, Cu, Mn, B and particle size distribution. Details of soil physical and chemical properties of the research site during both years are given in Table 1.

Field Layout: The experiments were laid out in a randomized complete block design (RCBD) with four replications. Tillage treatments were moldboard plow + two passes of disk harrow (MDD) and moldboard plow + one pass of rotavator (MR) as conventional tillage methods; chisel plow + one pass of rotavator (CR) and two passes of disk harrow (DD) as reduced tillage methods; one pass of rotavator (R) and one pass of tine cultivator (C) as minimum tillage methods and no-tillage (NT). During the study years, tillage treatments were carried out on the same plots. The size of each plot was 20.0 m long and 6.0 m wide. There were 12 rows of sugar beet in each plot with 50-cm row spacing. In both years of study, one of the commercial varieties of sugar beet cv.Zarghan was planted on April 3, 2008 and April 5, 2009

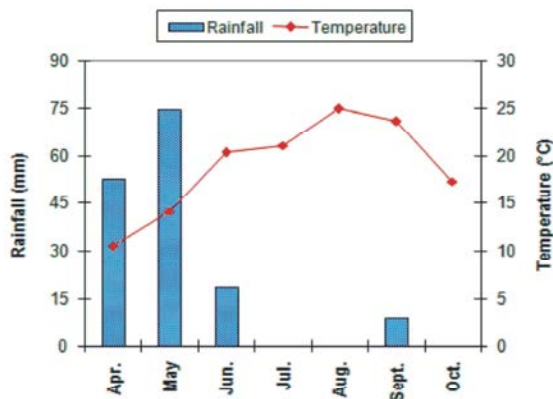


Fig. 1: Mean temperature and monthly rainfall during crop growth (mean of 2008 and 2009).

using a 6-row sugar beet drill. Recommended levels of urea @300 kg ha⁻¹ in both years and triple super phosphate (TSP) @50 kg ha⁻¹ only in the first year of study were used. For all treatments, irrigation scheduling was based on the basis of evaporation from A-class pan installed close to the experimental plots. Also, pest and weed control operations were performed based on common local practices and commendations. All other essential operations were kept identical for all the treatments.

Observation and Data Collection: At harvest, plants from an area of 12.0 m² per each plot were harvested to determine root yield for all treatments. Moreover, a sample of 20 kg of sugar beet roots were taken at random and sent to the Sugar Beet Laboratory at Hamedan Sugar Factory to determine quality characteristics, i.e. sugar content, K, Na, alpha-amino nitrogen and molasses for all treatments. Sugar (sucrose) content was measured in fresh root samples by using Saccharometer as described by AOAC [37]. K, Na, alpha-amino nitrogen and molasses were measured using an auto analyzer.

Statistical Analysis: All data were subjected to the analysis of variance (ANOVA) following Gomez and Gomez [38] using SAS statistical computer software. Moreover, means of the different treatments were separated by Duncan's Multiple Range Test (DMRT) at P = 0.05.

Table 1: Soil physical and chemical properties of the experimental site (0-30 cm depth), 2008 and 2009

Date	pH	EC(dS m ⁻¹)	OC(%)	N(%)	P(ppm)	K(ppm)	Fe(ppm)	Zn(ppm)	Cu(ppm)	Mn(ppm)	B(ppm)	Soil texture
2008	7.9	0.72	0.92	0.09	10.5	280	6.2	0.8	2.3	16.2	0.7	Loam
2009	8.3	0.55	0.36	0.04	25.6	310	6.4	1.0	2.4	14.4	0.7	Loam

RESULTS AND DISCUSSION

In this study, root yield and quality characteristics of sugar beet, i.e. sugar content, K, Na, alpha-amino nitrogen and molasses were studied to investigate the effect of different tillage methods on yield and quality of sugar beet. Results of ANOVA and means comparison for root yield and quality characteristics of sugar beet under different tillage methods during the years of study (mean of 2008 and 2009) are presented in Tables 2 and 3, respectively. Results showed that different tillage methods significantly ($P=0.05$) affect K, but there was no significant difference in other studied traits (Table 2).

Root Yield: Although there was no significant ($P=0.05$) difference in root yield during the study years, but results indicated that tillage operations were useful in increasing the root yield of sugar beet. The highest value of root yield (82.7 t ha^{-1}) was recorded in the MR treatment, while the lowest value of root yield (71.3 t ha^{-1}) was noted in the NT treatment. Based on the results, tillage method affected the root yield of sugar beet in the order of $\text{MR} > \text{CR} > \text{R} > \text{MDD} > \text{DD} > \text{C} > \text{NT}$ (Table 3). These results are in line with the results reported by other researchers [9-12, 20] that tillage practices can be associated with improved soil physical and mechanical properties (increased pore space, decreased bulk density, increased moisture preservation and decreased penetration resistance),

enhanced soil structure, better seed-soil/root-soil contact and superior weed control which positively influence the root yield of sugar beet. Similar results were also obtained by few other researchers [28-31]. They concluded that intensive tillage methods enhanced soil quality and had no significant effect on root yield of sugar beet. These results are also in agreement with those of previous researchers [15-16, 33-35, 39] who concluded that conservation and no tillage methods may be associated with worse soil physical and mechanical properties (decreased pore space, increased bulk density, decreased moisture preservation and increased penetration resistance), inferior seed/root-soil contact and raised diversity of weed species and population which negatively influence the root yield of sugar beet.

Quality Characteristics: The highest value of K (6.4 mmol/100 g) was recorded in the NT treatment, while the lowest value (4.5 mmol/100 g) was noted in the MR treatment. Although there was no significant difference in sugar content, Na, alpha-amino nitrogen and molasses during the years of study, results again indicated that tillage operations were useful in enhancing the quality of sugar beet. The highest value of sugar content (17.0%) was recorded in the MR treatment, while the highest values of Na (2.6 mmol/100 g), alpha-amino nitrogen (2.5 mg/100 g) and molasses (3.0%) were noted in the NT treatment. In contrast, the lowest value of sugar content

Table 2: Analysis of variance for root yield and quality characteristics of sugar beet under different tillage methods (mean of 2008 and 2009)

Source of Variation	Df	Mean square					
		Root yield	Sugar content	Potassium	Sodium	Aalpha-amino nitrogen	Molasses
Replication	3	257.9 ^{NS}	8.78 ^{NS}	0.22 ^{NS}	0.33 ^{NS}	0.78 ^{NS}	0.12 ^{NS}
Treatment	6	72.36 ^{NS}	3.03 ^{NS}	0.56 [*]	0.60 ^{NS}	0.54 ^{NS}	0.27 ^{NS}
Error	18	390.7	13.4	0.15	0.68	0.65	0.11
C.V. (%)	---	25.4	28.9	7.04	43.0	40.5	13.3

* = Significant at 0.05 probability level and NS = Non-significant

Table 3: Means comparison for root yield and quality characteristics of sugar beet between different tillage methods (mean of 2008 and 2009).

Treatment	Root yield (t ha^{-1})	Sugar content (%)	Potassium (mmol/100 g)	Sodium (mmol/100 g)	Alpha-amino nitrogen (mg/100 g)	Molasses (%)
MDD	78.5 a	16.8 a	5.4 b	1.9 a	1.9 a	2.4 a
MR	82.7 a	17.0 a	5.5 b	1.5 a	1.6 a	2.2 a
CR	81.0 a	17.0 a	5.3 b	1.6 a	1.7 a	2.3 a
DD	76.5 a	15.6 a	5.5 b	2.0 a	2.1 a	2.5 a
R	80.9 a	16.9 a	5.4 b	1.6 a	1.7 a	2.4 a
C	73.4 a	15.2 a	5.7 b	2.2 a	2.5 a	2.5 a
NT	71.3 a	15.2 a	6.4 a	2.6 a	2.5 a	3.0 a

Means in the same column with different letters differ significantly at 0.05 probability level according to DMRT.

(15.2%) was recorded in the NT treatment, while the lowest values of Na (1.5 mmol/100 g), alpha-amino nitrogen (1.6 mg/100 g) and molasses (2.2%) were noted in the MR treatment. Again, a similar trend was obtained for the selected quality characteristics and tillage method affected sugar beet quality in the order of MR > CR > R > MDD > DD > C > NT (Table 3). Similar results were also obtained by Romaneckas *et al.* [28], Adamaviciene *et al.* [29], Romaneckas *et al.* [30] and Jabro *et al.* [31]. They reported that different methods of tillage had no significant effect on most quality characteristics of sugar beet.

CONCLUSIONS

Different tillage methods significantly ($P = 0.05$) affected K, but there was no significant difference in root yield, sugar content, Na, alpha-amino nitrogen and molasses. Although there was no significant difference in most studied traits, tillage operations were useful in improving the root yield and quality characteristics of sugar beet.

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