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Effect of Different Tillage Methods on Yield and Quality of Sugar Beet (*Beta vulgaris*)

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Abstract: Field experiments were conducted at the Research Site of Hamedan Agricultural and Natural Resources Research Center, Hamedan, Iran on the loam soils to study the effect of different tillage methods on yield and quality of sugar beet (*Beta vulgaris*) during 2008 and 2009 growing seasons. Tillage treatments in the study were moldboard plow + two passes of disk harrow (MDD) as conventional tillage method; moldboard plow + one pass of rotavator (MR), 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) as direct drilling method. Root yield (RY) and some quality characteristics of sugar beet such as sugar content (SUGC), potassium (POTA), sodium (SODI), alpha-amino nitrogen (ALAN) and molasses (MLAS) were determined for all treatments. Different tillage methods significantly ($P \leq 0.05$) affected POTA, but there was no significant difference in other studied traits. The maximum value of POTA (6.4 mmol/100 g) was observed in case of NT treatment, while the minimum value of POTA (4.5 mmol/100 g) was noted in case of MR treatment. Although there was no significant difference in RY, SUGC, SODI, ALAN and MLAS, results of the study showed that tillage practices were beneficial in improving the yield and quality of sugar beet. The maximum values of RY (82.7 t ha^{-1}) and SUGC (17.0%) were observed in case of MR treatment, while the maximum values of SODI (2.6 mmol/100 g), ALAN (2.5 mg/100 g) and MLAS (3.0%) were noted in case of NT treatment. In contrast, the minimum values of RY (71.3 t ha^{-1}) and SUGC (15.2%) were observed in case of NT treatment, while the minimum values of SODI (1.5 mmol/100 g), ALAN (1.6 mg/100 g) and MLAS (2.2%) were noted in case of MR treatment. Results also showed that tillage method affected the yield and quality characteristics of sugar beet in the order of MR > CR > R > MDD > DD > C > NT. Based on the results, the reduced tillage treatments MR and CR and the minimum tillage treatment R can be recommended as more appropriate and profitable tillage methods in improving the yield and quality of sugar beet.

Key words: Sugar beet · Tillage method · Yield · Quality · Hamedan · Iran

INTRODUCTION

Sugar beet (*Beta vulgaris*) is one of the most important crops [1-3]. It is a hardly biennial plant whose root contains a high concentration of sucrose. It is grown commercially for sugar production in a wide variety of temperature climates. Sugar beet accounts for 30% of the world's sugar production. During its first growing season, it produces a large (1-2 kg) storage root whose dry mass is 15-20% sucrose by weight. In commercial sugar beet production, the root is harvested after the first growing season. In most temperature climates, sugar beet are planted in the spring and harvested in the autumn [4].

The European Union, the United States and Russia are the three largest sugar beet producers. 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 significant 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. Although the use of improved varieties and fertilizers,

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mechanical sowing, herbicides application for weed control and mechanical harvesting have increased sugar beet production to much extent, the full potential of sugar beet production has not yet been achieved when compared to the top ten sugar beet producer countries [6].

Tillage is one of the most important production factors that influence soil physical and mechanical properties [7, 8] and consequently crop yield [9-14]. Appropriate tillage practices can improve soil related constrains, while excessive, inappropriate and unnecessary tillage operations may cause a range of undesirable processes such as destruction of soil structure, accelerated soil erosion, reduction of organic matter and fertility and disruption in cycles of water, organic carbon and plant nutrients [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 emphasis on the shift to 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 contradictory [20]. Conservation tillage methods may reduce yield of sugar beet [4]. Conversely, reduction of soil tillage intensity may have no significant influence on the yield of many crops [25-27, 32, 33]. Conservation tillage methods may also lead to raised diversity of weed species and population [33, 34] and have a negative influence on crop yield [35]. However, other studies have confirmed the opposite [36].

Most of the cultivated area in Iran is under conventional tillage methods and conservation tillage methods have not been studied enough. Therefore, the purpose of this study was to investigate the effect of different tillage methods on the yield and quality of sugar beet in the semi-arid lands of Hamedan, Iran.

MATERIALS AND METHODS

Experimental Site: The study was carried out for two successive growing seasons (2008 & 2009) at the Ekbatan Research Site of Hamedan Province Agricultural and Natural Resources Research Center, Hamedan, Iran.

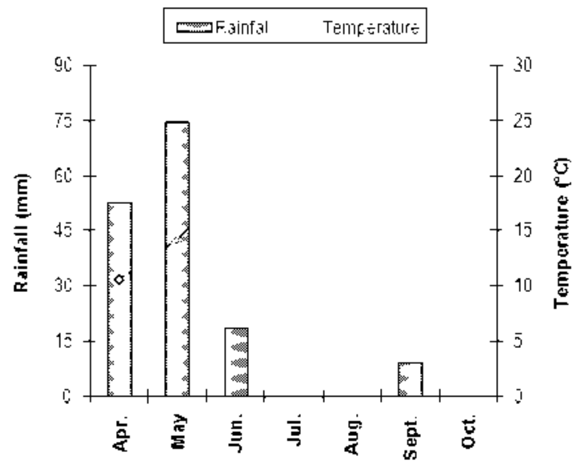

Fig. 1: Mean temperature and monthly rainfall during crop growth (mean of 2008 & 2009)

The site is located at latitude of 34°52′ N and longitude of 48°21′ E and is 1730 m above mean sea level, in semi-arid climate (298 mm rainfall annually) in the west of Iran, where the summers are moderate while the winters are cool. Mean temperature and monthly rainfall of the experimental site from sowing to harvest during study years (2008 & 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. Soil sample was analyzed in the laboratory for pH, EC, OC, N, P, K, Fe, Zn, Cu, Mn, B and particle size distribution. Soil pH and EC values were determined by using a HI9813-5 portable pH/EC/TDS/°C meter (HANNA instruments, Romania, 2002). Soil OC was determined by Walkley-Black procedure [37]. Total N was determined by the macro-Kjeldahl method [38]. Available P was found using Bray II method according to Olsen [39]. The exchangeable cations were calculated by the method described by Thomas [40]. Particle size distribution was determined by hydrometer method [41]. Details of soil physical and chemical properties of the experimental site during both years (2008 & 2009) are given in Table 1.

Field Methods: The experiments were laid out in a randomized complete block design (RCBD) with three replications. Tillage treatments in the study were moldboard plow + two passes of disk harrow (MDD) as conventional tillage method; moldboard plow + one pass of rotavator (MR), chisel plow + one pass of rotavator (CR) and two passes of disk harrow (DD) as reduced

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

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

tillage methods; one pass of rotavator (R) and one pass of tine cultivator (C) as minimum tillage methods and no-tillage (NT) as direct drilling method. The treatments were carried out on the same plots during both growing seasons. The size of each plot was 20.0 m long and 6.0 m wide. A buffer zone of 3.0 m spacing was provided between plots. There were 12 rows of sugar beet in each plot with 50-cm row spacing. In both growing seasons, one of the most commercial varieties of sugar beet cv. Zarghan was planted on April 3, 2008 and April 5, 2009 using a 6-row sugar beet drill. Recommended levels of urea (300 kg ha^{-1}) in both years and triple super phosphate (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 standard U.S. weather bureau class-A open-pan installed nearby the experimental plots. Pest and weed control performed according to general local practices and recommendations. All other necessary operations except those under study were kept normal and uniform for all the treatments.

Observation and Data Collection: At harvest, plants from an area of 12.0 m^2 per each plot were harvested to determine root yield (RY) 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 some quality characteristics, i.e. sugar content (SUGC), potassium (POTA), sodium (SODI), alpha-amino nitrogen (ALAN) and molasses (MLAS) for all treatments. Sugar (sucrose) content (SUGC) was measured in fresh root samples by using Saccharometer as described by AOAC [42]. Potassium (POTA), sodium (SODI), alpha-amino nitrogen (ALAN) and molasses (MLAS) were measured using an auto analyzer.

Statistical Analysis: All data were subjected to the Analysis of Variance (ANOVA) as described by Gomez and Gomez [43] using SAS statistical computer software. Means of the different treatments were also separated by Duncan's Multiple Range Test (DMRT) at $P \leq 0.05$.

RESULTS AND DISCUSSION

In this study, root yield (RY) and some quality characteristics (SUGC, POTA, SODI, ALAN and MLAS) of sugar beet were studied to analyze the effect of different tillage methods on the yield and quality of sugar beet. Results of ANOVA and means comparison for RY and selected quality characteristics of sugar beet under different tillage methods during the years of study (mean of 2008 & 2009) are presented in Table 2 and Table 3, respectively.

Statistical results of the study showed that different tillage methods significantly ($P \leq 0.05$) affected POTA, but there was no significant difference in other studied traits (Table 2). The maximum value of POTA (6.4 mmol/100 g) was observed in case of NT treatment, while the minimum value POTA (4.5 mmol/100 g) was noted in case of MR treatment (Table 3). These results support the findings of Romaneckas *et al.* [28], Adamaviciene *et al.* [29], Romaneckas *et al.* [30] and Jabro *et al.* [31] that different soil tillage methods had no significant influence on yield and most quality characteristics of sugar beet.

Although there was no significant difference in RY, SUGC, SODI, ALAN and MLAS during the years of study, results showed that tillage practices were beneficial in improving the yield and quality of sugar beet. The maximum values of RY (82.7 t ha^{-1}) and SUGC (17.0%) were observed in case of MR treatment, while the maximum values of SODI (2.6 mmol/100 g), ALAN (2.5 mg/100 g) and MLAS (3.0%) were noted in case of NT treatment (Table 3). Based on the results, tillage method affected the yield and quality of sugar beet in the order of MR > CR > R > MDD > DD > C > NT. These results are in agreement with those of Keshavarzpour and Rashidi [7], Rashidi and Keshavarzpour [8, 10], Khurshid *et al.* [9], Rashidi *et al.* [11, 13, 14], Rashidi and Khabbaz [12], Khan *et al.* [18, 19] and Iqbal *et al.* [20] who concluded that tillage practices can be associated with enhanced soil physical and mechanical properties (increased pore space, decreased bulk density, increased moisture preservation and decreased penetration resistance), improved soil structure, better seed/root-soil contact and superior suppressing of weed growth which positively influence yield and quality of sugar beet.

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

Source of variation	Df	Mean square					
		RY	SUGC	POTA	SODI	ALAN	MLAS
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

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

(RY: root yield; SUGC: sugar content; POTA: potassium; SODI: sodium; ALAN: alpha-amino nitrogen; MLAS: molasses)

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

Treatment	RY (t ha^{-1})	SUGC (%)	POTA (mmol/100 g)	SODI (mmol/100 g)	ALAN (mg/100 g)	MLAS (%)
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	4.5^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.

(RY: root yield; SUGC: sugar content; POTA: potassium; SODI: sodium; ALAN: alpha-amino nitrogen; MLAS: molasses)

In contrast, the minimum values of RY (71.3 t ha^{-1}) and SUGC (15.2%) were observed in case of NT treatment, while the minimum values of SODI (1.5 mmol/100 g), ALAN (1.6 mg/100 g) and MLAS (2.2%) were noted in case of MR treatment (Table 3). These results are in line with the results reported by Hill [15], Horne *et al.* [16], Ozpinar [33], Carter & Ivany [34], Borresen [35] and Bauder *et al.* [44] that conservation 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), poorer seed/root-soil contact and raised diversity of weed species and population which negatively influence the yield and quality of sugar beet.

CONCLUSION

Different tillage methods significantly ($P \leq 0.05$) affected POTA, but there was no significant difference in RY, SUGC, SODI, ALAN and MLAS. Although there was no significant difference in most studied traits, tillage practices were beneficial in improving the yield and quality of sugar beet. Based on the results, the reduced tillage treatments MR and CR and the minimum tillage treatment R can be recommended as more appropriate and profitable tillage methods in improving the yield and quality of sugar beet.

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REFERENCES

1. Jafari, A., S.S. Mohtasebi, H.E. Jahromi and M. Omid, 2006. Weed detection in sugar beet fields using machine vision. Int. J. Agric. Biol., 8: 602-605.
2. Sohrabi, Y. and G. Heidari, 2008. Influence of withholding irrigation and harvest times on yield and quality of sugar beet (*Beta vulgaris*). Int. J. Agric. Biol., 10: 427-431.
3. Abdel-Motagally, F.M.F. and K.K. Attia, 2009. Response of sugar beet plants to nitrogen and potassium fertilization in sandy calcareous soil. Int. J. Agric. Biol., 11: 695-700.
4. Draycott, A.P., 2006. Sugar Beet. Blackwell Publishing Ltd., Oxford, UK.
5. FAO Statistics, 2008. United Nation Food and Agriculture Organization.
6. Statistical Yearbook, 2009. Iranian Ministry of Agriculture.

7. Keshavarzpour, F. and M. Rashidi, 2008. Effect of different tillage methods on soil physical properties and crop. yield of watermelon (*Citrullus vulgaris*). World Appl. Sci. J., 3: 359-364.
8. Rashidi, M. and F. Keshavarzpour, 2008. Effect of different tillage methods on soil physical properties and crop. yield of melon (*Cucumis melo*). American-Eurasian J. Agric. and Environ. Sci., 3: 31-36.
9. Khurshid, K., M. Iqbal, M.S. Arif and A. Nawaz, 2006. Effect of tillage and mulch on soil physical properties and growth of maize. Int. J. Agric. Biol., 8: 593-596.
10. Rashidi, M. and F. Keshavarzpour, 2007. Effect of different tillage methods on grain yield and yield components of maize (*Zea mays L.*). Int. J. Agri. Biol., 9: 274-277.
11. Rashidi, M., F. Keshavarzpour and M. Gholami, 2008. Effect of different tillage methods on yield and yield components of forage corn. American-Eurasian J. Agric. and Environ. Sci., 3: 347-351.
12. Rashidi, M. and B.G. Khabbaz, 2009. Response of crop yield and yield components of tomato to different tillage methods in the arid lands of Varamin, Iran. In: Proceedings of Biennial Conference of the Australian Society for Engineering in Agriculture (SEAg). Brisbane, QLD, Australia, September, 13-16.
13. Rashidi, M., M. Gholami and B.G. Khabbaz, 2009a. Response of yield and yield components of tomato (*Lycopersicon esculentum*) to different tillage methods. Int. J. Agric. Biol., 11: 626-630.
14. Rashidi, M., S. Abbassi and M. Gholami, 2009b. Interactive effects of plastic mulch and tillage method on yield and yield components of tomato (*Lycopersicon esculentum*). American-Eurasian J. Agric. and Environ. Sci., 5: 420-427.
15. Hill, R.L., 1990. Long-term conventional and no-tillage effects on selected soil physical properties. Soil Sci. Soc. Amer. J., 54: 161-166.
16. Horne, D.J., C.W. Ross and K.A. Hughes, 1992. Ten years of maize/oats rotation under three tillage systems on a silt-loam soil in New Zealand. 1. A comparison of some soil properties. Soil and Tillage Res., 22: 131-143.
17. Lal, R., 1993. Tillage effects on soil degradation, soil resilience, soil quality and sustainability. Soil and Tillage Res., 51: 61-70.
18. Khan, F.U.H., A.R. Tahir and I.J. Yule, 1999. Impact of different tillage practices and temporal factor on soil moisture content and soil bulk density. Int. J. Agric. Biol., 1: 163-166.
19. Khan, F.U.H., A.R. Tahir and I.J. Yule, 2001. Intrinsic implication of different tillage practices on soil penetration resistance and crop. growth. Int. J. Agric. Biol., 3: 23-26.
20. Iqbal, M., A.U. Hassan, A. Ali and M. Rizwanullah, 2005. Residual effect of tillage and farm manure on some soil physical properties and growth of wheat (*Triticum aestivum* L.). Int. J. Agric. Biol., 7: 54-57.
21. Ecclestone, P., 2004. To plough or not to plough? British Sugar Beet Review, 72: 7-11.
22. Ecclestone, P., 2001. Minimum tillage, options for economic sugar beet production. British Sugar Beet Review, 69: 24-29.
23. Cannel, R.Q., 1985. Reduced tillage in north-west Europe-a review. Soil and Tillage Res., 5: 129-177.
24. Chaudhary, A.D., M. Javed, M.A. Rana, A. Sarwar and Q. Zaman, 1992. Comparative performance of direct drilling and conventional tillage practices under rice-wheat rotation system. Pakistan J. Agric. Sci., 29: 5-8.
25. Ekeberg, E., 1993. Minimum tillage for potatoes. Soil tillage and environment. The 228th Seminar of NJF. Finland.
26. Hao, X., C. Chang, R.L. Conner and P. Bergen, 2001. Effect of minimum tillage and crop. sequence on crop yield and quality under irrigation in Southern Alberta clay loam soil. Soil and Tillage Res., 59: 45-55.
27. Glab, T. and B. Kulib, 2008. Effect of mulch and tillage system on soil porosity under wheat (*Triticum aestivum*). Soil and Tillage Res., 99: 169-178.
28. Romaneckas, K., R. Romaneckiene and E. Sarauskis, 2006. The effect of primary soil tillage methods on sugar beet growth on a light loam luvisol. Zemdirbyste/Agri., 93: 81-87.
29. Adamaviciene, A., K. Romaneckas, E. Sarauskis and V. Pilipavicius, 2009. Non-chemical weed control in sugar beet crop under an intensive and conservation soil tillage pattern: II. Crop. Productivity, Agronomy Res., 7: 143-148.
30. Romaneckas, K., R. Romaneckiene and V. Pilipavicius, 2009. Non-chemical weed control in sugar beet crop under intensive and conservation soil tillage: I. Crop. weediness, Agronomy Res., 7: 457-464.
31. Jabro, J.D., W.B. Stevens, W.M. Iversen and R.G. Evans, 2010. Tillage depth effects on soil physical properties, sugar beet yield and sugar beet quality. Communication in Soil Science and Plant Analysis, 41: 908-916.

32. Hakansson, I., M. Stenberg and T. Rydberg, 1998. Long-term experiments with different depth of mouldboard ploughing in Sweden. Soil and Tillage Res., 46: 209-223.
33. Ozpinar, S., 2006. Effects of tillage systems on weed population and economic for winter wheat production under the Mediterranean dry land conditions. Soil and Tillage Res., 87: 1-8.
34. Carter, M.R. and J.A. Ivany, 2006. Weed seed bank composition under three long-term tillage regimes on a fine sandy loam in Atlantic Canada. Soil and Tillage Res., 90: 29-38.
35. Borresen, T., 1993. The long-term effect of tillage practice on soil properties and crop yields. Soil tillage and environment. The 228th Seminar of NJF. Finland.
36. Campbell, C.A., A.G. Thomas, V.O. Biederbeck, B.G. McConkey, F. Selles, D. Spurr and R.P. Zentner, 1998. Converting from no tillage to pre-seeding tillage: Influence on weeds, spring wheat grain yields and soil quality. Soil and Tillage Res., 46: 175-185.
37. Nelson, D.W. and L.E. Sommers, 1982. Total carbon, organic carbon and organic matter. In: Page, A.L., R.H. Miller and D.R. Keeny (Eds.). Methods of Soil Analysis. Part 2, 2nd ed., Agronomy Monograph No. 9. ASA and SSSA, Madison, WI, pp: 539-579.
38. Bremner, J.M., 1982. Total nitrogen. In: Page, A.L., R.H. Miller and D.R. Keeny (Eds.). Methods of Soil Analysis. Part 2, 2nd (ed.), Agronomy Monograph No. 9. ASA and SSSA, Madison, WI, pp: 915-928.
39. Olsen, S.R., 1982. Phosphorus. In: Page, A.L., R.H. Miller and D.R. Keeny (Eds.). Methods of Soil Analysis. Part 2, 2nd (ed.), Agronomy Monograph No. 9. ASA and SSSA, Madison, WI, pp: 403-430.
40. Thomas, G.W., 1982. Exchangeable Cations. In: Page, A.L., R.H. Miller and D.R. Keeny (Eds.), Methods of Soil Analysis. Part 2, 2nd (ed.), Agronomy Monograph No. 9. ASA and SSSA, Madison, WI, pp: 159-165.
41. Gee, G.W. and J.W. Bauder, 1986. Particle Size Analysis. *In*: Klute, A. (Ed.). Methods of Soil Analysis. Part 1, 2nd ed. Agronomy Monograph No. 9. ASA and SSSA, Madison, WI, pp. 383-411.
42. AOAC, 1995. Association of Official Analytical Chemists. Official Methods of Analysis, 16th Edition, AOAC International, Washington, DC.
43. Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agriculture Research. A Wiley-Inter Science Publication, John Wiley and Sons Inc., New York, USA.
44. Bauder, J.W., G.W. Randall and J.B. Swan, 1981. Effects of four continue tillage systems on mechanical impedance of a clay-loam soil. Soil Sci. Soc. Amer. J., 45: 802-806.