ORIGINAL RESEARCH

Research on Crop Ecophysiology
Vol. 10/2, Issue 1 (2015), Pages: 25 - 31

The Effect of Ratooning Practice in Cane Yield and Quality Parameters of Sugarcane

ASLAN HASHEMI[1], ALI REZA SHOKUHFAR[*1]
Department of Agronomy, Islamic Azad University, Ahvaz Branch, Ahvaz, Iran Author for Correspondence

[*] Corresponding author Email: alireza_shokuhfar@yahoo.com

Received: 10 August 2014 Accepted: 2 December 2014

ABSTRACT
Soil compaction is a main factor that reduces the cane yield in sugarcane fields, in Southwest of Iran, especially in ratoon cropping system. Therefore, sub-soiling practices could alleviate adverse effects of compaction and increased yield. In according to this aim, a study was to evaluate the effect of ratooning practice systems consisting of control (no subsoiler), two and four shanks subsoiler in two soil moisture conditions, before and after irrigation. Soil bulk density was measured in two depths of 0-20 cm and 20-40 cm, as an indicator of soil compaction. The results showed that sub-soiling with two and four shanks significantly reduced soil bulk density ($p<0.01$). In both depths compaction was not affected after irrigation treatment. The effect of sub-soiling was not significant for cane height, sheath moisture, leaf nitrogen content purity and refined sugar. Reduction of soil compaction significantly increased stalk weight, yield and sugar yield ($p<0.05$). Sub-soiling and irrigation treatments had significant ($p<0.01$) effect on reduction of fuel consumption.

Keywords: Ratooning practice, Subsoiler, Sugarcane, Yield, Fuel consumption

INTRODUCTION

Over the years, soil degradation has become one of the most important problems in agriculture. Erosion, salinization, compaction and loss of organic matter are the principal form of soil degradation (Muhieldeen *et al.,* 2014). Soil compaction is a general problem and a main reason that reduces the sugarcane yield, especially in ratoon cropping system, in Southwest of Iran. This adverse problem could have resulted from deficiency of soil organic matter (less than 1%), application of weighty machines in crop harvesting and fine texture of soils (silty clay – silty clay loam). Intense mechanization involving traffic of heavy machinery for harvesting in wet condition deteriorates for soil physical condition. Soil compaction results in increased bulk density, reduction in porosity, infiltration rates, and water storage capacity and impedes of root penetration (Kumar *et al.*, 2012). The compaction of inter-farrow between the cane rows could affect soil physical properties and cane yield. In according to improve detrimental effects of compaction in sugarcane cultivation in Southwest of Iran, the ratooning practices in which subsoiler with different shapes are used have been proposed. Tillage is one of the most effective ways to reduce soil compaction. Soil physical properties and crop growth are affected by tillage systems (Ji *et al.,* 2013). Where soil compaction is a problem, sub-soiling has been found to help alleviate it (Raper *et al.,* 1998). Sub-soiling the soil using a single shank tractor with a mounted oscillating subsoiler may increase the soil macro-porosity resulting in a lower bulk density (Naseri *et al.,* 2007).

The practice of sub-soiling could be a way to improve soil structure and aeration, creating a best environment for plant growth. Management of top soil helps in better moisture conservation, which is essential for proper establishment of the crop (Kumar *et al.,* 2012). In the present study, the effect of two type different subsoiler has been evaluated in reduction of bulk density and changing of cane yield and cane juice quality.

MATERIALS AND METHOD

This study was conducted as a field experiment in the second ratoon crop in Hakim Farabi Agro-Industrial Co. in Khouzestan province, Southwest of Iran (48° 36´ E, 30° 59´ N). The region is classified as arid and semi-arid, with annual rainfall of 200-250 mm and mean maximum and minimum temperature in period of crop season duration of 16.49°C to 45.18°C and from 5.23°C to 24.23°C for of respectively. In according to study soil physical characteristics, especially compaction in wheel traffic zones, the included treatments were three levels of subsoiler as control (without subsoiler), subsoiler with two (S2), and four shanks (S4) before and after irrigation. The triplicates treatments were arranged in the split plot designbased on a randomized complete block, that each plot had 1.17 ha. The treatment's irrigation and subsoiler were main plot and sub-plat, respectively. The application of fertilizer was traditional and accordingly, 350 Kg/ha urea was used.

Soil Analysis

Soil samples were collected from 0-30 cm and 30–60 depths. Data were collected on electrical conductivities of the saturation extract with conductivity apparatus (Rhoades 1996), soil acidity in soil extracts by pH meter; soil textures with a hydrometer method (Bouyoucos 1961), percentage of organic carbon by the wet oxidation method (Walkley and Black 1934) and bulk density (g/cm^3) by core sampler.

Data Collection

Cane yield, cane height, percentage of leaf nitrogen and percentage of sheath moisture were determined. The leaf nitrogen and sheath moisture were determined by Clement's method (Clements and Sund, 1974). The percentage of juice sugar (Pol %) based on a sample of 20 stalk was determined with addition of 2 g lead acetate to 100 mL cane juice and filtration with Whatman No. 42 filter paper. Then the amount of Pol reading was attained by polarimeter (AA-55 polarimeter-England). Afterwards, the percent of Pol was obtained by standard tables.

Percentage of dissolved solids (Brix%) was determined by a refractometer(SUMA Brixometer-England). The juice purity was computed by the production of Pol parentage and Pol factor divided to Brix% (Pol factor was attained from standard table and Brix%). Furthermore, the percentage of refined sugar (RS%) was calculated as followed:

$$RS\% = \frac{\text{Yield}}{0.83} \qquad (1)$$

where yield was obtained as 100/QR, quality ratio (QR) was computed from purity factor divided to reality Pol.

Statistical analysis

All data were processed by Microsoft Excel, and other statistical analyses were conducted using the MINITAB 16 software.

Results and Discussions

The results of soil analysis (as mean of 0-30 cm and 30-60 cm depths) indicated that the soil of experiment site had a fine texture (silty clay loam) that was ready for compaction. The reaction of soil was alkaline (pH 8.1) and soil could classify as saline soil (EC 2.14 dS m^{-1}). The amount of soil organic matter was low (0.18%) which is a reagent of arid and semi-arid regions (Table 1).

Table 1. Physico-chemical properties of experimental soil

	Soil Texture	O.M%	EC (dS m^{-1})	pH
0-30 cm	silty clay loam	0.21	2.07	8.1
30-60 cm	silty clay loam	0.14	2.21	8.1

Soil bulk density was measured in two depths, as 0-20 cm and 20-40 cm. As shown in Figure 1, the application of subsoiler before and after irrigation had no significant effect in reduction of bulk density. Sub-soiling with two shanks significantly reduced soil bulk density ($p<0.01$), as compared to control. Moreover, the application of four shanks subsoiler for significantly reduced compaction ($p<0.01$).

Reduction of soil bulk density was 29.5% and 37.95% in 0-20 cm in two and four shanks treatments, respectively. One of the main causes of soil compaction is machine traffic in the field that alters soil physical, chemical and biological properties and therefore has direct impact on crop yield. Conventional and direct effects of soil density on yield is through the increase resistance to root growth, and reduction in the availability of water (Bangite and Rao, 2012).

The effect of four shanks (S4) subsoiler in reduction of soil bulk density was greater than the effect of two shanks, but it was not significant. In depth of 20-40 cm, the reduction of bulk density was 36% and 20.6% for two (S2) and four (S4) shanks, respectively.

The results were similar for sub-soiling before and after irrigation. Based on these results, the use of subsoiler can reduced soil compaction, up to 40 cm (measured in this study) and improve soil conditions for plant growth.

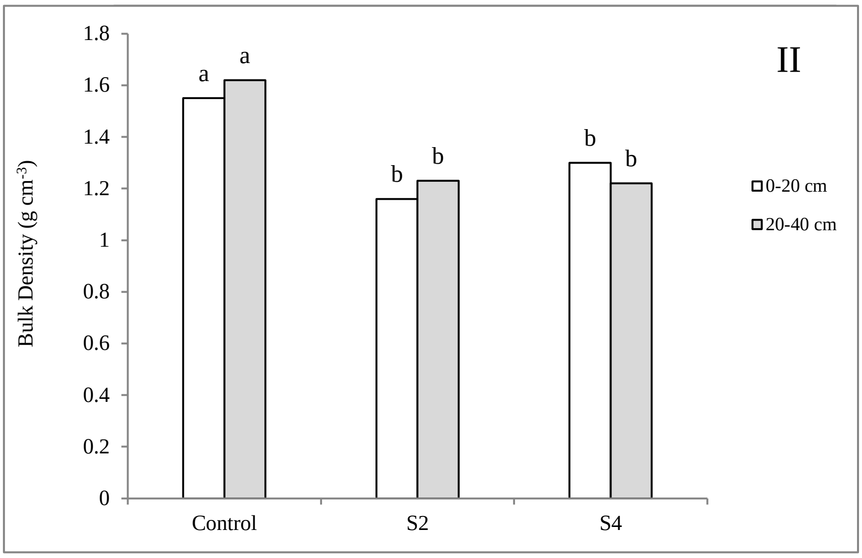

Figure 1. Effect of two and four shanks subsoiler before (I) and after (II) irrigation

These results were opposed with Ng Cheong *et al.* (2009) that concluded compaction induced by harvester traffic occur mainly in the top 20 cm, beneath it the soil remained relatively unaffected. Bangita and Rao (2012) showed that compaction relief treatment caused of compaction reduction in wheel traffic zones between cane rows.

Cane Height

Soil moisture content before and after of sub-soiling, could not increase cane height. The ratooning practice by subsoiler increased height of cane, but not significantly (Table 2). The highest cane height (234 cm) was obtained in subsoiler treatment, and the control treatment had the lowest height (223 cm). The application of subsoiler before of irrigation increased cane height more than sub-soiling after irrigation. In comparison with control treatment, cane height in two and four shanks subsoiler before of irrigation increased 5.9% and 7.2% respectively. On the other hand, sub-soiling practice after irrigation caused 3.2% and 4.7% increase in height in two and four shanks, respectively. The higher amount of soil moisture in after of irrigation might have lower effect on soil, as compared to sub soiling before irrigation. This founding could result from sugarcane root sensitivity for aeration and compaction (Swin *et al.*, 1984).

Stalk Weight

Irrigation treatments before and after sub-soiling did not improve cane stalk weight. The weight of stalk was significantly affected by sub-soiling practices, ($p<0.05$) (Table 2). The effects of both subsoiler treatments on stalk weight were similar and stalk weight in S2 treatment increased 9.7% and 11.48% in sub soiling before and after irrigation, respectively. The S4 treatment caused 9% and 3.23% increase in stalk weight in sub soiling before and after irrigation, respectively. Mandal and thakur (2009) showed that subsoiler increased 15% and 9.8% in cane yield and stalk weight, respectively.

Sheath Moisture Content and Leaf Nitrogen

The sheath moisture and content of leaf nitrogen were not affected significantly by ratooning practices and irrigation treatments (Table 2).

Table 2. Summary of analysis of variance of effects of irrigation and subsoiler on quantity and quality parameters of sugarcane

Treatments	Cane height	Stalk weight	Sheath moisture	Leaf nitrogen	Yield	Purity (%)	Refined sugar	Sugar yield	Fuel consumption
Irrigation (I)	ns	ns	ns	ns	ns	ns	ns	ns	**
Subsoiler (S)	ns	*	ns	ns	*	ns	ns	*	**
I × S	ns	ns	ns	ns	ns	ns	ns	ns	**

ns: non-significant; and* :significant at 5%; and probability levels, respectively 1%

Cane Yield

Cane yield was affected significantly by sub-soiling treatments ($P<0.05$) but not by irrigation before and after sub soiling (Table 2). Yield improvement due to subsoiler treatment ranged from 8.33% to 9.83% in sub soiling before irrigation and from 8.59% to 9.94% in sub soiling after irrigation. Therefore, the ratooning practice (sub-soiling) can be recommended for improvement of soil physical conditions and increase of sugarcane yield. Jagtab *et al.* (1992) in a field experiment showed that yield was increased 45% by sub-soiling practice. The practice of tillage in unsuitable conditions decreased yield in ratoon field. The ratooning practices can minimized the adverse effect of soil compaction. The treatments of two and four shanks did not difference significantly (Figure 2).

Quality Parameters

The purity percentage was not significantly different in sub-soiling treatments. The impact of sub-soiling on refined sugar (RS) was not significant. This result showed that purity percentage and refined sugar content were not affected by subsoiler. As shown in Table 2, the sub-soiling practice has been increased of sugar yield significantly, while irrigation the effect of was not significant. The sugar yield in four shanks treatment was the highest (9.13 ton ha^{-1}), and control treatment had the lowest sugar yield (8.12 ton ha^{-1}). The increase of sugar yield in sub-soiling treatments was originated from the effect of sub-soiling on cane yield.

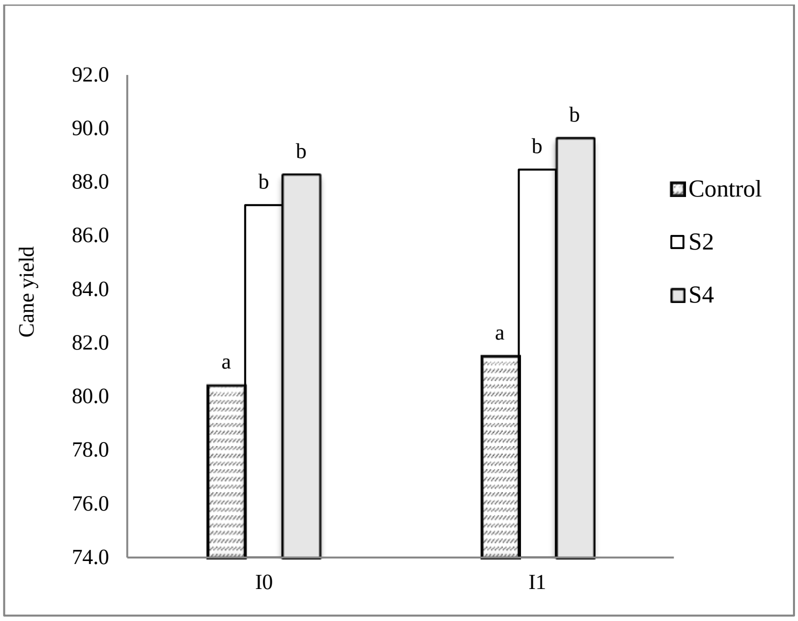

Figure 2. Effect of subsoiler on cane yield before (I0) and after (I1) irrigation

Fuel Consumption

In this study, the amount of fuel consumption was calculated by a direct method of the full tank. The statistical analysis (Table2) showed that, irrigation and sub-soiling, treatments had significant ($p<0.01$) effects on reduction of fuel consumption. Use of two shanks for reduction of compaction required lower fuel as compared to four shanks. The suitable moisture condition was affected in consumption of fuel. The lowest fuel consumption was obtained from sub-soiling after irrigation. Furthermore, the application of two shanks subsoiler after irrigation could be use for reduction of soil compaction.

Conclusion

The relief practice of sub-soiling to reduce compaction was conducted in the field. Applying two and four shanks subsoiler showed that reduction of soil bulk density was 29.5% and 37.95% in 0-20 cm depths, respectively. In depths of 20-40 cm, the reduction of bulk density was 36% and 20.6% for two and four shanks, respectively. Furthermore, sub-soiling practice reduced soil compaction. The ratooning practice by subsoiler increased height of cane, although it significant. Stalk weight was affected by sub-soiling practice, but irrigation was not. Cane yield was increased by significantly sub-soiling treatments, (8.33%-9.83% and 8.59%-9.94% in sub soiling before and after of irrigation). Two and four shanks treatments had not significant difference in significantly different cane yield. Purity percent and refined sugar were not significant in sub-soiling treatments. While sugar yield was increased from 8.12 ton ha^{-1} to 9.13 ton ha^{-1}. The results indicated that irrigation and subsoiler, treatments had significant effect on reduction of fuel consumption. In according to reduction of compaction and increase of yield it was suggested that two shanks subsoiler after irrigation is suitable in aspect of agronomic and economic consideration.

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