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Effects of Different Tillage Systems on Bulk Density and Sugarcane Yield

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Abstract

Behavior of different tillage operations within soil is quite different in sense of bulk density, compaction and porosity. Different crops require a variety of soil structure to facilitate their root systems. Deep rooted crops require deep tillage implements and shallow rooted crops gives good yield with shallow tine cultivation. The effects of combined tool system on soil varies according to the nature of tillage implements in the tool system. Favourable environment within soil for a particular crop is achievable by selecting a suitable tillage combination. In the conventional tillage operation, a sole formation is a common practice below root zone which restricts root penetration of deep rooted crops and hinder the downward movement of excessive water, that cause suffocation in the root zone. For sugarcane lower bulk density of soil does not confer good yield but deep tillage operation (chisel plowing) with inversion of top most layer (Disc harrow) gives favourable environment for good yield.

Key words: Tillage, bulk density, sugarcane, yield

Introduction

Farm mechanization is the need of the time to enhance our agricultural production to meet the food requirement of rapidly growing population. Most of our agriculture has already been fully or partially mechanized which includes tillage, seedbed preparation, sowing, planting, interculturing, harvesting and threshing. But still there is wide scope for further mechanization to boost the existing production. Tillage is a fundamental crop production practice to form a good seed bed for germination and subsequent plant growth. Tillage operation alters the soil bulk density and soil strength. Soil physical properties are effected by various tillage practices (Sprauge and Triplot, 1986).

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These soil properties change the environment within the soil and make it favorable for plant growth. The top soil is usually loosened during conventional tillage but at some depth just below the plow layer, a compacted layer commonly called plow sole develops and is characterized by abnormally high bulk density. This layer restricts the water movement and gaseous exchange. Under such condition, deep tillage (sub soiling, chiselling) has been reported beneficial for crop production by improving soil physical and chemical properties (Ahmed and Maurya, l988). Excessive soil manipulation by implements however is detrimental to the soil structure with serious consequences on the emergence and yield of crop (Sheikh *et al.* 1978). It is there fore important that proper type of implements should be selected for different soil condition so that suitable soil tilth can be achieved. A tillage tool does not work independently but operates in a combined tool system. When two tools are brought close to each other, the interference of one in the boundary conditions of the other causes a considerable change in the energy requirement of both tools and influences the resulting soil disturbance (Sheikh *et al.*1978). Trond and Njos (l994) also confer this statement that soil properties were influenced by ploughing depth. The soil structure measured as bulk density, porosity, air capacity, pore size distribution and aggregate stability was slightly more favourable to plant growth, especially in a top layer of 24 cm depth. Al. Tahan *et.al.* (1992), studied the effects of plowing depth, using different plow types on physical properties of soil and concluded that the lower values of bulk density are obtained by using disk plow compared with high value obtained by chisel plow.

In Pakistan sugarcane is planted on wide rang of soil types of south west sea level to the heights of Northern areas. Comparing with the other sugarcane producing countries, Pakistan ranks 5th, in acreage and 18th, in yield per unit area (Razzak, 1993). One of the important causes of lower average yield is the conventional method of land preparation and planting method of sugarcane. The conventional cultivator commonly used with tractor as primary and secondary tillage tool normally operates up to the depth of 8 – 10 cm. Generally 6 – 8 passes of cultivator results severe compaction of soil. When the soil is subjected to compaction, thee proportion of pores (larger than 30 μ

m) decreases while the proportion of micro pores increases (Eriksson, 1982). Bulk density is a major factor in soil compaction. Excessive use of heavy machinery and implements cause the soil compaction resultantly bulk density may effect the transmission of water and air through the soil, change of heat capacity, decrease the amount of nutrients mineralized from the soil, which results the reduction in crop yield. Compaction promotes hard pan below the soil surface. This hard pan restricts the root penetration and excessive irrigation may not drain down ward which causes suffocation and causes the retardation of plant growth. A healthy environment to the crop can be provided by using a proper tillage system. A suitable combination of different tillage implements can provide such an environment within soil by changing physical properties in terms of bulk density, moisture contents and penetration resistance etc.

The objective of this study was to determine the effects of different tillage systems on the bulk density and crop production and to select the cost effective tillage system for optimum sugarcane stalk production.

Procedure

Study was conducted at United Farms in Chak No. 19l/GB Tehsil & District Toba Tek Singh. The research area falls under hot arid climate where maximum temperature ranges between 30-45^{o}C while minimum temperature, range l0-27 ^{o} C in month of Nov; to February. The area is flat and canal irrigated and heavy rains usually falls in the month of July. This soil belt is considered suitable for cotton & sugarcane

In order to meet the objectives, experiment was designed to determine the effects of different tillage operation on soil and crop parameters. Soil samples were collected with core sampler from each plot for soil analysis. Total experimental area 73x 83 m was divided into three sub-plotes. Four different tillage combinations were applied randomly to the sub-plots.

Four implements chisel plow, disk plow, disk harrow and spring tine cultivator were used with following combinations:-

Tl = Chisel plow + 2 pass cultivator.
T2 = Disk plow + 2 pass cultivator.
T3 = Chisel plow + 2 pass disk harrow.
T4 = Cultivator 5 pass.

Chisel plow was operated to a depth of 30 cm. Disk plow was operated to the depth of l5 cm, while disk harrow and narrow tine cultivator were operated to the depth of l0 cm. After each operation planking was done. After completion of Tillage operation, soil samples were collected for the depth of 0-l0 cm and l0-l5 cm for determination of soil parameters. Sampling was replicated thrice for favorable results.

Soil and crop management.

Following management practices were adopted during this research study.

Crop	Sugar cane
Variety	SP. SG. 26
Seed Rate	98000 Sets/ha

Table 1: Fertilizer and weedicide application rate

Fertilizer	Time of application	Rate
TSP	Before plantation	5 bag/ha
DAP	Before plantation	5 bag/ha
Potash.	Before plantation	2.5 bag/ha
Urea.	2-months after plantation	2.5 bag/ha
Weedicide	0ne months after plantation	2,5 bag/ha

Bulk density.

Tillage operations were performed to increase the porosity of soil to determine the variation in bulk density with resect to depths. Samples were collected from 0-l0 cm & l0-l5 cm with the help of core sampler having core diameter 6.86 cm. Three samples from each plot were collected. Soil samples were oven dried at l05 ^{o} C for 24 hours. Following formula was used to calculate dry density of soil:

$$BD = \frac{DWS}{Vs}$$

Where

BD Bulk density (gms /cm^3)
DWS Dry weight of sample (gms)
VS Volume of the sample (cm^3)

Yield

Each plot was harvested separately and stalk yield/weight was measured with balance.

Results and Discussion

Mean dry density values of various depth, for different tillage combinations are given in Table 2.

Comparison of bulk density values for the depth 0-10 cm indicates that there is no significant difference among the different tillage combinations, that prove the identical behavior of different tillage operation on bulk density within upper layer of soil (0-10 cm), but for greater depth (10-15 cm) behavior of different tillage operation with bulk density is different. It means that bulk density values changes with respect to depth even with same tillage combinations. Lower value (2.043 gm/cm^3) of bulk density in T2 for the depth (10-15 cm) is due to operation of disc plow, which cuts and inverts the soil. While higher values (2.327 gm/cm^3) were obtained with T4 for 10-15 cm depth, which indicates that the range 10-15 cm is below the operational depth of narrow tine cultivator.

Table 2: Mean value of soil bulk density 0-10 cm and 10-15 cm depth

Treatment	Mean value of bulk density 0-10 cm (gms.cm^3)	Mean value of bulk density 10-15 cm (gms/cm^3)
T1	1.180	2.089
T2	1.130	2.043
T3	1.204	2.232
T4	1.145	2.327

Cane Yield

Each plot was harvested and weighed separately. Mean values of yield obtained from different treatments are given in Table 3.

Table 3: Mean value of sugar yield

Treatment	Cane yield tons/ha
T1	118.727
T2	122.553
T3	138.540
T4	120.047

Table 3 indicates that the plot treated with tillage combination (T3) has higher yield than any other treatment. At the same time results of table 2 revealed that minimum bulk density 2.043 gm/cm^3 has been calculated from T2. It means lower bulk density does not confer higher yield and there are other factors that play a significant role in higher yield.

Conclusions

- Chisels plow (one pass) + Disk harrow (2- pass) is the best tillage combination for higher yield in sugarcane.
- Excessive manipulation of upper layer of soil with out chiseling results lower bulk density of upper soil surface which does not provide favourable environment for sugarcane crop (Deep rooted crop)
- Shallow plowing is not recommended for sugarcane plantation as crop root zone lies below the operational depth of shallow plowing implements and upper layer treatment has no favourable effect on crop.

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