

## Determination of Infiltration Rate under Different Levels of Compaction by the Use of Double Ring Infiltrometer, A Case of Kagera Sugar Limited (KSL)

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### ABSTRACT

Irrigation is a major factor in sugarcane growing. Unquestionably, sugarcane is one of the most Water - demanding crops after rice. The amount of water recorded from rainfall or irrigation systems in a given field are always considered as uniform despite of heterogeneous condition within the field. The application of water in the soil is one but the uptake by plant is the most side of consign. Water uptake by plant which is among of the root function, is mainly influenced by infiltration rate. Other side of these is right to say, any hindrance factor to infiltration rate and its capacity is primary killer for plant growth. Soil compaction is one of greatest factor which hinder water percolation into the ground as it deform soil structure. In infiltration test conducted at 6P4D shows the statistical difference between infiltration rate in compacted and non-compacted portions. The highest and lowest infiltration rate recorded was 383mm/hour to 116mm/hour and 220mm/hour to 35mm/hour in non-compacted and compacted portions respectively. Once the data were subjected to ANOVA using GenStat software was found to be statistically difference at 5% level of confidence. Being in a side of quantifying its consequences will help to make friendly decision in our farming system and irrigation scheduling in order to avoid water loss through runoff and flooding as a result of poor infiltration. The main purpose of this writings is to examine quantitatively on how compaction influence infiltration rate and come-up with recommendation such as Controlled Traffic system.

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### 1.0 Introduction:

The mechanized farming system is nowadays increasing because is the key to food security and especially in developing countries. In pre industrialization the main strategies to increase productivity in agriculture sector was the adoption of mechanization system with the target of reducing labor cost while increasing quantity and quality operations.(Emami et al., 2018). This also aimed to promote production, distribution, utilization of varieties of tools, machinery and equipment for the development of agricultural land, planting, harvesting and

primary processing. Machinery utilization in sugarcane production is vital and inevitable not only because of its high biomass but also it has been cultivated in larger plantation. In Kagera Sugar Limit we are using light to heavier machine in different operations starting from land preparation, agrochemical application and haulage operations to about 13936.02ha and 4946.6ha under cane in Kagera and Kitungole side respectively. In haulage operation the adoption of these machine have not been up to the desired level in terms of standard though we are always improving. The machinery tend to move randomly in the field which pose some detrimental

effect both to the crop and soil. Some of these effects are Soil compaction which occurs anywhere in the fields due to unlimited pathway (Tramline). As soil compaction takes place both in inter row and along the cane row, it reduce infiltration rate down to the root level. Reduced water percolation lead to ponding, surface runoff and mostly inadequate moisture for crop production. Soil texture that is percentage composition of sand, silt, and clay is the major inherent factor affecting infiltration. Water moves more quickly through large pores of sandy soil than it does through small pores of clayey soil, especially if clay is compacted and has little or no structure or aggregation.”,(USDA-NRCS, 2019) Compaction cannot be avoided 100% but can be reduced or controlled. Fibrous root type in sugarcane elongate both vertically and horizontally, meaning water absorption is also taking place in both points. The lateral elongation towards inter row space is affected by matric water potential, that is with increased level of compaction the amount of water held at a high soil matric potential decrease and that make difficult for plant root to absorb it. To rig out the problem of compaction near the cane row, there a need to change the cane row spacing we are currently having.

**2.0 Materials and Methodology:**

Soil compaction and infiltration rate taste were both conducted at 6p4d field located at Kitongule side, 19km from Kagera headquarter across Kagera Bridge with sand clay loam soil type. Soil compaction was determined by hummer or cone penetro meter in 5 replicates marked by the aid of Global position system (GPS) in different location within the same field. Each pair was between damaged and undamaged portion were assumption was made on presence of compaction especially on damaged points. Aside each points, infiltration rate was tested by the use of double ring infiltrometer with the specification of 16cm to 30cm diameter inner and outer ring respectively. The option of double ring infiltrometer was made

against single ring to minimize lateral movement of water which interfere with accuracy as the observation targets only vertical movement of water. The infiltrometer height was 30cm in which 15cm was driven into the ground by using hummer of approximately 7kg. A sponge of 10cm\*7cm\*3cm was used to avoid soil disturbance during water pouring as a falling head was used. A measuring cylinder of 1000ml was used to record the water addition. The drop of water was recorded at interval of 10 minutes for one hour in each replicate by using stop watch while neglecting the constant flow despite of happening to most of measurement before one hour.

**3.0 Results:**

**3.1 Compaction due to machine traffic:**

The surface damage of machine was a driven factor towards point’s selection for infiltration rate and compaction taste. In penetration resistance observed between damaged and non-damaged point were found to have statistical difference following the comparison between extreme mean differences with average least significant difference (LSD). The purpose of compaction detection before infiltration test was to make sure on existence of numerical or statistical variation on penetration resistance before infiltration taste. Among five replications the highest penetration resistance of 18.04 J/Cm were recorded in replication number 2 (E'0304802 N'9862238) with lowest of 7.04 J/Cm in replication number 03 (E'0304733 N'9862237) from Damaged and non-damaged points respectively. On other hand in figure 02 below, the energy required to push a rod to one centimeter into the depth it was almost twice in damaged area to that in undamaged area. In figure number 01, it’s just showing the mean variation from one blow to another and for instance in blow number the difference was recorded to be 50%. Under this observation, one can predict on variation of infiltration time which may vary for up to twice a time per constant application rate.

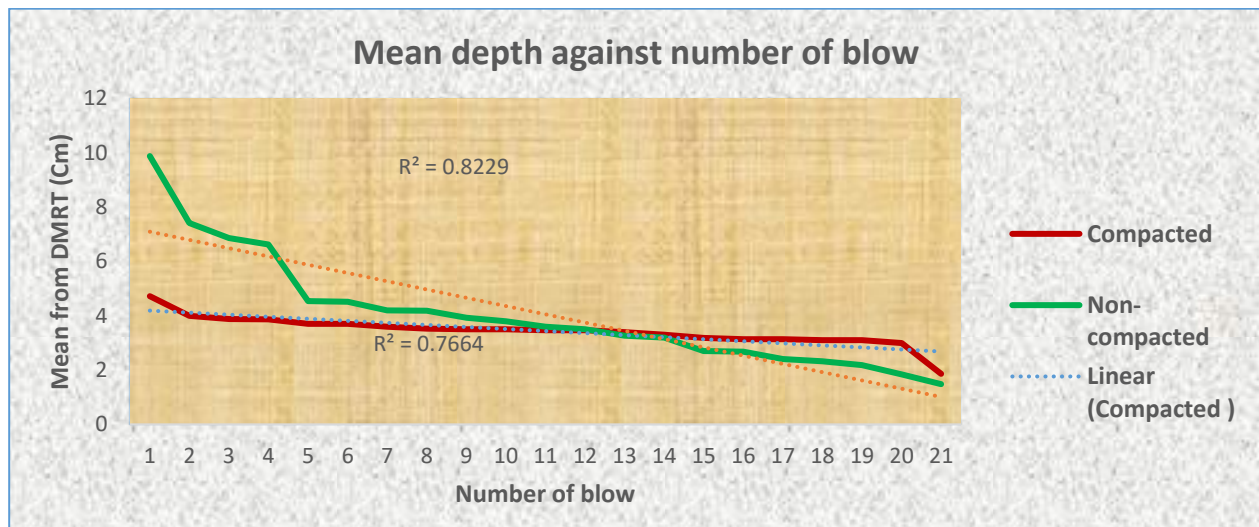


Figure 01: Graph showing a general mean of penetration depth per blow obtained from DMRT against the number of blow

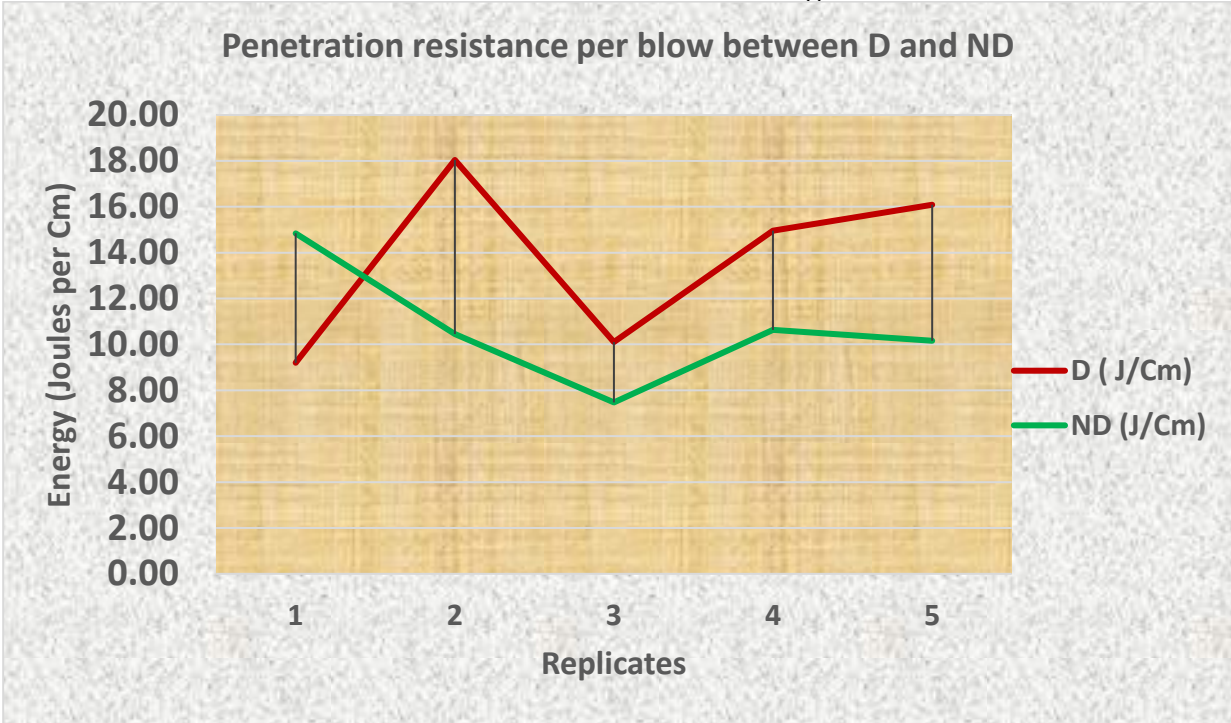


Figure 02: The graph showing the overall energy (Joules/cm) that required to push the rod into the ground per single centimeter.

**3.2 Effect of compaction level on infiltration rates:**

The results of the ANOVA conducted on infiltration rate and penetration resistance showed that there was a significant difference between the compacted and non-compacted infiltration rates. However, the experimental location had the same soil types and almost the same soil texture that is Sand Clay Loam. Five different trials were conducted in pair to come up with infiltration trend, where time was kept constant for one hour each but the data were collected for the interval of 10minutes. Statistically, overall comparison there was significant different with  $P > 0.001$  in infiltration rate between the two group of data. From the table 01 below, it shows the infiltration rate of 383mm/hour with 111mm/hour compared to 116mm/hour with 35mm per hour maximum and minimum in non-compacted and compacted infiltration rate respectively. The statistical data from table 02 below, where confidence level were set at 5%, despite of confirmed overall significance

difference, in their respective means from Duncan multiple range test such as from 40 to 60 minutes there was no statistical significance different though numerical difference exist. In either aspects, may be due to high soil density in sub surface layer or soil depth may be shallow. Otherwise in compacted portion is obviously due to high soil density from the surface and that’s why in 40 to 60 minutes we fail to reject a null hypothesis. In non-compacted, on the same time interval probably is due to saturation point because in some replication especially replication number 04 (E'0304755 N'9862321) constant infiltration rate were reached and ignored purposely because was not the intention of these findings. From 0-10, 11-20 and 21 -30 minutes there was a statistical difference where the mean difference from each time interval was higher than the overall average of Least Significance Difference (L.S.D).

Table 01 Summarized row data per replication with total summation of infiltration rate per one hour.

Replication	GPS Reading	Time (minutes)	mm/hour in C	mm/hour in NC
1	E'0304817 N'9862221	60	80	220
2	E'0304802 N'9862238	60	35	290
3	E'0304733 N'9862237	60	92	223
4	E'0304755 N'9862321	60	80	111
5	E'0304844 N'9862283	60	116	383

Table 02 Statistical data showing overall mean for infiltration rate under compaction and non-compaction portions obtained from ANOVA Duncan Multiple range taste

Time Interval	C (mm)	NC (mm)	NC -C	AVR L.S.D	Statistical difference
10	40.4	103.8	63.4	19.56	YES
20	21.8	58.8	37		YES
30	14.4	45.2	30.8		YES
40	3.6	23.501	19.9		YES
50	0.4	12.2	11.8		NO
60	0	2.4	2.4		NO

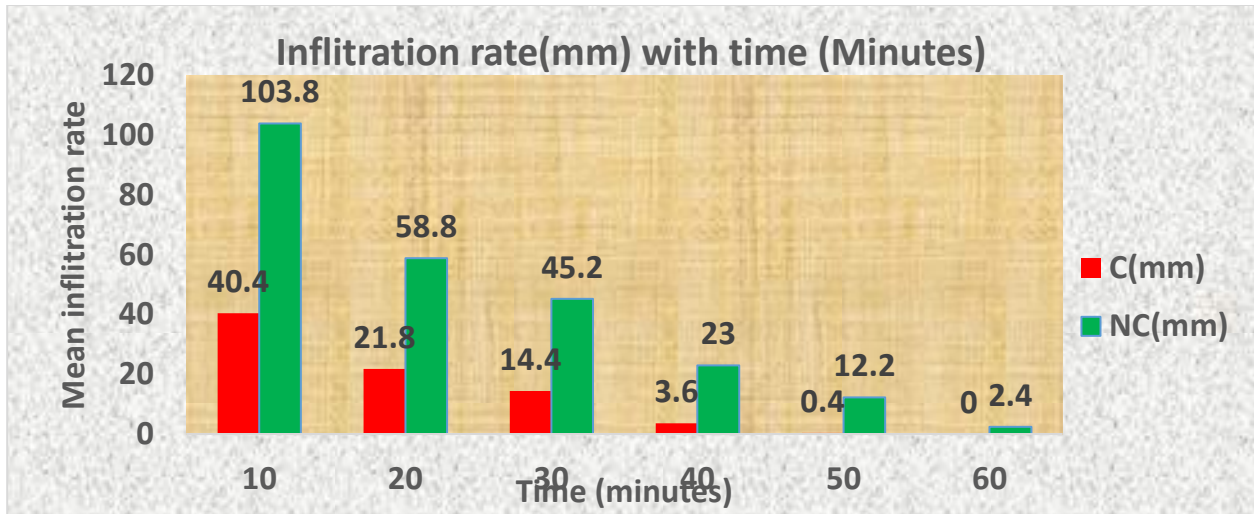


Fig 03: A simple histogram showing the mean infiltration rate against time between compacted and non-compacted portions.

**4.0 Conclusion and recommendation:**

Soil compaction was shown to have a negative effect on infiltration rates examined at 6p4d following haulage operation. Under the really situation, soil compaction is inevitable but it can be minimized or being localized by adopting Controlled Traffic system. (Antwerpen et al., 2000),

reported that, a more acceptable distance between the edge of the row and the side of the wheel is 0.40m, meaning compaction near cane row will be avoided. Unfortunately we haven't meet this standard especially to our hauling machines Grab loaders and Trailers and these is forcing us to Increasing the width of inter-rows in order to suit the standard.

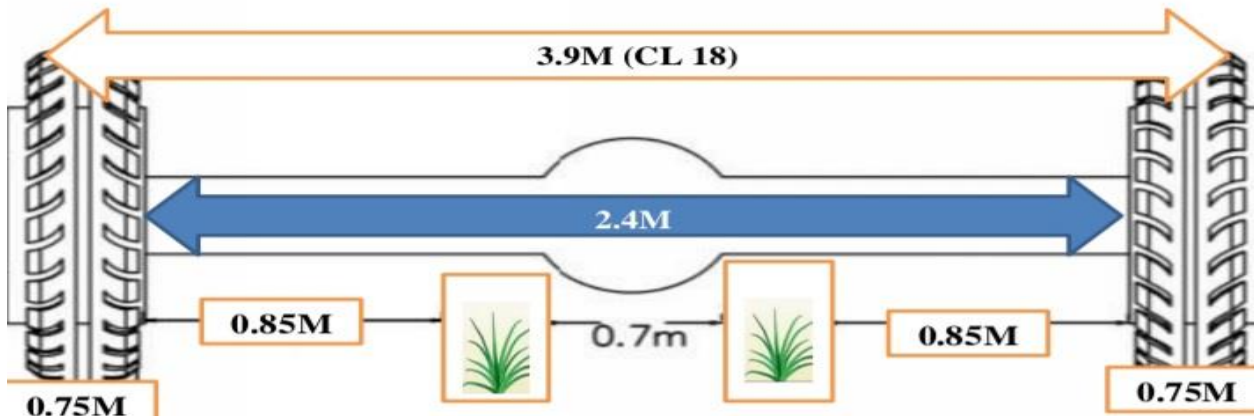


Fig 03: Showing a Proposed row alignment under specification of LO18

The new row alignment of 0.7m Separated by 2.0 m trafficked lanes will correspond with our machine which will give us a running meter of 7407 m with 925 m less from current dual row we have and 740 m more from our single row system of 1.5 m between the row. This will help to rigout from infiltration problem with it's accompany problem such as runoff, ponding and soil erosion.

#### **5.0 References:**

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