

The Effect of Tillage on Soil Compaction and Soil Moisture Content: A Preliminary Study on Paddy Soil in Merlimau, Melaka

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Abstract

Soil tillage is an important step before cultivating rice by using equipment to prepare the soil for crop growth. It has many procedures to follow in order to avoid future problem such as lower growth rate and fewer yield, as it affects the nutrients intake. This study was conducted to investigate the effect of soil tillage on the soil compaction and soil moisture before and after ploughing process at paddy field. Hence, this study was to identify the change of soil compaction and soil moisture content in each session of ploughing process and the relationship between soil compaction and soil moisture content after first and second ploughing. A tractor model WM1104 with 110hp did the soil preparation. Both ploughing sessions were using rotary tiller. The penetrometer was used for reading the resistance to penetration and measurement data can be read from the display meter. The average values of soil compaction before and after first and second tillage are 186.94 psi, 162.22 psi and 137.78 psi respectively. There is also show a positive relationship between soil compaction and soil moisture content. The higher soil compaction the lower soil moisture content and vice versa.

Keywords: Paddy soil, Soil tillage, Soil compaction, Soil moisture

Introduction

Rice is cultivated on 688,770 hectares land on Malaysia land (FOASTAT, 2018) which produce approximately 4107 kilograms per hectare in 2016 (STATISTA, 2019). Normally, rice cultivation involves ploughing before transplanting rice seedlings (Hobbs et al. 2007).

Soil tillage process is an important part of land preparation before cultivation and it gives more benefit to farmer. It can affect the soil compaction as the soil bulk density changed and influences soil porosity, soil water content and soil air permeability (Badalikova, 2010). Hobbs et al (2017) has listed a few reasons why tillage is favoured before planting such as land preparation for seed to grow since the soil soften and eased the nutrient intake, weed and insect control. Furthermore, this process gives impact to soil which can change soil condition. According to Verma and Dewangan (2006), tillage process before cultivating paddy can cause soil compaction which can reduce water losses. Hence, this study was conducted to see whether tillage process has affected the soil compaction and soil moisture on paddy soil.

Materials and methods

Study site and test parameters

The study was taken place at Merlimau paddy field in Melaka. The selected field was a two acre area with four plots and predominantly clay soil. There were two parameters taken during the study which are soil compaction value and soil moisture content.

Test procedure

1) Data collection preparation:

The data was taken trice which were before tillage taken place, after first ploughing and after second

ploughing process. Each plot was divided into nine square and the readings and samples were taken in the middle of each square. Figure 1 shows the design of study plot.

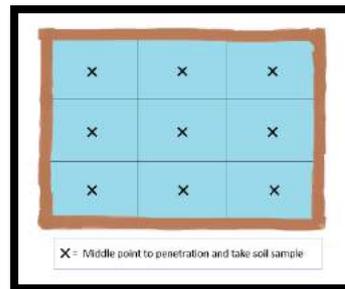


Figure 1: Design of study plot

2) Soil preparation in field

Tillage process was done by using a tractor model of WM1104 from China with 110hp. In normal practice, the first plough should use disc plough blade, while second and third plough are using rotary tiller. Unfortunately, due to bad weather condition with heavy rain, high labour cost and time constraint, the first plough using disc plough was waived. The tillage process was done using rotary tiller in wet condition paddy soil twice, hence became the first and second plough. Soil compaction reading was taken after each ploughing process.

3) Soil compaction reading

After study plot was designed, measuring process was taken place in the field. Soil compaction reading was taken using penetrometer. It is a soil compaction tester that used to measure soil compaction in pounds per square inch (Psi) unit. It has two cones to identify soil compaction which are ½ inch and ¾ inch base diameter. In this study, the latter base diameter was

used since it is suitable for soft soil. There are six levels for depth marks which are at 3, 6, 9, 12, 15, and 18 inches. For this study, the 3-9 inch mark was used because it is a level for root development area and level for disc depth ploughing. The penetrometer was used for reading the resistance to penetration and measurement data can be read from the meter as shown in Fig. 2.



Figure 2: The reading meter of penetrometer

4) Soil sampling analysis

The soil samples were taken in the same place of penetrometer readings were done. The samples were taken at depth of 5-7 inch from the surface level of the soil. Then, the soil samples were put in a plastic containers and marked manually. The samples later were taken to laboratory to undergo a standard laboratory procedures to measure its moisture content. The wet soil was weighted and then put in the laboratory oven with temperature of 110°C for 24 hours. After that, the soil was weighted once again to measure the dry soil. Then the moisture content was identified using the below formula and then is expressed as a percentage;

$$MC = \frac{W - D}{W} \times 100$$

where ;

MC = moisture content

W = wet soil weight

D = dry soil weight

Results and discussion

The data taken were analyzed to see the relationship of soil tillage on soil compaction and soil moisture content. Generally, there are two or three times of ploughing process which depend on farmers. But three times is better than two times plough in order to get fine clay soil and more nutrient can be taken up from soil. The first ploughing should be done in dry condition. For the second and third ploughing the soil should be in wet condition. However, in this study the data was taken during rainy season. Therefore, for the first plough, the soil was in wet condition and the paddy field was filled by water. The ploughing process undergo two times only due to weather condition.

Figure 3 exhibits the results of average soil compaction for four plots in two acres paddy field. Each plot have different value of compaction where Area B has the highest value of 273.33 psi while Area C has the lowest reading of 187.78 psi before tillage. Beside the different readings of compaction value, all plots show reduction from before tillage to the second plough session. It shows that, every ploughing session will loosen the soil further. Area B has shown a higher reduction of compaction reading compared to the other three where the total reduction is 32.22 psi.

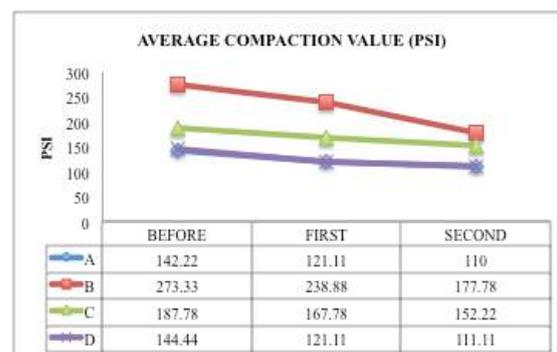


Figure 3: Average compaction reading for four paddy plots

The soil samples that were taken from the same plot of soil compaction readings have undergone drying process. The reason is to reduce the water content in the soil by heating so the value before and after drying process can be used to determine moisture content. As can be seen in Fig. 4, the hardest soil which is Area B contains the lowest percentage of moisture (22%). Moisture content are slightly lower in soil before tillage compared to after first and second plough. The graph shows an increment in moisture content percentage in all plots. As for moisture content, Area B shows an increment from before tillage to after tillage and slightly higher than other plot areas.

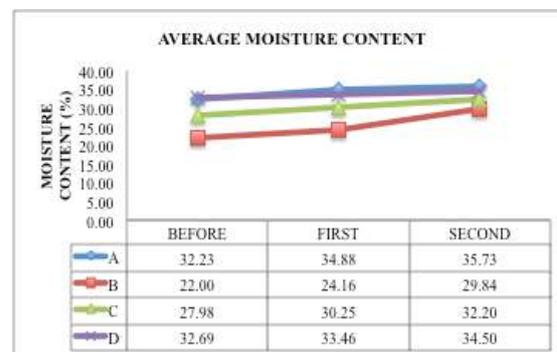


Figure 4: Average soil moisture content from four paddy plots

The results show that measurement of soil compaction has correlation with the moisture content. Referring to Fig. 3 and Fig. 4, the lower soil compaction, the higher percentage of soil moisture content. the highest compaction value after second

round of ploughing is 177.78 psi with moisture content 29.84% while the lowest is 110 psi with moisture content of 35.73%. The average values of soil compaction before and after first and second tillage are 186.94 psi, 162.22 psi and 137.78 psi with average moisture content 28.73%, 30.69% and 33.07% respectively

Conclusion:

The change of soil condition can be identified by compaction and moisture content. The results show that the more ploughing process, the lower soil compaction and the higher percentage of moisture content in wet soil condition. Furthermore, the compaction process does not only occur during ploughing but the movement of heavy vehicle and traffic-related activities on soil as well. The higher the compaction, the lower the soil pores and the lower the moisture content. From this study, it was found

that tillage can affect the soil compaction and soil moisture.

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