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The Impact of Combine Harvester Machine Usage on Soil Compaction And Some Soil Physical Properties in Mulya Sari Village, Tanjung Lago, Banyuasin

Suganda C. Saputra [*1], M. Edi Armanto[1], and Momon Sodik[1]

[1] *Crop Science Department, Graduate School of Agriculture, Sriwijaya University, Indonesia, Jalan Padang Selasa 524, Palembang, South Sumatra 30139, Indonesia.*

*Corresponding author

E-mail address: gandha.kanta@gmail.com (Suganda C. Saputra).
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Abstract *:*
Combine harvester is a rice harvester that can cut the panicles of standing plants, knock down and clean the grain while crossing the rice fields. The use of combine harvester can potentially damage the soil, the soil becomes hard and the use of fuel causes potential air pollution in the rice field environment. The objectives of this study were to identify: (1) whether the use of combine harvester machine will cause the decrease of soil porosity which inhibits the plant growth; and (2) the impact of soil compaction on soil physical properties due to the use of combine harvester machine. This research was carried out in Mulya Sari Village, Tanjung Lago, Banyuasin District in November 2017. The research method used was a survey method with purposive sampling technique. The treatment was the parking area of combine harvester machine, machine trajectory traversed by the combine harvester machine and the yard as a control. The observed variables were soil compaction, analyzed by using a dynamic cone penetrometer, bulk density, total pore space, soil moisture content, and groundwater content. The results showed that soil compaction caused porosity; soil compaction affected soil physical properties such as bulk density, porosity, and groundwater content.

Keywords: combine harvester, soil compaction, physical properties

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1. Introduction

Tanjung Lago District has an area of 829.40 Km2 and is divided into 15 villages, one of which is Mulya Sari Village. Mulya Sari Village has an area of 18.83 Km2. Geographically, Tanjung Lago District itself is bordered by Banyuasin II and Muara Telang District in the north, while in the south it is bordered by Talang Kelapa and Banyuasin III District [1].

Combine harvester is a technology that combines harvesting, threshing, cleaning, and in some instances, pocketing in one operation [2]. The use of a combine harvester produces a negative impact. The negative nature of this combine harvester machine can damage the environment because it can potentially damage the soil, the soil becomes hard and the use of fuel causes potential air pollution in the rice field environment [3].

On average 40.33 percent of the area of Tanjung Lago District is used for agriculture, 54.97 percent is used for non-paddy agriculture including forests and the remaining 4.73 percent is used for building land [4]. Tanjung Lago District has a rice harvest area of 12,749 ha with a total rice production of 55,089.4 tons [5]. In fact, in 2013 the Central Statistics Agency noted that the amount of rice production in Tanjung Lago District was 62,816.8 tons with a rice harvesting area of 12,621 ha, meaning that there was a significant decrease in production [6].

The decline in rice production that occurred in Tanjung Lago District is one of the causes, presuma-

bly due to soil compaction due to the use of a combine harvester machine. Compaction of the land will affect the physical condition of the soil. Soil compaction reduces porosity and permeability, thereby increasing the soil matrix suction pressure and reducing the availability of groundwater for plants. Soil compaction can also reduce soil aeration so that the movement of air in the soil becomes not smooth and provides oxygen tension to plants [7]. Soil compaction will limit the distribution of roots. Therefore, on dense soils, root growth will continue to the side [8].

Generally, compaction is the result of heavy equipment compressing the soil. Compacted soil contains several large pores and has a reduced level of water infiltration and drainage from compacted layers. Changes in pore space limit root growth, and gas exchange needed for plant growth and yield. Compaction limits water infiltration, increases runoff and erosion, which causes loss of valuable plant nutrients [9] [10].

According to [11], soil compaction reduces growth and yields by limiting root development and movement of water and air in the soil. Compressed soil generally has a dense undercoat, and cannot supply nutrients optimally for plants. Research of [12] found that in dense soils the growth of young plant height is inhibited, in addition to the reduced depth of root penetration. This causes the movement of nutrients for plants to be limited because the ability of plant roots to absorb nutrients is limited.

Therefore, there is a need for research on the impact of the use of a combine harvester machine on soil compaction and some soil physical properties in Mulya Sari Village, Tanjung Lago, Banyuasin. This study aimed to identify the impact of soil compaction due to the use of a combine harvester machine and to determine what physical properties can be affected by soil compaction due to the use of a combine harvester machine.

2. Materials and Methods

This research was carried out in Mulya Sari Village, Tanjung Lago District, Banyuasin Regency. This study used a survey method of soil sampling, namely purposive sampling with two treatments, namely on agricultural land that used a combine harvester machine and a plot of land that did not use a combine harvester machine. Each treatment was carried out three times.

Tools

The tools used in this research were 1) Ring sample (d. 7 cm; h. 3 cm), 2) Drill, 3) Munsell Soil Color Chart, 4) Field knife, 5) Soil penetrometer (type dynamic cone penetrometer h. 1 m), 6) Hoe, 7) Stationery, 8) Meter measurement, 9) Camera and others etc.

Materials

Materials used include: 1) Intact soil samples for BD analysis, porosity and groundwater content, 2) Disturbed soil samples for texture analysis, 3) Plastic bags, 4) Rubber bands, 5) Labels and other materials used in Laboratory for soil analysis.

Research Preparation

Preparations made before the research were to carry out a literature study, collected secondary data or information on research location, prepared the tools and materials for the field.

Preliminary survey

Before carrying out research in the field, the researcher first conducted a preliminary survey. The preliminary survey was intended to see the actual conditions in the field to be investigated. Besides, these preliminary survey activities can also facilitate research activities to be carried out.

Field activities

After conducting a preliminary survey at a predetermined research location then soil sampling was carried out according to a predetermined treatment that was, agricultural land that used a combine harvester machine and a plot of land that did not use a combine harvester machine. Soil samples were taken in the form of intact soil samples for BD, porosity, and soil moisture analysis and disturbed soil samples for texture analysis. Intake soil sampling and disturbed soil samples were taken at a depth of 0-30 cm three times for each treatment. While the parameters of soil density, groundwater level and soil color were observed directly in the field.

3. Results And Discussion

Soil Density

The results of soil density analysis by using soil collision analysis can be seen in Table 1.

Table 1. Average Values of Soil Density

Land use	Repetition I	Repetition II	Repetition III	Average
Parking area	3.17	2.29	2.29	± 2.58 a
Machine trajectory	1.90	1.78	1.65	± 1.78 b
Yards	1.02	0.89	1.02	± 0.96 c

Note: Numbers followed by different letters show significantly different at the 5% level of a t- test.

Table 1 shows the results of the analysis of the average level of the highest soil density at a depth of 0-30 cm was in the parking area, then the machine trajectory, and yard (control). Thus, based on these results it is known that, the combined harvester machine parking area had the highest density compared to the machine trajectory, and yard.

Generally, the use of heavy equipment can cause soil damage such as the opening of the soil layer and the soil will become solid. According to [13], the soil becomes solid due to engine weight, air pressure in tire, and tire size. Light weight on the machine only causes compaction at ground level, machines such as combining and fertilizing machines can weigh more than 30 tons can cause deeper compaction that cannot be repaired by tillage. Tire loading and size cause deeper compaction in wet soils than in dry soils. According to [14], factors that influence the process of soil compaction include the weight of the tool, tire air pressure, and groundwater content when passing through. In addition, there are other factors that need to be considered, namely the intensity of tool traffic, wheel slips, and whether or not the land has been previously processed. This is in accordance with [15] who stated that soil compaction is a problem in modern agriculture throughout the world related to excessive use of heavy equipment and intensification of planting systems.

Bulk Density

Bulk density is an indication of soil density. The denser a soil, the higher the bulk density, which means that it is more difficult to continue water or penetrate the roots of plants [16]. Based on the results of the analysis conducted, the average bulk density results were obtained as shown in Table 2. It can be seen that the parking area had a Bulk Density value of 1,482 gr/cm^3. The machine trajectory had a Bulk Density value of 1.206 gr/cm^3, and the yard had a Bulk Density value of 0.887 gr/cm^3. It can be said that the bulk density of the parking area was the highest compared to the machine trajectory and yard.

Table 2. Observation Results of Average Value of Bulk Density

Land use	Bulk Density (gr/cm^3)
Parking area	1.482
Machine trajectory	1.206
Yards	0.887

From the observations, it can be seen that the bulk density of the parking area was the highest compared to the machine trajectory and yard. The results of Bulk Density mean difference test on parking area and the Combine Harvester machine trajectory showed significant differences with BD on the yard. This showed the impact of soil compaction on soil BD. The higher the weight of the soil volume causes increased soil density, aeration and drainage disturbed, so that the root development becomes abnormal [17]. The tendency of the increase in bulk density value is caused by the pressure coming from the engine wheel combining the harvester pressing water and air so that the area affected by the pressure becomes denser and can directly increase the bulk density value of the soil. As stated by [18], an increase in the value of bulk density there may be 4 things that happen, namely (1) compression of solid particles, (2) compression of liquid and gas in the pore space, (3) changes in liquid and gas content in the pore space, and (4) changes in the composition of solid particles.

Based on the results of the analysis of soil bulk density in Table 2., It is known that the machine trajectory had a medium soil bulk density (1,206) (criteria of [19]. Even though it had a higher bulk density than in the yard, bulk density on the machine trajectory which had medium criteria was likely to be influenced by a texture dominated by dust and sand causing a number of pores that were not large and not small, in the sense that the soil of the machine trajectory still good in passing on water or penetrated by plant roots. This is in accordance with the statement of [20], that the soil with pore space decreases and the

weight of the soil per unit increases causing an increase in soil weight. Soils with large weights will find it difficult to pass on water or are difficult to penetrate plant roots, and vice versa soil with low content weights, plant roots more easily develop. Thus, soil on machine trajectory that have medium bulk density, is still good enough to be used as agricultural land because the soil is still good in passing water or penetrated by plant roots.

From these results it can also be seen that the soil after being crossed by the combine harvester machine wheels tended to show an increase in Bulk Density value which indicates soil compaction. This is consistent with [21], who stated that the use of heavy equipment causes increased soil mass density (bulk density), reduces total pore space, reduces infiltration rate, reduces soil permeability, reduces water holding capacity, and changes in soil grain structure. The tendency to increase the value of bulk density due to the higher intensity of the trajectory is caused by the pressure coming from the wheels pushing water and air so that the soil pores become narrower and the soil becomes denser and indirectly increases the bulk value soil density [22].

Some research results showed that dense soil causes seedling growth to be disturbed [23]. According to [24], soil density negatively affects the growth of plant roots towards the longitudinal (into the soil) and towards the radial (laterally) soils. Research of [25] showed that soil density significantly affects the growth response of young plant height, in addition to the depth response of root penetration. Growth of young plant height is inhibited on solid soils, in addition to the reduced depth of root penetration. This will cause the process of absorption of nutrients by the roots will be disrupted and limited, which in turn causes the growth of seedlings and trees will be disrupted or experience slower growth compared to trees that grow in loose soil.

Soil Pore Space

The results of the average value of soil pore space analysis are presented in Table 3.

Table 3. Average Value of Soil Pore Space

Land use	Soil Pore Space (%)
Parking area	44.08
Machine trajectory	54.48
Yard	66.52

It can be seen in Table 3, the percentage of total soil pore space in parking area, machine trajectory, and yard in the tidal land of Mulya Sari Village, Tanjung Lago District, Banyuasin District was significantly different. The parking area had the lowest percentage of soil pore space and the highest Bulk Density compared to machine trajectory and yard. Soil compaction is the shrinkage of solid particles in the soil due to compressive forces on the surface of the soil so that the soil pore space is reduced [26]. Most of the amount of soil pore space is filled with water and only a small portion is occupied by air, so that the pore space will be low in line with reduced air due to density and depth of soil [27]. In accordance with this, [28] said that the denser the soils, the less *porosity in the soil*. It means that compaction *decreases porosity.*

Groundwater Content

The results of groundwater content analysis are presented in Table 4.

Table 4. Average Value of Groundwater Content

Land use	Groundwater Content (%)
Parking area	24.65
Machine trajectory	37.88
Yards	69.48

The test results of the mean difference of groundwater content in parking area and the Combine Harvester machine trajectory showed a significant difference with the groundwater content in the yard. Groundwater content in parking area and machine trajectory was smaller than the groundwater content in the yard. This showed that the impact of soil compaction on groundwater content.

Groundwater content is influenced by the number of pores in the soil and soil organic matter, due to the fact that the soil contains more dust fractions, and is included in the dusty clay group so that the binding power is strong. Coarse-textured soil has the ability to retain less water than fine-textured soil [24].

Groundwater Level

The results of groundwater level analysis are presented in Table 4.

Table 4. Average Values of Groundwater Level

Land use	Groundwater Level (cm)
Parking area	- 67 a
Machine trajectory	- 64 b
Yard	- 55 c

Note: Numbers followed by different letters show significantly different at the 5% level of t- test

Table 4 shows that groundwater levels in parking area, machine trajectory, and yards in the tidal land of Mulya Sari Village, Tanjung Lago District, Banyuasin District were significantly different. Table 4 shows the groundwater level in the parking area of - 67 cm, the machine trajectory of - 64 cm and the yard of - 55 cm. Groundwater levels in parking area, machine trajectory, and yards in the tidal land of Mulya Sari Village, Tanjung Lago District, Banyuasin District were significantly different because the compaction of the soil on combine harvester machine parking area. The lower the groundwater level, the less the water content in the soil; and it will cause the soil to become denser. As a result of soil compaction, water-binding pores and soil resistance increase, but permeability will decrease with increasing soil density. In general, the value of permeability increases with increasing ground axis. Similarly, the wetter a soil (moist), the higher the permeability value. In drier soils, some pores are filled with air which inhibits the flow of water [21].

From the explanation above, it can be seen that soil density gives a very real influence on some physical properties of the soil such as; BD, soil pore space, and groundwater content. Thus, the hypothesis of this study which states that (1) the use of a combine harvester machine will decrease soil porosity that will inhibit plant growth; and (2) soil compaction due to the use of a combine harvester machine will affect the physical properties of the soil such as; BD, soil pore space, and groundwater content were accepted.

4. Conclusions

The result of the research showed that: (1) the use of a combine harvester machine on the tidal land of Mulya Sari Village, Tanjung Lago District, Banyuasin Regency causes the decrease of soil porosity which inhibited the plant growth; (2) soil compaction due to the use of a combine harvester machine affected several physical properties of the soil, where the Bulk Density value at the parking area and machine trajectory increases; the soil pore space and the groundwater content values decrease. The parking area of the combine harvester machine had the highest value of Bulk Density and the lowest values of water content and soil pore space compared to the machine trajectory.

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