

EFFECTS OF SOIL COMPACTION AND RICE-HUSK INCORPORATION ON SOIL HYDRAULIC PROPERTIES AND MAIZE PRODUCTIVITY UNDER IRRIGATION AT GERIO IRRIGATION PROJECT ADAMAWA STATE NIGERIA

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ABSTRACT

Compaction processes affect soil bulk density, hydraulic conductivity and penetration resistance which are the hydraulic properties associated with soil water movement. Rice-husk as an organic matter that can be added to the soil to cushion the effect of compaction, improve soil hydraulic properties and nutrient to enhance crop and good yield, their effectiveness has not been investigated in soil with different level of compaction. Hence, this study investigated the effects of soil compaction with various levels of rice-husk incorporation and number of tractor wheel passes on soil hydraulic properties and maize productivity under irrigation at Gerio. The research aimed at determining the effect of compaction and rice-husk incorporation on the hydraulic properties and irrigated maize crop productivity at Gerio irrigation project. The experiment was conducted at Gerio irrigation project of upper Benue River Basin Development Authority Yola, Nigeria. The experimental site was marked out to produced 5 rows of tractor wheel passes; 0,2,4,6,8 and 5 colons of 0%, 20%, 40%, 60%,80% of rice-husk levels which produced 25 subplots as treatment. In each of the subplots, measurements of bulk density, hydraulic conductivity, and penetration resistance were made using cylindrical core, falling head permeameter and cone penetrometer with the aim to determine whether the compaction by wheel passes and incorporation of the rice husk could have significant effect on the soil hydraulic properties. Also, non-hybridized maize seed was planted in each of the twenty five subplots, one seed per hole at 75cm x 25cm spacing at the depth of 5cm. the plots were irrigated using basin, weeds controlled was manually and the use of atrazine force herbicides. N.P. K. and urea fertilizer were applied at 3 and 7 weeks after planting, respectively and was harvested at 14weeks. Measurement of maize crop emergence, leaf area, plant, root weight and yield were made. From the results, bulk density increases with increase in number of tractor passes and also decreases with increase in rice-husk level in all the treatments. Maximum bulk density was obtained at 0% rice-husk in all the tractor passes with 1.64, 1.68, 1.70, 1.72 and 1.78mg/m³ respectively. The result also showed that, the hydraulic conductivity decreases with the increase in number of tractor passes at all the levels of rice-husk incorporation and increases with the increase in rice-husk at all the number of tractor passes. The treatment with 0 pass and 80% rice-husk produced the highest hydraulic conductivity of 0.18x10⁻⁴mm/sec. The result of penetration resistance in all the treatment was found to increase with the increase in number of tractor passes and decreases with the increase in rice-husk incorporation levels. Penetration resistance at 80% rice-husk with their corresponding tractor passes had lower values of 0.394, 0.4122, 0.480, 0.6100 and 0.747Mpa. Maximum maize crop productivity was obtained in treatment with 2 tractor passes and 20% rice-husk incorporation with maize yield of 2077.6kg/ha. From this study it could be seen that the rice-husk is effective in improving the soil hydraulic properties of Gerio agricultural soil. Therefore, farmers are advice to reincorporate rice-husk back into their farm before cultivation as it improves the soil structure. Light compaction is needed to a certain degree for a favorable hydraulic properties of the soil. 3. It is also recommended that Laboratory experiment using same rice-husk and proctor hammer blows as compaction effort be carried out to determine their influence on the soil hydraulic properties.

Keywords: soil compaction, rice-husk, bulk density, hydraulic conductivity, penetration resistance

1. INTRODUCTION

Hydraulic characteristic of the agricultural soil is greatly influence by compaction, which is defined as the densification of unsaturated soil due to reduction in air spaces without change in mass wetness [1], [2]. During most agricultural practices, soil fragmentation displacement and compaction occur which affects 68mha of land globally [3, 4]. The effect of changes on the hydraulic characteristics of soil due to compaction from tractor wheel passage and other farming activities during cultivation practice on the agricultural soils may increase soil bulk density, soil strength, reduce aeration and water movement in the root zone, [5, 6, 7, 8, 9]. Although soil compaction is regarded as one of the most serious environmental problems caused by conventional agriculture, it is the most difficult type of soil degradation to locate and rationalize, principally as it may show no evident marks on the soil surface. Unlike erosion and salting that give strong surface evidence of the presence of land degradation, the degradation of soil structure requires physical monitoring observation before it is uncovered and its extent, nature and cause resolved [10]. However, certain amount of soil compaction is needed to ensure better contact between seeds and soil particles [11, 12]. Any extra compaction increases soil strength and could cause several problems. Some of the ways employed to alleviate soil compaction due to farm machinery are: control of water content of soil during cultivation, control of tractor traffic over the soil, reduction of vehicle mass and contact pressure on the soil and addition of organic matter to the soil .the first three measures above employed with conventional methods of cultivation have been found to be time consuming and in most cases, impractical an ineffective [13]. Bulk and particle density of organic materials are lower compared with that of mineral soil [14]. The average bulk density of soil organic matter is 0.3 to 0.6 kg/m³ compared to soil density of 1.4 to 1.6kg/m³; so adding organic residue to the soil decrease the average soil density [15]. Since organic materials poses less bulk density than that of mineral soils, mixing them with soil would improve soil bulk density and porosity [16]. Manure is used extensively by farmers to reduce soil compaction and improve soil fertility [10, 16, 17] Reported that, organic matter also increases soil consistency limits and consequently increase the rate of soil moisture for optimum traffic ability and workability [18]. Among soil hydraulic properties, bulk density has a marked effect on root system development [19, 20]. According to [19], root growth is reduced in compacted soil while [21] found that maize roots were more tortuous in compacted soil with a greater branching density and shorted lateral roots. Although soil compaction is needed to a certain degree for crop growth and emergence, the cumulative effect of applied pressure can leave the soil in excess of what the crop needs [22]. The method of adding various organic materials to improve the soil physical and hydraulic properties is currently receiving attention of researchers [23]. Most research findings show that addition of organic materials to soil before compaction help in alleviating the problems of compaction on the hydraulic characteristics of agricultural soil. In the north east region of Nigeria 75% of the soil are mainly light and with the fact that human population is on the increase and the agricultural production is far from adequate to meet the need of the people, the use of heavy machines and implements on these soils is continuously employed to increase crop production [24, 25]. Hence the availability of information on the use of Rice-husk as locally available materials that could be incorporated to the soil before compaction will go a long way in solving problem associated with soil hydraulic properties. Compaction processes affect soil bulk density, hydraulic conductivity and soil penetration resistance which are the hydraulic properties associated with soil water movement. Soil water retention and transport properties are altered in response to changes in pore space geometry. The prevalent use of tractor for crop cultivation, natural compaction and trampling by animal during grazing in search of grasses has made the soil compacted and has influenced the hydraulic characteristics of the soil which has become a major problem in the state. This is because the roots of plants are less likely to enter soil layers with massive soil structure that have higher soil strength and as a result leads to reduction of plant population [24]. Hence for effective soil management practices, it is imperative to find and adopt a means of alleviating the effect of soil compaction on soil bulk density, hydraulic conductivity, penetration resistance and to improve maize crop yield at the Gerio irrigation project. Although, northern region of Nigeria has several varieties of organic materials that can be added to soils to cushions the effect of compaction and add nutrients to enhance crop growth and good yield, their effectiveness has not been fully investigated in all the soils used for crop production. In Adamawa state,

even though the effect of organic matter on soil physical properties and crop yield has been studied, the effect of compaction on rice-husk as organic matter is limited [24]. The bulk density, penetration resistance and hydraulic conductivity of the soil is greatly influence by the soil compaction although, the compaction is needed to a certain degree for maize crop emergence and growth. However, cumulative effect applied pressure by tractor traffic can change the soil hydraulic properties in excess of the need for maize crop production. The emergence of different varieties of rice has made it to be widely grown in Gerio, incorporating rice husk into soil before cultivation could improve soil structure, increase crop growth, yield and improve water holding capacity of the soil thereby reducing the adverse effect of dry spells which crop experience in Gerio irrigation project. Therefore, the objectives of the research paper is to determine the level of compaction and rice-husk incorporation that gives maximum bulk density, to determine the effect of compaction and rice-husk incorporation on the saturated hydraulic conductivity and penetration resistance, also to determine the effect of compaction and rice-husk incorporation on irrigated Maize crop emergence and yield on Gerio irrigation project.

2 MATERIALS AND METHOD

2.1 Study area

The experiment was conducted in Gerio of Upper Benue Development Authority Yola which is located between $9^{\circ}0'$ to $9^{\circ}40'N$ latitude and $12^{\circ}0'$ to $12^{\circ}40'E$ longitude with altitude range of 150 to 180 m above the mean sea level (Figure 1). The area has two major seasons; the rainy and the dry season. The rainy season lasts from the beginning of May to the end of October with average annual rainfall of 958.99 mm, while the dry season lasts from November to the end of April. The driest months are January to April with the average minimum relative humidity of 13%. This is mainly due to the prevalent dry and desiccating north- east trade winds. The dry season is favorable for cultivation of cereals, tubers and vegetables crops under irrigation since there is no rainfall during the period. The wettest months are August and September when the intensity of rainfall reaches up to 25% of total annual rainfall. The relative humidity in the area varies: the hottest months is April with monthly average maximum temperature of $39.7^{\circ}C$, while the coldest months are December and January with minimum average temperature of $16^{\circ}C$.

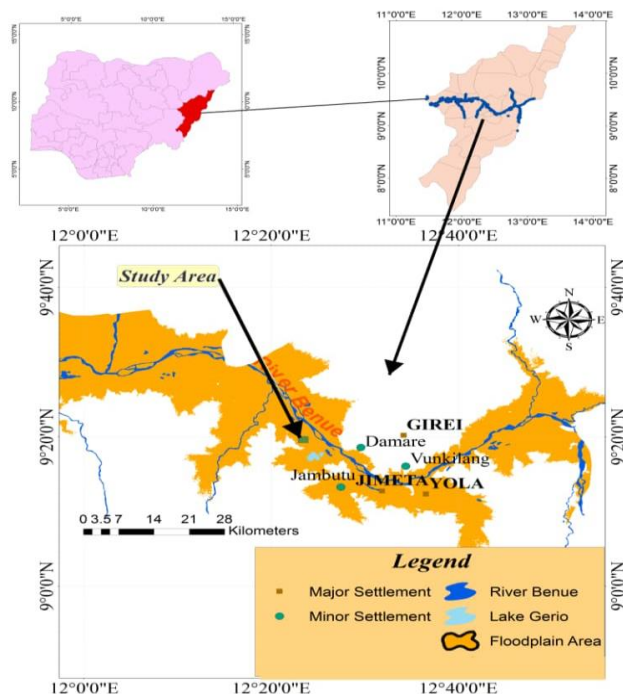


Figure 1. Map of Gerio irrigation scheme, yola.

2.2 Land Preparation

The experimental site had a dimension of 25m² and the site was cleared manually by removing dry grasses and crop residues. Furthermore, the site was ploughed using marssey ferguson 375 tractor. The site was marked out to produce 25 subplots of 5 m² each. The 5 rows produced was the main plot where tractor wheel traffic produce compaction of 0 pass, 2 passes, 4 passes, 6 passes and 8 passes, across the rows and rice-husk as an organic matter was incorporated manually into the columns at 0kg, 200kg, 400kg, 600kg and 800kg as in [32].

2.3 Field Layout and Experimental Design

The experiment was consisting of two factor split plot experiments: The two factors include number of tractor wheel traffic and different level of Rice-husk incorporation in kilogram (kg). The two factors were interacted (5x5) to give a total of twenty-five treatments. Also, in each of the 25 subplot bulk density, hydraulic conductivity, penetration resistance and moisture content were determined daily before the next irrigation scheduling which was determined from the soil textural classification. Non hybridized maize seed was planted in each of the twenty-five sub plot, one seed per hole at 75cm x 25cm spacing manually at the depth of 5cm. The plot was irrigated using basin irrigation. Weeds control was done manually and by spraying Atrazine force herbicide at 250 ml per 15 liter knapsack and NPK fertilizer application was applied at 200kg/ha at 3 weeks and 150kg/ha of UREA at 7 weeks after emergence as in [32], Kamara, et al . [33]. The experiment was carried out according to split plot design with three replications. Tractor wheel traffic was kept in main plots and Rice-husk incorporation treatments was assigned to sub-plots. Each treatment was replicated three times giving a total of seventy-five (75) treatment plots. Split plot Randomized Complete Block Design (RCBD) method was used in planning the experimental layout as in [36].

3 RESULT AND DISCUSSION

3.1 Soil Texture

The textural classification of the Gerio agricultural soil determined in the laboratory, From the table the textural class of the soil was found to be silty clay loam which indicate that the soil is suitable for maize product under basic irrigation system at the Gerio irrigation project because of its high-water holding capacity.

3.2 Dry Bulk Density

The result of soil bulk density of various tractor traffics and rice-husk incorporation levels in percentages of the Gerio agricultural soil was presented on Table 3.2 and figure 3.1. The results show that soil bulk density increase with the increase in number of tractors passes in all the rice-husk incorporation levels. At 0, 2, 4, 6, and 8 number of tractors passes. At 0% rice-husk, their respective soil bulk densities were: 1.64, 1.68, 1.70, 1.72 and 1.78 mg/m³. At 20% rice-husk their respective soil bulk densities at the various tractor passes were: 1.60, 1.62, 1.68, 1.70 and 1.72 mg/m³. At 40% rice- husk their bulk densities with the corresponding various tractor passes were: 1.42, 1.45, 1.52, 1.54 and 1.60 mg/m³. At 60% rice-husk also, with their corresponding tractor passes their soil bulk densities were: 1.38, 1.40, 1.42, 1.45 and 1.50 mg/m³. And at 80% rice-husk incorporation the soil bulk densities to their corresponding tractor passes were: 1.30, 1.32, 1.35, 1.38 and 1.42mg/m³, respectively. Similar observations were made by [14, 30, 33] explained this phenomenon that, the bulk density of the soils increases with increasing number of tractors passes because the pressure applied to the soils deceased the inter-particle bond hence, the soil bulk density increases with increased tractor passes. From the table 3.2, it was observed that, the maximum bulk density was obtained at 8 tractor passes which could be because moisture content are retained at higher compaction due to reduced pore spaces which increases the soil bulk density. In this study it was also observed that the soil bulk density decreases with the increase in rice-husk incorporation as shown in the table 4.2. At 0 passes, the bulk densities of the corresponding rice-husk incorporation levels were: 1.64, 1.60, 1.42, 1.38 and 1.30 mg/m³. At 2 tractor passes, the bulk densities for the corresponding rice-husk incorporation levels were: 1.69, 1.62, 1.45, 1.40 and 1.32 mg/m³. at 4 passes their respective soil bulk densities were: 1.70, 1.68, 1.52,

1.42 and 1.35mg/m³. 6 tractor passes the respective soil bulk densities at their corresponding rice-husk incorporation levels were: 1.72, 1.70, 1.54, 1.45 and 1.38 mg/m³. At 8 tractor passes the values of the bulk densities with their corresponding rice-husk incorporation levels were: 1.78, 1.72, 1.60, 1.50 and 1.42mg/m³. This result shows that the soil bulk density decreases with increase in rice-husk levels. Similar trend of this results was observed by [29, 33, 34] Started that the bulk density of soils decreases as rice-husk increases because addition of rice-husk created greater pure water pressure and the soil becomes less compactible.

3.3 Saturated Hydraulic Conductivity

The effect of rice-husk incorporation at different levels and different number of tractor wheel traffic on the hydraulic conductivity of Gerio agricultural soil are shown in Table 3.3 and figure 3.2. For all the levels of rice-husk incorporation and tractor wheel traffics, hydraulic conductivity decreases with increase in the number of passes. It was observed that at 0% rice-husk the hydraulic conductivity of 0, 2, 4, 6 and 8 passes were: 0.098, 0.096, 0.091, 0.076 and 0.075 x 10⁻⁴ mm/sec. At 20% rice-husk and the respective tractor passes their hydraulic conductivity value were: 0.114, 0.106, 0.098, 0.086 and 0.078 10⁻⁴ mm/sec. At 40% rice-husk and the respective tractor passes the values of their hydraulic conductivity were: 0.126, 0.116, 0.114, 0.092 and 0.086 x 10⁻⁴ mm/sec. At 60% rice-husk with their corresponding tractor traffic passes the hydraulic conductivity values were: 0.150, 0.134, 0.128, 0.101 and 0.098 x 10⁻⁴ mm/sec. similarly, at 80% rice-husk with their corresponding tractor passes the values of their hydraulic conductivity were: 0.189, 0.168, 0.130, 0.128 and 0.108 x 10⁻⁴ mm/sec. These results show that, the more compaction is induced by the tractor passes, the pore spaces within the soil are reduced thereby decreases the hydraulic conductivity. This result was in agreement with the findings that compaction decreased the rate of water transmission in the soil [28, 39, 38, 31] and [40]. The result in Table 3.3 also shows that for all the levels of rice-husk incorporation and the tractor wheel passes, hydraulic conductivity increases with the increased in rice-level. The hydraulic conductivity at 0 pass and their corresponding rice-husk incorporation were: 0.098, 0.114, 0.126, 0.150 and 0.189 x 10⁻⁴ mm/sec. At 2 passes with the corresponding rice-husk incorporation their hydraulic conductivity was: 0.096, 0.106, 0.116, 0.134 and 0.168 x 10⁻⁴ mm/sec. At 4 passes with their corresponding rice-husk incorporation, the values of their hydraulic conductivity were: 0.091, 0.098, 0.114, 0.128 and 0.130 x 10⁻⁴ mm/sec. At 6 passes with the corresponding rice-husk incorporation level, the hydraulic conductivity were: 0.076, 0.083, 0.092, 0.101 and 0.128 x 10⁻⁴ mm/sec. similarly, at 8 tractor passes with their corresponding rice-husk incorporation the values of their hydraulic conductivity were: 0.075, 0.078, 0.086, 0.098 and 0.108 x 10⁻⁴ mm/sec. The increase in the hydraulic conductivity with the increase in rice-husk levels could be inferred from the pore geometry of the soil [37, 38]. Figure 2 shows that hydraulic conductivity increases as the rice-husk level increases in all the tractor passes. However, the value was higher at 0 tractor pass and 80% rice-husk incorporation with 0.18x10⁻⁴ mm/sec. followed by at 2 passes of 60% rice-husk with 0.134x10⁻⁴ mm/sec. and the least was at 8 passes of the 0% rice-husk with 0.075x10⁻⁴ mm/sec. the trend of this result was similar in all the treatments. This result shoes that compaction reduces hydraulic conductivity since higher value was obtain at 0 tractor pass compare to the other treatment with higher number of tractors passes.

3.4 Penetration Resistance

The results of the penetration resistance at versus rice-husk in-corporation and all tractor wheel traffic are shown in Table 4 and figure 3 the result shows that penetration resistance increases with the increased in number tractor passes. Although, the value was higher at 0 or no traffic than the other treatment which was expected due to the soil consolidation at no tractor pass. This is expected because penetration resistance depends upon bulk density and moisture content of the soil [41, 29, 42]. At 0% rice-husk incorporation and their various tractor passes, the respective values of their penetration resistance were: 0.832, 0.854, 0.860, 0.946 and 1.024Mpa. At 20% rice-husk incorporation and their various tractor passes, the respective values of the penetration resistance were: 0.757, 0.760, 0.867, 0.886 and 0.984Mpa. At 40% rice-husk incorporation and their various tractor passes, the respective values of their penetration resistance were: 0.586, 0.627, 0.697, 0.704 and 0.792Mpa. At 60% rice husk incorporation and their various tractor passes, the respective values of their penetration resistance were: 0.5504, 0.602, 0.684, 0.760 and 0.828Mpa.

Similarly, at 80% rice-husk incorporation and their various tractor passes, the respective values of their penetration resistance were: 0.394, 0.4422, 0.480, 0.6100 and 0.747Mpa. The results show that penetration resistance increases with the increased number tractor passes similar study was observed by [27, 26]. The also show that penetration resistance of the Gerio agricultural soil incorporate with various rice-husk incorporation levels and tractor passes decreases with increase in rice-husk. For example, it was observed from the table 3.4 that at 0 pass with the various rice-husk levels their penetration resistance was: 0.832, 0.757, 0.586, 0.5584 and 0.394Mpa. At 2 passes and the various rice-husk levels, the respective values of their penetration resistance were: 0.854, 0.760, 0.627, 0.602 and 0.442Mpa. At 4 passes and the various rice-husk incorporation levels, the respective values of their penetration resistance were: 0.860, 0.857, 0.697, 0.684 and 0.480Mpa. At 6 passes and the various rice-husk incorporation levels, the respective values of their penetration resistance were: 0.946, 0.886, 0.704, 0.760 and 0.6100Mpa. Also, at 8 passes and their various rice-husk incorporation levels, the respective values of their penetration resistance were: 1.024, 0.984, 0.792, 0.828 and 0.747Mpa. The trend of this result shows a decreased in values of the penetration resistance as rice-husk was increases in each of treatment, this may be because the rice-husk has improved the soil structure. Such reduction of cone index values was reported with the addition of peat moss to three different soils by Ohu et al [28]; the addition of groundnut haulms to six different soils by [43], addition of peat and farm yard manure to two soils by [27] and addition of groundnut haulms to a dark clay soil by [26]. Figure 3 shows the penetration resistance decreases as the rice-husk increases in all the treatment. The penetration resistance at 0 pass increases from 0.832Mpa at 0% rice-husk level to 0.757Mpa at 20% and 0.394M at 80% rice-husk which was the minimum in all treatment. The highest penetration resistance was 1.024Mpa at 8 traffic and 0% rice-husk, the trend of this result has shown that rice-husk incorporated into soil helps in improving the soil structure for root development.

3.5 Maize crop emergence and yield

The result of maize crop emergence and yield of plots with various rice-husk incorporation levels and tractor wheel passes are shown in Table 5. The results show that at 0 tractor pass the average maize crop emergence was 94.8%. At 2 passes the average emergence was 89%. It further decreases to 74% emergence in 4 passes, 63% emergence in 6 passes and 53.2% emergence at 8 passes. This result shows that soil compaction is needed to a certain degree for crop growth and emergence, but cumulative effort of applied pressure can leave the soil compacted in excess of what the crop nee. [22, 44]. It was also observed that the maize yield was higher at 2 passes with 2859kg/ha and then decreases with the increase in number of tractor passes from 1195.6kg/ha at 4 passes, 1311.6kg/ha at 6 passes and 2320kg/ha at 8passes. It was also observed that maize leaf area was larger for 2 pass which corresponded with the yield. This observation showed the more sunlight was trapped by crop on plot with 2 passes followed 4, 6, and 8 passes hence, the yield of crops are directly related to the photosynthetic activities using sunlight as energy source. The crops with larger leaf area tend to yield more compared to those with less area provided the crop ha better access to moisture and nutrient as reported by [44]. It was also observed that treatment of 6 passes showed reduced percentage crop emergence of 80% and yield of 1311kg/ha compared to other plots that had lesser tractor passes although 8 passes had 75% emergence with 2320kg/ha. This shows that compaction of soil due to tractor passes had detrimental effect on the maize crop development and yield, this could have been caused by the reduction in soil pores pace and the inability of plant root to effectively penetrate the soil to extract nutrient and moisture. It was also observed that the plant height, leaf area and weight root mass in those plots have lower values. This could also be due to poor plant development in the compacted soil that resulted from poor photosynthetic activities using sunlight as energy source. Thus, crop with higher leaf area tends to yield more than compared to those with less leaf area provided the crops had better access to moisture and nutrient this has also been reported by [44, 45].

Table 1. Soil Textural Classification of Soil at the Gerio Irrigation Project

Depth of soil (M)	Particle size distribution (%)			Textural class
	Sand	Silt	Clay	
0.00 - 0.15	20	45	35	Silty clay loam
0.15 - 0.30	18	44	38	Silty clay loam
0.30 - 0.45	19	42	39	Silty clay loam
0.46 - 0.60	16	43	41	Silty clay loam
0.60 - 0.75	18	40	42	Silty clay loam

Based on USDA textural classification

Table 2. Soil Bulk Density of Various rice-husk incorporations levels and tractor passes (mg/m³)

Tractor Passes	Rice-husk incorporations levels				
	0% RH	20% RH	40% RH	60% RH	80% RH
OT	1.64	1.60	1.42	1.38	1.30
2T	1.68	1.62	1.45	1.40	1.32
4T	1.70	1.68	1.52	1.42	1.35
6T	1.72	1.70	1.54	1.45	1.38
8T	1.78	1.72	1.60	1.50	1.45

Mean of tractor traffic

Table 3. Soil Hydraulic Conductivity of various rice-husk incorporations levels and number of tractor wheel passes (x 10⁻⁴mm/sec)

Tractor Passes	Rice-husk incorporations levels				
	0% RH	20% RH	40% RH	60% RH	80% RH
OT	0.098	0.114	0.126	0.150	0.189
2T	0.096	0.106	0.116	0.134	0.114
4T	0.091	0.098	0.114	0.128	0.130
6T	0.076	0.083	0.092	0.101	0.128
8T	0.075	0.078	0.086	0.098	0.108

Mean of tractor traffic.

Table 4. Penetration Resistance for various tractor passes and rice husk incorporations level (Mpa)

Tractor Passes	Rice-husk incorporations levels				
	0% RH	20% RH	40% RH	60% RH	80% RH
OT	0.832	0.757	0.586	0.5505	0.394
2T	0.854	0.760	0.627	0.602	0.442
4T	0.860	0.857	0.697	0.684	0.480
6T	0.946	0.886	0.704	0.760	0.610
8T	1.024	0.984	0.792	0.828	0.747

Mean of tractor traffic

Table 5. Maize Crop Emergence (%) Leaf Area Crop Height Root of the Maize Productivity at the Gerio Irrigation Project

PLOTS	RICE HUSK (%)	TRACTOR TRAFFIC	EMERGENCE (%)	Dry Matter Maize yield (kg/ha)	Wet Root Mass (kg/ha)	Leaf (m ²) MAP	Area 3	Crop Height (m) 14 WAP
PLOT 1	0% RH	0	98	1192	309	0.79		0.193
PLOT 2	20% RH	0	98	1285	2431	1.03		1.38
PLOT 3	40% RH	0	96	1120	683	0.81		1.872
PLOT 4	60% RH	0	92	1195	1022	0.693		1.324
PLOT 5	80% RH	0	90	2330	2378	0.766		1.443
PLOT 6	0% RH	2	98	1856	1480	0.763		1.14
PLOT 7	20% RH	2	88	2859	2320	0.768		1.145
PLOT 8	40% RH	2	82	1310	1820	0.775		1.352
PLOT 9	60% RH	2	80	1458	1041	0.766		1.14
PLOT 10	80% RH	2	82	2905	2432	0.764		1.329
PLOT 11	0% RH	4	80	1132	896	0.86		1.465
PLOT 12	20% RH	4	76	1480	1022	0.978		1.456
PLOT 13	40% RH	4	72	1312	3451	0.794		1.371
PLOT 14	60% RH	4	70	1311	2320	0.892		1.432
PLOT 15	80% RH	4	75	1308	1820	0.632		1.045
PLOT 16	0% RH	6	60	1120	1041	0.645		1.012
PLOT 17	20% RH	6	71	1158	309	0.891		1.452
PLOT 18	40% RH	6	68	1092	2431	0.912		1.122
PLOT 19	60% RH	6	56	1158	683	0.897		1.433
PLOT 20	80% RH	6	60	1140	1041	0.858		1.389
PLOT 21	0% RH	8	55	1320	2432	0.878		1.487
PLOT 22	20% RH	8	51	1211	896	0.854		1.411
PLOT 23	40% RH	8	56	1128	1120	0.823		1.1
PLOT 24	60% RH	8	54	1280	1158	0.833		1.196
PLOT 25	80% RH	8	50	1002	683	0.856		1.101

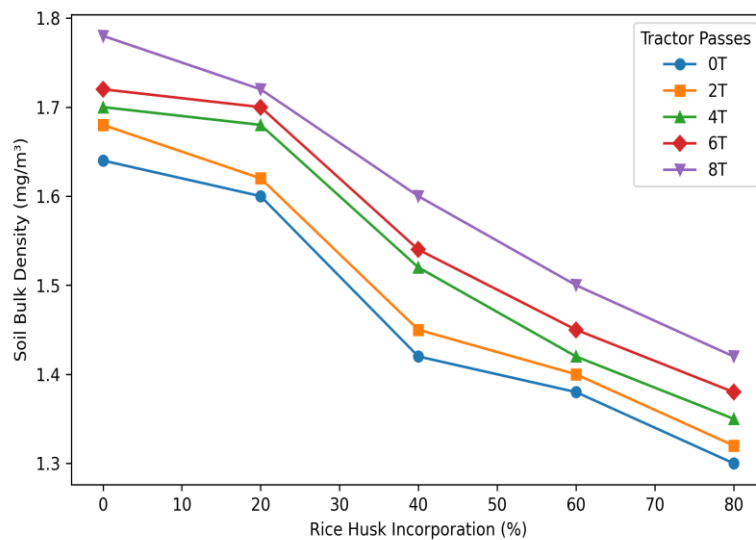


Figure 2. Plot of Soil Bulk Density of Various rice-husk incorporations levels and tractor passes (mg/m³)

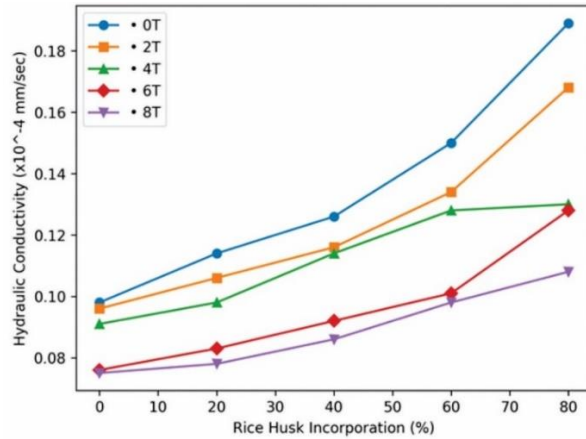


Figure 3. Plot of Soil Hydraulic Conductivity of various rice-husk incorporations level and number of tractor wheel passes ($\times 10^{-4}$ mm/sec)

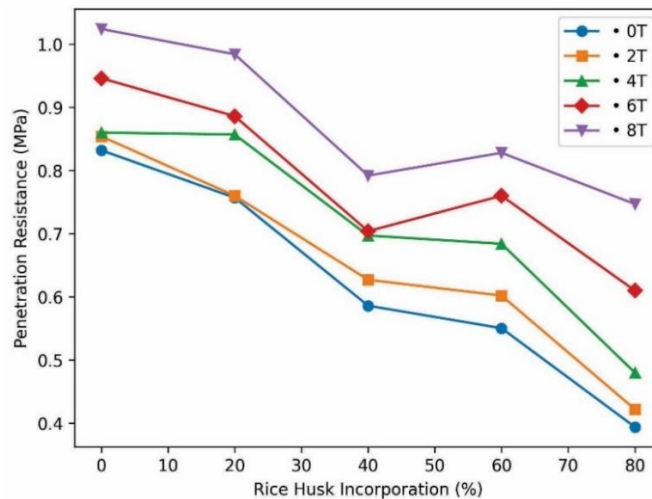


Figure 4. Results Penetration resistance for various tractor passes and rice husk incorporations level (Mpa)

4 CONCLUSIONS

Based on the result of this study, Incorporation of rice-husk into the soil before tractor passes during farm operations would reduce the soil bulk density. The soil bulk density of the study area decreases as the level of rice-husk incorporation increases and also, increases as the number of tractors passes increase. The maximum bulk density was obtained at 0%rice-husk incorporation and 0 tractor pass which is expected due to natural soil consolidation. For all the level of rice-husk incorporation and tractor wheel passes, hydraulic conductivity decreases with the increases in the number of passes, this was an indication that the more compaction is induced by tractor passes, the pore spaces within the soil reduced. Also, for all the level of rice-husk incorporation and the tractor passes the hydraulic conductivity increases with the increases in rice-husk level which was inferred from the pore geometry of the soil. The optimum hydraulic conductivity was obtained in treatment plot with 0 traffic and 80% rice-incorporation level. While, the penetration resistance in all the treatment increases with the increased in number of tractors passes and decreases with the increase level of rice-husk incorporation. The optimum penetration resistance of the study area was obtained in plot with 0 pass and 80% rice-husk treatment. Maize crop productivity was maximum in the plot with 2 passes and 20% rice-husk incorporation. In the treatment plot, maize crop leaf area was larger which corresponded with yield. This showed that more sunlight was trapped by crop in plot with 2 passes. Hence, the maize crop yield is directly related to the photosynthetic activities using sunlight as energy source as while as optimum soil hydraulic properties.

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