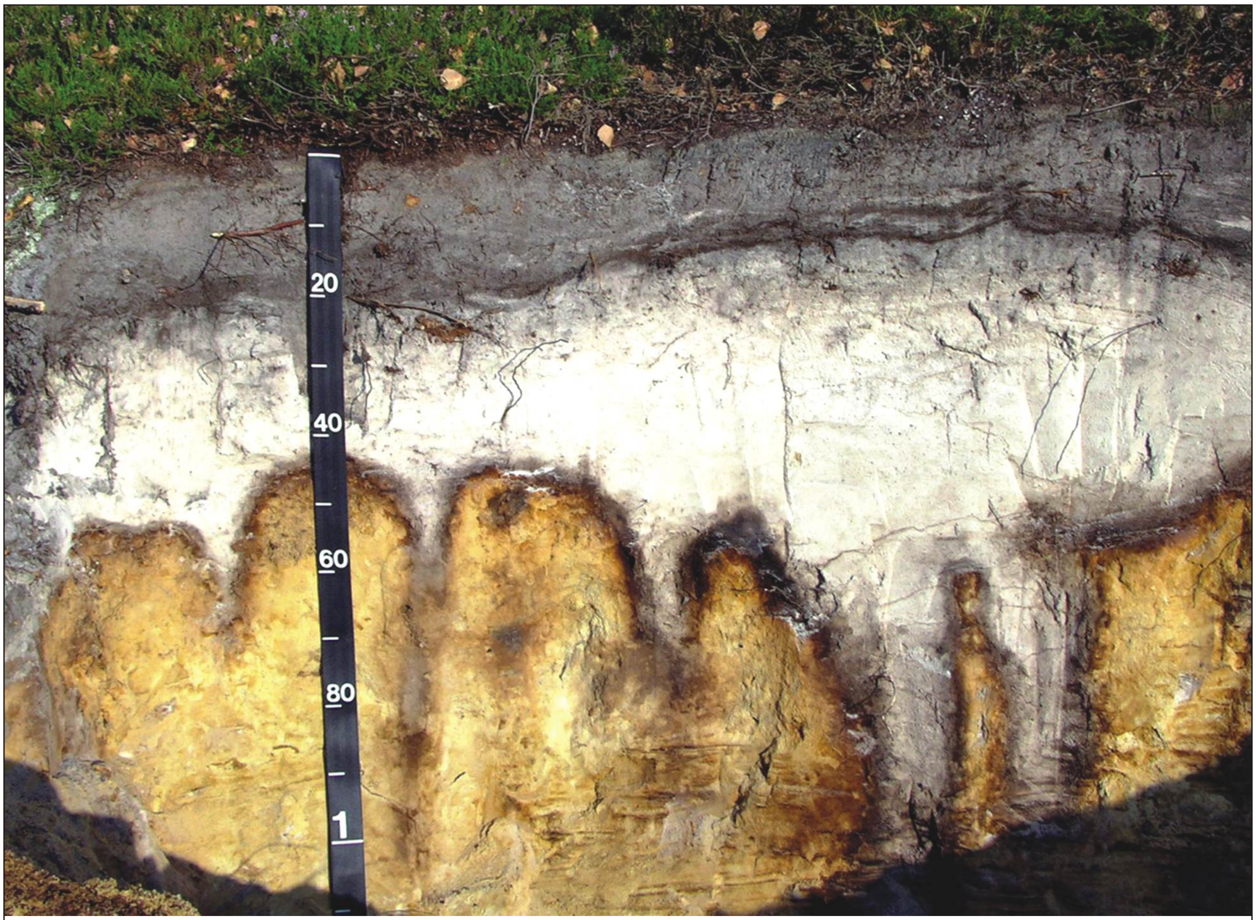

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Effects of Cocoa Husk Powder and Cow Dung on Moisture Content and Infiltration Rate of Sandy Soil

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ABSTRACT

Moisture retention affects soil quality and hence plant growth. Cocoa Husk Powder (CHP) and Cow dung serves as soil amendment agents. This study was carried out to investigate the effect of Cocoa Husk Powder (CHP) and Cow dung on soil physical properties (i.e., moisture content and soil infiltration rate) at Ho Polytechnic demonstration field. Four beds each were raised for moisture content and infiltration rates, respectively using sandy soils. Equal volumes of water and different quantities of CHP and Cow dung were applied to the beds using Completely Randomized Design (CRD). In all, 12 soil samples each were taken from both CHP and Cow dung treatment beds for analysis of moisture content using a gravimetric method. Double infiltrometer test was used to determine the infiltration rates. The results indicated that, for the CHP soil bed, treatment 1 (no CHP) had mean moisture content of 4.5%, treatment 2 (mixed with 2 kg CHP) had 7.0%, treatment 3 (mixed with 4 kg CHP) had 8.4% and treatment 4 (mixed with 6 kg CHP) had 13% while that of the corresponding cow dung treatments were 4.4, 5.4, 7 and 11%, respectively. The basic infiltration rates recorded were 36, 33 and 21 mm h^{-1} (with a cumulative infiltration of 58, 52 and 45 mm) for CHP for treatments 2, 3 and 4 while that of cow dung correspondingly were 39, 33 and 27 mm h^{-1} (with a cumulative infiltration of 69, 61 and 55 mm), respectively. The result shows that the more you applied the cocoa husk powder, the greater the moisture content and less infiltration rate. It is therefore recommended that further studies on effect of CHP on chemical properties of soils with salt problems be ascertained.

Key words: Cocoa husk powder, moisture content, infiltration rates, soil physical properties

INTRODUCTION

Crops development solely depends on the nature, physical and chemical properties of soil as well as the climatic conditions relating to the area specifically under cultivation. Soil health is a crucial factor for producing higher yield of crops. Excessive application of mineral fertilizers may affect soil health and sustainable productivity. Addition of organic manure which can supply nutrient requirement of crops with released nutrient in a gradual and controlled way, allows greater production with minor environmental impact (Khalid *et al.*, 2012). The influence of organic matter on crop growth and productivity is not just a matter of nutrient supply but they influence the physical characteristics and the chemical properties of the soil (Khalid *et al.*, 2012).

The objectives of every irrigation scheduling is to minimize water stress of plants, thus over irrigation and under irrigation to retain a considerable amount of water in the soil for crops use.

Soil properties such as: water holding capacity, cation exchange capacity, bulk density and soil fertility directly affect plant development. In soils where these properties are poor, conditions are often improved by the addition of soil amendments, including organic materials, synthetic chemical fertilizers, or humate-based products. Soil amendments are thought to aid plant establishment by providing for a rooting environment from the improvement of soil structure, aeration, water retention and nutrient availability (Corley, 1984). Soil physically need to be improved in order to keep it productive led to the realization of the significance of the cocoa husk powder on the soil physical properties.

The major problem regarding food crop production includes favourable soil temperature, moisture content or available water at root zone for crops and availability of soil nutrient. And inspite of all, sandy soil among others has a very high rate of infiltration because of its loosed particle nature and larger pore spaces to this effect it hardily holds a considerable amount of water and nutrient for plants use especially during peak period of crop water needs (mid-season stage) (Adegboyega, 2001).

Another general problem with soils of the tropics is the deterioration of soil physical conditions. The degradation can take many forms and has a variety of consequences including low fertility status due to poor soil quality (Lal and Pierce, 1991). In addition to its low release nutrient capability, organic matter is largely responsible for aggregation, soil moisture holding capacity and other improved physical properties of soil. If productivity is to be maintained, an agricultural system able to preserve a satisfactory physical condition in the soil must also be developed (Lal and Pierce, 1991).

Cocoa husks are usually discarded by majority of cocoa farmers as a waste product simply because they lacked adequate knowledge and information on its uses, although series of statistics have proven that it can be useful in so many ways to produce feeds for animals (feed for poultry birds and pigs) and can also be used to prepare inorganic fertilizers (compost) etc. (Oddoye *et al.*, 2010). The objectives of this study were to determine the impact of dry cocoa husk powder and cow dung on the moisture content of poor water retention soil and determine the infiltration rate of the soil samples.

MATERIALS AND METHODS

Climatic conditions of experimental area: Ho municipality was located within the southern half of the Volta Region. There are two main types of vegetation, namely the moist deciduous forest which covers mostly the northern hilly portions of the municipality and the savanna wood land which is predominant in the southern portion and occupies about 3/5 of the vegetation zone (Ho municipal Agriculture data).

The major soil type includes:

- The forest soils namely forest *Achrosols*, forest *lithosols* and the combination of the two types. There are in the hilly and wetter northern portions of the municipality
- The savanna soil of tree grassland vegetation namely: the tropical black earths and tropical grey earths. Notwithstanding the main study area, the soil at the experimental sites was sandy and loam soil

Land preparation and experimental design: Land preparation was the first process using indigenous tools such as cutlass, hoe and rake for clearing of the field and for seedbed preparation.

In all eight seedbeds were prepared with a dimension of 2 m^2. A bed was used as a control for each treatment, with 2, 4 and 6 kg of cocoa husk powder and cow dung, respectively being the treatments. The soil texture under study was sandy soil.

- **TA1** : Control for cocoa husk powder
- **TA2** : Treatment with 2 kg of cocoa husk powder
- **TA3** : Treatment with 4 kg of cocoa husk powder
- **TA4** : Treatment with 6 kg of cocoa husk powder
- **TB1** : Control for cow dung
- **TB2** : Treatment with 2 kg of cow dung
- **TB3** : Treatment with 4 kg of cow dung
- **TB4** : Treatment with 6 kg of cow dung

Hypotheses statement for moisture content

Null hypothesis (H_o) 1: It was stated that there was no significant difference between the various treatments with cocoa husk powder and cow dung at the initial stage:

$$(TA2, TA3 \text{ and } TA4) = (TB2, TB3 \text{ and } TB4)$$

Alternate hypothesis (H_a) 1: The alternate hypothesis was stated that there was a significant difference between the various treatments with cocoa husk powder and cow dung (thus all the treatments are not equal):

$$(TA2, TA3 \text{ and } TA4) \neq (TB2, TB3 \text{ and } TB4)$$

Null hypothesis (H_o) 2: It was also stated that there were no difference between the control and treatments with 2, 4 and 6 kg of either cocoa husk powder or cow dung:

$$TA1 = TA2 = TA3 = TA4 \text{ and } TB1 = TB2 = TB3 = TB4$$

Alternate hypothesis (H_a) 2: It was also stated that there were differences between the control and treatments with 2, 4 and 6 kg for either the cocoa husk powder or the cow dung:

$$TA \neq TA2 \neq TA3 \neq TA4 \text{ and } TB1 \neq TB2 \neq TB3 \neq TB4$$

Null hypothesis (H_o) 3: It was further stated that initially no significant difference could be realized between the cocoa husk powder treatments (with 2, 4 and 6 kg) and the cow dung treatments (with 2, 4 and 6 kg):

$$TA2 = TB2, TA3 = TB3 \text{ and } TA4 = TB4$$

Alternate hypothesis (H_a) 3: It was further stated that initially, there were significant difference between the cocoa husk powder treatments (with 2, 4 and 6 kg) and the cow dung treatments (with 2, 4 and 6 kg):

$$(TA2 \neq TB2, TA3 \neq TB3 \text{ and } TA4 \neq TB4)$$

Hypotheses statement for soil infiltration test

Null hypothesis (H_o) 4: It was stated that there was no significant difference between the various treatments with cocoa husk powder and cow dung at the initial stage:

$$(TA2, TA3 \text{ and } TA4) = (TB2, TB3 \text{ and } TB4)$$

Alternate hypothesis (H_a) 4: The alternate hypothesis was stated that there was a significant difference between the various treatments with cocoa husk powder and cow dung (thus all the treatments are not equal):

$$(TA2, TA3 \text{ and } TA4) \neq (TB2, TB3 \text{ and } TB4)$$

Null hypothesis (H_o) 5: It was also stated that there were no difference between the control and treatments with 2, 4 and 6 kg of either cocoa husk powder or cow dung:

$$TA1 = TA2 = TA3 = TA4 \text{ and } TB1 = TB2 = TB3 = TB4$$

Alternate hypothesis (H_a) 5: It was also stated that there were differences between the control and treatments with 2, 4 and 6 kg for either the cocoa husk powder or the cow dung:

$$TA \neq TA2 \neq TA3 \neq TA4 \text{ and } TB1 \neq TB2 \neq TB3 \neq TB4$$

Null hypothesis (H_o) 6: It was further stated that initially no significant difference could be realized between the cocoa husk powder treatments (with 2, 4 and 6 kg) and the cow dung treatments (with 2, 4 and 6 kg):

$$TA2 = TB2, TA3 = TB3 \text{ and } TA4 = TB4$$

Alternate hypothesis (H_a) 6: It was further stated that initially, there were significant difference between the cocoa husk powder treatments (with 2, 4 and 6 kg) and the cow dung treatments (with 2, 4 and 6 kg):

$$TA2 \neq TB2, TA3 \neq TB3 \text{ and } TA4 \neq TB4$$

Estimation of the moisture content and infiltration rate: The gravimetric method was used in moisture content determination in this research. Undisturbed soil samples were taken at random at a depth of 0.05, 10 and 15 cm, respectively. The moisture content capacity was estimated using the following relationship:

$$\text{Moisture content (MC \%)} = \frac{W2-W3}{W3-W1} \times 100$$

where, W_1 is the weight of tin (g), W_2 is the weight of moist sample+tin (g) and W_3 is the weight of dried soil+tin (g).

Fresh cocoa pod husks obtained was solar-dried to moisture content of about 8%, the husk was grinded into powder, the powder and the dried cow dung were then mixed with the soil thoroughly, it was then allowed for two months to decompose, soil sample was taken from the field into covered cans to ensure that the samples were not exposed to air (prevent evaporation). The Samples were then weighed after which it was put in the oven for drying at the temperature of 105°C for 24 h to avoid burning the humus content completely.

The samples were allowed to cool, weighed again and the results were recorded whiles the Moisture Content (MC) was calculated using the formula stated above.

The double ring infiltrometer was used to generate data for the infiltration rate analysis.

Data analysis: Two-Factor with Replication Analysis of Variance (ANOVA) was performed using SPSS version 16 to determined significant differences between treatments.

RESULTS

Moisture content: The moisture content generally increases with increasing amount of cocoa husk powder as shown in Table 1. Significant differences ($p>0.05$) were observed between the control treatment (TA1) and the various samples treated with different amount of cocoa husk powder (i.e., TA2, TA3 and TA4). The different treated samples also showed significant differences ($p>0.05$). The result further indicated that for TA1 and TA2, moisture content remained virtually same after 10 cm depth but decrease significantly for TA3 and TA4.

Similar trend was obtained when cow dung was used to treat the soil samples. Significant decrease ($p<0.05$) was noticed between the control (TB1) and the various treatments (TB2, TB3 and TB4). However, after the 10 cm depth, there were no significant decreases (($p>0.05$) in moisture content as was observed for the cocoa husk powder, this was indicated in Table 2.

It was observed that the average moisture content of treatment TA2 increased by 2.5% from the control (TA1) while treatment TA3 gave 1.6% average moisture content increment from TA2. It was also realized that treatment TA4 had an increased average moisture content of 3.6% from

Table 1: Effect of cocoa husk powder on moisture content of soil samples

	Mean moisture content (%)			
Cocoa husk powder	TA1	TA2	TA3	TA4
At a depth of 0.05 cm	1.0	2.8	4.2	6.4
At a depth of 10 cm	6.3	8.9	12.0	18.2
At a depth of 15 cm	6.3	8.8	9.0	14.3
Average	4.5	6.8	8.4	13.0

Table 2: Effect of cow dung on moisture content of soil samples

	Moisture content (%)			
Cow dung	TB1	TB2	TB3	TB4
At a depth of (0.05 cm)	0.7	1.7	3.7	5.5
At a depth of (10 cm)	6.5	7.3	8.4	13.5
At a depth of (15 cm)	6.0	7.3	8.3	13.0
Average	4.4	5.4	6.8	10.5

TA3. The same trend was observed for cow dung treatments but with a slight difference in the values. The average moisture content increment for TB2 was 1.0% from the control (TB1) and that of TB3 from TB2 was 1.4% while the average moisture increment of TB4 from TB3 was significantly 3.6%.

It was evident from the analysis that the average moisture content increment for cocoa husk powder was higher than that of cow dung for all the different treatments.

From Table 3, ANOVA analysis F = 0.784 which was less than F-crit = 4.494 among the samples (Cocoa husk powder and cow dung) so it appeared that the null hypothesis of hypothesis 4 could not be rejected. Its p-value of 0.389 which was greater than the alpha value of 0.05 ($\alpha = 0.05$) further confirmed the failure to reject the null hypothesis (1). So at 5% significance level there was insufficient evidence to infer that differences in water holding capacity existed between the two samples being cocoa husk powder and cow dung.

Also, at 5% significance level there was evidence to infer that differences existed in moisture content of the treatments levels 2, 4 and 6 kg. Since its F = 3.869, was greater than Fcrit = 3.239 with a p-value of 0.030 which indicated that the test was statistically significant. Therefore the null hypothesis in hypothesis (2) was rejected and concluded that differences in water holding capacity of poor water retention soil existed among the soil with treatment levels of 2, 4 and 6 kg.

Finally, at 5% significance level there was insufficient evidence to infer that the two factors interacted to affect the mean moisture content. Its p-value of 0.963 suggested there were not enough grounds to reject the null hypothesis of hypothesis (3). Furthermore, F = 0.093 was less than Fcrit = 3.239. This meant that it could not be concluded that water holding capacity of sandy soil would be high using the medium of cocoa husk powder neither could the same be said for the other treatment levels of 2, 4 and 6 kg.

The rate at which water moves through the soil in a given time known as infiltration rate is shown in Table 4 below with different treatment levels of cocoa husk powder. From the result obtained it was noticed that there was a significant difference in the infiltration between the control (TA1) and the various sample treatments (TA2, TA3 and TA4). The infiltration for the control is

Table 3: ANOVA for moisture content

Source of variation	SS	df	MS	F-value	p-value	F-crit
Sample	11.76	1	11.76	0.784	0.389	4.494
Columns	173.993	3	57.998	3.869	0.030	3.239
Interaction	4.173	3	1.391	0.093	0.963	3.239
Within	239.867	16	14.992			
Total	429.793	23				

Table 4: Effect of cocoa husk powder on infiltration on soil samples

Time interval (min)	TA1 (mm)	TA2 (mm)	TA3 (mm)	TA4 (mm)
2	8	6	5	6
2	6	5	5	6
4	7	5	4	4
5	5	4	4	4
5	13	9	7	7
10	13	7	6	5
10	11	12	11	7
20	20	10	11	7

higher than the rest of the sample treatments. The control and treatment TA2 reached terminal infiltration at cumulative time of 58 min with cumulative infiltration of 83 and 58 mm, respectively. The result again indicated that the sample treatments TA3 and TA4 had a terminal infiltration at cumulative time of 38 min but with cumulative infiltration of 42 and 39 mm, respectively. This implied that generally there was a significant difference in cumulative infiltration between the sample treatments. However, the cumulative time for treatments TA1 and TA2 were the same and that of TA3 and TA4 were also the same.

Similar trends were noticed among the sample treatments with cow dung. There was a significant difference between the control (TB1) and the rest of the sample treatments (TB2, TB3 and TB4). However, there was not a marked difference between sample treatments TB2, TB3 and TB4 themselves. Furthermore, the control sample and the treatment samples all reached terminal infiltration at the same cumulative time of 58 min with infiltration of 84, 67, 60 and 54 mm, respectively. The result indicated reduction in infiltration with an increase in treatment levels.

It was observed from the analysis that the treatment TA2 of cocoa husk powder had 7.556 mm min^{-1} average water infiltrations while cow dung had 8.667 mm min^{-1} average water infiltration but as the level of treatment has increased to TA3 the rate of infiltration of cocoa husk powder had decreased to 6.667 mm min^{-1} whiles that of cow dung had also decreased to 7.778 mm min^{-1}. Also, as the treatment level had been further increased to, TA4, the rate of infiltration of cocoa husk powder has further decreased to 5.667 mm min^{-1} with cow dung also decreased to 6.889 mm min^{-1}. This could be observed in Table 5.

It was evident from the analysis that, the rate of infiltration in general was higher with cow dung as it had a total rate of 8.528 mm min^{-1} as compared to 7.833 mm min^{-1} of cocoa husk powder. It was further observed that, the control treatment produced an average rate of 11.11 mm min^{-1} infiltration whiles average treatments levels for 2, 4 and 6 kg also produced an average of 8.11, 7.22 and 6.28 mm min^{-1}, respectively which indicated that as the quantity of cocoa husk powder and cow dung was increased the rate of infiltration also decreased but when compared to the control treatment it could be observed that the control had the highest rate of infiltration than the rest.

From Table 6, the analysis of variance F = 0.910 which was less than Fcrit = 3.991 among the samples (Cocoa husk powder and cow dung) so it appeared that the null hypothesis of hypothesis (4) could not be rejected. Its p-value of 0.344 which was greater than the alpha value of 0.05 (α = 0.05) further confirmed the failure to reject the null hypothesis. So at 5% significance level there was insufficient evidence to infer that differences in water infiltration existed between the two samples being cocoa husk powder and cow dung.

Table 5: Effect of cow dung on infiltration on soil samples

Time interval (min)	TB1 (mm)	TB2 (mm)	TB3 (mm)	TB4 (mm)
2	9	8	7	4
2	8	5	5	6
4	8	7	6	6
5	6	5	4	5
5	14	11	10	9
10	11	7	7	7
10	15	13	11	9
20	13	11	10	8
20	13	11	10	8

Table 6: ANOVA for rate of water infiltration

Source of variation	SS	df	MS	F-value	p-value	F crit
Sample	8.681	1	8.681	0.910	0.344	3.991
Columns	236.375	3	78.792	8.261	0.000	2.748
Interaction	11.153	3	3.718	0.390	0.761	2.748
Within	610.444	64	9.538			
Total	866.653	71				

Also, at 5% significance level there was evidence to infer that differences in water infiltration existed among the treatments of the sample been 2, 4 and 6 kg. Since its F = 8.261, was greater than Fcrit = 2.748 with a p-value of 0.000 which indicated that the test was highly significant. Therefore the null hypothesis in hypothesis (5) above was rejected and was concluded that differences in water infiltration existed among the treatment levels.

Finally, at 5% significance level there was insufficient evidence to infer that the two factors interacted to affect the mean water infiltration. Its p-value of 0.761 suggested that there were not enough grounds to reject the null hypothesis of hypothesis (6). Furthermore, F = 0.390 was less than Fcrit = 2.748. This meant that it could not be said that water infiltration would be high using the medium of cocoa husk powder neither could it be said for the other treatment of cow dung being 2, 4 and 6 kg.

DISCUSSION

Moisture content of soil is one of the essential parameters that determines soil characteristics and hence support plant growth. Poor quality soil is enriched by the addition of soil amendments to improve on its chemical, biological and physical properties.

It was discovered in this research that the soil samples treated with cocoa husk powder and cow dung significantly increased soil moisture content with corresponding decreased in infiltration rate. Generally, infiltration rate was high during the initial stages of soil wetting but decreased exponentially with time to approach a constant rate. This could be attributed to two factors (1) A decreased in metric potential gradient which occurred as infiltration proceeded and (2) The formation of a seal or crust at the soil surface. Since the control had a higher infiltration rate compared to other treatments be it cocoa husk powder or cow dung, the decreased infiltration observed with the treatments could be attributed to the soil amendments. The soil amendments affected the soil structure and the organic content of the soil amendments enhanced the sealing of the soil pores and thus determining the steady-state infiltration rate. This significant decreased in infiltration rate agreed with the assertion of Stern (1980) that the rate of entry of water was greatest when the soil was dry at the start of watering but decreased as the topsoil becomes saturated. FAO (1988) also reported that the infiltration rate was rapid when the water was first applied to the soil but when the topsoil became saturated, swelling was caused and hence, the infiltration gradually became constant. Again this could be attributed to an increase in soil organic matter which acted as a cementing factor necessary for flocculating soil particles to form stable aggregates and thus not easily permeating passage of water through it.

According to Ellerbrook *et al.* (2005) and Eynard *et al.* (2006), soil organic matter interacts with other soil properties to influence water behavior in soils. Thus, the high moisture content obtained from soil samples treated with cocoa husk powder and cow dung was a reflection of its relatively high organic content or organic matter content and a manifestation of the affinity of organic content for water (Oguike and Mbagwu, 2004). Thus the significant increased in water holding characteristics of soil sample treated with cocoa husk powder compared with that of cow dung treatment could be attributed to the former having a higher organic content or organic matter content than the latter. This agreed with the findings of other researchers, Rawis *et al.* (2003), indicated that the accumulation of soil organic matter led to increased soil water retention.

The addition of organic matter to the soil usually increases the water holding capacity of the soil. This is because the addition of organic matter increases the number of micropores and macropores in the soil either by "gluing" soil particles together or by creating favourable living conditions for soil organisms. Certain types of soil organic matter can hold up to 20 times their weight in water (Reicosky, 2005). Hudson (1994) showed that for each 1-percent increase in soil organic matter, the available water holding capacity in the soil increased by 3.7%. Soil water is held by adhesive and cohesive forces within the soil and an increase in pore space will lead to an increase in water holding capacity of the soil. As a consequence, less irrigation water is needed to irrigate the same crop.

It was observed from the Table 1 that beyond the depth of 10 cm, there was a significant reduction in the moisture content among the treatment levels. This could be attributed to the cocoa husk powder holding the moisture and preventing deep percolation. Though the same trend was evident with regard to cow dung treatments beyond 10 cm depth, the difference was not significant which again buttress the inference that the cocoa husk powder had a higher moisture holding capacity than that of cow dung (alternate hypothesis 1).

The research has showed that soil amendment with cocoa husk powder and cow dung at different rates may enhance soil moisture content and infiltration rate for increased productivity.

CONCLUSION

It could be concluded that the cocoa husk powder and cow dung can improves the moisture holding capacity of sandy soil and from the findings of the present research it is recommended for further investigation the effect of CHP on salt affected soils.

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