

Soil Physical and Chemical Properties as Affected by Land Configuration and Cow Dung Manure at Minna, Niger State, Nigeria

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Abstract

A 3 × 3 factorial experiment was carried out under rain-fed condition at the Federal University of Technology Teaching and Research Farm, Minna to determine the effect of land configuration (ridge, flat-bed and mound) and cow dung manure application rate (0, 5 and 10 t/ha) on soil physical and chemical properties. Treatments were laid out in a randomized complete block design and replicated four times. The land was ploughed and grown to Oba super 1 maize variety. Soil moisture content was determined at 3, 6, 9 and 12 weeks after planting. Following crop harvest, other soil physical (bulk density, total porosity and moisture content) and chemical (organic carbon, available phosphorus, exchangeable calcium, magnesium, potassium and sodium) properties were determined. Data generated were subjected to statistical analysis at 0.05 level of significance. Flat-bed configuration resulted in higher soil moisture content than ridge by 12 %. Also, 5 and 10 t/ha of cow dung manure gave rise to significantly ($P \leq 0.05$) higher moisture content than 0 t/ha by 30 and 23 %, respectively. Flat-bed treatment resulted in significantly highest soil organic carbon, available phosphorus, exchangeable magnesium and potassium content. Also, planting on flat-beds and mounds gave rise to higher exchangeable sodium content than planting on ridges. Application of 10 t/ha cow dung manure produced highest soil available phosphorus, exchangeable magnesium and potassium content. Interaction between land configuration and cow dung manure application rate had significant influence on soil organic carbon, exchangeable magnesium, potassium and sodium content.

Key words: Land configuration, cow dung manure, soil physical and chemical properties.

Introduction

Land preparation for agricultural purposes is as old as the practice of agriculture by man. Land is usually prepared in a manner that would provide soil tilth and a favourable environment for crop growth i.e. from seed germination to crop maturity. The common practice is to disturb or manipulate the soil surface to obtain various shapes or configurations as may be desired by the farmer. In Minna, as in most parts of Nigeria, Chiroma *et al.* (2008) reported that the common land configurations include flat-beds, raised-beds, open and tied ridges and mounds or heaps (open and tied). Various land configurations are aimed at gathering the surface or topsoil together. Most plant nutrients are found in the topsoil. Therefore, gathering surface soil together will provide access to adequate amounts of available plant nutrients for enhancement of crop growth and yields. Soils in Minna are mostly sandy, poor in structure and low in both organic matter content and plant nutrients. Land configuration is not only beneficial for enhancement of soil nutrient status, it also improves the physical condition of the soil surface for better crop performance (Deshmukh *et al.*, 2016). Soil nutrient availability, according to Chiroma *et al.* (2008), is enhanced under the influence of land configuration practices.

Organic manures are fertilizers (sources of plant nutrients) that are obtained from decayed organic materials of plant and animal origin. Organic manures such as those obtained from wastes from plant materials, and from domesticated animals such as cattle, poultry, goats, sheep and horse have been

widely reported to improve soil physical and chemical properties, and nutrient status. As an organic amendment, organic manures will not only enhance soil physical and chemical condition but will also result in higher crop growth and increased yields (Uwah *et al.*, 2014; Eze *et al.*, 2020).

Soil management practices have profound influence on soil properties especially where soil conditions are limited by constraints inherent in a given environment. Minna is located in the Southern guinea savanna zone of Nigeria (Ojanuga, 2006). This agro-ecological zone is characterized by low and erratic rainfall pattern (Nigeria Meteorological Agency, NIMET, 2020). Soils in this zone are inherently low in organic matter content and nutrient status. These soils are also known to exhibit poor physical condition. It is, therefore, not surprising, that poor crop growth and low yields in the Southern guinea savanna zone of Nigeria are associated with poor soil physical and chemical properties. The employment of management practices such as appropriate shape of the soil surface and application of adequate amount of organic manure could have potential for improving soil physical and chemical conditions. Therefore, the objective of this research is to determine the effect of land configuration and cow dung manure on selected soil physical and chemical properties.

Materials and Methods

In 2014 and 2015, a 3 x 3 factorial experiment was carried out under rainfed condition at the Teaching and Research Farm, Federal University of Technology, Minna. The experimental site is located at latitude 9° 33' N and longitude 6° 31' E, and 208 m above mean sea level. Minna is found in the Southern savanna agro-ecological zone of Nigeria. Annual rainfall amount in Minna is 1,257 mm, while average daily minimum and maximum temperatures are 22 °C and 33 °C, respectively (NIMET, 2020). The geological material of Minna is basement complex. The soils are mostly sandy in texture. The growing season in Minna commences between April and May and ends between September and October. The vegetation of Minna is characterized by few scattered trees and shrubs with vast grassland. Maize, rice, millet, sorghum, cowpea, groundnut, soybean, yam and vegetables are the commonly grown crops in Minna.

The treatments consisted of land configuration (flat bed, mound and ridge) and rate of application of cow dung manure (0, 5 and 10 t/ha). The treatments were laid out in a randomized complete block design and replicated four times. Land preparation was carried out using a tractor to plough the land following land clearing (removal of existing vegetation). The experimental plots (4 x 4 m each) were laid out and banded to minimize movement of materials (soil, water, fertilizer and cow dung) from one plot to another. Plots were separated from each other by a space of 0.5 m, while between replications the space was 1 m. Two weeks before planting, treatments were administered. Three to four seeds of Oba Super 1 maize variety were sown at a depth of 3 cm, and at a spacing of 0.75 x 0.5 m, inter and intra-row, respectively. Seedlings were thinned to two plants per stand, two weeks after planting. Weeds removal was done manually using a hand-hoe at 2, 6 and 9 weeks after planting (WAP). Organic manure (cow dung) that was applied on the surface was lightly incorporated into the topsoil during weed control using hand-hoe. NPK fertilizer was applied at recommended rate (60:30:30) in two split doses at 2 and 6 WAP. Maize cobs were harvested at physiological maturity (12 WAP). Soil samples were collected randomly using soil auger at 0 – 15 and 15 – 30 cm depths. The samples were bulked to obtain a composite sample. They were air-dried, gently crushed and passed through a 2 mm sieve in preparation for physicochemical analysis in the laboratory. Soil bulk density and total porosity were determined on core samples (Blake and Hartage, 1986; Ball-Coelho *et al.*, 1998). Soil moisture content was determined gravimetrically (Brady and Weil, 2002) at 3, 6, 9 and 12 weeks after planting (WAP), representing seedling establishment, vegetative growth, tasseling and physiological maturity stages, respectively. Soil organic carbon was determined using the Walkley-Black wet-oxidation method (Walkley and Black, 1934). Available phosphorus was extracted using Bray 1 method and measured using colorimetry (Bray and Kurtz, 1945). 1N neutral

ammonium acetate (NH_4OAc) solution was used to extract exchangeable bases (Ca^{2+} , Mg^{2+} , K^+ and Na^+) (Grant, 1982). Exchangeable Ca^{2+} and Mg^{2+} were determined by titration, while exchangeable K^+ and Na^+ were determined by flame photometry.

Data obtained were subjected to statistical analysis at 5 % level of probability, with the use of statistical software (Statistix 8.0, 2005). Differences among treatment means were separated using Duncan's multiple range test (DMRT).

Results and Discussion

Results of the effect of land configuration and cow dung manure on soil physical (Tables 1, 2 and 3) and chemical (Table 4) properties at 0 – 15 and 15 – 30 cm depths during 2014 and 2015 cropping seasons, and the pooled (average) values are hereby presented.

Soil Physical Properties

Results in Table 1 indicate that both land configuration and cow dung manure application rate had no significant effect on soil bulk density and total porosity at 0 – 15 and 15 – 30 cm depths. In an earlier study, Eze *et al.* (2006) reported that the effect of any treatment on bulk density and total porosity does not extend beyond three to four weeks after land cultivation or tillage. Following periods of rainfall events after cultivation, soil bulk density and total porosity return to their original condition because the soil remains bare during this period due to poor vegetation or crop canopy cover. Direct impact of raindrops on bare soil tend to give rise to soil surface compaction. However, flat-bed configuration resulted in a higher soil moisture content than ridge by 12 % (Table 2) at 0 – 15 cm depth. In contrast to this finding, Kiran *et al.* (2008) noted that ridges conserved more moisture than flat-beds, and consequently performed better in terms of plant height and total dry matter. Furthermore, 5 and 10 t/ha of cow dung manure gave rise to significantly ($P \leq 0.05$) higher moisture content than 0 t/ha by 30 and 23 %, respectively. At 15 – 30 cm depth, flat-bed and mound land shapes gave rise to higher ($P \leq 0.05$) moisture content than ridge by 19 and 18 %, respectively (Table 3).

Table 1: Effect of land configuration and cow dung on soil bulk density (g/cm³) and total porosity (%) at 0 – 15 and 15 – 30 cm depths.

| Treatment | 0 – 15 cm | | | | | | 15 – 30 cm | | | | | |
|------------------------|--------------|-------|--------|----------------|--------|--------|--------------|-------|--------|----------------|--------|--------|
| | Bulk density | | | Total porosity | | | Bulk density | | | Total porosity | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| Land configuration (A) | | | | | | | | | | | | |
| Ridge | 1.61a | 1.70a | 1.66a | 39.16a | 35.97a | 37.57a | 1.64a | 1.70a | 1.67a | 38.06a | 35.32a | 36.69a |
| Flat-bed | 1.62a | 1.70a | 1.66a | 38.97a | 36.09a | 37.53a | 1.62a | 1.70a | 1.66a | 38.93a | 34.92a | 36.92a |
| Mound | 1.61a | 1.68a | 1.65a | 39.04a | 36.52a | 37.78a | 1.64a | 1.70a | 1.67a | 38.17a | 36.55a | 37.36a |
| SE± | 0.04 | 0.03 | 0.02 | 1.35 | 0.99 | 0.91 | 0.03 | 0.02 | 0.02 | 1.15 | 0.95 | 0.73 |
| Cow dung rate (B) | | | | | | | | | | | | |
| 0 t/ha | 1.62a | 1.70a | 1.66a | 39.00a | 35.86a | 37.43a | 1.63a | 1.71a | 1.67a | 38.67a | 35.18a | 36.93a |
| 5 t/ha | 1.63a | 1.67a | 1.65a | 38.69a | 37.02a | 37.86a | 1.67a | 1.68a | 1.67a | 37.15a | 35.86a | 36.50a |
| 10 t/ha | 1.60a | 1.71a | 1.65a | 39.48a | 35.70a | 37.59a | 1.61a | 1.71a | 1.66a | 39.33a | 35.75a | 37.54a |
| SE± | 0.04 | 0.03 | 0.02 | 1.35 | 0.99 | 0.91 | 0.03 | 0.02 | 0.02 | 1.15 | 0.95 | 0.73 |
| Interaction | | | | | | | | | | | | |
| A x B | NS | NS | | NS | NS | | NS | NS | NS | NS | NS | NS |

Means with the same letter(s) in the columns are not significantly different according to Duncan's multiple range test at 5 % probability level.

NS: Not significant

Table 2: Effect of land configuration and cow dung on soil moisture content (%) at 0 – 15 depth.

| Treatment | Number of weeks after planting (WAP): | | | | | | | | | | | |
|------------------------|---------------------------------------|-------|--------|-------|-------|--------|-------|-------|--------|--------|-------|--------|
| | 3 WAP | | | 6 WAP | | | 9 WAP | | | 12 WAP | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| Land configuration (A) | | | | | | | | | | | | |
| Ridge | 14.0a | 11.0a | 12.5a | 11.1a | 12.9a | 12.0b | 10.0a | 11.9a | 11.0a | 8.6a | 11.2a | 9.9a |
| Flat-bed | 13.9a | 10.4a | 12.2a | 12.7a | 14.2a | 13.4a | 11.3a | 12.5a | 11.9a | 7.5a | 11.6a | |
| 9.6a | | | | | | | | | | | | |
| Mound | 13.1a | 10.4a | 11.7a | 11.8a | 13.6a | 12.7ab | 11.0a | 13.3a | 12.2a | 7.8a | 11.7a | 9.8a |
| SE± | 0.5 | 1.0 | 0.5 | 0.7 | 0.9 | 0.6 | 1.0 | 1.5 | 0.9 | 1.1 | 1.0 | 0.8 |
| Cow dung rate (B) | | | | | | | | | | | | |
| 0 t/ha | 13.3a | 10.2a | 11.8a | 11.2a | 13.4a | 12.3a | 11.3a | 13.4a | 12.4a | 8.3a | 9.8b | 9.1a |
| 5 t/ha | 13.6a | 10.5a | 12.1a | 11.9a | 13.6a | 12.8a | 10.9a | 13.5a | 12.2a | 7.4a | 12.7a | 10.1a |
| 10 t/ha | 14.0a | 11.1a | 12.5a | 12.4a | 13.7a | 13.1a | 10.1a | 10.8a | 10.4a | 8.2a | 12.1a | |
| 10.1a | | | | | | | | | | | | |
| SE± | 0.5 | 1.0 | 0.5 | 0.7 | 0.9 | 0.6 | 1.0 | 1.5 | 0.9 | 1.1 | 1.1 | 0.8 |
| Interaction | | | | | | | | | | | | |
| A x B | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Means with the same letter(s) in the columns are not significantly different according to Duncan's multiple range test at 5 % probability level.
NS: Not significant

Table 3: Effect of land configuration and cow dung on soil moisture content (%) at 15 – 30 depth.

| Number of weeks after planting (WAP): | | | | | | | | | | | | |
|---------------------------------------|-------|-------|--------|-------|-------|--------|-------|-------|--------|--------|-------|--------|
| Treatment | 3 WAP | | | 6 WAP | | | 9 WAP | | | 12 WAP | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| Land configuration (A) | | | | | | | | | | | | |
| Ridge | 15.8a | 13.4a | 14.6a | 12.4a | 14.6a | 13.5a | 10.9a | 19.2b | 15.0b | 8.2a | 12.7a | 10.5a |
| Flat-bed | 14.9a | 13.5a | 14.2a | 13.4a | 14.6a | 14.0a | 12.1a | 22.8a | 17.5a | 9.1a | 13.5a | 11.3a |
| Mound | 14.1a | 15.0a | 14.6a | 12.4a | 15.1a | 13.8a | 12.1a | 22.7a | 17.4a | 7.2a | 14.2a | 10.7a |
| SE± | 1.0 | 0.8 | 0.7 | 0.7 | 0.6 | 0.5 | 0.8 | 1.5 | 0.8 | 1.1 | 0.8 | 0.7 |
| Cow dung rate (B) | | | | | | | | | | | | |
| 0 t/ha | 15.5a | 13.5a | 14.5a | 12.2a | 14.9a | 13.6a | 11.9a | 22.3a | 17.1a | 8.2a | 13.2a | 10.7a |
| 5 t/ha | 14.6a | 14.1a | 14.3a | 13.0a | 15.1a | 14.0a | 12.0a | 21.5a | 16.7a | 7.9a | 13.4a | 10.6a |
| 10 t/ha | 14.8a | 14.3a | 14.5a | 13.1a | 14.3a | 13.7a | 11.1a | 20.9a | 16.0a | 8.5a | 13.8a | 11.1a |
| SE± | 1.0 | 0.8 | 0.7 | 0.7 | 0.6 | 0.5 | 0.8 | 1.5 | 0.8 | 1.1 | 0.8 | 0.7 |
| Interaction | | | | | | | | | | | | |
| A x B | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Means with the same letter(s) in the columns are not significantly different according to Duncan's multiple range test at 5 % probability level.
 NS: Not significant

Soil Chemical Properties

As shown in Table 4, flat-bed treatment gave rise to higher soil available phosphorus content than ridge and mound treatments by 31 and 45 %, respectively at 0 - 15 cm depth in 2014. Furthermore, in 2015, at 0 – 15 cm depth, planting on flat-bed resulted in higher soil organic carbon and exchangeable magnesium than planting on ridge. Mound treatment produced higher soil available phosphorus than both ridge and flat-bed treatments. Ridge treatment gave rise to lower soil exchangeable potassium and sodium than flat-bed and mound treatments. Flat-bed treatment resulted in soil exchangeable magnesium than ridge and mound treatments. Application of 10 t/ha cow dung manure produced highest soil available phosphorus, magnesium and potassium than 0 and 5 t/ha rates. In the pooled data for 2014 and 2015, flat-bed treatment resulted in higher soil organic carbon, exchangeable magnesium and potassium contents than ridge and mound treatments. Soil samples collected from mounds produced higher available phosphorus than samples collected from ridge and flat-bed treatments. Ridge treatment resulted in lower soil exchangeable potassium than flat-bed and mound treatments. Application of 10 t/ha of cow dung produced the highest soil exchangeable magnesium and potassium contents at 0 – 15 cm depth, and highest available phosphorus and exchangeable magnesium at 15 – 30 cm depth. It is worthy to note that in a similar study, application of 10 t/ha of cow dung manure resulted in significantly tallest plants, and highest cob length, cob weight and grain yield (Eze *et al.*, 2020).

Interaction between land configuration and cow dung manure application rate had significant influence on soil organic carbon, exchangeable magnesium, potassium and sodium content (Tables 5 - 7).

Combination of mound and 10 t/ha cow dung manure treatments resulted in highest soil organic carbon content (Table 5), highest soil exchangeable potassium (Tables 5 and 7) and highest soil exchangeable sodium content (Tables 6 and 7). Also, interaction between flat-bed treatment and 10 t/ha cow dung manure application rate produced best soil exchangeable magnesium content (Tables 5 and 7).

Table 4: Effect of land configuration and cow dung on soil chemical properties at 0 – 15 and 15 – 30 cm depths.

| 2014 | | | | | | | | | | | | |
|------------------------|-----------------|-------------------|-----------------------------------|-----------------------------------|----------------------|-----------------------|------------------|-------------------|-----------------------------------|-----------------------------------|----------------------|-----------------------|
| Treatment | 0 – 15 cm Depth | | | | | | 15 – 30 cm Depth | | | | | |
| | Org C g/kg | Avail. P mg/kg | Exch. Ca ²⁺ cmol/kg | Exch. Mg ²⁺ cmol/kg | Exch. K ⁺ | Exch. Na ⁺ | Org C g/kg | Avail. P mg/kg | Exch. Ca ²⁺ cmol/kg | Exch. Mg ²⁺ cmol/kg | Exch. K ⁺ | Exch. Na ⁺ |
| Land configuration (A) | | | | | | | | | | | | |
| Ridge | 20.0a | 8.1b | 0.11a | 0.02a | 0.16a | 0.82a | 22.0a | 9.8a | 0.08a | 0.02a | 0.13a | 0.73a |
| Flat-bed | 21.1a | 10.6a | 0.07a | 0.02a | 0.18a | 0.99a | 21.9a | 9.9a | 0.08a | 0.02a | 0.25a | 0.71a |
| Mound | 20.9a | 7.3b | 0.09a | 0.02a | 0.13a | 0.80a | 22.3a | 10.2a | 0.09a | 0.02a | 0.14a | 0.65a |
| SE± | 1.2 | 0.8 | 0.01 | 0.04 | 0.03 | 0.26 | 0.7 | 0.7 | 0.01 | 0.04 | 0.09 | 0.13 |
| Cow dung rate (B) | | | | | | | | | | | | |
| 0 t/ha | 22.1a | 8.6a | 0.09a | 0.02a | 0.14a | 0.78a | 23.0a | 9.7a | 0.09a | 0.02a | 0.25a | 0.67a |
| 5 t/ha | 21.1a | 8.7a | 0.09a | 0.02a | 0.15a | 0.89a | 21.6a | 9.8a | 0.09a | 0.02a | 0.13a | 0.70a |
| 10 t/ha | 18.7b | 8.7a | 0.08a | 0.01a | 0.17a | 0.94a | 21.6a | 10.5a | 0.08a | 0.02a | 0.14a | 0.72a |
| SE± | 1.2 | 0.8 | 0.01 | 0.04 | 0.03 | 0.26 | 0.7 | 0.7 | 0.01 | 0.04 | 0.09 | 0.13 |
| Interaction | | | | | | | | | | | | |
| A x B | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| 2015 | | | | | | | | | | | | |
| Land configuration (A) | | | | | | | | | | | | |
| Ridge | 14.3b | 2.8b | 23.3a | 3.2b | 0.16b | 0.34b | 16.3a | 1.9b | 20.6a | 3.3b | 0.20b | 0.34b |
| Flat-bed | 21.7a | 1.5b | 20.0a | 9.3a | 0.48a | 0.70a | 16.9a | 1.0b | 19.7a | 13.1a | 0.58a | 0.64a |
| Mound | 17.8ab | 6.5a | 21.0a | 6.0ab | 0.42a | 0.60a | 18.6a | 3.8a | 21.3a | 4.3b | 0.34ab | 0.57a |
| SE± | 2.3 | 0.9 | 2.5 | 1.6 | 0.08 | 0.07 | 3.7 | 0.5 | 1.2 | 1.4 | 0.14 | 0.07 |
| Cow dung rate (B) | | | | | | | | | | | | |
| 0 t/ha | 18.5a | 2.8b | 19.6a | 3.2b | 0.30b | 0.54a | 15.5a | 1.9a | 20.3a | 5.2b | 0.34a | 0.54a |
| 5 t/ha | 16.4a | 3.4ab | 21.1a | 6.7ab | 0.22b | 0.57a | 16.5a | 2.0a | 20.5a | 6.1b | 0.26a | 0.47a |
| 10 t/ha | 19.0a | 4.7a | 23.6a | 8.6a | 0.54a | 0.53a | 19.8a | 2.9a | 20.8a | 9.4a | 0.53a | 0.55a |
| SE± | 2.3 | 0.9 | 2.5 | 1.6 | 0.08 | 0.07 | 3.7 | 0.5 | 1.2 | 1.4 | 0.14 | 0.07 |
| Interaction | | | | | | | | | | | | |
| A x B | * | NS | NS | * | * | * | NS | NS | NS | NS | NS | * |
| Pooled | | | | | | | | | | | | |
| Land configuration (A) | | | | | | | | | | | | |
| Ridge | 17.2b | 5.5b | 11.7a | 1.6b | 0.16b | 0.58a | 19.2a | 5.8b | 10.3a | 1.7b | 0.17b | 0.54a |
| Flat-bed | 21.4a | 6.1ab | 10.0a | 4.7a | 0.33a | 0.85a | 19.4a | 5.5b | 9.9a | 6.6a | 0.42a | 0.68a |
| Mound | 19.4ab | 6.9a | 10.6a | 3.0ab | 0.28a | 0.70a | 20.5a | 7.0a | 10.7a | 2.2b | 0.24b | 0.61a |

| | | | | | | | | | | | | |
|-------------------|-------|------|-------|-------|-------|-------|-------|-------|-------|------|-------|-------|
| SE± | 1.3 | 0.7 | 1.2 | 0.9 | 0.04 | 0.14 | 2.0 | 0.4 | 0.6 | 0.7 | 0.09 | 0.07 |
| Cow dung rate (B) | | | | | | | | | | | | |
| 0 t/ha | 20.3a | 5.7a | 9.9a | 1.6b | 0.22b | 0.66a | 19.3a | 5.8b | 10.2a | 2.6b | 0.29a | 0.60a |
| 5 t/ha | 18.8a | 6.1a | 10.6a | 3.3ab | 0.19b | 0.73a | 19.0a | 5.9ab | 10.3a | 3.1b | 0.20a | 0.58a |
| 10 t/ha | 18.9a | 6.7a | 11.8a | 4.3a | 0.36a | 0.73a | 20.7a | 6.7a | 10.4a | 4.7a | 0.33a | 0.64a |
| SE± | 1.3 | 0.7 | 1.2 | 0.9 | 0.04 | 0.14 | 2.0 | 0.4 | 0.6 | 0.7 | 0.09 | 0.07 |
| Interaction | | | | | | | | | | | | |
| A x B | * | NS | NS | * | * | NS | NS | NS | NS | NS | NS | * |

Means with the same letter(s) in the columns are not significantly different according to Duncan's multiple range test at 5 % probability level.

*: Significant at 5 % level of probability

NS: Not significant

Table 5: Interaction effect of land configuration and cow dung on soil organic carbon (OC), exchangeable magnesium (Mg^{2+}), potassium (K^+) and sodium (Na^+) at 0 – 15 cm depth during the 2015 cropping season.

| Treatment | OC (g/kg) | | | Mg^{2+} (cmol/kg) | | | K^+ (cmol/kg) | | | Na^+ (cmol/kg) | | |
|--------------------|----------------------|--------|--------|----------------------|--------|--------|----------------------|--------|-------|----------------------|--------|--------|
| | Cow dung rate (t/ha) | | | Cow dung rate (t/ha) | | | Cow dung rate (t/ha) | | | Cow dung rate (t/ha) | | |
| Land configuration | 0 | 5 | 10 | 0 | 5 | 10 | 0 | 5 | 10 | 0 | 5 | 10 |
| Ridge | 14.2bc | 12.5c | 16.4bc | 2.3c | 5.3bc | 1.8c | 0.14c | 0.15c | 0.19c | 0.31c | 0.35c | 0.37c |
| Flat-bed | 28.0a | 22.1ab | 15.2bc | 3.9c | 11.2ab | 12.9a | 0.56b | 0.34bc | 0.54b | 0.85a | 0.80a | 0.43c |
| Mound | 13.4c | 14.7bc | 25.4a | 3.4c | 3.4c | 11.1ab | 0.19c | 0.18c | 0.90a | 0.47c | 0.55bc | 0.78ab |
| SE± | 4.0 | | | 2.9 | | | 0.14 | | | 0.12 | | |

Means with the same letter(s) in the rows and columns are not significantly different according to Duncan's multiple range test at 5 % probability level.

Table 6: Interaction effect of land configuration and cow dung on soil exchangeable sodium (cmol/kg) at 15 – 30 cm depth during the 2015 cropping season.

| Treatment | Cow dung rate (t/ha) | | |
|--------------------|----------------------|--------|--------|
| Land configuration | 0 | 5 | 10 |
| Ridge | 0.30d | 0.37cd | 0.35cd |
| Flat bed | 0.78a | 0.75ab | 0.40cd |
| Mound | 0.54bc | 0.28d | 0.91a |
| SE± | 0.11 | | |

Means with the same letter(s) in the rows and columns are not significantly different according to Duncan's multiple range test at 5 % probability level.

Table 7: Interaction effect of land configuration and cow dung on soil organic carbon (OC), exchangeable magnesium (Mg^{2+}) and potassium (K^+) at 0 – 15 cm depth and sodium (Na^+) at 15 – 30 cm depth for the 2014 & 2015 cropping seasons combined data.

| at 0 – 15 cm depth and sodium (Na ⁺) at 15 – 30 cm depth for the 2014 & 2015 cropping seasons combined data. | | | | | | | | | | | | |
|--|--|--------|--------|----------------------------|-------|-------|--------------------------|--------|-------|---------------------------|--------|---------|
| | OC (g/kg) | | | Mg ²⁺ (cmol/kg) | | | K ⁺ (cmol/kg) | | | Na ⁺ (cmol/kg) | | |
| | <----- 0 – 15 cm Depth -----> (15 – 30 cm Depth) | | | | | | | | | | | |
| Treatment | Cow dung rate (t/ha) | | | Cow dung rate (t/ha) | | | Cow dung rate (t/ha) | | | Cow dung rate (t/ha) | | |
| Land configuration | 0 | 5 | 10 | 0 | 5 | 10 | 0 | 5 | 10 | 0 | 5 | 10 |
| Ridge | 17.5bc | 16.6c | 17.4bc | 1.2c | 2.7bc | 0.9c | 0.14c | 0.14c | 0.20c | 0.52cd | 0.52cd | 0.57bcd |
| Flat bed | 25.1a | 21.9ab | 17.3c | 1.9c | 5.6ab | 6.5a | 0.36b | 0.27bc | 0.36b | 0.73abc | 0.79ab | 0.50cd |
| Mound | 18.4bc | 17.9bc | 21.9ab | 1.7c | 1.7c | 5.5ab | 0.16c | 0.16c | 0.52a | 0.56bcd | 0.44d | 0.84a |
| SE± | 2.2 | | | 1.5 | | | 0.08 | | | 0.12 | | |

Means with the same letter(s) in the rows and columns are not significantly different according to Duncan's multiple range test at 5 % probability level.

Conclusions

Based on the results obtained in this study, the conclusions are:

- i. Flat-bed configuration resulted in higher soil moisture content than ridge by 12 %.
- ii. Five and 10 t/ha of cow dung manure gave rise to significantly ($P \leq 0.05$) higher moisture content than 0 t/ha by 30 and 23 %, respectively.
- iii. Flat-bed treatment resulted in significantly highest soil organic carbon, available phosphorus, exchangeable magnesium and potassium content.
- iv. Planting on flat-beds and mounds gave rise to higher exchangeable sodium content than planting on ridges.
- v. Application of 10 t/ha cow dung manure produced highest soil available phosphorus, exchangeable magnesium and potassium content.
- vi. Interaction between land configuration and cow dung manure application rate had significant influence on soil organic carbon, exchangeable magnesium, potassium and sodium content.

Findings in this study has revealed strong indications that there exists appreciable potential in the capacity of flat-bed and mound land surface shapes to improve soil physical condition and soil nutrient status for enhancement of soil productivity and possibly, higher crop yields.

Recommendation

On the basis of the aforementioned conclusions, flat-bed and mound land shapes and application of 10 t/ha of cow dung manure are hereby recommended for enhancement of soil physical and chemical properties in Minna, Southern guinea savanna zone of Nigeria.

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