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# DYNAMICS OF SOIL REACTION AND EFFECTS ON GROWTH OF CORCHORUS OLITORUS L. UNDER SEQUENTIAL APPLICATION OF ANIMAL MANURES

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## ABSTRACT

Availability of nutrients from different manure origins when soil pH changes to support plants yield in order to encourage food security due to increment of global change is critical. Hence, manure variability such as types, rates and application time on soil pH necessitates further study. This experiment probed effects of three animal-manures and their residuals on soil pH kinetics and Fresh Shoot yield (FSY) response of *Corchorus olitorius* L. A randomized complete block design experiment was conducted for 154 days; three cycles of 42 days per cycle with three replications. The rate of dried cattle, goat and poultry manures incorporated separately once at onset of the research were; 5, 10, 20, 40, 60, 80, 120 and 150 t ha$^{-1}$. Besides, $N_{15}P_{15}K_{15}$ at 0.4 t ha$^{-1}$ was added at 14, 56 and 98 Days on separate plots as check (first, second and third cycles). After Incorporation of manures determination of soil pH was carried out at every 14 days. At 42 Days After Planting (DAP) in each cycle, *Corchorus olitorius* L. FSY was assessed. Across cycles, applied manures increased ($p<0.01$) soil alkalinity while $N_{15}P_{15}K_{15}$ increased soil acidity. Increment in FSY of *Corchorus olitorius* L. irrespective of manure rates at second and third cycles was more than first cycle. Addition of cattle manure at 40 t ha$^{-1}$, goat at 60 t ha$^{-1}$ and poultry at 20 t ha$^{-1}$ enhanced the soil pH and *Corchorus olitorius* L. performance at first, second and third cycles.

Keywords: Animal manures; *Corchorus olitorius* L. fresh shoot yield; residual effects; soil pH kinetics.

# INTRODUCTION

Soil pH remains a soil chemical property which can be determined to predict soil nutrients availability. Soil pH directly affects the activities of the microbes. It directly affects the solubility of many of the nutrients in the soil needed for proper plant growth and development (Hanlon *et al*., 1993). The issue of a soil to provide plants with sufficient nutrients which plants can assimilate for the quality productivity has been a major concern due to inadequate land for crop propagation.

Decrease of soil fertility which leads to decline in crop productivity is widespread in all agricultural systems. Some factors that cause decrease soil fertility reported by Hartemink (2003) include: nutrient depletion, nutrient mining, acidification, loss of organic matter and increase in toxic elements. To sustain crop production, low soil fertility requires replenishment in farming systems (Demelash *et al*., 2014) through different practices of bio-intensive gardening, crop rotation, cover cropping, composting, use of plant wastes and animal manures or organic manures (Ramasasa, 2010) or bush fallow, use of bio-fertilizer, and use of inorganic fertilizers (Joeleebass, 2012).

Use of inorganic fertilizers is attractive due to their huge response, easy availability, transportation and application (Graham and Vance, 2000). Despite the improvement of plant growth using chemical fertilizers (Sarfaraz, 2010), high costs, variable nature of soils and inherent low nutrient conversion efficiency limit inorganic fertilizer applications (AGRA, 2007).

The natural materials of either plant or animal origin, which include livestock manures, green manures, crop residues, household wastes, compost and woodland litter (Basic Concept, 2006) affect the soil chemical, biological and physical properties positively (Haby *et al*., 2006). Hence, due to apparent decline in soil fertility, utilization of animal manures for crop production is required (Maerere *et al*., 2001), as animal manures offer an affordable and readily available solution to many soil fertility problems (Spore, 2006) and as plant nutrients source (Liang *et al*., 2005). Soil pH directly affects the life and growth of plants because it affects the availability of all plant nutrients (Paul, 2004). It is a useful predictor of the various chemical activities within the soil (Slattery *et al*., 1999) and a guide to likely deficiencies and / or toxicities (Mckenzie *et al*., 2004).

Most plant nutrients are in their available state between pH 6.0 and 6.5 (Paul, 2004). Macronutrients such as Nitrogen (N), Potassium ($K^+$), Calcium ($Ca^{2+}$), Magnesium ($Mg^{2+}$) and Sulphur (S) are more available at pH range between 6.5 and 8.0, with the exception of phosphorus which is available within pH range of 6.0 to 7.0 (McCauley *et al*., 2009).

The strategy for increasing crop yields and sustaining them at a high level must include the use of animal manure for management of soil nutrients and good farming practices. There are tested recommendations on appropriate use of organic manures for improving soil pH and also for *Corchorus olitorius* L. production. There is still a need to study the effects of animal manure on soil pH kinetics and yield of *Corchorus olitorius* L. at different rates, as well as NPK 15-15-15 fertilizer at the recommended rate when applied to the soil under the same environmental conditions and at the same time of planting *Corchorus olitorius* L. in cycles. Hence, manure variability such as types, rates and application time on soil pH necessitates further study.

The objectives of this research were to:

i. determine the effects of animal manures and their residual effects on soil pH kinetics,

ii. determine the fresh shoot yield of *Corchorus olitorius* L. with applied animal manures.

# METHODOLOGY

**The location of the research area**

The research was carried out at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria, located between latitude 7° 12 N and longitude 3° 20"E (FUNAAB, 2013). The agrometeorological distribution of the area during the experimental season did not follow the general distribution of the past years due to inadequate rainfall (Table 1).

The experimental design

Cattle, goat and poultry manures were applied at the rates of 5, 10, 20, 40, 60, 80, 120 and 150 t $ha^{-1}$ separately at the commencement of the experiment. As check, NPK 15-15-15 fertilizer was applied at the rate of 0.4 t $ha^{-1}$. The experiment was a randomized complete block design (RCBD) and replicated three times. After mechanical land preparation, raised beds 0.3 m high were prepared manually using hoe and five drills made on each bed for planting of *Corchorus olitorus* L. seeds.

Area of the farmland

The total experimental site was 18 m × 20 m, vegetable gross plot size was 1.5 m × 1.5 m and a spacing of 0.5 m was left between the adjacent beds to avoid bed edge contact and also to serve as walking path. The vegetable net plot size was 1.5 m × 0.6 m and the two edge rows were avoided to prevent border effect. However, the distance of 0.15 m was left on each bed between the bed edge and first drill while a planting distance of 0.30 m was left within each drill. NPK 15-15-15 fertilizer was applied at 0.10 m distance from seeded drills.

Duration of the study

The experiment was carried out during the wet season between April and October, 2013. The crop was planted in three consecutive cycles of six weeks per cycle. These were carried out to determine the residual effects of the manures that were incorporated prior to the first planting. First cycle of planting was carried out from May $15^{th}$ to June $25^{th}$, 2013, second cycle was from June $26^{th}$ to August $6^{th}$, 2013 and third cycle was from August $20^{th}$ to October $2^{nd}$, 2013.

Sources of manures, inorganic fertilizer and *Corchorus olitorius* L. seed

The animal manures (cattle, goat and poultry) were sourced from the College of Animal Science and Livestock Production Farm at FUNAAB. NPK 15-15-15 and *C. olitorius* L. seeds were sourced from Ministry of Agriculture, Obantoko Abeokuta.

Manures and soil analyses

Soil samples were collected at every 14 days with the exception of 42 Days After Incorporation (DAI) of manure due to absence of rainfall while at 56, 98 and 154 DAI, *C. olitorius* L. FSY was measured in each cycle. The soil samples were air dried, prepared for laboratory analysis of pH. The cattle, goat and poultry manures used were digested with 2: 1 nitric per chloric acid (Silva and Queiróz, 2002; Watanabe *et al.*, 2013).

The extracts were analyzed for total N, P, OC, $K^+$, $Ca^{2+}$, $Mg^{2+}$ and $Na^+$ using standard procedures. De-ionized water was used for extraction to determine the EC and pH of the manures. Initial soil used for this research was analyzed for EC, pH, total N, available P, exchangeable bases ($K^+$, $Ca^{2+}$, $Mg^{2+}$ and $Na^+$) and OC using standard methods described by Saka *et al.* (2017).

*Corchorus olitorius* **L. characteristic**

The *C. olitorius* L. plants were harvested from net plot of each replicate and the roots were rinsed with water and dried using tissue paper, and then weighed with loaded scale to obtain fresh shoot weight/ kg. FSY was calculated using the formula;

$$FSY\ (t\ ha^{-1}) = \frac{FSW\ (kg\ ha^{-1})}{1000\ kg}$$

Where; FSY = fresh shoot yield (t $ha^{-1}$)

FSW = fresh shoot weight (kg $ha^{-1}$)

Conversion factor = 1000 (kg)

**Statistical analysis**

Data collected were subjected to Analysis of Variance (ANOVA) using SAS (1999). Duncan Multiple Range Test at 5 % probability level was used to check differences in the treatment rates means and also to show the significance effects on parameters measured in relation to control.

# RESULTS

**Agrometeorological parameters for the experimental period**

The rainfall/ month data obtained during first, second and third cycles of planting *C. olitorius* L. were 176.60, 213.80 and 166.00mm, average relative humidity/ day were 74.30, 81.76 and temperature/ day were 28.90, 30.12 and 27.23 °C, mean sunshine hour/ day were 5.70, 3.10 and 3.95 and evaporation/ day were 3.25, 0.77 and 3.97 mm, respectively (Table 1).

**Table 1: Agrometeorological parameters for the period of the experiment**

| Agrometeorological parameters | cycles of planting jute mallow (DAI) | | |
|---|---|---|---|
| | 1st (14-56) | 2nd (56-98) | 3rd (98-154) |
| Rainfall/ month (mm) | 176.60 | 213.80 | 166.00 |
| Average R. H./day (%) | 74.30 | 81.76 | 79.72 |
| Mean temp./ day (°C) | 27.60 | 47.00 | 25.98 |
| Soil temp./ day (°C) | 28.90 | 30.12 | 27.23 |
| Mean sunshine hr./ day | 5.70 | 3.10 | 3.95 |
| Evaporation/ day (mm) | 3.25 | 0.77 | 3.97 |

Temp. = temperature,mm=millimeter hr. = hourR . H . = relative humidity
Evap. = Evaporation1,st=first cycle, 3rd = third cycle, 2nd = second cycle
Source: Federal University of Agriculture, Abeokuta AGROMET STATION, May-October, 2013
Soil temperature at the depth of 20 cm

79.72 %, mean atmospheric temperature/ day were 27.60, 47.00 and 25.98 °C, mean soil

Manure analysis

The EC of dried cattle, goat and poultry manures applied gave 12.4, 8.8 and 16.4 dS $m^{-1}$ and pH 7.9, 7.7 and 7.8, respectively (Table 2). The total N gave 45.1, 48.2, 27.8 g $kg^{-1}$, available P gave 3.2, 0.7, 16.2 g $kg^{-1}$ and OC were 178.8, 223, 59.3 g $kg^{-1}$ for cattle, goat and poultry manures, respectively. However, total K gave 7.4, 3.7, 3.9 g $kg^{-1}$, Ca gave 29.6, 18.1, 17.7 g $kg^{-1}$, Mg gave 9.5, 10.0, 5.3 g $kg^{-1}$ and Na recorded 9.3, 4.6, 4.9 g $kg^{-1}$ for cattle, goat and poultry manures, respectively.

**Soil analysis**

The pre - cropping soil used for the research had EC value of 0.69 dS $m^{-1}$ and pH value of 7.6. The total N was 0.8 g $kg^{-1}$, available P was 7.5 mg $kg^{-1}$ and OC was 14.2 g $kg^{-1}$. Exchangeable bases ($K^+$, $Ca^{2+}$, $Mg^{2+}$ and $Na^+$) were 0.42, 10.96, 1.34 and 0.82 $cmol^+ kg^{-1}$, respectively. Soil particle size classifications were 770, 68 and 162 g $kg^{-1}$ for sand, silt and clay, respectively (Table 3).

**Impact of cattle, goat and poultry manures on soil pH**

**Impact of cattle manure on soil pH at first cycle of planting** ***C. olitorius***

At planting (14 DAI), soil with cattle amendment at 120 t $ha^{-1}$ had pH of 8.4 and gave highest increase of 22 % while lowest increase of 2.5 % was recorded with 5 and 10 t $ha^{-1}$ application with pH of 7.0 each (Table 4) more than control. Application of cattle manure relative to control increased soil pH depending on the rates. At 28 DAI, cattle manure rate of 80 t $ha^{-1}$ stimulated pH of 7.7 and recorded highest increase of 26.85 % while 5 t $ha^{-1}$ had 6.2 in soil pH and recorded least increase of 2.65 % above the control. Soil applied with cattle manure rate of 60 t $ha^{-1}$ was significantly higher in pH 8.1 increased by 28.52 % more than the control compared with other amendment rates at 56 DAI. The least increment of 3.17 % was recorded from NPK with pH 6.5 (Table 4).

Table 2: Some chemical properties of the cattle, goat and poultry manures used for the research

| Chemical properties | Values | | | |
|---|---|---|---|---|
| | Cattle | Goat | Poultry | NPK |
| pH Soil: $H_2O$ (1: 2) | 7.90 | 7.70 | 7.80 | - |
| Electrical conductivity (dS $m^{-1}$) | 12.40 | 8.80 | 16.40 | - |
| Total nitrogen (g $kg^{-1}$) | 45.10 | 48.2 | 27.8 | 150 |
| Total phosphorus (g $kg^{-1}$) | 3.20 | 0.70 | 16.2 | 150 |
| Total potassium (g $kg^{-1}$) | 7.40 | 3.70 | 3.90 | 150 |
| Total sodium (g $kg^{-1}$) | 9.30 | 4.60 | 4.90 | - |
| Total calcium (g $kg^{-1}$) | 29.60 | 18.10 | 17.70 | - |
| Total magnesium (g $kg^{-1}$) | 9.50 | 10.00 | 5.30 | - |
| Total organic carbon (g $kg^{-1}$) | 178.80 | 223.00 | 59.30 | - |
| Carbon: Nitrogen | 3.97 | 4.63 | 2.13 | - |

Residual effects of cattle manure on soil pH at second cycle of planting *C. olitorius*

At 70 DAI, cattle manure rate of 120 t $ha^{-1}$ gave soil pH 9.5 and recorded highest increment of 16 % over control (Table 4). The rate of 5 t $ha^{-1}$ stimulated soil pH 8.4 and had least increment of 2 % while soil applied with NPK recorded pH 5.2 and reduced by 58 %. At 84 DAI, cattle manure rate of 150 t $ha^{-1}$ stimulated pH 9.2 and gave greatest increment. But 5 t $ha^{-1}$ recorded pH 8.5 and had least increment of 2 % relative to control while NPK gave pH 7.5 and reduced the soil pH by 11 %. However, soil pH increment varied depending on the cattle amendment rates. At 98 DAI, 60, 80 and 150 t $ha^{-1}$ with soil pH 9.4 each recorded greatest increment by 12 % over the control. While 10 t $ha^{-1}$ stimulated pH 8.6 and had the least increment of 1 % but NPK had pH 7.6 and reduced by 11 %. The levels of increments in soil pH according to cattle amendment rates were not sequenced (Table 4).

Table 3: Some physical and chemical properties of the soil used for the research

| Physical and chemical properties | Values |
|---|---|
| pH Soil: $H_2O$ (1: 2) | 7.60 |
| Electrical conductivity (dS $m^{-1}$) | 0.69 |
| **Macro nutrients:** | |
| Total nitrogen (g $kg^{-1}$) | 1.20 |
| Available phosphorus (mg $kg^{-1}$) | 7.50 |
| **Exchangeable bases:** | |
| Potassium ($cmol^+$ $kg^{-1}$) | 0.42 |
| Sodium ($cmol^+$ $kg^{-1}$) | 0.82 |
| Calcium ($cmol^+$ $kg^{-1}$) | 10.96 |
| Magnesium ($cmol^+$ $kg^{-1}$) | 1.34 |
| Organic- carbon | 14.20 |
| **Particle size distribution:** | |
| Sand (g $kg^{-1}$) | 770.00 |
| Silt (g $kg^{-1}$) | 68.00 |
| Clay (g $kg^{-1}$) | 162.00 |
| Textural class | Sandy clay loam |

Table 4: Impact of cattle manure rates and NPK (t $ha^{-1}$) on mean soil pH at two weeks interval under first, second and third cycles of planting jute mallow

| | Mean of soil pH at two weeks interval with applied cattle manure | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | First cycle of planting | | | Second cycle of planting | | | Third cycle of planting | | |
| Rates t $ha^{-1}$ | 14 DAI | 28 DAI | 56 DAI | 70 DAI | 84 DAI | 98 DAI | 126 DAI | 140 DAI | 154DAI |
| 0 | $6.83^{c}$ | $6.07^{e}$ | $6.30^{c}$ | $8.17^{f}$ | $8.30^{d}$ | $8.43^{c}$ | $6.43^{d}$ | $6.40^{c}$ | $6.07^{d}$ |
| 5 | $7.00^{c}$ | $6.23^{d}$ | $7.17^{b}$ | $8.44^{e}$ | $8.50^{cd}$ | $8.50^{c}$ | $6.97^{c}$ | $6.83^{b}$ | $6.57^{c}$ |
| 10 | $7.00^{c}$ | $6.30^{d}$ | $6.57^{c}$ | $8.53^{e}$ | $8.30^{d}$ | $8.57^{c}$ | $6.33^{d}$ | $6.33^{c}$ | $6.90^{b}$ |
| 20 | $7.10^{c}$ | $6.27^{d}$ | $7.40^{b}$ | $8.53^{e}$ | $8.47^{cd}$ | $8.40^{c}$ | $6.90^{c}$ | $6.60^{bc}$ | $6.87^{b}$ |
| 40 | $7.75^{b}$ | $7.20^{c}$ | $7.97^{a}$ | $9.10^{d}$ | $8.70^{bc}$ | $9.00^{b}$ | $7.30^{b}$ | $6.97^{b}$ | $7.03^{b}$ |
| 60 | $8.03^{ab}$ | $7.30^{bc}$ | $8.10^{a}$ | $9.23^{cd}$ | $9.03^{a}$ | $9.43^{a}$ | $7.53^{a}$ | $7.53^{a}$ | $6.90^{b}$ |
| 80 | $7.73^{b}$ | $7.70^{a}$ | $7.33^{b}$ | $9.30^{bc}$ | $8.93^{ab}$ | $9.43^{a}$ | $7.30^{b}$ | $7.43^{a}$ | $7.70^{a}$ |
| 120 | $8.40^{a}$ | $7.63^{a}$ | $7.87^{a}$ | $9.53^{a}$ | $9.10^{a}$ | $9.27^{ab}$ | $7.30^{b}$ | $7.80^{a}$ | $7.63^{a}$ |
| 150 | $8.33^{ab}$ | $7.40^{b}$ | $8.03^{a}$ | $9.40^{ab}$ | $9.17^{a}$ | $9.43^{a}$ | $7.60^{a}$ | $7.57^{a}$ | $7.70^{a}$ |
| 0.4 | $6.83^{c}$ | $5.37^{f}$ | $6.47^{c}$ | $5.20^{g}$ | $7.47^{e}$ | $7.57^{d}$ | $5.13^{e}$ | $5.40^{d}$ | $5.43^{e}$ |

Means followed by the same letter(s) within the same columns do not differ significantly at $P < 0.05$ according to Duncan Multiple Range Test

DAI = days after incorporation of manures t $ha^{-1}$ = tons per hectare

Residual effects of cattle manure on soil pH at third cycle of planting *C. olitorius*

At126 DAI, cattle manure rate of 150 t $ha^{-1}$ had pH 7.6 and gave highest increment of 19 % over the control while 5 t $ha^{-1}$ recorded pH 6.9 and had lowest increment of 9 % but NPK had pH 5.2 and recorded a decrease of 20 % (Table 4). Cattle manure rate of 120 t $ha^{-1}$ had pH 7.8 and recorded highest increment of 22 %. Treatment with 20 t $ha^{-1}$ gave pH 6.6 and had least increment of 3 % relative to control at 140 DAI. There were reductions of soil pH in 10 t $ha^{-1}$ and NPK by 2 and 16 %, respectively. At 154 DAI, cattle manure rates of 80 and 150 t $ha^{-1}$ had pH 7.7 each and these recorded highest increase of 26 % above the control. The rate of 5 t $ha^{-1}$ gave soil pH 6.6 and had lowest increment of 8 % but there was a reduction of 16 % in NPK with pH 5.4. However, soil pH increment of 126, 140 and 154 DAI according to cattle amendment rates were not sequenced likewise across weeks after planting (Table 4).

Impact of goat manure on soil pH at first cycle of planting *C. olitorius*

At planting (14 DAI), soil incorporated with goat manure rate of 120 t $ha^{-1}$ gave pH 8.0 and had highest increment of 25 % while 5 t $ha^{-1}$and NPK gave pH 6.6 each and recorded lowest increment of 3 % relative to control (Table 5). Addition of goat manure increased the soil pH according to the rates except 60and 150 t $ha^{-1}$ that reduced by 4 and 3 %, respectively. At 28 DAI, goat manure rate of 120 t $ha^{-1}$ recorded soil pH 7.3 and gave highest increment of 22 % while 10, 20 and 40 t $ha^{-1}$ recorded pH value of 6.3 each and gave lowest increase of 5 % but NPK with pH value of 5.3 reduced by 11 % relative to control. The soil pH varied depending on goat amendment rates. At 56 DAI, goat manure rate of 150 t $ha^{-1}$ stimulated soil pH 7.5 and recorded highest increase of 12 % over the control. However, the soil pH values in accordance with goat manure rates were erratic (Table 5).

Table 5: Impact of goat manure rates and NPK (t $ha^{-1}$) on mean soil pH at two weeks interval under first, second and third cycles of planting jute mallow

| Rates t $ha^{-1}$ | Mean of soil pH at two weeks interval with applied goat manure | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | First cycle of planting | | | Second cycle of planting | | | Third cycle of planting | | |
| | 14 DAI | 28 DAI | 56 DAI | 70 DAI | 84 DAI | 98 DAI | 126 DAI | 140 DAI | 154DAI |
| 0 | $6.40^{d}$ | $5.96^{d}$ | $6.67^{de}$ | $7.83^{c}$ | $7.80^{d}$ | $7.80^{d}$ | $6.06^{f}$ | $5.93^{f}$ | $6.13^{e}$ |
| 5 | $6.63^{d}$ | $5.40^{d}$ | $6.93^{cd}$ | $8.40^{b}$ | $8.40^{abc}$ | $8.33^{c}$ | $6.40^{e}$ | $6.73^{d}$ | $6.23^{e}$ |
| 10 | $6.66^{d}$ | $6.33^{c}$ | $6.46^{ef}$ | $8.40^{b}$ | $8.27^{c}$ | $8.40^{c}$ | $6.43^{e}$ | $6.60^{d}$ | $6.47^{d}$ |
| 20 | $7.40^{c}$ | $6.33^{c}$ | $7.03^{c}$ | $8.43^{b}$ | $8.50^{ab}$ | $8.50^{bc}$ | $6.83^{cd}$ | $6.30^{e}$ | $6.83^{c}$ |
| 40 | $7.77^{ab}$ | $6.33^{c}$ | $6.70^{de}$ | $8.56^{b}$ | $8.50^{ab}$ | $8.57^{bc}$ | $6.93^{bc}$ | $7.00^{bc}$ | $6.80^{c}$ |
| 60 | $7.50^{bc}$ | $6.46^{c}$ | $7.17^{bc}$ | $8.50^{b}$ | $8.40^{abc}$ | $8.73^{b}$ | $6.50^{e}$ | $7.10^{b}$ | $6.97^{bc}$ |
| 80 | $7.63^{bc}$ | $7.03^{b}$ | $7.47^{ab}$ | $8.40^{b}$ | $8.37^{bc}$ | $8.57^{bc}$ | $6.70^{d}$ | $6.80^{cd}$ | $7.13^{ab}$ |
| 120 | $8.00^{a}$ | $7.30^{a}$ | $7.43^{ab}$ | $9.00^{a}$ | $8.60^{a}$ | $9.27^{a}$ | $7.30^{a}$ | $7.03^{bc}$ | $7.20^{a}$ |
| 150 | $7.80^{ab}$ | $7.06^{b}$ | $7.53^{a}$ | $8.50^{b}$ | $8.57^{ab}$ | $8.53^{bc}$ | $7.06^{b}$ | $7.33^{a}$ | $7.30^{a}$ |
| 0.4 | $6.60^{d}$ | $5.30^{e}$ | $6.33^{f}$ | $5.10^{d}$ | $7.47^{e}$ | $7.53^{d}$ | $5.23^{g}$ | $5.83^{f}$ | $5.37^{f}$ |

Means followed by the same letter(s) within the same columns do not differ significantly at $P < 0.05$ according to Duncan Multiple Range Test

DAI = days after incorporation of manures t $ha^{-1}$ = tons per hectare

**Residual effects of goat manure on soil pH at second cycle of planting *C. olitorius***

The result revealed that at 70 DAI, goat manure rate of 120 t $ha^{-1}$ gave soil pH 9.0 and recorded highest increment of 15 % while 5 t $ha^{-1}$ resulted to pH 8.4 and had least increment of 8 % in relation to control but NPK with pH 5.1 reduced by 35 % (Table 5). However, at 81 DAI, goat manure rate of 120 t $ha^{-1}$ resulted to pH 8.6 and recorded highest increment of 10 % over the control. While 10 t $ha^{-1}$ stimulated pH 8.3 and had least increment of 6 % but NPK recorded pH 7.5 and reduced by 4 %. At 98 DAI, soil applied with goat manure rate of 120 t $ha^{-1}$ gave PH 9.3 and recorded highest increase of 19 %, 5 t $ha^{-1}$ stimulated pH 8.3 and had lowest increment of 6 % while NPK had pH 7.5 and reduced by 4 % compared with control. The level of increment in soil pH varied according to goat amendment rates for 70, 84 and 98 DAI likewise across days after planting (Table 5).

**Residual effects of goat manure on soil pH at third cycle of planting *C. olitorius***

Goat manure rate of 120 t $ha^{-1}$ resulted to soil pH 7.3 (Table 5). This was significantly higher and increased the pH level by 20 %. While 5 and 10 t $ha^{-1}$ recorded pH 6.4 each and had least increase of 5 % but NPK had pH 5.2 and decreased by 15 % compared with control at 126 DAI. The levels of pH increment according to goat amendment rates were not consistent. There was a highest significant increase of soil pH in goat amendment rate of 150 t $ha^{-1}$ which had pH 7.3 by 24 %. While 20 t $ha^{-1}$ gave pH 6.3 and recorded least increase of 7 % relative to control. But 2 % decrease resulted with application of NPK with pH 5.8, at 140 DAI. At 154 DAI, soil added with goat manure rate of 150 t $ha^{-1}$ stimulated pH 7.3 which increased by 20 %, while least increase of 2 % was recorded from 5 t $ha^{-1}$ with pH value of 6.2, relative to control. Increase in rates of goat manure led to increase in soil pH (Table 5).

**Impact of poultry manure on soil pH at first cycle of planting *C. olitorius***

At planting (14 DAI), poultry manure rate of 40 t $ha^{-1}$ resulted to soil pH 7.5 and had highest increment of 15 % (Table 6). The rates of 5 and 20 t $ha^{-1}$ gave similar pH 6.6 each and had least increment of 2 % while NPK recorded pH 6.4 reduced the soil pH by 2 % in relation to control. At 28 DAI, poultry manure rates of 40 and 150 t $ha^{-1}$ stimulated same pH 6.5 each and had highest increase of 12 % while 5 t $ha^{-1}$ recorded pH 6.1 but had lowest increment of 5 % but NPK resulted to pH 5.5 and decreased by 5 % relative to control. At 56 DAI, poultry manure rate of 40 t $ha^{-1}$ stimulated pH 7.0 and recorded highest increase of 13 % while 5 t $ha^{-1}$ gave pH 6.4 and had least increase of 3 % above the control (Table 6).

**Residual effects of poultry manure on soil pH at second cycle of planting *C. olitorius***

At 70 DAI, poultry manure rate of 20 and 120 t $ha^{-1}$ gave pH 8.7 each, these recorded highest increment of 6 % (Table 6). The rate of 10 t $ha^{-1}$ stimulated pH 8.4 and had least increment of 2 % while NPK gave pH 5.2 and reduced by 37 % relative to control. At 84 DAI, poultry manure rate of 150 t $ha^{-1}$ resulted to pH 8.7 and recorded greatest increment of soil pH by 12 % over the control. Treatments of 5, 40 and 80 t $ha^{-1}$ that stimulated pH 8.5 each, had least increments of 9 % but NPK gave pH 7.4 and decreased by 5 %. At 98 DAI, poultry manure rate of 60 t $ha^{-1}$ had pH 8.9 and recorded highest increase of 10 % while 5 and 10 t $ha^{-1}$ recorded pH 8.5 each with the lowest increase of 5 %. But NPK gave pH 7.7 and reduced by 5 % relative to control. The level of increment in soil pH varied at 70, 84 and 98 DAI depending on the poultry amendment rates and also across weeks after planting (Table 6).

Table 6: Impact of poultry manure rates and NPK (t $ha^{-1}$) on mean soil pH at two weeks interval under first, second and third cycles of planting jute mallow

| Rates t $ha^{-1}$ | Mean of soil pH at two weeks interval with applied poultry manure | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | First cycle of planting | | | Second cycle of planting | | | Third cycle of planting | | |
| | 14 DAI | 28DAI | 56 DAI | 70 DAI | 84 DAI | 98 DAI | 126 DAI | 140 DAI | 154DAI |
| 0 | $6.50^{cd}$ | $5.83^{e}$ | $6.20^{d}$ | $8.23^{cd}$ | $7.83^{d}$ | $8.13^{c}$ | $6.30^{c}$ | $6.07^{f}$ | $6.17^{g}$ |
| 5 | $6.60^{cd}$ | $6.13^{d}$ | $6.47^{c}$ | $8.20^{d}$ | $8.50^{c}$ | $8.53^{b}$ | $6.43^{c}$ | $6.70^{d}$ | $6.30^{fg}$ |
| 10 | $6.73^{c}$ | $6.30^{bc}$ | $6.50^{c}$ | $8.37^{bcd}$ | $8.60^{ab}$ | $8.53^{b}$ | $6.77^{b}$ | $6.70^{d}$ | $6.47^{de}$ |
| 20 | $7.60^{cd}$ | $6.20^{cd}$ | $6.63^{bc}$ | $8.47^{abc}$ | $8.57^{bc}$ | $8.60^{b}$ | $6.80^{ab}$ | $6.50^{e}$ | $6.33^{ef}$ |
| 40 | $7.50^{a}$ | $6.47^{a}$ | $7.03^{a}$ | $8.67^{a}$ | $8.50^{c}$ | $8.77^{ab}$ | $6.83^{ab}$ | $6.93^{bc}$ | $6.70^{c}$ |
| 60 | $7.20^{b}$ | $6.17^{cd}$ | $6.63^{bc}$ | $8.53^{ab}$ | $8.53^{bc}$ | $8.97^{a}$ | $6.97^{a}$ | $7.03^{ab}$ | $6.57^{cd}$ |
| 80 | $7.30^{ab}$ | $6.40^{ab}$ | $6.53^{c}$ | $8.57^{ab}$ | $8.50^{c}$ | $8.73^{b}$ | $6.50^{c}$ | $6.70^{d}$ | $6.93^{b}$ |
| 120 | $7.43^{ab}$ | $6.37^{ab}$ | $6.53^{c}$ | $8.67^{a}$ | $8.53^{bc}$ | $8.60^{b}$ | $6.83^{ab}$ | $7.13^{a}$ | $7.00^{b}$ |
| 150 | $7.30^{ab}$ | $6.50^{a}$ | $6.77^{b}$ | $8.13^{d}$ | $8.67^{a}$ | $8.57^{b}$ | $7.00^{a}$ | $6.90^{c}$ | $7.20^{a}$ |
| 0.4 | $6.43^{d}$ | $5.53^{f}$ | $6.23^{d}$ | $5.23^{e}$ | $7.43^{e}$ | $7.67^{d}$ | $5.20^{d}$ | $5.17^{g}$ | $5.47^{h}$ |

Means followed by the same letter(s) within the same columns do not differ significantly at $P < 0.05$ according to Duncan Multiple Range Test

DAI = days after incorporation of manures t $ha^{-1}$ = tons per hectare

**Residual effects of poultry manure on soil pH at third cycle of planting** ***C. olitorius***

Poultry manure rate of 150 t $ha^{-1}$ stimulated pH 7.0 and had 11 % increases over the control, but the least increase of 2 % was recorded from 5 t $ha^{-1}$ with pH 6.4 (Table 6). A reduction of 35 % was recorded from NPK with pH 5.2 relative to control, at 126 DAI. However, at 140 DAI, poultry manure rate of 120 t $ha^{-1}$ stimulated pH 7.1 and gave highest increment of 16 % over the control. The rate of 20 t $ha^{-1}$ gave pH 6.5 and recorded least increase of 7 % while 15 % decrease resulted in NPK with pH 5.2 relative to control. At 154 DAI, poultry manure rate of 150 t $ha^{-1}$ resulted to pH 7.2 and had highest increase of 16 % while least increase of 2 % was recorded from 5 t $ha^{-1}$ with pH 6.3 compared with control. A decrease of 11 % was recorded from NPK with pH 5.5 relative to control. The level of increment according to the amendment rates for 126, 140 and 154 DAI were erratic similarly, across weeks after planting (Table 6).

**Characteristic of** ***C. olitorius*** **as affected by cattle, goat and poultry manures**

*The fresh shoot yield (FSY) (t $ha^{-1}$) of C. olitorius as affected by cattle, goat and poultry manures at harvesting of first cycle of planting*

Cattle amendment rate at 80 t $ha^{-1}$ had FSY 22.79 t $ha^{-1}$ and resulted to highest increase of 410 % while 120 t $ha^{-1}$ recorded FSY 8.06 t $ha^{-1}$ and resulted to least increase of 80 % more than the control (Table 7). The goat manure rate of 10 t $ha^{-1}$ recorded 22.59 t $ha^{-1}$ resulted to highest increase of 363 % but 5 t $ha^{-1}$ with FSY 1.83 t $ha^{-1}$ resulted to least increase of 112 % relative to control. The poultry amendment rate at 40 t $ha^{-1}$ had FSY 18.74 t $ha^{-1}$ and had highest increase of 289 % while 150 t $ha^{-1}$ with FSY 7.94 t $ha^{-1}$ gave least increase of 65 % above the control.

However, increments according to cattle, goat and poultry amendment rates were erratic (Table 7).

**Residual effects of cattle, goat and poultry manures on *C. olitorius* FSY (t ha$^{-1}$) at harvesting of second cycle of planting**

Cattle, goat and poultry manure rate of 150 t ha$^{-1}$ had highest FSY (38.53, 30.39 and 35.68 t ha$^{-1}$) with highest increase of 115, 93 and 170 % respectively over the control at harvesting of second cycle of planting (Table 7).

Table 7: Significance of cattle, goat, poultry manure rates and NPK fertilizer (t ha$^{-1}$) on mean fresh shoot yield (t ha$^{-1}$) of jute mallow at harvesting of first, second and third cycles of planting

| Rates t ha$^{-1}$ | Mean of fresh shoot yield of *Corchorus olitorius* (t ha$^{-1}$) | | | | | | | | | Mean across cycles | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cattle | | | Goat | | | Poultry | | | Cattle | Goat | Poultry |
| | FCP | SCP | TCP | FCP | SCP | TCP | FCP | SCP | TCP | | | |
| 0 | 4.47$^{e}$ | 17.90$^{c}$ | 9.87$^{b}$ | 4.88$^{b}$ | 15.76$^{b}$ | 15.81$^{b}$ | 4.82$^{c}$ | 13.20$^{b}$ | 15.17$^{a}$ | 10.75$^{d}$ | 12.15$^{e}$ | 11.06$^{c}$ |
| 5 | 8.54$^{de}$ | 32.56$^{a}$ | 15.47$^{b}$ | 10.32$^{ab}$ | 19.23$^{ab}$ | 15.67$^{b}$ | 8.61$^{bc}$ | 26.16$^{a}$ | 13.99$^{a}$ | 18.86$^{cd}$ | 15.07$^{e}$ | 16.25$^{bc}$ |
| 10 | 9.69$^{cde}$ | 29.62$^{abc}$ | 14.28$^{b}$ | 22.59$^{a}$ | 17.48$^{ab}$ | 19.48$^{ab}$ | 10.05$^{bc}$ | 29.18$^{a}$ | 18.29$^{a}$ | 17.86$^{cd}$ | 19.85$^{d}$ | 19.17$^{abc}$ |
| 20 | 18.11$^{ab}$ | 28.78$^{abc}$ | 24.15$^{ab}$ | 11.86$^{ab}$ | 27.53$^{ab}$ | 16.32$^{b}$ | 16.49$^{ab}$ | 22.56$^{ab}$ | 16.59$^{a}$ | 23.68$^{bc}$ | 18.57$^{d}$ | 18.55$^{abc}$ |
| 40 | 15.53$^{abcd}$ | 30.59$^{abc}$ | 21.43$^{ab}$ | 14.35$^{ab}$ | 30.11$^{a}$ | 23.22$^{ab}$ | 18.74$^{a}$ | 29.67$^{a}$ | 15.06$^{a}$ | 22.52$^{b}$ | 22.56$^{ab}$ | 21.16$^{ab}$ |
| 60 | 20.23$^{a}$ | 31.24$^{abc}$ | 35.50$^{a}$ | 22.49$^{a}$ | 31.29$^{a}$ | 31.90$^{a}$ | 13.15$^{bcd}$ | 25.88$^{a}$ | 24.89$^{a}$ | 28.99$^{a}$ | 28.56$^{a}$ | 21.31$^{ab}$ |
| 80 | 22.79$^{a}$ | 25.69$^{abc}$ | 26.68$^{ab}$ | 18.93$^{ab}$ | 28.09$^{ab}$ | 27.82$^{ab}$ | 12.86$^{bc}$ | 27.21$^{a}$ | 21.26$^{a}$ | 25.05$^{b}$ | 24.95$^{ab}$ | 20.44$^{ab}$ |
| 120 | 8.06$^{de}$ | 34.09$^{ab}$ | 25.88$^{ab}$ | 15.54$^{ab}$ | 30.89$^{a}$ | 28.02$^{a}$ | 8.66$^{bc}$ | 28.51$^{a}$ | 24.45$^{a}$ | 22.68$^{b}$ | 23.58$^{ab}$ | 20.54$^{ab}$ |
| 150 | 10.59$^{cde}$ | 38.53$^{a}$ | 27.38$^{ab}$ | 12.00$^{ab}$ | 30.39$^{a}$ | 24.51$^{ab}$ | 7.94$^{bc}$ | 35.68$^{a}$ | 23.81$^{a}$ | 25.50$^{a}$ | 22.30$^{ab}$ | 22..48$^{a}$ |
| 0.4 | 12.65$^{bcde}$ | 23.24$^{bc}$ | 18.56$^{ab}$ | 12.39$^{ab}$ | 29.32$^{ab}$ | 20.90$^{ab}$ | 9.66$^{bc}$ | 29.70$^{a}$ | 15.74$^{a}$ | 18.15$^{bcd}$ | 20.87$^{bc}$ | 18.37$^{ab}$ |

Means followed by the same letter(s) within the same columns do not differ significantly at $P < 0.05$ according to Duncan Multiple Range Test.
FCP = first cycle of planting. SCP = second cycle of planting. TCP = third cycle of planting.

Residual effects of cattle, goat and poultry manures on *C. olitorius* FSY (t ha$^{-1}$) at harvesting of third cycle of planting.

Highest increment of 260 and 102 % resulted in cattle and goat manure rate of 60 t ha$^{-1}$ over the control and this recorded FSY 35.50 and 31.90 t ha$^{-1}$, respectively, but there were no significant differences in poultry manure rates at harvesting of third cycle of planting (Table 7).

## DISCUSSION

Manure and soil characteristics

The EC of the cattle, goat and poultry manures applied were considered very strongly saline and confirmed the report of LAS (2014) that EC value above 3.2 mS cm$^{-1}$ was very strongly saline. This could be as a result of high concentration of cationic salts in the manures. More so, the highest EC value of poultry manure compared with the cattle and goat manures support the findings of Azeez and Van Averbeke, (2010[a]; 2010[b]), that poultry manure had greater EC values than cattle or goat manures. This could be attributed to the highest $NH_4^+$- N, $NO_3^-$-N and total P contents in poultry manure.

The pH of the goat and poultry manures were considered mildy alkaline whereas, while that of cattle manure was moderately alkaline. This corroborated the report of Pam and Brian (2007) that pH values of between 7.4 and 7.8 were mildy alkaline while that between 7.9 and 8.4 were moderately alkaline. This would allow for nutrients availability in the soil after mineralization.

The poultry manure had higher $NH_4^+$- N, $NO_3^-$-N and total phosphorus compared with cattle and goat manures. It was observed from the result that cattle manure had the higher total $K^+$, total $Na^+$ and total $Ca^{2+}$ over the goat and poultry manures. However, goat manure was higher in total N, Mg and OC in relation to cattle and poultry manures. Furthermore, very low value of total P in goat could be as a result of the nutrient concentrations of the feed given to the animals. The C: N ratio values of the cattle, goat and poultry manures were considered low (Brady and Weil, 1999; Sylvia *et al*., 2004). The cattle manure ratio did not follow 11.3 for liquid dairy manure and 17.2 for solid dairy manure reported by Burger and Venterea (2008) whereas, Bitzer and Sims (1988) suggested that poultry manure generally had quite low C: N ratio ranging from 1 – 27: 1. This would aid mineralization of nitrogen in the soil (Brady and Weil, 1999; Sylvia *et al*., 2004) that soil amendments with low C: N ratio values portend N mineralization and increased plant nutrients availability. These low C: N ratio of the three manures applied would improve the performance of *Corchorus olitorius* L. as reported (Azam, 2002; Azeez and Van Averbeke, 2010[b]) that manures with high C: N ratio would retard plant growth by reducing plant availability of soil N. Low C: N ratio in poultry manure compared with cattle and goat manures showed that poultry manure had higher quality than other two manures.

Equivalent amount of total N contents present in goat manure applied was higher than cattle and poultry manures while the $NH_4^+$- N and $NO_3^-$- N contents in poultry manure were superior to cattle and goat manures incorporated which showed that poultry manure had high N nutrient quality than cattle and goat manures (Azeez and Van Averbeke, 2010[b]). This implied that poultry manure contained more available N that *Corchorus olitorius* L. utilized during the research than cattle and goat manures while other organic N contents such as amino acids and fatty acids could be the reason behind high total N in cattle and goat manures. High P content in poultry manure could also contribute to the yield quality of *Corchorus olitorius* L. at lower rates than cattle and goat manures. These high rates of $NH_4^+$- N, $NO_3^-$- N and total P in poultry manure could be the reason for highest EC value in poultry manure than cattle and goat manures.

Cattle manure recorded higher equivalent amount of pH, total K, Na and Ca than goat and poultry manures. This could be attributed to the higher EC value in cattle manure than goat manure. This confirmed the studies of Monica (2013) that EC of a soil is influenced by the concentration and composition of dissolved salts. This contributed to low values of *Corchorus olitorius* L. at high rates of cattle manure during the first cycle of planting in the experiment. This is because excessive $K^+$ could lead to accumulation and elevated $K^+$ levels in the soil (Marx *et al*., 1999); excess $Na^+$ could lead to soil sodicity and dispersion while $Ca^{2+}$ could lead to dispersion of the soil (Emerson and Bakker, 1973; Davis *et al*., 2012).

Higher contents of total N, Mg, OC and C: N ratio in goat manure compared with cattle and poultry manures suggested the reason for lowest value of EC in goat manure applied during the research. This is because Mg was the only salt forming cation that was highest in goat manure. Higher total N could be as a result of N level in the feed given to the goat animals. This could contribute to the highest OC in goat manure applied.

The soil used for the research could be classified as very slightly saline since it was between 0.4 and 0.8 mS $cm^{-1}$ reported by LAS (2014). This could still support the growth of *Corchorus olitorius* L. since it was observed from this research that *Corchorus olitorius* L. was not a very salt sensitive crop. The soil was slightly alkaline which was between 7.4 and 7.8 stated by Pam and Brian (2007). This was optimal for performance of *Corchorus olitorius* L. since the vegetable performed well in slightly alkaline soils (Fasciola, 1990).

The soil was deficient in total nitrogen (USDA-SCS, 1974) and was 0.1 % which was equivalent to 1 g $kg^{-1}$ (McBride, 2015). Moreover, the $NH_4^+$- N content of 0.13 g $kg^{-1}$ of the soil was high. This could be attributed to low immobilization as a result of the normal C: N ratio of the soil. High $NO_3^-$- N content of 0.14 g $kg^{-1}$ of the soil could be as a result of low rainfall during this period. These could support the growth of *Corchorus olitorius* L. because they were the available form of nitrogen to crops (Marx *et* al., 1999). The Available P content of 7.5 mg $kg^{-1}$ was low (Mallarino, 2000; ENDMEMO, 2015).

Exchangeable $K^+$ and $Mg^{2+}$ were moderate; falling between 0.3 and 0.7 and 1 – 3 $cmol^+ kg^{-1}$ for $K^+$ and $Mg^{2+}$, respectively calibrated by Pam and Brian (2007) and were optimal for performance of the crop. High exchangeable $Na^+$ and $Ca^{2+}$ contents of the soil support the range of 0.7 – 2.0 and 10 – 20 $cmol^+ kg^{-1}$, respectively reported by Pam and Brian (2007). These high salts of $Na^+$ and $Ca^{2+}$ of the soil could be attributed to the decomposition of the organic matter content of the soil due to high temperature, evaporation rate, sunshine hours/ day and low rainfall during the research. This confirmed the studies of some researchers (Davidson and Jannssens, 2006; Friedlingstein et al., 2006). High $Na^+$ in the soil could lead to dispersion of ions in the soil which could cause reduction in water holding capacity and low aeration of the soil and support the report of McCauley et al. (2009).

The soil was sandy clay loam (USDA, 2010). This could support Corchorus olitorius L. performance as the plant grows well in light-sandy, medium- loamy and heavy clay soils (Fasciola, 1990). This would allow more salts to be deposited at the plant roots which could be the reason for yellowish colour of Corchorus olitorius L. leaves at 2 WAP and 4 WAP of first cycle of panting during this experiment. According to Virginia (2009), a given amount of salt in sandy soils will be more concentrated in its effect on plant roots than an equivalent amount in clay soils.

**Impact of cattle, goat and poultry manures on soil pH during first, second and third cycles of planting** C. olitorius

Increase in pH of the soil without amendment could be due to mineralization of the inherent organic materials in the soil prior to the experiment. Moderately, mildy and neutral soil pH of cattle, goat and poultry manures respectively between a day to two months of incorporation supports the ratings reported by Pam and Brian (2007). At these pH levels, macronutrients would be available in the soil and this corroborates the work of Lope/z- Masquera *et al.* (2008); McCauley *et al.* (2009), that macronutrients such as N, $K^+$, $Ca^{2+}$, $Mg^{2+}$ and S are more available within a pH range of 6.5 to 8.0 These availability of macronutrients in the soil did not support the growth potential of *C. olitorius* during this research at first cycle; this could be attributed to salinity level of the soil between a day and 56 days of manure applications. According to the amendment rates of cattle, goat and poultry manures, increased soil pH at two weeks after incorporation supports the work of Azeez *et al.*, 2010. The average pH range of the soil across the weeks after planting with cattle, goat and poultry manure treatments during first, second and third cycles of planting *C. olitorius* support the report of Paul, (2004), that most plant nutrients are in their most available state between pH 6.0 and 6.5 of the soil.

Increase in soil pH at 56 DAI of first cycle by cattle, goat and poultry manures might be due to low rainfall, high sunshine and evaporation rate during the experimental period relative to 14 and 28 DAI. During the second cycle, pH increase in cattle, goat and poultry manures applied soil, indicated that residual effect of these manures could raise the soil pH and that rainfall has positive influence on soil pH. Six weeks after planting of first and second cycles, lower values of soil pH were recorded from cattle, goat and poultry manure rates in relation to planting time which followed the studies of Azeez *et al.* (2010).

However, high soil pH allows for more basic cations on the exchange sites and this will decrease soil nutrients leaching while low soil pH let the basic cations leave the exchange sites and released into the soil solution to become exchangeable cations (McCauley *et al.*, 2009). However, high or low pH causes toxicity and decreases microbiological life in the soil (Awan, 2013). Thus, very high soil pH in high-salt soils greatly changes the nutrients availability to the plants (Provin and Pitt, 2012) and this could be the reason behind low FSY of *C. olitorius* during the first cycle.

Impact of NPK on soil pH during first, second and third cycles of planting *C. olitorius*

Addition of NPK decreased the soil pH during the three cycles of planting and supports, Gordon (1998), though fertilizer was reapplied prior to planting of second and third cycles because inorganic fertilizers add less nutrients to soil in the long term (Miller and Media, 2008). The low soil pH due to NPK incorporation could be attributed to concentration of salts in the fertilizer and acidity properties of the chemical fertilizer. This supports the studies of (Paul, 2004; Marx *et al.*, 1999) that intensive use of chemical fertilizer can lower soil pH by reducing useful microbiological life and organic matter contents. Despite the fact that NPK increased soil acidity, macronutrients would still be available in the soil because inorganic fertilizer supplied available nutrients quickly to plants (Stolton, 1997). Hence, soils treated with NPK 15-15-15 fertilizer increment at 14 days after incorporation suggested quick dissolution of the mineral fertilizer while the decrease at harvested period suggested quick leaching, volatilization and plant root uptake. Intensive inorganic fertilizer use can lower the soil pH, which will result in a decrease both in useful microbiological life and in organic matter content (Vagts, 2005). NPK fertilizer has low pH value and this is as a result of acidification of ammonium - ion to nitrate - ion caused by nitrification (Tom, 2002). NPK fertilizers usually release nutrients for a short period of time (Ojo *et al.*, 2008). As soil pH decreases, nutrients such as phosphorus, usually decreases in plant availability because of precipitate reactions with iron and aluminum.

**Impact of cattle, goat and poultry manures on** C. olitorius **performance during first, second and third cycles**

Additions of cattle, goat, poultry manures and NPK increased FSY in all the three cycles compared with control. The *C. olitorius* FSY increased at second and third cycles compared to first cycle. This indicated that the plants were able to utilize the nutrients from the soil between 70 and 154 days of manures application. Increase in *C. olitorius* FSY at second and third cycles could be attributed to reduction of the soil EC. Incorporation of cattle manure above 80 t $ha^{-1}$, goat and poultry manure treatments above 60 t $ha^{-1}$ negatively affected the *C. olitorius* FSY between 0 and 70 days of manures incorporation. There were better potential yields of *C. olitorius* in soil with pH level of between 8.6 and 9.3 during 70 and 154 days of manure application during the experiment.

## CONCLUSIONS AND RECOMMENDATIONS

Incorporations of cattle, goat and poultry manures improved the soil pH, this led to soil alkalinity while NPK reduced the soil pH (acidified the soil) relative to control. From this study, additions of cattle manures at 40 t $ha^{-1}$, goat manure at 60 t $ha^{-1}$ and poultry manure at 20 t $ha^{-1}$ would increase *C. olitorius* FSY compared with other lower rates between 0 and 154 days of application, but between 70 and 98 days, alkalinity increased with application of manures and acidity increased with application of NPK. However, between 126 - 154 days of manures application, soil alkalinity decreased with three manures applied and acidity increased with applied NPK.

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