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IMPACT OF HIGH RATES OF THREE ANIMAL MANURES ON SOIL EXCHANGEABLE SODIUM AND POTASSIUM AND WILD OKRA (*Corchorus olitorius* L.) PERFORMANCE

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ABSTRACT

There is paucity of information on effects of manure-induced factors on soil owing to high application rates. This necessitated the study to evaluate effects of three animal manures on soil K^+ and Na^+, and Corchorus olitorius L. The experiment was a randomized complete block design, replicated three times, in three cycles and six weeks per cycle. Cattle, goat and poultry manures were applied solely at the rates of 5, 10, 20, 40, 60, 80, 120 and 150 t ha^{-1}. During first cycle, percentage increases of soil K^+ bi-weekly over the control, were 550, 802, 763 % for cattle; 650, 783 1,086 % for goat and 380, 386, 500 % for poultry manure treatments at first, second and third cycle, respectively. Highest increase in soil Na^+ content at 6 weeks after planting of first, second and third cycles, were 9.36, 7.14, 4.83 cmol$^+$ kg^{-1} for cattle; 8.74, 5.65, 4.49 cmol$^+$ kg^{-1} for goat and 6.08, 4.80, 3.34 cmol$^+$ kg^{-1} for poultry amendments, respectively. At third cycle of planting, average reduction of soil Na^+ content for cattle, goat and poultry manure treatments, were quadrupled, cubic and doubled that of second cycle, respectively. Increase in Corchorus olitorius (L). leaf area irrespective of manure rates at second and third cycles doubled the values of first cycle. From the study, addition of cattle, goat and poultry manures above 60 t ha^{-1} increased soil K^+ and Na^+ but hindered Corchorus olitorius L. performance at first cycle and their residual effects enhanced the performance *at second and third cycles.*

Keywords: *C. olitorius* leaf area, manures' toxicity, K^+ and Na^+ dynamics.

INTRODUCTION

In African countries, soil productivity maintenance remains a major environmental issue (Oyetunji *et al.* 2001). Hence, it becomes imminent to sustain soil fertility by use of mineral fertilizers, organic wastes and various management techniques (UME 2015). Among the organic wastes are the animal manures which include faeces of cattle, goat, poultry, sheep, rabbit and pig manures (Joeleebass 2012). As a result of apparent decline in soil fertility, deliberate efforts are required to promote utilization of animal manures utilization for crop production (Maerere *et al.* 2001). Thus, for farmers to replenish their soils with animal manures there is need to understand the manure quality, correct application rates and time to meet the plants requirements. The use of organic waste as a means of replenishing soil nutrient is gaining more attention as the use of inorganic fertilizer tend to pose more harm than good on the soil and the environment. Although, manure provides all kinds of micro-nutrients and able to supply 60 - 80 % of the macro-nutrients required by plants (Porter 2004), obtaining a balance among manure nutrients is critical because application of manure to meet a particular nutrient demand may lead to toxicity of others (Azeez *et al.* 2010; Edmeades 2003). Nevertheless, correct application rates of organic manure would acts as good soil amendment (Duncan 2005; Agbede *et al.* 2008), though nutrient composition of manures varies (Azeez *et al.* 2009; MAFF 1994).

There is need to understand the mechanism of operation of organic manure in terms of quality, rate and time of application on K^+ and Na^+ kinetics in order to meet plants requirements. The main objectives of this research were to: (i) determine the toxic effects of three animal manures and their residual effects on soil K^+ and Na^+ kinetics, (ii) determine the toxic effects of three animal manures and their residual effects on the *C. olitorius* L. performance, (iii) determine the effect of K^+ and Na^+ on *C. olitorius* L. performance.

MATERIALS AND METHODS

Location of the study

The experiment was conducted 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).

Experimental design

The experiment was a Randomized Complete Block Design (RCBD) with three replications, in three cycles and each cycle with six weeks duration. Cattle, goat and poultry manures were spread on nylon under shade of the trees in FUNAAB. Dried cattle, goat and poultry manures were applied solely at 5, 10, 20, 40, 60, 80, 120 and 150 t ha^{-1} once at two weeks prior to commencement of first cycle and $N_{15}P_{15}K_{15}$ at 0.4 t ha^{-1} (Schippers 2000) a day to each cycle. These were applied with the use of spade by spreading them on different beds and mixed thoroughly.

Soil analysis

Soil used for the study was analyzed for EC, pH, NH_4^+- N and NO_3^-- N, available P, exchangeable bases (K^+, Ca^{2+}, Mg^{2+} and Na^+) and organic carbon (OC). Soil EC and pH were determined potentiometrically by 1: 2 soil: water medium using HANNA 215 EC meter (Richards 1954) and glass pH meter electrodes (HANNA pHep) (Van Reeuwijk 1993), respectively. The NH_4^+- N and NO_3^-- N were extracted in 2 Molar K_2SO_4 and determined colorimetrically using the method of Okalebo *et al.* (1993). Available P was extracted by Bray P-1extraction (Bray and Kurtz 1965) while colorimetric method of Murphy and Riley (1962) was used to determine the phosphorus in the solution. Exchangeable bases were extracted with 1N Ammonium-acetate solution in 1:10 soil solution ratio, K^+ and Na^+ were analyzed with flame photometer, while Ca^{2+} and Mg^{2+} were analyzed with Atomic Absorption Spectrophotometer (AAS) (Anderson and Ingram 1993). The OC content was determined using Walkley Black method (Nelson and Sommers 1990). At two weeks after incorporation of the three manures but a day after application of $N_{15}P_{15}K_{15}$ fertilizer, soil samples were collected from the net portion of each bed at a depth of 0 - 15 cm (within the rooting zone of *C. olitorius* L.). Particle size analysis was determined using the hydrometer method (Bouyoucos 1965) and dispersed with sodium hexametaphosphate reagent.

Manure analysis

The cattle, goat and poultry manures used were digested with nitric-perchloric acid (2:1) (Silva; Queiróz 2002; Watanabe *et al.* 2013; Saka *et al.* 2017). The extracts were analyzed for macro-nutrients using standard procedures (Saka *et al.* 2017; Cater 1993; Kaira and Maynard 1991). Deionized water was used to determine the EC and pH of the manures.

Planting of *C. olitorius* seeds was done two weeks after manure application. Weeding was done at the appropriate time. The plants were watered as a result of inadequate rainfall. Soil samples were collected bi -weekly with the exception of 4 Weeks After Planting (WAP) of first cycle due to unpredictable rainfall while at 6 WAP, *C. olitorius* Leaf Area (LA) was determined in each cycle. The soil samples were air dried, prepared for laboratory analysis and analyzed for exchangeable K^+ and Na^+.

Agronomic data

Leaf area was estimated manually from three selected *Corchorus* plants from the net plot using meter rule. The two edge rows on each bed were avoided to prevent border effect. The leaf area was determined using the regression equation described by Salau *et al.* (2008).

$$Y = -1.45 + 0.65 (L \times B)$$

Where constant = - 1.45 and + 0.65,

Y = Leaf area (cm^2)

L = Leaf length (cm)

B = Leaf maximum breadth (cm).

r^2 = Coefficient of determination = 0.99

Statistical analysis

The parameters collected were subjected to Analysis of Variance (ANOVA) using SAS (Statistical Analytical System) (1999), while Duncan Multiple Range Test at 5 % level of probability was used to determine differences in the treatment rates means and also to testify the significance effects on parameters determined compared to the control.

RESULTS

Agrometeorological data

The average agrometeorological data for rainfall, relative humidity, mean temperature, soil temperature, mean sunshine hour and evaporation during first, second and third cycles of planting were measured (Table 1). The data were collected from the Department of Water Resources Management and Agrometeorology, FUNAAB.

Table 1: Agrometeorological data for the period of the experiment

Agrometeorological parameters	Cycles of planting		
	First	Second	Third
Rainfall/ month (mm)	176.60	213.80	166.00
Ave. R. H./day (%)	74.30	81.76	79.72
Mean temp./ day (^{O}C)	27.60	47.00	25.98
Soil temp./ day (^{O}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

Source: Federal University of Agriculture, Abeokuta AGROMET STATION, between May and October, 2013

Temp. = temperature   mm = millimeter

Hr. = hour   R. H. = relative humidity

Ave. = average   Soil temperature at the depth of 20 cm

Pre-planting soil properties

The soil used for the research had EC, pH, total N, available P and OC of 0.69 dS m^{-1}, 7.6, 0.8 g kg^{-1}, 7.5 mg kg^{-1} and 14.2 g kg^{-1}, respectively. Exchangeable bases; K^+, Ca^{2+}, Mg^{2+} and Na^+ had the values of 0.42, 10.96, 1.34 and 0.82 cmol$^+$ kg^{-1}, respectively. The values of sand, silt and clay were 770, 68 and 162 g kg^{-1}, respectively.

Chemical properties of manure

Highest EC value was obtained from poultry manure followed by cattle and goat manures. The pH followed the order; cattle, poultry and goat manures. However, poultry manure had highest phosphorus followed by cattle manure while goat manure had the lowest value. Cattle manure had the highest value of potassium followed by poultry manure while goat manure had the lowest. The order of increment of calcium was cattle, goat and poultry manures. Highest values of magnesium and OC were from goat manure followed by cattle and poultry manures. Sodium was high from cattle manure followed by poultry and goat manures. NH_4^+- N and NO_3^-- N followed the trend of cattle, goat and poultry manures (Table 2).

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	-
Ammonium- nitrogen (g kg^{-1})	0.42	0.32	1.47	-
Nitrate- nitrogen (g kg^{-1})	0.44	0.36	1.49	-
Carbon: Nitrogen (g kg^{-1})	3.97	4.63	2.13	-

Influence of cattle manure on soil K^+ at first cycle of planting C. olitorius L.

During the first cycle of planting, 2 WAI (weeks after incorporation of manure), 2 WAP (weeks after planting) and 6 WAP, highest increase of 3.9, 5.5 and 6.9 $cmol^+$ kg^{-1} of soil K^+ was recorded in soil applied with cattle manure at the rate of 120 t ha^{-1} with percentage increases of 550, 802 and 763%, respectively over control. However, soil applied with rate of 5 t ha^{-1} which resulted in soil K^+ values of 0.9, 0.8 and 0.9 $cmol^+$ kg^{-1} had the lowest increment of 50, 33 and 13 % at 2 WAI, 2 WAP and 6 WAP respectively relative to control. It was observed from the result that the level of soil K^+ increased in all the manure rates across weeks after planting. This occurred in soil incorporated with cattle amendment while the reverse was the case for $N_{15}P_{15}K_{15}$ application (Figure 1 A).

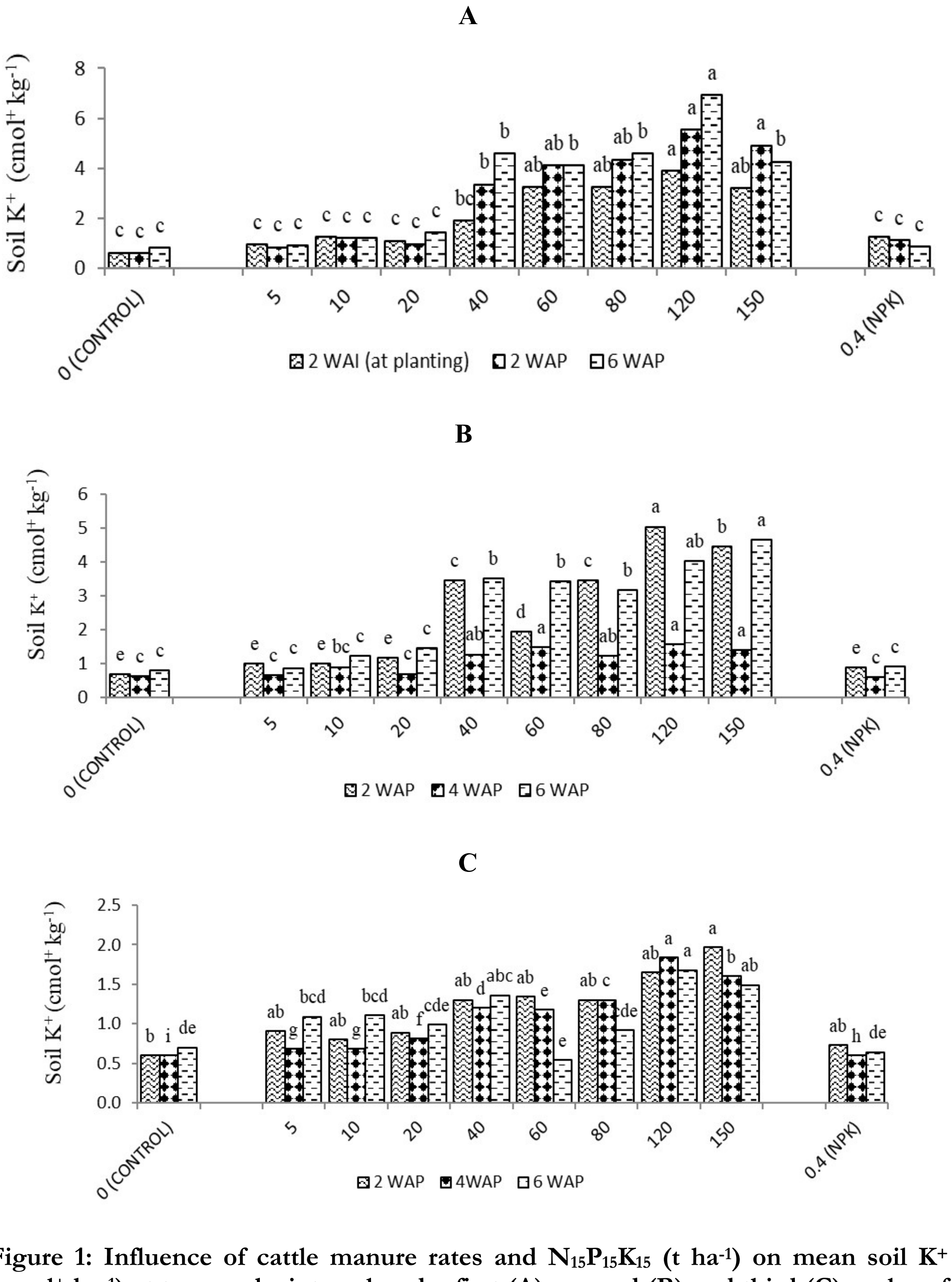


Figure 1: Influence of cattle manure rates and $N_{15}P_{15}K_{15}$ (t ha^{-1}) on mean soil K^+ (cmol$^+$ kg^{-1}) at two weeks interval under first (A), second (B) and third (C) cycles of planting *C. olitorius*.

WAI = weeks after incorporation of manures. WAP = weeks after planting *Corchorus olitorius.*

Residual effects of cattle manure on soil K^+ at second cycle of planting *C. olitorius* L.

Application of cattle manure at the rate of 120 t ha^{-1} resulted in soil K^+ values of 5.0 and 1.6 cmol$^+$ kg^{-1} but recorded the greatest increase of 614 and 167 % relative to control at 2 WAP and 4 WAP respectively. While at 6 WAP, application of cattle manure at the rate of 150 t ha^{-1} resulted to 4.7 cmol$^+$ kg^{-1} and gave highest increment of 488 % in relation to control. Meanwhile least values were recorded with the application of $N_{15}P_{15}K_{15}$ and 5 t ha^{-1} of cattle manure with soil K^+ values of 0.9, 0.7 and 0.9 cmol$^+$ kg^{-1} which translated to increase of 29, 17 and 13 % compared to control at 2, 4 and 6 WAP, respectively. However, increment of soil K^+ according to the amendment rates varied in relation to one another during the second cycle of planting, Figure 1 (B).

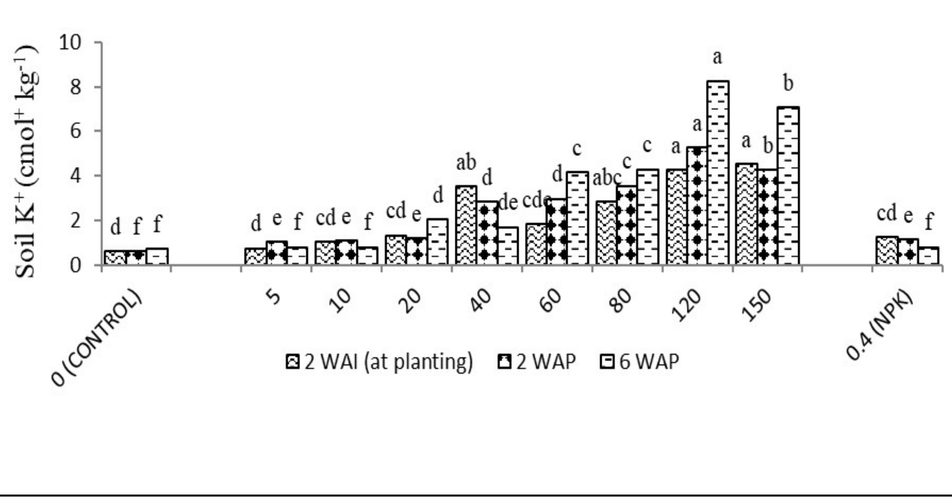
Residual effects of cattle manure on soil K^+ at third cycle of planting C. olitorius L.

At 2, 4 and 6 WAP, cattle manure rate of 120 and 150 t ha^{-1} gave soil K^+ values of 1.9,1.8 and 1.7 cmol$^+$ kg^{-1} with the greatest increase of 217, 200 and 143 %, respectively. However, plots on which $N_{15}P_{15}K_{15}$ and 5 t ha^{-1} of cattle manure treatment were incorporated had K^+ values of 0.7, 0.7 and 1.0 cmol$^+$ kg^{-1} with percentage increment of 17, 17 and 43 % over the control, respectively. Virtually, every amendment rate was; significantly different compared from control (Figure 1 C).

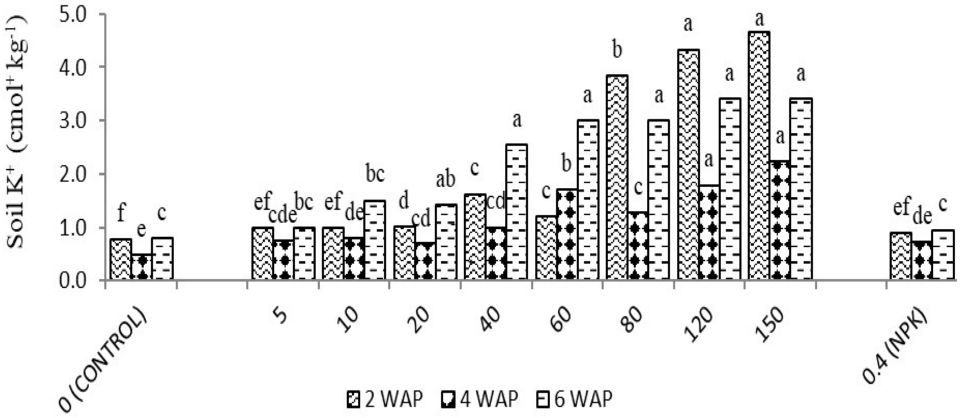
Influence of goat manure on soil K^+ at first cycle of planting C. olitorius L.

Soil added with goat manure rate of 150 t ha^{-1} resulted in soil K^+ value of 4.5 cmol$^+$ kg^{-1} with increment of 650 % at 2 WAI (planting) relative to control. At 2 WAP and 6 WAP, plots with application of goat manure rate of 120 t ha^{-1} recorded K^+ values of 5.3 and 8.3 cmol$^+$ kg^{-1}, with highest increase of 783 and 1,086 % respectively over the control. Meanwhile, the soil with goat manure rate of 5 t ha^{-1} resulted in K^+ values of 0.7, 1.0and 0.8 cmol$^+$ kg^{-1} with the lowest increase of 17, 67 and 14 % compared to control, at 2 WAI, 2 WAP and 6 WAP respectively. The level of soil K^+ varied in relation to the corresponding amendment rates at planting (Figure 2

A



B



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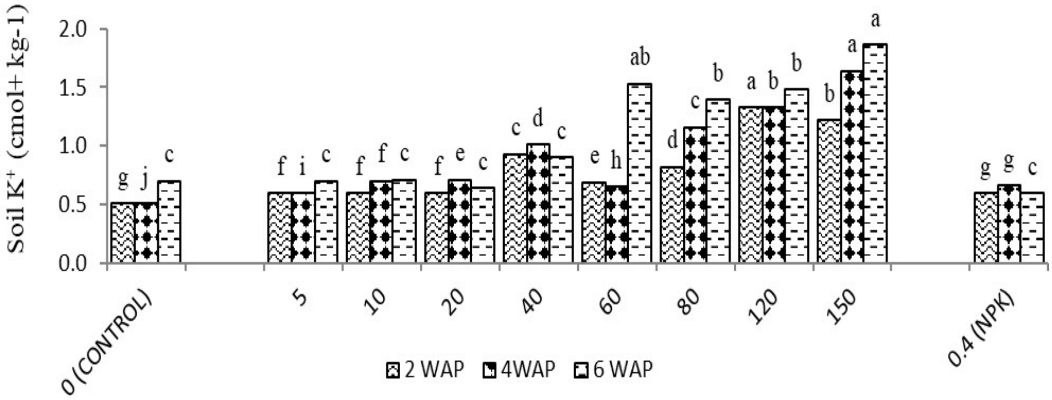


Figure 2: Influence of goat manure rates and $N_{15}P_{15}K_{15}$ (t ha^{-1}) on mean soil K^+ ($cmol^+$ kg^{-1}) at two weeks interval under first (A), second (B) and third (C) cycles of planting*C. olitorius*.

WAI = weeks after incorporation of manures. WAP = weeks after planting *Corchorus olitorius*.

Residual effects of goat manure on soil K^+ at second cycle of planting *C. olitorius* L.

Plots with the application of goat manure at the rate of 150 t ha^{-1} gave K^+ values of 4.7, 2.2 and 3.4 $cmol^+$ kg^{-1} which increased by 571, 340 and 325 % over the control at 2, 4 and 6 WAP, respectively. Whereas, the goat manure rate of 5, 10 t ha^{-1} and $N_{15}P_{15}K_{15}$ gave K^+ values of 0.6, 0.7 and 0.9 $cmol^+$ kg^{-1}, these recorded the lowest increases of 29, 40 and 13 % at 2, 4 and 6 WAP, respectively, relative to control, (Figure 2 (B)). More so, increments of soil K^+ according to the rates varied but there were decreases compared to corresponding rates at 2 WAP.

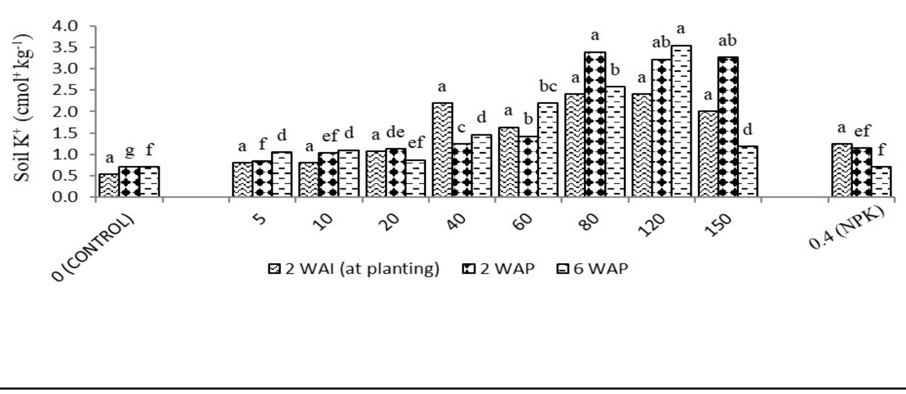
Residual effects of goat manure on soil K^+ at third cycle of planting *C. olitorius* L.

The soil K^+ value of 1.3 cmol$^+$ kg^{-1} was recorded in soil incorporated with goat manure at the rate of 120 t ha^{-1} and gave highest increase of 160 % while 5 t ha^{-1} with the K^+ value of 0.5 recorded the least increase of 20 % above the control at 2 WAP. (Fig 2c) The increment of soil K^+ according to the goat manure rates varied, Figure 2 (C). At 4 and 6 WAP, soil with the application of goat manure at the rate of 150 t ha^{-1} resulted in K^+ values of 1.6 and 1.9 cmol$^+$ kg^{-1} with highest increases of 220 and 171 % relative to control, respectively. While soil with the application of 5 and 40 t ha^{-1} of goat manure gave the lowest increases of 20 and 29 %, respectively over the control at 2, 4 and 6 WAP. But $N_{15}P_{15}K_{15}$ with K^+ value of 0.6 cmol$^+$ kg^{-1} reduced by 14 % relative to control. Increments according to the rates and also relative to corresponding rates were erratic. (Fig 2c)

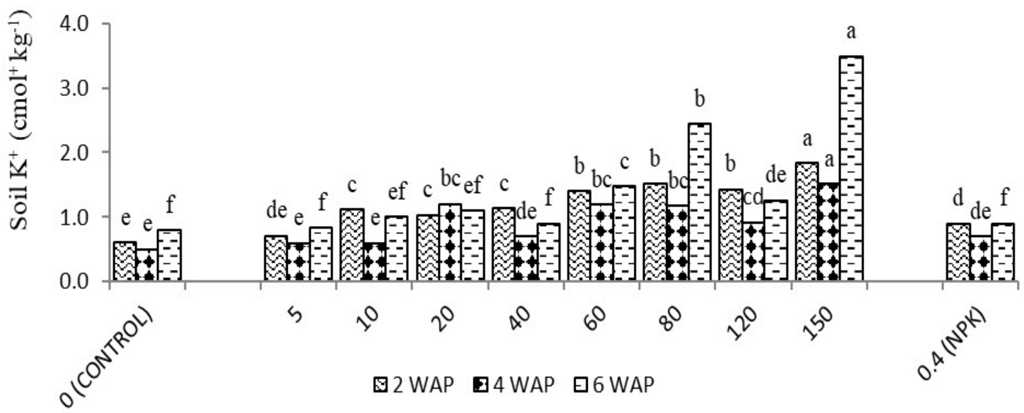
Influence of poultry manure on soil K^+ at first cycle of planting *C. olitorius* L.

Soil incorporated with poultry manure rate of 80 and 120 t ha^{-1} had similar K^+ value of 2.4 cmol$^+$ kg^{-1} and recorded the highest increase of 380 % over the control at planting (2 WAI) while plots treated with 5 and 10 t ha^{-1} with K^+ value of 0.8 cmol$^+$ kg^{-1} each recorded least increase of 60 %. All the amendment rates were not significantly different compared with one another. At 2 WAP, plots with application of poultry manure rate of; 80 t ha^{-1} resulted to 3.4 cmol$^+$ kg^{-1} and gave the highest increase of 386 % more than the control. The rate of 5 t ha^{-1} stimulated K^+ value of 0.8 cmol$^+$ kg^{-1} and gave the lowest increase of 14 % compared with control. The level of soil K^+ increased with increase in poultry manure amendment rates except 120 t ha^{-1} that decreased by 6 % from 80 t ha^{-1}. The level of soil K^+ varied in relation to the corresponding rates at planting. At 6 WAP, poultry manure rate of 60 t ha^{-1} recorded K^+ value of 4.2 cmol$^+$ kg^{-1} and had the highest increment of 500 % more than control but plots with addition of 5 t ha^{-1} gave K^+ value of 1 cmol$^+$ kg^{-1} and had the lowest increment of 43 %. There were significant differences in the amendment rates, though; control was not significantly different from $N_{15}P_{15}K_{15}$. Increments of soil K^+ according to the order of the amendment rates were not sequenced (Figure 3 (A).

A



B



C

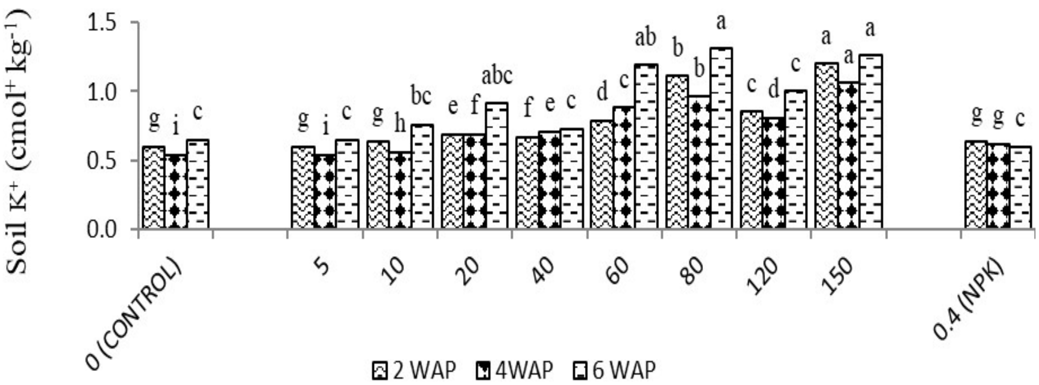


Figure 3: Influence of poultry manure rates and $N_{15}P_{15}K_{15}$ (t ha^{-1}) on mean soil K^+ ($cmol^+$ kg^{-1}) at two weeks interval under first (A), second (B) and third (C) cycles of planting*C. olitorius*.

WAI = weeks after incorporation of manures. WAP = weeks after planting *Corchorus olitorius.*

Residual effects of poultry manure on soil K^+ at second cycle of planting C. olitorius L.

During the second cycle, the plot with addition of poultry manure rate of 150 t ha^{-1} had soil K^+ values of 1.8 $cmol^+$ kg^{-1}, 1.5 $cmol^+$ kg^{-1} and 3.5 $cmol^+$ kg^{-1}, this recorded highest increases of 200 %, 200 % and 338 % at 2 WAP, 4 WAP and 6 WAP over the control. But plot with incorporation of poultry manure rate of 5 t ha^{-1} which had K^+ values of 0.7 $cmol^+$ kg^{-1}, 0.6 $cmol^+$ kg^{-1} and 0.9 $cmol^+$ kg^{-1} recorded the least increase of 17 %, 20 % and 13 % relative to control at 2 WAP, 4 WAP and 6 WAP, respectively. The increments of soil K^+ varied according to the amendment rates (Figure, 3 (B)).

Residual effects of poultry manure on soil K^+ at third cycle of planting C. olitorius

Plot with application of poultry manure rate of 150 t

ha^{-1} stimulated K^+ values of 1.2, 1.1 and 1.3 cmol$^+$ kg^{-1} and recorded highest increment of 100, 120 and 86 % at 2, 4 and 6 WAP, respectively. However, soil with 20 t ha^{-1} had K^+ value of 0.7 cmol$^+$ kg^{-1} with the least increase of 17 % more than control at 2 WAP. The increments of soil K^+ according to the rates were not consistent. At 4 WAP, plot with addition of $N_{15}P_{15}K_{15}$ and 5 t ha^{-1} recorded K^+ value of 0.6 cmol$^+$ kg^{-1} each and gave the lowest increase of 20 %. At 6 WAP, soil incorporated with poultry manure at the rates of 40 t ha^{-1} had K^+ value of 0.9 cmol$^+$ kg^{-1} and this recorded the least increment of 14 % while $N_{15}P_{15}K_{15}$ resulted in K^+ value of 0.6 cmol$^+$ kg^{-1} and decreased by 14 % relative to control (Figure 3 (C).
Influence of cattle, goat and poultry manures on soil exchangeable sodium (Na^+)

Influence of cattle manure on soil Na^+ at first cycle of planting C. olitorius L.

Plot with application of cattle manure rate of 150 t ha^{-1} with the soil Na^+ value of 7.41 cmol$^+$ kg^{-1} recorded the highest increase of 752 % over the control. But $N_{15}P_{15}K_{15}$ application resulted to Na^+ value of 1.03cmol$^+$ kg^{-1} and recorded the least increase of 18 %. The increments of soil Na^+ according to the amendment rates at planting (2 WAI) were not consistent. At 2 WAP, soil incorporated with cattle manure rate of 120 t ha^{-1} had Na^+ value of 9.93 cmol$^+$ kg^{-1} and increased by 787 % over the control. While soil with application of 20 t ha^{-1} had Na^+ value of 1.57 cmol$^+$ kg^{-1} and gave lowest increase of 40 %. At 6 WAP, plot with incorporation of cattle manure rate of 150 t ha^{-1} had Na^+ value of 9.36 cmol$^+$ kg^{-1}. This recorded the highest increment of soil Na^+ by 646 % relative to control but $N_{15}P_{15}K_{15}$ with Na^+ value of 1.54 cmol$^+$ kg^{-1} recorded the least increment of 22 %. Increments of soil Na^+ according to the amendment rates and corresponding rates at 2 WAP varied (Table 3).

Table 3: Influence of cattle manure rates and $N_{15}P_{15}K_{15}$ (t ha^{-1}) on mean soil Na^+(cmol$^+$ kg^{-1}) at two weeks interval under first, second and third cycles of planting *C. olitorius* L.

Residual effects of cattle manure on soil Na^+ at second cycle of planting *C. olitorius* L.

Rates	First cycle			Second cycle			Third cycle		
t ha^{-1}	2 WAI	2 WAP	6 WAP	2 WAP	4 WAP	6 WAP	2 WAP	4 WAP	6 WAP
0cm	0.87^f	1.12^c	1.26^c	1.73^d	0.99^c	1.19^d	1.03^f	1.04^j	1.79^e
5cm	1.52^{ef}	1.67^c	1.76^c	2.49^d	1.05^c	1.28^d	1.27^f	1.26^h	2.78^c
10cm	1.57^{ef}	2.02^c	1.57^c	2.80^d	1.48^c	1.84^d	1.54^e	1.32^g	2.49^{cd}
20cm	1.97^{def}	1.57^c	2.78^c	3.09^d	1.50^c	2.39^d	1.57^e	1.48^f	2.29^{cde}
40cm	2.86^{de}	5.54^b	6.18^b	10.24^b	2.52^b	3.97^c	2.22^d	2.55^c	1.81^{de}
60cm	3.65^{cd}	5.66^b	5.31^b	8.05^c	2.76^{ab}	5.63^b	2.41^{bc}	2.32^e	3.65^b
80cm	4.99^{bc}	6.15^b	6.78^b	9.26^b	2.64^{ab}	4.57^{bc}	2.35^{cd}	2.48^d	2.76^c
120cm	7.41^a	9.93^a	9.10^a	13.38^a	3.31^a	4.86^{bc}	2.81^a	3.28^a	4.83^a
150cm	6.50^{ab}	6.60^b	9.36^a	12.38^a	2.69^{ab}	7.14^a	2.58^b	2.86^b	4.75^a
0.4NPK	1.03^{ef}	1.18^c	1.54^c	2.18^d	1.21^c	1.26^d	1.08^f	1.13^i	1.95^{de}

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

WAI = weeks after incorporation of manures. WAP = weeks after planting *Corchorus olitorius.*
Cm = cattle manure
NPK = NPK 15-15-15

At 2 and 4 WAP, soil with application of cattle manure rate of 120 t ha^{-1} recorded Na^+ value of 13.38 and 3.31 $cmol^+ kg^{-1}$. These increased the soil Na^+ level by 673 and 234 %, respectively more than the control. The least increment of 26 and 6 % relative to control was obtained from $N_{15}P_{15}K_{15}$ and soil incorporated with 5 t ha^{-1} cattle manure with soil Na^+ values of 2.18 and 1.05 $cmol^+ kg^{-1}$ respectively. At 6 WAP, soil incorporated with cattle manure rate of 150 t ha^{-1} resulted in Na^+ value of 7.14 $cmol^+ kg^{-1}$ and recorded highest increment of 500 % over the control. But $N_{15}P_{15}K_{15}$ with Na^+ value of 1.26 $cmol^+ kg^{-1}$ recorded the least increment of 6 %. The level of increments of soil Na^+ varied according to the amendment rates (Table 3).

Residual effects of cattle manure on soil Na^+ at third cycle of planting C. olitorius L.

At 2, 4 and 6 WAP, plot treated with cattle manure rate of 120 t ha^{-1} had Na^+ values of 2.81, 3.28 and 4.83 $cmol^+ kg^{-1}$ recorded highest increment of 173, 215 and 170 %, respectively. But the lowest increases of 5, 9 and 9 % were recorded from $N_{15}P_{15}K_{15}$ with soil Na^+ values of 1.08, 1.13and1.95 $cmol^+ kg^{-1}$ respectively. Increment according to amendment rates were erratic (Table 3).

Influence of goat manure on soil Na^+ at first cycle of planting C. olitorius L.

Plot treated with goat manure rate of 150 t ha^{-1} resulted to soil Na^+ value of 8.81 $cmol^+ kg^{-1}$ and gave highest increment of 827 % over the control at planting (2 WAI). But plots amended with $N_{15}P_{15}K_{15}$ gave Na^+ value of 1.15 $cmol^+ kg^{-1}$ and had the lowest increase of 21 %. At 2 WAP, soil Na^+ value of 8.25 $cmol^+ kg^{-1}$ was recorded in plots with the application of goat manure at 120 t ha^{-1} and this gave the highest increase of 701 % over the control while plots treated with 5 t ha^{-1} gave Na^+ value of 1.52 $cmol^+ kg^{-1}$ and had lowest increase of 48 %. The levels of soil Na^+ according to the amendment rates were not sequenced (Table 3). At 6 WAP, plots amended with goat manure rate of 120 t ha^{-1} had Na^+ value of 8.74 $cmol^+ kg^{-1}$ with highest increment of soil Na^+ by 622 % more than the control. Furthermore, plots amended with the goat manure rate of 10 t ha^{-1} had Na^+ value of 1.22 $cmol^+ kg^{-1}$ and recorded the least increment of 1 % relative to control (Table 4).

Table 4: Influence of goat manure rates and $N_{15}P_{15}K_{15}$ fertilizer (t ha^{-1}) on mean soil Na^+(cmol$^+$ kg^{-1}) at two weeks interval under first, second and third cycles of planting *C. olitorius* L.

	First cycle of planting			Second cycle of planting			Third cycle of planting		
Rates t ha^{-1}	2 WAI	2 WAP	6 WAP	2 WAP	4 WAP	6 WAP	2 WAP	4 WAP	6 WAP
0gm	0.95^{e}	1.03^{e}	1.21^{d}	1.44^{d}	0.99^{e}	1.20^{d}	0.96^{g}	1.04^{i}	1.79^{d}
5gm	1.41^{de}	1.52^{de}	1.27^{d}	2.90^{bcd}	1.29^{de}	1.37^{d}	1.05^{f}	1.10^{h}	1.77^{d}
10gm	1.26^{e}	1.86^{de}	1.22^{d}	2.75^{d}	1.44^{de}	1.78^{cd}	0.80^{i}	1.41^{f}	2.24^{c}
20gm	1.94^{cde}	2.55^{d}	2.88^{d}	1.99^{d}	1.62^{de}	1.87^{cd}	1.00^{g}	1.38^{g}	2.80^{c}
40gm	3.08^{c}	4.15^{c}	2.20^{d}	4.41^{bc}	1.79^{d}	3.27^{c}	1.64^{c}	1.76^{d}	2.32^{c}
60gm	2.91^{cd}	4.20^{c}	5.58^{c}	4.64^{b}	3.40^{b}	3.99^{ab}	1.23^{e}	2.29^{b}	2.66^{c}
80gm	5.40^{b}	5.57^{b}	6.26^{b}	10.62^{a}	2.65^{c}	4.27^{ab}	1.54^{d}	2.20^{c}	2.81^{c}
120gm	6.74^{b}	8.25^{a}	8.74^{a}	11.87^{a}	3.69^{b}	4.80^{ab}	2.41^{a}	2.58^{a}	3.76^{b}
150gm	8.81^{a}	6.31^{b}	6.78^{b}	11.91^{a}	4.45^{a}	5.65^{a}	2.19^{b}	1.38^{g}	4.49^{a}
0.4NPK	1.15^{e}	1.88^{de}	1.48^{d}	2.28^{d}	1.19^{e}	1.27^{d}	1.08^{f}	1.15^{h}	1.83^{d}

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.

WAI = weeks after incorporation of manures. WAP = weeks after planting *Corchorus olitorius*.

Pm = poultry manure.

NPK = NPK 15-15-15

Residual effects of goat manure on soil Na^+ at second cycle of planting *C. olitorius*

At 2 WAP soil added with plots with the application of 20 t ha^{-1} goat manure recorded Na^+ value of 1.99 cmol$^+$ kg^{-1} and gave the least increment of 38 %. But at 4 WAP, plots with application of $N_{15}P_{15}K_{15}$ with Na^+ value of 1.19 cmol$^+$ kg^{-1} recorded the lowest increase of 20 % relative to control (Table 4).

Residual effects of goat manure on soil Na^+ at third cycle of planting *C. olitorius* L.

The plots incorporated with goat manure rate of 120 t ha^{-1} gave soil Na^+ values of 2.41, 2.58 and 4.49 cmol$^+$ kg^{-1} (150 t ha^{-1}) recorded the highest increases of 151, 148 and 150 % at 2, 4 and 6 WAP, respectively in relation to control. However, soil with 5 t ha^{-1} gave Na^+ values of 1.05 and 1.10 cmol$^+$ kg^{-1} recorded the lowest increment of 9 and 6 % at 2 and 4 WAP, respectively over the control. But at 6 WAP, the plots amended with goat manure rate of 10 t ha^{-1} gave the lowest increase of 25 % with soil Na^{+} value of 2.24 $cmol^{+}$ kg^{-1}, relative to control. Increments in relation to the rates were not consistent (Table 4).

Influence of poultry manure on soil Na^{+} at first cycle of planting *C. olitorius* L.

Virtually, every amendment rates were not significantly different from control at planting (2 WAI) and 2 WAP. However, at 6 WAP, plots amended with poultry manure rate of 150 t ha^{-1} resulted to soil Na^{+} value of 6.08 $cmol^{+}$ kg^{-1}. This recorded the highest increment of 424 % more than the control while soil with 5 t ha^{-1} with Na^{+} value of 1.38 $cmol^{+}$ kg^{-1} had the least increment of 19 %. Increment of soil Na^{+} according to the amendment rates and also in comparison with the corresponding rates at 2 WAP were not consistent (Table 5).

Table 5: Influence of poultry manure rates and $N_{15}P_{15}K_{15}$ fertilizer (t ha^{-1}) on mean soil Na^{+}($cmol^{+}$ kg^{-1}) at two weeks interval under first, second and third cycles of planting *C. olitorius* L.

	First cycle of planting			Second cycle of planting			Third cycle of planting		
Rates t ha^{-1}	2 WAI	2 WAP	6 WAP	2 WAP	4 WAP	6 WAP	2 WAP	4 WAP	6 WAP
0pm	0.81^{a}	1.21^{a}	1.16^{d}	1.14^{g}	0.99^{d}	1.19^{c}	0.95^{j}	1.04^{h}	1.79^{de}
5pm	1.27^{a}	1.64^{a}	1.38^{cd}	1.91^{f}	1.09^{d}	1.16^{c}	1.09^{h}	1.06^{g}	1.81^{de}
10pm	1.22^{a}	1.57^{a}	1.79^{cd}	2.97^{de}	1.62^{bc}	1.62^{c}	1.11^{g}	1.04^{h}	1.93^{de}
20pm	1.43^{a}	1.60^{a}	1.96^{c}	2.71^{e}	2.23^{b}	1.62^{c}	1.20^{f}	1.16^{f}	2.49^{bcd}
40pm	3.01^{a}	4.95^{a}	1.80^{cd}	3.13^{d}	1.29^{cd}	1.25^{c}	1.34^{e}	1.32^{e}	2.98^{abc}
60pm	2.58^{a}	5.29^{a}	4.98^{b}	3.93^{c}	1.48^{cd}	2.06^{c}	1.51^{d}	1.67^{c}	3.11^{ab}
80pm	2.19^{a}	5.40^{a}	5.76^{a}	4.61^{b}	1.81b^{c}	3.20^{b}	1.88^{b}	1.76^{b}	3.34^{a}
120pm	3.55^{a}	5.04^{a}	4.59^{b}	4.11^{c}	1.87^{bc}	3.62^{b}	1.54^{c}	1.45^{d}	2.95^{abc}
150pm	3.00^{a}	5.09^{a}	6.08^{a}	5.03^{a}	3.06^{a}	4.80^{a}	2.16^{a}	2.07^{a}	2.38^{cd}
0.4NPK	1.09^{a}	1.81^{a}	1.46^{cd}	2.20^{f}	1.29^{cd}	1.27^{c}	1.05^{i}	1.16^{f}	1.67^{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.

WAI = weeks after incorporation of manures. WAP = weeks after planting *Corchorus olitorius*.
Pm = poultry manure.
NPK = NPK 15-15-15

Residual effects of poultry manure on soil Na^+ at second cycle of planting *C. olitorius* L.

At 2, 4 and 6 WAP, plots with application of poultry manure the rate of 150 t ha^{-1} resulted to soil Na^+ values of 5.03, 3.06 and 4.8 $cmol^+$ kg^{-1} with highest increment of 341, 209 and 303 %, respectively compared with control. But soil with 5 t ha^{-1} recorded Na^+ values of 1.91 and 1.09 $cmol^+$ kg^{-1} gave the least increment of 68 and 10 % at 2 and 4 WAP, respectively relative to control. Whereas, at 6 WAP, plots with application of $N_{15}P_{15}K_{15}$ with Na^+ value of 1.27 $cmol^+$ kg^{-1} recorded the least increment of 7 % while plots amended with 5 t ha^{-1} that gave Na^+ value of 1.16 $cmol^+$ kg^{-1} had a reduction of 3 %. Increments of soil Na^+ varied according to the amendment rates and also when compared with the corresponding rates at 4 WAP (Table 5).

Residual effects of poultry manure on soil Na^+ at third cycle of planting C. olitorius L.

At 2 and 4 WAP, soil incorporated with poultry manure rate of 150 t ha^{-1} had Na^+ values of 2.16 and 2.07 $cmol^+$ kg^{-1} which gave highest increment of 127 and 99 %, respectively over the control. While plots amended with $N_{15}P_{15}K_{15}$ and 5 t ha^{-1} of poultry manure gave Na^+ values of 1.05, 1.16 and 1.09, 1.06 $cmol^+$ kg^{-1}, and recorded lowest increment of 11, 22 and 5, 2 % at 2 P and 4 WAP, respectively compared with control. The amendment rates of poultry manure on Na^+ were significantly different from one another. However, at 6 WAP, plots amended with poultry manure rate of 80 t ha^{-1} with Na^+ value of 3.34 $cmol^+$ kg^{-1} recorded the highest increment of 87 % more than control. While soil with 5 t ha^{-1} of poultry manure had Na^+ value of 1.81 $cmol^+$ kg^{-1} and recorded the lowest increment of 1 %. A reduction of 7 % was recorded in $N_{15}P_{15}K_{15}$ with Na^+ value of 1.67 $cmol^+$ kg^{-1} in relation to control. Increase in rates of poultry manure led to increase in soil Na^+ up till 80 t ha^{-1} while others decreased. The Na^+ increased in all the poultry amendment rates compared with control except 5 and 10 t ha^{-1} (Table 5).

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

Performance of *C. olitorius* as affected by cattle, goat and poultry manures during first cycle of planting

At harvesting (6 WAP) of first cycle, the Leaf Area (LA) of *C. olitorius* in plots amended with cattle manure ranged between 15.76 and 41.46 cm^2. The plots amended with cattle amendment rate of 60 t ha^{-1} had the LA value of 41.46 cm^2 and gave highest increase of 163 % while plots with 120 t ha^{-1} with the LA value of 18.55 cm^2 gave the least increase of 18 % relative to control (Plate 1). There were no significant differences in *C. olitorius* LA values of plots incorporated with goat manure, $N_{15}P_{15}K_{15}$ and the control. However, application of poultry manure at 40 t ha^{-1} resulted to *C. olitorius* LA value of 39.66 cm^2 and had the greatest increase of 148 % over the control. The least increase of 8 % was recorded in plots amended with 150 t ha^{-1} which had the *C. olitorius*LA value of 17.29 cm^2. It was observed from the result that *C. olitorius* LA values increased with increase in rates of poultry manure between 5 and 40 t ha^{-1} but the values reduced between 60 and

Table 6: Influence of cattle, goat and poultry manure rates and $N_{15}P_{15}K_{15}$ fertilizer (t ha^{-1}) on mean LA (cm^2) of *C. olitorius* L. during harvesting at first, second and third cycles of planting

	First cycle of planting			Second cycle of planting			Third cycle of planting		
Rates t ha^{-1}	Cattle	Goat	Poultry	Cattle	Goat	Poultry	Cattle	Goat	Poultry
0	15.76^{c}	16.23^{a}	15.99^{c}	41.39^{b}	39.42^{e}	29.22^{c}	28.17^{bc}	30.02^{cd}	26.11^{b}
5	20.49^{c}	22.78^{a}	17.80^{c}	49.26^{b}	47.08^{de}	59.88^{abc}	25.46^{c}	28.89^{d}	37.51^{ab}
10	19.69^{c}	29.05^{a}	21.43^{bc}	58.06^{ab}	56.25^{cd}	72.57^{a}	38.89^{abc}	41.30^{bcd}	48.01^{a}
20	39.94^{a}	28.80^{a}	36.49^{ab}	66.63^{ab}	59.30^{cde}	63.54^{ab}	48.17^{abc}	34.34^{cd}	31.25^{b}
40	35.60^{ab}	29.49^{a}	39.66^{a}	74.77^{a}	64.39^{abc}	62.53^{abc}	45.84^{ab}	46.70^{abc}	27.75^{b}
60	41.46^{a}	34.89^{a}	24.55^{abc}	78.35^{a}	68.68^{abc}	60.67^{abc}	50.77^{a}	53.84^{ab}	50.19^{a}
80	37.72^{a}	34.35^{a}	17.62^{c}	68.17^{ab}	74.73^{a}	60.61^{abc}	48.63^{a}	60.58^{a}	47.86^{a}
120	18.55^{c}	34.72^{a}	17.43^{c}	71.38^{ab}	72.31^{ab}	71.95^{a}	51.09^{a}	59.92^{a}	50.01^{a}
150	20.15^{c}	30.81^{a}	17.29^{c}	81.29^{a}	76.51^{a}	66.00^{ab}	51.18^{a}	43.64^{a}	48.74^{a}
0.4	23.41^{bc}	24.07^{a}	22.33^{bc}	54.98^{ab}	56.68^{cd}	50.09^{bc}	34.47^{abc}	35.18^{bcd}	34.49^{b}

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

Residual effects of cattle, goat and poultry manures on *C. olitorius* Leaf Area at second cycle of planting

The plots amended with cattle manure rate of 150 t ha^{-1} had *C. olitorius* LA value of 81.29 cm^2 recorded the highest increase of 97 %, while plots with 5 t ha^{-1} gave 49.26 cm^2 as the value for *C. olitorius* LA recorded the least increase of 19 % over the control. The LA of *C. olitorius* increased with increase in cattle manure rates except at 80 t ha^{-1} which decreased from 60 t ha^{-1} by 12 %. The plots incorporated with goat manure rate of 150 t ha^{-1} with *C. olitorius* LA value of 76.51 cm^2 resulted to highest increase of 94 % over the control. But plots with 5 t ha^{-1} which gave *C. olitorius* LA value of 47.08 cm^2 resulted to least increase of 19 %. The *C. olitorius* LA increased in plots with goat manure rates except 120 t ha^{-1} that decreased from 80 t ha^{-1} by 3 %. More so, plots amended with poultry manure rate of 10 t ha^{-1} recorded the *C. olitorius* LA value of 72.57 cm^2 and gave the greatest increment of 148 % while $N_{15}P_{15}K_{15}$ with the *C. olitorius* LA value of 50.09 cm^2 had the least increase of 71 % over the control; (Table 6).

Residual effects of cattle, goat and poultry manures on *C. olitorius* LA at third

cycle of planting

Soil incorporated with cattle manure rates of 150 t ha^{-1} had *C. olitorius*LA value of 51.19 cm^2 and highest increase of 82 % above the control. While $N_{15}P_{15}K_{15}$ recorded *C. olitorius* LA value of 34.47 cm^2 with the lowest increase of 22 %. The plots amended with goat manure rate at 80 t ha^{-1} recorded *C. olitorius* LA value of 60.58 cm^2 and resulted to highest increase of 102 % above the control. Whereas, soil with the rate of 20 t ha^{-1} gave *C. olitorius* LA value of 34.34 cm^2 and had lowest increase of 14 %. The plots amended with poultry manure rate of 60 t ha^{-1} had *C. olitorius* LA value of 50.19 cm^2 with highest increase of 92 % while 40 t ha^{-1} with *C. olitorius* LA value of 27.75 cm^2 had lowest increase of 6 % relative to control. However, the levels of increases in *C. olitorius* LA according to cattle, goat and poultry manures rates were not sequenced. The *C. olitorius* LA at second cycle of planting gave the highest values in all the amendment rates in comparison with the first and third cycles of planting (Table 6).

DISCUSSION

Soil properties

The soil used for the study could be classified as slightly saline (Las 2014). This could still support the growth of *C. olitorius* as observation from this research showed that *C. olitorius* was not a very salt sensitive crop. The soil was slightly alkaline (Pam and Brian 2007). This was optimal for *C. olitorius* performance since the vegetable performs well in slightly alkaline soils (Fasciola 1990). The soil was deficient in total N (McBride 2015; USDA-SCS 1974). These could support the growth of *C. olitorius* because they were the available form of N to crops (Marx *et al.* 1999). The Available P content was low (ENDMEMO 2015; Mallarino 2000) and could not support *C. olitorius* performance. However, the exchangeable K^+ and Mg^{2+} contents were moderate and optimal for performance of the crop while Na^+ and Ca^{2+} contents were high (Pam and Brian 2007). The 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 (Davidson and Jannssens 2006; Friedlingstein *et al.* 2006). According to McCauley *et al.* (2009), high Na^+ in the soil could lead to dispersion of ions which could cause reduction in water holding capacity and low aeration of the soil. The soil was sandy clay loam (USDA 2010) and could support *C. olitorius* performance as the plant grows well in light-sandy, medium- loamy and heavy clay soils (Fasciola 1990).

Manure properties

The EC of the cattle, goat and poultry manures incorporated were considered strongly saline (LAS 2014). However, highest EC value of poultry manure when compared to cattle and goat manures corroborated the works (Azeez and Van Averbeke 2010[a, b]). The pH of the dried pure goat and poultry manure values were considered mildy alkaline while cattle manure was moderately alkaline (Pam and Brian 2007). Cattle manure recorded highest 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 than goat manure. Therefore, low values of *C. olitorius* LA at high rates of cattle manure during the experiment could be due to this, as excessive K^+ could lead to accumulation and elevated K^+ levels in the soil (Marx *et al.* 1999), excess Na^+ to soil sodicity and dispersion (GRDC 2013). Highest contents of total N, Mg and OC in goat manure relative to cattle and poultry manures suggested the reason for lowest EC value of goat manure applied during the research.

The poultry manure gave higher NH_4^+- N, NO_3^-- N and total phosphorus compared with cattle and goat manures. Therefore, NH_4^+- N and NO_3^-- N contents in poultry manure which were higher than cattle and goat manures incorporated showed that poultry manure had high N nutrient quality than cattle and goat manures, this agrees with Azeez and Van Averbeke (2010[b]). Poultry manure contained more available N that *C. olitorius* utilized during the research than cattle and goat manures. This could have contributed to the production of high LA of *C. olitorius* in poultry manure at lower rates than cattle and goat manures during the study. This could be the reason behind the findings of Cam (2009) and Brader (2011), that N in the soil influences the yields mainly through LA expansion and dry matter production. Moreover, the organic N contents such as amino and fatty acids could be the reason behind high total N in cattle and goat manures during this research. High P content in poultry manure could also have contributed to the yield quality of *C. olitorius* at lower rates than cattle and poultry manures. However, very low value of total P in goat manure could be as a result of the nutrient concentrations of the feed given to the animals.

Influence of cattle, goat and poultry manures on K^+ and Na^+ during first, second and third cycles of planting *C. olitorius* L.

Application of cattle, goat and poultry manures increased the soil K^+ and Na^+ irrespective of the manures rates applied to soil. The soil K^+ contents were high in all the three cycles of planting *C. olitorius* (Pam and Brian 2007), though, first and second cycles values were excessive. High levels of K^+ and Na^+ would have contributed to the low yield performance of *C. olitorius* at first cycle as it would have accumulated in the shoot systems of the crops (Marx *et al.* 1999). This followed a similar trend with soil Na^+ during this study. The very high content of Na^+ (Pam and Brian 2007) in the soil would increase sodium adsorption ratio (SAR) of the soil which could lead to swelling and dispersion of clay particles as a result of increased sodicity due to high application rates of cattle, goat and poultry manures. However, the high sodicity led to limited soil wetting and water availability (Shaw 1997) by reducing soil water holding capacity and aeration (McCauley *et al.*, 2009). High sodicity could also lead to high salinity because sodicity and salinity often occur together (GRDC 2013). Hence, high value of *C. olitorius* LA in goat manure applied compared with cattle and poultry manures at first cycle could be due to nutrient contents in goat manure.

The soil K^+ contents reduced at second cycle while Na^+ increased compared with that of first cycle, likewise third to second cycle. This could be attributed to leaching of K^+ and Na^+ into the underground level as a result of rainfall during the period. This supports the study of Tomas *et al.* (2013); Levy; and Feigenbaum (1997) that soil Na^+ is readily leached. For the three cycles, sodicity increased according to the application rates but decreased across the cycles of planting. The higher the rates of the manures, the higher the K^+ and Na^+ level for the second and third cycles of planting.

Influence of cattle, goat and poultry manures on C. olitorius during first, second and third cycles of planting

During the first cycle of planting, application rates of 20 and 40 t ha^{-1} positively enhanced highest LA of *C. olitorius* in cattle and poultry manure treatments, respectively. This was in accordance with the work of Adenawoola and Adejoro (2005), that poultry manure rate of 30 and 50 t ha^{-1} was recommended to give higher yields of *C. olitorius*. However, applications at the rates of 120 t ha^{-1} and above for cattle and goat manure treatments and 80 t ha^{-1} and above for poultry manure treatment negatively affected the *C. olitorius* LA. This could be attributed to very high content of K^+ and Na^+ in the soil. This confirmed the studies of Rengasamy (2002) that sodicity can result in reduced plant growth and seedling emergence as a result of reduction in plant available water capacity and poor infiltration of rainfall and irrigation water or/ and anaerobic conditions (DPI&F 2004).

Increase in *C. olitorius* LA at second and third cycles could be attributed to reduction of the K^+ and Na^+ contents of the soil. This is because decreased in K^+ and Na^+ contents of the soil led to increase in *C. olitorius* LA across the cycles of planting. This could be subjected to infiltration of water into the soil as a result of minimum tillage that was carried out during harvesting of first and second cycles of planting (GRDC 2013) and high rainfall between 2 and $3^1/2$ months of the research.

Influence of $N_{15}P_{15}K_{15}$ fertilizer on soil and *C. olitorius* during first, second and third cycles of planting

The soils treated with $N_{15}P_{15}K_{15}$ fertilizer increment at two weeks after incorporation suggested quick dissolution of the mineral fertilizer and corroborated with the findings of Stolton (1997), that inorganic fertilizer supplied available nutrients quickly to plants. Hence, the decrease at harvested period suggested quick leaching, volatilization and plant root uptake.

CONCLUSIONS AND RECOMMENDATIONS

This study concluded that increase in rates of cattle, goat and poultry manures incorporated led to increase in soil K^+ and Na^+ at most weeks after planting at the three cycles of planting *C. olitorius* L. The concentration of K^+ and Na^+ in the soil reduced across the cycles of planting which implied that concentration of K^+ and Na^+ in the soil decreased with time. High contents of K^+ and Na^+ at 120 t ha^{-1} for cattle and goat manure treatments and 80 t ha^{-1} for poultry treatment, led to increase in excessive K^+ and sodicity of the soil between 0 – 2 months of the manure application. This hindered *C. olitorius* LA (0 – 2 months) but had greatest values for cattle, goat and poultry manures treatment between 2 and 5 months of the study.

Generally, the results of this experiment recommended that cattle; goat manures above 80 t ha^{-1} and poultry manure above 60 t ha^{-1} should not be applied to the soil for *C. olitorius* production. This study could be confirmed under different environmental conditions, more cycles and for different crops.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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