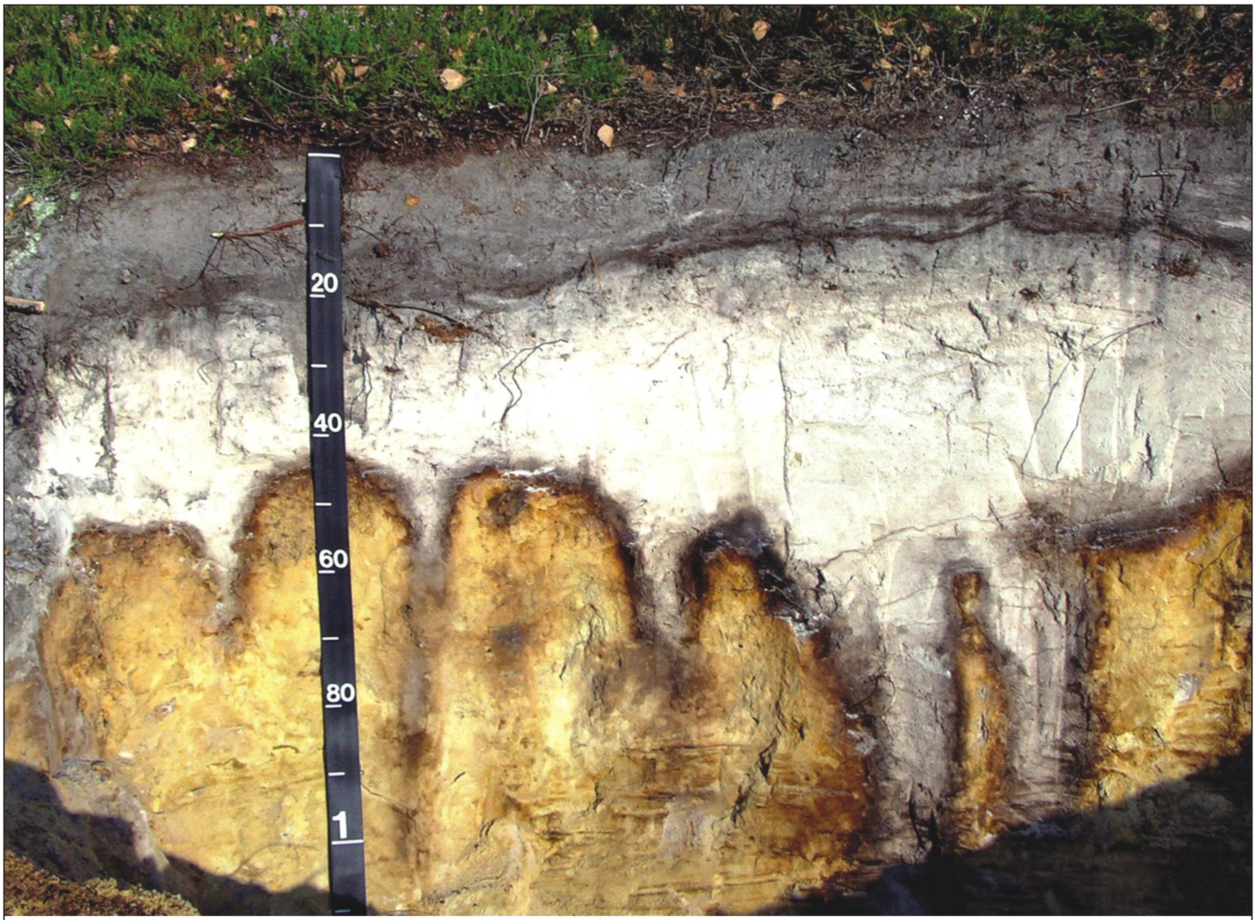

International Journal of Soil Science

ISSN 1816-4978

Academic Journals Inc.

www.academicjournals.com

OPEN ACCESS **International Journal of Soil Science**

ISSN 1816-4978
DOI: 10.3923/ijss.2025.1.15

Research Article
Effects of Three Animal Manures on Soil Electrical Conductivity and Growth Performance of *Corchorus olitorius* L.

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Abstract

Background and Objective: The effect of manure-induced factors on soil electrical conductivity (EC) and *Corchorus olitorius* L. when manures were applied at high rates had received little research attention. This study evaluated the effects of animal manures and their residuals on soil EC and *Corchorus olitorius* L. dry matter yield (DMY)/plant. **Materials and Methods:** The experiment was a randomized complete block design with three replications. The data collected were subjected to Analysis of Variance using a Statistical Analytical System. Cured cattle, goat and poultry manures were applied at 0, 5, 10, 20, 40, 60, 80, 120 and 150 t/ha once at the onset of the first cycle and $N_{15}P_{15}K_{15}$ at 0.4 t/ha per cycle. Soil samples collected bi-weekly in each cycle were analyzed for EC using standard procedures. Six weeks after planting (6 WAP) in each cycle, *Corchorus olitorius* L. DMY/plant was determined. Data were analyzed using ANOVA (Statistical Analytical System 22) and treatment means were compared using Duncan Multiple Range Test at a 5% probability level. **Results:** Across cycles, soil EC content decreased. Percentage increase of soil EC in the first, second and third cycles over the control, were 794, 667, 455; 660, 966, 430 and 675, 232, 205% for cattle, goat and poultry manure treatments, respectively. The *Corchorus olitorius* L. DMY/plant at the second and third cycles were higher than the first cycle by 33%. Incorporation of animal manures above 60 t/ha reduced *Corchorus olitorius* L. DMY/plant at the first cycle but improved the parameters at the second and third cycles. **Conclusion:** Consequently, the addition of cattle, goat and poultry manures above 60 t/ha increased the soil EC but decelerated *Corchorus olitorius* L. DMY/plant at the first cycle but their residual effects improved the DMY/plant of *Corchorus olitorius* L.

Key words: *Corchorus olitorius*, dry matter yield, animal manures, EC dynamics, residual effects

Citation: Saka, H.A., J.O. Azeez, M.M. Onaolapo and K.O. Alabi, 2025. Effects of three animal manures on soil electrical conductivity and growth performance of *Corchorus olitorius* L. Int. J. Soil Sci., 20: 1-15.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Electrical conductivity (EC) is the ability of a material to transmit or conduct an electrical charge or current and its magnitude varies according to the material[1]. It is one of the simplest, least expensive soil management available to precision farmers today and varies depending on the amount of moisture held by soil particles. However, when ions or salts are present in the soil, the EC of the soil solution increases. If no salts are present, the EC is low indicating that the solution does not conduct electricity well. The higher the dissolved material in water or soil samples, the higher the EC will be in that material, stated by Friedman[2].

The EC of soil is influenced by the concentration and composition of dissolved salts. According to Friedman[2], the ability of a solution to conduct an electrical current increased by salt contents, so a high EC value indicates a high salinity level. Water is lost from the soil due to evaporation and salts are effectively concentrated during drying conditions. Many plants experience stress due to salts, when the soil EC (1:2 soil:water) exceeds 0.25 dS/m (or 2.0 dS/m salt index), reported by Mushtaq *et al.*[3].

The most important properties of the soil can be described by the value of the soil EC. It can help to determine the exchangeable Calcium (Ca^{2+}) or Magnesium (Mg^{2+}) and the volume of organic origin of nitrogen (N) levels in the soil. The higher the organic content of the soil, the higher the EC. A low EC value indicates the lack of nutrients in the soil while a high EC value indicates the excess of nutrients[4]. Commercial operators are using EC to provide soil variability information to producers. It can be used to correlate soil physical properties, delineate areas with different yield potentials and delineate differences in organic matter content and cation exchange capacity (called electrical conductivity).

More so, it gives valuable information about soil differences and similarities. Variations in soil can be detected from soil EC. Water holding capacity or drainage can be identified using EC. Moreover, EC can be used to detect the temperature of the soil, as temperature decreases to the freezing point of water; soil EC decreases slightly[5]. According to Schoonover and Crim[6], the factors such as pore continuity, water content, salinity level, cation exchange capacity, depth and temperature can affect soil EC.

Efficient use of organic manure will alleviate the problem of declining land productivity. Organic manure is one of the inputs needed to achieve maximum yield[7]. It is a source of energy for many organisms and thus helps to hold the soil minerals against leaching. The main function of manure is not only to maintain soil fertility but also to raise the soil nutrients and enhance better growth, a more productive and profitable system of farming[8]. It introduces extra nutrients into the cycles of plant growth thereby increasing the yield, providing all kinds of micronutrients and can supply 60-80% of the macro-nutrients required. It can serve as chelate[9] and can bind organic micro-nutrient-elements. Organic manure increases the nutrient solubility and availability to plants[10,11]. Its decomposition and availability for the plants take a long period. The application of organic manure has been found to have a higher comparative economic advantage over the use of inorganic fertilizer, investigated by Adeniyan *et al.*[12].

There are tested recommendations on the appropriate use of organic manures for improving soil fertility and also for *Corchorus olitorius* L. production. There is still a need to study the effect of three animal manures on soil EC changes and performance of *Corchorus olitorius* L. at different rates and NPK fertilizer at the recommended rate when applied to the soil under the same environmental conditions and at the same time of planting in cycles. This study evaluated the effect of cattle, goat and poultry manures and their residuals on soil EC dynamics and *Corchorus olitorius* L. dry matter yield/plant.

MATERIALS AND METHODS

Study area: This research was conducted at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria, located between Latitude 7°C 12' N and Longitude 3°C 20' E, reported by Saka *et al.*[13]. The wet season is between April-October and the dry season is between November-March. This distribution creates two planting seasons generally categorized as early and late seasons. The maximum rainfall occurs during July and September with a dry spell in August. The annual rainfall is about 1,200 mm and a mean monthly temperature of 27°C. The university is located in the transition zone between tropical humid and savannah climate.

Experimental design: The experiment was a Randomized Complete Block Design (RCBD) and replicated three times. Cattle, goat and poultry manures were applied at the rates of 0, 5, 10, 20, 40, 60, 80, 120 and 150 t/ha separately while NPK 15-15-15 fertilizer was used as a check for each manure treatment and applied at the rate of 0.4 t/ha at the onset of each cycle.

Land preparation: The field area was manually cleared with a cutlass and a hoe and then packed. It was mechanically plowed twice using a tractor. The plowed field was marked before the preparation of beds. Raised beds of 0.3 m high were prepared manually using hoe and five drills made on each bed for planting of *Corchorus olitorius* L. seeds.

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

Duration of the study: The experiment was carried out during the wet season between April and October, 2013. Clearing of land, first and second plowing, layouts, preparation of beds and manure application were carried out on April 4th-24th, 2013. The beds were left for two weeks after incorporation of manures before planting between May 1st and 14th, 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 before the first planting. The first cycle of planting was carried out from May 15th to June 25th, the second cycle was from June 26th to August 6th and the third cycle was from August 20th to October 2nd, 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 the Federal University of Agriculture Abeokuta, Ogun State, Nigeria. Cattle dung was collected from the paddock of both sexes (bulls and cows) free of beddings where a semi-intensive system was practiced. The goat droppings that had been mixed with remains of feed materials (elephant grasses) and feedstuff (wheat offal) were obtained from the pens of both sexes (Billies and Nannies) under an intensive system. The droppings were sieved to remove the feed residues and plant materials were removed manually (hand picking) but still contained a minute quantity of furs. The poultry droppings were collected from the pen of layers underneath the battery cage system with no bedding. However, the manures freshly collected were dried and bagged before the commencement of the experiment.

The NPK 15-15-15 fertilizer and *Corchorus olitorius* L. seeds were procured from the Ministry of Agriculture, Asero, Abeokuta, Ogun State, Nigeria.

Manures and fertilizer application: The cured animal manures were weighed before application using Top loading balance with the model Camry Emperors (20×50 kg) and thoroughly worked onto the prepared vegetable beds to attain homogeneity of the manures and the soil at the rate of 5, 10, 20, 40, 60, 80, 120 and 150 t/ha before the first cycle of planting. This was allowed to equilibrate with the soil two weeks before planting[14]. These rates were applied to evaluate the optimal application rates of manures for *Corchorus olitorius* L. production and also to improve the chemical status of the soil.

The NPK 15-15-15 fertilizer was weighed using Gulex medical and scientific electronic balance (mode JT502N) and applied at the rate of 0.4 t/ha a day before each cycle of planting. This was carried out to compare the performance of *Corchorus olitorius* L. on NPK fertilizer treatment to animal manures.

Planting of crops: The seeds of *Corchorus olitorius* L. were soaked in cold water for three days to break the dormancy, sieved and air-dried[15]. Then the air-dried seeds were mixed separately with fine-dry sand before planting at a ratio of 1 g seed to 10 g fine-dry sand. This was weighed using Gulex medical and scientific electronic balance (mode JT502N) before spreading on each row to ensure adequate distribution. The prepared seeds were sown immediately because they could not be stored for long[16]. The seeding rate used was 2 kg/ha[17]. Direct seeding was practiced to avoid the shock of transplanting.

Cultural practices: The beds were mulched immediately after seeding at each cycle of planting using elephant grasses and the mulch materials were completely removed ten days after planting. The mulching prevented direct sunlight onto the beds and also helped to retain moisture by preventing evaporation from the soil due to inadequate rainfall, low relative humidity, high temperature and sunshine.

The beds were heavily irrigated with equal amounts of water for the first three consecutive days of planting. This was carried out to compliment the rainfall and more so to ensure uniform germination. The watering was changed to every other day after the germination of seeds in the absence of rainfall. Weeding was done manually by rouging (hand-pulling) during three and six weeks after planting (WAP) of each cycle of planting to reduce weed competition with the crops and also to create a pest and disease-free environment.

The termination of the crops commenced at 6 WAP equivalent to 42 days by uprooting as the maturation period of most *Corchorus* cultivars is from 30 to 40 days after planting according to Lawal *et al.*[18]. After harvesting of the first and second cycles of planting, each bed was tilled and re-drilled manually before the commencement of the second and third cycles of planting to pulverize the soil for easy germination of the new seeds, aeration of the soil, breaking up of organic residues, stimulate microbial activity and also to increase soil organic matter decomposition[19,20]. However, no control measure of pests and diseases was undertaken throughout the experiment.

Collection of manures and soil samples for laboratory analysis: Initial soil samples were taken randomly from nine points on the field immediately after the second plowing, at a depth of 0-30 cm which constitutes the rooting zone of the vegetables using a soil auger before manures incorporation. The soil samples collected were bulked, air-dried, crushed using a pestle and mortar, passed through a 2 mm sieve and packaged for soil routine physical and chemical analyses in the laboratory. The following are the chemical properties that were analyzed in the soil: pH, EC, NH_4^+-N, NO_3^--N and available P. Percentage clay and sand were the only physical properties that were analyzed.

Representative samples of manures applied were collected randomly, bulked, air-dried, milled, sieved through a 2 mm mesh size sieve and prepared for the selected routine chemical analyses in the laboratory. The samples were air-dried to prevent microbes from mineralizing the organic matter soil contents. The samples of cattle, goat and poultry manure prepared were analyzed for EC, pH, NH_4^+-N, NO_3^--N, total P, total K, total Na, total Ca, total Mg and OC. Separate chemical analysis were carried out to quantify the nutrient status of both the manures and soil.

Two weeks after the incorporation of manures but a day after the application of NPK fertilizer, soil samples were collected from the net portion of each bed at a depth of 0-15 cm (within the rooting zone of *Corchorus olitorius* L.) using a garden trowel. The collection of soil samples continued at every two-week interval during the first, second and third cycles of planting with the exception of four weeks after planting of the first cycle of planting due to some logistic problems. The samples were air dried in plates under shade and prepared for laboratory analysis. This was carried out to prevent volatilization of some nutrients. The prepared soil samples were analyzed for EC.

Manures, initial soil and soil samples collected bi-weekly were analyzed using standard procedure. Soil EC was extracted with a 1:2 soil:water ratio and measured using a HANNA 215 electrical conductivity meter[21].

Dry matter yield/plant (g) of *Corchorus olitorius* L.: Three *Corchorus* plants were selected from the net plot of each bed. The roots of these selected plants were rinsed with water and dried with tissue paper on the field. The plants were weighed using a Libror electronic scale (mode: EL -600 Shimadzu). The weighed plants were packaged in envelopes and put in the oven, dried at 60° C until constant weights were attained and the average values were recorded. This was determined using Libror electronic scale (mode: EL -600 Shimadzu). The dry matter yield was determined at constant dried weight.

Statistical analysis: Data collected were subjected to One-way Analysis of Variance (ANOVA) using Statistical Analytical System[22]. Duncan's Multiple Range Test at a 5% level of probability was used to determine differences in the treatment rates means and also to show the significant effects on parameters measured in relation to the control.

RESULTS AND DISCUSSION

Some chemical and physical properties of the soil used for the research: The result revealed that the soil used for the research had EC of very slightly saline with the value of 0.69 dS/m, slightly alkaline with a pH of 7.6 while total nitrogen was low and the value was 0.8 g/kg. Ammonium-nitrogen was 0.13 mg/kg while NO_3^-- N was 0.14 mg/kg (high). The available P content of 7.5 mg/kg was low. The soil was sandy clay loam with particle size classification values of 770, 68 and 162 g/kg for sand, silt and clay, respectively, (Table 1).

Some chemical properties of the cattle, goat and poultry manures used for the research: The EC of the cattle, goat and poultry manures applied with the values of 12.4, 8.8 and 16.4 dS/m, respectively were considered very strongly saline (Table 2). The pH of the cattle, goat and poultry manures was 7.9, 7.7 and 7.8, respectively. The total N of the cattle, goat and poultry manures was 45.1, 48.2 and 27.8 g/kg, respectively. Ammonium-nitrogen stimulated the values of 0.42, 0.32 and 1.47 g/kg while NO_3^--N resulted in 0.44, 0.36 and 1.49 g/kg for cattle, goat and poultry manures, respectively. However, total P was high with the values of 3.2, 0.7 and 16.2 g/kg for cattle, goat and poultry manures, respectively. Total K recorded values of 7.4, 3.7 and 3.9 g/kg for cattle, goat and poultry manures, respectively. Total Na had values of 9.3, 4.6 and 4.9 g/kg for cattle, goat and poultry manures, respectively. The values of total Ca were 29.6, 18.1 and 17.7 g/kg for cattle, goat and poultry manures, respectively. Total Mg gave 9.5, 10 and 5.3 g/kg for cattle, goat and poultry manures, respectively.

Table 1: Some chemical and physical 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)	0.69
Macronutrients	
Total nitrogen (g/kg)	1.20
Ammonium-nitrogen (mg/kg)	0.13
Nitrate-nitrogen (mg/kg)	0.14
Available phosphorus (mg/kg)	7.50
Particle size distribution	
Sand (g/kg)	770.00
Silt (g/kg)	68.00
Clay (g/kg)	162.00
Textural class	Sandy clay loam

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

	Values			
Chemical properties	Cattle	Goat	Poultry	NPK
pH Soil: H_2O (1:2)	7.90	7.70	7.80	-
Electrical conductivity (dS/m)	12.40	8.80	16.40	-
Total nitrogen (g/kg)	45.10	48.2	27.8	150
Total phosphorus (g/kg)	3.20	0.70	16.2	150
Total potassium (g/kg)	7.40	3.70	3.90	150
Total sodium (g/kg)	9.30	4.60	4.90	-
Total calcium (g/kg)	29.60	18.10	17.70	-
Total magnesium (g/kg)	9.50	10.00	5.30	-
Total organic carbon (g/kg)	178.80	223.00	59.30	-
Ammonium-nitrogen (g/kg)	0.42	0.32	1.47	-
Nitrate-nitrogen (g/kg)	0.44	0.36	1.49	-
Carbon: Nitrogen (g/kg)	3.97	4.63	2.13	-

Table 3: Agrometeorological data for the period of the experiment

	Cycles of planting		
Agrometeorological parameters	First	Second	Third
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: Hour, R.H.: Relative humidity, Evap.: Evaporation soil temperature at the depth of 20 cm and Source: Funaab Agromet Station

The values of total OC were 178.8, 223 and 59.3 g/kg for cattle, goat and poultry manures, respectively. The C:N ratios were 3.97, 4.63 and 2.13 for cattle, goat and poultry manures, respectively. It was observed from the result that cattle manure had the highest of total K, total Na and total Ca over the goat and poultry manures. However, goat manure was higher in total N, Mg and OC than cattle and poultry manure. The C:N ratio values of the cattle, goat and poultry manures were 3.97, 4.63 and 2.13, respectively and considered low.

Agrometeorological data for the period of the experiment: The values of rainfall, relative humidity, mean temperature and soil temperature at the second cycle of planting *Corchorus olitorius* L. were numerically higher while sunshine hours and evaporation values were numerically lower compared with the first and third cycles of planting (Table 3).

Soil electrical conductivity

Effect of cattle manure rates and NPK fertilizer (t/ha) on mean soil EC (dS/m) at various week intervals of the first cycle of planting *Corchorus olitorius* L.: The result Fig. 1a revealed that at planting, (2 WAI, two weeks after incorporation of manure but a day after application of NPK fertilizer), cattle manure rate of 120 t/ha had EC value of

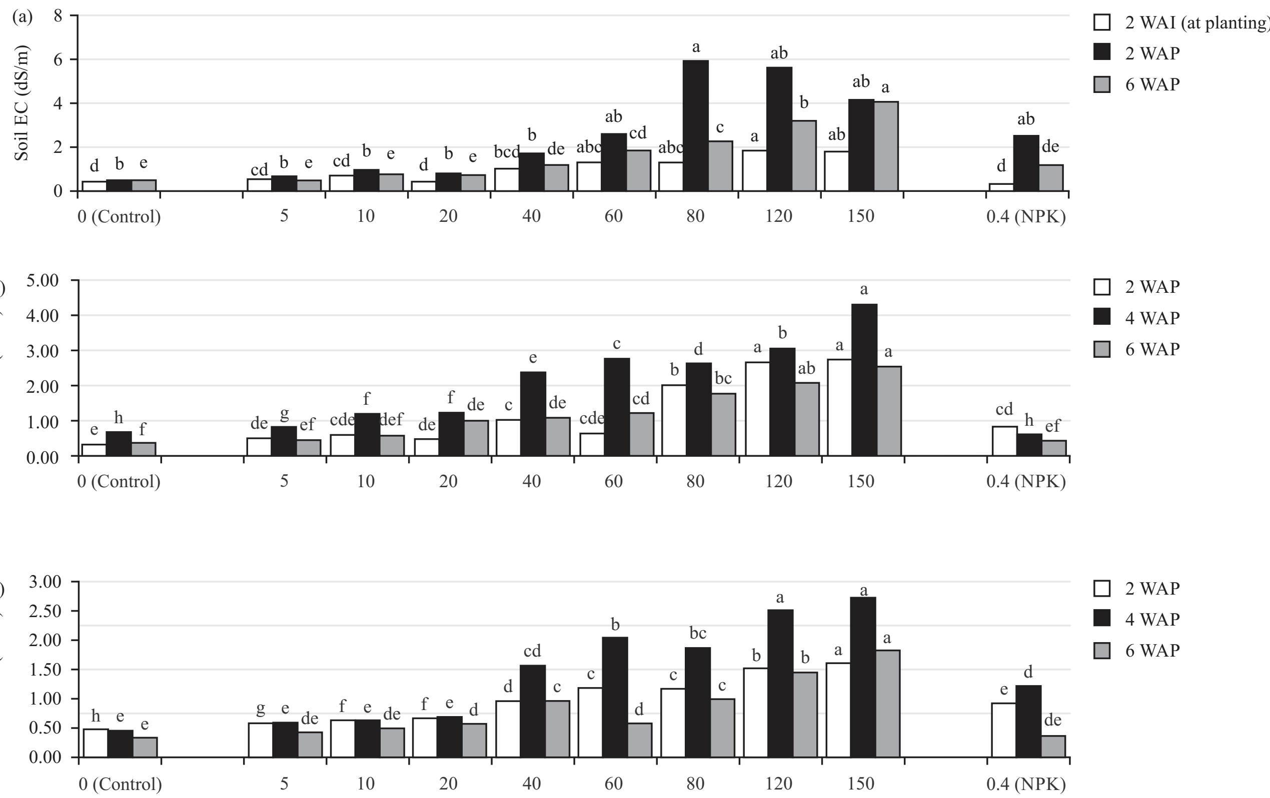

Fig. 1(a-c): Influence of cattle manure rates and NPK fertilizer (t/ha) on mean soil EC (dS/m) at 2 week intervals under different planting cycles of *Corchorus olitorius*, (a) First planting cycle, (b) Second planting cycle and (c) Third planting cycle
WAI: Weeks after incorporation of manures, WAP: Weeks after planting *Corchorus olitorius*, [abc]Statistically significant differences between groups. Bars sharing the same letter are not significantly different and while bars with different letters show a significant difference

1.85 dS/m and recorded the highest increase of 387%, while the rate of 5 t/ha which recorded EC value of 0.52 dS/m had the least increase of 37% over the control. The NPK fertilizer at the rate of 0.4 t/ha gave an EC value of 0.31 dS/m and decreased by 18% compared with the control.

At 2 WAP (4 WAI), the cattle amendment rate of 80 t/ha stimulated an EC value of 5.89 dS/m, this recorded the highest level of soil EC by 1153%, while 5 t/ha induced an EC value of 0.66 dS/m and recorded the lowest increment of 40% with control. The soil EC increased and varied with all the amendment rates compared with the control. There were no significant differences in 60, 80, 120, 150 t/ha and NPK fertilizer (Fig. 1a).

At 6 WAP (8 WAI), it was discovered that the cattle amendment rate of 150 t/ha resulted in a 4.11 dS/m value of EC and gave the highest increase over the control. The lowest increase of 7% was recorded in 5 t/ha which had the EC value of 0.49 dS/m relative to control. Control, 5, 10, 20, 40 t/ha and NPK showed no significant differences compared with one another (Fig. 1a).

The EC increased with increasing rates of application of cattle, goat and poultry manures. They all followed similar trends during the three cycles of planting *Corchorus olitorius* L. This response confirmed the findings of Azeez and van Averbeke[23,24], who observed in their experiment that there was a significant increase in soil EC with an increase in application rates of cattle, goat and poultry manures. This could be as a result of a high concentration of total K and Na in the manures incorporated. It could also be attributed to the deposited salt materials in the feed given to the animals.

Effect of cattle manure rates and NPK fertilizer (t/ha) on mean soil EC (dS/m) at two-week intervals of the second cycle of planting *Corchorus olitorius* L.: Figure 1b shows the residual effect of cattle manure rates and reapplication of NPK fertilizer on soil electrical conductivity at the second cycle of planting. At 2 WAP, it was observed that a cattle manure rate of 150 dS/m recorded the EC value of 2.71 dS/m and had the highest increment over the control. The rate of 5 dS/m stimulated the EC value of 0.49 dS/m and had the lowest increment in comparison with the control. However, control, 5, 10, 20, 60 t/ha and NPK fertilizer showed no significant differences.

At 4 WAP, 150 t/ha gave the EC value of 4.29 dS/m and recorded the greatest increment while 5 t/ha stimulated the EC value of 0.66 dS/m and had the lowest increase and NPK fertilizer with the EC value of 4.29 dS/m reduced compared with control. However, control and NPK fertilizer were not significantly different from each other.

At 6 WAP, a cattle manure rate of 150 t/ha with the EC value of 2.53 dS/m gave the highest increase over the control. This was not significantly different from 120 t/ha which recorded the EC value of 2.05 dS/m. An increase in rates of cattle manure led to an increment of soil EC.

Effect of cattle manure rates and NPK fertilizer (t/ha) on mean soil EC (dS/m) at two weeks interval of third cycle of planting *Corchorus olitorius* L.: Application of cattle manure rate of 150 t/ha stimulated the EC value of 1.61 dS/m and gave the highest increase in soil EC over the control. The rate of 5 t/ha had the EC value of 0.58 dS/m and stimulated the lowest increment compared with control, at 2 WAP (Fig. 1c).

At 4 WAP, the rate of 150 t/ha recorded an EC value of 2.72 dS/m and gave the greatest increase, 5 t/ha stimulated the EC value of 0.59 dS/m had the least increase relative to the control. However, statistical differences were not observed in the control, 5, 10, 20 and 40 t/ha for their EC values. Soil EC increased with an increase in cattle amendment rates except for 80 t/ha which reduced from 60 t/ha (Fig. 1c).

At 6 WAP, the cattle amendment rate of 150 t/ha stimulated the EC value of 1.83 dS/m and had the highest increase and NPK recorded the EC value of 0.37 dS/m and had the least increase compared with the control. Statistically, 5, 10, 20, 60 t/ha and NPK fertilizer were not significantly different. Soil EC increased with an increment in amendment rates. However, there was a sudden decrease between 40 and 60 t/ha (Fig. 1c).

Effect of goat manure rates and NPK fertilizer (t/ha) on mean soil EC (dS/m) at various week intervals of the first cycle of planting *Corchorus olitorius* L.: In Fig. 2a, a goat manure rate of 150 t/ha stimulated the value of 2.53 dS/m and recorded the highest increase in soil EC. While 5 t/ha had the value of 0.43 dS/m and recorded the least increase compared with the control, which had the value of 0.39 dS/m, at planting (2 WAI). However, goat manure rates of 5, 10, 20 t/ha, control and NPK fertilizer were not significantly different.

At 2 WAP, the goat amendment resulted in the highest increment from 120 t/ha over the control in soil EC (Fig. 2a). The rate of 10 t/ha gave the value of 0.74 dS/m and resulted in increment above control. Statistical analysis showed that control, 5 and 10 t/ha were not significant.

At 6 WAP, a goat manure rate of 150 t/ha resulted in a value of 4.18 dS/m was significantly higher in soil EC compared with other amendments and control. The highest increase resulted in 150 t/ha while 20 t/ha gave an EC value of 0.72 dS/m and stimulated the lowest increase in comparison with the control that had an EC value of 0.55 dS/m. Statistically, 5, 10, 20 and 40 t/ha and NPK fertilizer were not significantly different from the control (Fig. 2a). Application of goat manure increased the soil EC with an increase in rates.

Effect of goat manure rates and NPK fertilizer (t/ha) on mean soil EC (dS/m) at two weeks intervals of second cycle of planting *Corchorus olitorius* L.: Figure 2b showed that at 2 WAP, a goat m anure rate o f 120 t/ha gave the value of 2.60 dS/m, recorded the highest increase in soil EC, while 10 t/ha stimulated the value of 0.51 dS/m and had the least increase relative to control with the value of 0.30 dS/m. However, statistical analysis revealed that the rates of 5, 10 and 20 dS/m were not significantly different from the control.

At 4 WAP, 150 t/ha resulted with the value of 4.58 dS/m and had the highest increase of 545% and NPK fertilizer at the rate of 0.4 t/ha gave the EC value of 0.83 dS/m and had the lowest increase above control. There were no significant differences in control, 5 t/ha and NPK fertilizer. The addition of goat manure increased the soil EC with an increase in rates although a sudden decrease occurred between 80 and 120 t/ha (Fig. 2b).

The influence of goat manure at the rate of 150 t/ha recorded the value of 4.05 dS/m and had the greatest increment (Fig. 2b). While 5 t/ha gave the value of 0.53 dS/m and recorded the least increase at 6 WAP in comparison with control. Control, 5, 10, 20 t/ha and NPK fertilizer were not significant.

Effect of goat manure rates and NPK fertilizer (t/ha) on mean soil EC (dS/m) at two-week intervals of the third cycle of planting *Corchorus olitorius* L.: Figure 2c shows the effects of goat manure rates and NPK fertilizer on soil EC. At 2 WAP, the highest increase over the control was recorded in 150 t/ha which gave the EC value of 1.84 dS/m. While 5 t/ha stimulated the EC value of 0.54 dS/m and had the least increase in relation to control. However, statistical analysis revealed that there were no significant differences in control, 5 and 10 t/ha.

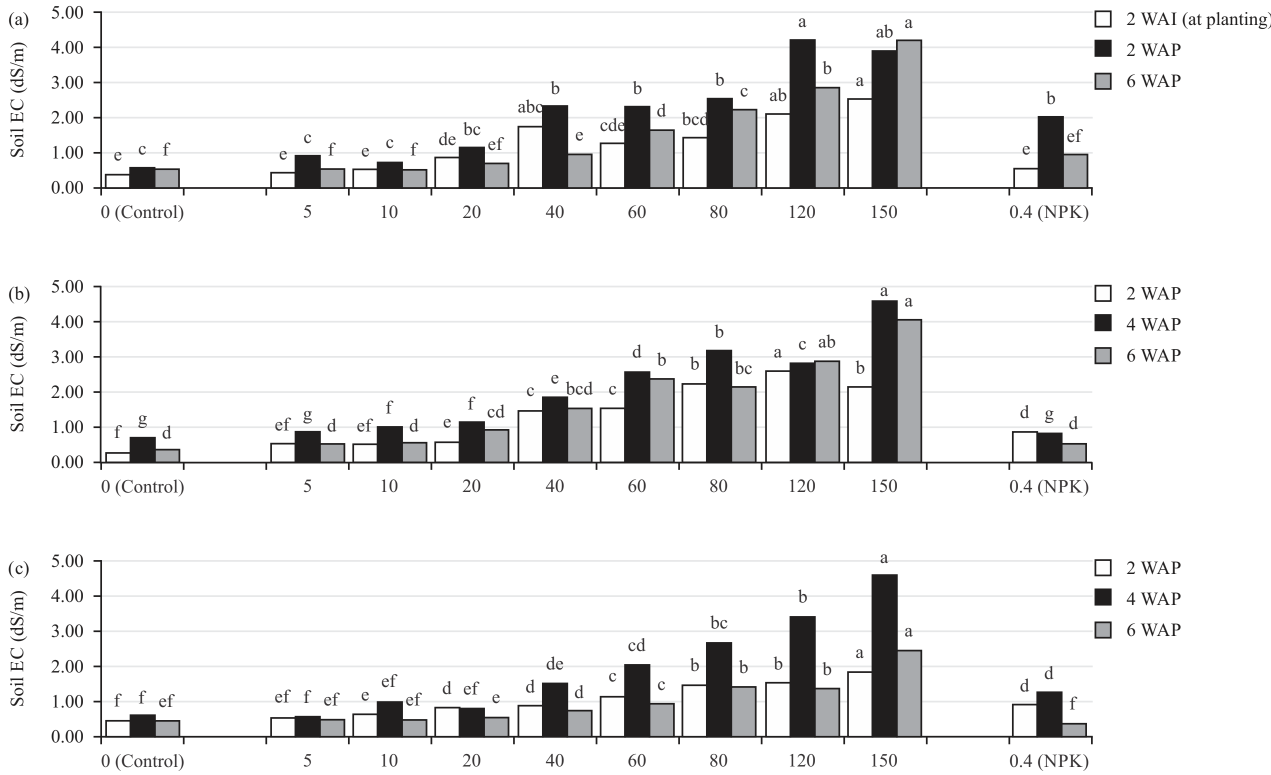

Fig. 2(a-c): Influence of goat manure rates and NPK fertilizer (t/ha) on mean soil EC (dS/m) at 2 week intervals under different planting cycles of *Corchorus olitorius*, (a) First planting cycle, (b) Second planting cycle and (c) Third planting cycle
WAI: Weeks after incorporation of manures, WAP: Weeks after planting *Corchorus olitorius*, [abc]Statistically significant differences between groups. Bars sharing the same letter are not significantly different and while bars with different letters show a significant difference

The level of soil EC was also significantly higher in 150 t/ha with the EC value of 4.61 dS/m with the highest increase over the control. The rate of 10 t/ha recorded the value of 0.59 dS/m and gave the least increase over the control at 4 WAP. No significant differences in control, 5, 10, 20 t/ha and NPK fertilizer, Fig. 2(c).

At 6 WAP, a goat manure rate of 150 t/ha also recorded the greatest soil EC value of 2.44 dS/m and had increment and the rate of 5 t/ha stimulated the EC value of 0.49 dS/m and recorded the lowest increase relative to the control. NPK fertilizer gave the EC value of 0.38 dS/m but decreased relative to the control. While 5, 10, 20 t/ha and NPK fertilizer had EC values of 0.49, 0.51, 0.56 and 0.38 dS/m, respectively but were not significantly different from the control. An increase in amendment rates leads to an increment of soil EC (Fig. 2c).

Effect of poultry manure rates and NPK fertilizer (t/ha) on mean soil EC (dS/m) at various week intervals of the first cycle of planting *Corchorus olitorius* L.: Figure 3a showed that at 2 WAI, the poultry amendment rate of 120 t/ha recorded the value of 1.86 dS/m and had the highest increase in soil EC over the control. The rate of 5 t/ha gave the value of 0.52 dS/m and recorded the least increase of 16% over the control. There were no significant differences in NPK fertilizer, control, 5 and 10 dS/m with the values of 0.39, 0.33, 0.38 and 0.52 dS/m, respectively. High EC indicates an excess of nutrients in the soil[4].

At 2 WAP (4 WAI), 80 t/ha stimulated the EC value of 3.87 dS/m and gave the highest increase in soil EC more than control. While 5 t/ha recorded the EC value of 0.81 dS/m and gave the least increase over the control. However, statistics showed that control, 5 and 10 t/ha show no significant differences (Fig. 3a).

It was observed that a poultry manure rate of 80 t/ha gave the value of 2.79 dS/m and recorded the highest increase in soil EC at 6 WAP, while 5 t/ha stimulated the value of 0.54 dS/m and had the lowest increase with control. Statistical analysis revealed that 5, 10, 20 and 40 t/ha and NPK fertilizer did not differ significantly compared with the control. The soil EC increased with an increase in poultry amendment rates although, there was a decrease between 80 and 120 t/ha (Fig. 3a).

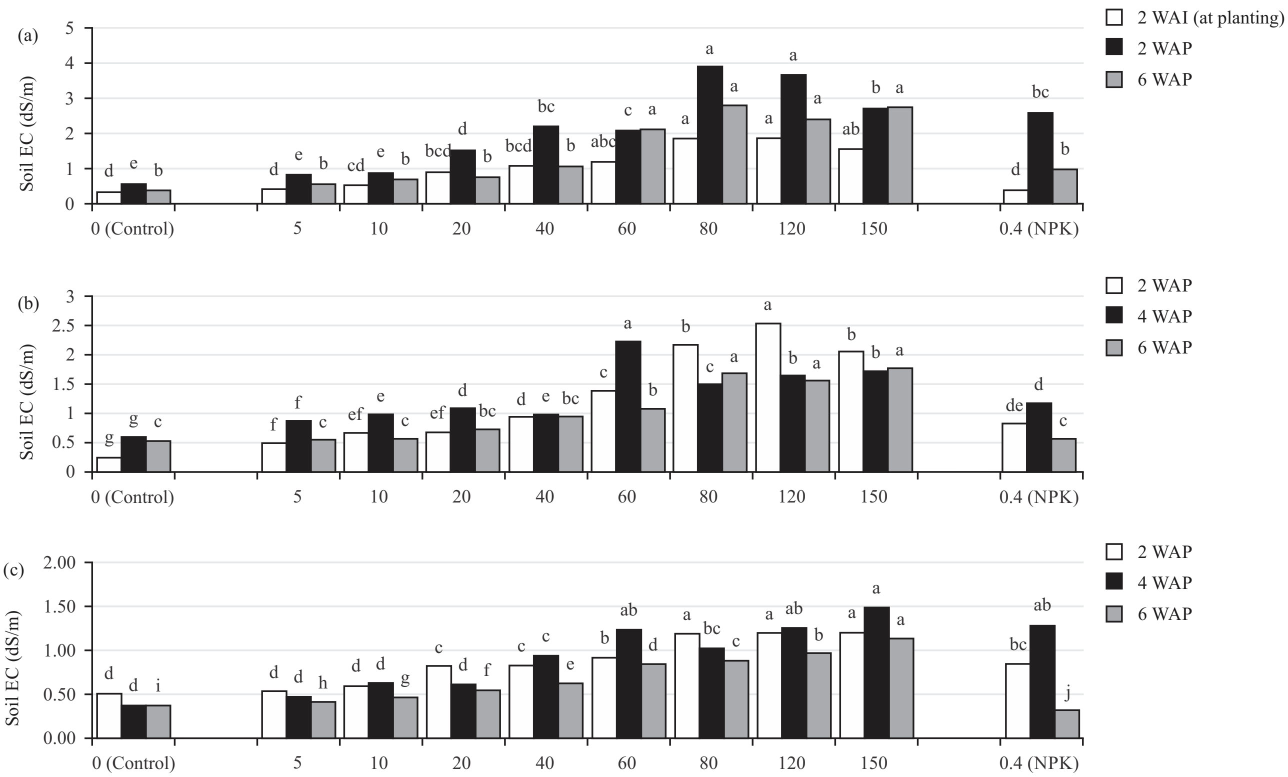

Fig. 3(a-c): Influence of poultry manure rates and NPK fertilizer (t/ha) on mean soil EC (dS/m) at 2 week intervals under different planting cycles of *Corchorus olitorius*, (a) First planting cycle, (b) Second planting cycle and (c) Third planting cycle
WAI: Weeks after incorporation of manures, WAP: Weeks after planting *Corchorus olitorius*, [abc]Statistically significant differences between groups. Bars sharing the same letter are not significantly different and while bars with different letters show a significant difference

Effect of poultry manure rates and NPK fertilizer (t/ha) on mean soil EC (dS/m) at two-week intervals of the second cycle of planting *Corchorus olitorius* L.: Figure 3b showed that at 2 WAP, poultry manure rate of 120 t/ha recorded the value of 2.56 dS/m and gave the highest increment of 885% in soil EC the rate of 5 t/ha had the EC value of 0.50 dS/m but gave the lowest increment of 92% relative to control. However, statistical analysis revealed no significant differences in 5, 10 and 20 t/ha. Furthermore, an increase in poultry amendment rates led to an increment of soil EC.

The influence of soil EC was greater in 60 t/ha which gave the EC value of 2.25 dS/m and stimulated the greatest increment of 269% over the control. The poultry manure rate of 5 t/ha had the EC value of 0.88 dS/m and recorded the least increase compared with control at 4 WAP.

The poultry manure rate of 150 t/ha stimulated the value of 1.79 dS/m and recorded the highest increase in soil EC over the control. The rate of 5 t/ha gave the value of 0.54 dS/m and had the least increase relative to control at 6 WAP (14 WAI). Statistics showed that control, 5, 10 t/ha and NPK fertilizer were not significantly different from one another (Fig. 3b).

Effect of poultry manure rates and NPK fertilizer (t/ha) on mean soil EC (dS/m) at two weeks interval of third cycle of planting *Corchorus olitorius* L.: At 2 WAP, the poultry amendment rate of 150 t/ha recorded the EC value of 1.20 dS/m and had the highest increment in soil EC (Fig. 3c). While 5 t/ha gave the value of 0.53 dS/m and stimulated the least increment compared with the control. Control, 5 and 10 t/ha were not differed significantly. An increase in the rate of poultry manure application increased the soil EC.

At 4 WAP, the poultry manure rate of 150 t/ha recorded the EC value of 1.49 dS/m and gave the highest increase in soil EC and the lowest increase was recorded from 5 t/ha which had the EC value of 0.47 dS/m in comparison with control. Control, 5, 10 and 20 t/ha were not significantly different (Fig. 3c).

At 6 WAP, poultry manure rate of 150 dS/m stimulated the EC value of 1.13 dS/m and gave the greatest increase in soil EC and the rate of 5 t/ha had the value of 0.41 dS/m and recorded the lowest increase above the control. While NPK fertilizer with the EC value of 0.32 dS/m had a decrease in relation to control. All the amendment rates were significantly different compared with one another (Fig. 3c).

The changes in soil EC values could be a result of the ions moving in and out of the soil with percolation of water into the soil and evaporation from the soil. High salinity led to high sodicity, thus increase in EC would lead to an increase in sodium adsorption ratio (SAR). The EC at 120 t/ha and above for cattle and goat manures and 80 t/ha and above for poultry manure across the two weeks interval of planting *Corchorus olitorius* L. Suggested that the salinity of the soil decreased with time of application. However, the decrease could be a result of leaching through the movement of water into the underground level during rainfall or irrigation practice on the field or uptake by plants at each cycle of planting.

Dry matter yield (DMY)/plant (g) of *Corchorus olitorius* L.

Effect of cattle manure rates and NPK fertilizer (t/ha) on mean DMY/plant (g) at harvesting of first, second and third cycles of planting *Corchorus olitorius* L.: The range of DMY/plant in accordance with cattle manure rates was between 0.64 and 3.19 g. The cattle amendment rate at 80 t/ha had DMY/plant value of 3.19 g and this resulted in highest increase. 5 dS/m recorded a DMY/plant value of 0.98 g and resulted in least increase of 8% more than the control. A reduction was recorded in 120 dS/m with the DMY/plant value of 0.64 g in relation to control. There were significant differences in the amendment rates, Table 4.

At third cycle of planting, the DMY/plant values ranged between 2.01 and 5.73 g. The highest increment of 120% resulted in a cattle manure rate of 60 t/ha over the control and recorded the DMY/plant value of 5.73 g, the least increment of 3% resulted in 10 t/ha with DMY/plant value of 2.68 g but 5 t/ha gave a reduction of 23% and had 2.01 g value of DMY/plant relative to control.

The additions of cattle manure rates and NPK fertilizer increased the DMY/plant in all three cycles compared with the control. The third cycle of planting stimulated the highest increase in DMY/plant in all the amendment rates compared with the first and second cycles of planting. Nevertheless, DMY/plant increased with an increase in the cycles of planting.

Table 4 shows that mean of DMY/plant for cattle manure ranged between 1.85 and 3.81 g across cycles at harvesting of *Corchorus olitorius* L. Highest increase of 84% resulted in 60 t/ha and had the DMY/plant value of 3.81 g, lowest increase of 32% resulted in 10 t/ha with the value of 2.73 g while 5 t/ha that had the value of 1.85 g resulted to a reduction of 11% to control. All cattle amendment rates and NPK fertilizer resulted to significantly higher values in DMY/plant relative to control except 5 t/ha.

Effect of goat manure rates and NPK fertilizer (t/ha) on mean DMY/plant (g) at harvesting of first, second and third cycles of planting *Corchorus olitorius* L.: At first cycle of planting, DMY/plant in accordance with goat manure rates range between 0.89 and 3.10 g. The goat amendment rate at 10 and 60 t/ha resulted to significantly higher values of DMY/plant compared with other goat amendment rates, control and NPK fertilizer. The rate of 10 t/ha which recorded the DMY/plant value of 3.10 g resulted in the highest increase of 425% and 5 t/ha with a DMY/plant value of 1.83 g resulted in the least increase of 106% relative to the control. All the amendment rates were significantly different about control (Table 4).

During the second cycle of planting, statistical analysis revealed that virtually every amendment rates was not significantly different from the control. More so, at the third cycle of planting, the values ranged between 2.84 and 5.02 g. The highest increment of 73% resulted in a goat manure rate at 120 t/ha with a DMY/plant value of 5.02 g, least increment of 3% was recorded in 5 t/ha and had a DMY/plant value of 3.00 g relative to control. All the goat amendment rates, NPK and control were significantly different. The addition of goat manure rates and NPK fertilizer increased the DMY/plant in all three cycles compared with the control. As a result, DMY/plant increased with an increase in the cycles of planting. This followed a similar trend with cattle amendment rates.

The mean DMY/plant of goat manure ranged between 1.91 and 4.04 g (Table 4) across cycles at harvesting of *Corchorus olitorius* L. The rate of 60 t/ha with the DMY/plant value of 4.04 g simulated the highest increase of 112% and 5 t/ha with the DMY/plant value of 2.55 g stimulated the lowest increase of 34% compared with control. There were significant differences in the amendment rates.

Effect of poultry manure rates and NPK fertilizer (t/ha) on mean DMY/plant (g) at harvesting of first, second and third cycles of planting *Corchorus olitorius* L.: The DMY/plant according to poultry manure rates ranged between 0.87 and 3.88 g at the first cycle of planting. The poultry amendment rate at 40 t/ha resulted to a significantly higher value in DMY/plant compared with other poultry amendment rates, control and NPK fertilizers. The rate at 40 t/ha had the DMY/plant value of 3.88 g and resulted in the highest increase of 346% while 150 t/ha with a DMY/plant value of 0.88 g resulted to least increase of 1% above the control. However, 120 t/ha which recorded the DMY/plant value in 0.69 g stimulated a decrease of 21% relative to the control. There were significant differences in the amendment rates. Though, the rate of 5 t/ha was not statistically different from 80, 120 and 150 t/ha (Table 4).

Table 4: Influence of cattle, goat and poultry manure rates and NPK fertilizer (t/ha) on mean of dry matter yield/plant (g) at first, second, third cycles and mean across cycles of planting *Corchorus olitorius* L.

	Mean of dry matter yield/plant (g) of *Corchorus olitorius* L.											
	Cattle			Goat			Poultry			Mean across cycles		
Rates (t/ha)	FCP	SCP	TCP	FCP	SCP	TCP	FCP	SCP	TCP	Cattle	Goat	Poultry
0	0.91^{cd}	2.70^{a}	2.61^{ab}	0.59^{b}	1.94^{a}	2.90^{ab}	0.54^{c}	2.03^{b}	2.53^{a}	2.07^{b}	1.91^{c}	1.81^{c}
5	0.98^{cd}	2.56^{a}	2.01^{b}	1.83^{ab}	2.81^{a}	3.00^{ab}	1.25^{c}	3.59^{ab}	2.30^{a}	1.85^{b}	2.55^{bc}	2.38^{bc}
10	1.47^{bcd}	4.05^{a}	2.68^{ab}	3.10^{a}	2.27^{a}	2.75^{b}	1.19^{b}	4.02^{a}	3.21^{a}	2.74^{ab}	2.71^{bc}	2.81^{abc}
20	2.83^{ab}	3.11^{a}	3.74^{ab}	2.66^{ab}	3.26^{a}	2.84^{ab}	1.94^{b}	3.69^{a}	3.23^{a}	3.08^{ab}	2.92^{bc}	2.95^{ab}
40	2.00^{abc}	3.56^{a}	3.59^{ab}	2.44^{ab}	4.01^{a}	4.24^{ab}	3.88^{a}	3.65^{ab}	2.66^{a}	3.05^{ab}	3.56^{ab}	3.40^{ab}
60	2.55^{ab}	3.16^{a}	5.73^{a}	3.09^{a}	4.03^{a}	4.99^{a}	3.02^{ab}	3.81^{ab}	4.31^{a}	3.81^{a}	4.04^{a}	3.71^{a}
80	3.20^{a}	2.83^{a}	4.21^{ab}	1.85^{ab}	3.42^{a}	4.33^{ab}	1.28^{c}	3.61^{ab}	3.49^{a}	3.41^{a}	3.20^{ab}	2.79^{ab}
120	0.64^{d}	3.51^{a}	3.97^{ab}	1.60^{ab}	3.16^{a}	5.02^{a}	0.69^{c}	4.28^{a}	4.13^{a}	2.70^{ab}	3.26^{ab}	3.03^{ab}
150	1.77^{bcd}	3.84^{a}	4.40^{ab}	2.00^{ab}	3.39^{a}	4.51^{ab}	0.88^{c}	4.46^{a}	3.52^{a}	3.14^{ab}	3.30^{ab}	2.95^{ab}
0.4	2.05^{abc}	2.82^{a}	3.43^{ab}	2.03^{ab}	2.91^{a}	3.54^{ab}	2.13^{ab}	3.46^{ab}	3.01^{a}	2.77^{ab}	2.83^{bc}	2.87^{ab}

Means followed by the same letter(s) within the same columns do not differ significantly at $p<0.05$ according to Duncan's Multiple Range Test, FCP: First cycle of planting, SCP: Second cycle of planting and TCP: Third cycle of planting

More so, at the second cycle of planting, the range of the DMY/plant is between 2.03 and 4.46 g. The poultry amendment rates of 10, 120 and 150 t/ha had the values of 4.02, 4.28 and 4.46 g, respectively and had significantly higher values of DMY/plant compared with other poultry manure rates, NPK and control. The rate of 150 t/ha gave the DMY/plant value of 4.46 g and recorded the greatest increase of 120% while NPK recorded the least increase of 70% and gave the DMY/plant value of 3.46 g relative to control. Statistical analysis revealed that every amendment rate was not significantly different from the control. The incorporation of poultry manure rates and NPK fertilizer increased the DMY/plant in all three cycles compared with the control. The second cycle of planting stimulated the highest increase of DMY/plant in all the amendment rates compared with the first and third cycles of planting (Table 4).

The applications of cattle, goat and poultry manures at the rates of 120 t/ha and above for cattle and goat manure treatments and 80 t/ha and above for poultry manure treatment negatively affected the *Corchorus olitorius* L. DMY/plant during the first cycle of planting which corresponded to 0-2 months of manures incorporation. Hence, this suggested that the EC of the soil above 2.80 dS/m would hinder *Corchorus olitorius* L. performance. Moreover, the performance of *Corchorus olitorius* L. in soil with a salinity level of below 2.1 dS/m between 4 and 5.5 months of manure application gave better potential yield in relation to 0-3.5 months of application. The soils treated with NPK 15-15-15 fertilizer increment two weeks after incorporation suggested the quick dissolution of the mineral fertilizer while the decrease at the harvested period suggested quick leaching, volatilization and plant root uptake.

The result from the soil used for this experiment had an EC of very slightly saline, slightly alkaline[25] while total nitrogen was low[26]. The EC 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 pH was optimal for the performance of *Corchorus olitorius* L. since the vegetable performs well in slightly alkaline soils[27]. Ammonium-nitrogen and NO_3^--N were high. High HH_4^+-N could be attributed to low immobilization as a result of the normal C:N ratio of the soil and high NO_3^--N 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[28]. The available P content was low[29]. The soil was sandy clay loam[30]. This could support *Corchorus olitorius* L. performance as the plant grows well in light-sandy, medium- loamy and heavy clay soils[31]. This would allow more salts to be deposited at the plant roots which could be the reason for the yellowish color of *Corchorus olitorius* L. leaves at 2 WAP and 4 WAP of the first cycle of planting during this experiment. As reported by Muhammad[32], 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 (Table 1).

The EC of the cattle, goat and poultry manures applied were considered very strongly saline and supported the report of Kumar *et al.*[25] (Table 2). This could be due to the high concentration of cationic salts in the manures. More so, the highest EC value of poultry manure compared with the cattle and goat manures supports the research of Azeez and van Averbeke[24,33], that poultry manure had greater EC values than cattle or goat manures. This could be due to the highest NH_4^+-N, NO_3^--N and total P contents in poultry manure applied.

The pH of the cattle manure was moderately alkaline while goat and poultry manures were mildly alkaline. This corroborated the report of Wilcock *et al.*[34] that pH values between 7.4-7.8 were mildly alkaline while that between 7.9-8.4 were moderately alkaline. This would allow for nutrient availability in the soil after mineralization. Ammonium-nitrogen and NO_3^--N stimulated high values which showed that poultry manure had higher N nutrient quality than cattle and goat manures[33]. 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.

It could be attributed to the production of high DMY/plant of *Corchorus olitorius* L. in poultry manure at lower rates than cattle and goat manure rates during the experiment. This could also be the reason behind the findings of Omololu *et al.*[35], who reported that N in the soil influences the yields mainly through dry matter production. However, total P was high and could also be attributed to the yield quality of *Corchorus olitorius* L. at lower rates than cattle and poultry manures. These high rates of NH_4^+-N, NO_3^--N and total P in poultry manure could be the reason for the highest EC value in poultry manure than cattle and goat manures.

Total K, Na, Mg and Ca were high. The higher amount of pH, total K, Na and Ca in cattle manure than goat and poultry manures applied could be due to the higher EC value in cattle manure than goat manure. This confirmed the findings of Friedman[2] that EC of a soil is influenced by the concentration and composition of dissolved salts. This could lead to low values of *Corchorus olitorius* L. DMY/plant at high rates of cattle manure during this research. The reason being that excessive K^+ could result in accumulation and elevated K^+ levels in the soil[28], excess Na^+ could cause soil sodicity and dispersion while Ca^{2+} could result in dispersion of the soil[36].

From the result, cattle manure had the highest total K, Na and Ca over the goat and poultry manures. However, goat manure was higher in total N, Mg and OC compared to cattle and poultry manures. Hence, the very low value of total P in goat manure applied could be due to the nutrient concentrations of the feed given to the animals (elephant grass and wheat offal) under an intensive system. However, the nutrient contents of the feed were not analyzed.

The C:N ratio values of the cattle, goat and poultry manures were considered low[37]. The cattle manure ratio was against 11.3 for liquid dairy manure and 17.2 for solid dairy manure reported by Burger and Venterea[38] whereas, Bitzer and Sims[39] suggested that poultry manure generally had quite a low C:N ratio ranging from 1-27:1. These low C:N ratio of the three manures applied would improve the performance of *Corchorus olitorius* L. as reported by Azeez and van Averbeke[33] and Azam[40] 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 high quality than other two manures.

The greatest contents of total N, Mg, OC and C:N ratio in goat manure compared with cattle and poultry manures could be led to the lowest value of EC in goat manure applied during the research, as Mg was the only salt-forming cation that was highest in goat manure. The greatest total N could be due to the N level in the feed fed to the goat animals.

The EC increased with increasing rates of application of cattle, goat and poultry manures. They all followed similar trends during the three cycles of planting *Corchorus olitorius* L. This response confirmed the findings of Azeez *et al.*[14]; Azeez and van Averbeke[23], observed in their experiment that there was a significant increase in soil EC with an increase in application rates of cattle, goat and poultry manures. This could be a result of high concentrations of total K and Na in the manures incorporated. It could also be attributed to the deposited salt materials in the feed given to the animals. The effect of EC in the soil among the soil chemical properties appeared to follow a similar trend with exchangeable K^+ and Na^+ according to the rates of application of manures and also across the cycles of planting.

The higher the rates of cattle, goat and poultry manures, the higher the level of soil EC, K^+ and Na^+ in the soil. The changes in soil EC values could be as a result of the ions moving in and out of the soil with percolation of water into the soil and evaporation from the soil. High salinity led to high sodicity, thus increase in EC would lead to an increase in sodium adsorption ratio (SAR).

The EC at 120 t/ha and above for cattle and goat manures and 80 t/ha and above for poultry manure across the two-week interval of planting *Corchorus olitorius* L. suggested that the salinity of the soil decreased with time of application. However, the decrease could be a result of leaching through the movement of water into the underground level during rainfall or irrigation practices on the field or uptake by plants at each cycle of planting.

The application of cattle, goat and poultry manures at the rates of 120 t/ha and above for cattle and goat manure treatments and 80 t/ha and above for poultry manure treatment negatively affected the *Corchorus olitorius* L. DMY/plant during the first cycle of planting which corresponded to 0-2 months of manures incorporation. Hence, this suggested that the EC of the soil above 2.80 dS/m would hinder *Corchorus olitorius* L. performance. Moreover, the performance of *Corchorus olitorius* L. in soil with a salinity level of below 2.1 dS/m between 4 and 5.5 months of manure application gave better potential yield with 0-3.5 months of application.

The soils treated with NPK 15-15-15 fertilizer increment two weeks after incorporation suggested the quick dissolution of the mineral fertilizer while the decrease at the harvested period suggested quick leaching, volatilization and plant root uptake.

CONCLUSION

Consequently, the addition of cattle, goat and poultry manures on the soil improved the soil EC compared with the control but the application of NPK 15-15-15 fertilizer had low soil EC compared to cattle, goat and poultry manures incorporated. However, an increase in rates of cattle, goat and poultry manures incorporated led to an increase in the soil EC at the three cycles of planting *Corchorus olitorius* L. The higher the rate of application of the three manures, the higher the concentration of EC in the soil at the first, second and third cycles of planting *Corchorus olitorius* L. The concentration of EC in the soil reduced across the cycles of planting which implied that the concentration of EC in the soil decreased with time. The high values of EC at the rate of 120 t/ha for cattle and goat manure treatments and 80 t/ha for poultry manure treatment led to an increase in the salinity of the soil but this hindered the *Corchorus olitorius* L. DMY/plant at the first cycle while these high rates led to increase in the *Corchorus olitorius* L. DMY/plant at second and third cycles.

SIGNIFICANCE STATEMENT

This study highlights the impact of high manure application rates on soil electrical conductivity (EC) and *Corchorus olitorius* L. growth, addressing a research gap in manure-induced soil changes. The findings indicate that cattle, goat and poultry manure applied at 80-150 t/ha significantly increased soil EC at two-week intervals, while the lowest increase was observed at 5 t/ha. In contrast, NPK fertilizer at 0.4 t/ha reduced EC compared to the control. The study's significance lies in identifying manure levels that may be detrimental to soil and crop growth, emphasizing that excessive initial applications hinder plant performance, whereas residual effects enhance it. This research provides insights into optimal manure application rates and timing, offering valuable guidance for sustainable soil fertility management. While variations exist across soil types and regions, these findings help inform best practices to maximize crop productivity without compromising soil health.

ACKNOWLEDGMENT

Authors appreciate the editor, reviewers and those who contributed to the success of this work.

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