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Abstract

Purpose: Tomato is one of the most popular and versatile vegetables in the world and organic production with high yields of desirable quality are a target of many producers. However, the yield of tomatoes in Uganda are low compared to other parts of the world. The reason is that most soils in Uganda are low in fertility. There is widespread soil degradation, due to massive soil erosion resulting into loss of organic matter, high soil acidity and nutrient imbalance hence low crop yields. This study aimed at establishing the effect of different poultry manure on the performance of tomatoes.

Methodology: The field trials were conducted in the mid altitude environment at BSU farm. Four treatments which included broiler, Layer, combination of Broiler and Layer chicken manure and the control were applied. The study was carried out in a randomized complete block design replicated four times. Measurements were made on number of leaves, number of flowers, plant height, fruit weight, fruit size, number of tomatoes and yield per hectare. Broiler and layer chicken manure increased the number of leaves, plant height number of flowers, number of fruits, fruit weight and fruit size significantly.

Findings: The results indicate that poultry manure is very rich in macro nutrients. Among the treatments, broiler and layer chicken manure gave the highest fruit yield of 13.8 and 13.4 tons per hectare (t/ha) respectively. A combination of the manure produced 12.8 t/ha and the control treatment gave the lowest yield of 8.1 tons per hectare (t/ha). There was no significant difference between broiler and layer chicken manure. Both manures were equally good and enhanced yield. Therefore, farmers may opt for either of the two depending on the availability.

Recommendation: The study recommend that either broiler or layer chicken manure can be used for production of tomato in order to achieve high yields.

Keywords: *Broiler manure, yield, layer manure, tomato, Uganda*

INTRODUCTION

According to Foolad (2018), tomato is the sixth most valuable crop in the world worth US$ 87.9 billion in 2016 and is grown in all soil types on a small scale for family use and commercial purposes. Tomato belongs to the *solanaceae* family and the genus *Lycopersicon* which is a small genus within the large and diverse genera that consists approximately 90 genera (Singh, 2019) and is one of the most consumed vegetables in the world. Tomatoes can be eaten fresh or in processed forms such as source, ketchup, puree, paste, powder and soup (Battistuzzi, 2012). Tomato is also a crop which is globally grown, some in the open field others in the green house. Indeterminate varieties are usually grown in greenhouses (Stoleru, 2020).

In Uganda, the crop is grown throughout the year. However higher profits are realized during the dry season since the demand is higher than supply. There is also less disease pressure during the dry season when the crop is grown under irrigation. Tomatoes play an important role in human diet because they are a good source of minerals and vitamins a remedy for night blindness. Tomatoes contain a high level of lycopene; substances that are used in some of the more pricy facial cleansers that are available for purchase (Wang, 2020). Tomatoes also help to prevent several types of cancer. Studies indicate that high levels of lycopene in tomatoes reduce the chances of developing prostate, colorectal and stomach cancer. Lycopene is a natural antioxidant that works effectively to slow the growth of cancerous cells (Bathla, 2019; Labrie & Marcelis; 2020).

Tomatoes help maintain strong bones. This is because they contain considerable amounts of calcium and Vitamin K. Both nutrients are essential in strengthening and performing minor repairs on the bones as well as the bone tissue (Amao, 2018). There are many varieties of tomatoes that are grown in Ugandan. These are Marglobe, Beauty, Roma, Heinz, Rio- Grande, DRD Hybrid, Asilla Hybrid, Eden Hybrid, Proster, Money maker Beinomugisha, (2019). Among these, Rio Grande tomatoes are the most commonly grown. The variety was used in the present study because it is the most commonly grown in Uganda because the seeds are cheap to buy, easy handling during harvesting and has long shelf life in the market (Liamngee, 2019).

According to El-Shafie (2020), the most leading tomato producing countries in the world are China, India, USA and Turkey with a production of 56.4, 19.4, 12.6 and 12.2 million tons respectively. Uganda produces 37,167 tons per year (FAO, 2020) with farmers harvesting 1.5 to 14 tons per hectare compared to the world average of 33.6 million tons per year. Egypt has a total annual production of 8.625 million tons and is the highest producer in Africa while Nigeria is the second producer with a total annual production of 1.560 million tones (FAO, 2014).

Li (2018) reports that tomato is a high yielding vegetable that requires a lot of fertilizers for its proper establishment, growth and yield. However negative effects of chemical fertilizers on the soils and environment have been recognized as one of the limiting factors in sustainable agricultural production (Chen & Ruan, (2018). Most farmers do not apply fertilizers due to high costs and unreliable availability of inorganic fertilizers. In addition, few farmers who use chemical fertilizers have adequate knowledge on the recommended rates (Dalokom, 2016) leading to application of high amounts of chemical fertilizers hence causing soil nutrient imbalance.

According to Birungi (2020), one of the most limiting factors to agriculture production and productivity in Uganda apart from pests and diseases is low and declining soil fertility. This is partly in agreement with Harris & Scow (2018) who reports that Ugandan soils are no longer fertile and therefore they need both organic manure and fertilizers to regain fertility and produce enough food to feed the growing population. Research comparing soil management using organic manure and chemical fertilizers has shown that soil organic matter and total nitrogen are high in soils where organic manure was applied (Ojeniyi, 2010). Organic materials such as poultry manure are recognized as suitable organic fertilizer. Poultry manure if well-handled is the most cherished of all animal manures (Vasilev, 2017). The use of poultry manure for soil fertility maintenance, growth and yield of tomatoes has been reported by Olorode (2020).

According to Alonso (2012), poultry manure is of different types such as deep litter manure, broiler manure, cage manure and deep pit manure. Deep litter manure is produced by the Layer birds during the laying period and Broiler manure is produced by meat producing birds during fattening period. According to Ashworth, (2020), the amounts of nutrients in poultry manure may differ due to different factors like breed of the birds, litter used, and moisture content of the manure and deity of the birds. Considerable research has been conducted to evaluate the effect of poultry manure on the growth and yield of a tomato crop. However; it is not yet clear whether response of the crop to Layers and Broiler manure may differ.

Statement of the Problem

Tomato productivity in Uganda is rated very low at 1.5 to 14 tons per hectare compared to world average of 56 tons per hectare by China (FAO, 2014). The most common limiting factors to tomato productivity are pests and diseases, drought, soil erosion, and declining soil fertility across Uganda (Birungi, 2020). It has been reported that low soil fertility is one of the leading constraints to production of tomato in Africa (Ogbomo, 2011). In Uganda, most soils are poor in fertility due to degradation and this has been a very challenging factor working against Ugandans' agricultural production due to the fact that most farmers rarely use fertilizers. Therefore, this calls for the adoption of both inorganic and organic fertilizers to increase crop production in Uganda.

However, over dependence on inorganic fertilizers for crop production has negative effects on the soils and environment hence limiting sustainable agricultural production (Chen & Ruan, 2018). Moreover, inorganic fertilizers are expensive and largely out of reach by the small scale farmers in Uganda. Therefore it is pertinent to explore the use of organic fertilizers to increase crop production in Uganda. Organic fertilizers such as cow, goat, compost, pig and poultry manure are very good alternative to mineral fertilizer. Research conducted by Azeez (2017) shows that poultry manure if well-handled is the most cherished of all animal manures since it contains all the essential plant nutrients such as phosphorous, nitrogen, potassium, zinc, iron, chlorine, calcium, magnesium, boron, copper, molybdenum and sulphur which are responsible for the fertilisation of the soils. This makes it the most appropriate organic manure for tomato production. Therefore, this study was done to evaluate the effect of layer and broiler chicken manure on the performance of Rio-Grande tomato (*Lycopersicon esculentum Mill).*

Main Objective

The main objective of the study was to evaluate the effect of different poultry manure on the performance of Rio-Grande tomato variety (*Lycopersicon esculentum Mill).*

Specific Objectives

To determine tomato growth and development under layer and broiler manure.
To assess the composition of macro and micro nutrients in layer and broiler manure.
To determine the effect of layer and broiler manure on tomato fruit production and yield.

LITERATURE REVIEW

Description of Tomato (*Lycopersicon esculentum*)

Tomato belongs to *solanaceae* family. It's an annual, climbing plant. The plant leaves are covered with shiny hairs which are usually prostrate, only the tips being erect. The leaves are large and deeply cleft, with many leaflets. The leaves are arranged alternately along the stems. Both the leaves and stems have strong smell. Clusters of four to six flowers sometimes more, form on the stems between the leaves (Zeist, 2017).

The flowers are about one centimeter in diameter (Wan, 2020). Tomato fruits exists in many shapes appearing large and round oval or elongated, depending on the variety (Sinha, 2020). The fruits may be orange, yellow or red when ripe, usually with numerous kidney or peer-shaped, hairy, light brown seeds (Bruno, 2018). Pink stage, some of the portion of the fruit is red or pink but the fruit is not fully ripe. It is the most suitable for local markets.

Comparison of Layer and Broiler Manures

Accounts of maggot production from chicken manure have rarely differentiated between broiler and layer manures. A study by Ofor (2012) showed that the level was significantly higher in broiler manure than in layer. Significantly higher quantity of maggot was harvested from broiler manure than layer. Floor litter from one-year-old laying hens (LHM) and from eight-week-old broiler chickens (BCM) were incorporated in the soil of two fields and evaluated as nitrogen (N) sources for cabbage production on a non-nutrient-depleted soil Jenkins, (2018). LHM had 3.4% moisture, 3.84% N and 3.41% phosphorus (P). BCM had 2.3% moisture, 4.46% N and 2.19% P. Field 1 received 2.4 t/ha BCM, 3.0 t/ha LHM, whereas Field 2 received 4.8 t/ha BCM and 6.1 t/ha LHM.

The Composition of Poultry Manure in Terms of Macro and Micro Nutrients

Poultry farming has effects on increased utilization of organic wastes. Organic wastes contain varying amounts of water, mineral nutrients, and organic matter Ismael (2012). While the use of poultry manure has been in practice for centuries world-wide and in the recent times. Furthermore, chicken manure is preferred amongst other animal wastes because of its high concentration of macro and micro nutrients (Dikinya, 2010). Application of chicken manure to soil enhances concentration of water soluble salts in soil. Plants absorb plant nutrients in the form of soluble salts, but excessive accumulation of soluble salts (or soil salinity) suppresses plant growth (Dikinya, 2010). The acidity due to poultry manure addition severely affects root growth and seed germination (Tiamiyu, 2012). Moreover, if applied correctly chicken manure acts as a good soil amendment and/or fertilizer (e.g. provides N, P and K) and can also increase the soil and leaf N, P, K, Ca, and Mg concentrations. Soil chemical properties provide information on the chemical reactions, processes controlling availability of nutrients and ways of replenishing them in soils.

The Effect of Poultry Manure on the Growth Rate of Tomatoes

In a study by Adekiya (2017) to obtain maximum economic value of plant nutrients in poultry manure and increase in tomato yield, field experiments were conducted at Owo, southwest Nigeria during 2012 and 2013 early cropping seasons. This was done to study the effect of two methods (broadcasting on the soil surface and the incorporated) and four times (3 weeks before transplanting), 0 week at transplanting, 3 weeks after transplanting, and 6 weeks after transplanting of poultry manure (PM)) applications on soil chemical properties, leaf nutrient concentrations, growth and yield of tomato. Poultry manure significantly affected all the parameters measured except plant height. All the parameters measured were increased in Roma

VF than in UC82-B except the number of flowers, days to first flowering, fruit length, fruit diameter, shoot fresh weight, fruit dry weight and shoot dry weight where the two varieties were similar. Application of 5 and 10 tha-1 poultry manure were similar and significantly increased fruit fresh weight above the control and 15 tha-1. However, the highest yield was obtained from 5 tha-1 poultry manure with either Roman VF or UC82B which were significantly at par.

In a study by Ewulo (2016) to study the effect of poultry manure (PM), NPK 15-15-15 fertilizer and NPK 15-15-15 fertilizer + poultry manure on the growth and yield of tomato. Findings showed that all levels of poultry manure and NPK 15-15-15 fertilizer + poultry manure increased leaf N, P, K, Ca and Mg levels. The soil chemical properties except pH increased with amount of poultry manure. NPK 15-15-15 fertilizer alone did not increase the soil and leaf Ca and Mg. All levels of poultry manure, NPK 15-15-15 fertilizer alone and NPK 15-15-15 fertilizer +poultry manure increased the number of leaves, plant height, leaf area, number of fruits and fruit weight significantly. Among poultry manure levels, 30 t ha-1poultry manure gave the highest fruit yield. Among the seven treatments, NPK 15-15-15 fertilizer + poultry manure gave the highest yield.

Study by Isitekhale (2013) showed that poultry manure is a suitable source of nutrients for tomato especially if applied at 30 t ha-1in the forest-savanna transition zone of southwest Nigeria. The combined use of NPK 15-15-15 fertilizer and poultry manure increased tomato yield compared to the application of NPK 15-15-15 fertilizer or poultry manure alone and is therefore recommended for sustainable productivity. In addition, lesser quantities of poultry manure and NPK 15-15-15 fertilizer would be required, therefore, reducing the amount of money spent on chemical fertilizer

The Effect of Poultry Manure on the Yield of Tomatoes

A study by Gaind (2010) indicated that poultry manure was rich in plant nutrients and the acidity was near neutral. The results revealed that there were significant increase in number of branches and plant height. Significant differences were observed among the different rates of poultry manure all through the period. Plants sown on plot treated with 10 t ha^{-1} rate of poultry manure had statistically the highest values of 88.49 cm and 7.03 as plant height and number of branches respectively. In comparison with the control, poultry manure treated plots had significantly higher increase than the control plots. The non-treated plots (control) significantly resulted in shorter plants and few numbers of branches suggesting that fertilization enhances the growth of tomato. The significant increase of number of branches in the treated plots suggest more number of fruits and invariably more tomato yield which is the ultimate goal of the farmer. This agreed with the work of (Ayeni *et al*. 2010) who reported significant increase in plant height, number of branches and number of leaves as a result of application of poultry manure.

The result obtained on number of trusses, flowers and fruits of tomato plant indicated that there were significant differences among the different rates of poultry manure throughout the period. Plants sown on plots treated with 10 t ha^{-1} poultry manure had the highest number of trusses, flowers and fruits per plant with the values of 23.18, 101.20 and 18.08, respectively. This may be attributed to the sufficient release of nutrients particularly N.P.K contain in the poultry manure applied, as these nutrients improve the growth and yield of crops. The number of fruits and leaves of crop significantly increased with increase in the concentration of poultry droppings. In comparison with the control, poultry manure treated plots had significantly higher number of trusses, flowers and fruits per plants than the control plots. The result on tomato fruit and seed yield indicated that significant differences were observed among the different rates of poultry manure used in the study by (Demir, 2010). The application of 10 t ha^{-1} rate of poultry manure resulted in highest fruit and seed yield values of 8570.66 and 18.13 kg hg^{-1}, respectively. Tomato fruit weight increased with increasing manure source. In comparison with the control, poultry manure treated plots had significantly higher yield than the control. Fruit and fruit quality improved as a result of application of poultry manure.

MATERIALS AND METHODS

The experiment was carried out at Bishop Stuart University farm located in Kakoba Division, Mbarara District in Western Uganda. The soil of the experimental field was medium black with good drainage and uniform texture with medium NPK status. The experiment followed a two year fallow.

Experimental Treatments and Design

There were four treatments as follows; Broilers manure (B), Layer manure (L), a combination of Broiler and Layer manure (C) and Control (CN) in which no manure was applied. These treatments were examined in a Randomized Complete Block Design (RCBD) and were replicated four times. Details of the experimental layout are given in figure1. Plot sizes were 4m by 4m separated by 0.5m. Crop spacing was 75cm between the rows and 45cm within the rows. Each plot contained twelve (12) tomato plants but only three (3) tomato plants were randomly selected and used to collect data. Seeds were planted in the nursery bed and the seedlings were transplanted after three weeks.

Rio Grande tomato variety was used because it is the most popular variety in Uganda. Different poultry manure types were applied to the planting holes one month before transplanting as suggested by Adekiya (2019). Each tomato plant received 340g of poultry manure which translates to 10t/ha of manure. Plants were kept weed free by regular weeding, disease infection and pest attack were controlled by the use of mancozeb, cypermethrine and Dimethoate fungicides and pesticides respectively. Spraying was done at an interval of two weeks.

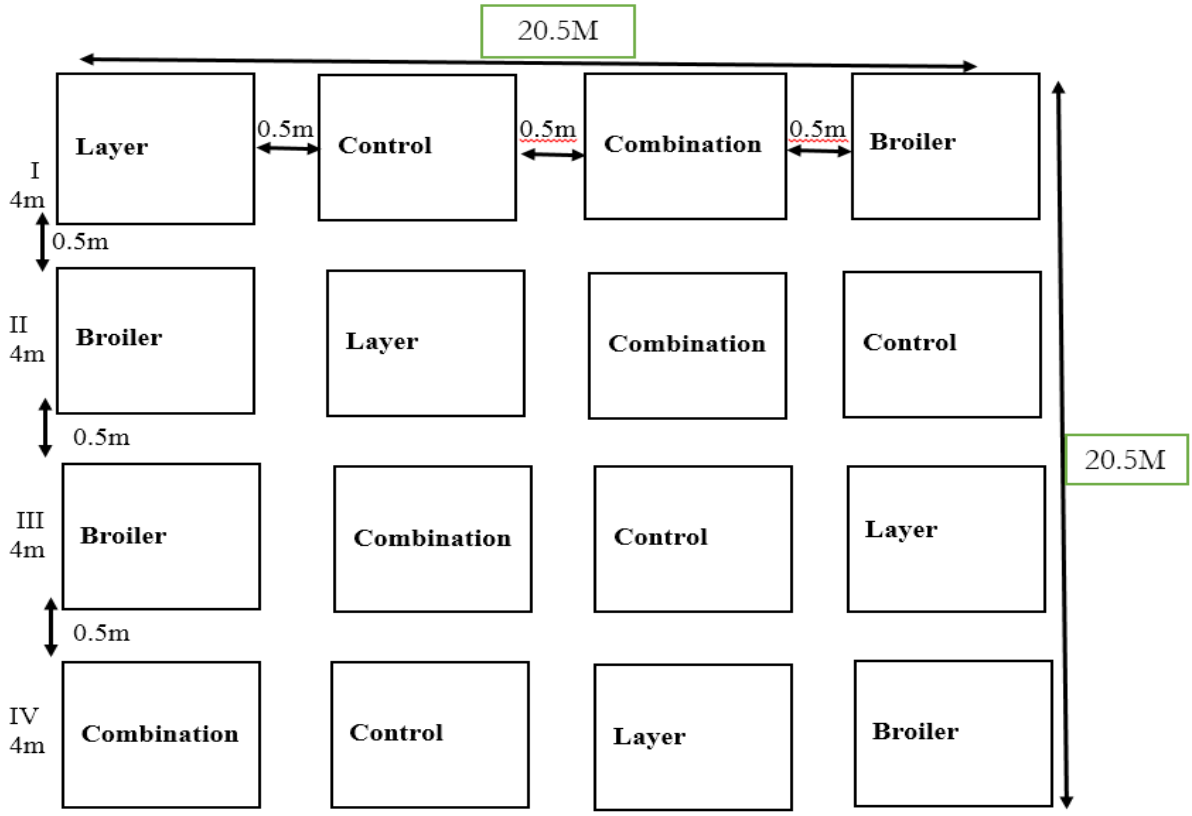

Figure 1: Experimental layout

Agronomic Management

After selection of the site, the nursery bed was prepared using a hand hoe and the soil was crushed up to get a fine tilth. All the grass, stones and roots were removed from the site. The beds were prepared and finally leveled. One wheelbarrow full of chicken manure which is equivalent to 10kgs was added into each bed. Beds of (3m X 1m) were prepared. After getting the bed of fine tilth, seeds of Rio Grande tomato were sown in beds uniformly at a depth of 5 to 8 inch and light irrigation was given immediately. All the beds were covered with grass to conserve moisture and hasten germination. The grass was removed after germination. In order to get good tilth of the soil for transplanting, first cultivation was done by using a hoe and followed by second cultivation which was done using both a hoe and a forked hoe and there after the field was marked as plots as shown in figure 1 before transplanting.

A well decomposed layer and broiler manure was applied to the each planting hole. Each planting hole received 340grames (g) of layer, broiler or a combination of layer and broiler manure except for the control treatment. Combination treatment was achieved by mixing equal amounts of layer and broiler manure. This was done one month before transplanting. Laboratory analysis of nutrients from the manure was done to determine the nutrient composition of the manure and the results of analysis. Seedlings of Rio Grande tomato of uniform growth were selected for transplanting. Seedlings in the nursery bed were irrigated before removal for transplanting in order to prevent or reduce seedling root damage during transplanting. Transplanting was done on 10th September 2019 and 3rd March 2020 and the field was irrigated regularly after transplanting until the onset of rains.

Experimental Measurements

Data collection started two (2) weeks after transplanting by which time the plants were well established and nearly 5cm tall.

The following measurements were made;

Plant height (cm) and number of leaves per plant.

From each treatment, a random sample of three plants was selected. Data was taken from the three plants throughout the season. Plant height was measured for each plant from the soil surface to the top of the plant using a tape measure. Measurement of plant height commenced three (3) weeks after transplanting and continued at two (2) week interval until the 8^{th} week. In addition, the numbers of green leaves were counted. The number of leaves was recorded from the same three plants after every two weeks. The numbers of flowers per plant were counted from same plants to determine the number of flowers per treatment. The numbers of flowers were determined when 50% flowering had occurred.

The number of fruits harvested from four randomly selected plants in each treatment was collected during each picking, counted and totaled together and average numbers of fruits per plant were calculated. The weight of five fruits was recorded separately using weighing balance and average weight was worked out for each treatment. All the tomatoes fully formed from each plant were considered. For each treatment, sample of 5 tomato fruits from each treatment were cut and fruit diameter was measured using a ruler. Fruits harvested from all the plants in each plot were weighted at each harvest. The total yield per plot was calculated after final harvest. This was then converted to yield/ha based on the area harvested. For growth and yield parameters, analysis of variance (ANOVA) table was generated using Gen Stat 11 statistical software. The confidential interval was set at 95% ($P \leq 0.05$).

RESULTS AND DISCUSSION

The Physical - Chemical Properties of the Soil from Experimental Site for the Two Seasons

The physical and chemical properties of the soils from the experimental site for season one and season two are given in Table 1. The physical and chemical properties of the soils were reasonably similar for the two seasons. For example pH was 5.6 in both seasons, EC was 77.1 and 71.4 in season 1 and 2 respectively; However, average phosphorous in season two was more than 15 times the average amount of phosphorous in season one. The average amount of phosphorous required in the soils for proper root growth and establishment is 15ppm. Therefore this shows that in season one the soils had low phosphorous whereas season two soils had relatively higher amount of phosphorous in the soil.

The soil pH with in the top 30 cm was slightly acidic (5.6) for both seasons. This favors availability of micro-organisms and soil nutrients to be in a solution form for plant up take since most crops grow well in a pH of 5.5 - 6.8. The amount of nitrogen and organic matter in the soil were significantly low for both seasons. The required amount of nitrogen and organic matter in the soil is 0.3 and 3% respectively. The amount of calcium, potassium and magnesium were high in the soils. The required amounts for proper crop growth are 1.75, 0.34 and 0.6 respectively. Calcium and magnesium moderates soil pH or acts as a good liming material hence increases soil pH which is the reason why the pH of the soil is better for crop growth (5.6). The soil texture was sandy loam which enhances drainage. The micronutrients of the soil are moderate due to moderate soil pH hence better conditions for crop growth.

Table 1: Physical - chemical properties of the experimental site for the two seasons

Sample Details	Lab	PH	EC .	OM	N	Av.P	K	Na	Ca	Mg	%Sand	%Clay	%Silt	Cu	Zn	Fe	Mn
	No.		µS/cm	%age		ppm	cmoles/kg				Texture			mg/kg(ppm)			
Season one	A	5.6	77.1	1.71	0.15	4.00	0.50	0.12	3.8	1.32	42.0	17.0	41.0	1.11	21.3	212.2	42.2
Season two	B	5.6	71.4	1.51	0.13	54.1	0.44	0.21	3.5	1.02	44.0	15.0	41.0	0.99	16.9	198.3	34.2

The Composition of Macro and Micro Nutrients in Broiler and Layer Manure

The chemical composition of the manure types used are given in Table 2. It is interesting to note that for both manure types the pH was very high (7.8-8.2). This is in contrast to pH recorded for the experimental site for both seasons given in table 1). The implication is that these manure types can be used to moderate pH for crop growth. The results also indicate that poultry manure had less phosphorus and magnesium and rich in nitrogen, potassium, calcium and micro nutrients thus providing a good source of plant nutrients and confirming earlier idea that both broiler and layer manure contain adequate quantities of macro and micro nutrients for plant growth. The normal amount of nitrogen, phosphorous, potassium, calcium and magnesium required for proper crop growth are 0.2%, 15ppm, 0.34 cmoles/kg 1.75 cmoles/kg and 0.6 cmoles respectively. This suggesting that poultry manure is a useful remedy for soils that are depleted of nutrients either through over use or degradation.

Table 2: Composition of macro and micro nutrients in broiler and layer manure

Sample Ref:	pH	N	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn	B
		g/100g (%age)						ppm (mg/kg)				
Broiler 1	8.2	2.3	0.91	2.11	0.56	0.21	0.68	6.54	452	85.5	46.5	9.2
Broiler 2	8.0	3.2	0.89	1.96	0.65	0.22	0.78	4.25	362	65.2	39.5	5.3
Broiler 3	7.9	3.3	1.02	2.02	0.58	0.31	0.66	5.32	390	89.3	45.4	3.3
Broiler 4	7.8	3.0	0.78	1.68	0.55	0.19	0.68	5.61	465	69.6	65.7	6.6
Broiler 5	8.1	2.2	0.77	1.32	0.65	0.21	0.65	4.94	568	78.9	54.8	4.9
Layer 1	7.9	2.0	1.22	1.26	0.96	0.32	0.44	3.85	541	120.	59.9	5.8
Layer 2	7.8	1.9	1.35	1.22	1.02	0.45	0.56	4.56	623	98.8	58.5	3.5
Layer 3	7.8	2.0	1.22	1.24	0.86	0.44	0.66	2.23	596	112.5	66.6	6.4
Layer 4	7.9	2.8	1.32	1.35	0.88	0.39	0.56	3.12	588	98.2	71.2	9.2
Layer 5	7.9	2.9	1.09	1.64	0.98	0.41	0.68	2.5.	612	102.1	69.3	8.1

Effect of Broiler and Layer Manure on Selected Growth Parameters of Tomato

The Number of Leaves per Plant

The effects of manure types on the number of leaves per plant are given in table 3a and 3b for season one and two respectively. The results from season one show that at four weeks after transplanting, there was no significant difference between the treatments (Table. 3a). This is probably because plants were still getting established. At six weeks after transplanting, differences between treatments were beginning to emerge. Application of manure types produced slightly higher number of leaves per plant than the control though the differences were not significant. At the 8th week after planting, average number of leaves was highest in treatments with layer and broiler manure giving an average of 31 and 29 leaves per plant respectively followed by the treatment with combination of manure. The control treatment produced significantly lower number of leaves in season one.

Similar patterns of results were recorded in season two (Table. 3b). At four weeks after planting, there was no significant difference between the treatments. At six weeks after planting, differences between treatments were beginning to emerge. At the 8th week after planting, average number of leaves were also considerably higher in treatments with layer and broiler manure giving an average of 41 and 39 leaves per plant respectively followed by the treatment with combination of manure as in season one. The control treatment again produced significantly lower number of leaves as in season one as shown in table 3a.

Table 3a: Effect of layer and broiler manure on the number of leaves per plant for season one

Manure type	4 weeks	6 weeks	8 weeks
Broiler	19.77	29.42	53.67
Layer	19.13	32.92	53.58
Combination	18.03	25.92	33.58
Control	17.63	22.75	29.58

Table 3b: Effect of layer and broiler manure on the number of leaves per plant for season two

Manure type	4 weeks	6 weeks	8 weeks
Broiler	8.8	11.3	39.2
Layer	7.8	10.3	41.8
Combination	8.5	11.3	33.8
Control	7.8	9.4	20.1

The Plant Height (Cm)

The effects of manure types on plant height are given in figure 4a and 4b for season one and two respectively. The results on plant height followed similar pattern as the number of leaves per plant. At four weeks after transplanting, there was no significant difference between treatments. All the treatments had average height of about 5cm, most likely because plants were still young and getting established. At six weeks after planting, all the treatments were better than control though not significantly different. The average plant height was slightly greater in plots with layer manure and broiler manure giving an average of 9.1 and 8.7 cm respectively.

At the 8th week after transplanting, average plant height was greater in treatments with layer and broiler manure giving an average of 53cm per plant followed by the treatment with a combination of manure. The control produced the shortest plants. As with the number of leaves, similar, pattern of results were recorded in season two as shown in table 4b. The results on plant height followed similar pattern as in season one however at 8 weeks after planting, broiler manure had slightly taller plants (61cm) than layer manure (59) unlike in season one where plant height was the same.

Table 4a: Effect of layer and broiler manure on the plant height for season one

Manure type	4 weeks	6 weeks	8weeks
Broiler	19.77	29.42	53.67
Layer	19.13	32.92	53.58
Combination	18.03	25.92	33.58
Control	17.63	22.75	29.58

Table 4b: Effect of layer and broiler manure on the plant height for season two

Manure type	4 weeks	6 weeks	8 weeks
Broiler	22.6	45.6	61.6
Layer	23	46.6	59.9
Combination	22.8	43.3	58.5
Control	19.8	42.4	46

The Number of Flowers

The effects of manure types on the number of flowers per plant are given in table 5a and 5b for season one and two respectively. The results indicate that plants started producing flowers at 6 weeks after transplanting. As expected, the number of flowers increased with time from an average of 3 flowers per plant at 6 weeks after planting to about 10 flowers per plant at 8 weeks after planting. By the 10^{th} week, the number of flowers had increased to an average of 12 flowers per plant. Broiler treatment produced significantly more flowers per plant than the rest.at 10 weeks after planting. The control treatment had the least number of flowers per plant by the end of 10^{th} week after planting.

Similar results were recorded in the second season. Flowers started to develop at 6 weeks after planting. Plants under Broiler treatment produced significantly more flowers than the rest of the treatment. There was almost no difference between the rest of the treatments and the control at six weeks after planting. The number of flowers increased from an average of 8 per plant to about 12 flowers per plant at 8 weeks after planting. By the 10^{th} week, the number of flowers had increased to an average of 14 flowers per plant. The control treatment had the least number of flowers by the end of 10^{th} week after planting.

Table 5a: Effect of layer and broiler manure on the number of flowers for season one

Manure type	6 weeks	8 weeks	10 weeks
Broiler	3.75	10	15.58
Layer	3.08	8.83	13.42
Combination	3.17	8.92	12.41
Control	2.42	6.5	11.5

Table 5b: Effect of layer and broiler manure on the number of flowers for season two.

Manure type	6 weeks	8 weeks	10 weeks
Broiler	9.8	14.8	14
Layer	7.7	14	13.9
Combination	7.9	13	12.1
Control	7.6	11	11.8

The Number of Fruits

The mean effect of manure types on the number of fruits per plant is given in Table 6. In season one, all treatments were significantly better than the control. The highest number of fruits per plant was achieved from broiler manure treatment (43.2) though this was not significantly different from the results from layer manure or combination of broiler and layer manure. In season two, results followed similar pattern although the highest number of fruits per plant was achieved from broiler treatment (42.7). This was however not significantly different from those from layer manure treatment or combination of broiler and layer manure.

Table 6: Mean effect of manure types on the number of fruits per plant

	Treatments				
Season	B	CN	C	L	LSD
1	43.2	18.7	35.9	36.8	7.54
2	42.7	22.5	36.8	33.7	9.92

B, CN, C, L and LSD stands for Broiler, Control, Combination, Layer and Least significant different respectively.

The Fruit Diameter (Cm)

The mean effect of manure types on the fruit diameter is given in Table 7. In season one, all treatments were significantly better than the control. The highest fruit diameter was a achieved from the combination manure treatment (4.975) though this was not significantly different from the results from layer or broiler manure treatment. As with other parameters, the control treatment had the smallest fruit diameter. In season two, results followed similar pattern although the highest number of fruits per plant was achieved from broiler treatment (4.879). This was not significantly different from those from layer manure treatment or combination of broiler and layer manure.

Table 7: Mean effect of manure types on the fruit diameter (cm)

	Treatments				
Season	B	CN	C	L	LSD
1	4.904	3.396	4.975	4.801	0.22
2	4.879	3.121	4.517	4.617	1.12

Fruit Weight per Plant

The mean effect of manure types on fruit weight per plant is given in table 8. In season one, all treatments were significantly better than the control. The highest fruit weight was achieved from the results from combination manure (346.3). Results from Broiler manure and combination manure were significantly better in terms of fruit weight than results from layer manure. In season two, results followed similar pattern and the highest fruit weight per plant was achieved from layer manure (317). This was not significantly different from those from broiler manure treatment or combination of broiler and layer manure.

Table 8: Mean effect of manure types on fruit weight per plant (g)

	Treatments				
Season	**B**	**CN**	**C**	**L**	**LSD**
1	335.7	181.5	346.3	295.2	42.85
2	305.2	282.6	308.1	317.0	12.32

Yield (Tones/Hectare)

In season one, all treatments were significantly better than the control. The highest yield per hectare was achieved from broiler manure (13.67). Results from Broiler manure and layer manure were significantly better in terms of yield per hectare than results from combination manure. In season two, results followed similar pattern and the highest yield per hectare was achieved from broiler treatment (14.08). Results from Broiler manure and layer manure were significantly better in terms of yield per hectare than results from the control.

Table 9: Mean effect of manure types on yield (tones/ hectare)

	Treatments				
Season	**B**	**CN**	**C**	**L**	**LSD**
1	13.67	8.1	12.83	13.44	2.56
2	14.08	7.83	11.49	13.19	2.14

DISCUSSION

Influence of Manure Types on Growth Parameters

The overall objective of the study was to evaluate the effect of manure types on the performance of tomato. On the number of leaves, the results showed no significant difference between broiler and layer manure in the two seasons. The number of leaves was slightly higher for the layer treatment compared to the broiler and combination treatments. Layer and broiler treated plants recorded the highest average number of leaves (31 and 29) per plant respectively than combination and control treatments. This was because the manure applied contained adequate nitrogen which supported vigorous growth. The vigorous growth was reflected in more number of leaves and taller plants. This observation is in agreement with the results of Direkvandi (2008) who reported significant increase in plant height, number of branches and number of leaves. He attributed the increase to high nitrogen levels in the manure. The control treatment produced the least average number of leaves (9.5) and was significantly different from chicken manure treatments. This result is also in line with the findings of Singh (2020) and Agbede (2008) who found out that application of poultry manure led to an increase in the number of tomato leaves.

On plant height, Broiler and layer manure application had no significant difference at four weeks after planting in both seasons. This is probably because the plants were still getting established. Broiler and layer manure treatments produced taller plants with the tallest plants being about the same (53.67cm) and (53.58 cm) respectively. This is most probably because the soils had adequate amount of nutrients for vigorous growth. The nutrient analysis showed that both manure types had high levels of nitrogen. This is probably responsible for the vigorous growth achieved in these treatments. This observation is in agreement with the results of (Oyewole, Opaluwa, & Omale, 2012) who reported that chicken manure applied at a rate of 150 kg/ha and 300 kg/ha produced taller plants compared to the control. Similarly the study by Ayeni (2010) and Direkvandi (2008) also showed significant increases in plant height, number of branches and leaves are as a result of poultry manure application. They explained that this was due to high nitrogen content in both layer and broiler manure. High amount of nitrogen ensures growth of tomato and stimulates in early flowering.

The control treatment had significantly shorter plants (29.58 cm) compared to those that received manure. Shorter plants produce few numbers of tomatoes than taller plants. This is largely because they have fewer sites for flower production. Improvement in the number of leaves and plant height though small can improve the leaf area index and consequently the light interception pattern of the crop.

Effect of Manure on the Number of Flowers and Number of Fruits per Plant

The number of flowers represents the reproductive structure in tomatoes because they represent the number of fruits that are likely to develop and consequently the amount of yield to be achieved. In the broiler treatment, the number of flowers increased from 3.7 per plant at six weeks after planting to 15 flowers per plant at 10 weeks after planting. Increased numbers of flowers in chicken manure treatments were as a result of high levels of nitrogen and potassium which were supplied through the application of chicken manure. Potassium ensures vigorous growth of tomato, stimulates early flowering and setting of fruits, thereby increasing the number of fruits per plant and the overall production. As seen earlier, the high levels of nitrogen and potassium in both broiler and layer manure might have led to improved production of flowers.

The results obtained are in agreement with those of Singh (2020), Adekiya (2017) and Agbede (2008) who reported that application of of poultry manure gave the highest number of flowers per plant. The control plots had the least average number of flowers (9.5) which is significantly different from chicken manure treatments. On the number of fruits per plant, they were significantly higher in all manure treatments than the control. The significant difference between the manure treatments and the control is largely because of the high amounts of nutrients in chicken manure. Both layer and broiler manure had higher amounts of nitrogen and potassium. As explained earlier, chicken manure ensures vigorous growth of tomato and stimulates in early flowering and setting of fruits, thereby increasing the number of tomatoes per plant. (Adekiya 2017)

Similar results were explained by Abou El-Magd, Hoda, and Fawzy (2005) who found that application of poultry manure increased yield largely through improved soil physical and biological properties and through availability of macro nutrients like nitrogen, phosphorous and potassium to the plants. The micro nutrients such as boron and zinc are also responsible for flowering, fruiting and ripening of the fruit.

Effect of Manure on Yield and Yield Parameters

The study revealed that all manure treatments had significantly larger fruit diameter than the control. This is because chicken manure contains high levels of nitrogen and potassium responsible for fruit formation and establishment. This might be the reason for improved size of tomatoes as explained earlier. Potassium ensures vigorous growth of tomato and stimulation of early flowering and setting of fruits. Nitrogen is also responsible for increased production in terms of number of fruits, fruit size, storage quality, color, and taste of tomato. The results are in line with the results of (Qiu, 2020) and Nicholson (1996) who revealed that broiler and layer manure has similar nutrient concentrations such as N, P, K, Mg, S and micro nutrients. Therefore fruit size increased as a result of application of chicken manure Fawzy (2005)

The study findings also showed that broiler, layers and combination manure treatments gave highly significant fruit weight per plant compared to the control. Difference in fruit weight may be due to the presence of Potassium and Nitrogen which are responsible for regulating plant growth. This is also in agreement with the findings of Adekiya and Agbede (2017) and Ghorbani (2008) who reported that tomato fruit weight increased with the application of poultry manure. He attributed this to nitrogen and potassium available in poultry manure which was applied. Tomato yield per hectare followed similar trend where by the manure treatments produced significantly better yield than the control.

Application of chicken manure produced the highest fruit yield of (13.8 t/ha) followed by broiler (13.4 t/ha) followed by layer and (12.8 t/ha) by combination. The lowest fruit yield (8.1 t/ha) was obtained from the control (no chicken manure) treatment. The highest yield per unit area achieved from manure application was largely due to the high number of fruits per plant and bigger fruit size. As explained eerier, chicken manure treatments produced significantly higher yield than the control because of high levels of Nitrogen, Phosphorous and potassium which are present in chicken manure. Nitrogen is responsible for increased production of number of fruits, fruit size, storage quality, color, and taste of tomato (Adekiya, 2017). The implication of these results is that the soils at the site of the experiment are low in fertility and this explains why the control plots achieved low yield (8t/ha). The physical- chemical analysis of soils at the experimental site indicate that nitrogen was only 0.15% and 0.13% for season one and two respectively compared to 0.2% of nitrogen expected in fertile soil.

CONCLUSION

The results showed that the application of chicken manure significantly enhanced high growth and yield of rio-grande tomato compared to the control treatment. Therefore poultry manure is recommended for better production of tomato. Slight differences were assessed between broiler and layer manure for example on the number of leaves, treatments where layer manure was applied had more number of leaves than other treatments. It is therefore recommended that farmers can use poultry manure to improve their yield of tomatoes particularly in highly degraded soils. The amount of chicken manure used in this experiment was not very high. It is therefore suggested that further research be conducted with high levels of manure.

The experiment did not reveal significant differences between broiler and layer manure on the yield of tomatoes and even their combination. It is therefore recommended that farmers may opt for either broiler or layer manure. Because many farmers have not been using poultry manure in tomato production, an intensive sensitization program by government through agricultural extension officers is recommended. The chemical composition of poultry manure with its levels of nitrogen, phosphorus and potassium and micro nutrients make it very suitable as a fertilizer. Once adopted for use by farmers, it can reduce deterious effects attributed to the use of chemical fertilizer. Application of chemical fertilizer leads to deterioration of soil characteristics and fertility, and also leads to accumulation of heavy metals in plant tissues which comprises the nutrition value and fruit quality.

The growth parameters such as number of leaves, plant height and number of flowers responded positively to the application of chicken manure compared to the control treatment.

The increased number of leaves, plant height and number of flowers was because of high nitrogen, phosphorous and potassium content found in both layer and broiler manure. The yield parameters such as the number of fruits, fruit size and weight were influenced by the application of chicken manure. For example the number of fruits increased due to application of chicken manure. This resulted to a better yield of 13.8 with broiler and 13.5t/ha with layer chicken manure hence increased yield of tomato. Results also revealed that chicken manure is a suitable source of nutrients for improving soil fertility and yield of tomato

The results showed that poultry manure contains 11 essential plant nutrients such as nitrogen, phosphorous, potassium, calcium, Magnesium, Sulfur, Copper, iron, manganese, Zinc and Boron. These macro and micro nutrients influenced positively the growth and yield of Rio-Grande tomato. It is therefore recommended that broiler and layer chicken manure have no significant difference in terms of both macro and micro nutrients they supply to the soils. Therefore, farmers may opt for either of the two depending on the availability since there was no significant difference.

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