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The influence of bio-slurry, chicken manure tea and Vermi compost tea on growth and yield of tomatoes

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Abstract
Tomato productivity has remained low due to a number of constraints including nutrient deficiency. In Zimbabwe, the crop is mainly grown by smallholder farmers whose soils are highly degraded. This study was carried out at the Foundation for Farming, a training center in Domboshawa Harare, Zimbabwe's Agriculture extension facility for Conservation farming to examine the influence of bio-slurry, chicken manure tea, and vermi-compos tea on growth, yield and profitability of tomato production. An indeterminate variety 'Big Boy' was grown. The soil was alkaline, loamy sand with a PH of 7.3, and very low in nitrogen, with a higher potassium and phosphorus imbalance, and 1.54% organic matter. The experiment was laid out in Complete Randomized Design with three replications and five treatments which significantly (p<0.05) improved the growth parameters studied. Chicken manure tea had the best growth characteristics, and the fruit yields (45.4 ton/ha) followed by vermi compost tea (31.8 Ton/ha), Bio slurry t (28.3 ton/ha), inorganic fertilizer (11.3 ton/ha). The control had the lowest values of tomato yield (1.7 ton/ha). Chicken manure tea, vermi-compost, and bio slurry had better economic profitability (Table 4). Tomato fruit production can therefore be sustained with the application of chicken manure tea, bio slurry, and vermi-compost. Rates of these organic can be studied to ensure minimum wastage.

Keywords: Tomato, bio-slurry, chicken manure tea, and vermi-compos tea

Introduction
Tomatoes (*Solanum lycopersicum*) require sufficient nutrients for growth and subsequent yield. It is a heavy feeder of nitrogen, phosphate, and potassium. Adekiya *et al*., (2022) [1], argues that, tomatoes respond well to organic and inorganic fertilizer applications. The current global situation underlines the importance of adopting environmentally friendly agricultural practices for long-term food production (Calicioglu *et al.* 2019) [28]. Inorganic fertilizers are becoming increasingly expensive, to the point that they are getting out of reach for smallholder farmers (Mugwe *et al*., 2021) [12]. The use of these chemical fertilizers at high rates has been linked to some ecological contamination, soil surface change, and alteration of soil physical properties (Adekiya & Agbede, 2017) [2]. Vegetables and fruits produced on chemically fertilized soils are more susceptible to insect and disease assaults (Adekiya *et al*., 2022) [1], and nearly half of inorganic fertilizers applied are lost through leaching or volatization (Adekiya *et al*., 2022) [1].
Organic Farming supports and sustain healthy ecosystems, soil, food production, communities, and economy (Lashgarara *et al*., 2017) [11]. Using organic fertilizers to preserve soil health and fertility has long been a noble and customary practice (Amjad *et al*., 2016) [26]. Consumers value the flavor of organic products (Gundala and Singh 2021.). The practice of organic fertilizers results in increased crop growth, yield and quality (Adekiya *et al*., 2022) [1].
Organic fertilizers which are made from animal matter, animal manure, and vegetable matter can be used in agriculture as liquid fertilizers, compost or crop residues (Marcelo & Sonia, 2019) [17]. Some researchers suggests that, application of organic manure results in tomato higher yield because organic nutrients are more efficient than inorganic fertilizers (Foundations for Farming *et al*., 2018) [7]. The aim of this study was to investigate the influence of bio-slurry, chicken manure tea and vermi-compost tea on growth and subsequent yield of tomatoes.

Materials and Methods

Study Site

The investigation was carried out at Foundation for Farming Training Centre, located in Domboshawa 17.6118° S, 31.1432° E Mashonaland East Province, Zimbabwe. Average annual rainfall in the area is 538 mm and the average temperature is 21 ^{0}C.

Experimental Set Up

The experiment was set up in a Complete Randomized Design (CRD) with three (3) replications. Treatments included; Bio slurry, Chicken manure tea, Vermi-compost tea, Synthetic fertilizer and Control with no fertilizer. Tomato seedlings were grown in a sandy loam soil in open field. The unit plot was 600 cm m x 110 cm in size. Each plot had 2 lines spaced at 18,5 cm between rows and 15 cm within rows spacing. Minimum tillage was practiced. Weed, stubbles, and crop residues were removed from the field. Mulch was applied on each experimental unit. Tomatoes seedling from Starke Ayres® were planted. All of the experimental treatments were assigned at random to each unit plot. Data were collected for three months.

Treatments

Control

Treatment in the absence of nutrients supply (Rokonujjman *et al*., 2019) [14]

Bio Slurry

The bio-digester was fed on a daily basis with a mixture of cow dung and water. Three (3) buckets of cow manure mixed with 30 liters of water was maintained in the digester for twomonths before being discharged as bio slurry. 300 ml of bio slurry was applied per plant station.

Chicken manure tea

50 kg of chicken manure was placed in a permeable bag and hanged in a 200-liter drum of water for three weeks. Stirring was done twice a day. After 3 weeks, one (1) liter of chicken manure tea was added to 10 liters of water. Application was done at a rate of 300 ml per plant station.

Vermi-compost

The red wriggle worms were incorporated in a compost bin and fed with organic materials. Water was added daily for 2 months. After 2 months, the liquid was fetched from the bin and applied as organic fertilizer. One (1) litter vermi-compost was diluted with 20 litters of water. 300 ml of the diluted vermi-compost was applied for each plant station.

Inorganic fertilizer

Pfumvudza Fert oasis 88 inorganic liquid fertilizer was used. This is a biodegradable soil enhancer that improves the soil and facilitates the passage of nutrients to the plant. It contains the necessary nutrients for the growth. Five milliliters were diluted with 10 litters of water and applied per plant station.

Data collection

From the transplanting date until termination of the experiment, 5 weeks following transplantation data were gathered on.

Stem collar diameter: This was taken 2–3 cm above the soil surface using a veneer calipers.

Plant height: Measured using a measuring tape from the soil surface to the apex.

Number of leaves were counted at 7-day intervals. Number of trusses per plant was counted at 72 days following transplantation.

Yield

In each experimental unit plot, the number and fresh weight of marketable fruits per plant were taken, and yield was estimated.

Analysis of soil, bio slurry, chicken manure tea, and vermi-compost tea

Soil and organic fertilizers were analyzed to develop application regime. The soil sample was taken at a depth of 17 cm in various locations throughout the 15 experimental units. Texture, color, and chemical properties were examined. Soils were air-dried and processed into a fine powder that could pass through sieve opening. The pH of the soil was determined using a pH meter, and the texture of the soil was determined using a hydrometer texture soil. A wet acid digest was used to quantify total nitrogen, which was then evaluated using colorimetric technique. The Mehlich technique was used to extract exchangeable Ca, Mg, K, and Na (Fukuda *et al*., 2017) [28], which was then measured using atomic absorption spectrophotometry. The Bray process was used to extract available P (Watson *et al*., 2021) [23], which was then evaluated using the molybdate blue procedure. Dry ashing was used to extract phosphorus, which was then evaluated using colorimetric process. The figures were expressed as a percentage of dry matter.

Chemical characteristics of the bio slurry, chicken manure tea, and vermi-compost tea were examined. Nitrogen was determined using kjeldhal distillation for all organic fertilizers, Dry ashing in a muffle furnace at 500 °C, dilution with aqua regia, and analyzed using an atomic absorption spectrophotometer to quantify the cations (Ca, Mg, and K). Phosphorus was determined using UV-V spectrophotometer for all liquid organic fertilizers (Horf *et al*., 2022) [6]. Nitrogen percentage per each organic fertilizer used was calculated as:

N % = [(Titer-blank 0.10) x 0.1 x 0.14 x 100]/weight of sample

Management of the crop

Standard management practices for tomato production were followed. A week before transplanting, bio slurry, chicken manure tea, and vermi-compost were applied to the plots, while prescribed doses of 300 mL of nitrogen, phosphate and potassium were administered at final land preparation as a basal and top dressing. 30 healthy and uniformly sized 40 days old seedlings were transplanted per bed.

Data analysis

Data was analyzed according to CRD model of

Yi=$\sum_{i=1}^{n} yij$= Measurement,

When

n= number of observation in a treatment.

$\bar{Y}i = Yi/ n$ = Treatment mean

$Y=\sum_{i=1}^{a}\sum_{j=1}^{n} yij =$ Experiment total,

Where

a = number of treatment

$\bar{Y}= Y/N$ = Experiment mean, where N = total number of observations in the experiment. LSD test was at probability level (p<0.001) was used to determine significance (Shrestha, 2019).

Results

Characteristics of soil, bio slurry, chicken manure tea and vermi compost tea

Table 1: Soil Analysis results

Hydrometer method AUSSS					
Sample #	AUSSS	CK 01	CK 03	Blank	Blank
Wt of Sam	50g	50g	50g	0	0
Hydro Rdg	3	22	10	-3	-3
Temp Rdg	26	26	26	26	26
Temp Cor	1.98	1.98	1.98	1.98	1.98
Temp.Cor	4.98	23.98	11.98	-1.02	-1.02
%Silt + %(	11.96	49.96	25.96	-1.0	
Hydro Rdg	-1	12	5	-3	-3
Temp Rdg	26	26	26	26	26
Temp Cor	1.98	1.98	1.98	1.98	1.98
Temp.Cor	0.98	13.98	6.98	-1.02	-1.02
					-1.0
% Clay	**4.0**	**30.0**	**16.0**		
% Silt	**8.0**	**20.0**	**10.0**		
% Sand	**88.0**	**50.0**	**74.0**		
Texture	LS	SCL	SL		
	AUSSS	CK 01	CK 03		

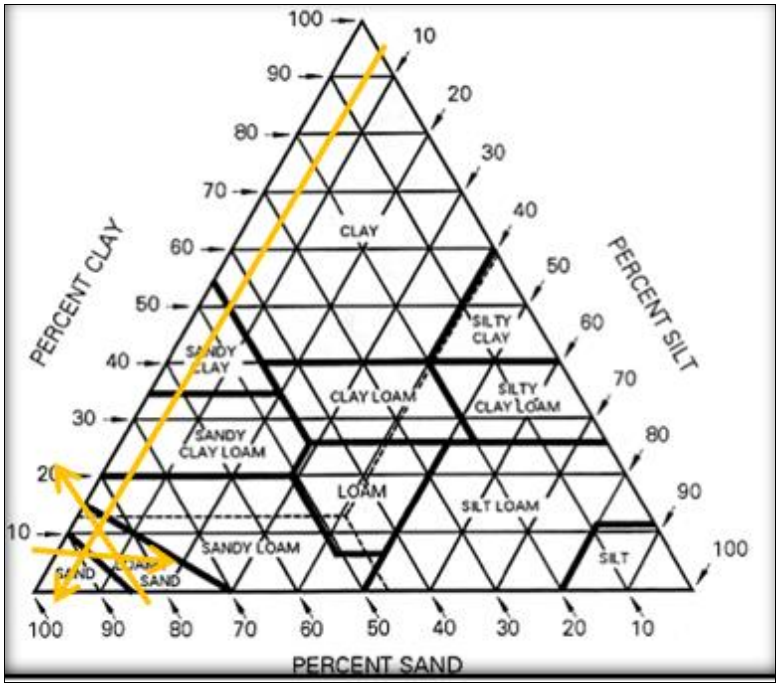

Fig 1: Soil texture triangle results

Table 2: Analytical data of the experimental soil

Parameters	Parameters	Parameters
PH	7.3	%
Clay	4	%
Silt	8	%
Sand	88	%
Organic Matter	1.54	%
Total Nitrogen(N)	7.39	%
Phosphorous (P)	97.21	ppm
Potassium (K)	93.54	ppm

Soil analysis results revealed good condition for tomato growth. The soils were loamy sand with a pH of 7.3 with low apparent density indicating a permeable soil with a high organic matter content. As indicated in table 2, the soil's accessible phosphorous concentration was good with high potassium level (93.54 ppm). The exchangeable cation values suggest that the soil was deeply imbalanced, with an over-abundance of magnesium and insufficient quantities of Nitrogen.

Nutrients composition of bio slurry, chicken manure tea and vermi compost tea

Total Nitrogen

As indicated in table 3, the nitrogen concentration ranged between 0.37% and 1.06%, with the highest value recorded from the chicken manure tea (1.06%) followed by the vermi-compost (0.38%) and lastly bio slurry tea that registered 0.37%.

Table 3: Nitrogen content of the different organic fertilizers

Sample	Volume	Final Volume	Initial Volume	Titer	Weight of Sample
Blank	50	0.1	0	**0.1**	non
Bio Slurry	50	0.5	0.1	**0.4**	1.11
Chicken Mnure Tea	50	1.4	0.5	**0.9**	1.05
Vermi Compost Tea(VCT)	50	1.8	1.4	**0.4**	1.09

Phosphorous

The phosphorus concentration of the bio slurry, chicken manure tea, and vermi-compost ranged from 80 to 90 percent (Fig 3). The highest P content was found in bio slurry (92.5%), followed by chicken manure tea (86.11%), and the lowest in vermi-compost (79.26%). Bio slurry and chicken manure tea both had comparable phosphorus content. The amount of phosphorus in vermi-compost was lower than in other treatments.

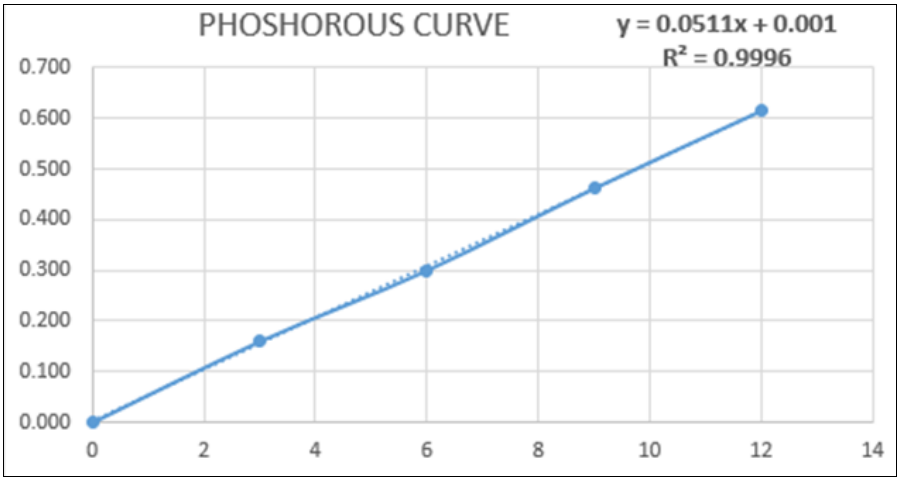

Fig 3: Phosphorous curve

X=(Y-0.001)/0.0511

Potassium

The value of accessible K in bio slurry, chicken manure tea, and vermi-compost ranged from 32 to 220 ppm (Table 1), with vermi-compost tea having the highest K content while chicken manure tea and bio slurry had the lowest K content (both 32 ppm).

Plant characteristics

Number of leaves, plant height, number of trusses, number of fruits per plant, fruit weight and yield were significantly influenced by different treatments at 1% (p<0.001) level of probability (Table 4 and Figure 4).

The influence of organic fertilizer types on tomato yield was significant (p< 0.001). When organic fertilizers were used, number of leaves and height of plants were higher than the control. Data presented in Table 4 and Fig 4 and 5 shows that bio slurry, chicken manure tea, and vermi-compost tea had positive effects. The application of bio slurry, chicken manure tea, and vermi-compost had a synergy effect on both the number of leaves and the height. The results in Table (4) and Figs (6, 7, 8, and 9) indicate that different organic fertilizers had a substantial impact on tomato yield and growth characteristics. Plants treated with chicken manure tea had the highest number of trusses, fruit number, fruit weight, and fruit yield. The no fertilizer treatment showed the least values of tomato yield parameters.

Table 4: Influence of organic and inorganic fertilizers on tomato growth parameters and yield

	TREATEMENTS							
Growth Parameters	**Chicken Manure Tea**	**Vermi Compost Tea (VCT)**	**Bio Slurry**	**Inorganic Fertilizer**	**Control**	**LSD**	**Mean**	**CV %**
Number of Leaves 1 week after Transpl.	4.00^{a}	4.33^{a}	4.67^{a}	3.33^{b}	2.00^{c}	0.909	3.67	13.2
Number of Leaves 2 week after Transplat.	7.00^{a}	7.00^{a}	6.00^{a}	5.33^{a}	5.00^{ab}	1.353	6.07	11.8
Plant Height	75.3^{ns}	58.7^{ns}	60.0^{ns}	58.5^{ns}	77.3^{ns}	37.77	66	30.44
Number of Trusses	11.00^{a}	9.00^{b}	8.00^{b}	6.00^{c}	4.33^{c}	1.945	7.67	13.5
Number of Fruits per plot	24.00^{a}	21.33^{a}	17.33^{b}	12.67^{c}	3.67^{d}	3.055	15.8	10.3
Weight of 2 fruits (g)	375.0^{a}	350.0^{a}	312.0^{b}	187.9^{c}	114.8^{d}	25.88	267.9	5.1
Yield (40 tomatoes per crate)	15.50^{a}	14.50^{a}	11.00^{b}	6.00^{c}	1.67^{d}	1.887	9.73	10.3

*: Significant for $p<0.001$; ns: Not significant; Values followed by the same alphabet within the column are not significantly different ($p<0.001$).

Number of leaves

Leaves are the main component of plants, producing and storing the green pigment chlorophyll, which is used in the photosynthetic process to produce dry matter. The number of leaves (Fig 4) was considerably higher for the chicken manure tea, vermi-compost and bio slurry. Tomato plants growing in plots treated with Chicken manure tea and vermi-compost had seven leaves, whilst tomato plants growing in plots fertilized with bio slurry had only six leaves, while synthetic fertilizer treatment had five leaves, and control had 2 leaves (Fig 3).

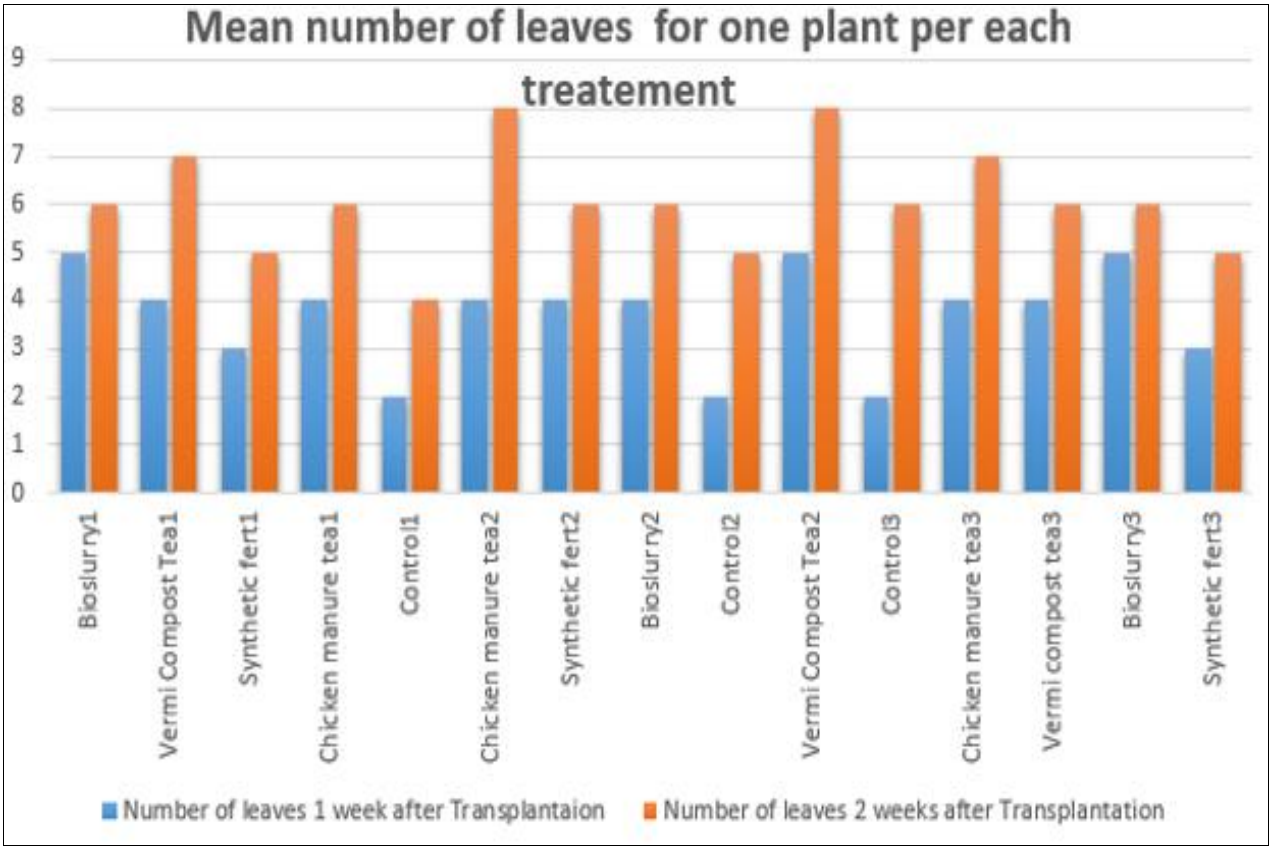

Fig 3: Number of leaves one and two weeks after transplantation

Plant height

Plant height is vital for optimal tomato yield since fruits are produced from the first branch to the last. Similar to a canopy, the higher the plant, the more fruits produced. At 56 days following transplanting, the tomato plant height was measured once at the pinnacle of vegetative development. At a probability level of 0.001, the effect of varied treatments on plant height was statistically significant (Table 4). Plant height was higher in all treatments compared to the control (Fig 4). Plant heights ranged from 25.17 to 80.10 cm depending on the treatment. The synthetic fertilizer treatment and the control had the shortest plants. Plant height was statistically similar and superior in chicken manure tea and vermi-compost tea compared to bio slurry, synthetic fertilizer, and the control treatment. Significant responses to fertilization were seen in terms of plant height. For chicken manure tea, vermi-compost, and bio slurry, a significant rise in tomato plant height was found from 2 weeks after transplantation.

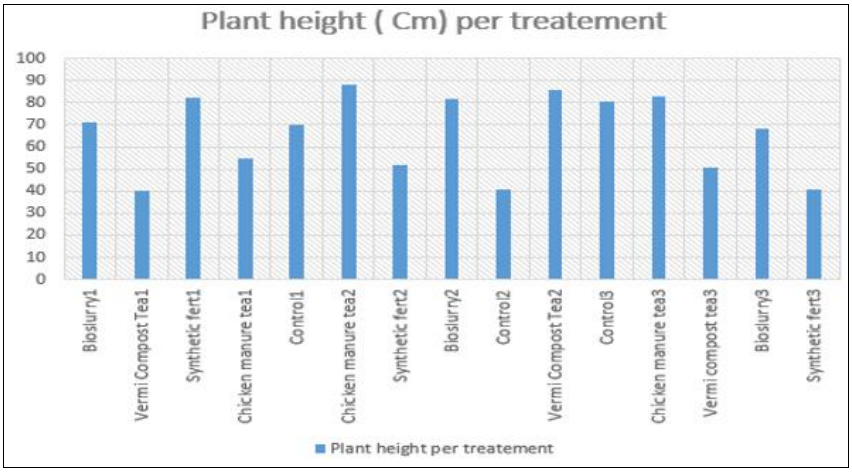

Fig 4: Plant height as influenced by different treatments

Number of truss per plant

Trusses grow from the stem rather than the leaf joint. It was noted that application of chicken manure tea, vermi-compost and bio slurry enhanced the number of tomato trusses. The control had the lowest number of trusses (Fig 5). Treatment with chicken manure tea, vermi-compost, and bio slurry, produced significant ($p< 0.001$) greater number of trusses compared to synthetic fertilizer and control treatments.

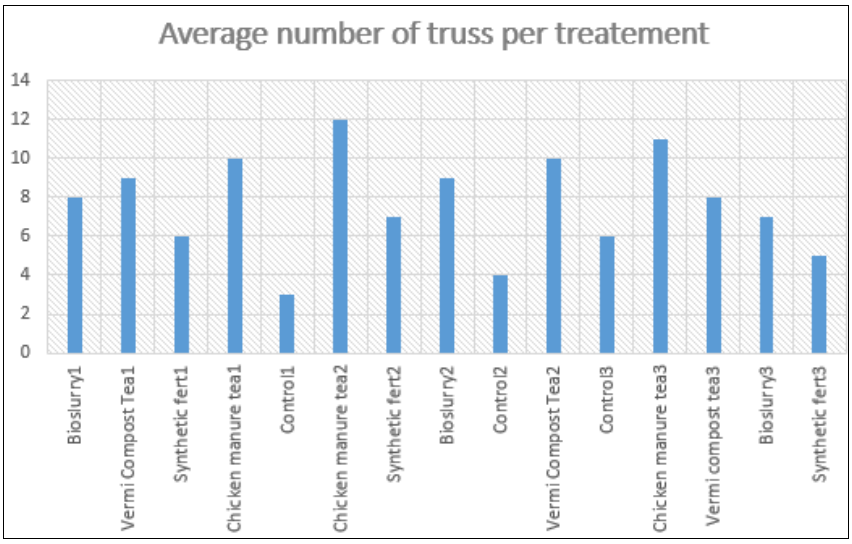

Fig 5: Average number of trusses per treatment

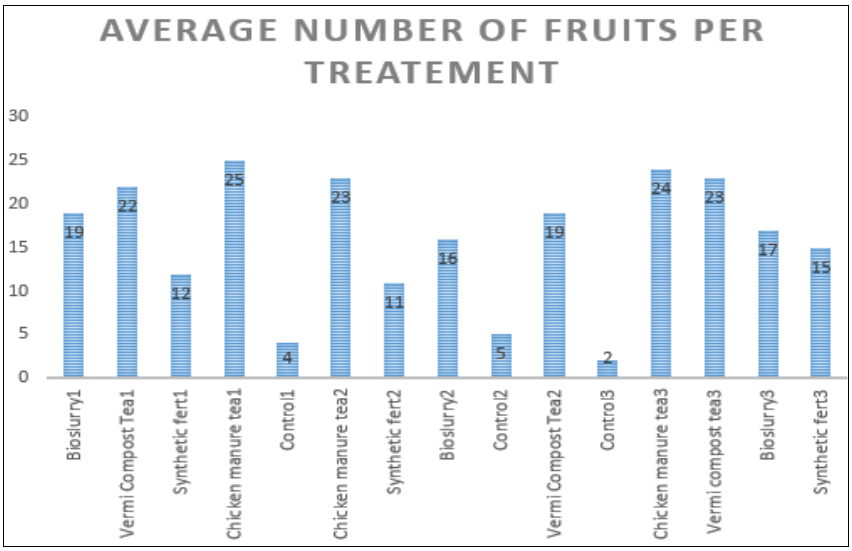

Fig 6: Average number of fruit per plant on different treatments

Number of fruits per plant

The most important production determining characteristic of tomato plants is the number of fruits per plant. The chicken manure tea treatment resulted in better fruits per plant (Fig 7), which was statistically significantly different (p<0.05) to all other treatments. As indicated in table 2, the quantity of fruits per plant varied from 24 tomatoes per plant for chicken manure tea treatment to 4 tomatoes per plant for the control (Fig 6).

Weight of fruits per treatment (g)

The effects of chicken manure tea, vermi-compost, bio slurry, and synthetic fertilizer treatments on tomato fruit weight were substantial. The average highest fruit weight (375 g per 2 fruits), was recorded in the chicken manure tea treatment followed by vermi-compost treatment (350 g per 2 fruits), bio slurry (312 g per 2 fruits), synthetic fertilizer (188 g per 2 fruits), and control 15 g per 2 fruits (Fig 7).

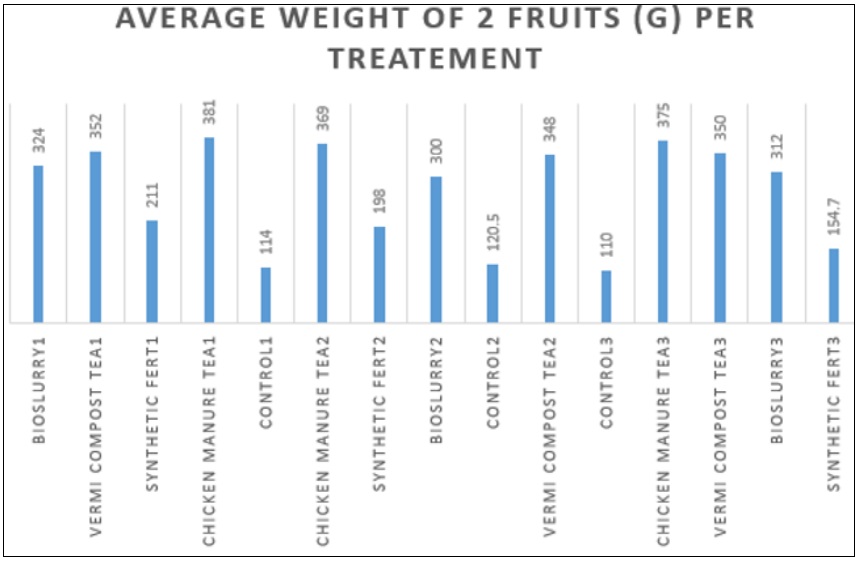

Fig 7: Influence of different treatments on weight of fruits

Yield

The use of chicken manure tea, vermi-compost tea, and bio slurry, had a substantial impact on tomato yield compared to synthetic fertilizer and control. The yield parameters in Table (4) shows highly significant (p<0.001) differences between treatments. Organic fertilizer treatment had a positive effect on tomato yield. When compared to the other treatments, chicken manure tea produced the highest weight. Maximum yield (45.4 ton/ha) was recorded in the chicken manure tea treatment. The control had the lowest values of tomato yield (1.7 ton/ha).

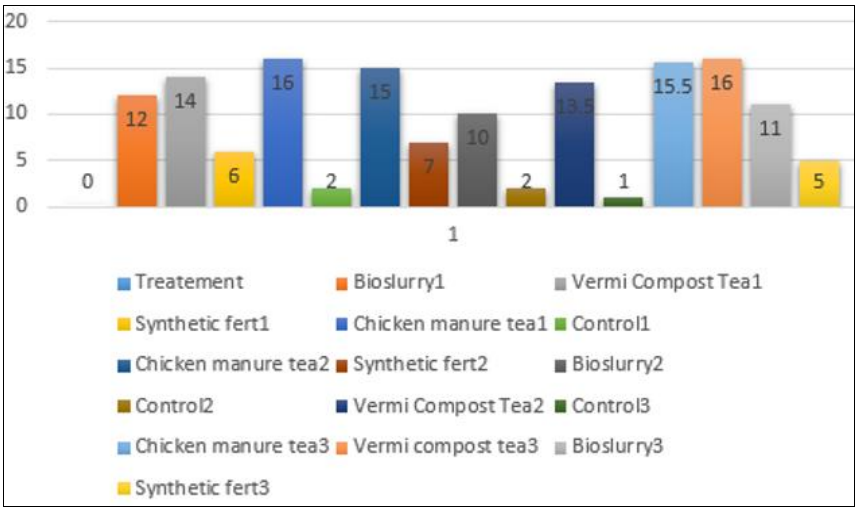

Fig 8: Tomato yield over treatments

Profitability

Commercial tomato production necessitates a high level of management, a significant amount of labor and capital, as well as meticulous attention to detail. Yield from chicken manure tea translated to 20 177.7 US$ per ha, vermi-compost 14 133.3 US$ per ha, bio slurry 12577.7 US$, Inorganic fertilizer 5 022.2 US$ per ha, and control 755.5 US$ per ha based on the average tomato prices received (Table 4). In Mbare Musika, Harare, Zimbabwe, the average tomato price ranged between 3.5 US$ and 4 US$/9 kg. The total net profit per Ha from tomatoes for each treatment was, chicken manure tea 18667.7 U.S. dollars, vermi-compost 12516.3 U.S. dollars, bio slurry 10677.7 U.S. dollars, inorganic fertilizer 3029.2 U.S. dollars, and control 257.5 U.S. dollars (Table 4).

Table 4: Gross and net profit of tomato sales as influenced by Organic and inorganic fertilizer.

Treatment	Yield (t/ha)	Total revenue ($/ha)	Cost of good sold ($/ha)	Gross profit ($/ha)	Expenses($/ha)	Net profit ($/ha)
Chicken manure Tea	45.4	20177.7	950	19227.7	560	18667.7
VCT	31.8	14133.3	1157	12976.3	460	12516.3
Bio slurry	28.3	12577.7	1455	11122.7	445	10677.7
Inorganic Fertilizer	11.3	5022.2	1650	3372.2	343	3029.2
Control	1.7	755.5	300	455.5	198	257.5

Discussion

Chicken manure tea, vermi-compost, and Bio slurry achieved good vegetative growth and yields. Rokonujjman *et al*., (2019) [24]; Foundations for Framing, (2018) [7]. Arancon *et al*., (2019) [4]; Jack *et al*., (2006) [13] and Rehman *et al*., (2023) [21] when examining the effect of bio fertilizers also concluded that, plants treated with chicken manure tea, vermi-compost, and bio slurry and cultivated in organic production systems exhibit vegetative growth and yields that are comparable to those produced with inorganic fertilizer. Also found that using organic fertilizers increased tomato yields by up to 99 percent. According to Marcelo & Sonia (2019) [17] and Gao, *et al.*, (2023) [9d] organic fertilizers fed tomato plants grew and yielded well by boosting soil fertility, particularly carbon, nitrogen, phosphorous and potassium levels. Chicken manure tea considerably increased tomato plant height, which could be attributed to the greater percentages of N, P, K, and S in chicken manure. Although the highest number of tomato fruit per plants were observed in the chicken manure tea and vermi-compost treatments, it was not significantly different (p<0.05) to bio slurry treatment indicating that chicken manure tea, vermi-compost, and bio slurry have a positive effect, similar to chemical fertilizer. This suggest that, these environmentally friendly organic fertilizers can readily be used to grow high quality tomatoes. The heaviest tomato fruit harvested from chicken manure tea, vermi-compost, and bio slurry treatments suggests that organic fertilizers have a positive impact on tomato fruit quality. Suggests that, organic fertilizers such as chicken manure tea, vermi-compost tea, and bio slurry have the highest economic profitability in tomato production. The integrated use of organic fertilizers has also been observed to improve tomato cropping system development, yield, and yield contributing characters (Marcelo& Sonia, 2019) [17] due to better plant uptake of total N, P, K, and S.

Chicken manure, cow dung, and vermicomposting worms make up the majority of organic fertilizers. Nutrient content, rate of release, and immobilization of nutrients all vary significantly between these products. In addition to nutrition, organic fertilizers provide vitamins and growth regulators (Amjad *et al*., 2016; Thomas *et al*.,2019; Phibunwatthanawong *et al*., 2019) [26, 27, 20].

Conclusion

Fertilizer use, particularly organic fertilizer applied to tomato fields, may be highly beneficial for smallholder farmers in Harare's northern region, with sustainable production gains. As plots treated with chicken manure tea produced higher yield than the rest, it is safe to recommend chicken manure tea, in tomato production.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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