The Journal of Animal & Plant Sciences, 28(3): 2018, Page: 845-853
ISSN: 1018-7081

ORGANIC SOIL AMENDMENTS: IMPLICATIONS ON FRESH TOMATO (*SOLANUM LYCOPESICUM*) YIELD, WEED DENSITY AND BIOMASS

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ABSTRACT

Low soil fertility and weed pressure are among the major challenges affecting field and horticultural crops. Field experiments were conducted at Marondera University of Agricultural Sciences and Technology in Zimbabwe during 2015-16 and 2016-17 to evaluate the effect of organic manure sources on tomato yield, weed density and biomass. Manure from cattle, goats and indigenous chickens were tested with and or without mineral (NPK) fertilizer. A total of eight treatments arranged in randomised complete block design replicated thrice were used. Results showed an increase in tomato yields by 36.94%, and 37.07% in treatments combining mineral fertilizer with cattle or goat manure compared to sole mineral fertilizer. Concomitantly applied organic soil amendments (OSAs) did not only benefit the tomato crop but resulted in higher weed density from sole and mineral fertilizer combined treatments of goat and cattle manure. Likewise above ground dry weed biomass showed an increase by 65.36 – 95.41% higher in sole and mineral fertilizer combined treatments of goat and cattle manure compared to sole mineral fertilizer treatments. Lower weed biomass was recorded from sole and mineral fertilizer combined treatment of chicken manure which was not significantly different from the standard mineral fertilizer application. A positive correlation (r= 0.79, $P \leq 0.02$) was recorded between weed biomass and fresh tomato yield meaning that applied OSAs did not only cause yield incremental benefits to tomato crop but weeds benefited as well. This implies that weed management should be vigilant in fields with improved fertility levels due to potential weeds being introduced from animal manure and increased weed growth that may result in weed crop competition. Results further suggested that chicken manure have potential of reducing weed biomass without affecting tomato yields in low nutrient soils when used in combinations with mineral fertilizers. It is therefore be concluded that OSAs has great potential in rehabilitating depleted soils and should be well cured before they are applied to field or horticultural crops in order to reduce weed prevalence.

Key words: Depleted soils, mineral fertilizers, organic soil amendments, small-scale farmers.

INTRODUCTION

The tomato fruit (*Solanum lycopesicum*) is an important edible vegetable, consumed fresh or processed (Frusciante *et al.,* 2007). It is rich in minerals such as iron, phosphorus, vitamins (B and C), essential amino acids, sugars and dietary fibres. The fruit therefore contributes to a healthy and well-balanced diet. Furthermore, the crop is an important cash generating project for small scale farmers and provides employment in the agro-processing industry where it is used as raw material.

In Zimbabwe small scale farmers contribute significantly to tomato production and market supply (Chigumira-Ngwerume 2000). However, due to lack of financial resources and capacity to raise the required collateral by banks to borrow money, smallholder farmers rely on open field production because they cannot afford to raise capital required for construction of plastic structures in frost prone areas. Most smallholder farmers in such areas prefer to grow tomatoes during warmer times of the year in protected gardens. Location of such gardens is mainly based on water availability regardless of soil type such that some of the gardens are located on soils depleted of nutrients. Furthermore, due to labour bottlenecks in summer, tomatoes grown during this period usually compete with field crops for labour and input resources (Maerere *et al*., 2010). Smallholder farmers usually preferentially allocate labour and input resources to field crops and this affect summer grown tomatoes. Furthermore, high disease incidence, insect pests and weed challenges are common in tomato production in summer resulting in depressed yields of less than 5 tonnes ha^{-1} against varietal potential of between 60-100 tonnes ha^{-1} (Starke ayres, 2012). It is therefore prudent to address the challenges faced by resource constrained farmers in order to improve their livelihoods.

The use of synthetic fertilizers by smallholder farmers to address low fertility challenges is limited due to high costs of fertilizers and perceived myth that synthetic fertilizers result in bitter vegetable taste (Shackleton *et al.,* 2009). The summer grown tomatoes also compete with field crops for the little fertilizer available and usually the staple maize crop receive preference over summer horticultural crops (Kurwakumire *et al* 2014). This is further coupled by weed pressure which is common in summer due to labour constrains since available labour will be first allocated to maize crop and other activities common beginning of rainy season. This result in established tomato crops being choked with weeds before adequate attention is given to the crop. Weeds affect tomato crop by competing for limited resources such as nutrients, water, light and space (Hakim *et al* 2013). Furthermore weeds harbour insect pests, plant disease and are alternative host of parasitic nematodes (Amare *et al.,* 2015). Poor weed management can reduce crop yields by up to 70 % (Brakht and Khan, 2014) and this has negative implications on rural livelihoods and the country's economy.

It is hypothesised that amending soil nutrients with organic material sources which can be used as alternatives to inorganic fertilizers has potential of increasing crop yield as well as increasing weed prevalence. Organic manure sources are believed to act as weed seed reservoirs resulting in high weed prevalence when applied to crop fields (Rupende *et al.,* 1998). However, it remains unclear whether there is a net benefit in crop yield or the crop yield is compromised by the increase in weed pressure. Furthermore, whether weed densities and biomass from different organic materials varies with source used or whether it varies with method of application (sole versus combined application of organic sources with mineral fertilizers) and the subsequent effect on tomato crop yields is not well understood. This study was carried out to evaluate the effect of different sources of organic fertilizers with and or without mineral fertilizers on tomato yield, weed density and biomass.

MATERIALS AND METHODS

Site description: This study was conducted at Marondera University of Agricultural Sciences and Technology, (18° 23' S and 31° 47' E). The College is located 40 km south of Marondera town and falls in Natural Region IIa. The area experiences sub-tropical climate with average summer temperatures of 25°C and annual rainfall of 800-1000mm year^{-1}. The two seasons, meteorological (rainfall and temperature) data of experimental site is presented in (Figure 1). The rainfall follows a unimodal pattern with rains received between September and April. The total rainfall received at the experimental site for 2015-16 and 2016-17 seasons was 518.5 and 873 mm respectively. In this case rainfall distribution was not even and the crop received supplementary irrigation to field capacity in periods when rain was not received for more than seven days. The soils are derived from granite parent material which is predominantly sandy Lixisols with low soil organic carbon (SOC), inherently poor nutrient supply and low water holding capacity. Initial soil characterisation is shown in (Table 1).

Initial soil and organic manure characterisation: Soil samples were collected from the experimental plots prior to planting and soil analysis results showed pH of moderate acidity and low total nitrogen content (Table 1). Organic manure was also analysed in the laboratory and it was observed that cattle and goat manure had slightly acidic to neutral pH of 6.2 and 7.0 respectively while indigenous chicken manure was of alkaline pH (8.9). Total nitrogen for all manure sources was low and ranged from 0.35% to 0.73% (Table 1).

Site preparation, experimental design and treatments: The site was ploughed to a depth of 25 cm using a tractor and the soil conditioned to a fine tilth. Permanent plots were demarcated using brick and mortar and gross plot size was 1.8 x 2 m. Organic soil amendments (OSAs) with or without inorganic basal NPKS fertilizer was broadcast on the soil surface and worked into the soil to a depth of 10 cm using a rake a week before transplanting seedlings.

A randomized complete block design experiment was set up with each treatment replicated thrice. A total of eight treatments were used namely mineral fertilizer as standard practice, three organic manures sources (cattle, goat and indigenous chicken) with each manure source used as sole and in combination with mineral fertilizer and unfertilized treatment as control. Previous work on cattle manure application in communal smallholder farming system in SSA and Zimbabwe has shown an optimum rate range between 5-10 tonnes ha^{-1} for field crops (Mugwira and Murwira 1997). In this experiment 10 tonnes ha^{-1}of each organic soil amendments sources was used on sole treatments and half rate (5 tonnes ha^{-1}) when combined mineral fertilizer. Organic soil amendments (OSAs) treatments combined with mineral fertilizers received 200kg ha^{-1} of basal NPK (N. 6 P_2O_5. 15 K_2O. 12) and 100kg ha^{-1} of ammonium nitrate (34.5% N) as top dressing. The treatment with mineral fertilizers only had 400kg ha^{-1} NPK and 200kg ha^{-1} ammonium nitrate. The crop was grown in permanent beds with treatments repeated on same plots over the two seasons. During the winter period an onion crop was grown on the same beds with the same treatments imposed on the same treatment plots. After harvesting of onion, soil samples was analysed again before the next tomato crop (Table 2). Cattle manure used was cured for one month prior to use while goat and chicken manures used were straight from the livestock pens.

Plots were designed with gross plot size of 3.6 m^{-2} and a net plot of 2 m^{-2}. Planting stations were marked using a spacing of 50 x 50cm to give a plant population of 12 plants per square meter. A tomato variety Rodade was transplanted on the 7th October in 2015 and due to non availability of the Rodade variety since it is being phased out, Rodade plus was used in the second season and was planted on the 5th October in 2016. The crop was drip irrigated soon after transplanting with dripper lines spaced 50cm apart such that the whole bed would be moist. The frequency of irrigation to field capacity was once in 5-7 days per cycle. The target was to apply about 550 - 600 mm of irrigation water but in this case the crop was grown in summer where supplementary irrigation was done when no rains were received within seven days. Total rainfall received was 518.5 and 837mm in season one and two respectively. After transplanting, the tomato crop was protected from cutworm damage by spraying with Lambda-cyhalothrin. In addition weekly fungicidal routine sprays for disease prevention were done and this commenced in week three after transplanting. The spraying program interchanged Cooper oxychloride and Mancozeb while the curative fungicide Difenoconazole was applied once in three weeks

Data collection and analysis: Parameters measured were fresh tomato fruit weight, weed density and biomass. Weed species density (counts m²) was measured by randomly throwing five 30 x 30cm quadrats into each plot. Weeds in the quadrat were identified by species counted on 28th and 49th day after transplanting. Identified weed species in the quadrat were harvested above ground, placed into khaki pockets and oven dried at 70°C for 48 hours. Weed biomass (g m²) was determined by weighing oven dried samples using digital scale. Tomato ripening started 75 days after transplanting (DAT) and reaping was done on weekly basis. Fresh fruit weight was recorded at harvesting by weighing fresh fruit weight from the net plot and expressing it in kg m².

Weed density (counts m^{-2}) was not normally distributed hence the data was transformed using the formula $\sqrt{(X+0.5)}$ before analysis (Steel *et al*., 1997). The transformed weed density data, above ground weed biomass (g m^{-2}) and fresh tomato fruit weight (kg m^{-2}) were subjected to analysis of variance (ANOVA) using Minitab version 17 statistical packages (State College 2013). Means were separated using $\pm$ standard error of the difference when F test showed significant treatment effect at $P \leq 0.05$.

RESULTS

Fresh tomato fruit weight at harvesting: Organic soil amendment significantly increased fresh tomato yield (kg m^2) during both seasons ($P \leq 0.05$) (Table 3). In the first season higher fresh tomato weights were recorded from sole mineral fertilizer treatments followed by cattle manure combined with mineral fertilizers. In the second season higher tomato fruit weights were recorded from OSAs combined with mineral fertilizer and specifically treatments with cattle manure and goat manure combined with mineral fertilizers gave significantly higher yields (11.2 and 11.5 kg m^{-2}) than all other treatments. Least yields in both seasons were obtained from unfertilized control treatment. Pooled tomato weight over seasons showed high fresh tomato weight from goat and cattle manure with each organic source combined with mineral fertilizer (10.938 and 10.944 kg m^{-2}) respectively compared to 7.987 kg m^{-2} from the standard mineral fertilizer. The lowest tomato yield was recorded from the unfertilized control with 3.122 kg m^{-2} (Table 3). Generally all treatments recorded higher fresh tomato yield in the second season compared to first.

Weed dominance, density and biomass: A total of fourteen weed species were identified and recorded from the research site. Ten weed species were in the Fabaceae (broad leaf), while three were in the Poaceae (grasses) and one Cyperaceae (sedge). In the first season the top five dominant weed species in descending order were *Galinsoga parviflora* (53.16%)*, Eleusine indica* (12.28%) *Setaria verticillata* (9.54%), *Tagetes minuta* (6.69%) *and Richardia scabra* (4.79%) (Table 4). In the second season the most dominant weed species were *Setaria verticillata, Eleusine indica, Galinsoga parviflora, fabaceus and Richardia scabra* (Table 4). Pooled dominance for the seasons showed the following dominance in descending order *Galinsoga parviflora* (33.54), *Setaria verticillata* (12.93%) *Eleusine indica* (12.62%). The least dominant weeds with less than 2% were *Acanthospermum hispidum, Leucus martinicensis, Portulaca oleracea* and *Cynodon dactylon.* Weed density (count m^2) significantly increased with organic soil amendment ($P \leq 0.05$) (Table 5). At day 28 and 49 after transplanting and in both seasons, higher weed counts m^{-2} were recorded from sole cattle and goat manure treatments followed by their combined application with mineral fertilizers (Table 5). In addition to sole cattle and goat manure, higher weed densities were also recorded from sole chicken manure treatment in the second season (Table 5). Lower weed counts were recorded in the sole mineral fertilizer treatments and unfertilized control treatments in both season (Table 5).

Organic soil amendment significantly increased above ground dry weed biomass in both seasons ($P \leq 0.05$). In the first season at 28 DAT, higher weed biomass was recorded from sole cattle manure treatments (288.1g m^{-2}) followed by cattle and goat manures in combination with mineral fertilizers (Fig 2). Significantly lower dry weed biomass was recorded from sole chicken manure and unfertilized control treatments with corresponding weights of 52.69 and 20.37 g m^{-2} (Fig 2). At 49 DAT higher dry weed biomass was recorded from sole cattle manure and goat manure with mineral fertilizers while lower weed biomass was recorded from chicken manure applied as sole and combined with mineral fertilizer treatments. During the second season at 28 DAT, higher weed biomass was recorded from sole cattle manure (169.2 g m^{-2}) followed by sole goat manure and in combination with mineral fertilizer treatments. Lower weed biomass was recorded from unfertilized control treatment with 0.93 g m^{-2}. Similarly at 49 DAT in the second season higher weed biomass 187.2 and 184.8 g m^{-2} were recorded from goat manure sole and combined treatments followed by cattle manure combined with mineral fertilizer (151.8 g m^{-2}) while the least weed biomass weight was recorded from the control treatment 24.5g m^{-2} (Fig 2). There was a positive Pearson correlation (r = 0.79, P≤0.02) between weed biomass and fresh tomato yield.

Table 1. Initial characterization of soil and organic amendments.

Description	pH	Total N	Available P	Potassium[b]	Calcium[c]	Magnesium[d]
	(Ca.Cl)	(%)	(mg kg^{-1})		mmol $_{(c)}$ kg^{-1}	
Soil	5.3	0.01	30.5	1.00	2.32	0.59
Cattle manure	6.2	0.35	52.9	5.56	1.75	1.12
Goat manure	7.0	0.48	49.5	9.20	1.96	0.60
Chicken manure	8.9	0.73	48.5	9.48	2.59	1.03

General fertility range interpretation: Adapted from Tanner and Grant (1963). (a). Available-P (resign-extracted):<7=very low; 7-15=low; 15-30=high. (b).Exchangeable-K; <0.15=very low; 0.15-0.3=low; 0.3-0.5=medium; >0.5=high. (c) Exchangeable-Ca; <5= very low; 5-10= low to medium; > 10= high (d) Exchangeable- Mg; <0.1= very low; 0.1-0.2=low to medium; >0.2=high.

Table 2. Soil and organic amendments characterisation before crop establishment in second year.

Soil /Manure analysis	pH	Total N	Available P	mmole$_c$ kg^{-1}		
	(Ca.Cl)	%	mg kg^{-1}	K	Ca	Mg
Control	5.20	0.010	22.50	1.00	2.02	0.60
NPKS	5.20	0.030	32.09	3.90	1.90	1.02
Sole cattle manure	5.60	0.020	35.50	3.60	2.69	1.50
Cattle manure+NPK	5.60	0.020	36.15	2.89	2.34	1.46
Sole goat manure	5.50	0.023	36.21	3.11	2.65	1.43
Goat manure+NPK	5.60	0.022	35.79	2.98	2.50	1.33
Sole chicken manure	5.70	0.032	37.34	8.00	2.00	0.95
Chicken manure+NPK	5.70	0.034	36.17	3.44	2.85	1.23
Cattle manure analysis	6.50	0.380	53.30	6.00	1.75	1.15
Goat manure analysis	7.45	0.540	50.00	9.50	2.00	1.00
Chicken manure analysis	7.95	0.750	49.00	8.50	2.10	1.05

General fertility range interpretation: Adapted from Tanner and Grant (1963). (a). Available-P (resign-extracted):<7=very low; 7-15=low; 15-30=high. (b).Exchangeable-K; <0.15=very low; 0.15-0.3=low; 0.3-0.5=medium; >0.5=high. (c) Exchangeable-Ca; <5= very low; 5-10= low to medium; > 10= high (d) Exchangeable- Mg; <0.1= very low; 0.1-0.2=low to medium; >0.2=high.

Table 3. Effects of organic and inorganic soil amendment on fresh tomato fruit weight at harvesting stage.

Treatment	2015-16 Fruit weight kg m^2	2016-17 Fruit weight kg m^2	Pooled Fruit weight kg m^2
Control	1.625[d]	4.618[d]	3.122[d]
NPKS	7.159[a]	8.815[c]	7.987[bc]
Sole cattle manure	5.583[ab]	11.282[b]	8.432[b]
Cattle manure+NPK	6.070[a]	15.807[a]	10.938[a]
Sole goat manure	4.957[bc]	11.852[b]	8.404[b]
Goat manure+NPK	6.262[a]	15.627[a]	10.944[a]
Sole chicken manure	5.052[ab]	9.175c	7.113[bc]
Chicken manure+NPK	6.458[a]	12.473[b]	9.466[b]
P value	0.043	0.00	0.001
±Sed	1.43	2.03	1.191
CV%	32.56	22.17	17.57

Means that do not share a letter in the column or row are significantly different (P≤0.05), R^2 adj. =71.57. NPK =mineral fertilizer.

Table 4. Weed species found on research site and their relative dominance% in descending order.

Scientific weed species	Common name	2015-16 Dominance%	2016-17 Dominance%	2015-17 Pooled dominance%
Galinsoga parviflora Cav	Gallant soldier	53.16	15.24	33.54
Eleusine indica (L.) Gaertn.	Rapoko grass	12.28	15.24	15.10
Setaria verticillata	Burgrass	9.94	15.72	12.93
Eleusine indica (L.) Gaertn.	Rapoko grass	9.80	15.24	15.10
Marah fabaceus	Wild cucumber	0.00	12.82	6.64
Targetes minuta	Mexican marygold	6.69	5.15	5.90
*Richardia scabra (*L.) St.-Hil.	Mexican clover	4.79	6.89	5.87
Amaranthus hybridus (L.)	Pig weed	2.65	7.84	5.82
Cyperus species	Nutsedge	1.86	4.98	3.47
Acacia karroo.	Acacia	1.21	4.76	3.05
Nicandra physaloides (L.) Gaertn.	Apple of Peru	2.60	3.29	2.96
Acanthospermum hispidum DC.	Upright stubur	1.81	1.39	1.59
Leucus martinicensis	Bobbin weed	1.07	1.43	1.26
Portulaca oleracea (L.)	Purslane	1.63	0.23	0.97
Cynodon dactylon (L.)	Couch grass	1.49	0.48	0.96

Table 5. Effects of organic soil amendment on weed density (counts m^2) at 28 and 49 days after transplanting (DAT) tomatoes.

Treatment	Crop cycle 1: 2015-16 season		Crop cycle 2: 2016-17 season	
	28 DAT	49 DAT	28 DAT	49 DAT
Control	52.80^{cd} (63.7)	47.77^{d} (38.51)	37.79^{e} (9.6)	52.5^{d} (58.5)
NPKS only	51.98 ^{cd} (52.6)	51.26^{c} (49.62)	48.32^{d} (45.9)	58.24^{cd} (100.7)
Sole cattle manure	78.28^{a} (181.5)	78.60^{a} (214.1)	71.09^{a} (88.9)	57.93^{cd} (106.7)
Cattle manure+NPK	68.46^{ab} (125.2)	70.00^{b} (128.88)	59.82^{ab} (105.9)	77.93^{a} (160.0)
Sole goat manure	72.30^{a} (165.2)	64.75^{b} (133.3)	66.77^{a} (118.5)	70.86^{b} (157.0)
Goat manure+NPK	67.32^{ab} (114.1)	69.17^{b} (150.4)	61.01^{ab} (83.0)	65.58^{b} (139.2)
Sole chicken manure	59.72^{c}(80.0)	56.75^{c} (74.1)	59.49^{ab} (115.5)	61.21^{bc} (118.5)
Chicken manure+NPK	56.20^{c} (73.3)	56.75^{c} (65.9)	55.94^{bc} (91.8)	56.47^{cd} (94.1)
P value	0.006	0.003	0.002	0.009
±Sed	6.407	6.443	6.17	5.820
CV %	12.38	12.77	13.14	11.39

*Means in the same column followed by different letters differ significantly (P≤0.05), and figures in brackets show untransformed data.

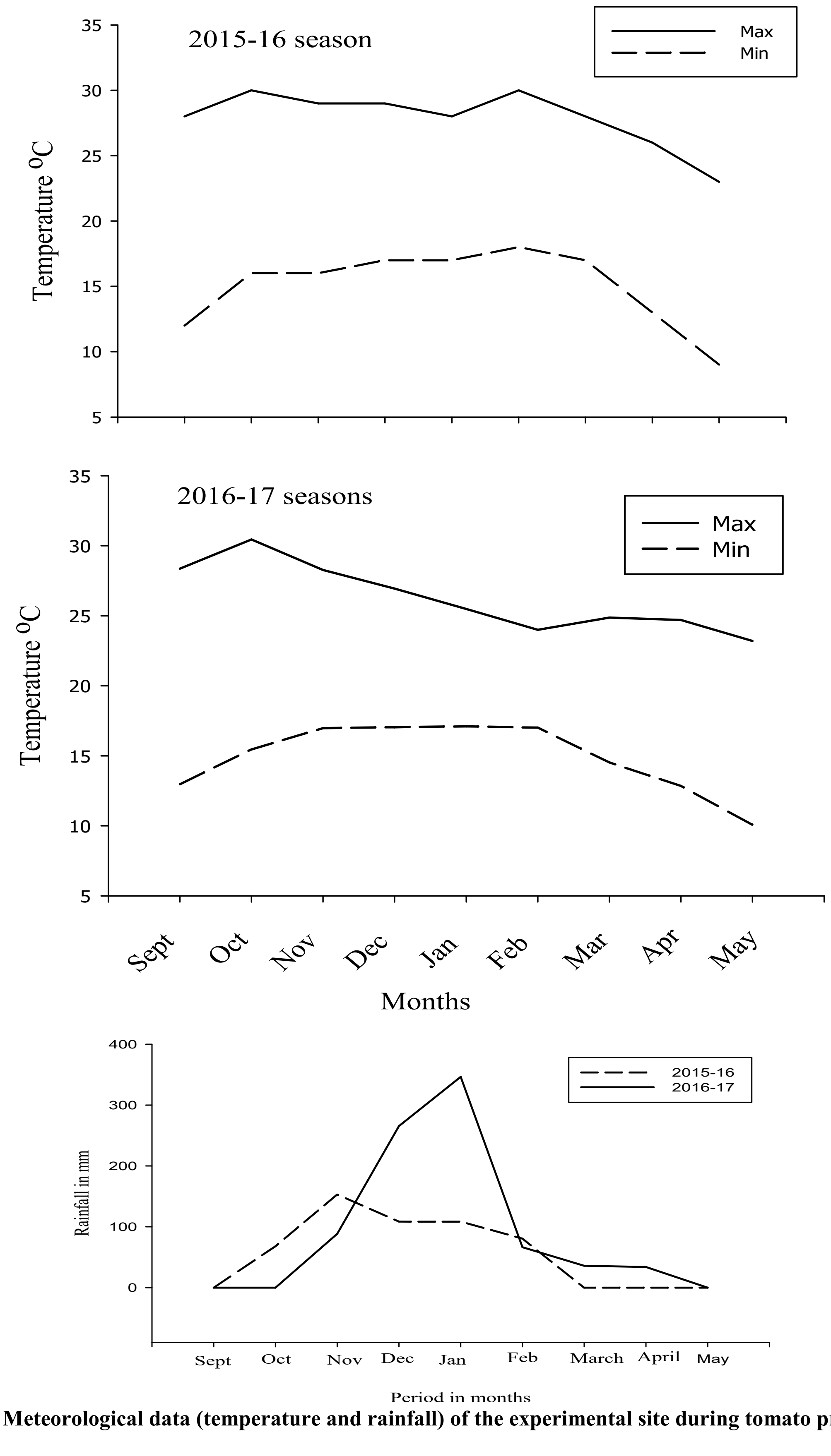

Figure 1. Meteorological data (temperature and rainfall) of the experimental site during tomato production.

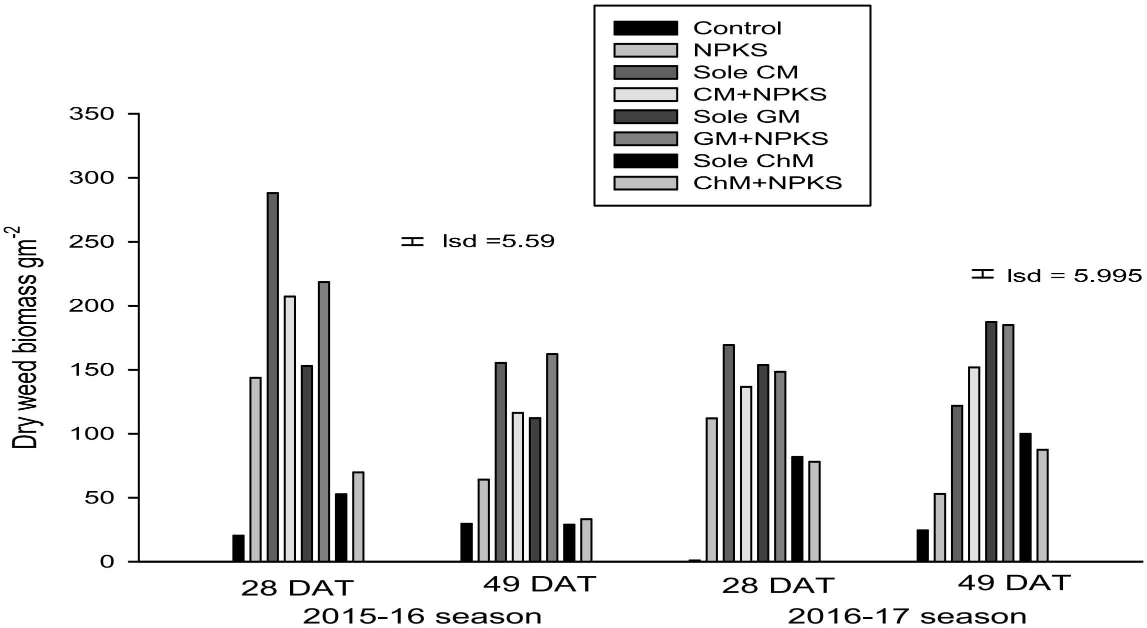

Figure 2. Effects of organic soil amendment on weed biomass (g m^2) at 28 and 49 days after tomato planting in 2015-16 and 2016-17 seasons.

DISCUSSION

The general trend over two seasons showed that organic soil amended (OSA) treatments combined with mineral fertilizers gave 1.08 to 1.4 time's higher yields compared to sole application of the same organic manures. Low performance of sole organic manure treatments compared to combined application with NPK mineral fertilizers is most likely linked to slow mineral nutrient release patterns from organic manure which failed to meet tomato crop demands during its growth cycle. In field crop production, Rusinamhodzi *et al.,* (2014) also reported an increased in maize crop yields where cattle manure combined with mineral fertilizer was used compared to sole manure or mineral fertilizer applications. Generally across all treatments fresh tomato yield was higher in second season compared to first season. The differences in yield can be attributed to an improved variety used in the second season Rodade plus compared to Rodade in the first season. In the first season Rodade also succumbed to blight attack early (flowering stage) and this could have influenced fresh tomato yield compared to late (ripening stage) inception of disease incidence in the second season. A higher incremental yield in OSA treatments could be attributed to the slow nutrient release nature of manures, combined with concomitant benefits such as improved soil structure, cation exchange capacity (CEC) and soil water holding capacity. A positive Pearson correlation between weed biomass and fresh tomato yield demonstrates that combined application of organic soil amendments and mineral fertilizers does not only benefit the crop but also have incremental benefits on weed density and biomass. However, the increase in weed density and biomass did not translate to yield loss when weeding was done twice and within three weeks from transplanting period.

Weed density results over the seasons demonstrate high weed density from cattle and goat manure applied as sole or in combination with mineral fertilizers. This is an indication that manure from cattle and goats carry a substantive amount of weed seeds especially when cured for a short period which in this case was one month for cattle manure and from pens for goat manure. Generally higher weed density on day 28 in the first season compared to subsequent measurements on day 49 in the first season, days 28 and 49 in the second season. This can be attributed to potential germinable weeds that could have been stimulated to germinate after the initial tillage of the research site. Furthermore, such weeds had a quick growth because of the high temperature experienced in October, November period before the tomato established. Similar findings were also reported by Materechera, and Modiakgotla, (2006), where cattle manure was found to carry large numbers of germinable weed seeds and are associated with high weed density and biomass in field crops especially when it has been cured for a period of between 1-5 months. Combined application of cattle or goat manure with mineral fertilizer could have also stimulated germination and growth of weed seeds in the soil seedbank. Findings of this study showed that weeds commonly associated with cattle manure was recorded in this study such as *Eleusine indica, Setaria verticillata, Amaranthus hybridus and Nichandria physaloides* and similar species were also reported by Materechera, and Modiakgotla, (2006).

An increase in *Marah fabaceus* (wild cucumber) which was not on site in the first season was observed and in the second season and it ranked forth on percentage dominance. Further observations were that *Acacia karroo* was mainly associated with both goat and cattle manure treated plots. The occurrence of these weeds in cattle and goat manure treatments is attributed to the grazing nature of livestock. During winter periods, cattle and goats are allowed graze on a free range and penned in kraals in the evening. The natural veld is also dry during this time of the year and animals prefer to feed on Acacia species pods as protein source. Seeds on the Acacia species will pass through the digestive system of animals without being damaged and will be present in manures. Furthermore some weed seeds may escape the composting process.

High weed density and biomass in OSA and NPK combined treatments could have been stimulated by synergistic effect of the combinations. Blackshaw (2004) reported that nutrient elements such as nitrogen and phosphorus are known to stimulate weed seed emergence through breaking seed dormancy. Likewise organic soil amendment sources modify soil physical properties such as aggregation, increase aeration and water holding capacity. Organic manure increase soil organic content which reduces soil surface crusting, lower bulk density and soil pH thereby increasing soil chemical properties such as cation exchange capacity and supply of plant nutrients and weed take advantage of such benefits as well (Wuta and Nyamugafata, 2012; Muhammad, 2013).
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Combined application of OSAs and inorganic fertilizers did not only benefit the crop but increase weed biomass as well. Similar findings were reported by Major *et al.,* (2005) who found out that application of both organic and inorganic fertilizers significantly increased ground cover, number of species and weed biomass. A combination of organic and inorganic fertilizers has been found to stimulate weed seed germination, growth and competitiveness against the crop (Rezvani *et al.,* 2012; Hassan & Khan., 2007; Blackshaw and Molnar, 2009). Furthermore organic manures sources can also act as weed seed reservoirs resulting in high weed prevalence when applied to crops (Rupende *et al*., 1998). However, indigenous chicken manure gave low weed biomass compare to other organic sources and this can be attributed to the feeding habits of chickens. Similarly Baig *et al.,* (2001) also reported low weed biomass on chicken manure treatments and this was attributed to presence of phyto-toxins in chicken manure which can supress some weed species.

Conclusion and recommendations: The study demonstrated that repeated applications organic soil amendment (OSA) combined with mineral fertilizer increases fresh tomato yield compared to sole application of organic and mineral fertilizers. It was also concluded that applied OSA and mineral fertilizer does not only benefit the crop but also increase in weed density and biomass. However, the increase in weed density and biomass in OSA treatments did not affect crop yield when weeding was done twice within three weeks interval. Furthermore, weed densities and biomass varied with manure source. Cattle and goat manure had high weed density and biomass compared to chicken manure which contains phyto-toxins that supress weeds. It is thus recommended to combine OSA with mineral fertilizer for maximum yield benefits. Furthermore, manures require composting reduce weed incidence and negative effects of immobilisation on tomato growth and yield.

Conflict of interest: The authors declare that there is no conflict of interest in this work.

Acknowledgement: Authors would like to acknowledge Marondera University of Agricultural Sciences and Technology for assisting with facilities to run the trial over the seasons and laboratory facilities to analyse the samples.

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