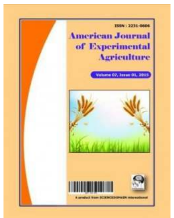

American Journal of Experimental Agriculture
12(1): 1-10, 2016, Article no.AJEA.24630
ISSN: 2231-0606

SCIENCEDOMAIN *international*
www.sciencedomain.org

Yield and Yield Attributes of Tomato as Influenced by Organic Fertilizer

Witness Mojeremane[1*], Ofentse Moseki[1], Thembinkosi Mathowa[1], Gabatshele M. Legwaila[1] and Sifanele Machacha[1]

[1]Department of Crop Science and Production, Botswana University of Agriculture and Natural Resources, Gaborone, Botswana.

Authors' contributions

This work was carried out in collaboration among the authors. Authors OM, WM and TM designed the study. Author OM carried out fieldwork. Author TM managed the analyses of the study and critically reviewed the first draft of the manuscript. Author WM produced the manuscript. Authors TM, GML and SM critically reviewed the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEA/2016/24630
Editor(s):
(1) Masayuki Fujita, Department of Plant Sciences, Faculty of Agriculture, Kagawa University, Japan.
(2) Mintesinot Jiru, Department of Natural Sciences, Coppin State University, Baltimore, USA.
Reviewers:
(1) M. Shanmugam, India.
(2) Maria Jose Alves Bertalot and Eduardo Mendoza, Instituto Elo de Economia Associativa, Botucatu, SP, Brazil.
Complete Peer review History: http://sciencedomain.org/review-history/13952

Original Research Article

Received 27th January 2016
Accepted 18th March 2016
Published 31st March 2016

ABSTRACT

A field experiment was established at the Botswana University of Agriculture and Natural Resources to evaluate the effects of organic fertilizer on yield and yield attributes of tomato from October 2014 to March 2015. The experiment was laid out in a randomised complete block design (RCBD) with four treatments being varying levels of organic fertilizer; 0 kg m^{-2}, 5 kg m^{-2}, 7.5 kg m^{-2} and 10 kg m^{-2} each replicated three times. The growth attributes measured were plant height, stem thickness, canopy diameter, number of leaves, fruits and fruit weight. Organic fertilizer application rates of 7.5 and 10 kg m^{-2} showed significantly (*P* = .05) taller plants from weeks 4 to 6 compared to other treatments. A highly significant difference in plant canopy was observed across the four application rates from weeks 1 to 5. Canopy spread was overall higher in the 10 kg m^{-2} application rate across all the weeks. A highly significant treatment effect was observed on leaf number with plants in the 10 kg m^{-2} application rate exhibiting the highest number of leaves. Stem thickness showed significance differences across treatments with the 10 kg m^{-2} application rate having thicker stems. A highly

**Corresponding author: E-mail: wmojeremane@yahoo.com;*

significant treatment effect was observed on number of harvested fruits with the 7.5 kg m^{-2} application rate showing higher yields between the first and fourth harvest and 10 kg m^{-2} application rate from fifth to sixth harvest. Organic fertilizer had a significant effect on fruit weight from first to third harvest with the 10 kg m^{-2} application rates having the heaviest tomato fruits. The 10 kg m^{-2} application rate outperformed the lower rates for most measured parameters. The organic fertilizer is recommended to small-scale vegetable growers because it is affordable and abundant in Botswana.

Keywords: Organic fertilizer; tomato; yield and yield attributes.

1. INTRODUCTION

Tomato (*Lycopersicon lycopersicum L.*) is an important and most popular versatile [1] and one of the leading commercial vegetable crop in the world [2,3]. It is also an important member of the nightshade family that are widely grown in many countries across the globe [2]. Tomato is a warm season fruit that is sensitive to cold [4] and can be grown both in the wet and dry seasons. In southern Africa the crop attracts higher profits during the dry season when the demand is higher than supply. Tomato has numerous health benefits which are attributed to its phytochemical constituents [5,6]. The red, edible fruit is an excellent source of nutrients and secondary metabolites (folate, potassium, vitamins C and E, flavonoids, chlorophyll, b-carotene and lycopene) that are important for human health [5]. The fruit contain lycopene, a carotenoid that helps in the prevention of cardiovascular diseases and certain cancers [6]. According to Giovannucci [7] and Giovannucci et al. [8] the dietary lycopene reduces incidence of cardiovascular disease and some cancers, notably prostate cancer.

Soil fertility plays an important role in the yield and quality of tomatoes [9]. Despite the importance of tomatoes to smallholder vegetable farmers, yields in Botswana are poor due to low soil fertility. Continuous cropping without organic/inorganic fertilizer inputs is common with smallholder vegetable producers in Botswana and elsewhere in the developing world [10]. This practice together with nutrient losses through harvest, soil erosion and leaching, contribute to declining soil fertility [11,12]. Commercial farmers have resources to purchase inorganic fertilizers to improve soil fertility [10] compared to smallholder farmers. However, continuous use of chemical fertilizers may cause soil deterioration [13,14], and reduce the nutritional value and quality of edible fruits [15]. They reduce the dry matter content of tomato fruits [16,17,18,19] in addition to making them more susceptible to disease and insect attacks [20].

Increasing costs associated with inorganic fertilizers drives smallholder farmers in Botswana and elsewhere to look for alternative sources such as organic manures that are sustainable to improve soil fertility. Organic fertilizers such as farmyard manure, sewage sludge, crop residues, industrial waste and compost improve soil fertility [21,22,23]. Their application increases soil organic matter content [24,25] and improves the physical, chemical and biological contents of soil [26,27]. The effect of organic fertilizer to plants is similar to that of inorganic fertilizers [28,29, 30,31,32,33,34] except that they release nutrients slowly [35] but can stay in the soil for longer periods. Organic fertilizers provide essential nutrients that improve crop growth and increase yield [36-38]. Organic fertilizers do not pollute the environment [37] which is beneficial to subsequent crops [36]. They suppress plant pest populations [22], control some crop diseases [39,40], prevent soil degradation and reduces the risk of water pollution [41]. They also increase the soil microbial biomass C, N, and P [42] by increasing the proportion of bacteria and decreasing the proportion of fungi [38]. There is very little information on the effect of organic fertilizers in the production of vegetables in Botswana. The present study was therefore carried out to evaluate the effect of different organic fertilizer application rates on the yield and yield attributes of tomato.

2. MATERIALS AND METHODS

2.1 Description of Study SITE

The field experiment was conducted from October 2014 to March 2015 at the Botswana University of Agriculture and Natural Resources (formerly Botswana College of Agriculture), Sebele. Sebele lies about 10 km from the centre of Gaborone City on latitude 24°34’S and longitude 25°57’E elevated at 994 m above sea level. The climate of Sebele is semi-arid [43]. Soils in the study site are predominantly sandy loams with low water holding capacity and pH of 6.3 [44,45].

2.2 Experimental Design, Treatments and Crop Establishment

The experiment followed a randomized complete block design (RCBD) with four treatments, each replicated three times. The four treatments were three different organic fertilizer application rates being 0, 5.0, 7.5 and 10.0 kg m^{-2} designated T_1, T_2, T_3 and T_4, respectively. The Organic Fertilizer [46] instruction manual recommends a general combined basal and top dressing application rate of 5 kg m^{-2} across vegetables and plants. The organic fertilizer is made from a mixture of animal droppings, food waste, bark, wood flour, maize husk and grass. Soil improving agent (microbes) mixed with water for about 20 minutes is sprayed on the prepared raw material. The pile is turned once every two weeks for 5 months to activate the bacteria. The temperature and moisture content is maintained at 40-75℃ and 50-60% respectively throughout the process. After 5 months, the product is subjected to high temperature in order to kill all the bacteria and weeds.

The site was cleared mechanically, ploughed and disked before marking and demarcating plots. Twelve plots each measuring 1.5 × 2.7 m and separated by a 0.5 m buffer were used. Plots were leveled using hand tools to provide a medium fine tilth suitable for the growth of the tomato crop after which the organic fertilizer was applied and mixed with soil per treatment requirement. Tomato seeds were sown on seedling trays on the 26 October 2014 and kept in a net shade for three weeks. On the 16 November 2014 vigorous seedlings were selected and transplanted into prepared plots. The inter-row spacing of 50 cm and intra-row spacing of 30 cm was used [47]. Twenty seven (27) tomato plants were planted in each plot.

2.3 Crop Management

Plots were regularly watered to keep the soil at field capacity. Weeds were removed manually whenever they appeared.

2.4 Determination of Plant Growth, Development and Yield Parameters

Ten seedlings were randomly selected and tagged from each plot for data collection throughout the study. Plant height and plant canopy diameter were measured weekly from week 1 to 6 after transplanting using a meter ruler. The number of leaves per plant was qualitatively measured for the same period by counting. The number of fruits harvested per plant was qualitatively measured from week 7 to 12 by counting. Ten tomato fruits were randomly harvested from each plot to measure their weight from week 7 to 9 using a bench top electronic balance model PGW 4502e. Stem thickness was measured approximately 2 cm above the soil at the end of study using a calibrated vernier caliper (150 mm).

2.5 Statistical Analysis

Collected data was subjected to analysis of variance (ANOVA) using the STATISTIX-8 program. Where a significant F-test was observed and means comparison tests were carried out using Least Significant Difference (LSD) at P = .05 to separate treatment means.

3. RESULTS AND DISCUSSION

3.1 Plant Height

There was no significant difference in plant height across treatments from week 1 to 3 (Table 1). This observation is not surprising because organic fertilizers release nutrients slowly [35,48] because they require microbes to convert them into inorganic forms available to plants [49]. There were significant differences (P = .05) in plant height across treatments from week 4 to 6. In week 4, T_4 had the tallest plants (28.92 cm) that were not significantly different from T_3 (27.01 cm) and the same trend was observed in week 5 and 6 (Table 1). Results in Table 1 show that T_3 and T_4 had significantly taller plants compared to T_1 and T_2 between weeks 5 and 6. This result is similar to results observed in other plants elsewhere, where plant height was found to increase with increasing organic fertilizer [5051, 52,53,54,55,56,57]. According to Ng'etich et al. [57] farm yard manure application rates of 11.5 and 15 t ha^{-1} significantly increased plant height in *Solanum scabrum* Mill. Agbo et al. [54] found that 30 t ha^{-1} of manure increased plant height compared to 0 and 10 t ha^{-1} in *Solanum melongena* L. The organic fertilizer used in the present study increased plant height probably by improving the physio-chemical properties of the soil [24,58,59].

3.2 Stem Thickness

Plant stem thickness was significantly ($P < .001$) influenced by different organic fertilizer application rates. The rates produced plants with thicker stems compared to the control (Table 2). However, stems of plants treated with the higher rate of organic fertilizer (T_4) were slightly thicker compared to T_2 and T_3. Stem thickness increased with increasing organic fertilizer amendments. This is in agreement with Hou et al. [56] who observed that different organic fertilizer rates increased tomato plant stem thickness. In a study conducted by Agbo et al. [54] farmyard manure applied at 30 t ha^{-1} produced *Solanum melongena* plants with thicker stems than 10 t ha^{-1}. Improvements in stem thickness observed in plants treated with organic fertilizer in the present study could probably be attributed to increased nitrogen, phosphorus and potassium [60] associated with organic fertilizers [61].

3.3 Plant Canopy Diameter

Results in Table 2 indicate that treatment effect was highly significant. However, there was no significant difference in plant canopy spread between T_1 and T_2 throughout the 6 weeks. Similarly, plants grown in T_2 and T_3 were not significantly different from week 1 to 3. However, from week 4 to 6, the canopy diameter of T_3 plants was significantly wider when compared to T_2 plants. No significant differences were observed in plant canopy diameter between T_3 and T_4 plants throughout the 6 weeks (Table 2). The canopy diameter of T_4 plants was consistently wider compared to T_1 and T_2 plants. These results demonstrate that the higher organic fertilizer amendment encouraged the uppermost lateral growth of the tomato plant. The observed plant canopy spread in T_3 and T_4 was probably enhanced by improved plant nutrients in the soil [62,63,6465] that stimulated photosynthesis. The higher organic fertilizer amendment can be used by smallholder vegetable producers to restore soil fertility [66,67] and increase productivity because they are rich in nitrogen (N), phosphorous (P) and potassium (K) [61].

3.4 Leaf Number

There were significant differences in the number of plant leaves across treatments from week 1 to 6 (Table 3). The number of plant leaves in T_1 was significantly lower compared to other treatments throughout the study. There were no significant differences in the number of plant leaves between T_2 and T_3 from week 1 to 3. Plants grown in T_4 produced significantly more leaves compared to T_1 and T_2 throughout the study. However no significant difference was observed between T_3 and T_4. These results show that the number of plant leaves increased with increasing organic fertilizer application. This is in agreement with [68,69] who reported that plant leaves increased with increasing organic manure application. According to Mohapatha and Das [70] and Dinesh et al. [71] organic manure enhances plant vegetative growth and biomass production in crops and stimulate photosynthesis because it increases carbon, nitrogen, pH, cation exchange capacity and exchangeable Ca, Mg and K [72].

Table 1. The effect of organic fertilizer on plant height (cm)

Treatments	Plant height (weeks after transplanting)					
	1	2	3	4	5	6
T_1	5.27	7.27	10.11	16.47^{c}	31.81^{b}	64.32^{b}
T_2	7.37	9.34	12.70	20.31^{bc}	38.52^{b}	68.84^{b}
T_3	9.53	11.96	15.71	27.01^{ab}	55.89^{a}	111.79^{a}
T_4	11.52	14.26	17.60	28.92^{a}	59.26^{a}	119.63^{a}
Significance	ns	ns	ns	*	*	*
LSD 0.05	ns	ns	ns	8.36	16.36	37.17
CV (%)	30.66	26.56	22.01	18.04	17.66	20.41

* Significant at $P = .05$, ^{ns} non-significant at $P > .05$. Means separated by Least Significance Difference (LSD) Test at $P = .05$. Means within columns followed by the same letters are not significantly different. Where T_1, T_2, T_3 and T_4 are application rates of 0 (control), 5.0, 7.5 and 10.0 kg m^{-2} respectively and week 1 to week 6 are dates from 15-12-14 to 19-01-15 respectively

Table 2. Mean tomato canopy diameter (cm) and stem thickness (mm) as influenced by organic fertilizer

Treatments	Weeks after transplanting						
	Canopy diameter						Stem thickness
	1	2	3	4	5	6	12
T_1	7.48^c	10.50^c	14.89^c	21.07^b	33.84^b	48.43^b	28.90^b
T_2	8.84^{bc}	12.96^{bc}	20.12^{bc}	26.54^b	43.74^b	63.53^b	40.00^a
T_3	10.31^{ab}	15.90^{ab}	25.77^{ab}	36.62^a	63.37^a	92.64^a	47.50^a
T_4	10.77^a	16.83^a	27.62^a	39.92^a	69.84^a	100.70^a	49.20^a
Significance	**	**	**	**	**	**	**
LSD 0.05	1.73	3.19	6.02	9.19	17.54	15.54	10.51
CV (%)	9.27	11.35	14.06	14.82	16.66	26.24	12.71

*** Highly significant at P < .001, means separated by Least Significance Difference (LSD) test at P = .05. Means within columns followed by the same letters are not significantly different. Where T_1, T_2, T_3 and T_4 are application rates of 0 (control), 5.0, 7.5 and 10.0 kg m^{-2} respectively and, week 1 to week 6 are dates from 15-12-14 to 19-01-15 respectively and week 12 is 02-03-15*

Table 3. The effect of organic fertilizer on tomato leaf number

Treatments	Leaf number (weeks after transplanting)					
	1	2	3	4	5	6
T_1	3.13^c	5.50^c	13.63^c	15.77^c	31.47^c	62.93^c
T_2	4.53^b	8.57^b	16.93^b	21.63^b	42.83^b	85.67^b
T_3	5.00^{ab}	9.90^{ab}	19.67^{ab}	28.20^a	56.07^a	112.13^a
T_4	6.10^a	11.77^a	23.10^a	31.67^a	62.47^a	124.93^a
Significance	**	**	*	**	**	**
LSD 0.05	1.28	2.43	5.96	5.57	10.64	21.28
CV (%)	13.68	13.60	16.26	11.47	11.04	11.04

***Highly significant at P < .001, *significant at P = .05. Means within columns followed by the same letter are not significantly different. Where T_1, T_2, T_3 and T_4 are application rates of 0 (control), 5.0, 7.5 and 10.0 kg m^{-2} respectively and week 1 to week 6 are dates from 15-12-14 to 19-01-15 respectively*

3.5 Fruit Number

Table 4 shows that fruit harvesting started seven weeks after transplanting. The results show that the effect of organic fertilizer application rates on tomato fruit number was highly significant across the treatments from week 7 to 12. More fruits were harvested per plant from T_3 in week 7. However, this was at par with T_4, but significantly higher compared to T_1 and T_2. A similar trend was observed in week 8 and 9. T_1 had significantly the lowest number of fruits harvested per plant compared to other treatments throughout the harvesting period. No significant difference was observed in the number of fruits harvested per plant across the organic fertilizer amended treatments in week 10. Furthermore, these results show that T_4 plants produced significantly more fruits compared to other treatments in week 11 and 12. The higher number of fruits produced by organic fertilizer amended plants could be attributed to improved soil physical, biological contents and nutrient availability [73,74,75]. The findings are supported by results of studies conducted elsewhere [22,28,29,31,32,33,69,76] which reported increased crop yield in soils amended with organic fertilizers.

3.6 Fruit Weight

Fruit weights recorded for three consecutive harvests are shown in Table 5. Across treatments, weights from the first harvest (week 7) were highly significant. Generally, plants from organic amended soil produced significantly heavier fruits compared to the control (T_1). However, T_4 had significantly heavier fruits compared to T_2 and T_3. There were no significant differences in fruit weight among T_2, T_3 and T_4 plants in week 8. However T_4 fruits were significantly heavier compared to the control (T_1). In week 9, there was no significant difference in fruit weights between T_1 and T_2, T_2 and T_3, and T_3 and T_4 plants. However, T_4 fruits were significantly heavier compared to T_1. Several studies demonstrated that organic fertilizers improve soil fertility and productivity, thus enhance crop yield and quality [51,71,70] which could have occurred in this study.

Table 4. Mean tomato fruit number as influenced by organic fertilizer

Treatments	Fruit number (weeks after transplanting)					
	7	8	9	10	11	12
T_1	0.33[c]	3.67[c]	16.33[c]	17.00[b]	12.67[c]	15.67[c]
T_2	9.00[b]	27.67[b]	45.33[b]	53.67[a]	47.67[b]	54.00[b]
T_3	18.33[a]	54.67[a]	66.67[a]	69.00[a]	60.67[b]	75.00[b]
T_4	13.67[ab]	23.33[b]	58.00[ab]	68.00[a]	95.67[a]	116.67[a]
Significance	**	**	**	**	**	**
LSD 0.05	7.17	15.26	17.05	18.06	27.58	39.19
CV (%)	34.74	27.94	18.32	17.42	25.49	30.02

[**]Highly significant at P < .001. Means within columns followed by the same letter are not significantly different. OF is organic fertilizer. Where T_1, T_2, T_3 and T_4 are application rates of 0 (control), 5.0, 7.5 and 10.0 kg m^{-2} respectively and week 7 to week 12 are dates from 26-01-15 to 02-03-15 respectively

Table 5. The effect of organic fertilizer on tomato fruit weight (g)

Treatments	Fruit weight (weeks after transplanting)		
	Week 7	Week 8	Week 9
T_1	31.56[c]	40.68[b]	47.74[c]
T_2	44.93[b]	54.65[ab]	57.51[bc]
T_3	44.80[b]	51.23[ab]	65.44[ab]
T_4	62.46[a]	66.47[a]	71.09[a]
Significance	**	*	*
LSD 0.05	11.89	16.44	13.28
CV (%)	12.96	15.45	11.00

[**]Highly significant at P < .001, [*]significant at P = .05. Means within columns followed by the same letter are not significantly different. Where T_1, T_2, T_3 and T_4 are application rates of 0 (control), 5.0, 7.5 and 10.0 kg m^{-2} respectively and week 7 to week 9 are dates from 26-01-15 to 09-02-15 respectively

4. CONCLUSION

Measured productive parameters performances increased with increase in application rate of organic fertilizer with the highest application rate 10 kg m^{-2} outperforming the rest. The use of organic fertilizer is therefore recommended to smallholder farmers because its components are readily available to most farmers in Botswana.

ACKNOWLEDGEMENTS

We are grateful to the Ministry of Education and Skills Development for providing a small research grant to Ofentse Moseki. We thank the University for providing the resources.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kochakinezhad H, Peyvast Gh, Kashi AK, Olfati JA, Asadii A. Fertilizers for tomato production. Journal of Organic Systems. 2012;7(2):14-25.
2. Sharma VK, Singh T. Productivity under polyhouse conditions in temperate areas. Journal of Agriculture and Crops. 2015;1(6):68-74.
3. Isack ME, Lyimo M. Effect of postharvest handling practices on physicochemical composition of tomato. International Journal of Vegetable Science. 2015;21(2):118-127.
4. Afshari M, Afsharmanesh GhR, Yousef K. The effect of enriched organic fertilizer and Methanol Spray on the greenhouse-tomato yield. Journal of Agricultural Science. 2014;6(11):14-20.
5. Wilcox JK, Catignani GL, Lazarus C. Tomatoes and cardiovascular health. Critical Reviews in Food Science and Nutrition. 2003;43(1):1-18.
6. Perkins-Veazie P, Roberts W, Collins JK. Lycopene content among organically produced tomatoes. Journal of Vegetable Science. 2006;12(4):93-106.
7. Giovannucci E. Tomatoes, tomato-based products, lycopene, and prostate cancer: Review of the epidemiologic literature. Journal of National Cancer Institute. 1999;4(91):317-331.

8. Giovannucci E, Rimm EB, Liu Y, Stampfer MJ, Willett WC. A prospective study of tomato products, lycopene, and prostate cancer risk. Journal of National Cancer Institute. 2002;94(5):391-398.
9. Murmu K, Ghosh BC, Swain DK. Yield and quality of tomato grown under organic and conventional nutrient management. Archives of Agronomy and Soil Science. 2013;59(10):1311-1321.
10. Mojeremane W, Motladi M, Mathowa T, Legwaila GM. Effect of different application rates of organic fertilizer on growth, development and yield of rape (*Brassica napus* L.). International Journal of Innovative Research in Science, Engineering and Technology. 2015;4(12):11680-11688.
11. Stoorvogel JJ, Smaling EMA, Janssen BH. Calculating soil nutrient balances in Africa at different scales. Supranational scale. Fertilizer Research. 1993;35:227-235.
12. Cooper PJM, Leakey RRB, Rao MR, Reynolds L. Agroforestry and the mitigation of land degradation in the humid and sub-humid tropics of Africa. Experimental Agriculture. 1996;32(3):235-290.
13. Doran JW, Sarrantonio M, Liebig MA. Soil health and sustainability. Advances in Agronomy. 1996;56:42-45.
14. Adediran JA, Taiwo LB, Akande MO, Sobulo RA, Idowu OJ. Application of organic and inorganic fertilizer for sustainable maize and cowpea yields in Nigeria. Journal of Plant Nutrition. 2004;27(7):1167-1181.
15. Shimbo S, Watanabe T, Zhang ZW, Ikeda M. Cadmium and lead contents in rice and other cereal products in Japan in 1998-2000. Science of the Total Environment. 2001;281(1):165-175.
16. Alvarez CE, Garcia C, Carracedo AE. Soil fertility and mineral nutrition of organic banana plantation in Tenerife. Biological Agriculture and Horticulture.1988;5(4):313-323.
17. Reganold JP. Comparison of soil properties as influenced by organic and conventional farming systems. American Journal of Alternative Agriculture. 1988;3:144-155.
18. Drinkwater LE, Letourneau DK, Workneh F, Bruggen AHC, Shennan C. Fundamental difference between conventional and organic tomato agroecosystems in California. Ecological Applications.1995;5(4):1098-1112.
19. Marzouk HA, Kassem HA. Improving fruit quality, nutritional value and yield of Zaghloul dates by the application of organic and/or mineral fertilizers. Scientia Horticulturae. 2011;127:249-254.
20. Karungi J, Ekbom B, Kyamanywa S. Effects of organic versus conventional fertilizers on insect pests, natural enemies and yield of *Phaseolus vulgaris*. Agriculture, Ecosystems and Environment. 2006;115:51-55.
21. Sarhan TZ, Mohammed GH, Teli JA. Effect of bio and organic fertilizers on the growth and quality of summer squash. Sarhad Journal of Agriculture. 2011;27(3):377-383.
22. Yanar D, Gebologlu N, Yanar Y, Aydin M, Cakmak P. Effect of different organic fertilizers on yield and fruit quality of ındeterminate tomato *(Lycopersicon esculentum).* Scientific Research Essays. 2011;6(17):3623-3628.
23. Mbatha AN, Ceronio GM, Coetzer GM. Response of carrot (*Daucus carota* L.) yield and quality to organic fertiliser. South African Journal of Plant and Soil. 2014;31(1-2)1-6.
24. Debosz K, Petersen SO, Kure KL, Ambus P. Evaluating effects of sewage sludge and household compost on soil physical, chemical and microbiological properties. Applied Soil Ecology. 2002;19:237-248.
25. Lal R. Challenges and opportunities in soil organic matter research. European Journal of Soil Science. 2009;60(2):158-169.
26. Santos I, Bettiol W. Effect of sewage sludge on the rot and seedling damping-off of bean plants caused by *Sclerotium rolfsii*. Crop Protection. 2003;22(9):1093-1097.
27. Eghball B, Power JF. Phosphorus and nitrogen-based manure and compost applications: Corn production and soil phosphorus. Soil Science Society of America Journal. 1999;63(4):895-901.
28. Hoitink HAJ, Boehn MJ. Biocontrol within the context of soil microbial communities: A substrate dependent phenomenon. Annual Review of Phytopathology. 1999;37:427-446.
29. Bulluck LR, Ristaino JB. Effect of synthetic and organic soil fertility amendments on southern blight, soil microbial communities, and yield of processing tomatoes. Phytopathology. 2002;92:181-189.
30. Martini EA, Buyer JS, Bryant DC, Hartz TK, Denison RF. Yield increases during

the organic transition: Improving soil quality or increasing experience? Field Crops Research. 2004;86:255-266.
31. Heeb A, Lundegardh B, Ericsson T, Savage GP. Effects of nitrate- ammonium- and organic-nitrogen-based fertilizers on growth and yield of tomatoes. Journal of Plant Nutrition and Soil Science. 2005a;168(1):123-129.
32. Heeb A, Lundegardh B, Ericsson T, Savage GP. Nitrogen form affects yield and taste of tomatoes. Journal of the Science of Food and Agriculture. 2005b;85:1405-1414.
33. Heeb A, Lundegardh B, Savage GP, Ericsson T. Impact of organic and inorganic fertilizers on yield, taste, and nutritional quality of tomatoes. Journal of Plant Nutrition and Soil Science. 2006;169:535-541.
34. Toor RK, Savage GP, Heeb A. Influence of different types of fertilizers on the major antioxidant components of tomatoes. Journal of Food Composition and Analysis. 2006;19(1):20-27.
35. Bi G, Evans WB, Spiers JM, Witcher AL. Effects of organic and inorganic fertilizers on marigold growth and flowering. HortScience. 2010;45(9):1373-1377.
36. Ghosh PK, Ajay KK, Bandyopadhyay MC, Manna KG, Mandal AK, Hati KM. Comparative effectiveness of cattle manure, poultry manure, phospho-compost and fertilizer-NPK on three cropping system in vertisols of semi-arid tropics. II. Dry matter yield, nodulation, chlorophyll content andenzymeactivity. Bioresource Technology. 2004;95:85-93.
37. El sayed AA, Mansure MA. Response of basil (*Ocimum basilicum* L.) to different chemical and organic fertilization treatments. Journal of Agriculture Science. 2002;20:401-1418.
38. Hou Y, Li Y, Song X, Yang J. Effect of organic fertilizers used in washed soil on the growth of tomatoes. Advanced Materials Research. 2014;1010-1012:576-579.
39. DeCeuster TJJ, Hoitink HAJ. Using compost to control plant diseases. BioCycle. 1999;40:61-63.
40. Viana FMP, Kobory RF, Bettiol W, Athayde SC. Control of damping-off in bean plant caused by *Sclerotinia sclerotiorum* by the incorporation of organic matter in the substrate. Summa Phytopathology. 2000;26(1):94-97.
41. Swift RS. Sequestration of carbon by soils. Soil Science. 2001;166:858-871.
42. Jannoura R, Joergensen RG, Bruns C. Organic fertilizer effects on growth, crop yield, and soil microbial biomass indices in sole and intercropped peas and oats under organic farming conditions. European Journal of Agronomy. 2014;52:259-270.
43. Legwaila GM, Marokane TK, Mojeremane W. Effects of intercropping on the performance of maize and cowpeas in Botswana. International Journal of Agriculture and Forestry. 2012;2(6):307-310.
44. Legwaila GM, Mathowa T, Makopola P, Mpofu C, Mojeremane W. The growth and development of two pearl millet landraces as affected by intra-row spacing. International Journal of Current Microbiology and Applied Sciences. 2014;3(9):505-515.
45. Madisa ME, Mathowa T, Mpofu C, Oganne TA. Effects of Plant Spacing on the Growth, Yield and Yield Components of Okra (*Abelmoschus esculentus* L.) in Botswana. American Journal of Experimental Agriculture. 2015;6(1):7-14.
46. Organic Fertilizer. Instruction manual-super 1 (Suitable for vegetable and plants). Gaborone, Botswana; 2014.
47. Bok I, Madisa M, Machacha D, Moamogwe M, More K. Manual for vegetable production in Botswana. Horticulture Research Program, Ministry of Agriculture, Gaborone, Botswana; 2006.
48. Naguib NYM. Organic vs chemical fertilization of medicinal plants: A concise review of researches. Advances in Environmental Biology. 2011;5(2):394-400.
49. Gaskell M, Smith R. Nitrogen sources for organic vegetable crops. Hort Technology. 2007;17(4):431-441.
50. Caturano E, Roccuzzo G, Canali S, Adamo S, Giuffrida F, Leonardi C. Organic vegetable production in Southern Italy: Soil fertility management and fertilization strategies. Proceedings of the 2nd Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR). 2008;1:228-231.
51. Berova M, Karanatsidis G, Sapundzhieva K, Nikolova V. Effect of organic fertilization on growth and yield of pepper plants (*Capsicum annuum* L.). Folia Horticulturae. 2010;22(1):3-7.
52. Ondieki MJ, Aguyoh JN, Opiyo M. Fortified compost manure improves yield and

growth of African nightshades. International Journal of Science and Nature. 2011;2(2):231-237.
53. Siavoshi M, Nasiri A, Laware SL. Effect of organic fertilizer on growth and yield components in rice (*Oryza sativa* L.). Journal of Agriculture Science. 2011;3(3):217-224.
54. Agbo CU, Chukwudi PU, Ogbu AN. Effects of rates and frequency of application of organic manure on growth, yield and biochemical composition of *Solanum melongena* L. (cv. 'Ngwa local') fruits. Journal of Animal and Plant Science. 2012;14(2):1952-1960.
55. Uko AE, Udo IA, Shiyam JO. Effects of poultry manure and plant spacing on the growth and yield of waterleaf (*Talinum fruticosum* (L.) Juss). Journal of Agronomy. 2013;12(3):146-152.
56. Hou Y, Hu X, Yan W, Zhang S, Niu L. Effect of organic fertilizers used in sandy soil on the growth of tomatoes. Agriculture Science. 2013;4(5B):31-34.
57. Ng'etich OK, Aguyoh JN, Ogweno JO. The Effect of integrated application of farmyard manure and calcium ammonium nitrate on growth and yield attributes of African nightshade (*Solanum scabrum* Mill.). Asian Journal of Agriculture and Food Science. 2014;2(2):158-65.
58. Zheljazkov VD, Warman PR. Source-separated municipal solid waste compost application to Swiss chard and basil. Journal of Environmental Quality. 2004; 33:542-552.
59. Zhang GY, Ran W, Zhang LP, Huang QW, Wie MF, Fan QL, Liu Z, Shen QR, Xu GH. Effect of *Glomus mosseae* on maize growth at different organic fertilizer application rates. Journal of Plant Nutrition. 2012;35(2):165-175.
60. Reyhan MK, Amiraslani F. Studying the relationship between vegetation and physico-chemical properties of soil, case study: Tabas Region, Iran. Pakistan Journal of Nutrition. 2006;5(2):169-171.
61. Elliot HA, Dempsey BA. Agronomic effects of land application of water treatment sludges. Journal of American Waste Water Association. 1991;83(4):126-131.
62. Atiyeh RM, Arancon NQ, Edwards CA, Metzger JD. Influence of earthworm processed pig manure on the growth and yield of greenhouse tomatoes. Bioresource Technology. 2000;75(3):175-180.
63. Hashemimajd K, Kalbasi M, Golchin A, Shariatmadari H. Comparison of vermicompost and composts as potting media for growth of tomatoes. Journal of Plant Nutrition. 2004;27(6):1107-1123.
64. Abafita R, Shimbir T, Kebede T. Effects of different rates of vermicompost as potting media on growth and yield of tomato (*Solanum lycopersicum* L.) and soil fertility enhancement. Sky Journal of Soil Science and Environmental Management. 2014;3(7):73-77.
65. Garhwal PK, Yadav PC, Sharma BD, Singh RS, Ramniw, AS. Effect of organic manure and nitrogen on growth yield and quality of kinnow mandarin in sandy soils of hot arid region. African Journal of Agricultural Research. 2014;9(34):2638-2647.
66. Krogman U, Boyles LS, Martel CJ, McComas KA. Biosolids and sludge management. Water Environment Research. 1997;69(4):534-549.
67. Benton MW, Wester DB. Biosolids effects on tobosograss and alkali sacatonin a Chihuahuan desert grassland. Journal of Environmental Quality. 1998;27(1):199-208.
68. Hasanuzzaman M, Ahamed KU, Khalequzzaman KM, Shamsuzzaman AMM, Nahar K. Plant characteristics, growth and leaf yield of *Aloe vera* as affected by organic manure in pot culture. Australian Journal of Crop Science. 2008;2(3):158-163.
69. Abolusoro SA, Abolusoro PF. Effects of organic manure types on the growth, yield as well as root and soil populations of root-knot nematodes (*Meloidogyne incognita)* of tomato. Agricultural Advances. 2012; 1(5):138-144.
70. Mohapatra SC, Das, TK. Integrated effect of bio-fertilizers and organic manure on turmeric (*Curcuma longa* L.). Environmental Ecology. 2009;27(3A):1444-1445.
71. Dinesh R, Srinivasan V, Hamja S, Mahjusha A. Short term incorporation of organic manures and fertilizers influences biochemical and microbial characteristics of soil under an annual crop turmeric. Bioresource Technology. 2010; 101(12):4697-4702.
72. Ayoola OT, Makinde EA. Performance of green maize and soil nutrient changes with fortified cow dung. African Journal of Plant Science. 2008;2(3):19-22.

73. Stephenson AH, McCaskey TA, Ruffin BG. A survey of broiler litter composition and potential value as a nutrient resource. Biological Wastes. 34(1):1-9.
74. Abou El-Magd MM, Hoda AM, Fawzy FZ. Relationship growth, yield of Broccoli with increasing N, P or K ratio in a mixture of NPK fertilizers (*Brassica oleracea* var. italica plenck). Annals Agricultural Science Moshtohor. 2005;43(2):791-805.
75. Gutiérrez-Miceli FA, Santiago-Borraz J, Molina JAM, Nafate CC, Abud-Archila M, Llaven, MAO, Rincon-Rosales R, Dendooven L. Vermicompost as a soil supplement to improve growth, yield and fruit quality of tomato (*Lycopersicon esculentum*). Bioresource Technology. 2007;98(15):2781-2786.
76. Atiyeh RM, Lee S, Edwards CA, Arancon NQ, Metzger JD. Influence of humic acids from earthworm-processed organic wastes on plant growth. Bioresource Technology. 2002;84(1):7-14.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/13952