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Effects of Organic Enriched Basal Fertilizer on Productivity of Tomatoes (Lycopersicon esculentum) in Smallholder Farming of Hurungwe District in Zimbabwe

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Abstract
A field experiment was carried out in Hurungwe district to determine the effects of organic enriched basal fertilizer (Compound C) on productivity of tomato *(Lycopersicon esculentum)*. The experiment was laid out using a Randomized Complete Block Design (RCBD) with three treatments and three replicates. There were three blocks and the blocking factor was slope. The treatments comprise of (Compound C) organic enriched fertilizer, (Compound C) chemical/inorganic enriched fertilizer and a control were no basal fertilizer was applied. Parameters evaluated include days to flowering and physiological maturity of tomatoes, number of fruits per plant, yield per hectare, shelf life of the produce and finally marketable yield. The data was analyzed using SPSS 17 and T-tests were used to compare the means. The results showed that there was a significant difference ($P<0.05$) in yield and shelf life from organic enriched fertilizer in comparison to chemical fertilizer. However chemical fertilizer recorded the highest yield of 37.3t ha^{-1}, whilst organic fertilizer recorded the highest number (9.2) of days before perishability of tomatoes. Treatments with no fertilizer recorded the lowest yield of 12.9t ha^{-1}, but there was no significant difference ($P=0.068$) in shelf life between no fertilizer and chemical treatments. There was also a significant difference ($P<0.05$) in days to 50% flowering, number of fruits per plant and marketable yield of tomatoes across the three treatments. From the results of the study, it can be concluded that organic enriched fertilizer can also be used for tomato production as there was a significant increase in yield and shelf life of tomatoes and hence are suitable for long distance markets. It can therefore be recommended that further research should be conducted to investigate the optimum rates of application of organic enriched fertilizer that produce higher yields than inorganic fertilizers.
Key words: organic enriched, productivity, tomatoes

1.0 Introduction

Tomato is one of the important vegetables acting as the best income generating crops in Zimbabwe accounting for 10% of the gross domestic product (GDP) (FAO, 2011). Commercially it is equally of great importance, from processing to fresh market and from beefsteak to grape tomatoes (Zahedi et al., 2012). The variety and usefulness of the fruit is virtually boundless. Most grandmothers as well as some parents are sending their grandchildren to school with income from tomato produce in their small gardens and they are also earning a living from the nutritional gardens introduced in communal areas for the most disadvantaged families by many non-governmental organisations (NGOs) like Lead Trust and Goal (Community Technology Development Association (CTDA), 2012).

Tomato is a significant nutritional source of lycopene, which is a powerful antioxidant that acts as an anti-carcinogen and provides vitamins and minerals (Clinton, 1988; Bhowmik et al., 2012). One medium ripe tomato (145g) can provide up to 40% of the recommended daily allowance of vitamin C and 20% of vitamin A. It also contributes B vitamins, potassium, iron and calcium to the diet and also reduces risk of heart diseases, lower cholesterol and neutralizes free radicals (Spooner, 2007).

The fruit has now become a staple item of the kitchen throughout the world and has largest impact as Zimbabweans enjoyed over 1.8 million tonnes of tomatoes each year (CTDA, 2012). Both determinate and indeterminate varieties are grown in the country but the most commercial varieties are determinate while smallholder farmers' varieties are indeterminate (Dobson *et al*., 2001). These determinate types have a defined period of flowering and fruit development. Greenhouse tomatoes are indeterminate which means that they produce flowers and fruit throughout the life of the plant (Feldman, 1975). Tomato is considered a tender warm season crop (Navazio, 2012), but is actually a perennial plant although it is cultivated as annual in Zimbabwe (Wright, 2001). Tomatoes are best grown in well drained fertile sandy loamy soils with a pH range of 5.0-6.5 (Asiegbu and Uzo, 1983) and are sensitive to frost (Whitmore, 2000). Most cultivated tomatoes require 75days from transplanting to first harvest (Dias *et al*. 2006a) and can be harvested for several weeks before production declines. High or low temperatures have negative effects on fruit set and quality. Tomatoes are self-pollinating plants and are effectively pollinated by wind currents (Agritex farm management handbook, 2011).

In Zimbabwe the major limiting factor to high productivity is high cost of chemical fertilizers among other contributing factors such as lack of adequate technical know-how (AGRITEX, 2010). Some farmers, especially small scale and communal farmers tend to spread the little fertilizers they have on large areas or do cropping without any fertilization due to lack of finance and high purchasing costs (AGRITEX, 2012). The use of inorganic fertilizers started long back in history and is known to produce good results and it was promoted by industrialization which caused complete eradication of organic manures. As a result of high costs and environmental hazards posed by use of inorganic fertilizers (Hussein, 2000) there is mass campaign of launching back to use of our crop culture to organic world since many trials done using different sources of tomato nutrition can sustain tomato production with similar results to inorganically fertilized crops (Gardener, 1968).

Organic enriched blends are now produced by one of the agrochemical companies in Zimbabwe with the aim of combating negative effects of chemical fertilizers such as soil acidity and at the same time providing adequate crop nutrition at affordable cheaper prizes to poor resource farmers (Nico-orgo, 2013). Many blends have been produced for major field crops like maize, cotton and tobacco. The organic enriched blend for tobacco also caters for horticultural crops including tomatoes. In Hurungwe these blends were introduced to farmers in the 2012-2013 season yielding different positive and negative results according to farmers' perceptions. The research was aimed at investigating effect of organic enriched fertilizer with same chemical composition to inorganic Compound C as a basal fertilizer on tomato productivity.

Farmers in Hurungwe district have been growing tomatoes for many years but realizing low yields of about 12-15t/ha. Smallholder farmers used to grow the crop without use of any fertilizers due to lack of income or use kraal and poultry manures as a substitute with unknown chemical composition, which require bulk applications (25-50tonnes/ha) and sometimes are unavailable due to the unavailability of livestock (Gardener, 1968). Organic enriched fertilizers are cheaper and are applied at a recommended rate of 600kg/ha while inorganic chemical fertilizers are more expensive and they are applied at a recommended rate of 1000-1500kg/ha depending on the soil condition (ZFC, 2013). The organic enriched fertilizers have thus the potential of offering nutritional benefits (Masarirambi, 2010), reduce the escalating effects of diseases, boost immunity and increase farm income (Vernon, 1999).

2.0 Materials and methods

The study was carried out in ward five of Hurungwe District in Mashonaland West Province. The area falls under the agro-ecological region 2a characterized by mean annual rainfall of 750-1000mm per annum and temperatures of 15-29^{0}C. Frost occurrence is common in June and July in the low lying areas and the area is cool with occasional steady winds. Sunshine hours range from 6.0-9.5 and high humidity occurrence is prevalent in February and low in October (Surveyor General, 1995). The altitude of the study area is at 1200m above sea level and the area has a savanna type of woodland. The soils are pale brownish loamy sands with a pH of 6.0 (Surveyor General, 1995).

2.1 Research design

The trial was carried out in a Randomized Complete Block Design (RCBD) with three treatments and three replicates. The area was divided into 3 blocks along the gradient with gradient as the blocking factor and the plots were divided at right angles to the gradient, so that the plots within each block experience the same fertility. The experimental plots were 27 in total and each block has a total of 9 experimental plots, and treatments were allocated according to a different set of random numbers. The treatments composed of organic enriched compound C fertilizer, inorganic compound C (chemical) fertilizer for basal dressing and lastly the control where no fertilizer was applied.

2.2 Land preparation

The land was cultivated to a fine seedbed. After preparing beds and planting stations basal dressing was done per planting station at a rate of 1250kg/ha using inorganic compound C chemical fertilizer and 600kg/ha using compound C organic enriched fertilizer and slightly closed with soil to avoid fertilizer burn to the crop.

2.3 Transplanting

The Rodade tomato (*Lycopersicon esculentum Mill*) variety was raised for six weeks on the seedbed and then transplanted at a spacing of 90cmx30cm. Seedlings measuring between 15 and 25cm tall were transplanted after the hardening process. Watering of plants was conducted two hours before transplanting for easy pulling and the seedbeds were watered to field capacity to link with residual moisture 6 hours before transplanting. Actual transplanting was carried out in the late afternoon to avoid transplanting stress (Mayana and Musiiwa, 1999).

Watering was carried out twice per week and removal of weeds was carried out mechanically whenever weeds were prevalent. Use of hoes was carried out to improve soil aeration and drainage a month after transplanting.

Trellising was carried out before flowering of tomatoes with plain wire and debarked poles at ends of experimental plots to facilitate high proportions of marketable fruits and reduce sunburn and rotting. Removal of side shoots was also carried out a week after start of flowering to encourage high rate of fruiting at the expense of vegetative phase and application of fungicidal spray of copper oxychloride was done as a preventive spray (Mukwirimba, 2000). Routine sprays of copper-oxchloride and rogor (dimethoate) were carried out for the pests and diseases identified respectively. Top dressing was done using ammonium nitrate (NH_3NO_4) at a rate of 100kg/ha at first flowering.

2.4 Data collection and analysis

Number of days to germination, flowering and physiological maturity of tomatoes were recorded. After harvesting, weight of produce was carried out using a graduated scale and recorded. This was done separately for each treatment and replicate. The marketable yield and days before perishability from different treatments was recorded as well. A sample of hundred tomatoes fruits was taken per treatment from the net plot and kept at room temperature and number of days before perishability was recorded. The percentage marketable yield after harvesting and grading was used as a measure of produce quality per treatment as it is a qualitative measure rather than quantitative one.

The data was also subjected to a two factor ANOVA with replication using SPSS 17. The two factors which were considered are treatments and blocks. Statistically pair wise comparisons carried using a T-test when significant differences appeared in the ANOVA.

3.0 Results

3.1 Effects of fertilizer treatment on days to 50% flowering of tomatoes

There was a significant difference ($P<0.05$) in days to 50% flowering of tomatoes. However highest number of days to flowering of (81) were obtained in organic fertilizer, while chemical fertilizer took (78.6) days. The lowest number of days to flowering of (74.6) was obtained in unfertilized treatment (Table 1). The pair-wise comparison of days to 50% flowering of tomatoes between organic and chemical treatments showed a significant difference in number of days to 50% flowering across the three treatments.

3.2 Effects of fertilizer treatment on number of fruits per plant

The pairwise comparison across the three treatments showed a significant difference ($P=0.000$) in number of fruits per plant. However highest number (17) of fruits were obtained in chemical fertilizer, while organic fertilizer recorded (13) fruits per plant. The lowest number (8) of fruits per plant was obtained in unfertilized treatment (Table 1).

3.3 Effects of fertilizer treatment on days to physiological maturity of tomatoes

The pairwise comparisons showed a significant difference ($P=0.000$) in number of days to physiological maturity of tomatoes across all the three treatments. However organic fertilizer recorded the highest number of days to physiological maturity of (129.6), while chemical recorded (128.3) days. The lowest number of days to physiological maturity of tomatoes (125.3) was recorded on unfertilized treatment (Table 1).

3.4 Effects of organic, chemical and no fertilizer treatment on yield of tomatoes in t ha^{-1}

Pairwise comparison of yields indicated a significant difference between organic and chemical while chemical and unfertilized also were significantly different. There was also a significant difference at $P<0.05$ between organic and no fertilizer treatment. There was a significant difference ($P<0.05$) in yield of tomatoes. However highest yield of (37.300t ha^{-1}) was obtained in chemical fertilizer, while organic treatment recorded yield of (32.888t ha^{-1}). The lowest yield of 12.900t ha^{-1} was recorded in unfertilized treatment (Table 1).

3.5 Effects of fertilizer treatment on shelf life of tomatoes (days before perishability)

There was a significant difference ($P=0.000$) in number of days before perishability of tomatoes. However organic recorded the highest number of (9.2) days before perishability, while no fertilizer recorded (8.0) days. The least number of days before perishability of (7.1) was recorded in chemical fertilizer treatment (Table 1). However the pair wise fertilizer showed no significant ($P=0.068$) between chemical and unfertilized treatment.

3.6 Effects of fertilizer treatment on marketable yield of tomatoes in t ha^{-1}

Comparison of marketable yield between organic and chemical showed a significant difference across all the treatments. There was a significance difference ($P<0.05$) in marketable yield of tomatoes. The highest marketable yield of (29.96 t ha^{-1}) was obtained in chemical fertilizer, while organic achieved marketable yield of

(27.95 t ha^{-1}). The lowest marketable yield (10.66 t ha^{-1}) was recorded in the control (Table 1).

Table 1: Effects of fertilizer treatment on number days to 50% flowering of tomatoes, number of fruits per plant, number of days to physiological maturity, yield in t ha^{-1}, marketable yield and shelf life.

Treatment	Number of days to 50% flowering of tomatoes	Number of fruits per plant	Number of days to physiological maturity	Yield in t/ha	Shelf life of tomatoes	Marketable yield t/ha
Organic	81^c	13^b	129.6^c	32.89^b	9.2^b	27.95^b
Chemical	78.6^b	17^c	128.3^b	37.30^c	7.1^a	29.96^c
No fertilizer	74.6^a	8^a	125.3^a	12.90^a	8.0^a	10.66^a
P. value	0.000	0.00	0.00	0.00	0.00	0.00

Numbers followed by different letters within the column are significantly different at 95% level of significance.

4.0 Discussion

4.1 Effects of fertilizer treatment on days to 50% flowering of tomatoes

According to the findings of the study, there was a significant difference in days to flowering were by organic enriched fertilizer recorded more days to flowering, followed by chemical and lastly the control. This was a result of longer period of exposure to nutrients offered by organic enriched treatment (Handreck and Black, 2002; Dede *et al*., 2000) in comparison to chemical fertilizers that leach easily (Owens and Johnson, 1996) or get used by plants instantly hence deplete fast (Masarirambi, 2010). The results are in line with research done by Fenner and Davison (1980), which indicated that organic fertilizers give plants exposure to nutrients for a longer period of time with adequate moisture and tend to have longer growing season unlike plants depleted of nutrients that tend to compensate through reproduction. This also coincides with the comments of farmers highlighted in the Zimbabwe farmer, (2013) that tomatoes from organic produce take more days to flowering with a lustrous green vegetative phase throughout their production cycle compared to chemical treatments.

4.2 Effects of fertilizer treatment on number of fruits per plant

From the results of the study, a significant difference was noted in number of fruits per plant, with more fruits for chemical fertilizer, followed by organic and lastly the control. However organic enriched input had the highest weight per fruit, followed by chemical and lastly the control. The results supported Nico-orgo, (2013) findings that the organic enriched fertilizer maintain constant compound decline with increase in fruit size when the same tomato cultivar is grown. This was similar to the work done by Heuvelink, (2005) were organic fertilizer recorded less fruits compared to chemical fertilizer but with a corresponding increase in fruit size. The decrease in number of fruits for organic enriched fertilizer compared to chemical fertilizer could have been contributed by their slow release mechanism (Murphree, 1990). The increase in fruit size could also have been attributed to an increase in time to physiological maturity, hence accumulation of more starch in terms of solids (Baldet et al., 2006; Ho and Hewitt, 1986; Mounet et al., 2009; Wang et al., 2009a).

The few fruits realized in the control treatment could be due to inadequate nutrition for reproduction as tomatoes are heavy feeders that require primary nutrients in higher amounts, secondary nutrients in small amounts as well as micro nutrients in their production (Jones, 1999; Amans *et al*., 2011).

4.3 Effects of fertilizer treatment on days to physiological maturity of tomatoes

There was a significant difference in days to physiological maturity of tomatoes across the three treatments, with organic enriched fertilizer recording a longer period to maturity, followed by chemical and the control respectively. This is so because plants tend to respond differently when exposed to different fertilizer treatment. Organic enriched fertilizers provide nutrients in synchrony to plant requirements for a longer period and thus enhancing long term soil fertility (Minhas and Sood, 1994; Berger *et al*, 2013; Hinds *et al*, 2013), at the same time increase water retention capacity of the soil (Hussein, 2000; Vengadaramana and Jashothan, 2012). There is a corresponding longer physiological development period of crop unlike crop which is under moisture stress or nutrient stress (Gardener, 1968; Sibomana *et al.*, 2013). This is in contrast with work done by Kemble *et al*, (2004) were organic fertilizer treatment has short production period compared to chemical fertilizer treatments.

4.4 Effects of fertilizer treatment on yield of tomatoes in t/ha

There was a significant difference in yield of tomatoes across all the treatments. Lower yield for organic enriched fertilizer compared to chemical fertilizer could have been attributed by the slow release mechanism as nutrients may not be released as soon as they are required by the crop (Murphree, 1990) or differences in the time of application and the time required for the mineralization process (Gaskell and Smith, 2007). Chemical fertilizer on the other hand release nutrients instantly hence immediate improvement to the crop in a few days

(Feldman, 1975; Trenkel, 2010; ZFC, 2013). The results of this study are in contrast to the results by Xu *et al*, (2005) and Caliskan *et al*., (2014) which obtained higher yields on organically grown leafy vegetables compared to those grown with chemical fertilizer. The differences in results could be as a result of different method of application of the organic fertilizer (Masarirambi, 2010). The effects of the organic fertilizers varies and some studies showed decreased plant yield using organic compared to inorganic fertilizers (Peet *et al*, 2004) and also because of the variation in timing of application as well as the application rates (Rosen and Allan, 2007). In similar studies, the highest yields were achieved with chemical fertilizer and the yields achieved under the optimized organic fertilization were 99.5% of the chemical fertilized crop (Kochakinezhad *et al,* 2012). This was because of the supply of plant-available N from organic fertilizer, resulting from a slow rate of mineralization (Bationo *et al*, 2004), which made crop yields in fields treated with organic fertilizer lower than in those treated with chemical fertilizer (Blatt,1991; Lee, 2010).

However in this study, the yield of organic enriched fertilizer was 2.5 times more than the yield of the control, hence an improvement in yield. This was because mixtures of the chemical and organic input in the organic enriched basal fertilizer have synergies which result in superior plant physiological processes hence better yield performance (Nico-orgo, 2013; Gardener, 1968). The low yields of the control were attributed by lack of plant nutrients to support both growth and reproduction (Sanchez *et al*, 1997) unlike the organic enriched and chemical fertilizers that supplied adequate plant nutrients (Jones, 1999).

4.5 Effects of fertilizer treatment on shelf life (days before perishability) of tomatoes

There was a significant difference in shelf life of organic enriched fertilizer and chemical fertilizer, while the control and chemical treatment were not significantly different. The control and chemical treatment were not significantly different as attributed by the fact that the produce from these treatments have more chemical compounds that have not depleted as the fruit matures unlike in the organic enriched treatments were chemical compounds decrease as the fruits matures (Nico-orgo, 2013; Heuvelink, 2005). However the organic enriched treatment showed an improvement in the shelf life of tomatoes hence an increase in actual marketable yield. Others experiments have also shown that organically produced crops have similar or better quality than conventionally grown crops (Atland *et al,* 2000; Treadwell *et al*, 2007; Zhao *et al,* 2009). The Zimbabwe farmer, (2013) reports also highlighted the increase in shelf life of organic enriched fertilizer produce, which is of great importance as 35% up to even 50% of the harvested yield is lost due to perishability from field to market (Agritex, 2010; FAO, 2012). Farmers could have harvested high yields from chemical produce, but losses are realized due to perishability yet more expenses are incurred in purchasing these chemical fertilizers.

4.6 Effects of fertilizer treatment on marketable yield of tomatoes in t/ha

The research findings indicate a significant difference across all the treatments in terms of actual marketable yield. A higher percentage (85%) was recognized in organic enriched fertilizer followed by 82.5% of the control and lastly 80% of chemical fertilizer. A 25% decrease in marketable yield for chemical fertilizer was attributed by losses due to perishability. Some of the tomatoes were discarded at the field as they were not suitable for marketing due to rots. Organic enriched fertilizer has a longer shelf life and low rate of perishability hence a corresponding increase in marketable yield. These results concur with the work of Ghanbarian *et al,* (2008) in *Cucumis melo* who found out that organic fertilizers produced higher marketable yields than chemically fertilized treatment. Other studies on vegetables have also highlighted the production of high yields and increased nutrient intake when using organic fertilizers (Ouda and Mahadeen, 2008; Ogunlela *et al*, 2005)

5.0 Conclusions and recommendations

The results of the study showed that chemical fertilizers have higher yields in terms of the quantity of tomatoes realized but organic enriched fertilizer on the other hand increase yield though lower than chemical treatment but shown to be the best in increasing tomato shelf life. The control have lower yield and this showed that both organic enriched fertilizer and chemical fertilizer have an impact of increasing yield of tomatoes as they offer the required plant nutrients for tomato productivity.

The study also showed that chemical fertilizer had more fruits per plant compared to organic enriched fertilizer but as number of fruits increase there is a corresponding decrease in fruit size per plant. Organic fertilizer compensated by increasing fruit size the decrease in number of fruits. Also as tomatoes increase number of days to physiological maturity in organic treatment, there was also an increase in fruit size hence productivity. Days to flowering of tomatoes have also shown to have an effect in number of fruits per plant as shown in organic treatment. Tomatoes that have few days to 50% flowering as shown in chemical treatment produced more flowers hence more fruits than those with a longer period to 50% flowering. Days to flowering have shown to have no impact on fruit size. As tomatoes increase in numbers per plant there is also an increase in yield to be realized compared to a plant with few tomatoes. Chemical fertilizers therefore increase number of tomato fruits per plant and yield.

From the results of the study it can be recommended that smallholder farmers should grow tomatoes using either chemical or organic enriched fertilizer as basal dressing depending on income availability to obtain high yields. Farmers can grow tomatoes using organic enriched fertilizers, if the produce is for export markets or meant for distance marketing due to longer shelf life. Further research should be carried out using different tomato cultivars/varieties to determine effects of organic enriched fertilizers on yield and shelf life of tomatoes. Various rates of the organic fertilizers should be used to find the optimum rate of the organic enriched fertilizer.

References

Agritex bulletin and fact sheet volume1, (2010/2012). Causeway Harare, Zimbabwe.

Agritex farm management handbook volume 1, (2011).Causeway Harare, Zimbabwe.

Agritex horticulture management handbook volume 1, (2011).Causeway Harare, Zimbabwe.

Amans, E.B., Abubakar, 1.U., and Babaji, B.A., (2011). Nutritional Quality of Tomato (*Lycopersicon esculentum* Mill) as Influenced by Mulching, Nitrogen and Irrigation Interval, Journal of Agricultural Science Vol. 3, No. 1, pp.266-270.

Atland, J. E. and Gilliam, C. H., Edwards, J. H., Keever, G. J. (2000). Influence of inorganic and organically based fertilizers on plant growth and nutrient leaching. *Hort Science* 35: 456

Baldet, P., Hernould, M., Laporte, F., Mounet, F., Just, D., Mouras, A., Chevalier, C., Rothan, C., (2006). The expression of cell proliferation-related genes in early developing flowers is affected by a fruit load reduction in tomato plants. *J. Exp. Bot*. 57, 961–970.

Bationo, A., Nandwa, J.M. Kimetu, J.M. Kinyangi, B.V. Bado, F. Lompo, S. Kimani, F. Kihanda and Koal, S. 2004. Sustainable intensification of crop-livestock system through manure management in eastern and western Africa: Lessons learned and emerging research opportunities, p. 173-198. In: Sustainable crop-livestock production in West Africa. TSBF ,Nairobi, Kenya.

Berger, L.R., Stamford, N.P., Santos, C.E.R.S., Freitas, A.D.S., L.O. Franco, L.O., and Stamford. T.CM, (2013). Plant and soil characteristics affected by biofertilizers from rocks and organic matter inoculated with diazotrophic bacteria and fungi that produce chitosan, *Journal of soil science and plant nutrition,* Vol.13 no.3, pp.

Blatt, C.R. 1991. Comparison of several organic amendments with a chemical fertilizer for
vegetable Production. *Scientia Horticulturae.* 47: 177–191

Bhowmik, D., Kumar, K.P.S., Paswan, S., and Srivastava, S. (2012). Tomato-A Natural Medicine and Its Health Benefits. *Journal of Pharmacognosy and Phytochemistry*, Vol. 1 No. 1, pp.33-42.

Caliskan, S., Yetisir, H. and Karanlik, S, (2014). Combined Use of Green Manure and Farmyard Manure Allows Better Nutrition of Organic Lettuce. *Not Bot Horti Agrobo*, Vol 42(1), pp.248-254.

Chemical and Soil Research Institute, (2011). Ministry of Agriculture, Harare, Zimbabwe.

Clinton, S.K. (1998). Lycopene: Chemistry, biology, and implications for human health and disease. Nutr. Rev. 56: pp35–51

Community Technology Development Association bulletin volume 1, (2012). Harare, Zimbabwe.

Currow, R. N., Hasted, A. M., Mead, R., (1993). Statistical Methods in Agriculture and Experimental Biology, Chapman Hall, London.

Dede, O.H., Dede, G . and Ozdemir, S., (2000). Agricultural and Municipal Wastes as Container Media Component for Ornamental Nurseries. *International Journal of Environmental Research, Vol. 4, No. 2, 2010, pp. 193-200*

Dias, D.C.F.S., Ribeiro, F.P., Dias, L.A.S., Silva, D.J.H., Vidigal, D.S. (2006b). Tomato seed quality harvested from different trusses. Seed Science and Technology Vol,34:pp.681-689.

Dobson, H., Cooper, J., Manyangarirwa, W., Karuma, J. and Chiimba, W. (2001). Intergrated vegetative pest management. Safe and sustainable protection of small-scale brassicas and tomatoes. Natural Resources Institute, University of Greenwich, Chatham Maritime, KENT, UK. pp.179.

FAO, 2011. Bulletin volume 1, Harare Zimbabwe.

Feldman, S., (1975). Vegetable Production in Tanzania, Ithaca publishing company, Daesalam.

Fenner, R. J and Davidson, A., (1980). Soil analysis and optimum fertilizer, Technical communication No. 174, Department of Agriculture South Africa.

Gardener, F., (1968). Commercial vegetable growing, Fredrick Muller Ltd, London.

Gaskell, M. and Smith, R,. (2007). Nitrogen sources for organic vegetable crops. *Hort Technology*. 17: 431-441

Ghanbarian, D., Youneji, S., Fallah, S., Farhadi, A. 2008. Effect of broiler litteron physical properties, growth and yield of 2 cultivars of cantaloupe (Cucumis melo L). *Intl. J. Agric. Bio*. 10:697-700.

Handreck, K.A and Black, N.D. (2002). Growing Media for Ornamental Plants and Tur. UNSW Press.

Heuvelink, E., (2005). *Tomatoes,* CABI Publishing, Cambridge.

Hinds, J., Wang, K., Marahatta, S.P., Meyer, S.L.F., and Hooks., C.R.R., (2013), Sunn Hemp Cover Cropping and Organic Fertilizer Effects on the Nematode Community Under Temperate Growing Conditions, *J Nematol*, Vol 45(4), pp. 265–271.

Ho, L.C., Hewitt, J.D., (1986). Fruit Development. In: Atherton, J.G., Rudich, J. (Eds.), The
Tomato Crop. Chapman and Hall, New York, pp. 201–240.

Hurst, W.C., (2006). Harvest, handling and sanitation in commercial tomato production, University of Georgia Cooperative Extension.

Hussein, J., (2000). Introduction to soil management. Harare, Zimbabwe Open University.

Jones, J. B., (1999). Tomato plant culture in the field, greenhouse and home garden. CRS Press. Boca Raton FL.

Kemble, J.M., Tyson, T.W and Curtis, L.M., (2004). Guide to commercial staked tomato production, Alabama.

Kochakinezhad, H., Peyvast, Gh., kasha, A. K., Olfati, J. A., Asadii, A., 2012. A comparison of organic and chemical fertilizers for tomato production. *Journal of organic systems* 7(2): 14-25

Lee, J. 2010. Effect of application methods of organic fertilizer on growth, soil chemical properties and microbial densities in organic bulb onion production. *Scientia Horticulturae*. 124: 299–305.

Mansour, B., (2003). Fresh market tomato; commercial vegetable guide. Oregon State University.

Masarirambi, M. T., Hlawe, M. M., Oseni, O. T., Sibiya, T. E. 2010. Effects oforganic feritilsers on growth, yield, quality and sensory evaluation of red lettuce (Lactuca sativa L) 'Venezia Rosa'. *Agric. Biol. J. N. Am* 1 (6): 1319-1324

Mayana, F. and Masiiwa, M., (1999). Agriculture Today, Book 3, Harare, Zimbabwe.

Minhas, R.S. and Sood, A. (1994). "Effect of inorganic and organic on yield and nutrients uptake by three crops in rotation in aid alfisol," Journal of the Indian Society of Soil Science, vol. 42, pp. 27–260, 1994.

Mounet, F., Moing, A., Garcia, V., Petit, J., Maucourt, M., Deborde, C., Bernillon, S., LeGall, G., Colquhoun, I., Defernez, M., Giraudel, J.L., Rolin, D., Rothan, C., Lemaire-Chamley, M., (2009). Gene and metabolite regulatory network analysis of early developing fruit tissues highlights new candidate genes for the control of tomato fruit composition and development. Plant Physiol. 149, 1505–1528.

Mukwirimba, A. R., (2000). Study Guide A, Agriculture, Harare Zimbabwe.

Murphree, M.W., (1990). Centre for Applied Science, University of Zimbabwe, Harare, Zimbabwe.

Navazio, J. (2012).The Organic Seed Grower: A Farmer's Guide to Vegetable Seed Production. Chelsea Green Publishing, pp388.

Nico-orgo Company, (2013). Fact sheet and price list, 2nd Avenue Showground Harare, Zimbabwe.

Nyamapfene, K.W., (1991). Soils of Zimbabwe, Harare Nehanda Publishers Pvt Ltd.

Ogunlela, V. B.; Masarirambi, M. T., Makuza, S. M., 2005. Effect of cattle manure application on pod yield and yield indices of okra (Abelmoschus esculentus L Moench) in a semi arid sub tropical environment. *Journal. Food Agric. Environ*. 3(1):125-129

Ouda, B. A. and Mahadeen, A. Y. 2008. Effect of fertilizer on growth and yield components, quality and certain nutrient contents in Broccoli (Brasssica oleracea). *Intl. J. Agric. Bio*. 10: 627-632

Owens, D.S and Johnson, G.V. (1996).Fertilizer Nutrient Leaching and Nutrient Mobility: A Simple Laboratory Exercise. J.Nat. Life Sci.Educ.Vol 25, no.2, pp.128-131.

Peet M. M., (1995). Sustainable practices for vegetable production in the South.Tomato Focus
Publishing, Newburyport.

Peet, M. M., Rippy, J. M., Nelson, P. V., Catignani, G. L. 2004. Organic production of greenhouse tomatoes utilising the bag system and soluble organic fertilizers. *Acta Hort*. 659: 707-719.

Petersen G and Wilson Roger., (1985). Design and Analysis of Experiments. Harare, Zimbabwe.

Rao, M. K., (1991). Textbook of horticulture. University of Madras, Chennai (Madras) India

Rosen, C. J. and Allan, D. L., (2007). Exploring the benefits of organic nutrient sources for crop production and soil quality. HortTechnology. 17: 422-430

Whitmore, J.S. (2000). Drought Management on Farmland. *Volume 35 of Water Science and Technology Library*, Springer Science & Business Media.

Rusike J, (2000). Agriculture and Food Marketing, Harare, Zimbabwe Open University.

Sanchez, P.A., Shepherd, K.D., Soule, M.J., Place, F.M., Buresh, R.J., Izac, A.M., Mokwunye, A.U., Kwesiga, F.R., Ndiritu, C.N. and Woomer, PL (1997). Soil fertility replenishment in Africa: an investment in natural resource capital. In: Buresh at al. (Eds). Replenishing Soil Fertility in Africa. SSSA Special Publication No 51. Madison, Wisconsin, USA.

Sibomana, I.C., Aguyoh, J.N. and Opiyo, A.M. (2013). Water Stress affects Growth and Yield Of Container Grown Tomato (Lycopersicon Esculentum Mill) Plants. *Global Journal of Bio-Science and Technology*, Vol.2 (4) 2013, pp.461-466.

Sithole, D. S., (1985). Study Guide A, Agriculture, Harare, Zimbabwe.

Spooner, A., (2007). Commercial tomato production handbook, CAES Publishing UGA.

Trenkel, M. E. (2010). Slow- and Controlled-Release and Stabilized Fertilizers: An Option for Enhancing

Nutrient Use Efficiency in Agriculture. International Fertilizer Industry Association (IFA) Paris, France.

Surveyor General, (1995). Fact sheet, Causeway, Harare, Zimbabwe.

Suslow, T. V and Cantwell, M., (2006). Tomato recommendations for maintaining post harvest quality,University of Califonia, Davis.

Swaider, J.M and Ware, G.W., (2002). *Producing Vegetable Crops 5th Edition* Interstate Publishers Inc, Danville.

Treadwell, D. D., Hochmuch, G. J., Hochmuch, E. H. Simmone, E. H., Davis, L. L., Laughln, W. L., Li, Y., Olezyk, T., Sprenkel, R. K., Osborne, L. S., (2007). Nutreient management in organic greenhouse herb production. Where are you now? *Hort Technology* 17: 461-466.

Vengadaramana, A. and Jashothan, P.T.J, (2012). Effect of organic fertilizers on the water holding capacity of soil in different terrains of Jaffna peninsula in Sri Lanka, *J. Nat. Prod. Plant Resour*, Vol 2 (4), pp 500-503.

Vernon, G., (1999). Sustainable vegetable production from start up to market. Cornell University. Ithaca, New York.

Wang, H., Schauer, N., Usadel, B., Frasse, P., Zouine, M., Hernould, M., Latche, A., Pech, J.C., Fernie, A.R., Bouzayen, M., (2009a). Regulatory features underlying pollination-dependent and -independent tomato fruit set revealed by transcript and primary metabolite profiling. Plant Cell 21, 1428–1452.

Wilson, C., (2009). Ripening that huge crop of green garden tomatoes. Calorado State University Cooperation Extension.

Windmill Pvt Ltd, (2013). Crop production and fertilizer guides, Causeway Harare, Zimbabwe.

Wright, C.A. (2001). Mediterranean Vegetables: A Cook's ABC of Vegetables and Their Preparation in Spain, France, Italy, Greece, Turkey, the Middle East, and North Africa with More Than 200 Authentic Recipes for the Home Cook. Harvard Common Press, pp. 388

Xu, H. L., Wang, R., Xu, R. Y., Mridha, M. A. U., and Goyal, S. 2005. Yield and yield quality of leafy vegetables grown with organic fertilizations. Acta. Hort. 627:25-33.

Zahedi, S.M., Ansari, N.A, and Eftekhari, S.A. (2012). Investigation of yield and adaptation of ten selected genotypes of tomato under subtropical climate conditions (Ahvaz). *Journal of Food, Agriculture & Environment* Vol.10 (1). pp 782-786.

Zhao, X., Nechols, J. R., Williams, K. A.,Wang, W., Coory, E. E. 2009. Comparison of phenolic acids in organically and conventionally grown pac chon (Brassica rapa L. chinensis). *J. Sci. Food Agric*. 89:940-946.

ZFC Pvt Ltd, (2013). Fact sheet and price list, Coventry Rd Workington Harare, Zimbabwe.

Zimbabwe farmer, (2013). Bulletin volume 1, Harare, Zimbabwe

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