Asian Journal of Agricultural Sciences 5(3): 67-70, 2013
ISSN: 2041-3882; e-ISSN: 2041-3890

Submitted: September 24, 2012 Accepted: December 13, 2012 Published: July 25, 2013

Fertilizer Formulations and Methods of their Application Influences Vegetative Growth and Productivity in Organic Greenhouse Tomato

N.R. Bhat, M. Albaho, M.K. Suleiman, B. Thomas, P. George,
S. Isat Ali, L. Al-Mulla and V.S. Lekha
Kuwait Institute for Scientific Research, P.O. Box 24885, 13109 Safat, Kuwait

Abstract: Investigations were conducted from 2006-2010 in order to develop a package of cultivation practices for producing organic greenhouse vegetables under Kuwait's environmental conditions. One of the objectives of these investigations was to evaluate different organic fertilizer formulations with a view to select fertilizers for organic greenhouse vegetable production. Commercial organic fertilizer formulations viz. Earth juice, fish hydrosylate (Neptunes Harvest), seaweed and desert bat guano (Squantos secret) were evaluated in different proportions, either as soil drench or foliar applications in tomato. Results revealed that soil application of Earth juice products and fish hydrosylate produced equally good or even better vegetative growth and fruit yields as compared to conventional fertilizers. Soil application of organic fertilizers was found to be significantly effective than the foliar application.

Keywords: Nutrient management, organic farming, organic fertilizers, protected agriculture

INTRODUCTION

In recent years, vegetable production under the protected environment has become an important agricultural activity in Kuwait (Bhat *et al*., 2010). Because of the excessive use of imported production inputs, synthetic fertilizers and pesticides in growing fresh vegetables, the local producers are faced with high production cost, rapid deterioration of soil health and productive capacity, increased risk of crop failures and declining crop productivity. The organic farming system, which has been shown to restore, promote and sustain soil health and its productive capacity, is considered crucial to the future of protected environment food production in Kuwait; however, as yet, this has not been tried in the country. Therefore, since 2006, efforts had been underway to develop practices for organic greenhouse vegetable production under Kuwait's environmental conditions.

Sewage Sludge Fertilizer (SSF) and Bark Compost (BC) were found to be effective, low-cost organic fertilizers in improving soil fertility by increasing soil EC as well as soil carbon and nitrogen levels in the soil. Application of these fertilizers increased the biomass yield in sorghum (Juniarti *et al*., 2012). Proper blends of organic and inorganic fertilizer are important for increasing yield as well as soil health and its continuous use speed up the process of reclamation of sodic soil (Dhanushkodi and Subrahmaniyan, 2012). Nutrient availability from organic sources at the right time and in optimum quantity produce balanced plants. A study to evaluate the performance of fertilizers (organic and inorganic) on the growth of cabbage showed that inorganic fertilizer treatments produced plants that were taller with greater number of leaves/plant, longer leaves and longer roots at the time of harvest (Hasan and Solaiman, 2012). A combination of green manure and treating seeds in solution containing *Bacillus* sp., Improved the yield as well as reduced incidence of scab incidence in potato (Yossen *et al*., 2011).

Most of the organic formulations are bye products of fish, livestock and food processing industries with variation in their nutrient contents. Bernard and Berrouard (1994) found blood meal, feather meal, meat meal, crab shell, fish, cotton seed and whey by-products to increase shoot weight over non-fertilized plants. Similarly Greer and Diver (2000) demonstrated that some algal products, bat guano and fish waste contain nutrients that are similar to inorganic fertilizer used in greenhouse production.

The study reported in this paper was conducted between 2006 and 2010 at KISR, Faisalia Farm, Wafra and the House of Development (HOD) Farm, Sulaibiya. The purpose of these studies was to compare different organic fertilizer formulations applied through soil and/or foliar application with inorganic fertilizer formuulations in selected greenhouse vegetables. Results of studies in tomato are discussed in this study

MATERIALS AND METHODS

Raising of seedlings: Certified organic seeds of two cultivars (Cindel F_1 and Sakura F_1) of tomato (*Lycopersicon esculentum* Mill.) were sown

Corresponding Author: N.R. Bhat, Kuwait Institute for Scientific Research, P.O. Box 24885, 13109 Safat, Kuwait

Table 1: Fertilizer formulations and application methods

Sr. no	Fertilizer formulation	Nutrient composition (N-P-K)	Quantity of stock solution*	Method of appl.	Freq. of appl.
T_1	Earth juice products (grow, bloom, catalyst and meta K)	2-1-1, 0-3-1, 0.03-0.01-0.1 and 0-0-10	50 mL/L	Soil drench	Weekly
T_2	Fish hydrosylate (neptune harvest) and soluble seaweed powder	2-4-1 and 1-0-10	50 mL/L	Soil drench	Weekly
T_3	Desert bat guano and soluble seaweed powder	8-4-1 and 1-0-10	10 g bat guano and 5 g seaweed/L	Soil drench	Bat guano weekly and seaweed monthly
T_4	Earth juice products (grow, bloom, catalyst and meta K)	2-1-1, 0-3-1, 0.03-0.01-0.1 and 0-0-10	50 mL/L	Foliar spray	Weekly
T_5	Fish hydrosylate (neptune harvest) and soluble seaweed powder	2-4-1 and 1-0-10	50 mL/L	Foliar spray	Weekly
T_6	Earth juice products (grow, bloom, catalyst and meta K)	2-1-1, 0-3-1, 0.03-0.01-0.1 and 0-0-10	100 mL/L	Soil drench	Weekly
T_7	Fish hydrosylate (neptune harvest) and soluble seaweed powder	2-4-1 and 1-0-10	100 mL/L	Soil drench	Weekly
T_8	Desert bat guano and soluble seaweed powder	8-4-1 and 1-0-10	20 g bat guano and 10 g seaweed/L	Soil drench	Weekly

individually in 5-cm polyethylene containers filled with a mixture of sphagnum peat moss; coco peat and perlite (2: 0.5: 1 by volume). Seedlings were fertilized weekly with organic fertilizers, Algafarm soluble K powder (Valagro, Italy) and Fontana (Memon B. V., Arnhem, Netherlands) in the nursery.

Production system: Twenty-five-litre flexible polyethylene containers filled with a locally formulated organic substrate containing vermicompost; sphagnum peat moss; coco peat and perlite @ 1: 1: 1: 1 ratio was used to grow the crop. DOrS (Stanes, India) containing 1.0% N, 0.75% P, 1.0% K, 16% organic carbon was mixed uniformly in the growing substrate @ 15 kg/m^3 prior to the planting of seedlings. One hardened seedling was planted in wet substrate in each container. Standard cultural practices were adopted to secure optimum crop performance (Bhat *et al*., 2010). The fertilizer treatments are given in Table 1.

Experimental design and data analysis: Fertilizer treatments were replicated three times in a randomized complete block design. Periodic data on plant height, number of leaves and chlorophyll index were recorded on fifteen randomly selected plants in each treatment. Moderate attacks of whiteflies and leaf curl virus was noticed but they were controlled by spraying 5 mL/L of Nimbecidine at weekly intervals. One spray of BioCure (*Trichoderma viride* 1.15% WP) was also applied as a prophylactic measure against fungal infestation. Nimbecidine spraying was alternated with Garlic barrier and BioCatch (selective stain of naturally occurring entomopathogenic fungusof *Verticillium lecanii*) sprayings to avoid the building up of resistance to the pesticide by pest the populations. The data were analyzed by ANOVA using the "R" procedure (Crowley, 2005) and significant treatment means were identified using Duncan's Multiple Range Test (Little and Hill, 1978). The data on the 140 D after Planting (DAP) stage are presented in this study.

Table 2: Average height, number of leaves and per plant yield of tomato plants (*Lycopersicon esculentum* cv. Cindel F_1) at 140 DAP in different fertilizer treatments

Treatments	Height (cm)	Number of leaves	Per plant fruit yield (kg)
T_1	205.3b	18.0c	2.80
T_2	205.1b	17.3c	2.76
T_3	195.3ab	16.4ab	2.56
T_4	188.7a	15.7a	2.57
T_5	184.9a	16.5ab	2.42
Control	171.1a	15.1a	2.59
Significance	***	*	NS

*: Significant for p<0.05; ***: Significant for p<0.001

Table 3: Average height, number of leaves, leaf chlorophyll and per plant yield of cherry tomato plants (*Lycopersicon esculentum* cv. Sakura F_1) produced in different fertilizer treatments

Treatments	Height (cm)	Number of leaves	Leaf chlorophyll	Per plant fruit yield (kg)
T_7	289.3c	18.6	18.8b	2.77b
T_8	258.5b	15.7	18.2b	1.85ab
T_9	273.4bc	18.6	13.9a	1.95ab
Control	219.1a	15.2	28.2c	2.23a
Significance	***	NS	***	*

*: Significant for p<0.05; ***: Significant for p<0.001; NS: Not significant; Values followed by the same alphabets within the column are not significantly different

RESULTS

Tomato (*Lycopersicon esculentum* cv. Cindel F_1): Tomato plants that received weekly soil applications of Earth juice products (T_1) and fish hydrosylates and seaweed (T_2) fertilizers were taller and contained greater number leaves than those received foliar application of these formulations (Table 2). The control plants were the shortest of all plants with least number of leaves. Though the plants which received soil application (T_1 and T_2) produced higher yield per plant than other treatments, there was no significant difference among treatments with respect to per plant fruit yield.

Cherry tomato (*Lycopersicon esculentum* cv. Sakura F_1): Plants that received soil-drench applications of

Earth juice products (T_6) were taller and contained greater numbers of leaves followed by application of desert bat guano (T_8) and fish hydrosylate (T_7) than the control plants. However, they had lower leaf chlorophyll levels than those of the plants used as control (Table 3). Highest yield was obtained for treatment T_6 with earth juice products than all other treatments (Table 3). Therefore treatment with Earth \juice products (T_6) was found superior in all the parameters in the cherry tomato (*Lycopersicon esculentum* cv. Sakura F_1) cultivation.

DISCUSSION

The results of this investigation demonstrated that the organic nutrient formulations produced similar vegetative growth and yields compared to inorganic fertilizers. These findings are in conformity with those reported by several researchers (Anderson, 2000; Delate *et al*., 2003; Rippy *et al*., 2004; Juniarti *et al*., 2012). These researchers have successfully demonstrated that plants fertilized with organic fertilizer formulations and grown in organic production systems produce vegetative growths and yields that are similar to those produced with inorganic fertilizers and intensive production systems In fact, in beans, Temple and Bomke (1989) reported 24% higher harvestable yields with foliar applications of sea weed fertilizer. Similarly, Czizinsky (1984) obtained as much as 99% higher yields in tomato with organic fertilizers. Crouch and Van Staden (1992) also reported increases in the fresh weights in early cucumbers and tomatoes. According to Aung and Flick (1980) and Emino (1981) plants receiving soil-drenching applications of fish-soluble nutrients or inorganic fertilizers produced similar growth and yield. In sorghum, Juniarti *et al*. (2012) found application of organic materials such as sewage sludge and bark compost to significantly increase biomass production by improving soil fertility, especially, carbon and nitrogen levels.

A majority of organic formulations currently available for crop production are the byeproducts of fish, livestock and food processing industries. These products vary significantly in nutrient contents, processing methods used, rate of release of various nutrients and immobilization of nutrients. Apart from nutrients, the organic materials contain a number of vitamins and growth regulators (Bhat *et al*., 2007, 2010; Crouch and Van Staden, 1993). A good organic fertilizer formulation should contain nutrients to sustain initial plant growth and release them slowly and uniformly throughout the duration of the crop (Christensen, 1985). Considerable fluctuations in the availability of nutrients, especially ammonium, potassium and phosphorus during the production period can be expected due to composting processes (Jensen and Leth, 1998). Since the dynamics of release of nutrients from organic fertilizer formulations and their subsequent long-term effects on soil fertility is not fully understood, studies linking the quality of the organic material to its fertilizer equivalency and its effect on the longer-term composition of soil organic matter and crop yields are needed. Additionally, a systematic framework for investigating the characterization of the quality of organic materials, assessment of the fertilizer equivalency value based on the quality of organics and experimental designs for determining optimal combinations of nutrient sources is needed.

Severe pest infestations especially of thrips and whiteflies in the early stages of seedling growth and their continuing impact on subsequent growth resulted in disruption flowering and subsequent fruit set and total yield. The natural pesticides used to control these pests took longer time to reduce insect populations to manageable levels. Hence, more efforts are needed to control insects to allow for uninterrupted vegetative growth, flowering and fruit set.

CONCLUSION

Results of the experiments reported in this study suggested that in tomato it was possible to produce acceptable yields with organic fertilizer formulations such as Earth juice products and Fish hydrosylate. Soil-drenching applications were found to be better than foliar applications in increasing vegetative growth and yield in greenhouse tomato.

ACKNOWLEDGMENT

The authors would like to thank the Kuwait Institute for Scientific Research, Kuwait Foundation for the Advancement of Sciences, Mr. Faisal Sultan Al-Essa and Mr. Hamad Al-Anjari for supporting this study.

REFERENCES

Anderson, B., 2000. Nutrient Analysis of Selected Commercial Organic Fertilizers for Greenhouse Lettuce Production. Co-operative Extension Service Hortfacts, 16-02, University of Kentucky, USA, pp: 4.

Aung, L.H. and G.J. Flick, 1980. The influence of fish solubles on growth and fruiting of tomato. Hort Sci., 15(1): 32-33.

Bernard, G. and S. Berrouard, 1994. Effects of several organic fertilizer on growth of greenhouse tomato transplants. Can. J. Plant Sci., 74(1): 167-168.

Bhat, N.R., M. Albaho, M.K. Suleiman, L. Al-Mulla, A. Christopher, B. Thomas, S. Isath Ali, P. George, V.S. Lekha, S. Jacob, M. Al-Zalzaleh and R. Bellen, 2007. Standardization of growing substrates and fertilizer application for organic greenhouse vegetable production. Kuwait Institute for Scientific Research, Report No. KISR 8912, Kuwait.

Bhat, N.R., M. Albaho, M.K. Suleiman., S. Al-Dosery, G. Al-Essa, R. Al-Nafisi, T. Al-Ati, B. Thomas, S. Isathali, P. George, R. Bellen and M. Al-Zalzaleh. 2010. Optimization and pilot scale greenhouse organic vegetable production. Kuwait Institute for Scientific Research, Report No. KISR 10272, Kuwait, pp: 179.

Christensen, B.T., 1985. Wheat and barley straw decomposition under field conditions: Effect of soil type and plant cover on weight loss, nitrogen and potassium content. Soil Biol. Biochem., 17: 691-697.

Crouch, I.J. and J. Van Staden, 1992. Effects of seaweed concentrate on the establishment and yield of greenhouse tomato plant. J. Appl. Physiol., 4: 292-296.

Crouch, I.J. and J. Van Staden, 1993. Evidence for the presence of plant growth regulators in commercial seaweed products. Plant Growth Regul., 13: 21-29.

Crowley, M.J., 2005. Statistics: An Introduction Using R. John Wiley and Sons Ltd., United Kingdom.

Czizinsky, A.A., 1984. Response of tomatoes to seaweed based nutrient sprays. Proceedings of the Annual Meeting of the Florida State Horticultural Society.

Delate, K. and H. Friedrich, V. Lawson, 2003. Evaluation of soil amendments and cover crops for certified organic pepper production. Annual Fruit/Vegetable Progress Report-2002, FG-601Muscatine Island Research and Demonstration Farm (MIRDF), Iowa State University, Ames, IA.

Dhanushkodi, V. and K. Subrahmaniyan, 2012. Soil management to increase rice yield in salt affected coastal soil a review. Int. J. Res. Chem. Environ., 2: 1-5.

Emino, E.R., 1981. Effectiveness of fish soluble nutrients as fertilizers on container-grown plants. Hort Sci., 16(3): 338.

Greer, L. and S. Diver, 2000. Organic Greenhouse Vegetable Production. ATTRA-National Sustainable Agriculture Information Service Fayetteville, Arizona, USA.

Hasan, M.R. and A.H.M. Solaiman, 2012. Efficacy of organic and organic fertilizer on the growth of *Brassica oleracea* L. (cabbage). Int. J. Agric. Crop Sci., 4(3): 128-138.

Jensen, H.E.K. and M. Leth, 1998. Forskning i kompost som voksemedie. Gartnertidende, 114: 10-11.

Juniarti, H.O., K. Yokoi, T. Masuda, K. Nishimura, Y. Niimi and T. Itani, 2012. Basic study on cultivation characteristics of energy crops in the hilly and mountainous areas of Hiroshima prefecture. Jpn. J. Environ. Res. Dev., 7: 24-36.

Little, T.M. and F.J. Hill, 1978. Agricultural Experimentation: Design and Analysis. John Wiley and Sons, Inc., USA.

Rippy, J.F.M., M.M. Peet, F.J. Louws, P.V. Nelson, D.B. Orrand and K.A. Sorenson, 2004. Plant development and harvest yields of green house tomatoes in six organic growing systems. Hort Sci., 39(20): 1-7.

Temple, W.D. and A.A. Bomke, 1989. Effects of kelp foliar application on bean crop growth. Plant Sci., 7: 24-92.

Yossen, V., R. Rojo, V. Barrera, G. Chiessa, G. Zumelu, J. Cozzi, K. Kobayashi and L. Gasoni, 2011. Effect of green manure and biocontrol agents on potato crop in Cordoba, Argentina. J. Plant Pathol., 13: 713-717.