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Utilization of rice straw compost for strawberry and tomato production

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Abstract

The use of agricultural waste is of great interest to sustainable agriculture. An investigation was carried out to evaluate the effects of compost and compost tea made from agricultural waste rice straw on the yield and quality of two horticultural crops strawberry and tomato. In strawberry experiment, six treatments were considered which wereT_1: 100% soil (as a control), T_2: 80% soil + 20% compost, T_3: 60% soil + 40% compost, T_4: 40% soil + 60% compost, T_5: 20% soil + 80% compost & T_6: 100% compost. Results revealed that number of fruit, fruit yield and total sugar (%)was increased with the increasing level of compost up to 80% after that decreased at 100% compost. The treatment T_5: 20% soil + 80% compost gave the best results among the treatments to grow strawberry with good yield (185.3 g/plant) and sweetness (total sugar 5.19%). On the other hand, six treatments i.e. T_1: Control, T_2: Compost (5 t/ha), T_3: Compost tea (50% concentration), T_4: Compost (5 t/ha) + Compost tea (50% concentration), T_5: Compost tea (100% concentration) and T_6: Compost (5t/ha) + Compost tea (100% concentration) were considered in tomato experiment. As a result, it was observed that combined application of compost (5 t/ha) along with compost tea (100% conc.) (T_6) gave the highest yield of tomato than not only control (T_1) but also single application of compost or compost tea (T_2, T_3, T_4&T_5). Level of compost tea concentration also showed significant effect on fruit yield of tomato. Comparing between treatment T_4 and T_6, fruit yield was found higher (1027.67 g/plant) in treatment T_6: Compost (5t/ha) + Compost tea (100% conc.) than 961.3 g/plant in T_4: Compost (5 t/ha) + Compost tea (50% conc.). So, it could be summarized that use of rice straw as compost and compost tea affects positively both in two experiments. The results of this study confirm the beneficial effects of compost to increase the yield and sweetness of strawberry and combination of compost and compost tea to increase the yield of tomato.

Key words: Rice straw, compost, compost tea, strawberry, tomato

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Introduction

Improper disposal of agricultural wastes caused environmental pollution and also waste a lot of valuable biomass resources which imperiled sustainable development and human health (Bin *et al.* 2016). Crop residue (residual stalks, straw, leaves, roots, husks, shell etc) are usually referred as "agricultural waste" because they are the byproduct of agricultural activities not the primary products. Many of the agricultural wastes are still largely underutilized and left to rot or open burned in the field, especially in developing countries (Sabiiti, 2011). Huge amount of rice straw is produced in rice based cropping system of Bangladesh. If rice straw is left in the field without proper management, it can cause the spreading of disease and can also encourage the breeding of pests. Rice straw is resistant to decay and can interfere with

succeeding years' operations if not plowed under to greater depths than standard operations call for (Kadam *et al*., 2000). The direct incorporation of rice straw in the soil may have a bad effect on the next crop and also may cause increasing CH_4 emissions from the fields (Weber *et al*., 2001). The impact of agricultural waste depends not only on the amounts generated but also on the disposal methods used. Some of the disposal practices pollute the environment (Tumuhairwe *et al.*, 2009). The burning of rice straw cause atmospheric pollution and incorporation into wet soil makes a temporary immobilization of N and methane emission that contributes to greenhouse gases (Dobermann and Fairhurst, 2002). Organic waste contains high levels of nitrogen, phosphorus and potassium and organic matter. In developing country due to limited waste recycling facilities, most of the nutrients are leached from the damp fills and end up polluting water bodies (Sabiiti, 2011).

Rice straw has large potential for plant nutrients in organic farming. Composting of agricultural waste is a sustainable solution to the common problem of organic wastes disposal (Mastouri *et al.*, 2005). Composting is the most promising low cost technologies to convert solid waste into value added biofertilizer (Misra *et al*., 2003) by stabilizing the organic matter, reducing malodor, destructing weed seeds and pathogens and producing a uniform organic fertilizer suitable for land application (Haga, 1990). Organic fruits are becoming more popular because they are perceived more nutritious and tasty. Moreover, food security reasons and environmental concerns are orienting the market and the growers toward sustainable agricultural systems, based on natural deriving methods with the reduction of synthetic inputs. Compost is popular in organic agriculture because it replaces fertilizers and improves soil global fertility (Pane *et al.*, 2013). Tomato is a major horticultural crop. It is grown on every continent and represents the horticultural product with the highest economic importance. Strawberry is a minor exotic fruit in Bangladesh. It is now cultivated in many parts of Bangladesh. There has been a bright prospect of farming strawberry a high value crop. Strawberry farming has started gaining popularity in all over the country (Chowhar *et al*., 2016). Sweetness of strawberry is a major problem in Bangladesh.

Compost and water based extracts of compost i.e. compost tea have been recognized as potentially valuable in promoting plant growth (Radovich and Arancon, 2011). Compost is nutrient rich humus like material to be used as a fertilizer and soil amendment (Bezanson, 2014). On the other hand, compost tea is produced through steeping compost in water, just like a bag of tea in hot water, producing an organic-rich, high-nutrient liquid (Ingram and Millner, 2007). Compost along with compost tea is promising in sustainable horticultural crop management. Compost has beneficial effects on physical, chemical, biochemical and biological properties of soils (Pane *et al.*, 2013). Compost teas are gaining great interest in many country of North America (Hargreaves *et al.*, 2009), Asia (Siddique *et al*., 2008) and recently, scientific attention for these products started also to expand in Europe (Litterick *et al.*, 2004). It is obtained through a liquid phase compost extraction ranging from few hours to two weeks, with or without active aeration and the addition of nutrients (Morales-Corts *et al.*, 2018).

By taking into account that compost along with compost tea are promising in sustainable horticultural crop management. So that to make agricultural wastes a resource that can be utilized and not just discarded, the present work was conducted to investigate the utilizing potential of aerated compost and compost tea obtained from rice straw in two horticultural crops strawberry and tomato. In this study compost and compost tea were tested to observe their capacity for promoting yield and quality of strawberry and tomato.

Materials and Methods

Two experiments were carried out to evaluate the efficiency of utilizing compost in strawberry production and combined application of compost and

compost tea in tomato production. Experiments on strawberry and tomato were conducted at BINA substation farm, Jamalpur during November 2016 to March 2017 and November 2017 to April 2018, respectively.

***Compost and compost tea preparation*:** Rice straw was cut into small pieces and heaped into piles under a cover shed over a 12-week period. Pile was constructed at a size of 5 ft x 2 ft x 2.33 ft (length x width x height). Compost material was watered and mixed properly to maintain moisture percent at 60 –70%. After that moistened composting materials were spreaded in the pile by maintaining a layer of 6-inch straw with 2-inch layer containing cowdung and grasses for rapid composting. The pile was covered by using a piece of polyethylene. Moisture content of the feed was kept at around 60 – 70% throughout the composting period by sprinkling adequate quantities of water. The compost pile was turned twice a month for the first 10 weeks and then the materials were allowed to attain maturity over a period of 2 weeks, with no turning. Following active composting method, the composted material was allowed for curing over a minimum of one month to create more stable compost. Compost tea was prepared by brewing compost and water at a ratio 1:5 (v/v). Aeration was done manually using a stick 3 times a day for 10 minutes in each time. For foliar spray application, compost tea was mixed with water to prepare compost tea blend 50% concentration. Compost tea was prepared each time of spraying.

***Experimental trial*:** The experiment on strawberry was conducted at BINA substation farm, Jamalpur during the period from November 2016 to March 2017. Six treatments were considered in this experiment which were T_1: 100% soil, T_2: 80% soil + 20% compost, T_3: 60% soil + 40% compost, T_4: 40% soil + 60% compost, T_5: 20% soil + 80% compost & T_6: 100% compost. Eighteen pots were taken and filled with soil and compost according to the ratio of soil and compost used in the treatments. Strawberry variety Rabi 3 was used in this study. Strawberry seedlings were hand-transplanted to the irrigated pot on 19 November 2016. One seedling was planted in each pot. Intercultural operations were done as necessity. The experiment was laid out in a Completely Randomized Design with three replications. Data on number fruits per plant (no./plant) and yield per plant (g/plant) were recorded immediate after harvesting of the fruits. Biochemical analysis was performed to measure sugar contents. Total sugar content was determined by the Anthrone method as per Dubois *et al.* (1951).

The experiment on tomato was conducted also at BINA substation farm, Jamalpur during the period of November 2017 to April 2018. Six treatments were considered in this experiment which were T_1: Control, T_2: Compost (5 t/ha), T_3: Compost tea (50% concentration), T_4: Compost (5 t/ha) + Compost tea (50% concentration), T_5: Compost tea (100% concentration) and T_6: Compost (5t/ha) + Compost tea (100% concentration). Eighteen pots were taken and filled with soil of 16 kg and compost according to the treatments. Tomato seedlings were hand-transplanted to the irrigated pot on 14 December 2017. Three seedlings were planted in each pot. After seedling establishment 1 seedling was uprooted to keep 2 seedlings in each pot. Intercultural operations were done as necessity. Compost tea was sprayed once a week start after 10 days of transplanting. It was sprayed a total of five times. No fungicide was used in this experiment. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Data were recorded on plant height, number of fruits per plant (no./plant) and yield per plant (g/plant) immediate after harvesting.

***Statistical analysis*:** The data were collected on various parameters from both of the experiments. The collected data were then statistically analyzed using Statistix10 software and the significance was tested by ANOVA. The means of different parameters were compared by Duncan's Multiple Range Test (DMRT) at 1% or 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Experiments were conducted to investigate the potentiality of using compost and compost tea made from rice straw on the yield and quality of strawberry and tomato. The results obtained from the present investigations have been presented and discussed crop wise under separate headings.

***Effects of compost obtained from rice straw on yield and quality of strawberry*:** Compost made from agricultural waste rice straw was applied on strawberry to determine the effects on the yield and sweetness of strawberry. The effects of compost on fruit no., yield and sweetness of strawberry are shown in Table 1. Considering different treatments of the amount of compost supplement, significant variations were found in the fruit number, yield and sweetness of strawberry. Fruits per plant is one of the most important yield contributing characters in all fruits and as well as strawberry. The results showed that all tested treatments significantly increased fruit number per plant compared with control. The highest number of fruits (18 no./plant) were observed in treatment T_4: 40% soil + 60% compost followed by T_3: 60% soil + 40% compost (12 no./plant) and the lowest in the control treatment T_1: 100% soil (3 no./plant).

Table 1. Effects of different levels of compost made from rice straw on fruit number, yield and sugar content of strawberry.

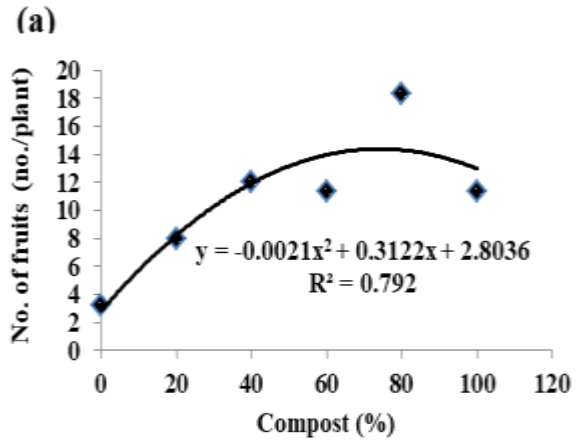
Treatment	Fruit Number (no./plant)	Yield (g/plant)	Total sugar (%)
T_1: 100% soil	3d	16.0e	2.29f
T_2: 80% soil + 20% compost	8c	63.3d	2.59e
T_3: 60% soil + 40% compost	12b	123.7b	2.78d
T_4: 40% soil + 60% compost	11b	115.7bc	3.64c
T_5: 20% soil + 80% compost	18a	185.3a	5.19a
T_6: 100% compost	11b	110.7c	4.44b
CV (%)	5.83	2.95	1.00
Level of significance	**	**	**
SE (±)	0.509	2.46	0.028

Values having same letters in a column do not differ significantly at 5% level by DMRT. *= Significant at 5% level and **= Significant at 1% level. CV = Coefficient of variation.

Fruit yield per plant was also significantly differed in different level of compost treatments. Highest yield 185.33 g/plant was recorded in treatment T_5: 20% soil + 80% compost and the lowest yield 16 g/plant was recorded in the treatment T_1: 100% soil. Organic management may positively affect sensory quality and nutritional value of the products regardless of the yield (Pane *et al.*, 2014). Compost application increased the plant growth due to the microbial population (Arancon *et al.*, 2006). Compost based fertilization have positive effect on crops (Tarchoun and Ben Khedher, 2010) due to its contribution on enrichment and maintenance of soil fertility and creation optimal conditions for plants growth through mineralization and made available for plant nutrients (Davet, 1996). Compost as soil amendment can have positive effects on yield but the results are not always positive and can vary depending on rates, compost maturity and available N (Cisar and Snyder, 1992). From the correlation study between amount of compost supplement and yield of

strawberry, it was observed that strawberry yield was increased with the increasing application of compost up to 80% after that yield was decreased at 100% compost (Figure 1).

In addition to fruit no. and yield of strawberry, compost had also positive effect on sweetness of strawberry. Significant variation among the treatments was also observed in case of total sugar (%). Lowest total sugar (%) was recorded in treatment T_1 (2.29%) which was increased with the increasing level of compost up to 80% (5.19%) after that decreased at 100% compost (4.44%). Similar result was found by Singh et al. (2008) who reported that increasing the dose of vermicompost enhanced TSS and sugar contents of fruits. Organic compost has beneficial effect on chemical properties of strawberry and produced higher quality fruit with sweetest in taste, longer shelf life and better flavor (Reganold *et al.*, 2010). Compost increased sweetness of strawberry by making soil slightly acidic (Chauhan, 2016). It also increased levels of organic acids (malic and citric acid) and sugar (fructose, glucose and total sugars) (Shiow and Shin-Shan, 2002) of strawberry and provided easy availability of macro and micronutrients which are responsible for the sweetness of strawberry (Chauhan, 2016).



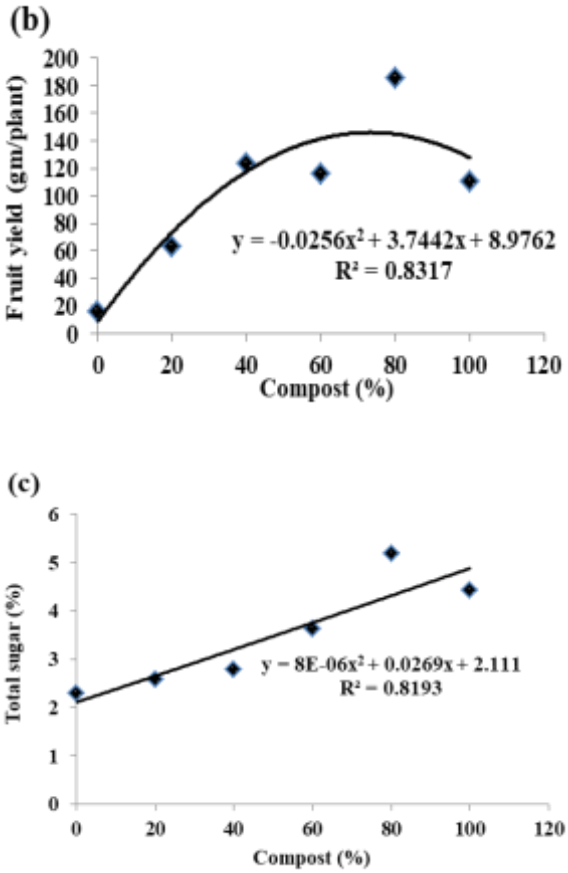


Figure 1. Relationship between compost supplement and (a) no. of fruits (b) yield and (c) sugar content of strawberry.

As strawberry yield and total sugar (%) both were increased by the increasing application of compost up to 80%, the treatment T_5: 20% soil + 80% compost may be considered as the best among the treatments to grow strawberry with good yield and sweetness. So, the results of this study confirm that the rice straw can be used in strawberry production through composting to increase the yield and sweetness of strawberry.

***Effects of compost along with compost tea originating from rice straw on yield of tomato*:** Aerated compost along with compost tea originating from rice straw have tested on tomato plants to determine its efficacy on plant height, no. of fruits and fruit yield of tomato. Responses to the treatments compared to their control

were reported in Table 2. The results showed that all tested treatments significantly increased plant height, no. and yield of tomato as compared with control. Result revealed that the highest significant plant height was recorded 87 cm in treatment T_3: Compost (5 t/ha) followed 85.7 cm in treatment T_5: Compost tea (100% conc.). Fruits number was found higher 21 no./pot in T_6: Compost (5t/ha) + Compost tea (100% conc.) following 20.3 no./pot in T_5: Compost tea (100% conc.) and 20.0 no./pot in T_4: Compost (5 t/ha) + Compost tea (50% conc.). Fruit yield of tomato of all the tested treatments ranged from 733.7g to 1027.7g of which the highest yield of 1027.67 g/pot was attained with the treatments T_6: Compost (5t/ha) + Compost tea (100% conc.). The lowest yield of 733.67 g/pot was obtained from the treatment T_1: Control. Combination of compost with compost tea (T_4& T_6) increased fruit yield than only control (T_1) but also single application of compost or compost tea (T_2, T_3 & T_5). So that combining compost tea (100% conc) with compost (5 t/ha) have better nutrient providers than the use of every single application method. Combining compost tea foliar spray with fertigation allows having better results than the use of every single application method (Khalfallah *et al*., 2015). Compost tea can positively influence plant yield and quality through increasing soil biological activity in multiple soil types (Joe *et al*., 2017). Aerated compost teas are oxygenated extracts of compost and improve plant growth and health because contains bioactive molecules and microorganisms (Pane *et al.*, 2014). Several researchers revealed that foliar feeding is more efficient than soil fertilization (Tariq *et al*., 2007). Both compost and compost teas can show biostimulants activity on plants due to their content in aromatic, hormone like organic molecules and useful microorganisms (Liguori *et al*., 2015) which improve plant physiological status (Zaccardelli *et al*., 2012). It is most often used as it contains millions of bacteria, fungi and other microorganisms that help plants free of diseases (Guet, 2003). The most widely described uses of compost tea are its ability in suppressing plant pathogens (Scheuerel and Mahaffee, 2002). Compost teas have been reported to act as natural pesticides and may contain various biopesticidal microbes and organic chelators. Compost tea applied directly to plant foliage has been shown to suppress phytopathogens on a variety of edible crops, including tomatoes (Scheuerell and Mahaffee, 2002). Compost tea can be counted among the most innovative organic source products developing in the field of crop management (Praveena and Narayan, 2013).

Table 2. Effects of single and combined application of compost and compost tea on yield of tomato.

Treatment	Plant height (cm)	Fruits (no./pot)	Fruit weight (g/pot)
T_1: Control	67.3c	15.7c	733.7d
T_2: Compost (5 t/ha)	80.7ab	19.7ab	938.3b
T_3: Compost tea (50% conc.)	87.0a	19.0b	799.7c
T_4: Compost (5 t/ha) + Compost tea (50% conc.)	75.0bc	20.0ab	961.3b
T_5: Compost tea (100% conc.)	85.7a	20.3ab	816.3c
T_6: Compost (5t/ha) + Compost tea (100% conc.)	75.0bc	21.7a	1027.67a
CV (%)	4.2	4.86	2.51
Level of significance	**	*	**
SE (±)	2.69	0.769	18.03

Values having same letters in a column do not differ significantly at 5% level by DMRT. *= Significant at 5% level and **= Significant at 1% level. CV = Coefficient of variation.

Level of compost tea concentration also affected the fruit yield of tomato. In this study it was observed that fruit yield was increased due to increasing level of compost tea concentration up to 100%. Comparing between treatment T_4 and $T_{6,}$ fruit yield was found higher in treatment T_6: Compost (5t/ha) + Compost tea (100% conc.) than T_4: Compost (5 t/ha) + Compost tea (50% conc.). Higher level of concentration gave increase in fruit yield as increase organic fertilizer concentration is a response to source of organic fertilizer (Omar *et al*., 2012). Hargreaves *et al.* (2009) found that the foliar spray of compost tea was effective as soil application of compost (Pane *et al.*, 2014). From this study it could be concluded that combined application of compost and compost tea increase the number of fruits and yield of tomato.

Conclusion

A large number of rice straw usually referred as agricultural waste is produced in the rice based cropping system in Bangladesh. Considering sustainable agriculture system and to address food and nutrition security through resource maximization, there is need to utilize rice straw in a proper way. Composting is effective, low cost and environmentally friendly process to recycle this waste product into a valuable resource. In this study it could be concluded that compost based fertilization through direct application in the soil and foliar application by using compost tea have positive effect on the yield and quality of vegetable crops strawberry and tomato. In the study 80% compost along with 20% soil in potting media produced the highest yield with highest sweetness of strawberry. On the other hand, combined application of compost (5 t/ha) and compost tea (100%) gave the best results in the number and yield of tomato. So the use of compost and compost tea through fertigation and foliar spray make the agricultural waste a resource that can be utilized and not just discarded. So the recycling of rice straw waste into compost and compost teas is being promoted as a viable option for treating waste material and use in horticultural crop production as compost to increase the yield and sweetness of strawberry and combination of compost and compost tea to increase the yield of tomato.

References

Arancon NQ, Edwards CA, Bierman P (2006). Influences of vermicomposts on field strawberries. Part-2. Effects on soil microbiological and chemical properties. Bioresource Technology, 97: 831-840.

Bezanson GS, Ells TC, Prange RK (2014). Effect of composting on microbial contamination and quality of fresh fruits and vegetables - a Mini – Review. Acta Horticulturae, 1018: 631-638.

Bin W, Faqin D, Mengjum C, Jingping Z, Jiangyue T, Xinmei F, Youzhi W, Shu C (2016). Advances in recycling and utilization of agricultural wastes in China: Based on environmental risk, crucial pathways, influencing factors, policy mechanism. Procedia Environmental Sciences, 31: (12-17).

Cisar JL, Snyder GH (1992). Sod production on a solid-waste compost over plastic. Hortscience., 27(3): 219-222.

Chauhan K (2016). Effect of organic manures and growing conditions on plant growth, yield and quality of strawberry. MS thesis, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, PauriGarhwal (Uttarakhand), India.https://pdfs.semanticscholar.org/8592/80d9f321e297977a6dfdcda7ef3749fd5024.pdf accessed on 21.10.2019.

Chowhar S, Hossain MM, Hogue MA, Rasul G, Roni MS (2016). Yield Performance of Strawberry Genotypes. Bangladesh Journal of Agricultural Research, 41(3): 481-489.

Davet P (1996). Vie microbienne du sol et production vegetale. Edition INRA, 383.

Dobermann A, Fairhurst TH (2002). Rice straw management. Better Crops Int., 16 (1): 7-11.

Dubois M, Gills KA, Hamilton JK, Robers PA, Smith F (1951). A colorimetric method for the determination of sugars. Nature, 168 167.

Gomez KA, Gomez AA (1984). Statistical Procedures for Agricultural Research, 2nd (ed). John Wiley &Son's.Inc.New York. pp. 141-177.

Guet G (2003). Memento d'agriculturebiologique: Guide pratique a usage professionnel. France agricole editions, 416.

Haga K (1990). Production of compost from organic wastes. Extension Bulletin NO 311. Taipei City, Republic of China on Taiwan.

Hagreaves JC, SinaAdl M, Warman PR (2009). Are compost teas an effective nutrient amendment in the cultivation of strawberrie? Soil and plant tissue effects. Journal of Food Agriculture, 89: 390-7.

Ingram DT, Millner PD (2007). Factors affecting compost tea as a potential source of *Escherichia coli* and *Salmonella* on fresh produce. Journal of Food Protection, 70 (4): 828-834

Joe V, Rock C, Mclain J (2017). Compost tea 101: What every organic gardener should know. A Cooperative Extension, az1739, pp. 1-5.

Kadam K, Forrest LH, Jacobsom WA (2000). Rice straw as a lignocellulosic resource: Collection, processing, transportation and environmental aspects. Biomass, Bioenerg, 18: 369-389.

Khalfallah KK, Turki N, Rebai M, Ghazel I (2015). Compost and compost tea fertilization effects on soil and artichoke mineral nutrition in organic farming. International Journal of Current Engineering and Technology, 5 (6): 3835-3842.

Liguori L, Pane C, Albanese D, Celano G, Zaccardelli M, Di Matteo M (2015). Compost and compost tea management of mini watermelon cultivations affects the chemical, physical and sensory assessment of the fruits. Agricultural Sciences, 6: 117-125.

Litterick AM, Harrier L, Wallace P, Watson CA, Wood M (2004). The role of uncomposted materials, composts, manures and compost extracts in reducing pest and disease incidence and severity in sustainable temperate agricultural and horticultural crop production – a review. Crit. Rev. Plant Sci., 23: 453-79.

Mastouri, Hassandokht MR, PadashtDehkaei MN (2005). The effect of application of agricultural waste compost in growing media and greenhouse lettuce yield. Proc. IS on soilless Cult. and Hydroponics. Ed: M. Urrestarazu Gavilan Acta Hort. 697 ISHS.

Misra RV, Roy RN, Hiraoka H (2003). On farm composting Methods. Food and Agriculture Organization of the United Nations (FAO), Rome, pp. 1-35

Morales-corts MR, Perez-Sanchez R, Gomez-Sanchez MA (2018). Efficiency of garden waste compost teas on tomato growth and its suppressiveness against soil borne pathogens. Scientia Agricola, 75 (5): 400-409.

Omar AEK, Belal EB, El-Naiem A (2012). Effects of foliar application with compost tea and filtrate biogas slurry liquid on yield and fruit quality of Washington navel orange (*Citrus sinenesis* Osbeck) trees. Journal of the Air an Waste Management Association, 62 (7): 767-772.

Pane C, Palese AM, Celano G, Zaccardelli M (2014). Effects of compost tea treatments on productivity of lettuce and kohlrabi systems under organic cropping management. Indian Journal of Agronomy, 9: 596.

Pane C, Villecco D, Zaccardelli M (2013). Short time response of microbial communities to waste compost amendment of an intensive cultivated soil in Southern Italy. Communication Soil Science and Plant Analysis, 44: 2344-52.

Praveena DK, Narayana RP (2013). Compost tea – an organic source for crop disease management. International Journal of Innovative Biological Research, 2: 51-60.

Radovich T, Arancon N (2011). Tea time in the tropics. A Handbook for compost tea production and use.College of Tropical Agricultural and Human Resources, University of Hawaii.3190 Maile Way, St. John 102 Honolulu, HI 96822.

Reganold JP, Andrews PK, Reeve JR, Carpenter-Boggs L, Schadt SW (2010). Fruit and soil quality of organic and conventional strawberry agoecosystems. Public Library of Science one (PLoS ONE), 5 (9): e12346.

Sabiit EN (2011). Utilizing agricultural waste to enhance food security and conserve the environment. African Journal of food, Agriculture, Nutrition and Development, 11: (6).

Scheuerel SJ, Mahaffee WF (2002). Compost tea: Principles and prospects for plant disease control. Compost Science and Utilization, 10: 313-338.

Shiow YW, Shin-Shan L (2002). Composts as soil supplement enhanced plant growth and fruit quality of strawberry. Journal of Plant Nutrition, 25 (10): 2243-2259.

Siddique Y, Meon S, Ismail R, Rahmani M and Ali A (2008). Bio-efficiency of compost extracts on the wet rot incidence, orphological and physiological growth of okra (Abelmoschusesculentus [(L.) Moench]. Science Horticulture, 117: 9-14.

Singh R, Sharma RR, Satyendra-Kumar, Gupta RKandPatil RT (2008). Vermicompost substitution influences growth, physical disorders, fruit yield and quality of strawberry (Fragaria x ananassaDuch.).Biorsource Technology, 99: 8507-8511.

Tarchoun N, Ben Khedher M (2010). Assessment of organic composts on growth and production of artichoke. International Journal of Vegetable Science, 16(2): 191-198.

Tariq M, Sharif Z, Shah Z and Khan R (2007). Effect of foliar application of micronutrients on the yield and quality of sweet orange (*Citrus sinensis* L.). Pakistan Journal of Biological Science, 10: 1823-1828.

Weber S, Luoders T, Friedrich MW, Conrad R (2001). Methanogenicpopulations involved in the degradation of rice straw in anoxic paddy soil. FEMS Microbial, Ecol., 38:11-20.

Zaccardelli M, Pane C, Scotti R, Palese AM, Celano G (2012). Use of compost tea as bio-agrochemicals and bio-stimulants in horticulture.ItalusHortus, 19: 17-28.