**Natural Resources, 2015, 6, 457-464**
Published Online July 2015 in SciRes. http://www.scirp.org/journal/nr
http://dx.doi.org/10.4236/nr.2015.67044

# Optimizing Yield and Nutrients Content in Tomato by Vermicompost Application under Greenhouse Conditions

**Syed Ishtiaq Hyder*, Muhammad Farooq, Tariq Sultan, Arshad Ali, Muhammad Ali, Muhammad Zahid Kiani, Shahbaz Ahmad, Tausif Tabssam**

National Agricultural Research Centre (NARC), Islamabad, Pakistan
Email: *hyder292002@yahoo.com

Received 10 June 2015; accepted 21 July 2015; published 24 July 2015



## Abstract

**Optimizing yield and nutrients content in crop production is the high time demand of arable farming. Vermicompost furnishes one of the most promising alternatives to costly chemical fertilizer. Therefore, a greenhouse experiment was conducted at NARC, Islamabad, to investigate the effect of different levels of vermicompost [having C/N=15/1 and 14 Plant Growth Promoting Rhizobacteria (PGPR)] on growth, yield and nutrients content in hybrid tomato (National Tunnel Tomato-04-08) under greenhouse conditions during Rabi 2015. The data revealed that different rates (0.5 t·ha$^{-1}$, 1 t·ha$^{-1}$, 1.5 t·ha$^{-1}$ and 2 t·ha$^{-1}$) of vermicompost produced varied and significant ($P < 0.05$) effect on the vegetative growth parameters (shoot length, root length, dry shoot weight and dry root weight), yield parameters (number of fruits per treatment and total yield) recorded at physiological maturity. Tomato fruit yield was the maximum (4.383 t·ha$^{-1}$) at the application of 2.0 t vermicompost ha$^{-1}$ followed by 3.226 t·ha$^{-1}$ where vermicompost was applied @ 1.5 t·ha$^{-1}$. N, P and K content in tomato fruit and plant increased significantly with the application of increasing levels of vermicompost. The highest content of N (3.7%), P (0.67%), K (5.17%) in tomato fruit and N (3.4%), P (0.32%), K (3.2%) in tomato plant respectively were registered with soil application of vermicompost @ 2.0 t·ha$^{-1}$. This study confirms that the vermicompost has a tremendous potential of plant nutrients supply for sustainable crop production.**

## Keywords

**Vermicompost, PGPR, Tomato, Yield, Nutrients and Humic Acid**

*Corresponding author.

**How to cite this paper:** Hyder, S.I., Farooq, M., Sultan, T., Ali, A., Ali, M., Kiani, M.Z., Ahmad, S. and Tabssam, T. (2015) Optimizing Yield and Nutrients Content in Tomato by Vermicompost Application under Greenhouse Conditions. *Natural Resources*, **6**, 457-464. http://dx.doi.org/10.4236/nr.2015.67044

## 1. Introduction

Application of excessive chemical fertilizers may affect soil health and sustainable productivity. It is imperative to search for possible alternate organic manures that can sustain soil health and crop production. Organic manures having humic substances not only improve soil fertility by modifying soil physical and chemical properties [1], [2] but also improves the moisture holding capacity of soil, thus resulting in enhanced crop productivity along with better quality of crop produce [3]. Although organic manures contain plant nutrients in small quantities as compared with the chemical fertilizers, the presence of PGPR strains that plays an important role in increasing availability of nitrogen and phosphorus besides improving biological fixation of atmospheric nitrogen and enhancing phosphorus availability to crop [4] and growth promoting substances like enzymes and hormones, along with plant nutrients make them essential for improvement of soil fertility and productivity [5]. Sustainability in agriculture refers to the capacity to remain productive while maintaining the soil fertility but without effecting soil biodiversity. Humus derived from vermicompost is most commonly used for sustainable production [3] due to its beneficial effects on nutrient uptake and retention, pest control and productivity [6]. Among such preparations, vermicompost has been recognized as having considerable potential for soil amendments [7]. Humus originated from vermicompost is a finely divided manure peat like material with high porosity, aeration, drainage and water holding capacity and microbial activity and is stabilized by interaction between earthworms and microorganisms in a non-thermophilic process [8]. Vermicompost is made up primarily of carbon (C), hydrogen (H) and oxygen (O) and contains nutrients such as $NO_3$, $PO_4$, Ca, K, Mg, S and other micronutrients which exhibit similar effects on plant growth and yield as inorganic fertilizers when applied to soil [9]. Vermicompost also contains a high proportion of humic substances (humic acids, fulvic acids and humin) which provide numerous sites for chemical reaction; microbial components known to enhance plant growth and disease suppression through the activities of bacteria (*Bacillus*), yeast (*Sporobolomyces* and *Cryptococcus*) and fungi (*Trichoderma*), as well as chemical antagonists such as phenols and amino acids [10]. The significant increase in soil enzyme activities such as urease, phosphomonoesterase, phosphodiesterase and arylsulphatase was reported by [11] with vermicompost application. Several studies also report vermicompost application suppresses infection by insect pests, repel crop pests and induce biological resistance in plants against pests and diseases due to the presence of antibiotics and actinomycetes [12]. Use of vermicompost in horticulture at large scale can solve the management and disposal problem associated with macrophytes and also resolves the deficiency of organic matter in such soils in addition to nutrient depletion [13]. The objective of the study was to optimize yield and nutrients content in tomato plant under greenhouse conditions through vermicompost application.

## 2. Materials and Methods

The experiment was conducted with collaboration of organic farming institute at tunnel of NARC. Seedlings of hybrid tomato (National Tunnel Tomato-04-08) were grown during 2014 and 2015 to determine the effect of vermicompost. The vermicompost was applied at the beginning of November 2014. Field plots were 3 m long and 2 m wide (6 $m^2$) and vermicompost was applied at the rate of 0 $t\cdot ha^{-1}$ (control), 0.5 $t\cdot ha^{-1}$, 1.0 $t\cdot ha^{-1}$, 1.5 $t\cdot ha^{-1}$ and 2 $t\cdot ha^{-1}$. The vermicompost was incorporated into the top 15 cm of rhizosphere. The plots were arranged in a completely randomized design with 3 replications of each treatment. All the necessary cultural practices and plant protection measures were followed uniformly for all the treatments during the entire period of experimentation

Soil and vermicompost samples were analyzed for various physic-chemical properties using standard methods using ICARDA manual [14] (**Table 1-3**).

### 2.1. Preparation of Vermicompost

Different plant material including plat waste were collected from NARC and then mixed with cattle dung in 2:1 ratio (100 kg plant material: 50 kg of cow dung). Healthy and adult individuals of earthworm (*Eisenia fetida*) were allowed to feed on mixture and converted them into vermicompost during 60 days duration [13].

#### 2.1.1. Effect of Vermicompost on Yield of Tomato

Vermicompost significantly affected yield of tomato fruits. Results in **Figure 1** showed the maximum fruit yield 4.383 $t\cdot ha^{-1}$ was registered where vermicompost was applied @ 2.0 $t\cdot ha^{-1}$ followed by 3.226 $t\cdot ha^{-1}$ where vermin-

**Table 1.** Physico-chemical analysis of soil.

| Soil characters | Unit | Values |
|---|---|---|
| pH | - | 7.6 |
| EC (1:1) | $(dS\cdot m^{-1})$ | 1.6 |
| $NO_3$-N | $(mg\cdot kg^{-1})$ | 3.4 |
| K | $(mg\cdot kg^{-1})$ | 140 |
| Available P | $(mg\cdot kg^{-1})$ | 1.5 |
| Textural Class | | Loam |

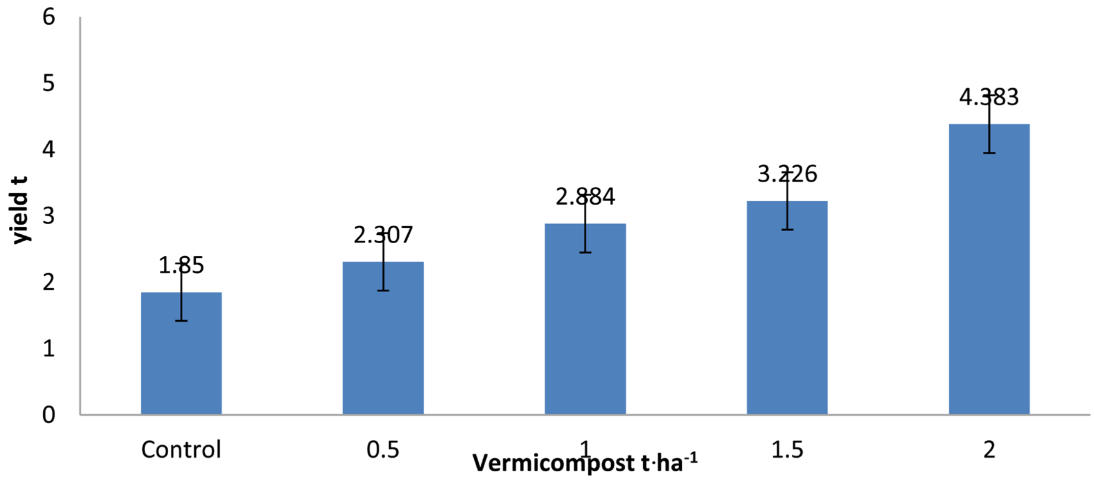
**Table 2.** Physico-chemical analysis of vermicompost.

| Soil characters | Unit | Values |
|---|---|---|
| pH | - | 7.5 |
| EC (1:1) | $(dS\cdot m^{-1})$ | 3.0 |
| Total N | % | 2.3 |
| K | % | 2 |
| Total P | % | 0.3 |
| C/N | | 15/1 |
| Organic matter | % | 25 |
| PGPR strains | | 14 |

**Table 3.** Biochemical characterization of isolated PGPR.

| Sr. No | Strain Name | Form | Catalase | Amylase | Protease | Pectinase | Pikovskaya |
|---|---|---|---|---|---|---|---|
| **1** | VC1 | circular | + | - | | + | +++ |
| **2** | VC2 | spindle | + | + | + | - | - |
| **3** | VC3 | circular | + | + | + | - | ++ |
| **4** | VC4 | circular | + | + | - | - | + |
| **5** | VC5 | circular | + | + | + | - | - |
| **6** | VC6 | irregular | + | + | + | - | + |
| **7** | VC7 | circular | + | + | - | - | + |
| **8** | VC8 | punctiform | + | + | - | + | - |
| **9** | VC9 | spindle | + | + | - | + | + |
| **10** | VC10 | circular | + | + | - | + | - |
| **11** | VC11 | circular | + | + | - | - | + |
| **12** | VC12 | circular | + | + | - | - | + |
| **13** | VC13 | circular | + | + | - | + | + |
| **14** | VC14 | circular | + | + | - | + | + |

compost was applied @ 1.5 $t\cdot ha^{-1}$. It was probably due to humic acid derived from vermicompost having more readily available nutrients and growth regulating substances such as urease, phosphomonoesterase, phosphodiesterase and arylsulphatase. Similar findings have been reported by [15] who attributed plant growth was due to more readily available nutrients and PGPR having growth regulating substances present in the vermicompost. The significant increase in yield might be attributed to improved uptake of N, P and K from vermicompost as well as increased chlorophyll production in the leaves [16]. vermicompost increase microbial populations with production of plant-growth-influencing materials and build-up of plant resistance or tolerance to crop disease and nematode attack [17]. Moreover macronutrients play important role in enhancing yield based on their role in activation of enzymes for chlorophyll synthesis, growth, fruit ripening and maintenance of the plant's enzyme system [18].




(a)


Control

0.5 t·ha$^{-1}$

1.0 t·ha$^{-1}$

1.5 t·ha$^{-1}$

2.0 t·ha$^{-1}$

(b)

**Figure 1.** Effect of vermicompost application on tomato yield (t·ha$^{-1}$).

#### 2.1.2. Effect of Vermicompost on Number of Fruits/3 Plants and Diameter (cm) of Tomato Fruit

Vermicompost significantly affected number of tomato fruit. Results in **Figure 2** and **Figure 3** showed the highest number of fruit yield/3 plants (97) and diameter of fruit (6.75 cm) followed by 80 and (5.96 cm) number and diameter of fruit were registered where vermicompost was applied @ 2.0 t·ha$^{-1}$ and 1.5 t·ha$^{-1}$ respectively. It was probably due to vermicompost having more readily available nutrients and growth regulating substances such as urease, phosphomonoesterase, phosphodiesterase and arylsulphatase. These results are in consonance to findings of [15] who attributed plant growth was due to more readily available nutrients and growth regulating substances of PGPR present in the vermicompost. The significant increase in yield and fruit quality of *L. esculentum* might be attributed to improved uptake of N, P and K from vermicompost as well as increased chlorophyll production in the leaves [16]. Vermicompost increase microbial populations with production of plant-growth-influencing materials and build-up of plant resistance or tolerance to crop disease and nematode attack [17].

### 2.1.3. Effect of Vermicompost on Shoot and Root Length of Tomato

Vermicompost significantly affected plant growth parameters. Results in **Figure 4** showed the maximum shoot and root length were 217 cm and 37 cm where vermicompost was applied @ 2.0 t·ha$^{-1}$ followed by 203 cm and 36 cm where vermicompost was applied @ 1.5 t·ha$^{-1}$. Plant growth was due to more readily available nutrients and plant growth regulating substances of PGPR present in the vermicompost as reported by [15]. The significant increase in growth parameters with application of vermicompost in *L. esculentum* was reported by [19]. Vermicompost having hormone-like activity aids in greater root initiation, increased root biomass, enhanced plant growth [20].

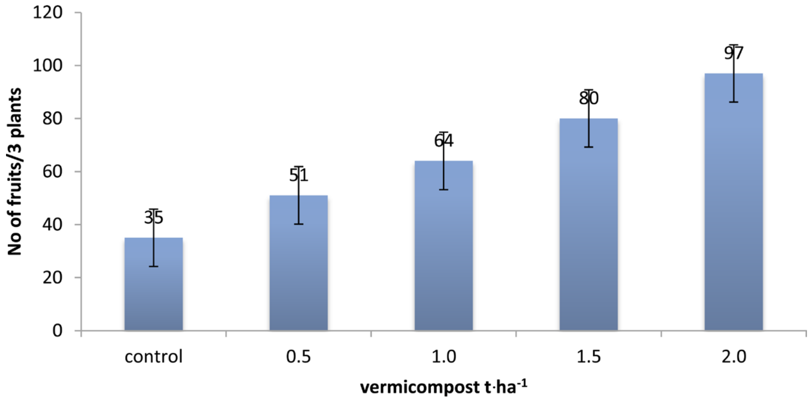



**Figure 2.** Effect of vermicompost on number of fruits/3 plants.

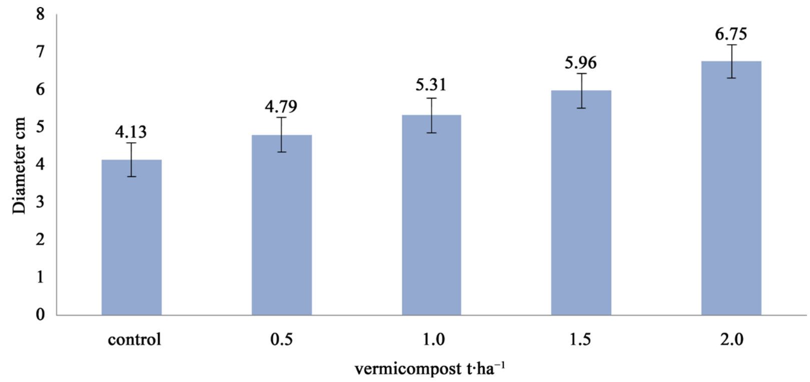



**Figure 3.** Effect of vermicompost on diameter (cm) of tomato.

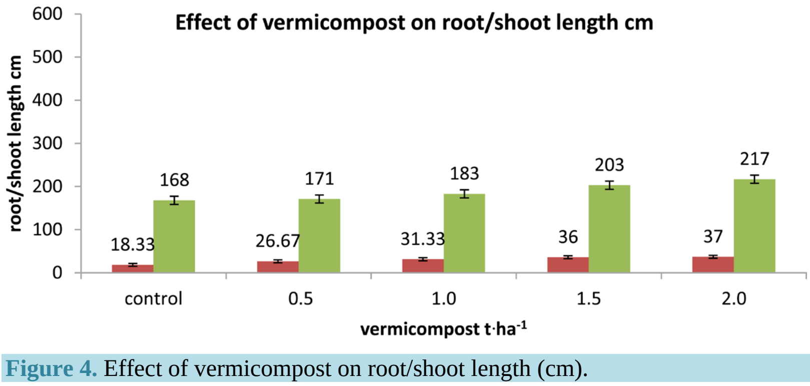



**Figure 4.** Effect of vermicompost on root/shoot length (cm).

#### 2.1.4. Effect of Vermicompost on Dry Shoot and Root Weight of Tomato

Vermicompost significantly affected plant growth parameters. Results in **Figure 5** showed the maximum dry shoot and root weight were 140 g and 10.7 g where vermicompost was applied @ 2.0 t·ha$^{-1}$ followed by 125 g and 9 g where vermicompost was applied @ 1.5 t·ha$^{-1}$. According to [20] vermicompost increased dry weight in french marigold, pepper, tomato and cornflower.

### 2.2. Nitrogen, Phosphorus and Potassium Content in Tomato Fruit (%)

Nitrogen, Phosphorus and Potassium content in tomato fruit were significantly increased by application of vermicompost. Results in **Figure 6** show that the highest concentration of N (3.7%) which was 76% more than control , P (0.67%) which was 37% more than control and K (5.17%) 30% more than control were recorded in tomato fruit at maturity with vermicompost application @ 2.0 t·ha$^{-1}$. The increase in N, P and K concentration might be due to PGPR nitrogen fixation, the enhancement of plant growth by mycrorrhizal colonization and enhanced uptake of phosphorous has been reported by [21]. Vermicompost contains most nutrients in plant available forms such as phosphates, exchangeable calcium, soluble potassium and other macronutrients with huge quantity of beneficial microorganisms, vitamins and hormones which influence growth and yield of plants [10].

### 2.3. Nitrogen, Phosphorus and Potassium Content in Tomato Plant (%)

Nitrogen, Phosphorus and Potassium content in tomato fruit were significantly increased by application of vermicompost. Results in **Figure 7** show that the highest concentration of N (3.2%), P (0.32%) and K (3.4%) were

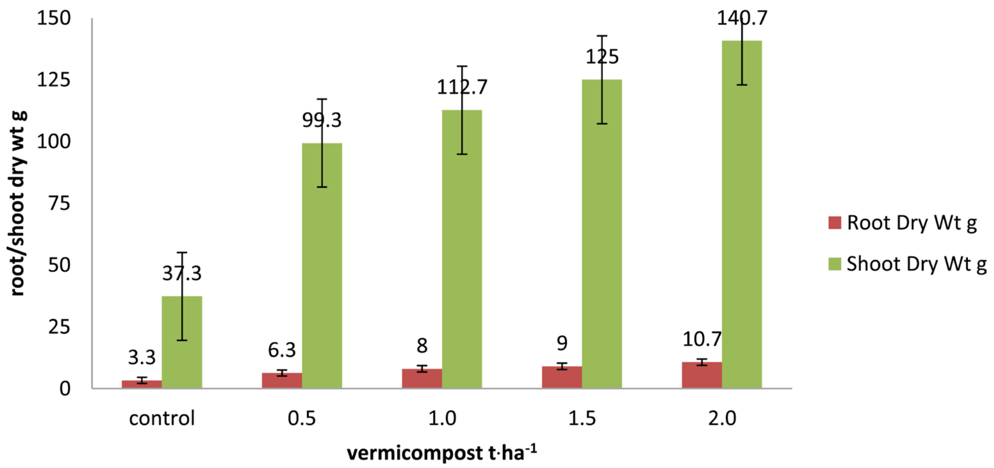



**Figure 5.** Effect of vermicompost on shoot/root dry wt (g) of tomato.

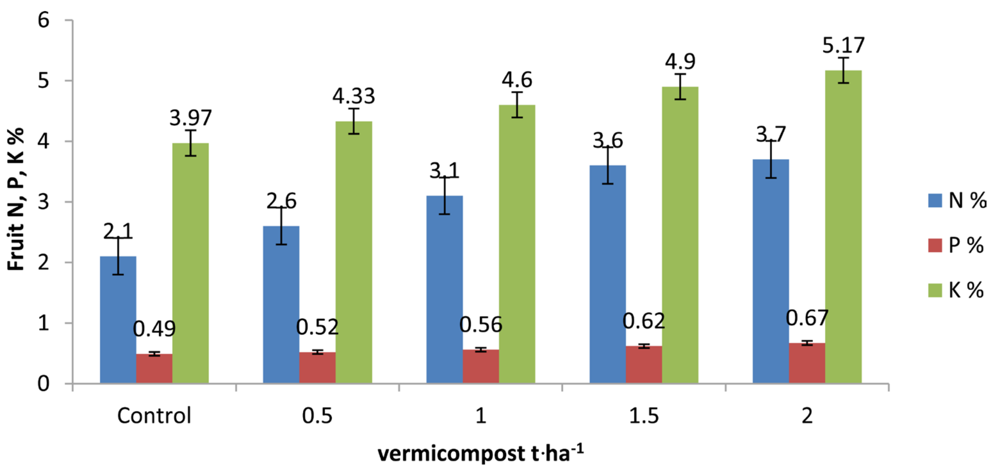



**Figure 6.** Effect of vermicompost on N, P and K (%) tomato fruit.

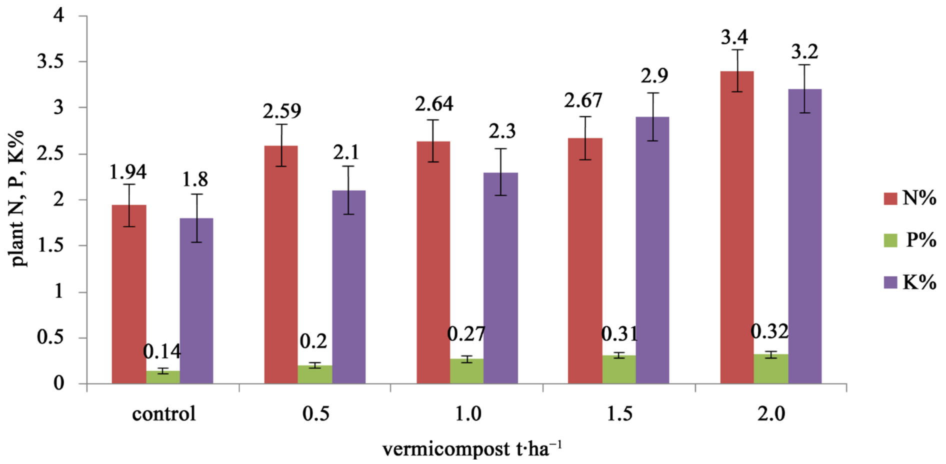



**Figure 7.** Effect of vermicompost on N, P, K (%) of tomato plant.

recorded in tomato plant after 30 days of vermicompost application. Whereas N (1.94%), P (0.14%) and K (1.8%) in control having no vermicompost were recorded. The increase in N, P and K concentration might be due to PGPR nitrogen fixation, The enhancement of plant growth by mycrorrhizal colonization and enhanced uptake of phosphorous has been reported by [21].

## 3. Conclusion

The maximum tomato fruit yield (4.383 t·ha$^{-1}$) followed by (3.226 t·ha$^{-1}$) were registered with the application of 2.0 t vermicompost ha$^{-1}$ and 1.5 t vermicompost ha$^{-1}$ respectively. The highest content of N (3.7%), P (0.67%), K (5.17%) in tomato fruit and N (3.4%), P (0.32%), K (3.2%) in tomato plant respectively were registered with soil application of vermicompost @ 2.0 t·ha$^{-1}$. It is concluded that increasing rate of vermicompost not only optimizes tomato yield and nutrients content but also has a tremendous potential of plant nutrients supply for sustainable crop production. Nutrients supply is the result of microbial activity which is excreted through earthworm gut.

## References

[1] Asik, B.B., Turan, M.A., Celik, H. and Katkat, A.V. (2009) Effect of Humic Substances to Dry Weight and Mineral Nutrients Uptake of Wheat on Saline Soil Conditions. *Asian Journal of Crop Science*, **1**, 87-95. http://dx.doi.org/10.3923/ajcs.2009.87.95

[2] Heitkamp, F., Raupp, J. and Ludwig, B. (2011) Soil Organic Matter Pools and Crop Yields as Affected by the Rate of Farmyard Manure and Use of Biodynamic Preparations in a Sandy Soil. *Organic Agriculture*, **1**, 111-124. http://dx.doi.org/10.1007/s13165-011-0010-7

[3] Premsekhar, M. and Rajashree, V. (2009) Influence of Organic Manures on Growth, Yield and Quality of Okra. *American-Eurasian Journal of Sustainable Agriculture*, **3**, 6-8.

[4] Bhat, T.A., Gupta, M., Ganai, M.A., Ahanger, R.A. and Bhat, H.A. (2013) Yield, Soil Health and Nutrient Utilization of Field Pea (*Pisum sativum* L.) as Affected by Phosphorus and Biofertilizers under Subtropical Conditions of Jammu. *International Journal of Modern Plant and Animal Science*, **1**, 1-8.

[5] Szczeck, M.M. (1999) Suppressiveness of Vermicompost against Fusarium wilt of Tomato. *Journal of Phytopathology*, **47**, 155-161. http://dx.doi.org/10.1111/j.1439-0434.1999.tb03822.x

[6] Barrios-Masias, F.H., Cantwell, M.I. and Jackson, L.E. (2011) Cultivar Mixtures of Processing Tomato in an Organic Agroecosystem. *Organic Agriculture*, **1**, 17-30. http://dx.doi.org/10.1007/s13165-010-0002-z

[7] Wei, Y.Y., Aziz, N.A.A., Shamsuddin, Z.H., Mustafa, M., Aziz, S.A. and Kuan, T.S. (2012) Enhancement of Plant Nutrient Contents in Rice Straw Vermicompost through the Addition of Rock Phosphate. *Acta Biologica Malaysiana*, **1**, 41-45. http://dx.doi.org/10.7593/abm/1.1.41

[8] Edwards, C.A. and Burrows, I. (1988) The Potential of Earthworm Composts as Plant Growth Media. In: Edwards, C.A. and Neuhauser, E.P., Eds., *Earthworms in Environmental and Waste Management*, SPB Academic Publishers, Netherlands, 211-220.

[9] Singh, R., Sharma, R.R., Kumar, S., Gupta, R.K. and Patil, R.T. (2008) Vermicompost Substitution Influences Growth, Physiological Disorders, Fruit Yield and Quality of Strawberry (*Fragaria xananassa* Duch). *Bioresource Technology*, **99**, 8507-8511. http://dx.doi.org/10.1016/j.biortech.2008.03.034

[10] Theunissen, J., Ndakidemi, P.A. and Laubscher, C.P. (2010) Potential of Vermicompost Produced from Plant Waste on the Growth and Nutrient Status in Vegetable Production. *International Journal of Physical Science*, **5**, 1964-1973.

[11] Albiach, R., Canet, R., Pomares, F. and Ingelmo, F. (2000) Microbial Biomass Content and Enzymatic Activities after Application of Organic Amendments to a Horticultural Soil. *Bioresource Technology*, **75**, 43-48. http://dx.doi.org/10.1016/S0960-8524(00)00030-4

[12] Munroe, G. (2007) Manual of On-Farm Vermicomposting and Vermiculture. Publication of Organic Agriculture Centre of Canada, Nova Scotia.

[13] Najar, I.A. and Khan, A.B. (2013) Management of Fresh Water Weeds (Macrophytes) by Vermicomposting Using *Eisenia fetida*. *Environmental Science and Pollution Research*, **20**, 6406-6417. http://dx.doi.org/10.1007/s11356-013-1687-9

[14] Ryan, J., Estenfan, G. and Rashid, A. (2001) Soil and Plant Analysis. Laboratory Manual, National Agricultural Research Centre, Islamabad.

[15] Pritam, S., Garg, V.K. and Kaushik, C.P. (2010) Growth and Yield Response of Marigold to Potting Media Containing Vermicompost Produced from Different Wastes. *Environmentalist*, **30**, 123-130. http://dx.doi.org/10.1007/s10669-009-9251-3

[16] Tejada, M., Gonzalez, J., Hernandez, M. and Garcia, C. (2007) Agricultural Use of Leachates Obtained from Two Different Vermicomposting Processes. *Bioresource Technology*, **99**, 6228-6232. http://dx.doi.org/10.1016/j.biortech.2007.12.031

[17] Arancon, N.Q., Edwards, C.A. and Bierman, P. (2006) Influences of Vermicomposts on Field Strawberries: Effects on Soil Microbial and Chemical Properties. *Bioresource Technology*, **97**, 831-840. http://dx.doi.org/10.1016/j.biortech.2005.04.016

[18] Grusak, M.A. and DellaPenna, D. (1999) Improving the Nutrient Composition of Plants to Enhance Human Nutrition and Health. *Annual Review of Plant physiology and Plant Molecular Biology*, **50**, 133-161. http://dx.doi.org/10.1146/annurev.arplant.50.1.133

[19] Joshi, R. and Vig, A.P. (2010) Effect of Vermicompost on Growth, Yield and Quality of Tomato (*Lycopersicum esculentum* L). *African Journal of Basic and Applied Science*, **2**, 117-123.

[20] Bachman, G.R. and Metzger, J.D. (2008) Growth of Bedding Plants in Commercial Potting Substrate Amended with Vermicompost. *Bioresource Technology*, **99**, 3155-3161. http://dx.doi.org/10.1016/j.biortech.2007.05.069

[21] Cavender, N.D., Atiyeh, R.M. and Michael, K. (2003) Vermicompost Stimulates Mycorrhizal Colonization of Roots of *Sorghum bicolor* at the Expense of Plant Growth. *Pedobiologia*, **47**, 85-89. http://dx.doi.org/10.1078/0031-4056-00172