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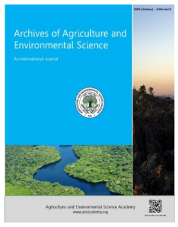

ORIGINAL RESEARCH ARTICLE

Effects of integrated nutrient management on agronomical attributes of tomato (*Lycopersicon esculentum* L.) under field conditions

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ABSTRACT

In this investigation the effects of different integrated nutrient management on agronomical attributes of tomato (*Lycopersicon esculentum* L. cv. F_1 Hybrid Arka Rakshak) under field conditions were investigated. Ten nutrients treatments viz., without nutrient (control) (T_1), recommended dose of fertilizer (RDF) (T_2), agro residue vermicompost (ARV) @ 5 t ha^{-1} (T_3), sugarcane pressmud compost (SPC) @ 5 t ha^{-1} (T_4), cattle dung compost (CDC) @ 12.5 t ha^{-1} (T_5), sewage sludge (SS) @ 2 t ha^{-1} (T_6), T_7 (50 % RDF + ARV @ 5 t ha^{-1}), T_8 (50 % RDF + SPC @ 5 t ha^{-1}), T_9 (50 % RDF + CDC @ 12.5 t ha^{-1}) and T_{10} (50% RDF + SS @ 2 t ha^{-1}) were used for the cultivation of *L. esculentum*. The results showed that different treatments showed significant (P<0.05/P<0.01) change in EC, OC, TKN, PO_4^{3-}, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cd, Cr, Cu, Fe, Mn and Zn of the soil. Among various treatments the most plant height, root length, dry weight, chlorophyll content, LAI, number of flowers/plant, fruits/plant, crop yield/plant, and biochemical ingredient like crude protein, dietary fiber, total carbohydrates and total sugar of *L. esculentum* was recorded with 50% RDF + ARV @ 5 t ha^{-1}. The agronomical performance of *L. esculentum* was recorded in the order of $T_7 > T_{10} > T_9 > T_8 > T_3 > T_6 > T_5 > T_4 > T_2 > T_1$ treatments. Thus, sole ARV and 50% RDF along with ARV @ 5 t ha^{-1} can be used to achieve the maximum crop yield of *L. esculentum*.

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INTRODUCTION

The use of integrated nutrient management concerned to the protection of soil productiveness and to provide these nutrients to the cultivated plants at an most favorable level for sustaining the desired yield through optimization of the benefits from all probable sources of organic, inorganic and biological ingredients in an integrated way (Prabhakar *et al.,* 2007; Sujatha *et al.,* 2008; Tetarwal *et al.,* 2011). Soil's potential to generate agricultural crops is principally determined by the environment that the soil provides for root growth. Roots absorb air, water, nutrients, and plenty space in which they develop (Shanwad *et al.,* 2010). Soil properties, such as the capability to hold up water, acidity, depth, and density determine how well roots development. Alteration in these soil characteristics unswervingly affects the health of the plant. For example, bulk density, a determination of the compactness of a soil, affects agricultural productivity (Praharaj and Rajendran, 2007; Spurti *et al.,* 2015).

Organic fertilizers hold comparatively low concentrations of nutrients in contrast to chemical one, but they perform significant functions which the chemical fertilizers do not do (Jeyajothi and Nalliah, 2015). The addition of organic fertilizers and their appropriate administration can be decreased the need for chemical fertilizers thus allowing the small farmers to save in the part the price of manufacture. Additionally, the discharge of inorganic fertilizers compared to organic one is higher. As a result, available nutrients are utilized and lost rapidly by different means. Alternatively, organic fertilizers were decomposed gradually and nutrients are accessible for longer period of time which helps to preserve soil nutrient status (Praharaj and Rajendran, 2007; Tetarwal *et al.,* 2011).

The growth of crop plants is the result of a complex process whereby the crop plants synthesizes sun power, carbon dioxide, water, and nutrients from the soil. In all, between 21 and 24 elements are necessary for plant growth (Kalhapure *et al.,* 2013). The primary nutrients for plant growth are nitrogen, phosphorus, and potassium (NPK). Whilst inadequate, these primary nutrients are mainly accountable for limiting crop development (Antil and Singh, 2007; Pandey and Chandra, 2013). Nitrogen, the most intensively used element, is accessible in almost infinite quantities in the atmosphere and is repeatedly recycled among plants, soil, water, and air. However, it is often unavailable in the right form for proper absorption and synthesis by the plant (Togay *et al.,* 2008).

As a vegetable tomato *(Lycopersicon esculentum)* is the most essential vegetable crops for human nutrition in most countries (Javaria and Khan, 2010; Pandey and Chandra, 2013). Tomato is one of the vital vegetable crops cultivated in India. Among the major contributing states Andhra Pradesh, Uttarakhand, Orissa, Karnataka, Madhya Pradesh, West Bengal, Uttar Pradesh, Bihar and Maharashtra the average productivity is highest in (35 t/ha) mostly due to the favorable environmental conditions and adoption of high yielding hybrids. However, India yet to attain the yield potential (80-120 t/ha) due to low adoption of hybrids and incidence of pests, diseases and other abiotic factors (Pandey and Chandra, 2013).

The dearth of plant nutrients causes different alteration in the physiological and biochemical processes within the plant cell resulting in a reduction of growth, delay of development and qualitative and quantitative decrease of yield (Saxena and Diwakar, 2012). The organic sources besides supplying N, P and K also formulate unavailable basis of elemental nitrogen, bound phosphorus, and other micronutrients, and decomposed plant residues into an obtainable form to make possible to plant to take up the nutrients. But, it is also the fact that most favorable yield of maize yield can not be achieved by using only organic manures due to their low nutrient content (Nehra and Hooda, 2002; Islam *et al.,* 2012). The usefulness of organic sources to meet the nutrient requisite of crop is not as assured as mineral fertilizers, but the joint employ of chemical fertilizers along with various organic sources is capable of improving soil quality and higher crop productivity on long- term basis (Islam *et al.,* 2012). Highest productivity of crops in sustainable manner with no worsening the soil and other natural resources could be achieved only by applying proper amalgamation of different organic manures and inorganic fertilizers (Chandrashekara *et al.,* 2000; Das *et al.,* 2004; Chopra *et al.,* 2012). It is important to identify the appropriate type of available organic resources which can be used as fertilizers and their best combination with appropriate proportion of inorganic fertilizer (Venugopalan and Pundarikakshudu, 1999; Rochester *et al.,* 2001; Basavaneppa and Biradar, 2002; Hepperly *et al.,* 2009; Pandey and Chandra, 2013). Keeping in view, this experimental trail was carried out to study the effects of integrated nutrient management on agronomical attributes of tomato (*Lycopersicon esculentum* L.) under field conditions.

MATERIALS AND METHODS

Experimental design: The field experiments were conducted in the Experimental Garden of the Department of Zoology and Environmental Sciences, Gurukula Kangri University Haridwar, India (29°55'10.81" N and 78°07'08.12" E) during the year 2013 and 2014. For the cultivation of *L. esculentum*, ten plots (each plot had an area of 9× 9m^2) were selected for the ten treatments viz., without nutrient (control) (T_1), recommended dose of fertilizer (RDF) (T_2), agro residue vermicompost (ARV) @ 5 t ha^{-1} (T_3), sugarcane pressmud compost (SPC) @ 5 t ha^{-1} (T_4), cattle dung compost (CDC) @ 12.5 t ha^{-1} (T_5), sewage sludge (SS) @ 2 t ha^{-1} (T_6), T_7 (50 % RDF + ARV @ 5 t ha^{-1}), T_8 (50 % RDF + SPC @ 5 t ha^{-1}), T_9 (50 % RDF + CDC @ 12.5 t ha^{-1}) and T_{10} (50 % RDF + SS @ 2 t ha^{-1}) (Table 1). All the treatments were placed within randomized complete block design.

Preparation of nursery and transplantation of *L. esculentum*: Seeds of a high yield variety of *L. esculentum*, cv. F_1 Hybrid Arka Rakshak, were procured from Indian Council of Agriculture Research (ICAR), Pusa, New Delhi, and sterilized with 0.01% Thiram. The nursery was prepared before one month of transplantation of *L. esculentum*. For the nursery preparation 0.6 g seeds of *L. esculentum* were sown in the nursery beds (farm yard manure mixed soil). The bed for nursery preparation was covered with mulch of wheat straw till the germination of seeds. The plants were watered as per requirement and other agronomical practices like weeds removal and hoeing for soil preparation were performed till the plants were transplanted in the field. Four weeks old plants of *L. esculentum* were transplanted in 6 rows with a distance of 60×60 cm between plants (Chopra and Kanwar, 1976; Saxena and Diwakar, 2012). The plants in each plot were irrigated twice in a month with 100 gallons of bore well water and necessary agronomical practices were performed.

Study of crop parameters: The agronomic parameters of *L. esculentum* at different stages (0-110 days) were determined following standard methods for plant height, root length, number of flowers and crop yield (Saxena and Diwakar, 2012); dry weight was estimated as per method of Denison and Russotti, 1997; chlorophyll content was determined by Porra, 2002 and leaf area index (LAI) was measured by following Milner and Hughes (1968). The biochemical parameters like crude protein, dietary fiber, total carbohydrate and total sugar in *L. esculentum* were determined following standard methods (Cerning and Guilhot, 1973; Chaturvedi and Sankar, 2006).

Soil and heavy metals analysis: The soil was analyzed after harvest of *L. esculentum* for various physico-chemical parameters like EC, pH, OC, TKN, PO_4^{3-}, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cd, Cr, Cu, Fe, Mn and Zn following standard methods (Jackson, 1973; Chaturvedi and Sankar, 2006). For heavy metals analysis 1.0 g of air dried soil or plants were taken in digestion tubes separately. For each sample 3 ml of concentrate HNO_3 was added and digested in an electrically heated block for 1 hour at 145°C. To this mixture 4 ml of $HClO_4$ was added and heated to 240°C for 1 hour. The mixture was cooled and it was filtered using the filter paper Whatman # 42. The volume was made to 50 ml by adding double distilled water and used for analysis. Metals were analyzed using an atomic absorption spectrophotometer (PerkinElmer, Analyst 800 AAS, GenTech Scientific Inc., Arcade, NY) following methods (Chaturvedi and Sankar, 2006).

Data analysis: Data were statistically analyzed using Origin (ver. 6.1). Data were subjected to one-way analysis of variance (ANOVA). The means of the values were calculated with Microsoft Excel (ver. 2013, Microsoft Redmond Campus, Redmond, WA) and graphs were prepared through Sigma plot (ver. 12.3, Systat Software, Inc., Chicago, IL).

RESULTS AND DISCUSSION

Effects of integrated nutrients on soil characteristics: The physico-chemical characteristics of soil after harvest of *L. esculentum* with different treatments are presented in Table 2. The results indicated that the treatments showed significant (P<0.05/P<0.01) change in EC, OC, TKN, PO_4^{3-}, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cd, Cr, Cu, Fe, Mn and Zn of the soil. Among various treatments the most values of EC (1.12 dS m^{-1}), OC (24.85 mg Kg^{-1}), TKN (245.90 mg Kg^{-1}), PO_4^{3-} (64.30 mg Kg^{-1}), Na^+ (68.25 mg Kg^{-1}), K^+ (140.34 mg Kg^{-1}), Ca^{2+} (280.75 mg Kg^{-1}) and Mg^{2+} (149.23 mg Kg^{-1}) in the soil were recorded with 50 % RDF + ARV @ 5 t ha^{-1} treatment (Table 2) and it might be due to the presence of more contents of these parameters in ARV. The most contents of Cd (1.54 mg Kg^{-1}), Cr (1.13 mg Kg^{-1}), Cu (1.83 mg Kg^{-1}), Fe (2.88 mg Kg^{-1}), Mn (1.84 mg Kg^{-1}) and Zn (3.55 mg Kg^{-1}) of the soil were observed with treatment T_6 i.e. sewage sludge (SS) (Figure 1). The higher contents of heavy metals in the soil after treatment with T_6 might be due to the presence of more contents of heavy metals in sewage sludge. Patil *et al*. (2003) reported that use of FYM in the soil reduced soil pH from 7.99 to 7.65 with each dose of FYM, the soil pH changed appreciably due to organic generation of acids during its decomposition. Application of organic manures such as FYM, vermicompost, crop residues improved the soil accessible nitrogen, phosphorus and potassium as compared to recommended dose of fertilizers (Patil *et al.,* 2003).

Effects of integrated nutrients on agronomical characteristics of *L. esculentum*: The mean values of agronomical parameters of *L. esculentum* cultivated with different treatments are shown in Table 3. The most values of plant height (125.40 and 145.86 cm), root length (16.20 and 18.90 cm), dry weight (78.90 and 94.50g), chlorophyll content (4.50 and 4.68 mg/gfwt), LAI (4.78 and 4.84), number of flowers/plant (45.78 and 50.53), fruits/plant (38.21 and 45.12), crop yield/plant (4680.20 5680.88 g) of *L. esculentum* were recorded with sole ARV (T_3) and 50% RDF along with ARV @ 5 t ha^{-1} (T_7), respectively and it is likely due to the presence of optimum contents of various nutrients required by *L. esculentum*. The agronomical performance of *L. esculentum* was recorded in the order of $T_7 > T_{10} > T_9 > T_8 > T_3 > T_6 > T_5 > T_4 > T_2 > T_1$ treatments (Table 3). Thimma Naik (2006) also reported that mixture of different organic fertilizers as 50% farm yard manure, 50% poultry manure, 50% vermicompost, 50% poultry manure, 50% neem cake and poultry manure@7.5 t ha^{-1} to fertilize the chilli crop significantly increased number of branches per plant and plant height, leaf area. The findings are also in the conformity with Sable *et al.* (2007) who reported higher number of branches and fruit yield with the combination of 50% nitrogen by adding neem cake and 50% nitrogen by applying vermicompost. Moreover, vermicompost moreover as a rich supply of micronutrients also acts as chelating agent and regulates the accessibility of metallic micronutrients to the plants and enhances the plant growth and yield by supplying nutrients in the accessible form and based on crop requirement. The use of organics *viz*., farm yard manure at the rate of 10 t ha^{-1} resulted in higher fruit yield and uptake of nutrients like N, P, K, Ca, Mg, S and Fe over RDF alone (Kattimani, 2004).

Effects of integrated nutrients on biochemical characteristics of *L. esculentum*: The mean values of biochemical parameters of *L. esculentum* cultivated with different treatments are shown in Figure 2. During the present study, the most values of crude protein (1.05 g/100g), dietary fiber (1.36 g/100g), total carbohydrates (4.05 g/100g) and total sugar (2.78 g/100g) of *L. esculentum* was recorded with T_7 (i.e. 50 % RDF + ARV @ 5 t ha^{-1}). It may be likely due to the maximum production of these biochemical parameters in the occurrence of most favorable uptake of essential nutrients needed by *L. esculentum*. Prabakaran

Table 1. Description of various treatments used for the cultivation of tomato (*L. esculentum*).

Treatment	Description
T_1	Without nutrient (Control)
T_2	Recommended dose of fertilizer (RDF)
T_3	Agro residue vermicompost (ARV)@ 5 t ha^{-1}
T_4	Sugarcane pressmud compost (SPC) @ 5 t ha^{-1}
T_5	Cattle dung compost (CDC) @ 12.5 t ha^{-1}
T_6	Sewage sludge (SS)@ 2 t ha^{-1}
T_7	50 % RDF + ARV @ 5 t ha^{-1}
T_8	50 % RDF + SPC @ 5 t ha^{-1}
T_9	50 % RDF + CDC @ 12.5 t ha^{-1}
T_{10}	50 % RDF + SS @ 2 t ha^{-1}

Table 2. Changes in physico-chemical characteristics of soil used for the cultivation of tomato (*L. esculentum*) after use of various treatments.

Treatment	EC (dS m^{-1})	pH	OC (mg Kg^{-1})	TKN (mg Kg^{-1})	PO_4^{3-} (mg Kg^{-1})	Na^+ (mg Kg^{-1})	K^+ (mg Kg^{-1})	Ca^{2+} (mg Kg^{-1})	Mg^{2+} (mg Kg^{-1})
T_1	0.35	7.52	10.42	124.50	21.34	23.40	45.00	224.44	34.56
T_2	0.45ns	7.65ns	10.35ns	140.30*	21.55ns	34.56ns	50.30ns	230.38ns	36.10ns
T_3	0.68*	7.23ns	11.24ns	156.90*	36.86*	42.80*	87.22*	278.90*	45.90ns
T_4	0.55*	7.34ns	12.56ns	175.44*	35.36*	50.34*	74.50*	225.66ns	38.00ns
T_5	0.76*	7.77ns	13.55ns	220.76*	44.98*	47.20*	80.90*	254.60*	40.84ns
T_6	0.52ns	7.84ns	23.87*	208.34*	58.90*	35.90ns	82.66*	230.80ns	36.92ns
T_7	1.12**	7.65ns	24.85*	245.90**	64.30**	68.25**	140.34**	280.75*	149.23*
T_8	0.88*	7.84ns	14.70ns	234.66**	48.77*	54.23*	110.20**	258.45*	124.50*
T_9	0.95*	7.45ns	18.45*	240.20**	50.34*	56.88*	118.90**	268.40*	118.77*
T_{10}	1.04**	7.80ns	16.50*	224.80**	46.90*	58.94*	120.86**	260.25*	112.96*
F-calculated	3.02	0.34	3.89	20.18	6.10	8.46	12.80	34.20	10.02
CD	2.34	1.12	2.78	9.45	4.06	3.23	7.54	10.24	5.46

Least square means; *, ** significantly different to the control at P<0.05 and P<0.01 level of ANOVA, respectively; ns-not significant; CD- critical difference.

Table 3. Effects of various treatments on agronomical attributes of tomato (*L. esculentum*).

Treatment	Plant height (cm)	Root Length (cm)	Dry weight (g)	Chlorophyll content (mg/gfwt)	LAI	Flowers/ plant	Fruits/ plant	Yield/plant (g)
T_1	85.25	10.13	20.37	3.45	4.21	30.20	27.12	3245.90
T_2	96.80*	12.87ns	34.78*	3.56ns	4.26ns	34.50ns	29.40ns	3350.60ns
T_3	125.40**	16.20ns	78.90**	4.50ns	4.78ns	45.78*	38.21*	4680.20*
T_4	110.34*	14.20ns	60.55**	3.66ns	4.35ns	37.10ns	31.20ns	3570.55ns
T_5	112.37*	15.88ns	65.87**	3.75ns	4.40ns	38.90ns	32.08ns	3780.90ns
T_6	120.70**	14.90ns	72.80**	3.80ns	4.70ns	40.78*	35.26ns	4120.10*
T_7	145.86**	18.90*	94.50**	4.68ns	4.84ns	50.23**	45.12*	5680.88*
T_8	126.30**	18.25*	78.90**	4.02ns	4.45ns	40.22*	35.40ns	3890.45ns
T_9	130.55**	17.34*	82.75**	4.45ns	4.54ns	45.42*	36.22ns	4420.60*
T_{10}	135.88**	18.55*	84.50**	4.52ns	4.77ns	46.15*	38.08ns	4890.75*
F-calculated	76.34	10.07	8.27	0.24	0.12	4.35	3.55	110.80
CD	12.34	4.52	3.24	1.23	1.10	3.23	2.56	28.57

Least square means; *, ** significantly different to the control at P<0.05 and P<0.01 level of ANOVA, respectively; ns-not significant; CD- critical difference.

and Pichai (2002) reported that the application of recommended quantity of nitrogen in the form of poultry manure recorded highest pH, total soluble solids, titrable acidity, contents of reducing sugar, non-reducing sugar, quantitative crude protein and ascorbic acid content in tomato fruit.

Effects of integrated nutrients on contents of heavy metals in L. esculentum: The mean contents of Cd, Cr, Cu, Fe, Mn and Zn in *L. esculentum* cultivated with different treatments are shown in Figure 3. The results revealed that the most contents of Cd (0.35 and 0.32 mg Kg^{-1}), Cr (0.18 and 0.15 mg Kg^{-1}), Cu (1.28 and 1.26 mg Kg^{-1}), Fe (2.25 and 2.20 mg Kg^{-1}), Mn (0.78 and 0.74 mg Kg^{-1}) and Zn (2.14 and 2.05 mg Kg^{-1}) in *L. esculentum* were recorded with T_6 (i.e. sewage sludge) and T_{10} (i.e. 50 % RDF + SS @ 2 t ha^{-1}), respectively and it is likely due to the presence of more contents of these metals in the sewage sludge and soil treated with these treatments. Kumar and Chopra (2013) also reported the higher contents of Cd, Cr, Cu, Fe, Mn and Zn in French bean (*Phaseolus vulgaris* L.) amended with sewage sludge.

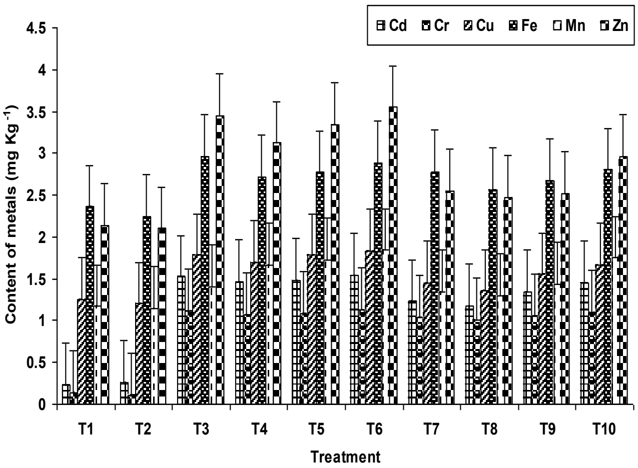

Figure 1. *Contents of heavy metals in the soil used for the cultivation of tomato (L. esculentum) after use of various treatments. Error bars are standard error of the mean.*

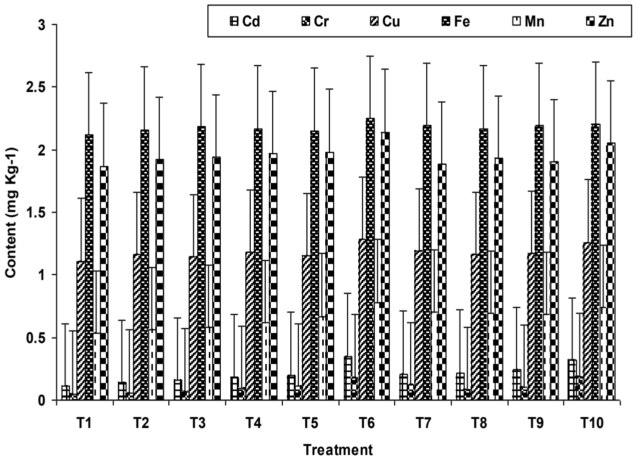

Figure 3. *Contents of heavy metals in tomato (L. esculentum) after use of various treatments. Error bars are standard error of the mean.*

Conclusion

The present study concluded that different treatments showed significant (P<0.05/P<0.01) change in EC, OC, TKN, PO_4^{3-}, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cd, Cr, Cu, Fe, Mn and Zn of the soil. The results showed that the most plant height, root length, dry weight, chlorophyll content, LAI, number of flowers/plant, fruits/plant, crop yield/plant, crude protein, dietary fiber, total carbohydrates and total sugar of *L. esculentum* was recorded with 50 % RDF + ARV @ 5 t ha^{-1} in the various applied treatments. The agronomical performance of *L. esculentum* was recorded in the order of $T_7 > T_{10} > T_9 > T_8 > T_3 > T_6 > T_5 > T_4 > T_2 > T_1$ treatments. Therefore, sole ARV and 50% RDF along with ARV @ 5 t ha^{-1} can be used to achieve the maximum crop yield of *L. esculentum*.

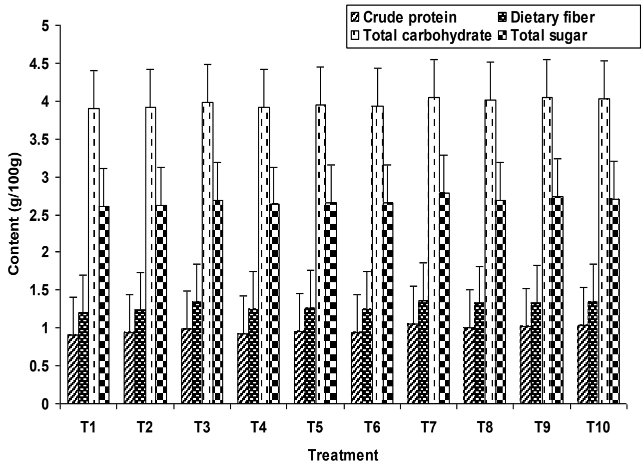

Figure 2. *Contents of crude protein, dietary fiber, total carbohydrates and total sugar of tomato (L. esculentum) after use of various treatments. Error bars are standard error of the mean.*

REFERENCES

Antil, R.S. and Singh M. (2007). Effects of organic manures and fertilizers on organic matter and nutrients status of the soil. *Archives of Agronomy and Soil Science,* 53(5): 519-528.

Basavaneppa, M.A. and Biradar, D.P. (2002). Integrated nutrient management practices on the production of cotton-maize-bengal gram sequence under irrigated ecosystem in Tungabhadra Project area. *Journal of Cotton Research and Development,* 16:125-129.

Cerning, J. and Guilhot, J. (1973) Changes in carbohydrates composition during maturation of wheat and barley kernel. *Cereal Chemistry,* 50: 220-224.

Chandrashekara, C.P., Harlapur, S.I., Murlikrishna, S. and Girijesh, G.K. (2000). Response of maize (*Zea maize* L.) to organic manures with inorganic fertilizers. *Karnataka Journal of Agriculture Science,* 13(1): 144-146.

Chaturvedi, R.K. and Sankar, K. (2006). Laboratory manual for the physico-chemical analysis of soil, water and plant. Wildlife Institute of India, Dehradun.

Chopra, S.L. and Kanwar, J.S. (1976). Analytical Agricultural Chemistry, Kalyani Publishers, New Delhi.

Chopra, A.K., Srivastava, S., Kumar, V. and Pathak, C. (2012) Agro-potentiality of distillery effluent on soil and agronomical characteristics of *Abelmoschus esculentus* L. (okra). *Environ. Monit. Assess.,* DOI 10.1007/s10661-012-3052-8.

Das, A., Prasad, M., Shivay, Y.S. and Subha, K.M. (2004). Productivity and sustainability of cotton (*Gossypium hirsutum* L)-wheat (*Triticum aestivum* L) cropping system as influenced by prilled urea, FYM and *Azotobacter*. *Journal of Agronomy and Crop Science,* 190: 298-304.

Denison, R.F. and Russotti, R. (1997). Field estimates of green leaf area index using laser-induced chlorophyll fluorescence. *Field Crops Research,* 52: 143-150.

FAO (1998). Guide to efficient plant nutrient management, Rome: Land and Water Development Division, Food and Agricultural Organization of the United Nations.

Hepperly Paul, Lotter Don, Ulsh Christine Ziegler, Seidel Rita and Reider Carolyn (2009). Compost, manure and synthetic fertilizer influences crop yields, soil properties, nitrate leaching and crop nutrient content. *Compost Science Utilization,* 17(2): 117-126.

Islam, M.R., Sikder, S., Bahadur, M.M. and Hafiz, M.H.R.

(2012). Effect of different fertilizer management on soil properties and yield of fine rice cultivar. *Journal of Environmental Science and Natural Resources,* 5(1): 239-242.

Jackson, M.L. (1973). In: *Soil Chemical Analysis*. Prentice Hall of India Private Limited, New Delhi, India.

Javaria, S. and Khan, M.Q. (2010). Impact of integrated nutrient management on tomato yield quality and soil environment. *Journal of Plant Nutrition,* 34(1): 140-149.

Jeyajothi, R. and Nalliah D.S. (2015). Influence of Integrated Nutrient management Practice on Yield Attributes, and Economics of Transplanted Rice (Oryza Sative) in South Zone of Tamil Nadu. *International Journal for Innovative Research in Science & Technology,* 1(11): 2349-6010.

Kalhapure, A.H., Shete, B.T. and Dhonde, M.B. (2013). Integrated nutrient management in maize (*Zea Mays* L.) for increasing production with sustainability. *International Journal of Agriculture and Food Science Technology,* 4(3): 195-206.

Kattimani, S. (2004). Response of chilli (*Capsicum annuum* L.) genotypes to integrated nutrient management. M.Sc(Agri) Thesis, University of Agriculture Science, Dharwad, Karnataka, India.

Kumar, V. and Chopra, A.K. (2013). Accumulation and translocation of metals in soil and different parts of French bean (*Phaseolus vulgaris* L.) amended with sewage sludge. *Bulletin of Environmental Contamination and Toxicology,* 92 (1): 103-108.

Milner, C. and Hughes, R.E. (1968). Methods for the measurement of primary production of grassland. IBP Handbook No.6 Blackwell Sci. Pub., Oxford, England.

Nehra, A.S. and Hooda, I.S. (2002). Influence of integrated use of organic manures and inorganic fertilizers on lentil and mung bean yields and soil properties. *Research of Crops,* 3(1): 11-16.

Pandey, S.K. and Chandra, K.K. (2013). Impact of integrated nutrient management on tomato yield under farmers field conditions. *Journal of Environmental Biology,* 34: 1047-1051.

Patil, P.V., Chalwade, P.B., Solanke, A.S. and Kulkarni, V.K. (2003). Effect of fly ash and FYM on physic-chemical properties of vertisols. *Journal of Soils and Crops,* 13(1): 59-64.

Porra, R.J. (2002). The chequered history of the development and use of simultaneous equations for the accurate determination of chlorophylls *a* and *b*. *Photosynthesis Research,* 73: 149-156.

Praharaj, C.S. and Rajendran, T.P. (2007). Long-term quantitative and qualitative changes in cotton (*Gossypium hirsutum* L.) and soil parameters under cultivars, cropping systems and nutrient management options. *Indian Journal of Agricultural Sciences,* 77 (4): 280-285

Patil, P.V., Chalwade, P.B., Solanke, A.S and Kulkarni, V.K. (2003). Effect of fly ash and FYM on physic-chemical properties of vertisols. *Journal of Soils and Crops,* 13(1): 59-64.

Prabhakar, T. Reddy, Umadevi, M., Rao, P.C. and Bhanumurthy, V.B. (2007). Effect of fly ash and farm yard manure on soil enzyme activities and yield of rice grown on an inceptisol. *Crop Research,* 34(1-3): 27-31.

Rochester, I.J., Peoples, M. B., Hulugalle, N.R., Gault, R.R. and Constable, G.A. (2001). Using legumes to enhance nitrogen fertility and improve soil condition in cotton cropping systems. *Field Crops Research,* 70: 27-41.

Sable, C.R., Ghuge, T.D., Jadhav, S.B. and Gore, A.K. (2007). Impact of organic sources on uptake, quality and availability of nutrients after harvest of tomato. *Journal of Soils and Crops,* 17(2): 284-287.

Saxena, R. and Diwakar, R. (2012). Biochemical Analysis of Chlorophyll Content of Brinjal Leaves. *VEGETOS,* 25 (2): 83-85

Shanwad, U.K., Aravindkumar, B.N., Hulihalli, U.K., Ashok Surwenshi, Mahadev Reddy and Jalageri, B. R. (2010). Integrated nutrient management (INM) in maize- bengal gram cropping system in Northern Karnataka. *Research Journal of Agriculture Science,* 1(3): 252-254.

Spurti, M., Malavathu, M., Mainak, G., Dulal, C. Ghosh and Jagadish, T. (2015). Effect of Integrated Nutrient Management on Growth and Productivity of Hybrid Rice. *Journal of Agricultural Science and Technology*, 5: 297-308 doi: 10.17265/2161-6264/2015.05.001.

Sujatha, M.G., Lingaraju, B.S., Palled, Y.B. and Ashalatha, K.V. (2008). Importance of integrated nutrient management practices in maize under rainfed condition. *Karnataka Journal of Agriculture Science,* 21(3): 334-338.

Tetarwal, J.P., Baldev Ram and Meena, D.S. (2011). Effect of integrated nutrient management on productivity, profitability, nutrient uptake and soil fertility in rainfed maize (*Zea mays*). *Indian Journal of Agronomy,* 56(4): 373-376.

Thimma Naik, M. (2006). Studies on the effect of organic manures on growth, yield and quality of chilli (*Capsicum annuum* L.) under Northern Transition Zone of Karnataka M.Sc (Agri) Thesis, University of Agriculture Science, Dharwad, Karnataka, India.

Togay, N., Togay, Y. and Doğan, Y. (2008). Effects of municipal sewage sludge doses on the yield, some yield components and heavy metal concentration of dry bean (*Phaseolus vulgaris* L.). *African Journal of Biotechnology,* 7(17): 3026-3030.

Venugopalan, M.V. and Pundarikakshudu, R. (1999). Long-term effect of nutrient management and cropping system on cotton yield and soil fertility in rainfed vertisols. *Nutrient Cycling in Agroecosystem,* 55: 159-164.