INFLUENCE OF *KUNAPAJALA* TREATMENT FROM VRIKSHYAURVEDA ON THE FRUITS OF TOMATO UNDER ORGANIC FARMING CONDITION AND ITS COMPARISION WITH N.P.K. FARMING

R. S. Deshmukh[1]* N. A. Patil[1] and T. D. Nikam[2]

[1] Post Graduate Research Centre in Botany, Tuljaram Chaturchand College, Baramati 413102 Dist. Pune (M.S.) India.
[2] Department of Botany; University of Pune, Pune- 411007(M.S.) India.
drupali77@yahoo.com

ABSTRACT

Kunapajala is a liquid manure of antiquity suggested in *Vrikshayurveda*. It is a fermentation product of easily available ingredients and it can be used for any plant at any growth stage. Experiments were conducted in PG Research Centre, Tuljaram Chaturchand College, Baramati, Dist-Pune (M.S.) India, using pot culture for N.P.K (N = 11g/plant, P= 21.5 g/plant and K= 4.5 g/plant respectively) and *kunapajala* treatment (5 times at interval of 10 days). *Kunapajala* treatment was found to be more effective for inducing early flowering and enhancing fruiting period, size, fresh weight and shelf life of fruit and weight of seeds as compared to N.P.K. farming. Analysis of nutritional value showed that *kunapajala* had upper hand, followed by N. P. K. farming in terms of total solids, fiber content, lycopene, ascorbic acid, carotenoids, soluble proteins, total carbohydrates and proline. It is interesting to know that the antioxidant property of tomato fruit was highest in the plants treated with *kunapajala.* The activity of oxidative enzymes like peroxidase and polyphenol oxidase was also highest (70 % and 78 %), followed by N.P.K. farming (36 % and 65 %) respectively but caloric value of *kunapajala* treated tomato fruits was lower (13 %) which is important from diet point of view for diabetic patients. So, it can be concluded that *kunapajala* treatment is superior to increase the reproductive growth, nutritional value and yield of tomato fruits along with enhancement in antioxidant property as compared to N.P.K. farming, which is very significant from both economic and health point of view.

Key words: *Kunapajala*, N.P.K.farming, tomato fruit.

INTRODUCTION

Tomato is native of tropical America. It spread to other part of the world in the 16th century and became popular in India within the last six decades. Tomato is the top source of Vitamin A and C in the diet. It also contains a significant amount of dietary fiber, beta-carotene, iron, lycopene, magnesium, niacin, potassium, phosphorus, riboflavin and thiamine. It is low in saturated fat, cholesterol and sodium.

India is the third largest synthetic NPK fertilizer producer in the world (www.apitco.org). In India, chemical fertilizers played a significant role during Green Revolution, not only in terms of meeting total requirement of food grains but also generating exportable surpluses. According to Fertilizers Association of India, during the Year 2008-09, the production of fertilizers in India was 143 lakhs tonnes and India had to import over 100 lakhs tonnes to meet the domestic requirement (Abdelaziz *et al.,* 2007). Many researchers have started to give attention to the negative effects of using NPK fertilizers in agriculture. The intensive use of chemical fertilizers has polluted underground water, destroyed beneficial soil microorganisms and reduced soil fertility (www.apitco.org). Therefore, the development of satisfactory alternatives for supplying the nutrients needed by crops could decrease the problems associated with conventional NPK chemical fertilizers and thereby protect both the environment and human health.

Organic food is believed to be healthier. It is assumed that the children whose diet consists of organic food items would have a lower probability of neuralgic health risk (Kummelinj *et al.,* 2004). In 2001, the total market value of certified organic products was U$ 20 billion which reached 40 billion in 2006. The increase in the demand for organic food is steady with annual average growth rate of 20 – 25 %.

The prices of organic food are 1.5 to 5 times higher than the conventional food (Subramanian 2006). The growth boosters or fertilizers when sprayed on the plant enter the metabolic pathway of plant and alter them, which is against the concept of organic farming. This is avoided by soil application method, where the plant absorbs required nutrients in required quantities in organic way. Though liquid fertilizer is a modern concept, the theme of liquid bio-fertilizers is mentioned in ancient Indian literature under the generic name '*Kunapajala*' by Sarangadhara (1283–1301 AD) in '*Upavanvinoda'*, Surapala (1000 AD) in '*Vrikshayurveda*' and Chakrapani Mishra (1577 AD) in '*Vishvavallabha*'. *Kunapajala* is a fermentation product using easily available ingredients like *Sesamum indicum* L. (Tila), bone marrow, flesh (sheep, goat, fish etc), milk, black gram (*Vigna mungo*), ghee, honey etc. The beauty of *kunapajala* is that, it can be used on any plant at any growth stage by soil application method.

So, with this background, an attempt is made in the present investigation to evaluate the influence of *kunapajala* treatment on the fruits of tomato (*Lycopersicon esculentum* Mill. cv. Selection 22) and compare it with N.P.K. farming.

MATERIALS AND METHODS

The experiments were carried out at P.G. Research Centre, Department of Botany, Tuljaram Chaturachand College, Baramati (18º3' N to 18º12' latitude and 74º13' E to 74º40' E longitude and 548 m above mean sea level), Dist. Pune, (M.S.) India, in shade house using pot culture method during the year 2008 to 2010. The earthen pots (40×40 cm) were used for the experimentation. N.P.K. farming (T-1) was carried out by giving the treatment of NPK dose as mentioned in the 'Krushi Sanwardhini', Dr. Panjabrao Deshmukh Krushi University, Akola (2005). *Kunapajala* (T-2) was prepared as per formula of Deshmukh *et al.* 2011 and treatment was given to plants (20 DAS) for five times at the interval of 10 days by soil application method. The pots without any treatment were considered as control. The seeds of tomato (*Lycopersicon esculentum* Mill. cv. Selection 22) were sown randomly in these pots. The experiments were carried out in triplicate.

Morphology tomato fruit was studied using routine laboratory methods. Healthy and ripened fruits from ten different plants of each treatment and control were collected, cleaned properly, blotted dry. These were cut into small pieces and composite sample was prepared. Analysis of nutritional value like pH, total acids, total solids, total soluble solids, moisture percent, fiber content, lycopene contents were measured by using the methods described by Rangana, 1977. The photosynthetic pigments like chlorophylls and carotinoids were estimated by method proposed by Arnon, 1949. Caloric value was calculated according to formula proposed by Sainy *et al*., 2006. Ascorbic acids content was estimated following the method of Sadashivam and Balasurbraminan, 1987. The biochemical constituents were analyzed using the methods proposed by Lowry *et al*., 1951 for soluble proteins, Sadashivam and Manikam, 2005 for total carbohydrates and Bates *et al*., 1973 for proline. The activity of peroxidase enzyme was determined according to the method of Malik and Singh, 1980 and that of polyphynol oxidase by Mahadevan and Shridhar, 1982. Activities of super oxide dismutase and IAA oxidase were analyzed using the methods proposed by Giannopolitis and Ries, 1977 and Tang and Bonner 1947 respectively.

RESULTS AND DISCUSSION

Impact of T-1 and T-2 (N.P.K. farming and *kunapajala*) on yield attributes in fruits of tomato is depicted in Table-1 along with control. There was decrease in number of days required for flower initiation (48, 40 and 39 days), days required for 50 % flowering (59, 51 and 49 days) and days required for fruit initiation (79, 62 and 61 days) with control, T_1, and T_2 respectively. The present results show that there was early flowering and fruiting under all treatments. Increase in length of flowering period (12 days) was the same under all the treatments compared to control plants. However the length of fruiting period, number of flowers per plant and number of fruits per plant increased by 4, 90 % and 87 % respectively with T-1 and by 14, 95 % and 91 % respectively with T-2.

This means that the best results were obtained in flowering, fruit set, early yield and yield per plant with T_2. Similar results were also obtained by Djanaguiraman *et al*., 2005, by spraying ANTONIK (nitrophenol) on tomato plant.

Kumar, 2003 obtained increase with application of Farm Yard Manure in combination with NPK to tomato. The fruit characters like length and diameter of fruit showed the highest increase under T-2 (64 % each), followed by T-1 (31 % each) compared to the control. This is an indication of better quality produced by T-2 in organic way. Prabhu *et al*., 2008 pointed out that the marketable yield per plant is correlated with plant height, branches per plant, mean fruit weight, fruit length and number of fruits per plant. In the present investigation, T-2 fruits gave more marketable yield along with good quality. The number of seeds per fruit and total weight of seeds per fruit to fruit weight ratio decreased with T-1 and T-2 respectively. At the same time weight of 100 seeds and fruit yield per plant increased with T-1 (65 % and 262 %) respectively and with T-2 (65 % and 262 %) respectively. In the present study, there is highest increase in weight of 100 seeds with T-2. This leads to better germination ability and healthy future crop. This is supported by observations of Chitale *et al*., 2010 in brinjal. As per the parameter yield per plant, T-2 showed upper hand to T-1. According to Colla *et al*., 2002, fruit yield were similar in Sustainable Agriculture Farming system (SAFs), Organic farming, Conventional Management Practices and Low Input System. So increase in yield with T-2 is remarkable. Syed *et al*., 2009 stated that plant absorbed nutrients are synthesized into compounds which determine the shelf life. In the present investigation, the shelf life increased in T-1 and T-2 and highest in T-2.This shows that better quality of fruits are produced with T-2 treatment over T-1 and control. Table-2 reveals the impact of T-1 and T-2 treatment on nutritional value of tomato fruit. There was decrease in pH value of fruit with T-1 and T-2 (0.45 each) treatment respectively. Decrease in pH gives more acidic property to fruit. Total acids and total solids were increased significantly with T-2 compared to control. According to Salam *et al*., 2010, total acids or acidity is an important factor for canning of fruits. In the present study the fruits of tomato obtained under T-2 treatment showed more acidity that leads to better preservation property.

Table 1: Impact of N.P.K. farming (T-1) and *kunapajala* (T-2) treatments on yield attributes in fruits of tomato (*Lycopersicon esculentum* Mill. cv. Selection 22.)

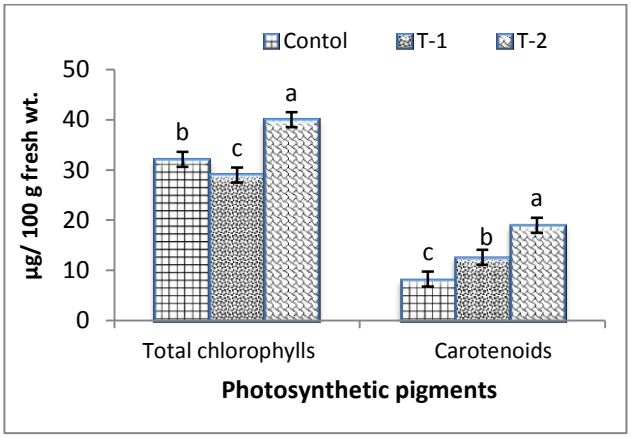
Sr. No.	Parameters	Control	Treatments	
			N.P.K. farming (T - 1)	*Kunapajala* (T - 2)
01	Days required for flower initiation	48	40	39
02	Days required to 50 % flowering	69	51	49
03	Days required for fruit initiation	81	70	61
04	Length of flowering period (days)	128	140	140
05	Length of fruiting period (days)	38	42	52
06	Number of flowers per plant	6.2^{c} ±0.633	11.81^{b} ±0.325	12.10^{a} ±0.345
07	Number of fruits/ plant	3.2^{c} ±1.363	6.0^{b} ±0.982	6.12^{a} ±0.512
09	Diameter of fruit (cm)	11.0^{c} ±1.832	14.4^{b} ±0.512	18.0^{a} ±0.502
10	Fresh weight of fruit (g)	19.78^{c} ±0.986	30.00^{b} ±0.934	30.25^{a} ±0.782
11	Number of seeds/ fruit	112.66^{a} ±1.210	106.6^{b} ±0.839	87.33^{c} ±0.413
12	Weight of 100 seeds (g)	0.290^{c} ±0.333	0.395^{b} ±0.327	0.480^{a} ±0.181
13	Total weight of seeds/fruit to fruit weight ratio	0.016	0.014	0.013
14	Fruit yield/plant (kg)	0.85^{c} ±0.515	2.84^{b} ±0.222	3.08^{a} ±0.212
15	Shelf life (days)	10.33^{c} ±0.1	11.98^{b} ±0.2	18.00^{a} ±0.22

Table 2: Impact of N.P.K. farming (T-1) and *kunapajala* (T-2) treatments on nutritional value of tomato fruits (*Lycopersicon esculentum* Mill. cv. Selection 22).

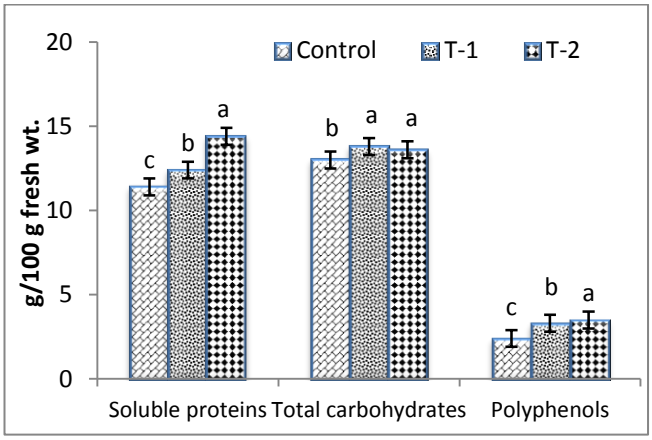
Sr. No.	Parameter	Control	Treatments	
			N.P.K. farming (T - 1)	*Kunapajala* (T - 2)
01	pH	5.25^{a} ±0.1	4.80^{b} ±0.326	4.80^{b} ±0.312
02	Total acids (%)	0.38^{c} ±0.22	0.39^{b} ± 0.01	0.45^{a} ± 0.01
03	Total solids (g)	2.09^{c} ±0.10	3.19^{b} ±0.5	3.42^{a} ±0.5
04	Total soluble solids (%)	4.48^{a} ±0.1	4.32^{b} ±0.01	3.63^{c} ±0.01
05	Caloric value (calories/100 g)	17.92^{a} ±0.1	17.28^{b} ±0.1	15.60^{c} ±0.1
06	Moisture (%)	196.0^{b} ±0.42	124.2^{a} ±0.33	96.0^{c} ±0.32
07	Fiber (%)	1.71^{b} ±0.5	1.713^{b} ±0.5	1.810^{a} ±0.5
08	Lycopene (g/100 g)	9.7^{c} ±0.5	12.33^{b} ±0.5	13.23^{a} ±0.2
09	Ascorbic acid (mg/100 g)	1333 ±0.22	1666^{b} ±0.11	2632^{a} ±0.22
10	Proline (mg/100 g dry wt.)	18.37^{c} ±0.34	24.66^{b} ±0.33	26.32^{a} ±0.22

Data presented in the Tables 1 and 2 are mean ± SE scored after 60 days from 10 plants per treatment and experiment repeated thrice. Mean followed by same letters are not significantly different at $P \leq 0.05$ level by Duncan's multiple range test.

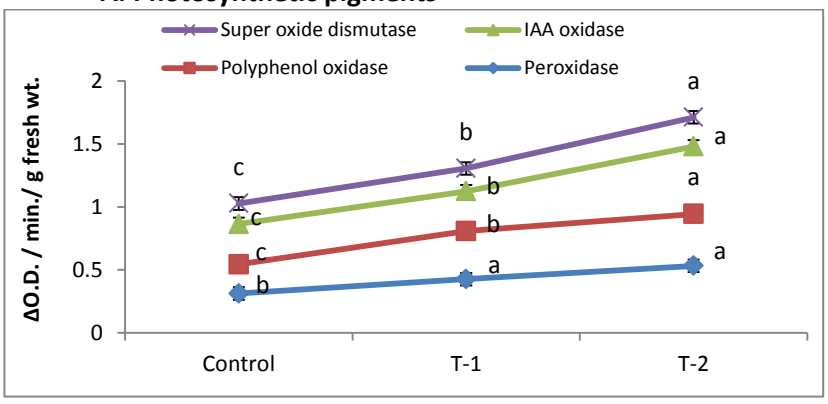
Fig. 3: Comparison of influence of N.P.K. farming (T-1) and *kunapajala* treatment (T-2) on fruits of tomato ((*Lycopersicon esculentum* Mill. cv. Selection 22) as on 60 DAS in terms of A. Photosynthetic pigments B. Bio-organics C. Oxidative enzymes.



A. Photosynthetic pigments



B. Bio-organics



C. Oxidative enzymes

Data presented in the Figure A, B and C is mean ± SE scored after 60 days from 10 plants per treatment and experiment repeated thrice. Mean followed by same letters are not significantly different at $P \leq 0.05$ level by Duncan's multiple range test.

Increase in total solids makes the fruit fleshy. So, the fruits obtained under T-2 treatment are fleshier than T-1. Total soluble solids and caloric value content decreased with T-1 and T-2, with significant decrease in T-2. Low caloric value of tomato makes it a favored choice by obese people from health point of view. Moisture percentage decreased with T-1 and T-2. Fiber percentage increased significantly with T-2.

Fiber content in tomato helps to lower the cholesterol level which maintains the blood sugar at low level (www.wikipedia.com retrieved on 06/04/2009). Lycopene content in tomato is found to be helpful in enhancing coronary health (Agarwal and Rao, 1998). Shi *et al*., 2000 reported that lycopene is a pigment responsible for the characteristic deep red colour of ripe tomato fruits and tomato products. In the present study, there was increase in lycopene content under T-1 and T-2 (27 % and 36 %) respectively. So, T-2 fruits gave better colour and better shinning. In T-2, appearance of more deep-red colour of tomato increases its market value. In the present investigation, the ascorbic acid content increased with T-1 (25 %) and T-2 (97 %) respectively. Ascorbic acid is an essential component of the cellular anti-oxidative defense system, which keeps active oxygen species under control and functions as the reductant for many free radicals, thereby minimizing the damage caused by oxidative stress (Noctor and Foyer, 1998). From this observation, it becomes clear that the percentage of ascorbic acid under T-2 treatment is highest which increases the nutritional quality of tomato fruit and at the same time, increases in proline content in T-2 (109 %) makes fruit tasty. This is supported by observation made by Chitale *et al*., 2010 in brinjal.

Figure 1 represents the effect of T-1 and T-2 on A. Photosynthetic pigments, B. Bio-organics and C. Oxidative enzyme activity in fruits of tomato. In Figure - 1 A, as compared to control, chlorophyll and caretenoid content increased with T-1 (10 % and 53 %) and T-2 (38 % and 73 %) respectively. When fruits mature, the chlorophyll content decreases leaving the caretenoid content, which is responsible for the beautiful colour of most fruits (http://www.leffingwell.com/careten.htm retrived on 13/03/2011). Krinsky, 1998 reported that caretenoid pigments such as beta-carotenoid or xanthophylls such as lutien and zeaxanthin are widely distributed in nature, where they play an important role in protecting cells and organisms against the harmful effects of light, air and sensitizer pigments. He further added that the carotenoids can also serve as antioxidant under conditions other than photosensitization. In the present investigation, there was increase in chlorophyll and caretenoid content under all the treatments compared to the control plant, with T-2 showing highest increase. This implies that the tomato plants grown under T-2 treatment undergo oxidative damage to lower level due to the higher level of carotenoid content.

In the present investigation, the analysis of bio-organics shows that there was increase in soluble proteins, total carbohydrates and polyphenol content with T-1 (71 %, 5 % and 75 %), and T-2 (185 %, 22 % and 82 %) respectively compared to the control (Figure 1- B). Datta, 2010 stated that the sweetness of fruit increases with increased production of glucose, by hydrolysis of polysaccharides (especially starch). So, increase in bio-organics content under the T-2 treatment make fruits sweeter and tastier in organic way. Salem and Michail, 1981 remarked that the polyphenols are secondary metabolites that play a significant role in disease resistance. They also inhibit the activity of IAA oxidase (Shekhawat *et al*., 1980).

Figure 1- C shows the comparative study of T-1 and T-2 treatments on fruits of tomato in terms of oxidative enzymes. As compared to control, there was increase in the activity of peroxidase (POD), polyphenol oxidase (PPO), IAA Oxidase (IAO) and Super oxide dismutase (SOD) under T-1 (36 %, 65 % ,0.6 % and 12 % respectively) and T-2 (70 %, 78 %, 66 % and 42 % respectively). Peroxidase catalyses the dehydrogenation of structurally diverse phenolic substrates by H_2O_2 and thus often regarded as antioxidant enzyme (Shigeoka *et al*., 2002). The present results clearly established that peroxidase activity was increased most under the T-2 treatment which leads to decrease of H_2O_2 content, necessary for an effective defense against the action of free radicals. Polyphenol oxidase (PPO) oxidizes phenolic compounds and is associated with antioxidant activity.

During periods of stress, this plastidial enzyme is released into the cytoplasm and it oxidizes phenols to produce quinines and helps in avoiding of chlorophyll bleaching (Mayer and Harel, 1979). The present investigation shows that T-2 leads to more decrease in activity of polyphenol oxidase and IAA oxidase compared to the peroxidase and superoxide dismutase enzyme activity. This leads to increase in anti-oxidant properties of tomato, which is significant from health point of view.

In general, the present study clearly proves that the treatment of *kunapajala* (T-2) induced early flowering and early fruiting. The quality and quantity of fruits increased along with shelf life of fruits of tomato under *kunapajala* (T-2) treatment in organic way. This is supported by observations of Mishra, (2010) who proved that the herbal *kunapajala* effectively enhanced yield attributes of rice than NPK fertilizer. The increase in total solids, total acids, fiber percentage and decrease in pH and total soluble solids gave qualitative enhancement in the yield under *kunapajala* (T-2) treatment. *Kunapajala* (T-2) treatment as a soil application method led to increased lycopene, ascorbic acid and proline content which increase nutritional value of fruits of tomato.

Carotene content enhance colour of fruits of tomato under *kunapajala* (T-2) treatment where as the soluble proteins, total carbohydrates and polyphenol content increase the sweetness and taste of the fruit. Higher level of activity of oxidative enzymes such as peroxidase, polyphenol oxidase, IAA oxidase and super oxide dismutase in fruits of *kunapajala* (T-2) treated plants enhances anti-oxidant property of tomato.

Thus it can be concluded that, by and large, *kunapajala* treatment (T-2) is superior to N.P.K. farming (T-1) as it brings about qualitative and quantitative increase in yield of tomato under organic farming conditions.

LITERATURE CITED

Abdelaziz M Pokluda R Abdelwahab M, 2007. Influence of compost, microorganisms and NPK fertilizer upon growth, Chemical composition and essential oil production of *Rosmarinus officinalis* L. *Not. Bot. Hort. Agrobot. Cluj.,* **35**(1): 86-90.

Agarwal S and Rao AV, 1998. Tomato lycopene and low-density licoprotein oxidation: a human dietary intervention study. *Lipids*, **33:** 981 - 984.

Arnon DI, 1949. Copper enzymes in isolated chloroplasts, polyphenol oxidase in *Beta vulgaris* L. *Plant Physiology*, **24:** 1 - 15.

Bates LS, Waldren RP and Tease ID, 1973. Rapid determination of free proline for water stress studies. *Plant and Soil*, **39:** 205 - 207.

Chitale R, 2010. Role of oxygenated peptone in improving the productivity of brinjal (*Solanum malongena* L. cv. Ajay). Ph. D. Thesis. P. G. Research Center, Department of Botany, Tulajram Chaturchand College Baramati, Dist. Pune (M.S.) India.

Colla G, Mitchell JP, Poudel DD and Temple SR, 2002. Changes of tomato yield and fruit elemental composition in conventional, low input, and organic system. *Journal of Sustainable Agriculture*, **20**(2): 53 - 67.

Djanaguiramam M, Pandiyan M and Durga Devi D, 2005. Abscission of tomato fruit follows oxidative damage and its manipulation by ANTONIC spray. *International Journal of Agriculture and Biology*, **7**(1): 39 - 44.

Datta S. 2010. The time is ripe. *Dream 2047*. **13**(1): 30 - 32.

Deshmukh RS, Patil NA and Nikam TD, 2011. *Kunapajala*: Formulation and Standardization of Dosages for Cultivation of Tomato. In: Proceedings of International Conference on Traditional Practices in Conservation Agriculture. *18-20 September, 2010*. Janardhan Rai Nagar, Rajasthan Vidyapeeth University, Pratap Nagar, Udaipur, Rajasthan, India, edited by Choudhary SL, Khandelwal SK and Nene YL. (Asian Agri History Foundation, Secunderabad, India): 125 - 132.

Giannopolitis CN and Ries SK, 1977. Super oxide dismutase. I. Occurrence in higher plants. *Plant Physiol*., **59:** 309 - 314.

Krinsky NI, 1998. The antioxidant and biological properties of the carotenoids. *Ann. N. Y. Acad Sci.*, **854:** 443 - 447.

Kumar P, 2003. *Effect of integrated nutrient management on sustainable cabbage and tomato production.* Ph.D. Thesis. Department of Vegetable crops, Dr. Y. S. Parmar university of Horticulture and Forestry, Nauni, Solan (HP), India.

Kummelinj I, Huber M, Penders J. and Dagenlie PC, 2004. Consumption of organic foods and risk of atopic disease during the first two years of life in the Netherlands. *British J. of Nutrition,* **97** (4): 735 - 743.

Lowry OH, Rosebrough NT, Farr AL and Randall RJ, 1951. Protein measurement with folin phenol reagent. *Journal of Biological Chemistry*, **193**: 265 - 275.

Mahadeven A and Shidhar R. 1982. *Methods in Physiological Plant Pathology.* 2nd edition. Pb. Sivakami, Madras, India.

Malik CP and Singh MB, 1980. *Plant Enzymology and Histoenzymology*, Kalyani Publishers, New Delhi.

Mayer AM and Harel E, 1979. Polyphenol oxidases in plants. *Phytochem.*, **18,** 193-215.

Mishra PK, 2010. Implication of Biofertilizer (Kunapa Jalam) on Yield Attribute and Economics of Rice Cultivation. *International Journal of Biological Science and Engineering***, 1**(1): 40-42.

Noctor G and Foyer CH, 1998. Ascorbate and glutathione: Keeping active oxygen under control. *Annu. Rev. Plant Physiol. Plant Mol. Biol.*, **49,** 249 - 279.

Prabhu M, Natrajan S. and Pugalendhi IL, 2008. Correlation and path analysis in brinjal (*Solanum melongena* L.). *Adv. Plant Sci.,* **21** (1): 135-136.

Rangana S, 1977. Manual for analysis of fruit and vegetable products. Pb. Tata Mc Graw Hill Co. Pvt. Ltd., New Delhi, Pp 1-72

Sadasivam S and Balasurbraminan T, 1987. In: Practical manual in biochemistry, Tamil Nadu Agricultural University, Combatore, India. Pp 14.

Sadhhivam S and Manikam A, 2005. *Biochemical Methods*. 2nd Edition, Pb. New Age International, New Delhi, India.

Saini RS, Shrama KD, Dhankhar OP and Kaushik RA, 2006. Laboratory Manual of Analytical Techniques in Horticulture. Pb. Agrobios, Jodhpur, India, Pp 71

Salam MA, Siddique MA, Rohim MA, Rahman MA and Saha MG, 2010. Quality of Tomato (*Lycopersicon esculentum* Mill.) as influence by boron and zink under different levels of NPK fertilizers. *Bangladesh J. Agril. Res*. **35**(3): 475 - 488.

Salem MA and Michail SH, 1981. The role of polyphenols, oxidative and macerating enzymes in onion bulb cultivars infected with *Botrytis ali. Acta Phytophathologica Academaioe Scientarum Hungaricae*, **16**(1/2): 56 - 65.

Shekhavat NS, Jain HC and Arya HC, 1980. Accumulation of aromatic amino acids, the precursors of auxin and phenols in pearl millet infected with *Sclerospora graminicola. Comp. Physiol. Ecol.* **5**(1): 39 - 42.

Shi J, LE and Maguer M. 2000. Lycopene in tomatoes. Chemical and physiological properties affected by food processing, *Critical Reviews in Biotechnology* **20:** 293-334.

Shigeoka I, Tammoli M, Miyagawa Y, Takeda T, Yabuta Y and Yoshimora K, 2002. Regulation and function of ascorbate peroxidase isoenzymes. *Jr. Exp. Bot*., **53,** 1305-1309.

Subramanian VTC, 2006. *Organic farming in India: Prospects and Challenges.* In: Trends in Organic Farming. (Eds. Purohit, S. S. and Gehlot, D.), Pb. Agrobios, Jodhpur, India, Pp 29-38.

Syed I, Kausadikar HK and Waikar SL, 2009. Quality of the agricultural produce in organic farming. In: Agrobios Newletter, **7**(8): 37 - 39.

Tang YW and Bonner RA, 1947. The enzymatic inactivation of IAA. *Arch. Biochem. Biophysics*, **13**: 11.

Websites:

www.apitco.org

www.wikipedia.com

http://www.leffingwell.com/careten.htm