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Studies on integrated nutrients management for growth and yield of sustainable productivity of tomato (*Lycopersicon esculentum* Mill.)

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Abstract
A field experiment with eleven treatments including control was conducted at the Rajola Farm of the Faculty of Agricultural Sciences, MGCGV, Chitrakoot – Satna (MP), during the Kharif season of 2009 to find out the most appropriate integrated nutrient management system for sustainable tomato production. The best treatment comprising of organic manures (FYM and Vermicompost), inorganic fertilizers (N, P and K), and plant growth regulator GA_3 on growth and yield of Tomato, for this region. It was found that application of T_9 100% RDF + VC 10 t ha^{-1} + Seedling treatment with GA3 100 ppm gave maximum growth and fruit yield (49.79 t ha^{-1}) over control (40.70 t ha^{-1}) which was significantly higher over all the treatments. The organic sources of nutrition along with inorganic sources showed incremental effect for almost all parameters including yield over inorganic sources alone.

Keywords: Tomato, INM, Nitrogen, Phosphorus, Potash, Growth, Yield

Introduction
India is a leading vegetable producing country in the world. Presently it occupies 7.49 million hectares area with the annual production of 116.03 million tonnes and productivity of 15.49 t ha^{-1} (National Horticulture Board; Area, Production and Productivity of Horticultural Crops for the year 2006 – 07). The country being blessed with the unique gift of nature of diverse climate and distinct seasons, make it possible to grow an array of vegetables, number exceeding more than hundred types (Rai and Pandey, 2007) [12].

The tomato (*Lycopersicon esculentum* Mill.), family solanaceae is one of the most important productive foods both because of its nutritive value and also bid to its widespread production. It is the world's largest vegetable crop after potato and sweet potato, but it tops the list of canned vegetable. Tomato is cultivated in India over 5.4 lakh hectare with a total production of 5.3 million tonnes (United Nations, Food and Agricultural Organisation estimates).

The tomato has many medicinal uses. It is an excellent source of minerals, proteins and particularly ascorbic acid (vitamin C); the pulp and juice are blood purifier and promoter of gastric secretion. It is good in chronic dyspepsia, stimulating to rapid liver and is also considered to be intestinal antiseptic and useful in treating cancer of mouth.

One of the major aspects for high yield of tomato is manuring. Therefore, balanced application of manures and fertilizers is very important for successful crop production. Nitrogen deficiency causes general paling and stunted plants; phosphorus deficiency results in dirty greyish green leaves and premature shedding while potassium deficiency causes interveinal chlorosis of young leaves followed by yellowing and premature shedding. Well-rotten farmyard manure and/or poultry manure should also be thoroughly incorporated at the time of land preparation.

Gibberellic acid and auxin like NAA and IAA play a major role in plant growth. The endogenous gibberellic acid synthesized by the seeds are not sufficient and as such the external application boost the growth by increasing cell multiplication and cell elongation, resulting in higher plant growth. The rapid and early germination also help in producing vigorous growth of seedlings during subsequent period of growth.

Materials and Methods

The present investigation entitled "*Studies on integrated nutrients management for sustainable productivity of tomato* (*Lycopersicon esculentum* Mill.)" was conducted at Chitrakoot, Satna (M. P.) during the rainy (*Kharif*) season of 2009. The experiment was conducted at the Rajola Farm of the Faculty of Agricultural Sciences, MGCGV, Chitrakoot – Satna (Madhya Pradesh), during the Kharif season of 2009. All the facilities necessary for conducting the experiment, including labour and resources, which were necessary for normal cultivation were readily available in the department. Chitrakoot is situated at an altitude of 306 m above mean sea level at 24° 31' N latitude and 81° 15' E latitude. The climate of the region is semi-arid and sub-tropical having extreme winter and summer.

The experiment was laid out in Randomized Block Design having 11 treatments comprising of organic manures (farmyard manure and vermicompost), inorganic fertilizers (nitrogen, phosphorus and potassium) and plant growth regulator GA_3 applied either alone or in combination, each replicated three times, making a total of 33 plots. Treatments were randomly arranged in each replication. The treatment description is presented in, T_0Control, T_1Farmyard manure (FYM) @ 20 t ha^{-1}, T_2Vermicompost (VC) @ 10 t ha^{-1}, T_3 100% RDF (N : P : K @ 120 : 60 : 60 kg ha^{-1}), T_4 100% RDF + Seedling treatment with GA3 100 ppm, T_5 100% RDF + Seedling treatment with GA3 100 ppm + foliar application of GA3 100 ppm at 30 DAT, T_6 100% RDF + Seedling treatment with GA3 150 ppm + foliar application of GA3 150 ppm at 30 DAT, T_7 100% RDF + FYM 20 t ha^{-1}+ Seedling treatment with GA3 100 ppm, T_8 100% RDF + FYM 20 t ha^{-1}+ Seedling treatment with GA3 150 ppm, T_9 100% RDF + VC 10 t ha^{-1} + Seedling treatment with GA3 100 ppm, T_{10}, 100% RDF + VC 10 t ha^{-1}+ Seedling treatment with GA3 150 ppm. The growth and yield parameters were measured by randomly selecting five plants from each net plot.

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads

Growth parameters

Plant height (cm) and Number of leaves plant^{-1}

Application of FYM and vermicompost along with 100% recommended dose of fertilizers (RDF) i.e. N : P : K @ 120 : 60 : 60 kg ha^{-1} and seed inoculation with GA_3 recorded significantly higher plant height as compared to control. On increasing the concentration of GA_3 from 100 to 150 ppm, the plant height registered a decline, both in case of FYM and vermicompost. 100% RDF + Vermicompost @ 10 t ha^{-1} + seedling treatment with GA_3 100 ppm (T_9) recorded highest plant height (19.50, 33.80, 49.27 and 63.69 cm at 20, 40, 60 and 80 DAT, respectively) followed by 18.53, 32.17, 48.17 and 61.74 cm with FYM + 75% NPK (T_8) and 65.09 cm with 100% RDF + Vermicompost @ 10 t ha^{-1} + seedling treatment with GA_3 150 ppm (T_{10}).

Appropriate supply of nitrogen, phosphorus and potash and its availability might have helped the plants to attain more vigour in terms of plant height than lower quantity of N as well as control. Better nitrogen supply significantly increased the plant height because of enough availability of nitrogen at growing stages.

Gibberellins are derivative of Gibberellic Acid. They are natural plant hormones and promote flowering stem elongation and break dormancy of seeds. Gibberellins are fundamental to plant development especially with respect to the growth of stem and Number of leaves plant^{-1}100% RDF + Vermicompost @ 10 t ha^{-1} + seedling treatment with GA_3 100 ppm (T_9) recorded maximum number of leaves per plant (54.07 at 80 DAT, respectively) followed by FYM + 75% NPK (T_8) and 56.47 with 100% RDF + Vermicompost @ 10 t ha^{-1} + seedling treatment with GA_3 150 ppm (T_{10}). These findings are in close conformity with the results reported by Matsubara *et al*. (1995) [8], Samawat *et al*. (2001) [16], Krishna and Krishnappa (2002) [7].

Number of branches plant^{-1} and Stem diameter (cm)

With increase in concentration of GA_3 from 100 to 150 ppm registered a decline in number of branches per plant. 100% RDF + Vermicompost 10 t ha^{-1} + seedling treatment with 100 ppm GA_3 (T_9) recorded maximum number of branches per plant (3.77, 8.55, 14.64 and 18.72 at 20, 40, 60 and 80 DAT, respectively) followed by 3.57, 8.42, 14.51 and 18.39 with 100% RDF + Vermicompost 10 t ha^{-1} + seedling treatment with 150 ppm GA_3 (T_{10}) and these values were statistically at par. the Stem diameter (cm)100% RDF + Vermicompost @ 10 t ha^{-1} + seedling treatment with GA_3 100 ppm (T_9) recorded maximum stem diameter (1.58, 2.25, 2.64 and 3.03 cm at 20, 40, 60 and 80 DAT, respectively, followed by 1.53, 2.19, 2.58 and 2.97 cm with 100% RDF + Vermicompost @ 10 t ha^{-1} + seedling treatment with GA_3 150 ppm (T_{10}). These findings are more or less similar to the results reported by Matsubara *et al*. (1995) [8], Krishna and Krishnappa (2002) [7], Reddy *et al*. (2002) [14] and Sharma and Sharma (2004) [18] in their experiments. Haq *et al*. (1999) [5] also reported similar results in Tomato.

Days to 50% flowering and Days to first fruit set

Application of 100% NPK + Vermicompost 10 t ha^{-1} + seedling treatment with GA_3 100 ppm (T_9) recorded earliest flowering (41.20 days) as compared to 42.40 100% NPK + Vermicompost 10 t ha^{-1} + seedling treatment with GA_3 150 ppm (T_{10}). The beneficial effect of GA_3 in early flowering might be attributable to the well known fact that gibberellins increases cell division and cell elongation when applied in proper concentration, as well as the two enzymes (amylase and protease) induced by gibberellic acid. Days to first fruit set treatment T_9 (100% RDF + Vermicompost @ 10 t ha^{-1} + seedling treatment with GA_3 100 ppm) emerged as superior over all other treatments and the untreated control with regard to vegetative growth of tomato plants. Matsubara *et al*. (1995) [8] and Khankhane and Yadav (2003) [6] reported similar findings in their experiments. Gavaskar and Anburani (2004) [4] also reported similar results in brinjal. These findings are in close conformity with the results reported by Renuka and Sankar (2001) [15], Mohd. Rafi *et al*. (2002) [9], Naidu *et al*. (2002) [10] and Shukla *et al*. (2006) [19]. Rao and Sankar (2001) [13] also reported similar results in Tomato.

Table 1: Effect of INM on growth parameters of Tomato

Treatment		Plant Height			
		20 DAT	40 DAT	60 DAT	80 DAT
T_0	Control	15.07	28.05	43.53	50.13
T_1	Farmyard manure (FYM) @ 20 t ha^{-1}	15.55	29.27	44.67	52.12
T_2	Vermicompost (VC) @ 10 t ha^{-1}	15.89	30.33	45.00	53.48
T_3	100% RDF (N : P : K @ 120 : 60 : 60 kg ha^{-1})	16.33	30.66	45.37	54.29
T_4	100% RDF + Seedling treatment with GA_3 100 ppm	17.07	30.87	46.40	55.80
T_5	100% RDF + Seedling treatment with GA_3 100 ppm + foliar application of GA_3 100 ppm at 30 DAT	17.44	31.33	46.89	58.53
T_6	100% RDF + Seedling treatment with GA_3 150 ppm + foliar application of GA_3 150 ppm at 30 DAT	17.25	31.10	46.67	57.13
T_7	100% RDF + FYM 20 t ha^{-1} + Seedling treatment with GA_3 100 ppm	17.87	31.80	47.60	60.79
T_8	100% RDF + FYM 20 t ha^{-1} + Seedling treatment with GA_3 150 ppm	17.60	31.60	47.11	59.70
T_9	100% RDF + VC 10 t ha^{-1} + Seedling treatment with GA_3 100 ppm	19.50	33.80	49.27	63.69
T_{10}	100% RDF + VC 10 t ha^{-1} + Seedling treatment with GA_3 150 ppm	18.53	32.17	48.17	61.74
	S. Ed. (±)	NS	0.09	0.13	0.25
	C. D. at 5%	NS	0.18	0.27	0.52

Table 2: Effect of INM on growth parameters of Tomato

Treatments		Growth Parameters				
		Number of leaves per plant	No. of branches per plant	Stem diameter (cm)	Days to 50% flowering	Days to first fruit set
T_0	Control	43.83	11.14	2.51	47.20	**54.20**
T_1	Farmyard manure (FYM) @ 20 t ha^{-1}	45.06	11.98	2.57	45.93	53.53
T_2	Vermicompost (VC) @ 10 t ha^{-1}	45.85	14.06	2.61	45.87	53.11
T_3	100% RDF (N : P : K @ 120 : 60 : 60 kg ha^{-1})	46.33	14.83	2.67	45.13	52.73
T_4	100% RDF + Seedling treatment with GA_3 100 ppm	47.03	16.19	2.77	44.66	52.40
T_5	100% RDF + Seedling treatment with GA_3 100 ppm + foliar application of GA_3 100 ppm at 30 DAT	48.64	17.22	2.88	43.47	51.90
T_6	100% RDF + Seedling treatment with GA_3 150 ppm + foliar application of GA_3 150 ppm at 30 DAT	47.51	16.87	2.83	44.07	52.10
T_7	100% RDF + FYM 20 t ha^{-1} + Seedling treatment with GA_3 100 ppm	52.05	17.69	2.94	42.87	51.00
T_8	100% RDF + FYM 20 t ha^{-1} + Seedling treatment with GA_3 150 ppm	50.66	17.56	2.92	43.00	51.73
T_9	100% RDF + VC 10 t ha^{-1} + Seedling treatment with GA_3 100 ppm	54.07	18.72	3.03	41.20	48.53
T_{10}	100% RDF + VC 10 t ha^{-1} + Seedling treatment with GA_3 150 ppm	52.95	18.39	2.97	42.40	50.20
	S. Ed. (±)	0.32	0.19	0.02	0.13	0.15
	C. D. at 5%	0.67	0.41	0.04	0.27	0.30

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