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RESEARCH PAPER

Devising of nutrients in production of tomato (*Solanum lycopersicum* L.)

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Abstract : Research trialed by the soil application of basic, primary, secondary and micronutrients along with beneficial element during *Kharif* 2011 and *Rabi* 2012, to divulge the effects of nutrients combination on tomato (*Solanum lycopersicum* L.). The mobilizing efficacies of the applied nutrients from soil as well as in invaded plant were found to be differed significantly with the applied nutrients combination. However, the treatments treated with the nutrients as recommended dose of nutrients along with silicon (60 kg/ha) and organic carbon (60 kg/ha) influenced significantly and lead to minimum residual nutrients prevalence in the soil after crop harvest, it could reveal to be due to the synergetic effect of applied nutrients import the essential nutrient availability for the plants from the soil nutrients present inherently as well as applied externally.

Key Words : Silicon, Organic carbon, Nutrients, Tomato

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INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belongs to the family Solanaceae and it is largest grown vegetable after potato and onion in the world, with an area of 4.81 m ha with a production of 163.02 m t and productivity of 33.90 t/ha. In India, tomato is grown to the tune of 0.88 m ha with 18.73 m t production and 21.20 t/ha productivity (Anonymous, 2014). Since, there is a large gap between tomato productivity of world and India, to tackle this huge gap the nutrient consortium may play a vital role to improve the Indian tomato productivity. Nutrient consortium is made with a combination of primary, secondary and micronutrients along with beneficial element (Takahashi *et al*., 1990; Korikanthimath *et al*., 2002 and Chang *et al*., 2008). Nutrient consortium is made up of with well balanced nutrients proportions, which meet the probable needful nutrients required by the plants, these nutrient consortium may called as specialty fertilizers and are successfully used in vegetables production, soil application of these nutrients rapidly improve the plant nutrition by avoiding losses through leaching and runoff (Anonymous, 2012). The

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nutrient consortium will have the great contribution to modify and control the growth behaviour of tomato crop. Therefore, the nutrient consortium is become one of the most important inputs for boost the production and productivity. Hence, forth, the study had been conducted to know the influence of nutrient consortium on tomato production and their efficacy on mobilization of inherent as well as applied nutrients in combination.

MATERIAL AND METHODS

The study was carried out during *Kharif* and *Rabi* seasons of 2011-12 at College of Horticulture, Kolar, Karnataka, India. The experiment laid out using commercial tomato F_1 hybrid US-3140 as per Randomized Complete Block Design (RCBD) with three replications and 13 treatments as T_1- recommend dose of fertilizer (RDF) 250 kg N, 250 kg P and 250 kg K per hectare, T_2- 250 kg N, 250 kg P and 250 kg K with 20 kg organic carbon per hectare, T_3- 250 kg N, 250 kg P and 250 kg K with 40 kg organic carbon per hectare, T_4-250 kg N, 250 kg P and 250 kg K with 30 kg organic carbon per hectare, T_5-250 kg N, 250 kg P and 250 kg K with 165 kg silicon and 60 kg organic carbon per hectare, T_6 - 250 kg N, 250 kg P and 250 kg K with 262.5 kg silicon and 60 kg organic carbon per hectare, T_7 - 250 kg N, 250 kg P and 250 kg K with 150 kg silicon and 60 kg organic carbon per hectare, T_8-250 kg N, 250 kg P and 250 kg K with 75 kg silicon and 60 kg organic carbon per hectare, T_9 - 250 kg N, 250 kg P and 250 kg K with 60 kg silicon and 60 kg organic carbon per hectare, T_{10} - 250 kg N, 250 kg P and 250 kg K with 1.50 kg zinc, 160g copper, 2.56 kg manganese and 2.49 kg organic carbon per hectare, T_{11} - 250 kg N, 250 kg P and 250 kg K with 6.76 kg organic carbon per hectare, T_{12} - 250 kg N, 250 kg P and 250 kg K with 120g zinc, 20g copper, 10 g manganese, 40 g silicon and 8.51 kg organic carbon per hectare and T_{13}- absolute control without application of any manure and fertilizers. Farm yard manure (FYM) was applied at the rate of 25 t/ha during the time of field preparation, the nutrients 50 per cent of N as basal dose through urea and full dose of P as di-ammonium phosphate and K as muriate of potash, silicon as silica and elemental micronutrients with organic carbon were applied at the time of transplanting and remaining 50 per cent N top dressed at 30 days after transplanting (DAT). One month old seedlings were transplanted in plots of 3 m x 3.6 m size at a spacing of 90 cm x 60 cm, crop was raised under drip irrigated condition with water dispersal rate of four litre per hour per day. The mean data were subjected to statistical analysis as per Gomez and Gomez (1984).

RESULTS AND DISCUSSION

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

Configuration of soil nutrients upon specialty fertilizers application to soil :

The initial soil sample drawn before the experimentation were analyzed for various nutrients contents (Table 1) formed the base for comparison of influence of special fertilizers on nutrient residue in the soil after experimentation of two seasonal studies Table 2 and 3. The significant differences not observed in soil pH and electrical conductivity of soil samples analyzed, the results clearly depicts that upon soil application of special fertilizer did not varied the chemical properties of soil significantly, it seems these fertilizers are highly suitable for neutral soils for better crop production.

Significantly the maximum available nitrogen of soil in *Kharif* 2011 and *Rabi* 2012 seasons was recorded from the plots receiving 250 kg N, 250 kg P and 250 kg K with 20 kg organic carbon per hectare (T_2), whereas the maximum available phosphorus of soil was recorded from the plots receiving 250 kg N, 250 kg P and 250 kg K with 30 kg organic carbon per hectare (T_4) in *Kharif* and *Rabi* seasons and the maximum available potassium of soil in *Kharif* and *Rabi* seasons was recorded from the plots receiving 250 kg N, 250 kg P and 250 kg K with 40 kg organic carbon per hectare (T_3) in both *Kharif* and *Rabi* seasons, closely followed by plots receiving 250 kg N, 250 kg P and 250 kg K with 6.76 kg organic carbon per hectare (T_{11}) and 250 kg N, 250 kg P and 250 kg K with 1.50 kg zinc,160g copper 2.56 kg manganese and 2.49 kg organic carbon per hectare (T_{10}) (Table 2). On closer examination of these results revealed that the higher residual available NPK were observed in the treatment plots which received special fertilizers containing lower quantities of organic carbon compared to the other special fertilizers containing higher rate of organic carbon along with silicon at varied proportion indicating synergetic effects of silicon and organic carbon on nutrients mobilization of applied and native nutrients from soil to plant. Takahashi *et al*. (1990) revealed the silica in the form of salicylic acid uptake is related to the development stages of the plant and in the soil system, the silicate ion can replace and release the phosphate ion fixed in the soil, thus, increasing the amount of phosphate available to the plant and helps to promote the translocation of phosphorus. Application of higher rate of organic manure is known to enhance both available N content of soil (Korikanthimath *et al.*, 2002; Mukharjee and Ghosh 1986 and Stangel *et al.*, 1994), organic carbon content of soil highly related with soil N and P content of soil (Chang *et al.*, 2008; Nagaraja, 1997 and Purakayastha *et al.*, 2008).

The organic carbon was recorded high in the plots

Table 1 : Initial contents of availability of nutrient (kg/ha) in soil and pH and EC after crop harvest of *Kharif* and *Rabi* seasons

Initial soil analysis data		Soil analysis data after crop harvest				
		Treatments	pH		EC	
Chemical properties			*Kharif*	*Rabi*	*Kharif*	*Rabi*
Soil pH	7.40	T_1	7.6	7.8	0.09	0.46
Electrical conductivity (ds/m)	0.10	T_2	7.6	7.9	0.12	0.38
Organic carbon (%)	0.65	T_3	7.8	7.8	0.10	0.29
Nutrients status		T_4	8.1	8.0	0.15	0.21
Available N (kg/ha)	310.00	T_5	7.9	7.8	0.09	0.36
Available P (kg/ha)	41.60	T_6	8.2	8.1	0.13	0.18
Available K (kg/ha)	289.00	T_7	7.8	7.8	0.13	0.24
Available Ca (meq/100g)	5.40	T_8	7.9	7.8	0.15	0.39
Available Mg(meq/100g)	1.90	T_9	8.0	7.9	0.12	0.23
Available S (ppm)	12.38	T_{10}	7.7	7.8	0.09	0.28
Available Cu (ppm)	1.21	T_{11}	7.6	7.6	0.10	0.28
Available Zn (ppm)	1.02	T_{12}	7.8	7.7	0.12	0.27
Available Fe (ppm)	57.84	T_{13}	7.5	7.6	0.11	0.34
Available Mn (ppm)	25.78	S.E. ±	0.28	0.26	0.12	0.35
Available Si (ppm)	8.50	C.D. (P=0.05)	NS	NS	NS	NS

NS= Non-significance

Table 2 : Influence of specialty fertilizers on availability of nutrient (kg/ha) in soil

Treatments	Nitrogen		Phosphorus		Potassium		Copper		Zinc		Manganese		OC		Silicon	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	296.51	297.68	42.56	41.56	291.56	284.56	0.95	0.89	1.11	1.09	23.14	23.08	0.45	0.49	7.51	7.01
T_2	302.42	304.48	38.96	39.14	288.15	291.76	0.95	0.89	1.09	1.07	22.15	22.09	0.51	0.54	7.48	6.98
T_3	288.46	289.78	42.78	42.18	298.12	294.38	0.96	0.91	1.03	1.10	21.76	21.70	0.48	0.48	7.68	7.18
T_4	275.36	280.46	43.16	42.73	282.15	284.56	0.95	0.90	1.13	1.11	22.76	22.70	0.61	0.62	7.84	7.34
T_5	282.43	283.51	42.16	40.16	276.13	273.11	0.97	0.92	1.15	1.13	22.17	22.11	0.64	0.64	15.46	14.96
T_6	271.58	274.38	40.78	39.18	288.78	282.14	0.96	0.91	1.10	1.08	18.13	22.40	0.68	0.66	25.72	25.22
T_7	267.40	272.38	38.71	37.14	275.14	270.14	0.93	0.88	1.08	1.06	23.13	23.07	0.63	0.62	13.86	13.36
T_8	265.14	267.81	37.36	36.78	268.15	266.14	0.94	0.89	1.14	1.12	22.14	22.08	0.68	0.67	10.78	10.28
T_9	263.12	264.36	38.12	39.36	281.56	282.16	0.95	0.90	1.09	1.07	23.15	23.09	0.69	0.68	9.86	9.36
T_{10}	288.16	291.17	40.12	40.13	289.56	286.56	1.33	1.28	1.46	1.44	25.14	25.08	0.59	0.62	7.78	7.28
T_{11}	278.13	280.14	41.39	37.12	288.71	288.81	0.98	0.93	1.06	1.04	21.24	21.18	0.60	0.58	7.81	7.31
T_{12}	266.43	263.13	38.16	38.01	278.50	286.14	1.02	1.01	1.21	1.19	23.79	23.73	0.63	0.63	7.64	7.47
T_{13}	274.36	256.78	35.50	32.18	264.14	218.18	0.97	0.92	1.11	1.02	22.56	18.07	0.41	0.38	7.84	7.34
S.E. ±	10.38	9.38	1.86	1.67	10.86	9.86	0.01	0.01	0.03	0.02	0.10	0.12	0.02	0.02	0.03	0.09
C.D. (P=0.05)	29.40	28.13	4.82	3.82	30.28	28.56	0.02	0.03	0.08	0.06	0.28	0.36	0.06	0.06	0.08	0.27
CV %	8.93	7.87	3.49	4.98	6.93	8.18	3.95	3.29	1.21	2.09	1.21	0.75	0.48	0.57	0.39	1.59

received special fertilizers containing organic carbon significantly. The difference in organic carbon was proportioned to quantity of organic carbon applied through special fertilizers, same trend was observed in case of silicon content of soil. Application of 250 kg N, 250 kg P and 250 kg K with 60 kg silicon and 60 kg organic carbon per hectare (T_9) recorded the maximum organic carbon in *Kharif* and *Rabi* seasons, closely followed by treatment plot T_8 (Table 2). The higher residual organic carbon recorded would be due to the higher dose application of organic carbon containing special fertilizers. The rate of soil organic matter accumulation depends on inherent soil and source, regional climatic characteristics such as texture, mineralogy and temperature (Alvarez and Lavado, 1998). The significant maximum available silicon was recorded in the plots receiving 250 kg N, 250 kg P and 250 kg K with 262.5 kg silicon and 60 kg organic carbon per hectare (T_6) followed by the treatment T_5 in *Kharif* and *Rabi* season revealed that increased residual silicon recorded

Table 3 : Influence of special fertilizers on uptake of nutrients and fertilizer use efficiency (FUE, kg/ha)

Treatments	Nutrient uptake						FUE	
	Nitrogen		Phosphorus		Potassium			
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	8.78	8.98	2.44	2.56	8.29	8.17	34.21	28.17
T_2	12.51	12.87	3.49	3.99	12.51	12.32	42.10	32.20
T_3	13.18	13.78	3.44	3.69	12.80	13.39	38.70	32.98
T_4	13.62	13.24	4.03	4.41	13.05	13.62	49.56	41.63
T_5	12.47	12.11	3.56	3.21	12.65	12.83	52.65	44.40
T_6	11.16	11.16	3.45	3.45	11.82	11.98	55.94	43.56
T_7	11.34	11.84	3.45	3.62	11.51	12.00	47.99	45.42
T_8	12.16	11.99	3.77	3.94	12.16	11.65	60.63	50.16
T_9	11.80	11.97	3.37	3.54	11.29	11.63	62.94	51.19
T_{10}	12.32	13.24	3.44	3.68	12.32	12.51	47.33	41.13
T_{11}	11.84	12.52	3.43	3.26	12.18	11.84	53.31	44.11
T_{12}	11.17	11.50	3.45	2.96	11.66	11.17	60.22	49.42
T_{13}	4.49	5.56	1.26	1.72	4.55	5.07	NA	NA
S.E. ±	0.09	2.98	0.07	1.02	1.16	2.66	1.44	1.73
C.D. (P=0.05)	0.27	9.23	0.24	3.08	3.06	9.16	5.72	3.58
CV %	1.34	3.21	0.35	0.95	1.21	4.12	4.92	5.04

Table 4 : Economics of cultivation (Rs. lakh)

Treatments	Yield plant^{-1}		Yield plot^{-1}		Yield ha^{-1}		Expenditure		Gross returns		Net returns		B: C	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	2.33	2.06	35.92	29.58	33.26	27.39	1.44	1.36	3.33	3.99	1.89	2.63	1.31	1.93
T_2	2.79	2.52	45.15	33.81	41.80	31.31	1.45	1.36	4.18	5.02	2.74	3.65	1.89	2.68
T_3	2.58	2.48	40.62	34.63	37.61	32.06	1.43	1.35	3.76	3.76	2.33	2.41	1.63	1.79
T_4	3.15	2.99	52.04	43.71	48.18	40.48	1.42	1.34	4.82	5.78	3.40	4.45	2.39	3.32
T_5	3.31	3.11	55.28	46.62	51.18	43.16	1.51	1.43	5.12	6.14	3.60	4.71	2.38	3.29
T_6	3.69	3.09	62.73	45.73	58.08	42.35	1.49	1.40	5.81	6.97	4.32	5.57	2.90	3.98
T_7	3.07	3.05	50.39	47.69	46.65	44.15	1.47	1.39	4.67	5.60	3.20	4.21	2.18	3.03
T_8	3.73	3.40	63.66	52.66	58.94	48.76	1.46	1.38	5.89	7.07	4.43	5.69	3.03	4.12
T_9	3.90	3.47	66.08	53.74	61.19	49.76	1.45	1.36	6.12	7.34	4.67	5.98	3.22	4.40
T_{10}	3.03	2.96	49.70	43.18	46.01	39.99	1.44	1.36	4.60	5.52	3.16	4.17	2.19	3.07
T_{11}	3.45	3.12	55.98	46.32	51.83	42.89	1.47	1.38	5.18	6.22	3.72	4.84	2.53	3.51
T_{12}	3.74	3.44	63.23	51.89	58.55	48.05	1.42	1.33	5.85	7.03	4.44	5.69	3.13	4.28

from the plots which received special fertilizers with high silicon content. John *et al*. (2005) examined the application of silicon fertilizers to soil increased the silicon content in soil, salicylic acid content of leaves increased proportionally with increased salicylic acid concentration in the culture solution lead to the decreased incidence of powdery mildew in strawberry (Miyake and Eiichi, 1986). Significantly the maximum DTPA extractable copper, zinc and manganese (Table 1) in both *Kharif* and *Rabi* seasons were recorded from the treatment T_{10} receiving T_{10} is 250 kg N, 250 kg P and 250 kg K with 1.50 kg zinc, 160g copper 2.56 kg manganese and 2.49 kg organic carbon per hectare, closely followed by treatment T_{12} in *Kharif* and *Rabi* seasons (Table 2). After analyzing, the results revealed that higher residues of micronutrients in plots were recorded with the higher dose of specialty fertilizers containing micronutrients.

Configuration of plant nutrients and fertilizers use efficiency upon specialty fertilizers application to that soil :

Plants receiving 250 kg N, 250 kg P and 250 kg K with 30 kg organic carbon per hectare (T_4) recorded the maximum content of nitrogen, phosphorus and potassium in shoot (Table 3) both during *Kharif* and *Rabi* seasons, closely followed by treatment T_3. The present investigation reveals that the maximum nutrient content recorded might be due to low level of nutrients mining from the soil for production of fruits as evidenced by higher dry biomass recorded than fruit yield. The significantly lower fruit recorded in these treatments, in contrary the treatments received organic carbon with silicon yielded significantly more than organic carbon alone. Findings were supported by Veeranna *et al*. (2001); Umamaheswarappa *et al*. (2004) and Valavan and Senthil (2008). Significantly the maximum fertilizer use efficiency was recorded from the treatment plants receiving 250 kg N, 250 kg P and 250 kg K with 60 kg silicon and 60 kg organic carbon per hectare (T_9) in both *Kharif* and *Rabi* seasons, closely followed by the treatment T_8 (Table 3). After keen observation of analyzed data, it was found that the highest fertilizer use efficiency recorded could be due to beneficial synergetic effects of both silicon and organic carbon on mobilization applied nutrients enables the better uptake of nutrients by the plants thus, obtaining higher yields was supported by Veeranna *et al*. (2001) in chilli, Law-Ogbomo and Egharevba (2009) in tomato.

Cost economics of tomato production :

The treatment T_9 which received 250 kg N, 250 kg P and 250 kg K with 60 kg silicon and 60 kg organic carbon per hectare is turned out to be the most profitable as revealed by the net income of Rs. 4.67 lakh rupees and 5.98 lakh per hectare in *Kharif* and *Rabi* season, respectively. The total income from this treatment was Rs. 6.12 and 7.34 lakh per hectare in *Kharif* and *Rabi* seasons, respectively. The B:C worked out to 3.22 and 4.40 in *Kharif* and *Rabi* seasons, respectively. Even though the higher yields obtained in the *Kharif* than in the *Rabi*, the gross and net returns were high in *Rabi* due to the high market price prevailed in *Rabi* than *Kharif* (Table 4). The maximum returns were obviously due to the higher fruit yield obtained in T_9 followed by T_8 treatments than the others, findings regarding of cost benefit ratio are in live with those of Yadav *et al*. (2004) in tomato, Jan *et al*. (2004); Narayanamma *et al*. (2006) in brinjal and Premsekhar and Rajashree (2009) in tomato.

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