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Studies on Effect of Organic, Inorganic and Biofertilizers on Plant Nutrient Status and Availability of Major Nutrients in Tomato

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Abstract

The present study was aimed to assess the influence of integrated use of organic manures (FYM and vermicompost), inorganic fertilizers and *azotobacter* and phosphate solubilizing bacteria containing biofertilizers (*Azophos*) on plant nutrient uptake and post harvest soil fertility status of tomato cultivation. The field experiment was carried out by combining 14 different treatment combinations during winter season of 2005-06 and 2006-07 at UBKV, Pundibari, CoochBehar, West Bengal, India. The pooled results revealed that uptake of major nutrients were significantly influenced by the combination of different sources of nutrients. The finding showed that application of 4 tonnes vermicompost per hectare supplemented with 75% of recommended inorganic fertilizer inoculated with *Azophos* resulted in maximum uptake of macro nutrients by the tomato plants. Similarly the soil status of N, P, and K was also increased by the same treatment combination. Integrated application of diverse source of nutrients not only increased the uptake of plant nutrients but also improved the post harvest soil fertility and subsequently helped for achieving the much desired crop production with sustainable soil health.

1. Introduction

India is the second largest producer of vegetables just after China in the world and contributed 14% of world production where tomato occupied an area of 0.86 million ha with 16.8 million metric ton production (Anonymous, 2011). Being a heavy feeder it can removed 80 kg nitrogen, 20 kg phosphorus and 130 kg potassium for 37 tonnes of fruit production (Prem Nath et al., 2008). Therefore supply and monitoring of nutrients are essential to sustain the productivity. Soils of foothills of Himalaya is characterized by medium to light in texture, moderate in o. matter, acidic in pH, low in bases, P and K with multiple micro nutrients deficiencies, collectively addressing the low productivity of principal crops. Excess use of nitrogenous fertilizers encourages nitrate accumulation in fruits and ground water pollution. With the changing scenario, recent years have witnessed a renewed interest for sustainable crop production with greater emphasis on application of organic manures supplementing the chemical fertilizers. Organic manures act as a store house of plant nutrients and played direct role in supplying macro and micro nutrients and indirectly in improving the physical, chemical and biological properties of soil (Palaniappan and Siddeswaran, 1994). Several workers reviewed the significant role of FYM, vermicompost and biofertilizers in influencing the soil properties and enhancing the yield and quality of different vegetable crops like tomato (Patil et al., 1998), chilli (Patil and Biradar, 2002), cabbage (Mahendran and Kumar, 1997) etc. However, under acid soil of north east India the role of organic manure in combination with inorganic fertilizers and biofertilizers is meagre in tomato. Reviewing the fact, the present work was formulated to frame out a strategy for judicious combination of sources of nutrients, which will not only augment the efficiency of both the sources but will also minimize the ill effect of over use of chemicals in tomato cultivation.

2. Materials and Methods

The field experiment was conducted at the Instructional field of UBKV, Pundibari, Coochbehar, West Bengal during winter season (November to March) of 2005-06 and 2006-07. The site is located at 89°23′53″ E longitude and 26°19′86″ N latitude and at 43 m above mean sea level. The soil was well drained sandy loam having pH of 5.74, organic carbon content 0.85% and available N, P_2O_5, K_2O, were 150.85 kg ha^{-1}, 15.23 kg ha^{-1}

and 71.90 kg ha^{-1} respectively. The treatments consisted of 14 combinations of different nutrient sources and were laid out in randomized block design (RBD) with three replications. The treatments were selected for sole and combined application of varied levels of vermicompost and FYM along with 100% and 75% of recommended dose of inorganic fertilizers in presence and absence of biofertilizers. The combinations were T_1-100% Recommended dose of fertilizer (RDF) (100:60:60 kg NPKha^{-1}) ; T_2-100% RDF+FYM (6 t ha^{-1})+biofertilizers ; T_3-100% RDF+vermicompost (2 t ha^{-1})+biofertilizers ; T_4-100% RDF+FYM (3 t ha^{-1})+vermicompost (1 t ha^{-1})+biofertilizers ; T_5 -75% RDF+FYM (6 t ha^{-1}); T_6 -75% RDF+FYM (6 t ha^{-1})+biofertilizers ;T_7-75% RDF+vermicompost (2 t ha^{-1}) ; T_8-75% RDF+vermicompost (2 t ha^{-1})+biofertilizers ; T_9-75% RDF+FYM (3 t ha^{-1})+vermicompost (1 t ha^{-1})+biofertilizers ; T_{10}-75% RDF+FYM (12 t ha^{-1}) ; T_{11}-75% RDF+FYM (12 t ha^{-1})+biofertilizers ; T_{12} -75% RDF+vermicompost (4 t ha^{-1}) ; T_{13}-75% RDF+vermicompost (4 t ha^{-1})+biofertilizers and T_{14} -75% RDF+FYM (6 t ha^{-1})+vermicompost (2 t ha^{-1})+biofertilizers. Tomato seedlings (cv. Pusa Ruby) were transplanted in 3.75×3.75 m^2 plots with a spacing of 75 cm within and between rows. Vermicompost and FYM were applied to the respective plots at the time of transplanting. *Azophos*, the *azotobacter* and phosphate solubilizing bacteria containing biofertilizers was applied as seedling dipping (250 g litre^{-1} water) just before transplanting. Full dose of P_2O_5 and K_2O along with half N were applied as basal and rest N was top dressed at 30 days after transplanting. The crop was raised adopting standard cultural practices. The data was analyzed statistically with the help of INDOSTAT statistical package (version 7.00, Hyderabad, India).

3. Results and Discussion

3.1. Nitrogen content in plant

The results revealed that nitrogen content of tomato plants was significantly influenced by the combination of different sources of nutrients (Table 1). The treatment comprising of 100% recommended inorganic fertilizer along with vermicompost (2 t ha^{-1}) and biofertilizers (T_3) recorded the highest nitrogen content in fruits (3.26%) and plant residues (2.46%) followed by the treatments T_4 and T_2.These three treatments were statistically at par with each other. The pooled data revealed that the treatment T_3 recorded 29% higher nitrogen in plant over the treatment T_1.The findings also showed that among the treatment combination having 75% inorganic fertilizers, Irrespective of sources, with the increase in organic manure doses the nitrogen content in fruit as well as plant was increased significantly. As the treatment T_{13} and T_{11} recorded 22% and 18% improvement respectively in total nitrogen content of plant over the treatment T_1. Addition of biofertilizers with higher level of organic manures (T_{13} and T_{11}) has further increased the nitrogen content of the plant over the uninoculated plants (T_{12} and T_{10}). Higher nitrogen content in the treatment comprising 100% recommended inorganic fertilizer along with vermicompost and biofertilizer may be explained on the light of the finding of Barani and Anburani (2004) in okra, who reported that inorganic nitrogen which is readily available to the plant and on the verge of exhaustion uninterrupted supply of organic nitrogen from vermicompost is assured, moreover, the nitrogen present in vermicompost get easily mineralized into available form for the uptake of plant. Maximum uptake of nitrogen under higher level of inorganic fertilizers has also been reported by Prabhu et al. (2004) in brinjal and Mali et al. (2005) in cucumber.

3.2. Phosphorus content in plant

The results showed differences among the treatments with respect to phosphorus content of tomato plants and the treatments inoculated with biofertilizers recorded higher amount of phosphorus content compared to uninoculated treatments (Table 1). The highest phosphorus content in fruits (0.47%) as well as plant residues (0.36%) was recorded by the treatment containing 100% recommended inorganic fertilizer along with vermicompost (2 t ha^{-1}) and biofertilizers (T_3). The pooled data revealed that the treatment T_3 recorded 98% higher phosphorus in plant over the treatment T_1.The results further showed that among the 75% inorganic fertilizer treatment combination, the treatment T_{13} recorded the maximum phosphorus content for fruits (0.41%) as well as plant residues (0.32%) followed by the treatment T_{14} and T_{12}. Again the results indicated that higher amount of organic manure in combination with biofertilizers inoculation results higher phosphorus content in tomato plants as the treatment T_{13} with 4 tonnes vermicompost per hectare recorded 12% more phosphorus in plant over the biofertilizers uninoculated treatment T_{12}.Whereas higher amount of FYM in combination with biofertilizers (T_{11}) recorded 8% more phosphorus in plant over the uninoculated treatment T_{10}. Addition of higher amount of organic manure and biofertilizers might have prevented the fixation of phosphorus in the soil and ensure steady supply throughout the growth period that helped in better root growth, higher availability and better uptake of soil phosphorus by the tomato plants. Again inoculation with biofertilizers might have increased the solubility and availability of phosphorus by contributing organic acid and growth hormone like auxins and cytokinins which might have mobilize the soil phosphorus to the plant and enhanced the phosphorus content in plant parts.

3.3. Potassium content in plant

The result showed non significant differences among the treatments for potassium content of plant (Table 1). However

Table 1: Effect of different sources of nutrients on fruit yield and plant nutrient status in tomato (pooled mean of 2 years)

Treatments	Nitrogen (%)		Phosphorous (%)		Potassium (%)	
	Fruits	Plant residues	Fruits	Plant residues	Fruits	Plant residues
T_1-100% RDF (100:60:60 kg NPK ha^{-1})	2.45	1.97	0.24	0.18	2.18	2.12
T_2-100% RDF+FYM (6 t ha^{-1})+biofert.	3.12	2.18	0.42	0.33	2.51	2.43
T_3-100% RDF+VC (2 t ha^{-1})+biofert.	3.26	2.46	0.47	0.36	2.54	2.47
T_4-100% RDF+FYM (3 t ha^{-1})+VC (1t ha^{-1})+biofert.	3.19	2.32	0.44	0.34	2.52	2.45
T_5-75% RDF+FYM (6 t ha^{-1})	2.71	1.98	0.28	0.26	2.35	2.27
T_6-75% RDF+FYM (6 t ha^{-1})+biofert.	2.84	1.94	0.30	0.29	2.38	2.27
T_7-75% RDF+VC (2 t ha^{-1})	2.89	2.00	0.29	0.27	2.41	2.29
T_8-75% RDF+VC (2 t ha^{-1})+biofert.	2.97	2.06	0.33	0.29	2.43	2.29
T_9-75% RDF+FYM (3 t ha^{-1})+VC (1 t ha^{-1})+biofert.	2.93	2.03	0.31	0.29	2.40	2.31
T_{10}- 75% RDF+FYM (12 t ha^{-1})	2.99	2.13	0.34	0.30	2.42	2.32
T_{11}-75% RDF+FYM (12 t ha^{-1})+biofert.	3.05	2.16	0.38	0.31	2.43	2.33
T_{12}-75% RDF+VC (4 t ha^{-1})	3.11	2.18	0.35	0.30	2.45	2.34
T_{13}-75% RDF+VC (4 t ha^{-1})+biofert.	3.17	2.21	0.41	0.32	2.47	2.37
T_{14}-75% RDF+FYM (6 t ha^{-1})+VC (2 t ha^{-1})+biofert.	3.13	2.20	0.39	0.32	2.44	2.35
SEm±	0.09	0.09	0.02	0.02	0.07	0.06
CD (p=0.05)	0.27	0.25	0.06	0.05	NS	NS

RDF: Recommended dose of fertilizers ; VC: Vermicompost; NS: Non significant

the highest potassium content in tomato fruits (2.54%) as well as plant residues (2.47%) was recorded by the treatment T_3 and the lowest potassium content in fruits (2.18%) as well as plant residues (2.12%) was recorded for the treatment containing 100% of recommended inorganic fertilizers only (T_1). The pooled data revealed that the treatment T_3 recorded 17% higher potassium in plant over the treatment T_1.The results further showed that among the 75% inorganic fertilizer treatment combination, the treatment T_{13} recorded the maximum potassium content for fruits (2.47%) as well as plant residues (2.37%) followed by the treatment T_{12} and T_{14}. Higher amount of potassium in plant under vermicompost and biofertilizers inoculated plots may be due to better potassium utilization in the presence of vermicompost and biofertilizers. In addition, the efficacy of biofertilizers could have increased under vermicompost based growth medium, which further enhanced the uptake of potassium by the tomato plants.

3.4. *Available nitrogen of soil*

The results showed that higher amount of nitrogen in the rhizosphere soil was recorded in the plots received 75% inorganic fertilizers in combination with organic manure and biofertilizers combination (Table 2). The highest available nitrogen of the soil (174.45 kg) was recorded by the treatment comprising of 75% of recommended inorganic fertilizer along with vermicompost (4 t ha^{-1}) and biofertilizers (T_{13}) followed by the treatments T_{14} and T_{12} .The lowest available nitrogen content was recorded for the plots received 100% of recommended inorganic fertilizer only (T_1) (147.38 kg). The data revealed that among the 100% inorganic fertilizer treatment combination, the treatment T_3 recorded the maximum soil nitrogen content (161.32 kg) followed by the treatment T_4 and T_2.The findings further indicated that among the 75% inorganic fertilizer treatment combination, increase in the level of organic manure has increased the available nitrogen in the soil. As in the FYM treated plots increase in FYM level from 6 t ha^{-1} (T_6) to 12 t ha^{-1} (T_{11}) the available nitrogen in the soil increased by 5%, while increase in vermicompost level from 2 t ha^{-1} (T_8) to 4 t ha^{-1} (T_{13}) recorded 6% improvement in available nitrogen in the soil, irrespective of inorganic fertilizers and biofertilizers. Again, application of organic manure in the form of vermicompost has recorded higher available nitrogen in the soil compare to the treatments having higher FYM. Furthermore addition of biofertilizers with higher level of vermicompost (T_{13}) recorded 3% more available nitrogen in the soil over the uninoculated treatment combination T_{12}. In contrast inoculation of biofertilizers with higher level of FYM in the treatment T_{11} resulted in 1% improvement in available nitrogen in the soil over the uninoculated treatment T_{10}. The inoculation of *azophos* under vermicompost based medium might have enhanced the fixing the atmospheric nitrogen and increased the solubility and mobility of the nitrogen which may have added further nitrogen in the soil. Barani and Anburani (2004) also reported highest post harvest soil nitrogen content of okra under combined application of 75% of inorganic fertilizers along with FYM (25 t ha^{-1}) and vermicompost (5 t ha^{-1}).

Table 2: Effect of different sources of nutrients on post harvest soil nutrient status (pooled mean of 2 years)

Treatments	Nitrogen (kg ha^{-1})	Phosphorous (kg ha^{-1})	Potassium (kg ha^{-1})
T_1-100% RDF (100:60:60 kg NPK ha^{-1})	147.38	13.29	61.53
T_2-100% RDF+FYM (6 t ha^{-1})+biofert.	156.43	17.24	85.62
T_3-100% RDF+VC (2 t ha^{-1})+biofert.	161.32	17.94	83.13
T_4 -100% RDF+FYM (3 t ha^{-1})+VC (1t ha^{-1})+biofert.	159.23	17.56	81.29
T_5 -75% RDF+FYM (6 t ha^{-1})	152.21	14.52	68.24
T_6 -75% RDF+FYM (6 t ha^{-1})+biofert.	160.27	15.87	69.87
T_7 -75% RDF+VC (2 t ha^{-1})	158.16	16.18	72.38
T_8 -75% RDF+VC (2 t ha^{-1})+biofert.	164.20	17.05	76.48
T_9-75% RDF+FYM (3 t ha^{-1})+VC (1 t ha^{-1})+biofert.	161.52	16.31	74.57
T_{10} - 75% RDF+FYM (12 t ha^{-1})	166.24	17.84	78.31
T_{11}-75% RDF+FYM (12 t ha^{-1})+biofert.	168.38	18.73	79.62
T_{12} -75% RDF+VC (4 t ha^{-1})	169.26	18.89	90.37
T_{13}-75% RDF+VC (4 t ha^{-1})+biofert.	174.45	22.34	93.14
T_{14}-75% RDF+FYM (6 t ha^{-1})+VC (2 t ha^{-1})+biofert.	172.31	20.61	87.32
SEm±	2.29	1.24	1.73
CD (p=0.05)	6.48	3.51	4.91

RDF: Recommended dose of fertilizers ; VC: Vermicompost; NS: Non significant

3.5. Available phosphorus of soil

The results (Table 2) showed that the integration of 75% recommended inorganic fertilizers along with vermicompost (4 t ha^{-1}) and biofertilizers (T_{13}) recorded the highest available phosphorus content (22.34 kg) followed by the treatments T_{14}. The treatments T_{13} and T_{14} recorded 68% and 55% respectively more available phosphorus in the soil over the treatment T_1. Again within 75% inorganic fertilizer treatment combination, inoculation with biofertilizers with higher level of vermicompost (T_{13}) recorded 18% more available phosphorus content over the un inoculated treatment T_{12}. Similarly inoculation of biofertilizers with higher level of FYM (T_{11}) resulted in 5% improvement in available phosphorus over the uninoculated treatment T_{10}. The increase in available phosphorus in the biofertilizers inoculated plot may be due to better solubility and availability of the soil phosphorus as inoculation with *Azophos* might have contributed organic acid and growth hormone like auxins and cytokinins that helped to transform the complex form of phosphate into more soluble and simple form of phosphorus thus resulted in increased availability of phosphorus in the rhizosphere soil.

3.6. Available potassium of soil

The highest available potassium of soil (93.14 kg) was recorded (Table 2) by the treatment comprising of 75% of recommended inorganic fertilizers along with vermicompost (4 t ha^{-1}) and biofertilizers (T_{13}) followed by the treatments T_{12} and T_{14}. The lowest available potassium content of soil (61.53 kg) was recorded for the plots received 100% of recommended inorganic fertilizer only (T_1).The results showed that the treatment T_{13} recorded 51% more available potassium whereas the treatment T_{12} recorded 47% more available potassium over the treatment T_1. The results also showed that among the 75% inorganic fertilizer treatment combination, increase in the level of organic manure has increased the available potassium content of soil. As in the FYM treated plots increase in FYM level from 6 t ha^{-1} (T_6) to 12 t ha^{-1} (T_{11}) the available potassium content of soil increased by 14%, while for vermicompost level increased from 2 t ha^{-1} (T_8) to 4 t ha^{-1} (T_{13}) recorded 22% improvement in available potassium content of soil, irrespective of inorganic fertilizers and biofertilizers. Again application of organic manure in the form of vermicompost has recorded higher available potassium content of soil compare to the treatments having FYM as source of organic manure, when higher level of vermicompost (4 t ha^{-1}) was applied with inorganic fertilizers and biofertilizers (T_{13}) recorded 17% improvement in available potassium content of soil over higher level of FYM (12 t ha^{-1}) in combination with inorganic fertilizers and biofertilizers (T_{11}). Addition of higher amount of organic manure and biofertilizers might have helped to release unavailable free potassium to available form in the soil solution and increased the potassium content in the soil.

4. Conclusion

Based on the findings of the field experiments it can be concluded that Judicious integration of vermicompost (4 t ha^{-1}) in presence of 75% of RDF inorganic fertilizers, inoculated with azotobacter and phosphate solubilizing bacteria (PSB) containing biofertilizers proved its superiority in respect of the macronutrient content (N, P, K) of the plants as well as gradual enrichment in residual soil NPKstatus. In addition to saving of 25% doses of inorganic fertilizers, it will improve the fertilizer use efficiency and subsequently will help in achieving sustainability in acid soil of foothills of eastern Himalaya.

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