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Soil Test Crop Response Based Fertilizer Requirement for Tomato Grown on Mollisol

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Abstract Soil test crop response correlation studies were conducted to formulate the fertilizer requirement equations for target yield of tomato. Response of tomato to selected combinations of three levels of FYM (0, 10 and 20 t ha^{-1}), four levels of nitrogen (0,75, 150 and 225 kg ha^{-1}) , four levels of phosphorus (0,45, 90 and 135 kg P_2O_5 ha^{-1}) and four levels of potassium (0,45, 90 and 135 kg K_2O ha^{-1}) at different fertility levels was studied. Nutrient requirement to produce one quintal of tomato fruit was found to be 0.58 kg, 0.11 kg, and 0.55 kg of N, P and K, respectively. Percent contribution of N, P and K was 45.22, 66.08 and 48.61 from soil and 22.29, 30.46 and 30.96 from FYM, 67.84, 69.98 and 134.37 from chemical fertilizer and 72.55, 76.98 and 140.67 from combined use of chemical fertilizer with FYM. Fertilizer adjustment equations were developed with and without FYM with the help of basic data for tomato grown on Mollisol.

Keywords Tomato (*Lycopersicon esculentum* Mill.), Fertilizer, Mollisol, Nutrient.

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Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetable crop grown throughout the world. In India, it is cultivated in an area of 865 thousand hectares with an average annual production of 16,826 thousand tonnes having productivity of 19.5 t ha^{-1} [1]. Escalating cost of fertilizers, their short supply and declining soil fertility due to multiple cropping coupled with balanced fertilizer use is drawing attention to promote organic manuring . Easy availability of traditional bulky organic manures is also a problem in modern era of mechanized farming. Therefore, better option would be to utilize both the organic sources and chemical fertilizers in appropriate combination for crop nutrition. Balanced fertilization of macro and micro nutrients

Table 1. Basic data for calculating nutrient requirement with abd without FYM for targeted yield of tomato. * Soil test values (0-15 cm,depth); alkaline $KMnO_4$-N(kg ha^{-1}), Olsen's -P (kg ha^{-1}) and NH_4OAc-K (kg ha^{-1}).

	Without FYM			With FYM		
Particulars	N	P	K	N	P	K
NR (kg q^{-1})	0.58	0.11	0.55	0.58	0.11	0.55
CS (%)*	45.22	66.08	48.61	45.22	66.08	48.61
CF (%)	67.84	69.98	134.37	72.55	76.98	140.67
CFYM (%)	–	–	–	22.29	30.46	30.96

is essential for the production of high yield and quality products [2, 3].

The target yield concept given by Trough [4] and later modified by Ramamoorthy et al. [5] clearly demonstrated that definite amount of the nutrient is required by the plant for producing certain yield. Soil test based fertilizer requirement is based on the assumption that an increase or decrease of available nutrient in the soil will directly influence crop yield. Therefore, it is inevitable to frame out a strategy for efficient fertilizer management on the basis of soil testing which will not only augment the efficiency of both the sources but will also minimize the ill effects of over use of chemicals. This distortion in soil fertility and deterioration in soil health due to indiscriminate and imbalanced use of fertilizers can be corrected only with proper manure-fertilizer schedule based on soil fertility evaluation [6]. Moreover no systematic study has been conducted so far for fertilizer requirements based on soil test values for tomato grown on Mollisols. Hence, the present study was undertaken to compute soil test crop response based nutrient requirement for desired yield targets of tomato on a Mollisols.

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Materials and Methods

Soil test crop response correlation studies on tomato var Haemsohna was conducted at Norman E. Borlaug Crop Research Center of GB Pant University of Agriculture and Technology, Pantnagar. Experimental soil was sandy loam in texture with low available nitrogen and medium available potassium and available phosphorus content. The field experiment was carried out in two phases i.e. fertility gradient experiment and test crop experiment. Three fertility gradients were created by dividing the experimental site into three equal strips, which were fertilized with $N_0P_0K_0$ (No N, P_2O_5 and K_2O), $N_1P_1K_1$ (100 kg each N, P_2O_5 and K_2O ha^{-1}) and $N_2P_2K_2$ (200 kg each N, P_2O_5 and K_2O ha^{-1}) levels. Forage sorghum was grown as an exhaust crop and after the harvest of exhaust crop in second phase test crop experiment on tomato was conducted. Layout was made according to the plan of AICRP on STCR . Each strip (made in the fertility gradient experiment in the previous season) was divided into twenty four plots (21 treatments + 3 control) resulting in seventy two plots of equalsize. These treatments comprised of various selected combinations and four levels of nitrogen (0, 75, 150 and 225 kg ha^{-1}), four levels of phosphorus (0.45, 90 and 135 kg P_2O_5 ha^{-1}), four levels of potassium (0, 45, 90 and 135 kg K_2O ha^{-1}) and three levels of farm manure (0,10 and 20 t FYM ha^{-1}) were randomized in each of the three strips. Nitrogen, phosphorus, potassium and organic manure were applied through urea, single super phosphate, muriate of potash and FYM, respectively. Half dose of nitrogen, full dose of phosphorus, potash and FYM was applied as basal. While remaining half of nitrogen was applied at 30 days after transplanting. Four weeks old seedlings of uniform size were transplanted in March 2013 and an attempt was made to keep the crop free of weeds, insects, pests and diseases. Pickings of mature tomatoes were done at 7-8 days intervals and crop was harvested in June 2013.

Table 2. Fertilizer adjustment equations. Where T=Yield target (q ha^{-1}) SN = Alkaline $KMnO_4$-N (kg ha^{-1}) SP= Olsen's-P (kg ha^{-1}) SK=Amm Ac -K (kg ha^{-1}).

Fertilizer dose	Without FYM	With FYM
Nitrogen dose (kg N ha^{-1})	FN = 0.86 T- 0.67 SN	FN = 0.80 T- 0.62 SN- 0.31 FYM-N
Phosphorus dose (kg P ha^{-1})	FP = 0.16 T- 0.94 SP	FP = 0.14 T - 0.86 SP- 0.40 FYM-P
Potassium dose (kg K ha^{-1})	FK = 0.41 T- 0.36 SK	FK = 0.39 T - 0.35 SK- 0.22 OM-K

After picking of mature fruits from each plot in each harvest, the fruit yield was reported in q ha^{-1}. Dry weight was worked out on percent basis while dry matter yield of fruit and shoot on weight basis. The plant samples fruit and shoot were analyzed for total N, P and K content and the total uptake was computed using tomato fruit and shoot dry matter yield data.

The initial soil samples before transplanting of tomato from each plot were collected and analyzed for available N [7], available P [8] and available K [9]. Using the data on tomato fruit yield, nutrient uptake, initial soil available nutrients and fertilizer doses applied, the basic parameter, viz., nutrient requirement (kg q^{-1}), contribution of nutrients from soil, (Cs), contribution of fertilizers in absence (Cf) and presence (Cf *) of FYM and contribution of nutrients from FYM were estimated as described earlier [10, 11]. These parameters were used to compute soil test based nutrient requirement for desired yield targets of tomato with chemical fertilizers alone as well as with combined use of FYM.

Results and Discussion

Available nitrogen extracted by alkaline-$KMnO_4$ method in the experimental field varied from 115.4 to 245.4 kg N ha^{-1} with a mean value of 153.7 kg N ha^{-1}, available phosphorus ranged from 6.7 to 13.8 kg Olsen -P ha^{-1} with a mean value of 11.0 kg P ha^{-1} while available potassium extracted by neutral normal NH_4OAc method ranged from 91.8 to 243.4 kg K ha^{-1} with a mean of 158.8 kg K ha^{-1}. Fruit yield in experiment varied from 95.3 to 340.8 q ha^{-1} with a mean of 275.4 q ha^{-1}. Nitrogen uptake in experimental field varied from 50.6 to 221.0 kg ha^{-1} with a mean of 160.0 kg ha^{-1}. Phosphorus uptake in experimental field varied from 7.6 to 44.2 kg ha^{-1} with a mean of 31.1 kg ha^{-1}. Potassium uptake in experimental field varied from 43.6 to 219.7 kg ha^{-1} with mean of 152.7 kg ha^{-1}. The above data clearly indicated that a wide variability existed in the soil test values, tomato yield and total nutrient uptake which is the prerequisite for calculating the basic parameters and fertilizer adjustment equations for calibrating the fertilizer doses for specific yield targets of tomato. Similar type of finding was also reported Jadhav et al. [12] for tomato.

The basic parameters , viz., the nutrient requirement for producing one quintal of tomato (kg q^{-1}), the per cent contribution of nutrients from soil (Cs), per cent contribution of nutrients from applied fertilizers (Cf), per cent contribution of nutrients from applied fertilizers in presence of FYM (Cf*) and percent contribution of nutrient from FYM (Cfym) have

Table 3. Fertilizer nutrient requirements for different yield targets of tomato without FYM.

Soil test value (kg ha^{-1})	Yield target of tomato (q ha^{-1}) 200	250	300
Alkaline $KMnO_4$ N		Fertilizer – N (kg ha^{-1})	
150	71.5	114.5	157.5
200	38.0	81.0	124.0
250	4.5	47.5	90.5
Olsen-P		Fertilizer – P (kg ha^{-1})	
20	22.6	30.6	38.6
15	17.9	25.9	33.9
20	13.2	21.2	29.2
Amm Ac K		Fertilizer – K (kg ha^{-1})	
150	28.0	48.5	69.0
200	10.0	30.5	51.0
250	–	12.5	33.0

Table 4. Fertilizer nutrient requirement for different yield targets of tomato with conjoint use of FYM (10 tonnes).

Soil test value ($kg\ ha^{-1}$)	Yield target of tomato ($q\ ha^{-1}$) 200	250	300
Alkaline $KMnO_4$ N		Fertilizer – N ($kg\ ha^{-1}$)	
150	57.7	97.7	137.7
200	26.7	66.7	106.7
250	–	35.7	75.7
Olsen –P		Fertilizer – P ($kg\ ha^{-1}$)	
10	13.4	20.4	27.4
15	9.1	16.1	23.1
20	4.8	11.8	18.8
Amm Ac – K		Fertilizer – K ($kg\ ha^{-1}$)	
150	19.2	38.7	58.2
200	1.7	21.2	40.7
250	–	3.7	23.2

been calculated (Table 1). The nutrient requirement for production of one quintal of tomato was 0.58 kg of nitrogen, 0.11 kg of phosphorus and 0.55 kg of potassium. Percent contribution of nitrogen, phosphorus and potassium from soil was 45.22, 66.08 and 48.61, respectively. Percent contribution of fertilizer nutrients was 72.55, 76.98 and 140.67 with FYM and 67.84, 69.98 and 134.37 without FYM for nitrogen, phosphorus and potassium, respectively. Percent contribution of nutrients from applied FYM for nitrogen, phosphorus and potassium was 22.29, 30.46 and 30.96, respectively.

The data indicated that nutrient contribution from fertilizer along with FYM was greater than that of without FYM and from soil. The application of FYM might have played an important role for enhancing the microbial population which lead to the higher availability of nutrients and thereby efficiency of added nutrients increased. The organic acids released during the decomposition of added FYM in the soil might have played a role in reducing phosphorus fixation [12]. These findings are in close conformity with those reported earlier [13—16]. The contribution of potassium from fertilizer was more than 100 %, which might be due to the interactive effect of higher doses of N, P_2O_5 and priming effect of starter K_2O doses caused the release of potassium from non-labile pool to labile pool. Similar type of higher efficiency of K fertilizer was also reported in beet root on Alfisols [6].

Fertilizer adjustment equations for calculating the fertilizer nutrient requirement with and without FYM were developed (Table 2) with the help of basic data. On the basis of these equations a ready reckoner was prepared for a range of soil test values and for the production of different yield targets of tomato with chemical fertilizers alone as well as with combined use of FYM (Table 3 and Table 4 respectively). Fertilizer doses decreased with increasing soil test values for a particular yield target. However, for a particular soil test value fertilizer doses increased with increasing target yields. The value of fertilizer equivalence was found highest at higher yield level while it decreased with increasing soil test values. Average saving of fertilizer by 10 tonne FYM was 13.8 $kg\ ha^{-1}$ N, 9.8 $kg\ ha^{-1}$ P and 8.4 $kg\ ha^{-1}$ K within the range of soil test values and yield targets. Similar type of finding was also reported for onion on inceptisols [6].

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