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# Soil test crop response correlation studies for targeting yield of tomato on Entisol

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## ABSTRACT

**Soil test crop response correlation studies were conducted to formulate the yield target equation for tomato var. Dhanashree under integrated plant nutrition system on Entisol. Fertilizer adjustment equations under IPNS were formulated for tomato by following Ramamoorthy's inductive-cum-targeted yield model. The nutrient requirement for producing one tonne of tomato was 2.40, 0.70 and 3.10 kg of N,$P_2O_5$ and $K_2O$, respectively. The per cent contribution from soil and fertilizer nutrients were found to be 21.0 and 45.52 for nitrogen, 75.25 and 18.25 for phosphorus and 15.12 and 60.03 for potassium, respectively. Similarly, the per cent contribution of fertilizers in presence of FYM was 58.12 for nitrogen, 28.22 for phosphorus and 90.12 for potassium. The per cent nutrient contribution of FYM was 12.25 for nitrogen, 6.13 for phosphorus and 15.22 for potassium. The initial soil bacterial, fungal and actinomycetes population ranged from 55-66 x $10^6$ $g^{-1}$, 3-12 × $10^4$ $g^{-1}$ and 19-48 × $10^5$ $g^{-1}$ with a mean of 60.5 × $10^6$ $g^{-1}$, 7.5 × $10^4$ $g^{-1}$ and 33.5 × $10^5$ $g^{-1}$ respectively with the 40 $tha^{-1}$ FYM treatment block. In the same block at harvest soil bacterial, fungal and actinomycetes population increased and ranged from 89-142 × $10^6$ $g^{-1}$, 8-21 × $10^4$ $g^{-1}$ and 32-95 × $10^5$ $g^{-1}$ with a mean of 115.5 × $10^6$ $g^{-1}$, 14.5 × $10^4$ $g^{-1}$ and 63.5 × $10^5$ $g^{-1}$, respectively.**

**Key words:** Tomato, STCR-IPNS, fertilizer adjustment equation, Entisol.

## INTRODUCTION

Soil test based fertilizer recommendation is based on the basic assumption that an increase or decrease of available nutrient in the soil will directly influence crop yield. It can vary purley emperical to semi-quantitative or quantitative, depending upon the methodology and approach of soil testing. They can be classified a) soil testing rating in to low, medium and high, b) critical level, c) targeted yield which describes "how much fertilizer nutrient is to apply for a profitable responses (Goswami, 3). This concept is based on quantitative idea of the fertilizer needs based on yield and nutritional requirement of the crop, per cent contribution of the soil available nutrient and that of the applied fertilizers (Ramamoorthy *et al.*, 9).

Application of fertilizers by the farmers in the field without information on crop requirement might cause adverse effects on soils and crops both regarding nutrient toxicity and deficiency either by overuse or inadequate use. Further, the fertilizer use in required amounts depends much upon the purchasing power of the farmer. Accordingly economic rationality dictates a more comprehensive approach for fertilizer utilization incorporating soil tests, field research and economic evaluation of results. Tomato is one of the most important commercial vegetable crop grown in India. Tomato ranks third in priority after potato and onion in India but ranks second after potato in the world. The major tomato growing countries are China, USA, Italy, Turkey, India and Egypt.

The fertilizer application practices based on targeted yield approach indicated the possibility of enhancing production potentials of tomato in the major tomato growing pockets of Maharashtra, *viz.*, Nasik, Ahmednagar, Pune, Solapur, Satara, Sangli and Nagpur. Though the research on the above aspects has been done in the past but the targeted yield approach with FYM has not been studied specifically for tomato. Hence, the present study was undertaken to develop balanced fertilizer schedule under FYM application for desired yield targets of tomato in Entisol.

## MATERIALS AND METHODS

Soil test crop response correlation studies on tomato hybrid var. Dhanashree was conducted on a *Typic Ustorthent* soil at Soil Test Crop Response Correlation Project farm, Department of Soil Science and Agricultural Chemistry, MPKV., Rahuri, Dist. Ahmednagar. The soil represents Rahuri series, which is non calcareous well drained and slightly alkaline (7.6) in reaction. The alkaline $KMnO_4$-N, Olsen's P and $NH_4OAc$-K in the experimental field were 178, 22 and 280 kg $ha^{-1}$ respectively. The inductive-cum fertility gradient approach was followed for conducting the experiment (Ramamoorthy *et al.*, 9). Four fertility gradients were created by dividing the experimental

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field in to four equal strips which were fertilized with $N_0P_0K_0$, $N_{½}P_{½}K_{½}$, $N_1P_1K_1$, and $N_2P_2K_2$ levels. These fertility gradients were fertilized as $L_0$-no N, $P_2O_5$ and $K_2O$, $L_{½}$: 100:75:75 kg ha$^{-1}$ $L_1$: 200:150:150 kg ha$^{-1}$ and $L_2$: 400:300:300 kg ha$^{-1}$, N, $P_2O_5$ & $K_2O$, respectively. Fodder maize (var. African Tall) as an exhaust crop was grown so that the fertilizers could undergo transformations in the soil with plant and microbial agencies. By growing the exhaust crop the operational range of soil fertility was created in the fertility strips which was evaluated in terms of variations in the fertility strips which was evaluated in terms of variations in fodder yield, uptake and soil test values. After the harvest of exhaust crop, the main experiment on tomato was conducted. Each strip was divided in to 24 equal size plots. Twenty selected fertilizer treatments ($N_{100}P_{00}K_{00}$, $N_{100}P_{100}K_{00}$, $N_{100}P_{100}K_{100}$, $N_{200}P_{00}K_{00}$, $N_{200}P_{00}K_{100}$, $N_{200}P_{100}K_{00}$, $N_{200}P_{100}K_{100}$, $N_{200}P_{200}K_{00}$, $N_{200}P_{200}K_{100}$, $N_{200}P_{200}K_{200}$, $N_{300}P_{00}K_{00}$, $N_{300}P_{100}K_{100}$, $N_{300}P_{200}K_{200}$, $N_{300}P_{300}K_{00}$, $N_{300}P_{300}K_{100}$, $N_{300}P_{300}K_{200}$, $N_{400}P_{200}K_{100}$, $N_{400}P_{200}K_{200}$, $N_{400}P_{200}K_{100}$, $N_{400}P_{300}K_{200}$) constituted of different combinations of various levels of N (100, 200, 300 & 400 kg ha$^{-1}$), $P_2O_5$ (00, 100, 200 & 300 kg ha$^{-1}$) and $K_2O$ (00, 100 & 200 kg ha$^{-1}$) were randomly distributed in each strip along with four control plots $N_{00}P_{00}K_{00}$. The FYM levels (0, 20 and 40 t ha$^{-1}$) were imposed across each fertility gradient strips. The initial soil samples before transplanting of tomato from each plot were collected and analyzed for $KMnO_4$-N (Subbaih and Asija, 15), Olsen P (Olsen *et al.*, 7) and neutral normal $NH_4OAc$-K (Hanway and Heidal, 4). The FYM used in the experiment was analysed for total nitrogen by $H_2SO_4$ digestion mixture using macro-Kjeldhal's method (AOAC, 1) while phosphorus and potassium were estimated by digesting 1 g dry FYM sample with 10 ml triacid mixture (9:3:1 $HNO_3$:$HClO_4$:$H_2SO_4$) at 180-200°C. The test crop tomato (var. Dhanashree) was transplanted during January. The plot-wise yield of tomato fruits from six pickings and biomass yield were recorded. The plant samples (tomato fruit and biomass) from each plot were analyzed for total N, P and K content (Piper, 8) and the total uptake was computed using tomato fruit and biomass yield data. Using the data on tomato fruit yield, nutrient uptake, initial soil available nutrients and fertilizer doses applied, the basic parameter, *viz.*, nutrient requirement (kg t$^{-1}$), contribution of nutrients from soil, ($C_s$), contribution of fertilizers in absence ($C_{fa}$) and presence ($C_{fp}$) of FYM and contribution of nutrients from FYM were estimated (Ramamoorthy *et al.*, 9). These parameters were used for the formulation of fertilizer adjustment equation for deriving fertilizer doses and the soil test based fertilizer recommendations were prescribed in the form of a ready reckoner for desired yield targets of tomato under NPK as well as with FYM.

## RESULTS AND DISCUSSION

The range and mean values of initial soil fertility status were mentioned in Table 1. The initial $KMnO_4$-N were ranged from 150.52 to 206.97 kg ha$^{-1}$ with mean of 178.74 kg ha$^{-1}$, Olsen-P from 16.17 to 22.63 kg ha$^{-1}$ with a mean of 19.40 kg ha$^{-1}$ and $NH_4OAc$-K from 257.6 to 537.6 kg ha$^{-1}$ with a mean of 397.60 kg ha$^{-1}$. The range and mean values of tomato fruit yield, and total nutrient uptake of treated and control plots are furnished in Table 2. The tomato yield in treated plots ranged from 56.77 to 78.27 t ha$^{-1}$ with a mean of 67.52 t ha$^{-1}$ and in control plots ranged from 14.63 to 20.51 t ha$^{-1}$ with a mean of 17.57 t ha$^{-1}$. The total nitrogen, phosphorus and potassium uptake in treated plots were ranged from 162.81 to 174.68 kg ha$^{-1}$, 52.41 to 54.15 kg ha$^{-1}$ and 199.97 to 222.88 kg ha$^{-1}$ with a mean of 168.74, 53.28 and 211.42 kg ha$^{-1}$, respectively. However, in control plots, nitrogen phosphorus and potassium uptake ranged from 37.07 to 50.92, 12.21 to 17.35 and 54.23 to 86.46 kg ha$^{-1}$ with a mean of 43.99, 14.78 and 70.34 kg ha$^{-1}$, respectively. The tomato yield and uptake of nitrogen, phosphorus and potassium were higher in both the FYM blocks alongwith different fertilizer treatment combinations. The application of organic matter in the form of FYM might have hastened the availability of micronutrients thereby enhancing the tomato yields (Selvi *et al.*, 13; Kulkarni *et al.*, 6).

The above data clearly indicated that a wide variability existed in the soil test values, tomato yield and total nutrient uptake in treated and control plots, which is a prerequisite for calculating the basic parameters and fertilizer adjustment equations for calibrating the fertilizer doses for specific yield targets.

The basic parameters, *viz.*, the nutrient requirement for producing one tone of tomato (kg t$^{-1}$), the per cent contribution of nutrients form soil ($C_s$), per cent

**Table 1.** Range and mean values of soil available nutrients in the initial soil samples of tomato experimental plots.

| Initial soil status (kg ha$^{-1}$) | Range | Mean |
|---|---|---|
| $KMnO_4$-N | 150.52-206.97 | 178.74 |
| Olsen-P | 16.17-22.63 | 19.40 |
| $NH_4OAc$-K | 257.6-537.6 | 397.60 |

**Table 2.** Range and mean values of tomato yield and nutrient uptake in treated and control plots.

| Parameter | Treated | | Control | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Tomato yield (t $ha^{-1}$) | 56.77 to 78.27 | 67.52 | 14.63 to 20.51 | 17.57 |
| Total nutrient uptake (kg $ha^{-1}$) | | | | |
| Nitrogen | 162.81 to 174.68 | 168.74 | 37.07 to 50.92 | 43.99 |
| Phosphorus | 52.41 to 54.15 | 53.28 | 12.21 to 17.35 | 14.78 |
| Potassium | 199.97 to 222.88 | 211.42 | 54.23 to 86.46 | 70.34 |

contribution of fertilizer nutrients in absence of FYM ($C_{fa}$), contribution of fertilizer nutrients in presence of FYM ($C_{fp}$) and per cent contribution of nutrient from FYM ($C_{fym}$) have been calculated as described by (Reddy *et al.*, 11; Subbarao and Srivastava, 14) and furnished in Table 3. These basic parameters were used for formulating the fertilizer prescription equation under NPK alone and along with FYM.

The nutrient requirement per tonne of tomato were observed to be 2.40, 0.70 and 3.10 kg N, $P_2O_5$ and $K_2O$, respectively. The per cent contributions of soil were 21.00, 75.25 and 15.12 for N, $P_2O_5$ & $K_2O$, respectively. The per cent contribution of fertilizer nutrients in absence and presence of FYM were 45.52 and 58.12 for nitrogen, 18.25 and 28.22 for phosphorus and 60.03 and 90.12 for potassium, respectively. Similarly, the per cent contribution of N, $P_2O_5$ and $K_2O$ from FYM were 12.25, 6.13 and 15.22, respectively.

The data on $C_s$ and $C_{fa}$ or $C_{fp}$ indicated that nutrient contributions from fertilizer source along with FYM were greater than that of in absence of FYM and from soil. The application of FYM might have played an important role for enhancing the microbial population which leads to the higher availability of nutrients and thereby efficiency of added nutrients increased. Further, the application of FYM might have increased the carbon content of soil which acts as a source of energy for microflora. The organic acids released during the decomposition of added FYM in the soil might be plated a role in reducing phosphorus fixation. These findings are in close conformity with those reported by Balasubramaniam *et al.* (2), Kadam and Sonar (5), Ray *et al.* (10), Selvi *et al.* (17), and Tamboli *et al.* (12).

The magnitude of nutrient availability from fertilizer source in presence of FYM were higher than that of without FYM. This might be due to application of FYM along with inorganic fertilizer accelerated the soil microflora leads to the higher mineralization. Further, FYM application might have served the energy source for the proliferation of microbial activity. The population of bacteria, fungi and actinomycetes in soil were studied at initial and at harvest of the tomato experiment in two blocks of FYM across the fertility gradient and furnished in Table 4. The bacterial, fungal and actinomycetes population in soil was higher in 40 t $ha^{-1}$ FYM applied block than that of 20 t $ha^{-1}$ FYM applied block. At initial soil bacterial, fungal and actinomycetes population was ranged from 55-66 to 89-142 × $10^6$, 3-12 to 8-21 × $10^4$ and 19-48 to 32-95 × $10^5$ with a mean of 60.5 × $10^6$, 7.5 × $10^4$ and 33.5 × $10^5$ $g^{-1}$, respectively in the 40 t $ha^{-1}$ FYM applied block at initial and at harvest. It is evident from the data, the soil microbial population (bacteria, fungi and actinomycetes) were increased with higher magnitude in 40 t $ha^{-1}$ block than 20 t $ha^{-1}$ FYM block.Which might be attributed to the higher organic matter addition in soil serves as a energy source for their proliferation Suresh and Suryaprabha (16), Selvi *et al.* (13), and Kulkarni *et al.* (6).

Soil test based fertilizer prescription equations for targeted yield of tomato were formulated using the basic parameters and are furnished in Table 5. On the basis of these equations a ready reckoner was prepared for a

**Table 3.** Nutrient requirement, per cent contribution from soil, fertilizer and FYM for tomato.

| Parameter | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|
| Nutrient requirement (kg $t^{-1}$) | 2.40 | 0.70 | 3.10 |
| Contribution from soil available nutrients (%) ($C_s$) | 21.00 | 75.25 | 15.12 |
| Contribution from fertilizer nutrients in absence of FYM (%) ($C_{fa}$) | 45.52 | 18.25 | 60.03 |
| Contribution from nutrients from fertilizer in presence of FYM (%) ($C_{fp}$) | 58.12 | 28.22 | 90.12 |
| Contribution nutrients from FYM (%) ($C_{fym}$) | 12.25 | 6.13 | 15.22 |

**Table 4.** Range and mean soil microbial population in the FYM blocks of tomato experimental plot.

| Soil microbial population | 20 t $ha^{-1}$ FYM | | | | 40 t $ha^{-1}$ FYM | | | |
|---|---|---|---|---|---|---|---|---|
| | Initial | | At harvest | | Initial | | At harvest | |
| | Range | Mean | Range | Mean | Range | Mean | Range | Mean |
| Bacteria (x $10^6$ $g^{-1}$ CFU) | 49-60 | 54.5 | 84-130 | 107 | 55-66 | 60.5 | 89-142 | 115.5 |
| Fungi (x $10^4$ $g^{-1}$ CFU) | 3-10 | 6.5 | 7-19 | 13 | 3-12 | 7.5 | 8-21 | 14.5 |
| Actinomycetes (x $10^5$ $g^{-1}$ CFU) | 8-44 | 26 | 18-99 | 58.5 | 19-48 | 33.5 | 32-95 | 63.5 |

range of soil test values and for yield targets of 55 and 65 t $ha^{-1}$ under different fertilizer programmes (Table 6). It is evident from the data that the fertilizer N, $P_2O_5$ and $K_2O$ requirements decreased with increase in soil test values. For producing 55 t $ha^{-1}$ of tomato on Entisol, the fertilizer doses required for the average soil test values of the test crop experiment (220, 16 and 350 kg $ha^{-1}$ N, P and K respectively) was found 192, 147 and 196 kg $ha^{-1}$ of N, $P_2O_5$ and $K_2O$, respectively. However, in order to produce 65 t $ha^{-1}$ tomato with an average soil test values of the experiment (220, 16 and 350 kg $ha^{-1}$ N, P and K respectively) the fertilizer requirement would be 151, 106 and 132 kg $ha^{-1}$ N, $K_2O_5$ and $K_2O$, respectively. Application of FYM @ 20 t $ha^{-1}$ to tomato along with soil test based fertilizer recommendation would be able to save 22.6, 11.4 and 15 kg $ha^{-1}$ N, $P_2O_5$ and $K_2O$, respectively. Similar, results were also reported by Santhi *et al.* (12) for onion on Inceptisols.

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**Table 5.** Soil test based fertilizer prescription equations for targeted yields of tomato.

| Without FYM | | With FYM | |
|---|---|---|---|
| FN | : 5.33 T - 0.46 SN | FN | : 4.13 T - 0.43 SN - 1.13 FYM |
| $FP_2O_5$ | : 3.88 T - 4.16 SP | $FP_2O_5$ | : 2.50 T - 2.78 SP - 0.57 FYM |
| $FK_2O$ | : 5.16 T - 0.25 SK | $FK_2O$ | : 3.44 T - 0.22 SK - 0.75 FYM |

**Note:** FN, $FP_2O_5$ and $FK_2O$-Fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$ respectively; T - Yield target in t $ha^{-1}$; SN, SP and SK- $KMnO_4$-N, Olsen-P and $NH_4OAc$-K in kg $ha^{-1}$ respectively; FYM: t $ha^{-1}$.

**Table 6.** Soil test based fertilizer recommendations for tomato.

| Soil test value (kg ha$^{-1}$) | NPK alone | | NPK + FYM (15 t ha$^{-1}$) | |
|---|---|---|---|---|
| | 55 q ha$^{-1}$ | 65 q ha$^{-1}$ | 55 q ha$^{-1}$ | 65 q ha$^{-1}$ |
| Nitrogen | | | | |
| 180 | 210 | 264 | 127 | 168 |
| 200 | 201 | 254 | 119 | 160 |
| 220 | 192 | 245 | 110 | 151 |
| 240 | 183 | 236 | 101 | 142 |
| 260 | 174 | 227 | 92 | 133 |
| Phosphorus | | | | |
| 12 | 163 | 202 | 93 | 118 |
| 14 | 155 | 194 | 87 | 112 |
| 16 | 147 | 186 | 82 | 106 |
| 18 | 139 | 178 | 76 | 100 |
| 20 | 131 | 170 | 70 | 94 |
| Potassium | | | | |
| 250 | 221 | 273 | 119 | 154 |
| 300 | 209 | 260 | 108 | 143 |
| 350 | 196 | 248 | 97 | 132 |
| 400 | 184 | 235 | 86 | 121 |
| 450 | 174 | 223 | 75 | 110 |

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