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# SCHEDULING OF NUTRIENTS FOR SOILLESS TOMATO CULTIVATION

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**Abstract**
***Terrace cultivation of vegetable crops is gaining popularity because of unavailability of area and health concerns. The objective of this study was to standardize the nutrient schedule for soilless tomato production (grown in containers). Incubated groundnut cake + PGPR mix 1($S_2$) at 125 % of recommended dose of fertilizers was found to be the best nutrient schedule for soilless tomato cultivation in growbags.***
***Keywords- Tomato, soilless, terrace farming, PGPR, nutrient management***

## I. INTRODUCTION

Unlike rural residents, city dwellers have limited opportunities to grow their own food and are thus more likely to purchase their food mainly due to inadequate land and availability of good quality soil. The scarcity of land available for cultivation can be compensated by terrace farming. The problem of inadequate availability of good quality soil for cultivation can be solved to a great extent by promoting soilless culture. Reports are available from different parts of the world indicating the feasibility of soilless culture. Soilless culture in bags, pots, or troughs with a lightweight medium is the simplest, most economical, and easiest to manage of all soilless systems. Successful production of container-grown plants is largely dependent on the chemical and physical properties of the growing media.

Coconut is one of the oldest crops in India is being grown at present in 1.5 million hectares with an approximate production 10,000 million nuts/year. India ranks third in the world, in the production next to Indonesia and Philippines [1]. It is assessed that around 7.5 million tonnes of coirpith is being produced annually in India [2]. Coir pith can be successfully utilized as a soilless medium for vegetable crops such as tomato, bhindi and brinjal [3].

Presence of large concentration of complex polymeric organic compounds such as lignin [4] of low bio degradability, non-availability of essential nutrients, such as nitrogen and phosphorous, as these are mostly organically bound and high C:N ratio may reduce yield in coir pith media [5]. An alternative to this is coir pith compost. Coir pith compost along with FYM in 2:1 proportion is an ideal medium for the cultivation of bhindi in soilless culture [6].

Farm yard manure, a traditional manure, supplies both major and minor nutrients, improves physical condition of soil and supplies substances that stimulate plant growth. Neopeat is an eco-friendly organic soil conditioner with high water holding capacity and highly suitable for commercial floriculture and horticulture. PGPR Mix 1 is a consortium of nitrogen fixer, phosphorus and potassium solubilizing bacteria that reduce the use of chemical fertilizers and enhance the productivity of the crops.

Vegetables are rich sources of minerals, vitamins, fibre and contain a fair amount of protein as well as carbohydrates. India is the second largest producer of vegetables next only to China in World and accounts 11.4% share of World vegetable production [7].

Tomatoes have been reported to be an important source of antioxidants such as lycopene, phenolics, and vitamin C in human diet and have been linked with reduced risk of prostate and various other forms of cancer, as well as heart diseases. Tomatoes, aside from being tasty, are very healthy as they are a good source of vitamins A and C. Lycopene is a very powerful antioxidant which can help to prevent the development of many forms of cancer.

With this background this study was undertaken with the objectives of standardizing the scheduling of nutrients and to work out economics of different treatments.

## II. MATERIALS AND METHODS

The experiment was carried out at College of Agriculture, Vellayani. The growing media used in the experiment was coirpith compost + farmyard manure (FYM) in 2:1 ratio. 7 kg media was filled in 12 litre capacity grow bags. Four sources of nutrients at three different levels were tried. The variety of tomato used for the experiment is Manulakshmy released from Kerala Agricultural University. It is resistant to bacterial wilt disease and bears large fruits.

The treatments were fermented groundnut cake ($S_1$), Incubated groundnut cake + PGPR mix 1($S_2$), As chemical fertilizers in solid form, direct media application($S_3$) and As chemical fertilizers in liquid form, direct media($S_4$) application. The different nutrient levels tried were Package of practices recommendations (POP)( $N_1$), 75 % of POP ($N_2$) and 125 % of POP($N_3$). The experiment was conducted in four replications in completely randomized design. The observations on yield and yield attributes were taken.

## III. RESULT AND DISCUSSION

### 3.1. Effect of nutrient levels and sources on yield and yield attributes of tomato

Effect of nutrient sources and levels on yield and yield attributes like days to first flowering, days to fruit set, inflorescence/plant, fruit set, fruits/plant, fruit length, fruit girth and fruit weight were analyzed in the study.

Among the different nutrient sources, incubated groundnut cake + PGPR mix 1($n_3s_2$) registered the highest yield. This recorded 56% higher yield than the next best treatment *i.e.*, fermented groundnut cake ($S_1$). Fermented groundnut cake recorded the highest number of inflorescence per plant and fruit setting percentage but it was on par with incubated groundnut cake + PGPR mix 1. This superiority of these two organic nutrient sources may be due to favourable effect on growth characters like branching. Better branching must have resulted in production of more number of leaves and better utilization of solar radiation. This tapping coupled with high nutrient content and better availability have resulted in more number of fruits per plant, fruit girth and length and resulted in higher yield in $S_1$ and $S_2$.

Superiority of oil cake has been reported by several researchers. Oil cake is considered as good manure to be applied during land preparation of brinjal, chilli and bhindi for better yield [8]. Yield improvement by the application of groundnut cake might be due to the higher NPK percentage in the oil cakes. Nitrogen influences the growth and yield of crops[9]. Superiority of oilcakes is also reported in increasing the yield in amaranthus compared to fertilizers [10]. Plant growth promotion by some PGPR has been associated with the solubilization and increased uptake of phosphate [11].

 

***Table 1. Effect of nutrient sources and levels on plant height (cm)***

| Treatments | 30 DAT | 60 DAT | 90 DAT |
|---|---|---|---|
| Nutrient levels | | | |
| $N_1$ –POP | 48.74 | 78.22 | 103.53 |
| $N_2$ - 75 % of POP | 46.64 | 75.71 | 101.01 |
| $N_3$ - 125 % of POP | 49.67 | 76.80 | 101.80 |
| SEm(±) | 1.395 | 1.636 | 1.580 |
| CD (0.05) | NS | NS | NS |
| Nutrient sources | | | |
| $S_1$ | 47.35 | 76.41 | 101.83 |
| $S_2$ | 49.33 | 76.16 | 101.57 |
| $S_3$ | 48.69 | 78.52 | 103.53 |
| $S_4$ | 48.03 | 76.55 | 101.56 |
| SEm(±) | 1.611 | 1.889 | 1.825 |
| CD (0.05) | NS | NS | NS |
| Interaction | | | |
| $n_1s_1$ | 45.01 | 79.90 | 104.90 |
| $n_1s_2$ | 48.95 | 77.21 | 103.45 |
| $n_1s_3$ | 48.60 | 79.07 | 104.07 |
| $n_1s_4$ | 52.40 | 76.72 | 101.72 |
| $n_2s_1$ | 46.47 | 73.12 | 99.37 |
| $n_2s_2$ | 46.20 | 76.16 | 101.15 |
| $n_2s_3$ | 48.65 | 77.50 | 102.50 |
| $n_2s_4$ | 45.25 | 76.05 | 101.05 |
| $n_3s_1$ | 50.57 | 76.20 | 101.20 |
| $n_3s_2$ | 52.85 | 75.11 | 100.11 |
| $n_3s_3$ | 48.82 | 79.00 | 104.00 |
| $n_3s_4$ | 46.45 | 76.90 | 101.90 |
| SEm(±) | 2.791 | 3.272 | 3.161 |
| CD (0.05) | NS | NS | NS |

POP - Package of practices recommendations
$S_1$ - Fermented groundnut cake $S_2$ - Incubated groundnut cake + PGPR mix
$S_3$ - As chemical fertilizers in solid form $S_4$ - As chemical fertilizers in liquid form

 

***Table 2. Effect of nutrient sources and levels on number of primary branches and crop duration***

| Treatments | Number of primary branches | Crop duration (days) |
|---|---|---|
| Nutrient levels | | |
| $N_1$–POP | 5.25 | 112.43 |
| $N_2$ - 75 % of POP | 5.05 | 110.56 |
| $N_3$ - 125 % of POP | 5.31 | 113.00 |
| SEm(±) | 0.109 | 0.420 |
| CD (0.05) | NS | 0.736 |
| Nutrient sources | | |
| $S_1$ | 5.58 | 113.91 |
| $S_2$ | 5.37 | 113.42 |
| $S_3$ | 4.87 | 110.75 |
| $S_4$ | 5.01 | 109.92 |
| SEm(±) | 0.126 | 0.420 |
| CD (0.05) | 0.255 | 0.849 |
| Interaction | | |
| $n_1s_1$ | 5.60 | 113.25 |
| $n_1s_2$ | 5.40 | 115.75 |
| $n_1s_3$ | 5.12 | 110.75 |
| $n_1s_4$ | 4.90 | 110.00 |
| $n_2s_1$ | 5.37 | 112.50 |
| $n_2s_2$ | 5.22 | 109.75 |
| $n_2s_3$ | 4.75 | 110.50 |
| $n_2s_4$ | 4.87 | 109.50 |
| $n_3s_1$ | 5.77 | 116.00 |
| $n_3s_2$ | 5.50 | 114.75 |
| $n_3s_3$ | 4.75 | 111.00 |
| $n_3s_4$ | 5.25 | 110.25 |
| SEm(±) | 0.219 | 0.728 |
| CD (0.05) | NS | 1.471 |

POP- Package of practices recommendations
$S_1$- Fermented groundnut cake $S_2$- Incubated groundnut cake + PGPR mix
$S_3$- As chemical fertilizers in solid form $S_4$- As chemical fertilizers in liquid form

 

***Table 3. Effect of nutrient sources and levels on days to first flowering, days to fruit set, inflorescence/plant and fruit set (%)***

| Treatments | Days to first flowering | Days to fruit set | Inflorescence per plant | Fruit set (%) |
|---|---|---|---|---|
| Nutrient levels | | | | |
| $N_1$ –POP | 25.62 | 7.42 | 4.13 | 57.78 |
| $N_2$ - 75 % of POP | 28.31 | 8.35 | 4.13 | 51.31 |
| $N_3$ - 125 % of POP | 25.50 | 7.50 | 4.94 | 56.97 |
| SEm(±) | 0.204 | 0.129 | 0.197 | 0.808 |
| CD (0.05) | 0.412 | 0.262 | 0.398 | 1.633 |
| Nutrient sources | | | | |
| $S_1$ | 28.00 | 8.27 | 5.17 | 57.46 |
| $S_2$ | 25.50 | 7.45 | 4.75 | 55.59 |
| $S_3$ | 26.91 | 7.96 | 3.67 | 53.33 |
| $S_4$ | 25.50 | 7.34 | 4.00 | 55.04 |
| SEm(±) | 0.235 | 0.149 | 0.227 | 0.933 |
| CD (0.05) | 0.412 | 0.262 | 0.398 | 1.633 |
| Interaction | | | | |
| $n_1s_1$ | 27.50 | 8.00 | 4.75 | 65.37 |
| $n_1s_2$ | 25.50 | 7.25 | 4.50 | 56.25 |
| $n_1s_3$ | 26.00 | 7.45 | 3.75 | 54.25 |
| $n_1s_4$ | 23.50 | 7.00 | 3.50 | 55.25 |
| $n_2s_1$ | 30.00 | 8.92 | 5.00 | 46.00 |
| $n_2s_2$ | 27.50 | 8.12 | 3.50 | 54.00 |
| $n_2s_3$ | 28.25 | 8.60 | 3.50 | 52.25 |
| $n_2s_4$ | 27.50 | 7.77 | 4.50 | 53.00 |
| $n_3s_1$ | 26.50 | 7.90 | 5.75 | 61.00 |
| $n_3s_2$ | 23.50 | 7.00 | 6.25 | 56.54 |
| $n_3s_3$ | 26.50 | 7.85 | 3.75 | 53.50 |
| $n_3s_4$ | 25.50 | 7.25 | 4.00 | 56.87 |
| SEm(±) | 0.408 | 0.259 | 0.394 | 1.616 |
| CD (0.05) | 0.825 | NS | 0.796 | 3.267 |

POP - Package of practices recommendations
$S_1$ - Fermented groundnut cake $S_2$ - Incubated groundnut cake + PGPR mix
$S_3$ - As chemical fertilizers in solid form $S_4$ - As chemical fertilizers in liquid form

 

***Table 4. Effect of nutrient sources and levels on number, length, girth and weight of fruit and yield/plant***

| Treatments | Fruits/plant | Fruit length (cm) | Fruit girth (cm) | Fruit weight(g) | Yield/plant (g) |
|---|---|---|---|---|---|
| Nutrient levels | | | | | |
| $N_1$ - POP | 19.71 | 5.93 | 11.78 | 31.42 | 632.26 |
| $N_2$ - 75 % of POP | 17.57 | 5.73 | 11.65 | 30.68 | 527.97 |
| $N_3$ - 125 % of POP | 21.56 | 6.43 | 12.71 | 31.89 | 687.31 |
| SEm(±) | 0.57 | 0.07 | 0.17 | 0.71 | 26.96 |
| CD (0.05) | 1.162 | 0.142 | 0.359 | NS | 54.494 |
| Nutrient sources | | | | | |
| $S_1$ | 20.60 | 6.08 | 11.91 | 29.63 | 667.32 |
| $S_2$ | 20.38 | 6.32 | 13.35 | 35.12 | 723.21 |
| $S_3$ | 16.27 | 5.56 | 10.32 | 27.75 | 453.26 |
| $S_4$ | 18.2 | 6.16 | 12.61 | 34.16 | 619.60 |
| SEm(±) | 0.66 | 0.08 | 0.20 | 0.82 | 31.13 |
| CD (0.05) | 1.342 | 0.164 | 0.415 | 1.663 | 62.925 |
| Interaction | | | | | |
| $n_1s_1$ | 23.70 | 6.00 | 12.12 | 29.29 | 674.38 |
| $n_1s_2$ | 20.12 | 6.25 | 13.02 | 36.40 | 735.80 |
| $n_1s_3$ | 17.65 | 5.37 | 9.27 | 29.62 | 523.25 |
| $n_1s_4$ | 17.37 | 6.10 | 12.20 | 34.37 | 595.62 |
| $n_2s_1$ | 21.27 | 5.62 | 11.37 | 28.74 | 571.06 |
| $n_2s_2$ | 16.82 | 6.20 | 13.37 | 31.65 | 531.97 |
| $n_2s_3$ | 15.18 | 5.07 | 9.87 | 26.83 | 407.85 |
| $n_2s_4$ | 17.00 | 6.02 | 12.50 | 35.50 | 601.00 |
| $n_3s_1$ | 25.85 | 6.62 | 12.25 | 30.84 | 756.51 |
| $n_3s_2$ | 24.20 | 6.52 | 13.65 | 37.30 | 901.85 |
| $n_3s_3$ | 16.00 | 6.25 | 11.82 | 26.79 | 428.69 |
| $n_3s_4$ | 20.22 | 6.33 | 13.15 | 32.62 | 662.18 |
| SEm(±) | 1.15 | 0.14 | 0.35 | 1.42 | 53.62 |
| CD (0.05) | 2.324 | 0.284 | 0.719 | 2.881 | 108.990 |

POP - Package of practices recommendations
$S_1$ - Fermented groundnut cake $S_2$ - Incubated groundnut cake + PGPR mix
$S_3$ - As chemical fertilizers in solid form $S_4$ - As chemical fertilizers in liquid form

 

***Table 5 Effect of nutrient sources and levels on net income and BCR***

| Treatments | Net income | BCR |
|---|---|---|
| Nutrient levels | | |
| $N_1$ – POP | 3.77 | 1.36 |
| $N_2$ - 75 % of POP | 1.89 | 1.17 |
| $N_3$ - 125 % of POP | 4.79 | 1.69 |
| SEm(±) | 0.06 | 0.04 |
| CD (0.05) | 0.113 | 0.089 |
| Nutrient sources | | |
| $S_1$ | 4.72 | 1.55 |
| $S_2$ | 5.50 | 1.61 |
| $S_3$ | 0.66 | 1.12 |
| $S_4$ | 3.04 | 1.34 |
| SEm(±) | 0.06 | 0.05 |
| CD (0.05) | 0.130 | 0.102 |
| Interaction | | |
| $n_1s_1$ | 4.87 | 1.57 |
| $n_1s_2$ | 5.74 | 1.63 |
| $n_1s_3$ | 1.95 | 1.26 |
| $n_1s_4$ | 2.52 | 1.29 |
| $n_2s_1$ | 2.87 | 1.33 |
| $n_2s_2$ | 1.73 | 1.19 |
| $n_2s_3$ | 0.02 | 1.10 |
| $n_2s_4$ | 2.93 | 1.33 |
| $n_3s_1$ | 6.44 | 1.76 |
| $n_3s_2$ | 9.02 | 2.02 |
| $n_3s_3$ | 0.02 | 1.01 |
| $n_3s_4$ | 3.67 | 1.40 |
| SEm(±) | 0.11 | 0.09 |
| CD (0.05) | 0.225 | 0.177 |

POP - Package of practices recommendations
$S_1$ - Fermented groundnut cake $S_2$ - Incubated groundnut cake + PGPR mix
$S_3$ - As chemical fertilizers in solid form $S_4$ - As chemical fertilizers in liquid form

Compared to organic sources, fertilizers recorded less productivity in soilless culture. This better performance of organic sources may be due to the continuous availability of nutrients in a slow and steady manner. Nutrients from fertilizers must have released immediately and due to the porous nature of growth media chances for leaching loss of nutrients is more. Similar response was seen with respect to effect on other yield parameters.

 

The highest nutrient level ($N_3$) showed earliness in flowering and fruit set, maximum number of inflorescence per plant and fruit setting percentage. This better responses on yield contributing characters resulted in a productivity of 687.31g per plant which was significantly higher the than other two nutrient levels tested.Critical examination of the results of the study indicated that fruit girth, fruit weight and per plant yield were the highest in treatment that received the highest level of nutrient (125%) as incubated groundnut cake + PGPR mix I ($n_3s_2$). Fruits per plant and fruit length were maximum for the plants that received fermented groundnut cake (125 % of POP). This was on par with incubated groundnut cake + PGPR mix I (125 % of POP).

Results revealed that incubated groundnut cake + PGPR mix I at 125 % of recommended dose (94:50:31 kg NPK $ha^{-1}$) was superior to other treatments. Better nutrient availability and uptake during the vegetative phase might have increased the production, translocation and assimilation of photosynthates to growing points and stimulated the plants to produce more number of fruits and better fruit characters [12].

It is clear that the number of inflorescence per plant and fruit setting percentage were higher in incubated groundnut cake + PGPR mix I (125 % of POP). The higher availability and uptake of nutrients might have enabled the plant to produce more number of flower buds which in turn increased the number of fruits and yield per plant. Increased fruit yield may be due to better vegetative growth, better availability of nutrients, greater synthesis of carbohydrates and their proper translocation [13]. Successive doses of fertilizer levels increased considerably the number of cluster per plant, number of fruits per cluster, size of fruit, weight of fruit and yield per plant in tomato [14]. Increased fruit yield in bhindi at higher levels of nutrient application is also reported[12].

The reason attributed for higher yield with PGPR might be due to the stimulated plant growth by the production of growth promoting substance like auxin, increased the availability of nutrients by N fixation and solubilisation of phosphorus and potassium in the media [15]. Supplementation of essential plant nutrients in relatively higher amount resulted in better growth and development of crop [16]. Reports show that with the increment in supply of essential nutrients, their availability, acquisition, mobilization and influx into the plant tissues increased and thus improved growth and yield components in tomato[17].

Beneficial effect of groundnut cake might be due to supplementation of essential nutrients in relatively higher amount which resulted in better growth and development of the crop[18]. Reports revealed that PGPR can stimulate growth and increase yield in sugar beet [19]. Facilitating plant nutrition could be the mechanism by which PGPR enhance crop yield and fruit size, since the nutritional plants status is enhanced by increasing the availability of nutrients in the rhizosphere [20, 21].

### 3.2. Effect of nutrient levels and sources on economic analysis

A perusal of data presented in table 15 on economic analysis revealed that there is a marked increase in the net income and BCR with the progressive increase in levels of the nutrients. Among the nutrient levels tried, the highest level ($N_3$) recorded the highest cost of cultivation of about Rs. 8.95 grow $bag^{-1}$. The same nutrient level registered the highest gross returns of Rs. 13.75 grow $bag^{-1}$. Among the nutrient sources, organic sources performed better than chemical fertilizers. Organic sources were found economically superior to chemical fertilizers. Between the two organic sources, incubated ground nut cake + PGPR mix I($S_2$) recorded the highest net income (Rs. 5.50 grow $bag^{-1}$) and this was due to the highest gross return resulted from higher productivity and low cost of cultivation. Interaction effect of different sources and levels of nutrients revealed that incubated ground nut cake + PGPR mix I applied at 125% of POP ($n_3s_2$) recorded the highest net income (Rs. 9.02 grow $bag^{-1}$) and BCR (2.02)( Fig. 11) indicating the economic feasibility organic nutrition in soilless culture. An increase in net income and BCR with increase in nutrient levels are reported by several workers[18, 12]. These results have got practical significance in urban agriculture.

 

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