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*Review Article*_____ *Chapter –18*

TOMATO PRODUCTION AFFECTED BY NUTRIENT SOURCES AND TRAINING UNDER PROTECTED CULTIVATION

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Abstract

Balance fertilizations in tomato crop during all growth stages is necessary for satisfactory growth, development and also yield. Among different nutrients nitrogen, phosphorus and potassium are considered as the most important nutrients. Mineral fertilizers are costly and sometimes may be unavailable due to which its application in balance amount cannot be possible for most farmers.Neem seed cake was found to have high manurial value; Indian farmers have traditionally used deoiled neem cake as fertilizer on their fields (NRC, 1992). Bio-fertilizers enclose useful microorganisms in a viable state, dedicated to seed or soil application and intended to improve soil fertility. The use of organic liquid products like *Panchagavya* results in higher growth, yield and quality of crops.

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Introduction

Tomato (*Lycopersicon esculentum* Mill.) is a solanaceous crop with chromosome number 2n = 24 and one of the most popular vegetables grown all over the world. It tops in the list of processed vegetables in the world (Dhaliwal *et al.*, 1999). It is cultivated as a cash crop as well as a vegetable crop on commercial lines in almost all parts of India. Its fruits are abundantly rich in vitamins A and B and an excellent source of vitamin C (Yawalkar, 1985),mineral, organic acids and also contain various flavoring compounds, which enrich the taste and flavor of all vegetable dishes prepared from it. Among all the solanaceae crops, tomato has been proved as the best experimental material for research in genetics, physiology, plant protection, processing etc. It also gives good response to the plat nutrients and growth substances and hence tomato crop widely preferred in hormonal studies.It is popularly known as *Wolf apple, Love of Apple or Vilayati baingan*. Besides, being popular for salad and soup, tomato is mixed in cooked vegetable curries. It is also one of the most important raw materials for processing industry for making several processed products.

The 100 g fruit contains 94.22 g water, 2.7 g carbohydrates, 17 kcal energy, 0.89 g protein, 0.24 g total fat, 1.21 g dietary fibre, 0.59 g ash, 3.74 mg sodium, 12.1 mg magnesium, 22.9 mg phosphorus, 10.9 mg sulphur, 48.3 mg chlorine, 265 mg potassium, 10.9 mg calcium, 56.8 µg Manganese, 0.13 mg iron, 0.049 mg copper, 0.09 mg Zinc, 92 µg vitamin A, 0.024 mg thiamine, 0.005 mg riboflavin, 0.543 mg niacin, 23.7 mg vitamin C, 0.77 mg vitamin E (Hedges and Lister, 2005). It is the richest fruit for natural foods by which the stomach and intestine feel good condition and thus has very good medicinal property.Because of its wider adaptability and versatility, tomato is grown throughout the world either in open field or in protected structure. The estimated world production of tomato is about 180.77 million tonnes from an area of about 50.30 lakh ha (Anon., 2019a).The production in India was 19.40 lakh tonnes and area is 7.78 lakh ha (Anon., 2019b).Total production in Gujarat was 9.61lakhtonnesand area is 31,340 ha. However the highest area of 5130 hectare with production of 1.85lakh tones was obtained in the Banaskantha district of Gujarat (Anon., 2017).

Protected cultivation of vegetables emphasizes the need for having appropriate plant densities and training systems in order to boost up the production by utilizing the available space and nutrient applied.The decision on the number of plants to be grown in a given area of greenhouse is based upon expected light condition during the growth of a crop. So, plants grown under protected structures are given a specific retainable structural frame by way of training, which is oftenly achieved through regular pruning of suckers in tomato. Plant spacing and training are important factors in proper utilization of production area and to improve yield and quality of tomatoes (Ara *et al.*, 2007).Pruning limits vegetative growth and allows more light penetration, and thereby improve qualitative and quantitative characteristics of tomato fruits (Preece and Read, 2005). Training system emphasizes on the plant ability to obtain sunlight for growth. It is also important to maintain sufficient air circulation around the plant to reduce the risk of pests. The leaves of a well-trained plant dry off faster, so bacterial and fungal pathogens have less opportunity to spread. Soil is less liable to splash up onto well trained plants. Plant density and pruning of suckers play a key role in efficient use of the area in protected structures. Pruning methods vary with different growth habits of tomato cultivars and plant densities.

Training the plant to one stem, two stem or three stem is generally practiced for indeterminate and semi-determinate cultivars of tomato. Properly trained plants produce larger and earlier fruit than untrained plants in crops grown under protected structures. Yield per truss increases steadily due to increase in fruit size and fruit number per truss with the intensity of pruning in tomato.

Almost all farmers are relying on commercial fertilizers for profitable yields, thus less or no build-up of organic matter occurs in soil. Mineral fertilizers when applied continuously over the years, affects the physical properties of the soil and may not have the ability to produce more yields (Zia *et al*., 2000). Now-a-days, organic farming is one of the fastest growing sectors of agriculture all over the world. Its goal is to create a balance between combined systems of soil organisms, plants, animals as well as humans (Karanatsidis and Berova, 2009).Nitrogen fixing bacteriafixing N and produce ammonia for their own use and support the plant by supplying nitrogen, as an exchange carbon and protected habitat (Marschner, 1995). Phosphate dissolving bacteria dissolve phosphorus from organic phosphorus complexes to make it soluble for the plant through the production of enzymes phosphate. They also produces biotic compounds, such as hormones like auxin and gibberellic acid (Mehrvarz and Chaich, 2008). Potassium dissolving bacteria breakdown potassium from complex insoluble minerals into a simple form (Alexander, 1985).Neem cake improves the growth and yield of crops because it contains essential nutrients necessary for the growth of crops (Garba and Oyinlola, 2014; Oyinlola *et al*., 2014).The *Panchagavya*, is ecofriendly organic preparations made from cow products. This liquid organic solution is prepared from cow dung, urine, milk, curd and ghee. They contain macro nutrients, essential micro nutrients, many vitamins, essential amino acids and growth promoting factors like IAA, GA and beneficial microorganisms (Palekar, 2006; Natarajan, 2007; Sreenivasa *et al*., 2010).

In India, information on various aspects of crop production under protected culture in various agro-climatic conditions is rather meager. Manipulation of plant architecture through training with appropriate spatial arrangements has also been revealed as a key management factor for getting maximum yield from greenhouse crops (Cebula, 1995). Increased plant population in field increases early flowering, fruit size and total yield per unit area (Richard and Jules, 1970).

Related Studies

Effect of Nutrient Through Chemical Fertilizer

Tesfaye (2008) conducted a field experiment on response of tomato cultivars differing in growth habit to nitrogen and phosphorus fertilizers and spacing on vertisol in Ethiopia and results revealed that 110 kg N + 120 kg P_2O_5/ha gave significantly the highest plant height (81.7 cm), number of fruits per cluster (5.97), ten fruit weight (1.31 kg), total fruit yield per plot (80.5 kg) and marketable fruit yield per plot (76.1 kg). Kibria *et al.* (2016) studied the effects of biogas plant residues (BPR) and NPK fertilizer on growth, yield and quality of tomato (*Lycopersicon esculentum*) and recorded that the application of inorganic fertilizer produced statistically similar number fruits per plant, weight of fruits per plant and yield (t/ha) to those found with BPR from 10 to 40 t/ha. There was no significant variation in single fruit of tomato among the treatments. Mineral

nutrient content of tomato were not significantly affected by application of fertilizer and BPR except nitrogen in the fruit tissues. Chemical fertilizer and biogas plant residues ensured good performance in terms of yield and quality of tomato.Jayasinghe and Weerawansha (2019) concluded thatthere were no significant differences between treatments consisted with 100% of NPK fertilizer + 50% of compost and 50% of NPK fertilizer on days to attained 50% of flowering, number of fruit per plant and yield of varieties except the yield of Roma variety.

Effect of Nutrient Through Organic Material

Nileema and Sreenivasa (2011) noticed the influence of liquid organic manures on growth, nutrient content and yield of tomato (*Lycopersicon esculentum* Mill.) in the sterilized soil. They reported significantly highest plant growth and root length was recorded with the application of recommended dose of fertilizer + *Beejamruth* +*Jeevamruth* + *Panchagavya.* Navjot Singh*et al*. (2015) carried out an experiment on effect of organic manures and biofertilizers on fruit yield and contributing traits of tomato (*Solanum lycopersicum* L.) at Nauni, Solan (H.P.) and observed that the Vermicompost + Biofertilizers performed the best for number of primary branches per plant (3.47), days to 50 % flowering (41.00 days), plant height (160.57 cm), harvest duration (49.33 days), number of fruits per plant (19.47), average fruit yield per plant (1.31 kg), fruit yield per plot (42.17 kg), fruit yield (390.45 q/ha).Rajya*et al.* (2015) conducted the experiment oneffect of organic manures and inorganic fertilizers on plant growth, yield, fruit quality and shelf life of tomato at SHIATS, Allahabad and concluded the 50 % RDF + 50 % FYM recorded maximum plant height (133.53 cm), minimum days to first flowering (29.47 days), maximum number of flower clusters per plant (8.67), maximum number of flowers per cluster (7.27), maximum number of fruits per cluster (5.67), maximum number of fruits per plant (36.72), maximum average fruit weight (41.67 g), maximum fruit yield per plant (849 g), maximum fruit yield per plot (13.50 kg) and maximum fruit yield per ha (33.77 t).Angadi*et al.* (2017) investigated the effect of organic manures and biofertilizers on plant growth, seed yield and seedling characteristics in tomato (*Lycopersicon esculentum* Mill.) at Naini, Allahabad and revealed that bio-fertilizers with RDF recorded the highest growth and yield parameters like plant height (53.08, 87.23 and 136.24 cm), number of leaves per plant (90, 139.13 and 132.40) at 30, 60 and 90 days after transplanting respectively and shows minimum days to 50 % flowering (37.77 days), number of fruits per plant (31.13), fruit weight per plant (1.35 kg), number of seeds per fruit (81.93), seed yield per plant (3.04 g), seed yield per plot (36.58 g) and seed yield per hectare (97.55 kg).

Meena *et al.* (2017) studied the impact of bio-fertilizers on growth, yield and quality of tomato at Lucknow and they observed that the treatment with 75% RDF + 25% FYM + *Azospirillum*was highly significant for morphological as well as maturity parameters like plant height (30.52 cm), number of branches (13.08), number of flower/plant (31.43), number of cluster/plant (9.13), number of fruits per plant (14.00), fruit weight (64.94 g), fruit diameter (63.61 mm), plant yield per plant (0.92 kg), plot yield (14.09 kg), yield (37.01 t/ha), tritable acidity (0.67 %), TSS (4.18^{o}B) and vitamin-C (23.87 mg/100ml).Oyinlola *et al.* (2017) studied the effect of Neem seed cake and inorganic fertilizer on yield of tomato and soil properties in Northern Guinea Savanna of Nigeria and

observed that Neem seed cake (2.0 t/ha) + ½ fertilizer recommended rate (62.5 kg/ha) proved superior for tomato fruit yield and mean fruit weight than other treatments.Parmar *et al.* (2019) studied the effect of integrated nutrient management on growth development and yield traits of tomato (*Solanum lycopersicon* L.) at Indore, Madhpradesh and concluded that 75 % RDF + Neemcake (6.25 %) + Vermicompost (6.25 %) + FYM (6.25 %) + Poultry manure (6.25 %) + PSB + *Azospirillum* was highly significant in number of flowers per plant (53.77), minimum days to flowering (41.67 days), days to 50 % flowering (44.75 days), days to first fruiting (47.76 days), fruit length (6.07 cm), number of fruit per cluster (10.20), fruit yield (359.95 q/ha).

Yadav*et al.* (2019) conducted the experiment on response of bio-enhancer on growth and yield of tomato (*Solanum lycopersicum* L.) in Gwalior, M.P. and result revealed that spray of 4 % *panchgavya* gave higher growth and yield attributing character like plant height (55.22 cm), no. of branches/plant (6.00), no. of flower/plant (13.28), days to first flower initiation (44.67 days), days to fruit setting after flowering (10.65 days), no. of fruits/plant (10.93), average fruit weight (53.72 gm) and fruit yield (34.50 t/ha).Roger and Jean (2020) investigated effect of soil amendment with Neem seed cake on tomato plant growth and development, fruit quality and storability in West Region of Cameroon, Mifi Division and Subdivision of Bafoussam and observed that the plant height, stem diameter, number of leaves per plant, number of branches per plant, time elapsed between the seedling transplanting date and the date of the appearance of the first flower, number of flower buds per plant, number of flowers per plant, number of fruits per plant, fruit physiological weight loss (PWL), fruit titratable acidity (TA) and fruit senescence rate were positively influenced by the soil application of neem seed cake 12 g/plant. Sharma*et al.* (2020) investigatedthe differential responses of organic manure and bio-fertilizer on morphophenological traits and yield attributes of cherry Tomato (*Solanum lycopersicum* var cerasiformae) genotypesat Jabalpur and recorded that the application of vermicompost 5.0t/ha and *Azotobacter* 4.0kg/ha in G4 2018/TOC VAR-4 genotype gave significantly higher values for morphological and phonological traits such as plant height (66.74 and 123.96 cm) at 60 and 120 DAT, minimum days taken to first flower (29.84), minimum days to first picking (81.3 days), with average fruit weight 45.50 g, mean number of fruits per plants (144.3), yield per plant (0.82 kg) and fruit yield per ha (272.52 q/ha). Maximum number of branches per plant at final harvest (15.32), minimum days to first flower (29.35 days), early harvesting (81.3 days), average fruit weight (41.18g), fruit yield per plant (0.87 kg) and yield per hectare(289.60q/ha).

Effect of Training

Ara *et al.* (2007) conducted an experiment on effect of spacing and stem pruning on the growth and yield of tomato at Ishurdi, Pabna and result revealed that wider spacing (50 cm) gave the higher marketable yield (82.39 t/ha) and two stem pruning yielded the highest marketable yield (87.18 t/ha). Patel*et al.* (2016) investigated the response of tomato (*Solanum lycopersicum* L.) to varying levels of spacing and training under protected conditions at Navsari Agricultural University,Navsari, Gujarat. They observed that wider spacing produced better result for reproductive parameters like days to first flowering (28.11 days) and number of fruits per cluster (5.04) as well as for yield parameters namely average fruit weight (110.95 g) and fruit yield per plant (3.14 kg).

Among various levels of training systems, single stem showed significant effect on plant height to the tune of 125.96, 163.11, and 216.69 cm at 60. 90 and 120 DAP respectively, leaf area (857.09 cm), days to first flowering (28.22 days), number of flowers per cluster (8.78), number of fruits per cluster (6.19), number of fruits per plant (31.83), average fruit weight (92.86 g), fruit yield per plant (2.71 kg) and fruit yield per m^2 (6.76 kg).Sultana *et al.* (2016) carried out an experiment on effect of pruning on growth and yield of tomato at Dhaka. They reported that three stem pruning produced the maximum fruits per plant (35.33) and the highest yield (66.86 t/ha).

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