International Journal of Plant & Soil Science

34(22): 125-132, 2022; Article no.IJPSS.89955
ISSN: 2320-7035

Impact of Fertigation Schedule on Growth and Quality Parameters in Tomato

T. Vinitha Reddy [a*], M. Elayarajan [a], V. Ravikumar [b], P. Janaki [a] and P. Pramila [b]

[a] Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore - 641003, Tamil Nadu, India.
[b] Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore - 641003, Tamil Nadu, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i2231365

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/89955

Original Research Article

Received 24 May 2022
Accepted 29 July 2022
Published 02 August 2022

ABSTRACT

Nutrient availability to plants precisely can be done by combining cognitive irrigation systems with nutrient application, and proper scheduling of fertilizers is the mainstay for availability of appropriate amount of nutrients for plant growth. Based on the statement a, field experiment was carried out to evaluate the efficiency of fertigation influence on growth, physiological, quality and yield parameters of TNAU Tomato hybrid CO 4. The experiment consisting of seven treatments laid in randomized block design was replicated three times. `Fertigation was given at fortnightly interval with urea, MAP, MOP as a source of N, P& K in ten splits in 150 days. Significant differences were observed with regard to growth, physiological, quality and yield parameters. All the growth, physiological, and yield parameters were higher in tomato plants which received fertigation NPK @ 75% K + 100 % N&P. Lycopene content of tomatoes was increased to 4.73 mg 100 g^{-1} in fertigation NPK @ 75% K + 100 % N&P (T_6). Ascorbic acid, Titratable acidity, TSS, β-carotene showed the highest value in treatment which received fertigation NPK @ 75% K + 100 % N&P.

Keywords: Tomato; fertigation schedule; growth; yield; quality.

**Corresponding author: E-mail: vinithareddythondamanadu@gmail.com;*

1. INTRODUCTION

India has a total land area of 328.7 million hectares. Out of which the total cultivated area is about 160 million ha, and in that 39 million hectares of land are irrigated by exploitation of ground water resources. The agricultural sector alone uses 80% of all ground water. Water is a major limiting factor in agriculture. Water management in agriculture has become a universal precedence [1]. In India about two thirds of land depends on the monsoon for cultivation. With the change in time, water availability is decreasing and our country is advancing to a state of water scarcity. As a result, per capita water availability has also decreased. Tamil Nadu is the sixth most inhabited place in India, which has 6% of the national population and it covers 4% of the total area of the country. It is one of the most water-starved states, having only 3% of the nation’s water resources, resulting in high stress on irrigation water availability and is at risk of seasonal fluctuations inflicting uncertainty on agricultural production [2].

Water and fertilizers are the two cardinal inputs impacting on crop production. A major portion of water has been lost to surface irrigation, because of seepage, leaching and evaporation losses in the field. This can be controlled to a larger extent by fostering micro irrigation. By using drip irrigation systems, water and nutrients can be applied directly to the crop at the root level, having positive effects on nutrient uptake, yield and water saving and increasing the irrigation performance [3]. The usage of drippers to control water supply has an impact on plant root and shoot growth as well as fertilizer efficiency. Drip irrigation lowers water and chemical fertilizer waste, optimizes nutrient usage by providing nutrients at essential stages and at the right place and time, and so improves water and nutrient use efficiency by reducing the weed growth.

After China, India is the world's second-largest consumer of fertilizers. To meet its consumption requirements, India imports 20% of nitrogenous fertilizers, 90% of phosphatic fertilizers, and nearly 100% of potassic fertilizers [4]. Fertilizers which are applied using traditional methods do not effectively used by crops [5,6]. Fertilizer use efficiency was very much decreased in that case. Fertigation allows a nutrient to be applied directly to a high concentration of active roots as needed by the crop. Fertigation allows for appropriate water and nutrient inputs, as well as precise timing and homogeneous distribution, to meet crop nutrient requirements. Furthermore, fertigation assures significant fertilizer savings and lowers leaching losses [7].

The tomato is considered as one of the most important vegetable crops grown throughout the world. It is a prominent source of vitamin A, C and minerals. It has gained importance in recent years as a good source of lycopene, a potent antioxidant, which acts as an anticarcinogen. Tomato is a principal source of vitamins and minerals [8]. Fertilizer is an important aspect in increasing tomato output. Tomato is a massive feeder crop, fertilizer application is frequently extensive during production. Apart from the variety, fertilizer is a crucial aspect in increasing tomato output and observed exorbitant tomato yield by fertigation than banded and furrow irrigation [5].

Fertilizers should be applied in a way that becomes available in time for crop demand in order to maximize fertilizer nutrient utilization [9,10]. Fertilizers should be applied in lesser quantities in synchronization with crop need during the growing season, taking into account soil and crop limits. Agriculture is being challenged with managing water and fertilizer in such a way that production gains are maximized while negative environmental effects are avoided [10]. Fertigation allows for adequate supplies of water and nutrients to be delivered at exact times and in a uniform manner to meet crop nutrient requirements [11]. Therefore, the aim of this present study is to determine the best and effective fertigation schedule for TNAU Tomato hybrid CO 4.

2. MATERIALS AND METHODS

Field Experiment was carried out during 2021-22 in the Eastern Block, field Number: 75 at irrigation cafeteria of Water Technology Centre, Tamil Nadu Agricultural University (TNAU), Coimbatore. The experimental field is located at 11˚ N latitude, and 77 ˚E longitude at an altitude of 426.7 m above the sea level. Soil texture is sandy clay loam, with 0.42% Organic Carbon (low), pH of 8.39 (moderately alkaline), Electrical Conductivity (EC) 0.56 dSm^{-1} (non saline), bulk density of 1.33 Mg m^{-3}, particle density of 2.22 Mg m^{-3}, porosity of 40%, Available Nitrogen of 268 kg ha^{-1} (low), Phosphorus of 17.2 kg ha^{-1} (medium), Potassium of 310 kg ha^{-1} (high) in soil at the initial stage of the experiment. The experiment was carried out with TNAU Tomato Hybrid CO 4 in a Randomized Block Design. Twenty-Five days old seedlings of tomato were transplanted on each bed in the main field with a spacing of 60 cm between the rows and 45 cm between the plants. The experiment consists of seven treatments and with three replication which includes T_1- Fertigation NPK @100% Recommended dose i.e., 200:250:250 kg ha^{-1} (CPG, TNAU 2020), T_2- Fertigation NPK @ 75% N + 100% P & K), T3- Fertigation NPK @125% N + 100% P&K, T_4- Fertigation NPK @ 75% P + 100% N&K, T_5- Fertigation NPK @125% P + 100% N&K, T_6- Fertigation NPK @ 75% K + 100% N&P, T_7- Fertigation NPK @ 125% K+ 100% N&P. The fertilizers which are used as a source of N,P,K in the experiment are Urea, Mono Ammonium phosphate (MAP), Muriate of potash (MOP). The amount of fertilizers given through fertigation was calculated by following TNAU CPG for Horticulture (2020). Fertigation was given at 15 days interval through the Automated fertigation unit. Application of N, P, K in all treatments to identify the best treatment and to propose it as an optimal fertigation schedule for tomato hybrid CO 4. Crop production and plant protection measures were followed as per (CPG, TNAU 2020). Observations were taken from plants in the field at critical growth stages (vegetative, flowering, fruiting, harvesting) of tomato like Plant height (cm), Root length (cm), Dry weight (g), Chlorophyll content. Observations for yield parameters like number of fruits per plant, individual fruit weight, yield per plant (kg) were recorded by collecting mature fruits from each treatment separately. Fruits were harvested and analyzed for lycopene content (mg $100g^{-1}$), titratable acidity (% citric acid $100g^{-1}$), β-carotene (mg $100g^{-1}$), ascorbic acid (mg $100g^{-1}$), and total soluble solids (˚Brix) from each treatment.

3. RESULTS AND DISCUSSION

3.1 Growth and Physiological Parameters

The response of different growth parameters of tomato to varied levels of fertigation schedule with N, P and K is provided in Tables 1 and 2. Growth parameters like plant height, root length, plant dry weight were found to be maximum in the treatment, which received fertigation NPK @ 75% K + 100% N&P (T_6). However, they are at par with each other in plants that received fertigation NPK@ 125% P + 100% N&K (T_5) and fertigation NPK @ 100% NPK. (T_1), followed by fertigation NPK @ 75% P + 100% N&K (T_4) and fertigation NPK @ 75% N + 100% P & K (T_2). The mean of the plant height in all four stages shown maximal value of 77.6 cm in T_6, when compared with all other treatments. The application of NPK fertilizer at relevant time and appropriate quantity helps in increasing the accessibility of nitrogen in the soil, which in turn is helpful for the formation of protein. Passable amounts of protein are useful in the process of cell division, the advancement of tissue and organ growth. Nitrogen acts as a component of protein in plant stem growth [12,13]. The highest value of root length (17.2 cm), and the plant dry weight (107.2 g) was shown by T_6. However, the solid fertilizers frequently result in an unbalanced distribution of fertilizers in the root zone. To ensure optimal dispersion in the soil, all of the soluble N, P, and K fertilizer can also be applied using a drip fertigation system. This is proof of the longer fertigation activity, when nutrients were routinely applied to match crop uptake [6]. Dry weight of the plants showed a maximal value in T_6 (Table 2). This is because nitrogen fertilization causes an increase in photosynthate source capacity, which promotes vegetative growth and biomass accumulation [14] and [15]. Physiological parameter like chlorophyll content also showed a significantly higher value in T_6 (53.6). An increase in chlorophyll content is observed up to 90 days after transplanting and then there is a decrease as shown in Table 2. Chlorophyll levels were low during the vegetative growth stage, then increased until the first two clusters of fruit started to ripen. Immediately following the fruit set, a decrease in SPAD readings was noted [16].

3.2 Yield Parameters

The total number of fruits per plant and flowers per plant varied among different treatments, the maximum value noted with fertigation of NPK @ 75% K + 100% N&P (T_6) followed by fertigation NPK@ 125% P + 100% N&K (T_5) and Fertigation NPK @ 100% NPK (T_1) (Table 3). Fruit production performed better when important nutrients like nitrogen and phosphate were provided [17]. The maximal number of fruits is also due to the effective interactivity between the applied N, P, and K. Another reason would be that when critical nutrient supplies to tomatoes increased, so did their availability, acquisition, mobilization, and influx into plant tissues, which improved the quantities of flowers/cluster and fruits/cluster [18].

Table 1. Influence of fertigation schedule on Growth Parameters of Tomato Hybrid CO 4

Treatment		Plant height (cm)					Root length (cm)				
		30 DAT	**60 DAT**	**90 DAT**	**120 DAT**	**Mean**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**	**Mean**
T1	Fertigation NPK (100 % NPK)	(43.4±1.0)[b]	(68.2±0.1)[b]	(86.0±0.9)[a]	(96.0±1.8)[b]	73.4	(4.24±0.09)[b]	(15.5±0.03)[b]	(21.1±0.5)[b]	(22.7±0.5)[b]	15.9
T2	Fertigation NPK (75% N + 100 % P&K)	(37.2±0.1)[c]	(57.4±0.3)[c]	(74.9±1.6)[b]	(85.5±1.2)[c]	63.7	(3.6±0.08)[c]	(12.3±0.1)[c]	(17.3±0.4)[c]	(19.1±0.3)[c]	13.1
T3	Fertigation NPK (125% N + 100 % P&K)	(26.5±0.2)[d]	(50.2±0.05)[d]	(60.8±1.2)[c]	(74.9±0.6)[d]	53.1	(2.6±0.05)[d]	(8.40±0.1)[d]	(12.4±0.1)[d]	(15.6±0.5)[d]	9.7
T4	Fertigation NPK (75% P + 100 % N&K)	(38.7±0.7)[c]	(59.6±1.4)[c]	(75.1±1.8)[b]	(86.7±0.1)[c]	65.0	(3.75±0.005)[c]	(12.4±0.1)[c]	(17.8±0.3)[c]	(19.5±0.3)[c]	13.4
T5	Fertigation NPK (125% P + 100 % N&K)	(45.0±0.5)[ab]	(70.7±1.4)[ab]	(88.5±1.1)[a]	(98.8±0.7)[ab]	75.7	(4.45±0.09)[ab]	(15.85±0.04)[ab]	(21.9±0.1)[ab]	(24.4±0.08)[ab]	16.6
T6	Fertigation NPK (75% K + 100 % N&P)	(46.5±0.7)[a]	(72.1±0.2)[a]	(89.2±0.1)[a]	(102±0.9)[a]	77.6	(4.47±0.05)[a]	(16.1±0.3)[a]	(22.4±0.4)[a]	(25.8±1.6)[a]	17.2
T7	Fertigation NPK (125% K+ 100 % N&P)	(25.6±0.3)[d]	(48.0±0.6)[d]	(59.7±1.3)[c]	(71.8±0.06)[d]	51.3	(2.55±0.01)[d]	(8.10±0.1)[d]	(11.5±0.2)[d]	(14.7±0.4)[d]	9.2
SEd		0.82	1.18	1.59	1.83		0.09	0.25	0.44	1.36	
CD (P=0.05)		1.79	2.58	3.48	3.99		0.21	0.56	0.96	2.98	

**DAT – Day after transplanting*

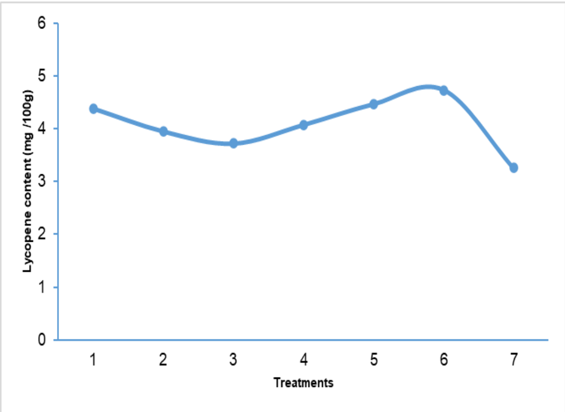
Table 2. Influence of fertigation schedule on Dry weight and Chlorophyll content of Tomato Hybrid CO 4

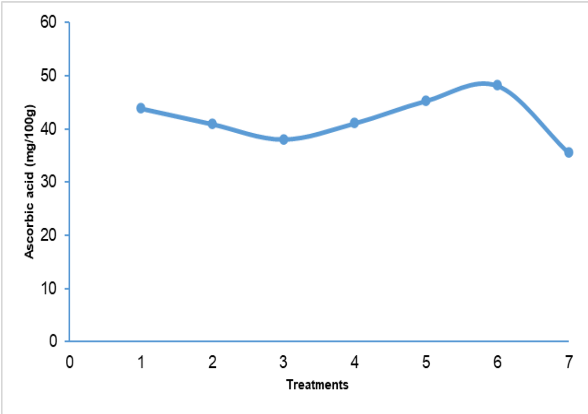
Treatments		Plant Dry weight (g)					Chlorophyll content				
		30 DAT	60 DAT	90 DAT	120 DAT	Mean	30 DAT	60 DAT	90 DAT	120 DAT	Mean
T1	Fertigation NPK (100 % NPK)	(11.0±0.1)[b]	(70.7±1.5)[b]	(120.0±0.8)[b]	(203.4±2.7)[b]	101.3	(42.3±0.8)[b]	(51.6±0.2)[b]	(57.6±1.3)[b]	(53.7±0.2)[b]	51.3
T2	Fertigation NPK (75% N + 100 % P&K)	(10.3±0.2)[c]	(57.5±0.8)[c]	(101.5±0.7)[c]	(158.5±1.6)[c]	81.9	(34.9±0.2)[c]	(43.9±0.02)[c]	(48.1±0.4)[c]	(47.3±0.5)[c]	43.5
T3	Fertigation NPK (125% N + 100 % P&K)	(9.5±0.2)[d]	(50.6±0.1)[d]	(91.5±0.8)[d]	(126.1±3.0)[d]	69.4	(32.7±0.5)[d]	(40.5±0.8)[d]	(45.7±0.4)[d]	(42.4±0.5)[d]	40.3
T4	Fertigation NPK (75% P + 100 % N&K)	(10.5±0.2)[c]	(59.2±0.7)[c]	(105.3±1.1)[c]	(165.0±4.3)[c]	85.0	(35.8±0.1)[c]	(44.9±0.3)[c]	(49.5±0.5)[c]	(48.8±0.1)[c]	44.7
T5	Fertigation NPK (125% P + 100 % N&K)	(11.3±0.2)[ab]	(72.4±0.9)[ab]	(124.0±1.9)[ab]	(208.0±2.1)[ab]	103.9	(43.3±0.3)[ab]	(52.4±0.6)[ab]	(59.3±0.7)[ab]	(54.9±0.6)[ab]	52.5
T6	Fertigation NPK (75% K + 100 % N&P)	(11.5±0.1)[a]	(74.5±0.9)[a]	(128.3±2.2)[a]	(214.5±1.1)[a]	107.2	(44.1±0.02)[a]	(53.6±0.2)[a]	(61.0±0.02)[a]	(55.8±0.8)[a]	53.6
T7	Fertigation NPK (125% K+ 100 % N&P)	(9.2±0.04)[d]	(47.8±1.0)[d]	(87.6±1.5)[d]	(121.3±2.5)[d]	66.5	(32.2±0.6)[d]	(39.5±0.6)[d]	(44.7±0.9)[d]	(41.2±0.5)[d]	39.4
	SEd	0.20	0.74	0.95	1.20		0.63	0.77	1.05	0.72	
	CD (P=0.05)	0.44	1.52	1.88	2.40		1.38	1.67	2.28	1.56	

DAT – Day after transplanting

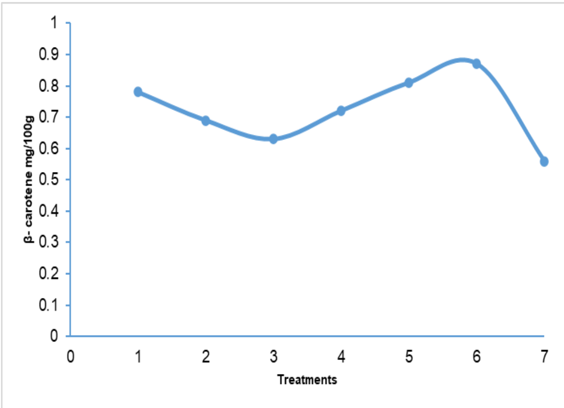
Table 3. Influence of fertigation schedule on Yield parameters of Tomato Hybrid CO 4

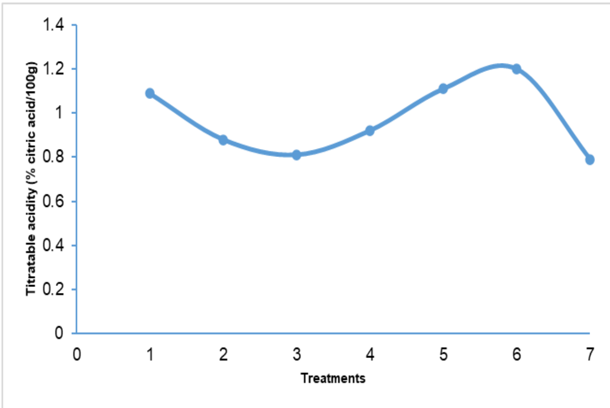
Treatments		Total number of flowers plant^{-1}	Total number of fruits plant^{-1}	Individual fruit weight	Yield plant^{-1}
T1	Fertigation NPK (100 % NPK) 200:250:250 kgha^{-1}	(90±2.1)[b]	(48±0.9)[b]	(42.9±0.1)[b]	(2.06±0.02)[b]
T2	Fertigation NPK (75% N + 100 % P&K)	(80±0.9)[c]	(44±1.0)[c]	(41.2±0.08)[c]	(1.81±0.005)[c]
T3	Fertigation NPK (125% N + 100 % P&K)	(75±1.2)[d]	(40±0.04)[d]	(40.3±0.08)[d]	(1.61±0.003)[d]
T4	Fertigation NPK (75% P + 100 % N&K)	(82±1.9)[c]	(45±1.0)[c]	(41.3±0.6)[c]	(1.86±0.04)[c]
T5	Fertigation NPK (125% P + 100 % N&K)	(94±1.8)[ab]	(49±0.9)[b]	(43.1±0.6)[b]	(2.11±0.04)[b]
T6	Fertigation NPK (75% K + 100 % N&P)	(97±0.3)[a]	(52±0.4)[a]	(45.2±1.1)[a]	(2.35±0.01)[a]
T7	Fertigation NPK (125% K+ 100 % N&P)	(73±0.8)[d]	(37±0.7)[e]	(38.5±0.02)[e]	(1.43±0.02)[e]
	SEd	2.23	1.18	0.73	0.04
	CD (P=0.05)	4.86	2.57	1.59	0.09



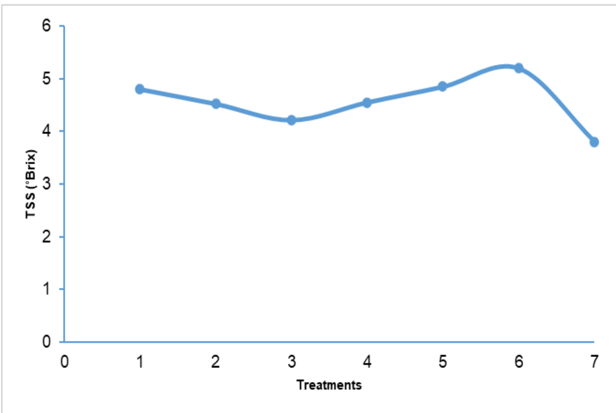


(a) Lycopene content (mg 100g^{-1}) (b) Ascorbic acid (mg 100g^{-1})





(c) β - Carotene (mg 100g^{-1}) **(d) Titratable acidity (% citric acid 100g^{-1})**



(e) TSS (˚Brix)

Fig. 1. (a-e): Influence of fertigation schedule on Quality parameters of TNAU Tomato Hybrid CO 4

According to reports, combined NPK applications boost the number of flowers per cluster and flowering clusters per plant in tomatoes [19]. Individual fruit weight and fruit yield per plant show the highest value in fertigation NPK @ 75% K + 100% N&P (T_6), because inorganic fertilizers contain soluble inorganic nutrients that were readily available to crops and help to get better yields [20,21]. The increase in yield is due to highest interactive effects of fertilizers too.

Whereas lowest observed in fertigation NPK @ 125% K+ 100% N&P (T_7). This is due bumping up potassium rates to 185 lb/acre caused yield to increase at a decreasing pace, showing that a K rate of 240 lb/acre had no beneficial effects on fruit yield [22].

3.3 Quality Parameters

Substantial differences were perceived in all treatments after analysis (Fig. 1). Fresh tomato fruit lycopene content varies according to tomato variety, fruit maturity, and environmental conditions. By considering the performance of various treatments, highest lycopene content (4.73 mg $100g^{-1}$), ascorbic acid (48.2 mg $100g^{-1}$), total soluble solids (5.2˚Brix) was shown in fertigation NPK @ 75% K + 100% N&P (T_6). Fruit ripening had a powerful influence on quality parameters, which increases TSS, β-carotene (0.87mg $100g^{-1}$). As a result, of proper spacing between the plants reveals a better penetration of light to the crown of the plant [23], increasing β- carotene content, Titratable acidity (% citric acid $100g^{-1}$) was observed in T_6 (fertigation NPK @ 75% K + 100% N&P). It is on par with T_5 (fertigation NPK@ 125% P + 100% N&K) and T_1(Fertigation NPK @ 100 % NPK). The minimum of all these quality parameters were recorded in T_7. More acid content breakdown during ripening likely increased ash and vitamin C levels [24,25]. The hydrolysis of starch to sugar in the fruits, results in an increase in TSS content as ripening is advanced [26].

4. CONCLUSION

The quality and yield parameters are elevated in the treatment received with NPK @ 75% K + 100% N&P. There is an increase in yield up to 2.35 kg per plant in treatment that received fertigation NPK @ 75% K + 100% N&P, further increase in potassium levels to 125% in treatment 7 shows a decline in both yield and quality parameters. Therefore, treatment, which received fertigation NPK @ 75% K + 100% N&P may be deemed a best treatment, and the fertigation schedule followed for NPK @ 75% K + 100% N&P (T_6) begins with the application of 10% of those 75%K and 100% N&P at initial 2-3 days after transplanting, and 40% was equally divided and applied at 15th and 30th day after transplanting, 30% of those N, P and K was evenly shared at 45th and 60th day after transplanting, and the remaining 10% was evenly distributed in the fortnightly interval will enhance the quality of tomato fruits and yield of tomatoes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Alcon F, Navarro N, de-Miguel MD, Balbo AL. Drip irrigation technology: Analysis of adoption and diffusion processes. Sustainable Solutions for Food Security. 2019;269-285.
2. Anonymous. “ENVIS Centre: Tamil Nadu State of Environment and Related Issues”. Government of Tamil Nadu; 2018.
3. Nagaz K, Masmoudi MM, Mechlia BN. Effects of deficit drip-irrigation scheduling regimes with saline water on pepper yield, water productivity and soil salinity under arid conditions of Tunisia. Journal of Agriculture and Environment for International Development – JAEID. 2012; 106: 85–103.
4. Anonymous. FAO Statistics Citation. Indian Database (National Horticulture Board). 2015;65-69.
5. Hebbar SS, Ramachandrappa BK, Nanjappa HV, Prabhakar M. Studies on NPK drip fertigation in field grown tomato (*Lycopersicon esculentum Mill*.). Europ. J. Agronomy. 2004;21:117–127.
6. Badr MA, Abou Hussein SD, El-Tohamy W. A, Gruda N. Nutrient uptake and yield of tomato under various methods of fertilizer application and levels of fertigation in arid lands. Gesunde Pflanzen. 2010; 62(1):11–19.
7. Mmolawa K, Or D. Water and solute dynamics under a drip-irrigated crop: Experiments and analytical model. Trans. ASAE. 2000;43 (6):1597-1608.
8. Murtaza G, Riaz U, Aziz H, Shaheen N, Sohail MI, Saleem MH, Abualreesh MH, Alatawi A, Ali S. Health risk assessment, pore water chemistry, and assessment of trace metals transfer from two untreated sewage sludge types to tomato crop (*Lycopersicon esculentum*) at different application levels. Sustainability. 2021;13: 12394.
   Available:https://doi.org/10.3390/su132212394.
9. Boyhan G, Granberry D, Kelley, T. Onion production guide, (Bulletin 1198). College of Agriculture and Environmental Sciences, University of Georgia. 2001;56.

10. Shayamaa IS, Sahar MZ, Yassen AA. Effect of method and rate of fertilizer application under drip irrigation on yield and nutrient uptake by tomato. Ozean Journal of Applied Sciences. 2009;2:4-6.
11. Patel N, Rajput TBS. Fertigation-a technique for efficient use of granular fertilizer through drip irrigation. IEI Journal. 2004;85:50-54.
12. Hardjowigeno, Tanah I, Preisindo A, Ali JM, Wulan W. Effects of sand and sugar consentration rosella (*Hisbiscus sabdariffa Linn*) against quality of jelly candy. Teknoboyo. 2003;2(1).
13. Hariyadi BW, Ali M, Pratiwi YI. Effect of Organic Liquid Fertilizer tambsil on the growth and resultskale crop land (Ipomoea Reptans Poir). Agricultural Science. 2018; 1(2), 49–60.
14. Tei F, Benincasa P, Guiducc IM. Effect of N availability on growth, N uptake, light interception and photosynthetic activity in processing tomato. Acta Horticulturae. 2002;571:209–216.
15. Bilalis D, Magdalini K, Roussis I, Panayiota P, Travlos I, Nikolina C, Argyro D. Effects of organic and inorganic fertilization on yield and quality of processing tomato (*Lycopersicon esculentum Mill*.). Folia Hort. 2018;30(2):321-332.
16. Soval-Villa M, Wood CW, Guertal EA. Tomato leaf chlorophyll meter readings as affected by variety, nitrogen form, and night time nutrient solution strength. Journal of Plant Nutrition. 2002; 25(10):2129–2142.
17. Balemi T. Response of tomato cultivars differing in growth habit to nitrogen and phosphorus fertilizers and spacing on vertisol in Ethiopia. Acta Agriculturae Slovenica. 2008;91(1):103–119.
18. Shukla YR, Thakur AK, Joshi A. Effect of inorganic and bio-fertilizer on yield and horticultural traits in tomato. Indian Journal of Horticulture. 2009;66(2):285-287.
19. Khan AL, Waqas M, Sang-Mo K, Al-Harrasi A. Bacterial endophyte *Sphingomonas sp*. LK11 produces gibberellins and IAA and promotes tomato plant growth. Journal of Microbiology. 2014;52(8):689–695.
20. Chassy AW, Bui L, Renaud EN, Van Horn M, Mitchell AE. Three-year comparison of the content of antioxidant micro-constituents and several quality chara-cteristics in organic and conventionally managed tomatoes and bell peppers. J. Agric. Food Chem. 2006;54, 8244-8252.
21. Riahi A, Hdider C, Sanaa M, Tarchoun N, Kheder MB, Guezal I. Effect of conventional and organic productions systems on the yield and quality of field tomato cultivars grown in Tunisia. J. Sci. Food Agric. 2009;89:2275-2282.
22. Qiang Z, Monica OH, Li Y, Morgan K. Effects of Potassium Rates on Yield and Postharvest Qualities of Winter Fresh Tomato Grown on a Calcareous Soil. Proc. Fla. State Hort. Soc. 2016;129:140–144.
23. Law-Ogbomo KE, Egharevba RKA. Effects of Planting Density and NPK Fertilizer Application on Yield and Yield Components of Tomato (*Lycospersicon esculentum Mill*) in Forest Location. World J. Agri. Sci. 2009;5(2):152-158.
24. Kamis AB, Modu AS, Mwajim B. Effect of ripening on the proximate and some biochemical composition of a local tomato cultivar (Nadaffreta) grown at Lake Alau Region of Borno State. J. Appl. Sci. 2004; 4(3):424–426.
25. Priyankara GGDS, Karunarathne CLSM, Sarananda KH, Ariyaratne M. Effect of maturity stage on ripening and quality characters of four tomato (*Solanum lycopersicum L*.) varieties of Sri Lanka. Trop Agric. Res. 2017;28(4):496–502.
26. Moneruzzaman KM, Hossain ABMS, Sani W, Saifuddin M. Effect of stages of maturity and ripening conditions on the biochemical characteristics of tomato. Am. J. Biochem. Biotechnol. 2008;4(1):336–344.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/89955