Original Research Article

Impact of Fertigation Schedule on Growth and Quality Parameters in Tomato

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 ~~per~~plant growth.Based on the statement ~~an,~~ field experiment was carried out to evaluate the efficiency of fertigation ~~influence~~ on growth, physiological, quality and yield parameters of Tomato Hybrid CO 4. The experiment ~~was~~consist of seven treatments ~~and~~ laid in randomized block design ~~which~~ was replicated three times. `Fertigation was given at fortnightly interval with urea, MAP, MOP as a source of N, P& K in ten splits during the entire crop growth period. ~~Field observations and analytical analysis was made at the critical growth stages of tomato and data were collected then analysis of variance was done to find out the significant mean.~~ Significant difference was 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 Treatment 6. Ascorbic acid, Titratable acidity, TSS, β-carotene showed the highest value in treatment which received fertigation NPK @ 75% K + 100 % N&P. ~~Considering the different fertigation schedule was determined that the fertigation NPK @ 75% K + 100 % N&P resulted in better enactment with respect to all growth and quality parameter.~~

Keywords: Fertigation schedule, Growth, Yield, Quality

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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]. Proper utilization of water resources which is accessible is vital for a country like India, which has 17% of the total global population, with an area of 2.5%, and water resources is about only 4%. 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.

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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 [2]. 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 [3]. Fertilizers which are applied using traditional methods do not effectively used by crops [4,5]. 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 [6].

The tomato is considered as one of the most important vegetable crops grown throughout the world. ~~It is a member of the Solanaceae family.~~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. ~~It is usually called as "Poor mans Orange", because of having extreme concentrations of Ascorbic acid.~~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 [4] observed exorbitant tomato yield by fertigation than banded and furrow irrigation.

Fertilizers should be applied in a way that becomes available in time for crop demand in order to maximize fertilizer nutrient utilization [7,8]. 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 [8]. 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 [9].

Effective fertigation schedule requires estimation of nutrient requirements based on plant requirements and soil nutrients, selection of the most effective formulations, preparation of solution injection, and scheduling injections to ensure that essential nutrients are available as needed [10]. In general plant requires small amount of fertilizer at initial stages of growth and somewhat additional quantities required during flowering and fruiting stages, if in case recommended fertilizer dose is supplied in splits of large quantities during initial growth stages and small quantities during later stages efficacy of the fertilizer becomes diminished. Fertigation scheduling refers to the amount of fertilizer that should be applied at any given moment to ensure that the plant has had enough time to absorb the fertilizer before the next fertigation [11]. Green fruit production was increased at harvest when fertilizer N was applied at a higher rate than was required for maximum marketable output [12]. Excessive nitrogen fertilizer input in tomato cultivation is widespread [13], however it reduces yield and quality may bewhile also increasing soil environmental concerns [14,15]. For sufficient uptake and optimal growth of tomato, the content of N, P&K in the nutrient solutions, as well as the application time and intervals, are critical. However, it is pivotal to figure out when and how often to apply fertilizer by drip at different stages of crop.

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2. MATERIAL AND METHODS

2.1. Experiment Location and Details

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Field Experiment was carried outduring 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.

2.2. Soil of the experimental site

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Soil texture is sandy clay loam, with 0.42% Organic Carbon (low), pH of 8.21 (moderately alkaline), Electrical Conductivity (EC) 0.56 dSm^{-1} (nonsaline), bulk density of 1.33 Mg m^{-3}, particle density of 2.22 Mg m^{-3}, porosity of 40%, Available Nitrogen of 228 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.

2.3. Treatments and Experimental Design

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The experiment was carried out with Tomato Hybrid CO 4 in a Randomized Block Design. Twenty-Five days old seedlings of tomato were transplanted in double rows 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). Theamount of fertilizers given through fertigation ~~which~~ was calculated by following TNAU CPG for Horticulture (2020). Fertigation was given at 15 days interval through the Automated fertigation unit. ~~The Variation shown in the~~ 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).

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2.4. Data Observation

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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 Table 1and 2. Growth parameters like plant height, root length, plant dry weight was found to be maximum in the treatment, which received fertigation NPK @ 75% K + 100% N&P (T_6). However, they are on par with each other in plants that received fertigation NPK@ 125% P + 100% N&K (T_5) and fertigation NPK @ 100% NPK. (T_1),

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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 [16, 17]. The highest value of ~~the meanin~~ root length ~~is~~ 17.2 cm, and the plant dry weight ~~is~~ 107.2 g showed in 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 fertilizers 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 [5]. Dry weight of the plants showed a maximal value in T_6 (table 2). This is due to Nitrogen fertilization ~~is~~ linked to an increase in photosynthate source capacity, it has a favourableeffect on vegetative growth and biomass accumulation [18] and [19]. 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 [20].

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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 [21]. 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 [22]. According to reports, combined NPK applications boost the number of flowers per cluster and flowering clusters per plant in tomatoes [23]. 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 [24,25]. 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

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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 [26].

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

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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	68.2	86.0	96.0	73.4	4.24	15.5	21.1	22.7	15.9
T2	Fertigation NPK (75% N + 100 % P&K)	37.2	57.4	74.9	85.5	63.7	3.6	12.3	17.3	19.1	13.1
T3	Fertigation NPK (125% N + 100 % P&K)	26.5	50.2	60.8	74.9	53.1	2.6	8.4	12.4	15.6	9.7
T4	Fertigation NPK (75% P + 100 % N&K)	38.7	59.6	75.1	86.7	65.0	3.75	12.4	17.8	19.5	13.4
T5	Fertigation NPK (125% P + 100 % N&K)	45.0	70.7	88.5	98.8	75.7	4.45	15.85	21.9	24.4	16.6
T6	Fertigation NPK (75% K + 100 % N&P)	46.5	72.1	89.2	102.7	77.6	4.47	16.1	22.4	25.8	17.2
T7	Fertigation NPK (125% K+ 100 % N&P)	25.6	48.0	59.7	71.8	51.3	2.55	8.1	11.5	14.7	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	

Table 2. Influence of fertigation schedule on Dry weight and Chlorophyll content of Tomato Hybr

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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	70.7	120.0	203.4	101.3	42.3	51.6	57.6	53.7	51.3
T2	Fertigation NPK (75% N + 100 % P&K)	10.3	57.5	101.5	158.5	81.9	34.9	43.9	48.1	47.3	43.5
T3	Fertigation NPK (125% N + 100 % P&K)	9.5	50.6	91.5	126.1	69.4	32.7	40.5	45.7	42.4	40.3
T4	Fertigation NPK (75% P + 100 % N&K)	10.5	59.2	105.3	165.0	85.0	35.8	44.9	49.5	48.8	44.7
T5	Fertigation NPK (125% P + 100 % N&K)	11.3	72.4	124.0	208.0	103.9	43.3	52.4	59.3	54.9	52.5
T6	Fertigation NPK (75% K + 100 % N&P)	11.5	74.5	128.3	214.5	107.2	44.1	53.6	61.0	55.8	53.6
T7	Fertigation NPK (125% K+ 100 % N&P)	9.2	47.8	87.6	121.3	66.5	32.2	39.5	44.7	41.2	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	

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

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	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	48	42.9	2.06
T2	Fertigation NPK (75% N + 100 % P&K)	80	44	41.2	1.81
T3	Fertigation NPK (125% N + 100 % P&K)	75	40	40.3	1.61
T4	Fertigation NPK (75% P + 100 % N&K)	82	45	41.3	1.86
T5	Fertigation NPK (125% P + 100 % N&K)	94	49	43.1	2.11
T6	Fertigation NPK (75% K + 100 % N&P)	97	52	45.2	2.35
T7	Fertigation NPK (125% K+ 100 % N&P)	73	37	38.5	1.43
	~~SEd~~	~~2.23~~	~~1.18~~	~~0.73~~	~~0.04~~
	CD (P=0.05)	4.86	2.57	1.59	0.09

3.3 Quality Parameters

Substantial differences were perceived in all treatments after analysis (figure 1). Fresh tomato fruit lycopene content varies according to tomato variety, fruit maturity, and environmental circumstances. The paramount performance of various treatments showed that highest lycopene content (4.73 mg 100g^{-1}). Tomato fruits exposed to sunlight during ripening contained more lycopene than those ripened in the shade, ascorbic acid (48.2 mg 100g^{-1}), total soluble solids (5.2˚Brix) fruit ripening had a powerful influence on quality parameters, which increases TSS, β-carotene (0.87mg 100g^{-1}). Carotenoid levels are higher in fruits that receive more light. As a result, of proper spacing between the plants reveals a better penetration of light to the crown of the plant [27], 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 [28,29]. The hydrolysis of starch to sugar in the fruits, results in an increase in TSS content as ripening is advanced [30].

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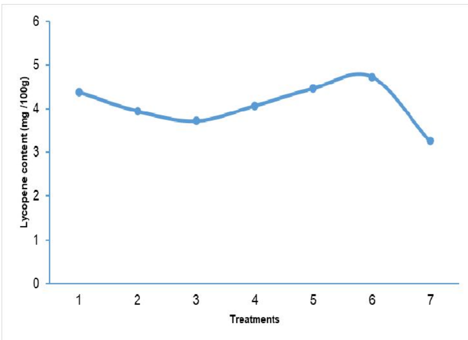
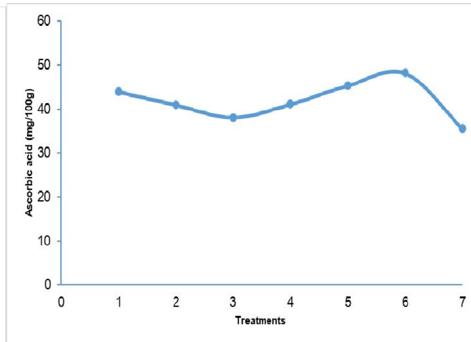
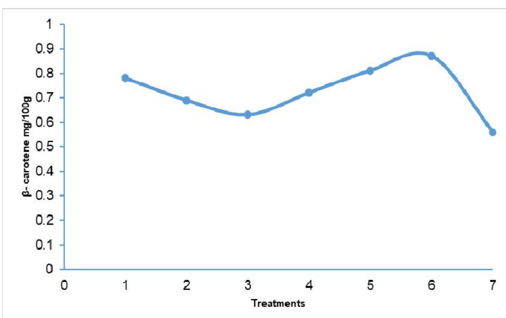
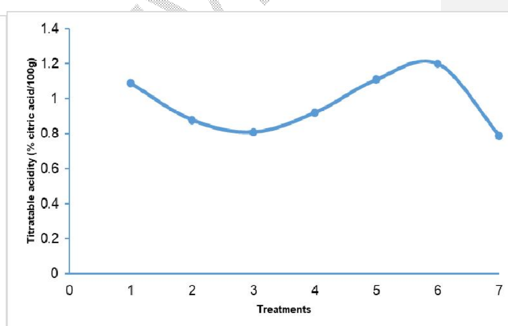


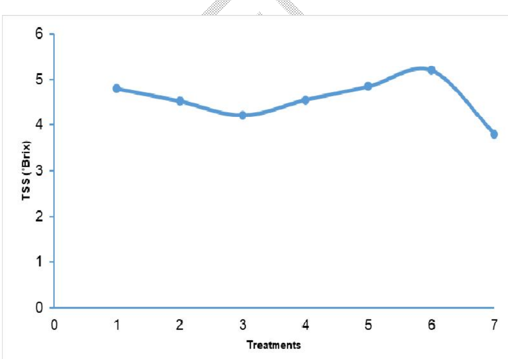


(a) Lycopene content (mg 100g^{-1}) **(b) Ascorbic acid (mg 100g^{-1})**





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



(e) TSS (˚Brix)

Fig 1. Influence of fertigation schedule on Quality parameters of Tomato Hybrid CO 4

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 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.

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