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Effect of levels of fertigation on quality parameters and economics of tomatounder polyhouse condition

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Abstract
The polyhouse experiment was carried out at College of Horticulture, Hiriyur during 2020, to study the effect of levels of fertigation on quality of tomato. The experiment was laid out in randomized block design with seven treatments and three replications. The soil of experimental site was clay loam in texture, alkaline inpH, medium in Organic matter and phosphorous. Low in available nitrogen and medium in available potassium. The results of experiment indicated that soil application of 100:100:100 kg NPK per acre increased the quality of tomato significantly over other fertigation treatments. Treatments received soil application of 100:100:100 kg NPK per acre gave higher shelf life (9.38 days), TSS (3.41 ^{0} brix), lycopene content (56.60 mg 100g^{-1}) and ascorbic acid (123.37 mg 100g^{-1}) and was significantly superior over all other treatments. Among the fertigation treatments higher shelf life (8.71 days), TSS (3.08 ^{0} brix), lycopene content (51.91 mg 100g^{-1}) and ascorbic acid (110.24 mg 100g^{-1}) was recorded by the treatment which received soil application of 40:40:40 kg NPK per acre + 4 kg 19:19:19 per acre through fertigation and was on par with treatment that received soil application of 40:40:40 kg NPK per acre + 3 kg 19:19:19 per acre through fertigation. However, the lowest values for higher shelf life (7.36 days), TSS (2.55^0 brix), lycopene content (42.18 mg 100g^{-1}) and ascorbic acid (96.39 mg 100g^{-1}) was registered in treatment which received soil application of 20:20:20 kg NPK per acre + 2 kg 19:19:19 per acre through fertigation.

Keywords: Fertigation, polyhouse, drip irrigation, total soluble solids, lycopene, ascorbic acid

Introduction
The use of fully water-soluble fertilizers is generally recommended to protect drip irrigation systems over the long term. Conventional fertilizers used in fertigation may cause emitter clogging due to incomplete dissolution and residue formation. However, the high cost of water-soluble fertilizers is a major limitation of fertigation technology. Therefore, the suitability of commonly available commercial fertilizers needs to be evaluated for use in fertigation systems. Fertigation has been reported to improve fertilizer use efficiency because nutrients are applied frequently and directly to the active root zone, allowing a reduction in fertilizer rates without compromising tomato yield. Weekly fertigation is considered more practical in non-automated fertigation systems.

Fertilization and irrigation are critical management practices for improving crop productivity and quality. Proper irrigation scheduling is one of the key factors in achieving high yields and maintaining fruit quality in greenhouse-grown tomato (Yuan *et al*., 2001). Appropriate deficit irrigation can sustain marketable fruit yield while positively influencing fruit quality (Ya-dan *et al*., 2017) [6]. Water deficit conditions often increase fruit quality attributes because reduced water availability leads to osmotic adjustment in the tomato pericarp, resulting in higher concentrations of total soluble solids, carotene, and ascorbic acid compared with well-irrigated plants, although fruit size may be reduced (Hao *et al*., 2013) [1]. Smaller fruits may also contribute to higher lycopene content, as tomato skin, which contains a high proportion of lycopene, accounts for approximately 37 percent of total fruit lycopene (Toor and Savage, 2005) [5]. Smaller fruits have a greater skin surface area relative to fruit volume, which can result in higher lycopene concentration.

Similarly, fertigation through a drip system delivers nutrients directly to the active root zone, improving fertilizer use efficiency and leading to higher yields and better fruit quality compared with conventional fertilization practices.

In view of these considerations, the present study was conducted to determine the optimum irrigation regime and fertigation level for producing high-quality tomato under polyhouse conditions.

Materials and Methods

A field experiment on effect of levels of fertigation on growth and quality of tomato under polyhouse condition was conducted at college of horticulture, Hiriyur. The soils of the experimental site was clay loam in texture having pH-8.31, organic carbon 0.71 per cent with medium in available nitrogen (128.25 kg ac^{-1}), medium in available phosphorus (21.35 kg ac^{-1}) and high in available potassium (197.30 kg ac^{-1}). The experiment was conducted with following treatment details.

Treatment details

- **T_1:** 100:100:100 kg NPK ac^{-1}(RDF under open condition)
- **T_2:** 20:20:20 kg NPK ac^{-1} + 3 kg 19:19:19ac^{-1}through fertigation (RDF under polyhouse condition)
- **T_3:** 20:20:20 kg NPK ac^{-1} + 2 kg 19:19:19 ac^{-1}through fertigation
- **T_4:** 20:20:20 kg NPK ac^{-1} + 4 kg 19:19:19 ac^{-1}through fertigation
- **T_5:** 40:40:40 kg NPK ac^{-1} + 2 kg 19:19:19 ac^{-1}through fertigation
- **T_6:** 40:40:40 kg NPK ac^{-1} + 3 kg 19:19:19 ac^{-1}through fertigation
- **T_7:** 40:40:40 kg NPK ac^{-1} + 4 kg 19:19:19 ac^{-1}through fertigation

Note:

- 50:100:100 kg NPK ac^{-1}, 20:20:20 kg NPK ac^{-1}, 40:40:40 kg NPK ac^{-1} was applied to the soil as basal dose
- 19:19:19 is through fertigation after 30 days of transplanting at weekly interval

The experiment was laid out in a randomized block design, replicated thrice and Novo 81 a semi-determinate high yielding private hybrid seeds was used in the present study. Fifteen days old healthy seedlings were transplanted in the main field at a spacing of 50 cm X 45 cm. Fertilizers used for soil application were urea, di ammonium phosphate and muriate of potash and water soluble fertilizers 19:19:19. In fertigation the fertilizers were injected in weekly intervals through the drip line. TSS, lycopene content and Ascoric acid content were determined using standard procedures.

Results and Discussion

In tomato fruit quality was judged by shelf life, ascorbic acid content, total soluble solids, reducing sugar, lycopene, shelf life. These qualitative traits become much more important when produce goes to industry for the development of products such as tomato jam, juice, sauce and ketchup. Quality parameters *viz*., shelf life, TSS, lycopene content and ascorbic acid content in fruits differed markedly among different treatments (Table 1).

Results showed that fruits quality parameters like shelf life, TSS, lycopene content and ascorbic acid content differed markedly among different treatments (Table 1). Soil application at 100:100:100 kg NPK per acre (T_1) recorded significantly higher shelf life (9.38 days) which was superior over all other treatments. Among the remaining treatments, T_7 (soil application of 40:40:40 kg NPK ac^{-1}+ 4 kg 19:19:19 ac^{-1}through fertigation) recorded the higher shelf life (8.71 days) which was on par with treatment received soil application of 40:40:40 kg NPK per acre + 3 kg 19:19:19 per acre through fertigation (T_6) and the lowest shelf life was recorded in T_3 (soil application of 20:20:20 kg NPK ac^{-1}+ 2 kg 19:19:19 ac^{-1} through fertigation)

The highest total soluble solids (TSS) recorded by the treatment T_1 which received Soil application at 100:100:100 kg NPK per acre (3.40 ^{0}Brix). Among the fertigation treatments T_7 (Soil application of 40:40:40 kg NPK ac^{-1} + 4 kg 19:19:19ac^{-1} through fertigation at weekly interval) recorded higher TSS and was on par with T_6 (Soil application of 40:40:40 kg NPK ac^{-1} + 4 kg 19:19:19 ac^{-1} through fertigation at weekly interval), T_5 (Soil application of 40:40:40 kg NPK ac^{-1} + 4 kg 19:19:19 ac^{-1} through fertigation at weekly interval) and T_4 (Soil application of 40:40:40 kg NPK ac^{-1} + 4 kg 19:19:19 ac^{-1} through fertigation at weekly interval) which recorded 3.08 ^{0}Brix, 3.04 ^{0}Brix and 2.93 ^{0}Brix, respectively and the least TSS (2.55 ^{0}Brix) recorded in T_3 (soil application of 20:20:20 kg NPK ac^{-1} + 2 kg 19:19:19 ac^{-1} through fertigation). (Plate 1, Table 1 and Figure 1).

Higher lycopene and ascorbic acid content was recorded in T_1 (56.60 and 123.37 mg $100g^{-1}$, respectively) and was superior over all other treatments (Figure 1). Among the other treatments, T_7 (51.90 and 110.24 mg $100g^{-1}$, respectively) recorded the higher lycopene and ascorbic acid content and was on par with T_6 (50.80 and 107.44 mg $100g^{-1}$, respectively), T_5 (47.62 and 107.31 mg $100g^{-1}$, respectively) and T_4 (47.23 and 105.84 mg $100g^{-1}$, respectively).

The lowest values for lycopene and ascorbic acid was recorded in T_3 (42.18 and 96.39 mg $100g^{-1}$, respectively). The higher fruits quality parameters might be due to enhanced vegetative growth, leading to enhanced accumulation of solids and more conversion of organic acids to sugar with increase in nutrient level at higher levels of fertilizes. Also enhancement of enzyme activity of a lycopene which involved in carbohydrate metabolism and there exists positive and close relationship with formation of lycopene content in fruits. The results are in accordance with the findings of Rana*et al.* (2005).

Plate 1: Fruit samples kept for drying

Table 1: Effect of different levels of fertigation on quality parameters of tomato

Treatments	Quality parameters			
	Shelf life at maturity stage (days)	TSS (^{0} Brix)	Lycopene (mg 100g^{-1})	Ascorbic acid (mg 100g^{-1})
T_1	9.38	3.40	56.60	123.37
T_2	7.41	2.77	42.63	96.44
T_3	7.36	2.55	42.18	96.39
T_4	7.61	2.93	47.23	105.84
T_5	8.12	3.04	47.62	107.31
T_6	8.48	3.04	50.80	107.44
T_7	8.71	3.08	51.90	110.24
S.Em±	0.16	0.09	1.48	2.36
CD @ 5%	0.50	0.30	4.56	7.28

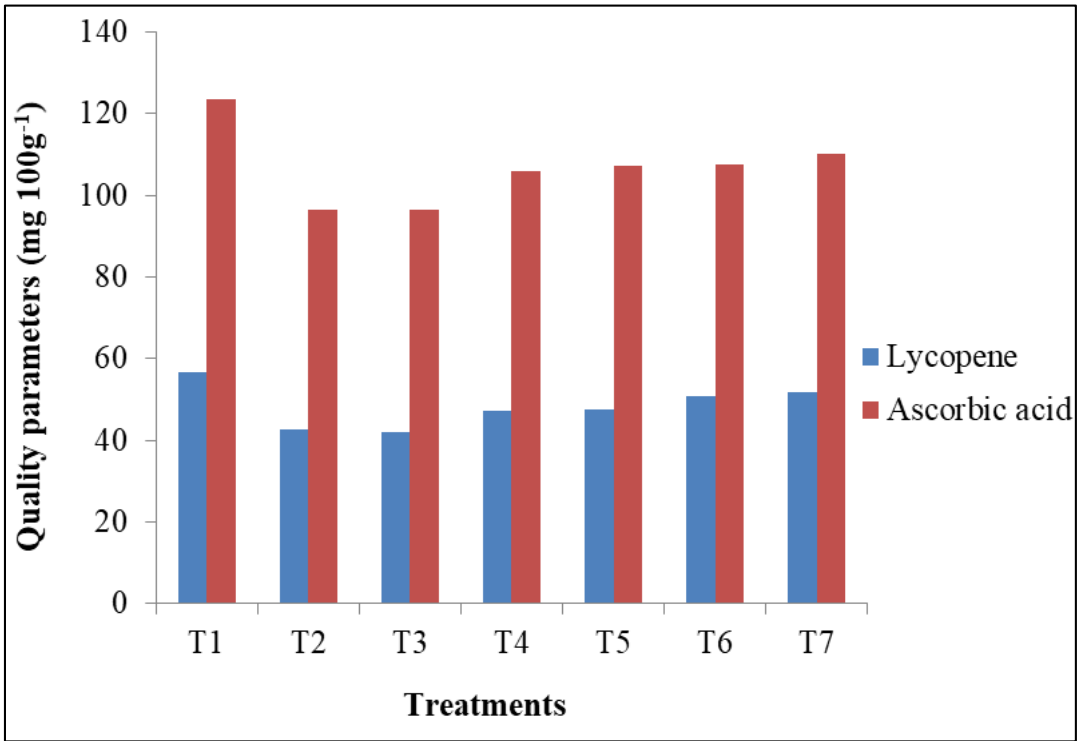

Fig 1: Effect of levels of fertigation on quality parameters of tomato

Economics of the crop

The benefit cost (B:C) ratio of tomato cultivation as affected by fertilizer levels is presented in Table 2. It can be observed that the maximum B:C ratio (2.12) is for T_1 (soil application of 100:100:100 kg NPK per acre). However, there was increase in B:C ratio with increase in fertilizer dosage among the fertigation treatments. Fertilizer levels as affected the value cost ratio (VCR) of tomato cultivation is presented in table 2. The maximum VCR of 49.51 was recorded in T_1 (soil application of 100:100:100 kg NPK per acre) and least was in T_3.

The maximum B:C and VCR was due to maximum yields obtained under low cost of fertilizers (urea, MOP, DAP) as compared to high cost water soluble fertilizer like 19:19:19. Tomato crop was heavy feeder and need more nutrients to overcome net returns and B:C ratio of the tomato crop.

Table 2: Effect of levels of fertigation on economics of the crop

Treatments	Total cost of cultivation (Rs ha^{-1})	Marketable Yield (t ha^{-1})	Gross Income (Rs ha^{-1})	Net Returns (Rs ha^{-1})	VCR	B:C
T_1	4,45,923	63.27	949050	503127	49.15	2.12
T_2	4,36,776	50.73	760950	324174	22.59	1.74
T_3	4,34,676	49.93	748950	314274	26.86	1.72
T_4	4,38,876	53.45	801750	362874	2030	1.82
T_5	4,38,537	54.68	820200	381663	18.57	1.86
T_6	4,40,637	55.31	829650	389013	19.83	1.87
T_7	4,42,737	58.12	871800	429063	15.63	1.96

Conclusion

Treatment T_1, which received the recommended dose of fertilizers at 100:100:100 kg NPK per acre under open conditions, recorded significantly higher shelf life, total soluble solids, ascorbic acid content, and lycopene content compared to all other treatments. Among the fertigation treatments, T_7 (soil application of 40:40:40 kg NPK per acre combined with weekly fertigation of 4 kg 19:19:19 per acre) recorded significantly higher values for all quality parameters, followed by T_6 (soil application of 40:40:40 kg NPK per acre with fertigation of 3 kg 19:19:19 per acre).

An increasing trend in fruit quality parameters was observed with increasing fertilizer doses under fertigation treatments. Although soil application of nutrients combined with drip irrigation resulted in the highest fruit quality and net returns, optimized fertigation treatments also produced comparable quality with reduced fertilizer inputs. Therefore, integrated nutrient management through judicious use of soil application and fertigation can be recommended for achieving high-quality tomato production with better economic returns.

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