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Influence of plant growth regulators and nutrients on fruit quality and shelf life of tomato hybrid (COTH 3)

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Abstract
An experiment was conducted on tomato to know the influence of pre-harvest spray of growth regulators and nutrients on quality and shelf life of tomato hybrid (COTH 3) at the college orchard, Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during the period 2014-2015. Design followed was RBD with seven treatments *viz*., Control (without any growth regulators and nutrients); Chlormequat chloride @ 300 ppm on 30 DAT; Mepiquat chloride @ 500 ppm on 30 DAT; Calcium sulphate @ 1% on 45 DAT; Borax @ 0.2% on 45 DAT; Chlormequat chloride @ 300 ppm on 30 DAT + Calcium sulphate @ 1% on 45 DAT; Chlormequat chloride @ 300 ppm on 30 DAT + Borax @ 0.2% on 45 DAT; Mepiquat chloride @ 500 ppm on 30 DAT + Calcium sulphate @ 1% on 45 DAT; Mepiquat chloride @ 500 ppm on 30 DAT + Borax @ 0.2% on 45 DAT and these treatments are replicated thrice. The observations were recorded on total soluble solids (^{o}Brix), ascorbic acid content (mg/ 100g), citric acid content (%), lycopene content (mg/100g), physiological loss in weight (%), shelf life (days). Results revealed that, quality parameters such as total soluble solids (5.61and 4.77^{0} Brix), ascorbic acid (36.9and 35.0mg/100g), citric acid (0.730 and 0.732 per cent) and lycopene (7.68and 6.68 mg/100g) content in fruits were higher in the treatment T_7 (Chlormequat chloride @ 300 ppm on 30 DAT + borax @ 0.2per centon 45 DAT) in *Kharif* and Summer season respectively.
The treatment T_6 (Chlormequat chloride @ 300 ppm on 30 DAT + calcium sulphate @ 1 percent on 45 DAT) recorded the highest shelf life of (16.6 and 15.4) days in *Kharif* and Summer season respectively.

Keywords: Influence, plant, regulators, nutrients, tomato, COTH 3

Introduction
Tomato (*Solanum lycopersicum* L.), belongs to the Solanaceae family, is one of the most important vegetable crops because of its nutritive value. It is rich in vitamins and minerals. It has a chromosome number of {2n = 24} and the origin of tomato was Peru–Equador region. It is one of the most popular salad vegetables and is taken with great relish. It is widely used in cannery and made into soups, conserves, pickles, ketchup, sauces, juices etc. Tomato juice has become an exceedingly popular appetizer and beverage (Uddain *et al*., 2009) [14].
The application of less than optimal fertilizers decreases the quality of tomato fruit (Kiviani *et al*., 2004) [6]. The fruit quality depends on the cultivar and the climate in which it is grown as well as an optimum supply of fertilizers (Ahmad *et al.*, 2011) [1]. Generally, a balanced supply of nutrients is essential for optimum fruit quality (Akhtar *et al*., 2010) [2].
Since tomato is highly perishable, it encounters several problems in its transportation, storage and marketing. Even though some research efforts have helped to increase the production of tomato to some extent, the purpose of obtaining maximum profit will be served only if the increased production is supplemented with the similar efforts to minimize the post harvest losses and enhance the shelf life (Nirupama *et al.*, 2010) [8]. In the past, some efforts have been made in this direction by employing certain chemicals or plant growth hormones to hasten or delay ripening, to reduce losses and to improve and maintain the colour and quality by slowing down the metabolic activities of the fruit. Hence, this study was taken up to find out the effect of pre-harvest spray of growth regulators and nutrients on quality and shelf life of tomato

Materials and Methods
The present study was carried out under field conditions in order to study the "Influence of pre-harvest spray of plant growth regulators and nutrients on quality and shelf life of tomato hybrid COTH 3 (*Solanum lycopersicum* L.)" during the period 2014-2015 at the college orchard, Department of Vegetable Crops, Horticultural College and Research Institute

Tamil Nadu Agricultural University, Coimbatore. The design followed was RBD with nine treatments and three replications. The treatments were T_1: Control (without any growth regulators and nutrients); T_2: Chlormequat chloride @ 300 ppm on 30 DAT; T_3: Mepiquat chloride @ 500 ppm on 30 DAT; T_4: Calcium sulphate @ 1% on 45 DAT; T_5: Borax @ 0.2% on 45 DAT; T_6: Chlormequat chloride @ 300 ppm on 30 DAT + Calcium sulphate @ 1% on 45 DAT; T_7: Chlormequat chloride @ 300 ppm on 30 DAT + Borax @ 0.2% on 45 DAT; T_8: Mepiquat chloride @ 500 ppm on 30 DAT + Calcium sulphate @ 1% on 45 DAT; T_9: Mepiquat chloride @ 500 ppm on 30 DAT + Borax @ 0.2% on 45 DAT.

Results and Discussion

Total Soluble Solids (°Brix)

The total soluble solids of tomato fruit was varied significantly among the treatments (Table 1). The mean values of two seasons varied between 5.19 °Brix in T_7 to 4.36 °Brix in T_1. In both seasons total soluble solids were significantly higher than other treatments with 5.61° Brix in the treatment T_7 (Chlormequat chloride @ 300 ppm on 30 DAT + borax @ 0.2% on 45 DAT) followed by the treatment T_9 (Mepiquat chloride @ 500 ppm on 30 DAT + borax @ 0.2% on 45 DAT) with 5.50 °Brix. The treatment T_1 (control) expressed the lower total soluble solids of 3.82 °Brix. Ascorbic acid content (mg/ 100g) The ascorbic acid content of tomato fruit ranged 36.0 mg/ 100g in T_7 (Chlormequat chloride @ 300 ppm on 30 DAT + Borax @ 0.2% on 45 DAT) to 33.3 mg/ 100g in T_1 (control) from the two season mean value (Table 2). The ascorbic acid content was higher (36.9 mg/100g) in the treatment T_7 (Chlormequat chloride @ 300 ppm on 30 DAT + borax @ 0.2% on 45 DAT) and was followed by the treatment T_9 (Mepiquat chloride @ 500 ppm on 30 DAT + borax @ 0.2% on 45 DAT) with 35.6 mg/100 g which was on par with treatment T_8 (Mepiquat chloride @ 500 ppm on 30 DAT + calcium sulphate @ 1% on 45 DAT) in *Kharif* season. Treatments T_1 (control) recorded low ascorbic acid of 34.4 mg/100g.

But in summer season, the treatment T_7 (Chlormequat chloride @ 300 ppm on 30 DAT + borax @ 0.2% on 45 DAT) registered higher ascorbic acid of 35.0 mg/100g followed by the treatment T_8 (Mepiquat chloride @ 500 ppm on 30 DAT + calcium sulphate @ 1% on 45 DAT) with 34.9 mg/100g. Treatments T_1 (control) and treatment T_2 (Chlormequat chloride @ 300 ppm on 30 DAT) showed low ascorbic acid content.

Citric acid content (%): Among the treatments, the treatment T_7 (Chlormequat chloride @ 300 ppm on 30 DAT + borax @ 0.2% on 45 DAT) registered the highest two season mean value of 0.731 per cent citric acid and the treatment T_1 (control) was the lower with 0.670 per cent mean value (Table 3). In *Kharif* season, T_7 (Chlormequat chloride @ 300 ppm on 30 DAT + borax @ 0.2% on 45 DAT) registered significantly higher citric acid content of 0.730 per cent over all other treatments and it was followed by T6 (Chlormequat chloride @ 300 ppm on 30 DAT + calcium sulphate @ 1% on 45DAT) with 0.720 per cent.

Similar trend was obtained in the summer season also. The treatment T_7 (Chlormequat chloride @ 300 ppm on 30 DAT + borax @ 0.2% on 45 DAT) registered the higher citric acid content of 0.732 per cent followed by T6 (Chlormequat chloride @ 300 ppm on 30 DAT + calcium sulphate @ 1% on 45DAT) with 0.721 per cent. The lowest citric acid content of 0.670 per cent was recorded in T_1 (control).

Lycopene content (mg/100g): The treatment T_7 (Chlormequat chloride @ 300 ppm on 30 DAT + borax @ 0.2% on 45 DAT) had higher lycopene values of 7.68 mg/100g in *Kharif* season, and 6.68 mg/100g in the summer season respectively followed by the treatment T_9 (Mepiquat chloride @ 500 ppm on 30 DAT + borax @ 0.2% on 45 DAT) with 6.64 mg/100g and 6.60 mg/100g.Treatments T_1 (control) registered less lycopene values in *Kharif* and summer season with 5.70 mg/100g and 5.03 mg/100g respectively (Table 4).

Physiological loss in weight (%): Significant differences were observed among all the treatments with respect to physiological loss in weight percentage during the entire storage period of 12 days (Table 5). In treatment T_6 (Chlormequat chloride @ 300 ppm on 30 DAT + calcium sulphate @ 1% on 45DAT) weight loss was lower (4.88%) and was *on par* with the T_8 (Mepiquat chloride @ 500 ppm on 30 DAT + calcium sulphate @ 1% on 45 DAT) followed by treatment T_4 (Calcium sulphate @ 1% on 45 DAT) with 5.69% in *Kharif* season. Treatments T_1 (control) had highest value of 8.19%.

In summer season, a significant reduction in the PLW was observed. Treatment T_6 (Chlormequat chloride @ 300 ppm on 30 DAT + calcium sulphate @ 1% on 45 DAT) was found to be more effective in reducing PLW with percentage of 4.40% followed by T_8 (Mepiquat chloride @ 500 ppm on 30 DAT + calcium sulphate @ 1% on 45 DAT) which recorded 5.22% of PLW. Treatments T_1 (control) exhibited maximum PLW of 8.43%.

Shelf life (Days): The *Kharif* season mean value of shelf life ranged from 8.53 (T_1) to 16.6 days (T_6) and from 8.05 days (T_1) to 15.4 days (T_6) in summer season (Table 6). Pooled analysis showed that the treatment T_6 recorded the highest shelf life of 16.0 days followed by T_8 (14.2 days). The lowest shelf life was recorded in the treatment T_1 (8.29 days).

Discussion

In the present study, foliar spray of chlormequat chloride at 300 ppm and 0.2 per cent borax (T_7) was found to be most effective treatment in increasing total soluble solids content of fruits followed by mepiquat chloride at 500 ppm + 0.2 per cent borax (T_9) in both *Kharif* and summer seasons. This may be attributed to the translocation of sugars from the site of synthesis to the storage tissue in the plant. Similar relationship was recorded in tomato by Phookan *et al*. (1991) [9].

Acidity is yet another factor that decides the quality of fruit juice. A proper blend of soluble solids and acidity gives the flavour for the resultant production of any fruit namely jams, sauce, ketchup etc. Besides for the product preparation, tomato is also used as a substitute for tamarind in day to day kitchen preparation especially by south Indian wives. Hence, the acidity seems to be the most important quality trait for tomato as a fresh market produce used in culinary preparation. Being the result of complex chemical reaction, the organic acids are synthesized and these incorporate the sour taste to the juice. Organic acids synthesis is influenced by the hormonal balance inside the plant system. High acidity may also cause a setback in quality by shifting the sugar acid ratio

to a much lower level. So maintenance of proper acidity, simultaneously increasing the soluble solids would go a long way not only for the production of better table tomato for culinary purpose but also for processed products like tomato jam, sauce, ketchup etc. The plants treated with chlormequat chloride at 300 ppm and 0.2 per cent borax (T_7) was recorded higher citric acid content of the fruit in both *Kharif* and summer seasons.

This effect is in conformity with previous works of Suresh *et al*. (2010) [13] in cauliflower and Salam *et al.* (2010) [10] in tomato.

The ascorbic acid content of tomato was significantly influenced by the seasons. The foliar spray of chlormequat chloride at 300 ppm and 0.2 per cent borax (T_7) in both *Kharif* and summer seasons increased quantity of ascorbic acid content in the present study. These findings are in agreement with Sathya *et al*. (2010) [12] in tomato.

Among the nine treatments, the plants treated with foliar application of chlormequat chloride at 300 ppm and 0.2 per cent borax (T_7) increases the lycopene content followed by foliar spray of mepiquat chloride at 500 ppm + 0.2 per cent borax (T_9) in *Kharif* and summer seasons. This effect was in consonance with previous findings like Salam *et al*. (2010) [10] and Mohsen (2013) [7] in tomato.

Foliar application of chlormequat chloride @ 300 ppm + calcium sulphate @ 1 per cent had significantly altered the physiological loss in weight and shelf life of tomato fruits during storage. The physiological loss in weight during storage occurs continuously due to moisture loss; thereby the fruits lose their freshness. In the present study the tomato fruits stored well for 8-16 days at ambient conditions. The transpiration and respiration could have caused loss of turgor pressure in the fruits (Bourne, 1976) [4]. The rate of textural deterioration varied widely depending upon the commodity and storage conditions as observed earlier by various workers. In the case of bitter gourd the fruits stored well upto 4-6 days (Sankaran, 1999) [11] and Jayaraman and Raju (1992) [5].

The fruits received chlormequat chloride 300 ppm and 1 per cent calcium sulphate had higher shelf life of (16.6 days) than other treatments. This may be due to membrane functionality and integrity maintenance with lower losses of phospholipids and proteins and reduced ion leakage which could be responsible for the lower weight loss and in delaying ripening process. Similar results were also reported by Nirupama*et al*. (2010) [8] in tomato, Umuhoza and Habimana (2014) [15] in mango and Amrollah (2012) [3] in rose flowers.

Table 1: Influence of plant growth regulators and nutrients on the total soluble solids (°Brix) of tomato hybrid (COTH 3)

Treatments	TSS (°brix)		
	Kharif	***Summer***	**Mean**
Control (T_1)	4.90	3.82	4.36
Chlormequat Chloride (300 ppm) on 30 DAT (T_2)	5.21	4.51	4.86
Mepiquat Chloride (500 ppm) on 30 DAT (T_3)	5.10	4.20	4.65
Calcium Sulphate (1%) on 45 DAT (T_4)	5.11	4.17	4.64
Borax (0.2%) on 45 DAT (T_5)	5.30	4.45	4.88
Chlormequat Chloride (300 ppm) on 30 DAT + Calcium Sulphate (1%) on 45DAT (T_6)	5.33	4.63	4.98
Chlormequat Chloride (300 ppm) on 30 DAT + Borax (0.2%) on 45 DAT (T_7)	5.61	4.77	5.19
Mepiquat Chloride (500 ppm) on 30 DAT + Calcium Sulphate (1%) on 45 DAT (T_8)	5.40	4.40	4.90
Mepiquat Chloride (500 ppm) on 30 DAT + Borax (0.2%) on 45 DAT (T_9)	5.50	4.50	5.00
Mean	5.27	4.38	
S.Ed	0.10	0.08	
CD(P=0.05)	0.21	0.18	

Table 2: Influence of plant growth regulators and nutrients on the ascorbic acid content (mg/ 100g) of the fruit in tomato hybrid (COTH 3)

Treatments	Ascorbic acid content (mg 100 g^{-1})		
	Kharif	***Summer***	**Mean**
Control (T_1)	34.4	32.1	33.3
Chlormequat Chloride (300 ppm) on 30 DAT (T_2)	34.9	32.8	33.9
Mepiquat Chloride (500 ppm) on 30 DAT (T_3)	35.5	34.6	35.1
Calcium Sulphate (1%) on 45 DAT (T_4)	35.1	34.0	34.6
Borax (0.2%) on 45 DAT (T_5)	35.7	34.5	35.1
Chlormequat Chloride (300 ppm) on 30 DAT + Calcium Sulphate (1%) on 45DAT (T_6)	35.7	34.1	34.9
Chlormequat Chloride (300 ppm) on 30 DAT + Borax (0.2%) on 45 DAT (T_7)	36.9	35.0	36.0
Mepiquat Chloride (500 ppm) on 30 DAT + Calcium Sulphate (1%) on 45 DAT (T_8)	35.6	34.9	35.3
Mepiquat Chloride (500 ppm) on 30 DAT + Borax (0.2%) on 45 DAT (T_9)	35.6	34.2	34.9
Mean	35.5	34.0	
S.Ed	5.65	0.55	
CD(P=0.05)	11.9	1.17	

Table 3: Influence of plant growth regulators and nutrients on the citric acid content (%) in tomato hybrid (COTH 3)

Treatments	Citric acid content (%)		
	Kharif	***Summer***	**Mean**
Control (T_1)	0.670	0.670	0.670
Chlormequat Chloride (300 ppm) on 30 DAT (T_2)	0.690	0.691	0.691
Mepiquat Chloride (500 ppm) on 30 DAT (T_3)	0.680	0.680	0.680
Calcium Sulphate (1%) on 45 DAT (T_4)	0.700	0.703	0.702
Borax (0.2%) on 45 DAT (T_5)	0.710	0.714	0.712

Chlormequat Chloride (300 ppm) on 30 DAT + Calcium Sulphate (1%) on 45DAT (T_6)	0.720	0.721	0.721
Chlormequat Chloride (300 ppm) on 30 DAT + Borax (0.2%) on 45 DAT (T_7)	0.730	0.732	0.731
Mepiquat Chloride (500 ppm) on 30 DAT + Calcium Sulphate (1%) on 45 DAT (T_8)	0.710	0.717	0.714
Mepiquat Chloride (500 ppm) on 30 DAT + Borax (0.2%) on 45 DAT (T_9)	0.710	0.715	0.713
Mean	0.70	0.705	
S.Ed	0.02	0.01	
CD(P=0.05)	0.03	0.03	

Table 4: Influence of plant growth regulators and nutrients on the lycopene content (mg/ 100g) in tomato hybrid (COTH 3)

Treatments	Lycopene content (mg/100g)		
	Kharif	***Summer***	**Mean**
Control (T_1)	5.70	5.03	5.37
Chlormequat Chloride (300 ppm) on 30 DAT (T_2)	6.33	5.66	6.00
Mepiquat Chloride (500 ppm) on 30 DAT (T_3)	6.44	6.11	6.28
Calcium Sulphate (1%) on 45 DAT (T_4)	6.46	6.13	6.30
Borax (0.2%) on 45 DAT (T_5)	6.42	5.75	6.09
Chlormequat Chloride (300 ppm) on 30 DAT + Calcium Sulphate (1%) on 45DAT (T_6)	6.41	6.08	6.25
Chlormequat Chloride (300 ppm) on 30 DAT + Borax (0.2%) on 45 DAT (T_7)	7.68	6.68	7.18
Mepiquat Chloride (500 ppm) on 30 DAT + Calcium Sulphate (1%) on 45 DAT (T_8)	6.41	5.74	6.08
Mepiquat Chloride (500 ppm) on 30 DAT + Borax (0.2%) on 45 DAT (T_9)	6.64	6.60	6.62
Mean	6.50	5.97	
S.Ed	0.14	0.38	
CD(P=0.05)	0.30	0.82	

Table 5: Influence of plant growth regulators and nutrients on the physiological loss in weight (%) in tomato hybrid (COTH 3)

Treatments	Physiological loss in weight (%)		
	Kharif	***Summer***	**Mean**
Control (T_1)	8.19	8.43	8.31
Chlormequat Chloride (300 ppm) on 30 DAT (T_2)	7.19	7.40	7.30
Mepiquat Chloride (500 ppm) on 30 DAT (T_3)	6.99	7.02	7.01
Calcium Sulphate (1%) on 45 DAT (T_4)	5.69	5.74	5.72
Borax (0.2%) on 45 DAT (T_5)	6.09	6.31	6.20
Chlormequat Chloride (300 ppm) on 30 DAT + Calcium Sulphate (1%) on 45DAT (T_6)	4.88	4.40	4.64
Chlormequat Chloride (300 ppm) on 30 DAT + Borax (0.2%) on 45 DAT (T_7)	5.71	5.65	5.68
Mepiquat Chloride (500 ppm) on 30 DAT + Calcium Sulphate (1%) on 45 DAT (T_8)	5.02	5.22	5.12
Mepiquat Chloride (500 ppm) on 30 DAT + Borax (0.2%) on 45 DAT (T_9)	6.03	6.23	6.13
Mean	6.20	6.27	
S.Ed	0.15	0.10	
CD(P=0.05)	0.32	0.22	

Table 6: Influence of plant growth regulators and nutrients on the shelf life (days) of tomato hybrid (COTH 3)

Treatments	Shelf life (days)		
	Kharif	***Summer***	**Mean**
Control (T_1)	8.53	8.05	8.29
Chlormequat Chloride (300 ppm) on 30 DAT (T_2)	11.0	10.0	10.5
Mepiquat Chloride (500 ppm) on 30 DAT (T_3)	9.37	9.60	9.49
Calcium Sulphate (1%) on 45 DAT (T_4)	12.9	11.6	12.3
Borax (0.2%) on 45 DAT (T_5)	9.22	8.07	8.65
Chlormequat Chloride (300 ppm) on 30 DAT + Calcium Sulphate (1%) on 45DAT (T_6)	16.6	15.4	16.0
Chlormequat Chloride (300 ppm) on 30 DAT + Borax (0.2%) on 45 DAT (T_7)	11.9	10.7	11.3
Mepiquat Chloride (500 ppm) on 30 DAT + Calcium Sulphate (1%) on 45 DAT (T_8)	14.7	13.7	14.2
Mepiquat Chloride (500 ppm) on 30 DAT + Borax (0.2%) on 45 DAT (T_9)	13.2	12.1	12.7
Mean	11.9	11.0	
S.Ed	0.31	0.19	
CD(P=0.05)	0.66	0.40	

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