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Studies on pre-harvest treatments on physiological and plant protection characteristics in tomato (*Lycopersiconesculentum* Mill.)

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ABSTRACT: *Afield experiment was conducted to study the influence of pre harvest treatments on physiological and plant protection characteristics ontomato fruits. Treatments with growth regulator GA_3, chemicals like KNO_3 and Silicic acid were used as pre harvest spray. The tomato fruits were studied for different physiological as well as plant protection characteristics at green mature, breaker and red ripe stage of fruit maturity. The study revealed that pre harvest spray of GA_3, KNO_3 and Silicic acid improves the physiological attributes such as plant height, fruit weight, fruit length, fruit girth and fruit yield and minimize the incidence of insect – pest and diseases.*

Key Words: *Tomato, Gibberellic acid, Potassium Nitrate, Silicic acid, Plant protection.*

INTRODUCTION

Tomato (*Lycopersiconesculentum*Mill.) is the world's largest vegetable crops next to potato and sweet potato, cultivated all over the world for its fleshy fruits. The major tomato producing countries in the world are Chinafollowed by USA and India (FAOSTAT, 2010). Tomatoes have been traditionally credited as rich sources of carotenoids and vitamins, particularly â-carotene, provitamin A, ascorbic acid, and vitamin C (Hanson *et al*., 2004).

Gemici *et al.* (2006) reported that application of gibberellins (GAs) is effective in increasing both yield and quality of tomato. Tomato fruit setting was promoted by gibberellic acid (GA_3) at low concentration (Sasaki *et al*., 2005; Khan *et al*., 2006) and reduced pre-harvest fruit drop with increased number of fruits per plant. Furthermore, Bensen and Zeevaart (1990) reported that GA_3 is more effective on tomato stem growth at concentration of 10 ppm or below.

Potassium (K) is well recognized as the essential plant nutrient with the strongest influence on many quality parameters of fruits and vegetables (Usherwood, 1985). Increased application of K resulted in enhanced yield of tomato fruits through larger proportion of flower forming fruits. Majumdar *et al.* (2000) reported that, increased levels of potassium had significant influence on the fruit yield of tomato. The K requirements of tomato are extraordinarily high due to the rapid growth of the plant in combination with the heavy fruit load (Chapagain and Wiesman, 2004). To cope with high K requirements, tomato has evolved efficient mechanisms to acquire K under conditions of low K levels in the root zone (Chen and Gabelman, 2000; Rubio *et al*., 2006).

Epstein (1994) have reported beneficial effect of silicic acid such as enhancement of growth and yield as it plays an important role in favorable exposure of leaves to light, hence promotes photosynthesis. Si content provides resistance to herbivores ranging from phytophagous insects to mammals. According to Miyake and Takahashi (1978), Si should be considered an essential nutrient for tomato because at the time of flowering severe deficiency of Si was recorded.

In view of the above reports, the present study has been undertaken to evaluate the potential of pre harvest treatments of Gibberellic acid (GA_3), Potassium nitrate (KNO_3) and Silicic acid on physiological and plant protection characteristics of tomato fruit during different developmental stages.

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MATERIALS AND METHODS

The field experiment was conducted at Anand Agricultural University, Gujarat during 2011-2012 to find out the influence pre harvest chemical treatments on physiological and plant protection characteristics of tomato cv. "Anand Tomato-3" fruit during different maturity stages. The pre harvest treatments were laid out in a factorial randomized block design replicated four times. There were seven pre harvest treatments *viz*., GA_3 @ 0.05% (T_1), GA_3 @ 0.1% (T_2), KNO_3 @ 0.25% (T_3), KNO_3 @ 0.5% (T_4), silicic acid @ 0.05% (T_5), Silicic acid @ 0.1% (T_6) and control (T_7). Treatments were given by pre harvest spraying of these chemical at 50% flowering stage. The fruits were harvested at three stages *viz.* mature green, breaker and red ripe stages were washed with water to remove the soil and used for analyses.

Physiological attributes: Physiological attributes as affected by the pre harvest treatments and maturity stages were measured by selecting five random plants from each plot. Plant height was measured from the base of the stem to the apex of the central leaf at the time of harvest and average was worked out and expressed in centimeters.Other fruit characteristics such as fruit weight, fruit length, fruit girth, fruit volume, fruit density and fruit yield were measured from the fruitsof different maturity stages *viz*. mature green, breaker and red-ripe stage, after harvest.

Moisture (%) and Total soluble solids (% Brix): Moisture content of tomato fruits were determined by drying the weighed sample of tomato fruit at 105 ^{0}C for 5 hours and the loss of weight was expressed as moisture content (A.O.A.C., 2000).

Total soluble solids (TSS) were recorded by using hand refractometer (Mazumdar and Majumder, 2003). The sample was thoroughly mixed and a few drops were taken on prism of refractrometer and readings were expressed in % Brix.

Plant protection attributes: Plant protection attributes such as per cent leaf curl, fruit borer incidence and white flies attack were recorded by visual observation on the selected five plants in each replication.

RESULTS AND DISCUSSION

Physiological Attributes

The data on physiological parameters showed that among the treatments KNO_3 @ 0.5% i.e. T_4 had significantly higher value of plant height (Table 1), fruit weight (Table 2), fruit volume (Table 3), fruit length (Table 4) and fruit girth (Table 5) while the fruit density (Table 6) were followed decreasing trend. The data obtained in the present investigation are in agreement with the findings of various scientists (Mengel and Kirkby, 1980; Marschner, 1995; Usherwood, 1985) who observed that this might be due to that among essential plant nutrients, potassium is the one that is absorbed by the tomato plant in the largest amounts and it is considered to be the key to promote the growth of meristematic tissue as well as increased level of nitrogen also promotes the vegetative growth. The fruit weight is in conformity with the findings of Gaur and Bajpai (1982) in tomato and Altmdisli in wine grapes (1999). The fruit volumeresults are found in conformity with the reports of Siddiqui *et al.* (1989) in tomato fruits.Bishnu and Wiesman (2004) reported that increased potassium level in plants improved the fruit quality parameterssuch as fruit length and fruit girth.

Higher concentration of gibberellic acid treatment gave lowest fruit girth because GA_3 may works at low concentration but in present study the concentration of GA_3 used was 0.1 %. This high concentration of GA_3 shows negative effect on fruit characteristics.

Fruit density (g/cm^3): The data revealed that maturity stage, sprayed chemical treatment and its interactions were found to be significant. From the Table 6, it was observed that the fruit density was decreased with increasing maturity. However fruit density was increased by 19.02% in gibberellic acid @ 0.1% while it was reduced by 22.82% under silicic acid @ 0.1% as compared to control.

Fruit Yield (q/ha.): Influence of different sprayed chemical treatments on fruit yield was found to be significant (Table 1). The fruit yield was recorded from 102.31q/ha to 258.33q/ha. It was found that silicic acid @ 0.1% showed a positive effect among the different treatments. This might be due to increased silicon level in plants improved the fruit quality parameters by hindering the biotic and abiotic stresses.Gibberellic acid treatment does not show any significant difference.

Moisture (%): The moisture percentage of tomato fruits resulted from the different stages and sprayed chemical treatments were found to be significant (Table 7). The moisture content was increased with increasing maturity. Norman, (1992) indicated that, tomato fruits contained about 93% moisture. The results obtained by the present investigation indicate that as the fruit matures the moisture per cent begins to increase, due to increase in fruit juice per cent. These changes in moisture per cent were in agreement with reported by various researchers (Gopalan *et al.*, 1984; Suthar, 1998 and Joshi and Khandekar, 1993).

Table 1
Effect of sprayed chemical treatments on plant height and fruit yield of tomato fruit during development

Treatment	*Plant height at harvest (cm)*	*Fruit yield (q/ha)*
T_1	105.25	104.16
T_2	104.49	104.16
T_3	105.10	156.48
T_4	106.68	240.90
T_5	105.80	258.33
T_6	104.21	223.30
T_7	95.89	102.31
Mean	103.92	194.23
SEm±	1.70	0.27
CD at 5 %	5.05	0.81
CV %	3.27	5.39

Table 2
Effect of sprayed chemical treatments on fruit weight (g) of tomato fruit during development

Treatments	*Maturity stages*			*Mean T*
	S_1 *(Mature green)*	S_2 *(Breaker)*	S_3 *(Red ripe)*	
T_1	41.30	48.75	53.99	48.01
T_2	16.80	21.06	45.08	27.65
T_3	49.63	54.55	64.23	56.14
T_4	46.89	67.14	75.52	63.18
T_5	48.22	54.02	55.65	52.63
T_6	45.66	51.08	52.66	49.80
T_7	34.25	38.33	45.91	39.50
Mean S	40.39	47.85	56.15	
	S	T	S X T	
SEm±	0.84	1.28	2.21	
CD at 5 %	2.36	3.61	6.25	
CV %	9.18			

Table 3
Effect of sprayed chemical treatments on fruit volume (cm^3) of tomato fruit during development

Treatments	*Maturity stages*			*Mean T*
	S_1 *(Mature green)*	S_2 *(Breaker)*	S_3 *(Red ripe)*	
T_1	21.91	32.24	39.81	31.32
T_2	8.2	11.13	28.73	16.02
T_3	31.58	50.71	59.15	47.15
T_4	37.01	53.02	62.75	50.93
T_5	38.03	42.48	47.65	42.72
T_6	33.73	44.69	56.06	44.83
T_7	23.35	28.09	38.33	29.92
Mean S	27.69	37.48	47.50	
	S	T	S X T	
SEm±	0.71	1.09	1.88	
CD at 5 %	2.01	3.07	5.32	
CV %	10.20			

Table 4
Effect of sprayed chemical treatments on fruit length (cm) of tomato fruit during development

Treatments	*Maturity stages*			*Mean T*
	S_1 *(Mature green)*	S_2 *(Breaker)*	S_3 *(Red ripe)*	
T_1	4.48	4.58	4.61	4.57
T_2	3.67	3.74	4.46	3.96
T_3	4.28	4.56	4.95	4.60
T_4	4.90	5.08	5.10	5.03
T_5	4.33	4.41	4.64	4.46
T_6	4.33	4.41	4.89	4.54
T_7	4.13	4.15	4.37	4.22
Mean S	4.30	4.42	4.72	
	S	T	S X T	
SEm±	0.04	0.07	0.12	
CD at 5 %	0.13	0.19	0.33	
CV %	5.25			

Table 5
Effect of sprayed chemical treatments on fruit girth (cm) of tomato fruit during development

Treatments	*Maturity stages*			*Mean T*
	S_1 *(Mature green)*	S_2 *(Breaker)*	S_3 *(Red ripe)*	
T_1	4.21	4.46	4.69	4.45
T_2	3.11	3.23	4.40	3.58
T_3	4.38	4.47	4.84	4.56
T_4	4.70	5.10	5.31	5.04
T_5	4.24	4.26	4.88	4.46
T_6	4.59	4.68	4.70	4.66
T_7	3.80	4.09	4.29	4.06
Mean S	4.15	4.33	4.73	
	S	T	S X T	
SEm±	0.04	0.06	0.11	
CD at 5 %	0.11	0.17	0.30	
CV %	4.79			

Table 6
Effect of chemical treatments on fruit density (g/cm^3) of tomato fruit during development

Treatments	*Maturity stages*			*Mean T*
	S_1 *(Mature green)*	S_2 *(Breaker)*	S_3 *(Red ripe)*	
T_1	1.88	1.67	1.36	1.58
T_2	2.05	1.89	1.57	1.84
T_3	1.34	1.03	1.02	1.13
T_4	1.48	1.32	1.28	1.36
T_5	1.27	1.27	1.17	1.24
T_6	1.35	1.14	0.94	1.15
T_7	1.47	1.36	1.20	1.49
Mean S	1.55	1.36	1.22	
	S	T	S X T	
SEm±	0.04	0.05	0.09	
CD at 5 %	0.10	0.15	0.26	
CV %	11.57			

Table 7
Effect of sprayed chemical treatments on moisture content (%) of tomato fruit during development

Treatments	*Maturity stages*			*Mean T*
	S_1 *(Mature green)*	S_2 *(Breaker)*	S_3 *(Red ripe)*	
T_1	91.26	92.80	93.79	92.62
T_2	91.44	93.06	93.90	92.80
T_3	91.66	93.14	93.64	92.81
T_4	92.21	92.59	93.82	92.87
T_5	92.01	92.48	93.95	92.81
T_6	90.91	92.91	93.39	92.40
T_7	91.90	93.45	93.77	93.04
Mean S	91.63	92.92	93.75	
	S	T	S X T	
SEm±	0.18	0.27	0.47	
CD at 5 %	0.51	NS	NS	
CV %	1.08			

Table 8
Effect of sprayed chemical treatments on total soluble solids Brix (%) of tomato fruit during development

Treatments	*Maturity stages*			*Mean T*
	S_1 *(Mature green)*	S_2 *(Breaker)*	S_3 *(Red ripe)*	
T_1	6.43	6.45	6.50	6.46
T_2	6.15	6.20	6.58	6.31
T_3	6.23	6.35	6.70	6.43
T_4	5.80	5.90	6.63	6.11
T_5	6.00	6.20	6.90	6.37
T_6	5.95	6.18	6.23	6.12
T_7	5.90	5.93	6.15	5.99
Mean S	6.06	6.17	6.53	
	S	T	S X T	
SEm±	0.03	0.04	0.07	
CD at 5 %	0.07	0.11	0.19	
CV %	2.14			

Total soluble solids (% Brix): The data revealed that maturity stage, sprayed chemical treatment and its interactions were found significant (Table 8). The TSS was increased with increasing maturity. Total soluble solids are known to increase fruit quality, which fits well with consumers' demand for high quality produce (El-Saeid *et al.*, 1996). The total soluble solids increased during the ripening due to degradation of polysaccharides to simple sugars thereby causing a rise in TSS (Naik *et al.,* 1993; Artes *et al.,* 1999). Among the all sprayed chemical treatments GA_3 shows positive response to the total soluble solids.These changes in total soluble solids were in agreement with reported by various scientists (Boe *et al.,* 1967; Siddiqui *et al.,* 1986; Karki, 1995; Suthar 1998; Gelmesa *et al.,* 2010; Saleem *et al.,* 2008; and Radwan *et al.*, 1979).

Table 9
Effect of sprayed chemical treatments on percent leaf curl, number of larvae of fruit borer per plant and number of white flies per plant of tomato fruit during development

Treatments	*Percent leaf curl*	*Fruit borer*	*White flies*
T_1	30.40	12.53	4.00
T_2	26.88	10.53	4.00
T_3	24.19	9.39	4.00
T_4	22.46	8.53	3.50
T_5	21.31	7.02	2.50
T_6	14.71	5.17	2.50
T_7	43.64	13.10	5.75
Mean	26.23	9.47	2.50
SEm±	1.48	0.37	0.27
CD at 5 %	4.40	1.11	0.79
CV %	11.30	7.91	14.16

Plant Protection Attributes

The data on per cent leaf curl, incidence of fruit borer and white flies in response to sprayed treatments were found to be significant (Table 9). The lowest leaf curl per cent was recorded with T_6 (silicic acid @ 0.1%) treatment as compared with the control (T_7 treatment). This might be due to increased silicon level in plants improved the fruit quality parameters by hindering the biotic and abiotic stresses.

Among the different sprayed chemical treatmentsnumber of larvae of fruit borer per plant was significantly lower in treatment T_6 silicic acid @ 0.1%. Our findings are in agreement with the results obtained by Savant *et al.* (1997) who reported that the silicon suppresses insect pest infestationin tomato plant.

The data on number of white flies per plant in response to sprayed chemical treatments were found to be significant. The numbers of white flies were reduced by 56.52% in treatment T_6 as compared to the control i.e. T_7 treatment.

It was found that silicic acid @ 0.05% and 0.1%showed a positive effect among the different treatments. There is ample evidence for the protection that silicon often provides plant species against insect pests.

CONCLUSION

The obtained results indicate that the pre harvest application of potassium nitrate and silicic acid showed improved physiological fruit characteristics. The silicic acid treatment was found superior to minimize the pest and disease incidence and improves the fruit yield. Thus it may be concluded

that the pre harvest chemical treatments selected for the present study have the potential to improve the physiological characteristics and capable to minimize the yield losses by pest population.

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