International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(5): 2414-2417

Received: 23-07-2017
Accepted: 24-08-2017

Tawseef Rehman Baba
Division of Fruit Science, Sher-e-Kashmir University of Agricultural science and Technology of Kashmir, Jammu and Kashmir, India

Angrej Ali
Division of Fruit Science, Sher-e-Kashmir University of Agricultural science and Technology of Kashmir, Jammu and Kashmir, India

Rehana Javid
Division of Fruit Science, Sher-e-Kashmir University of Agricultural science and Technology of Kashmir, Jammu and Kashmir, India

Amit Kumar
Division of Fruit Science, Sher-e-Kashmir University of Agricultural science and Technology of Kashmir, Jammu and Kashmir, India

Shahid Qayoom
Division of Fruit Science, Sher-e-Kashmir University of Agricultural science and Technology of Kashmir, Jammu and Kashmir, India

Ab Waheed Wani
Division of Fruit Science, Sher-e-Kashmir University of Agricultural science and Technology of Kashmir, Jammu and Kashmir, India

Mohammed Tauseef Ali
Division of Fruit Science, Sher-e-Kashmir University of Agricultural science and Technology of Kashmir, Jammu and Kashmir, India

Correspondence
Tawseef Rehman Baba
Division of Fruit Science, Sher-e-Kashmir University of Agricultural science and Technology of Kashmir, Jammu and Kashmir, India

Periodic response of vegetative growth of strawberry to salicylic acid and Triacontanol

Tawseef Rehman Baba, Angrej Ali, Rehana Javid, Amit Kumar, Shahid Qayoom, Ab Waheed Wani and Mohammed Tauseef Ali

Abstract
The present study entitled "Periodic response of vegetative growth of strawberry (*Fragaria* x *ananassa* Duch.) cv. Camarosa to salicylic acid and triacontanol". Treatments consisted of three levels of salicylic acid (0, 1 and 2mM) and three levels of triacontanol (0, 5 and 10µM), constituting total 9 treatment combinations. Results revealed that the exogenous application of salicylic acid as well as triacontanol had significant effect on vegetative growth of strawberry cv. Camarosa compared to control, although the interaction effect of these two growth regulators was non-significant for all the parameters studied. Among the salicylic acid treatments, the salicylic acid @ 2mM resulted maximum plant height, plant spread, leaf area and number of leaves per plant. Among the triacontanol treatments, application of triacontanol @10 µM resulted maximum plant height, plant spread, leaf area and number of leaves per plant. The present study indicated that strawberry showed positive responses to exogenous application of salicylic acid and triacontanol in terms of enhanced vegetative growth. It is therefore concluded that the salicylic acid @ 2mM and triacontanol @10 µM was effective in enhancing overall growth of strawberry cv. Camarosa.

Keywords: Salicylic acid, Strawberry, Triacontanol and Vegetative growth.

Introduction

Modern cultivated strawberry (*Fragaria* × *ananassa* Duch.) is an octaploid (2n=8x=56 chromosomes) hybrid species (Hummer *et al*., 2011) [6]. It is an accidental hybrid from two New World species; *F. chiloensis* and *F. virginiana*. Strawberry is herbaceous perennial that has a central stem (crown) from which leaves, roots, stolons (runners) and inflorescences emerge. Each leaf has three or more leaflets depending on the variety, and the leaflets are oval to oblong with coarsely toothed edge. Strawberry is a fruit plant of temperate climate, but it is successfully grown in a broad range of climates including temperate, grassland, Mediterranean, and subtropical (Hancock, 2000) [4]. It is most important berry and globally produced in twice the amount of all other berry crops combined (Stewart, 2011) [22]. The five main producers of strawberries in the world are USA (California), Spain, Japan, Poland and Italy (Lim, 2012) [14].

In India, temperate regions of Jammu Kashmir, Himanchal Pradesh and Uttarakhand have been known for strawberry cultivation. Strawberry crop in Kashmir valley, deserves worthy enthrallment due to growing interest of the farmers. In field conditions, strawberry crop often face the environmental challenges that exert adverse effects on plant growth and development. Under such conditions, plant growth regulators are considered vital for several processes in the life cycle of plants.

Salicylic acid is considered to be a potent plant hormone because of its diverse regulatory role in plant metabolism (Raskin, 1992) [20]. Under changing environment, exogenous application of salicylic acid has been found beneficial in growth and bio-productivity of crop plants due to its key role in photosynthesis, plant water relations, various enzyme activities and its effect on the plants exposed to various biotic and abiotic stresses (Hayat *et al*., 2010) [5].

It is believed that triacontanol enhances the physiological efficiency of the cells, and thus, exploits the genetic potential of plant to a large extent (Naeem *et al*., 2012) [16]. In several crops, exogenous application of triacontanol has found beneficial effect on chlorophyll contents, photosynthetic rate and chlorophyll fluorescence (Perveen *et al*., 2010; Krishnan and Kumari, 2008) [18, 11].

Present investigation of application of salicylic acid and triacontanol on vegetative growth of

strawberry plant to delve the role of these growth regulators with objective to study the effect of salicylic acid and triacontanol on vegetative growth of plant.

Material Methods

The experiment was carried out at different concentration of salicylic acid (0, 1 and 2mM) and triacontanol (0, 5 and 10µM) were sprayed 1st at 3-4 leaf stage during spring growth & 2nd at 15 days after 1st application. Plants were spaced 45 cm between rows and 30 cm between plant to plant. Data on vegetative growth characters (plant height, plant spread, number of leaves per plant, and leaf area per plant) were recorded on 15th day of each month from April to August, 2015, from an experimental farm, division of Fruit Science, Shalimar, Srinagar (J&K), under temperate conditions.

The vegetative growth characters were measured with the help of measuring scale and results were expressed as average in centimeters. The height of fully developed plants was measured from the ground level to the leaf apex of primary shoot in centimeters and results were expressed as average height in centimeters. Plant spread was measured in centimeters with the help of measuring scale from North to South and East to West. The average of both the directions were taken as spread of the plant. The number of leaves was recorded from ten randomly selected plants from both rows in all the treatments and result were expressed as average leaf number per plant. The observation on leaf area was recorded during growing season, where five leaves per plant were collected randomly from five plants per treatment. The leaf area was recorded in square centimeter from 45 leaves collected from different plants of each treatment. A leaf area meter (Systronics) was used in this study.

Experimental design and statistical analysis

The data collected on various parameters during an experiment were subjected to statistical analysis in Randomised Complete Block Design following 2 × 3 Factorial arrangements as per standard procedure given by Panse and Sukhatme (1985).

Result and Discussion

Application of salicylic acid and triacontanol revealed remarkable variations on vegetative growth characters of strawberry. Salicylic acid and triacontanol at different concentrations significantly influenced plant height of strawberry cv. Camarosa in the month of June, July and August whereas no significant effect of salicylic acid and triacontanol was found in the month of May (Table 1). Salicylic acid at 2mM recorded highest plant height of 21.93, 24.94 and 27.00 cm in the month of June, July and August whereas control treatment recorded lowest plant height of 18.99, 21.56 and 23.30 cm in the month of June, July and August. Salicylic acid (SA), an endogenous plant growth regulator has been found to generate a wide range of metabolic and physiological responses in plants there by affecting their growth and development (Hayat *et al*., 2010) [5]. These results are in agreement with findings of Qureshi *et al*. (2013) [19] who reported highest plant height of strawberry plants treated with salicylic acid. Pre-harvest spray of salicylic acid increases the shoot length of plants (Khodary, 2004; Niakan *et al.*, 2010) [10, 17]. Triacontanol at 10µM recorded highest plant of 22.7, 24.37 and 27.26 cm in the month of June, July and August whereas control treatment recorded lowest plant height of 18.56, 21.99 and 23.55 cm in the month of June, July and August. Triacontanol treatment increased hydrolysis and/or mobilization of starch and sucrose in the plant resulting in increased growth Kumar *et al*. (2012) [13] in strawberry also reported that triacontanol treated plants recorded highest plant height. These findings are also in close conformity with the findings of Khan *et al.* (2009) [8].

Salicylic acid and triacontanol significantly influenced the plant spread of strawberry cv. Camarosa in the month of June, July and August whereas no significant effect of salicylic acid and triacontanol was found on the plant spread in the month of May, respectively (Table 2). It was observed that salicylic acid at 2mM recorded highest plant spread of 17.46, 22.89 and 24.98 cm in the month of June, July and August whereas control treatment recorded lowest plant height of 15.80, 19.86 and 21.99 cm in the month of June, July and August. Salicylic acid is known to increase the fresh and dry weight in strawberry plants thereby enhancing the spread of plants (Amborabe *et al.*, 2002) [1]. Increase in plant spread was also reported by Qureshi *et al*. (2013) [19] in strawberry. Triacontanol at 10µM recorded highest plant spread of 18.05, 22.94 and 25.08 cm in the month of June, July and August whereas control treatment recorded lowest plant spread of 15.75, 19.70 and 22.16 cm in the month of June, July and August. Increased spread by triacontanol might be attributed to the fact that triacontanol regulates directly or indirectly several physiological and biochemical processes (Ries and Houtz, 1979) [21]. The results are also in conformity with findings of Choudhary *et al.* (2013) in *Citrus reticulata* and Kumar *et al*. (2012) [13] in strawberry.

Salicylic acid significantly influenced the number of leaves in the month of July and August but number of leaves were not significantly affected by salicylic acid in the month of April, May and June respectively (Table 3). Salicylic acid at 2mM recorded highest number of leaves in the month of July (13.50) and August (17.19) whereas the lowest number of leaves (12.04 and 15.21) were recorded by control treatment in the month of July and August. These findings are in conformity with Ghaderi *et al*. (2015) [3] and Qureshi *et al*. (2013) [19] who also reported similar results in strawberry. Triacontanol at 10µM recorded highest number of leaves in the month of June, July and August whereas no significant effect of triacontanol was found on number of leaves in the month of May. It was observed that triacontanol10µM recorded highest number of leaves of 9.58, 13.92 and 17.88 cm in the month of June, July and August whereas control treatment recorded lowest number of leaves (8.71, 11.68 and 14.94) in the month of June, July and August respectively. Triacontanol affected the photosynthesis by increasing the level of ribulose-1, 5-bisphosphate carboxylase oxygenase (RuBisCO) and by improving the status of photosystems (Chen *et al*., 2003) [2]. The results are in accordance with the findings of Kumar *et al.* (1996) [12], Kumar *et al*. (2012) [13] also reported that strawberry plants treated with triacontanol recorded highest number of leaves per plant.

It was found that salicylic acid at 2mM recorded highest leaf area of 117.57 cm^2 in the month of June whereas control treatment recorded lowest leaf area of 107.97 cm^2 in the month of June (Table 4). However, the salicylic acid treatment shows non-significant effect on leaf area in the month of May, July and August. It is suggested that because salicylic acid has anti-senescence influence on plant organs, vegetative growth may be prolonged following its application consequently leading to higher leaf area. Salicylic acid and its close analogues enhanced the leaf area and dry mass production (Khan *et al*., 2003) [9]. These results are in conformity with the findings of Ghaderi *et al*. (2015) [3],

Kazemi (2013) [7] and Qureshi *et al*. (2013) [19] who reported that strawberry plants treated with salicylic acid recorded maximum leaf area. The results showed that the highest leaf area recorded with triacontanol at 10µM was 119.63, 129.38 cm^2 in the month of June and July whereas control treatment recorded lowest leaf area (106.02and 119.05 cm^2) in the month of June and July (Table 4). The triacontanol treatment did not had significant effect on leaf area in the month of May and August. This might be due to the fact that triacontanol enhances effective leaf area, stimulation of photosynthesis and increase in the activities of RuBisCO (Muthuchelian *et al.*, 2003) [15]. These findings are supported by findings of Kumar *et al*. (2012) [13] and Thakur *et al.* (1991) [23] who reported that application of triacontanol increase leaf area in strawberry.

Table 1: Response of strawberry cv. Camarosa to salicylic acid and triacontanol on plant height (cm).

S↓ C→	April*				May				June				July				August			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
S_0	8.98	8.51	8.85	8.78	12.59	12.88	13.50	12.99	16.74	19.52	20.71	18.99	20.28	22.05	22.35	21.56	22.19	22.32	25.39	23.30
S_1	8.85	8.85	9.05	8.91	12.95	13.41	13.61	13.32	18.61	21.05	22.05	20.57	22.40	22.29	24.99	23.23	23.95	25.85	27.37	25.72
S_2	9.31	8.91	8.85	9.02	13.55	13.65	13.81	13.67	20.32	22.01	23.47	21.93	23.28	25.77	25.77	24.94	24.51	27.46	29.03	27.00
Mean	9.05	8.76	8.91		13.03	13.31	13.64		18.56	20.86	22.07		21.99	23.37	24.37		23.55	25.21	27.26	
CD at 5%																				
	*Base Period																			
	Triacontanol (C)								NS				1.16				1.44			1.30
	Salicylic acid (S)								NS				1.16				1.44			1.30
	C × S								NS				NS				NS			NS

S= Salicylic acid; S_0 -Control (water spray), S_1 - Salicylic acid (1 mM) and S_2 - Salicylic acid (2 mM). C = Triacontanol; C_0 - Control (water spray), C_1 - Triacontanol (5 µM) and C_2 - Triacontanol (10 µM). *Base period: Month in which growth regulators were applied

Table 2: Response of strawberry cv. Camarosa to salicylic acid and triacontanol on plant spread (cm)

S↓ C→	April*				May				June				July				August			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
S_0	8.69	8.47	8.71	8.63	11.02	10.86	11.57	11.15	14.50	16.07	16.82	15.80	18.55	19.38	21.64	19.86	19.98	21.93	24.07	21.99
S_1	8.63	8.25	8.55	8.48	11.36	11.09	12.00	11.48	16.13	16.77	18.15	17.02	19.84	20.60	22.88	21.11	23.01	23.86	24.41	23.76
S_2	8.18	8.48	8.34	8.33	11.02	11.47	11.80	11.43	16.09	17.13	19.16	17.46	20.70	23.66	24.29	22.89	23.49	24.68	26.78	24.98
Mean	8.50	8.40	8.53		11.13	11.14	11.79		15.57	16.66	18.05		19.70	21.21	22.94		22.16	23.49	25.08	
CD at 5%																				
	*Base Period																			
	Triacontanol (C)								NS				1.00				1.22			1.26
	Salicylic acid (S)								NS				1.00				1.22			1.26
	C × S								NS				NS				NS			NS

S= Salicylic acid; S_0 -Control (water spray), S_1 - Salicylic acid (1 mM) and S_2 - Salicylic acid (2 mM). C = Triacontanol; C_0 - Control (water spray), C_1 - Triacontanol (5 µM) and C_2 - Triacontanol (10 µM). *Base period; Month in which growth regulators were applied

Table 3: Response of strawberry cv. Camarosa to salicylic acid and triacontanol on number of leaves per plant

S↓ C→	April*				May				June				July				August			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
S_0	2.40	2.33	2.27	2.33	4.40	4.53	4.77	4.57	8.40	9.27	9.20	8.96	10.73	12.33	13.07	12.04	13.53	14.67	17.43	15.21
S_1	2.40	2.20	2.33	2.31	4.20	4.60	5.13	4.64	8.67	9.47	9.53	9.22	12.40	13.20	13.53	13.04	14.87	16.93	18.07	16.62
S_2	2.40	2.40	2.33	2.38	4.87	4.73	4.77	4.79	9.07	9.20	10.00	9.42	11.90	13.43	15.17	13.50	16.43	17.00	18.13	17.19
Mean	2.40	2.31	2.31		4.49	4.62	4.89		8.71	9.31	9.58		11.68	12.99	13.92		14.94	16.20	17.88	
CD at 5%																				
	*Base Period																			
	Triacontanol (C)								NS				0.55				0.77			0.89
	Salicylic acid (S)								NS				NS				0.77			0.89
	C × S								NS				NS				NS			NS

S= Salicylic acid; S_0 -Control (water spray), S_1 - Salicylic acid (1 mM) and S_2 - Salicylic acid (2 mM). C = Triacontanol; C_0 - Control (water spray), C_1 - Triacontanol (5 µM) and C_2 - Triacontanol (10 µM). *Base period; Month in which growth regulators were applied

Table 4: Response of strawberry cv. Camarosa to salicylic acid and triacontanol on leaf area (cm^2)

S↓ C→	April*				May				June				July				August			
	C0	C1	C2	Mean	C0	C1	C2	Mean	C0	C1	C2	Mean	C0	C1	C2	Mean	C0	C1	C2	Mean
S0	35.28	35.70	35.06	35.34	60.15	59.59	58.74	59.49	100.25	107.27	116.39	107.97	115.13	119.99	128.00	121.04	98.97	100.36	101.74	100.35
S1	35.63	35.49	36.38	35.83	61.37	62.79	60.27	61.48	104.27	118.99	117.85	113.70	122.29	127.26	128.38	125.98	99.40	106.42	107.45	104.42
S2	35.72	34.62	34.63	34.99	58.38	60.87	61.17	60.14	113.54	114.53	124.64	117.57	119.73	127.75	131.76	126.42	102.87	105.73	109.59	106.06
Mean	35.54	35.27	35.36		59.97	61.08	60.06		106.02	113.60	119.63		119.05	125.00	129.38		100.41	104.17	106.26	
CD at 5%																				
	*Base Period																			
	Triacontanol (C)								NS				4.03				5.52			NS
	Salicylic acid (S)								NS				4.03				NS			NS
	C × S								NS				NS				NS			NS

S= Salicylic acid; S_0 -Control (water spray), S_1 - Salicylic acid (1 mM) and S_2 - Salicylic acid (2 mM). C = Triacontanol; C_0 - Control (water spray), C_1 - Triacontanol (5 µM) and C_2 - Triacontanol (10 µM). *Base period; Month in which growth regulators were applied.

Conclusion

Both salicylic acid and triacontanol used as growth regulators in the present study were found effective for increase in vegetative growth of strawberry cv. Camarosa (plant height, plant spread, number of leaves per plants and leaf area).

Acknowledgement

All the authors are highly thankful to Division of Fruit Science, Sher-e-Kashmir University of Agricultural science and Technology of Kashmir. We are very thankful to anonymous referees and the editor whose comments help improving the text of the article.

References

1. Amborabe BE, Lessard PF, Chollet JF, Roblin G. Antifungal effects of salicylic acid and other benzoic acid derivatives towards *Eutypa lata* structure-activity relationship. Plant Physiology Biochemistry. 2002; 40:1051-1060.
2. Chen X, Yuan H, Chen R, Zhu L, He G. Biochemical and photochemical changes in response to triacontanol in rice (*Oryza Sativa* L.). Plant Growth Regulation. 2003; 40:249-256.
3. Ghaderi N, Normohammadi S, Javadi T. Morpho-physiological responses of strawberry (*Fragaria* × *ananassa*) to exogenous salicylic acid application under drought stress. Journal of Agricultural Science and Technology. 2015; 17:167-178.
4. Hancock HF. Strawberries. In: Temperate fruit crops in warm climates (Ed. A. Erez). Kluwer Academic Publishers, Dordreht, the Netherlands, 2000, 445-455.
5. Hayat Q, Hayat H, Irfan M, Ahmad A. Effect of exogenous salicylic acid under changing environment: A review. Environmental and Experimental Botany. 2010; 68:14-25.
6. Hummer KE, Bassil N, Njuguna W. Fragaria. In: Wild Crop Relatives: Genomic and Breeding Resources-Temperate Fruits (Ed. C. Cole), 2011, 17-44.
7. Kazemi M. Foliar application of salicylic acid and calcium on yield, yield component and chemical properties of strawberry. Bulletin of Environment, Pharmacology and Life Sciences. 2013; 12(11):19-23.
8. Khan MMA, Bhardwaj G, Naeem M, Moinuddin F, Singh M, Idrees M *et al.* Response of tomato (*Solanum lycopersicum* L.) to application of potassium and triacontanol. Acta Horticulturae. 2009; 823:199-208.
9. Khan W, Prithviraj B, Smith DL. Photosynthetic responses of corn and soybean to foliar application of salicylates. Journal of Plant Physiology. 2003; 160:485-492.
10. Khodary SEA. Effect of salicylic acid on the growth, photosynthesis and carbohydrate metabolism in salt stressed maize plants. International Journal of Agriculture and Biology. 2004; 6:5-8.
11. Krishnan RR, Kumari BDR. Effect of N-triacontanol on the growth of salt stressed soybean plants. Journal of Biosciences. 2008; 19:53-62.
12. Kumar J, Rana SS, Verma HS, Jindal KK. Effect of various growth regulators on growth, yield and fruit quality of strawberry cv. Tioga. Haryana Journal of Horticultural Science. 1996; 25(4):168-171.
13. Kumar R, Saravanan S, Parshant B, Bandral J. Influence of plant bio-regulators and picking time on yield of strawberry (*Fragaria* × *ananassa* Duch.) cv. Sweet Charlie. Asian Journal of Horticulture. 2012; 7(1):137-139.
14. Lim TK. Edible medicinal and non-medicinal plants. 2012; 4:395-410.
15. Muthuchelian K, Velayutham M, Nedunchezhian N. Ameliorating effect of triacontanol on acidic mistreated Erythrina variegata seedlings changes in growth and photosynthetic activities. Plant Science. 2003; 165:1253-1257.
16. Naeem M, Khan MMA, Moinuddin. Triacontanol: a potent plant growth regulator in agriculture. Journal of Plant Interactions. 2012; 7(2):129-142.
17. Niakan M, Jahanbani A, Ghorbanli M. Spraying effect of salicylate different concentrations on growth parameters, amount of photosynthetic pigments, anthocyanin, flavonoids and solution sugars of (*Coriandrum sativum* L.) Journal of Plant Science Researches. 2010; 18(2):10-18.
18. Perveen S, Shahbaz M, Ashraf M. Regulation in gas exchange and quantum yield of photosystem II (PS II) in salt-stressed and non-stressed wheat plants raised from seed treated with triacontanol. Pakistan Journal of Botany. 2010; 42:3073-3081.
19. Qureshi MK, Chughta S, Qureshi SU, Abbas AN. Impact of exogenous application of salt and growth regulators on growth and yield of strawberry. Pakistan Journal of Botany. 2013; 45(4):1179-1185.
20. Raskin I. Salicylate: A new plant hormone. Plant Physiology. 1992; 99:799-803.
21. Ries S, Houtz R. Triacontanol as a plant growth regulator. Horticulture science. 1979; 18:654-662.
22. Stewart PJ. Fragaria history and breeding. In: Genetics, Benomics and Breeding of Berrie. (Eds. Folta, K.M. and Kole). Science Publishers, New Hampshire, USA, 2011, 114-137.
23. Thakur AS, Jindal KK, Sud A. Effect of growth substances on vegetative growth, yield and quality parameters in strawberry. Indian Journal of Horticulture. 1991; 48(4):286-290.