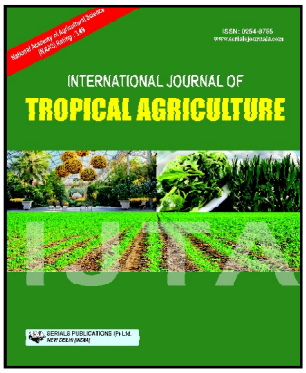

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Effect of Salicylic Acid on growth and yield of Onion (Allium cepa L.)

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Abstract: The field experiment was carried out at Scheme for Research on Onion Storage, Department of Horticulture, Mahatma Phule krishi Vidyapeeth, Rahuri during the *rabi* season of 2015-16 to study the effect of salicylic acid on onion (*Allium cepa* L.) cv. N-2-4-1. The experiment was laid out in a Factorial Randomized block design with two replications consisting two factors, Factor-A (03) with levels of concentration and water spray and Factor-B (07) with seven levels of time of applications.

The result indicated that, there was significant influence of foliar application of salicylic acid on growth parameters *viz.,* plant height (68.28-76.45 cm), number of leaves per plant (13.15-15.30), neck thickness (0.84-1.07) and higher level of chlorophyll content (0.58-0.75 mg 100 g^{-1} f.w) as compare to water spray. The foliar application of salicylic acid at lower concentration (100 mg/l) gives significantly maximum plant height, number of leaves per plant, total chlorophyll content, bulb diameter, average weight of bulb, total bulb yield, marketable bulb yield as compare to higher dose (150 mg/l) and water spray.

Three foliar sprays at 30, 45 and 60 DAT were beneficial for vegetative growth, yield, quality and storability of onion cv. N 2-4-1 than either single or two sprays of salicylic acid.

Key words: onion, vegetative growth, chlorophyll, salicylic acid, yield.

1. INTRODUCTION

Onion (*Allium cepa* L.) is being extensively cultivated all over the world. India is the 2nd largest producer of onion, in the world next only to China but the productivity of onion in India is very low. It occupies an area of 12.03 lakh ha, with production lakhtonnes. The export of onion during 2013-14 was 14.82 lakh MT with a value of Rs 316.961 crores (Anon. 2014). As far as onion production per hectare is concerned, improved and modern agronomic practices and application of Plant Growth Regulators (PGRs) might be useful in increasing onion production. In

recent years, salicylic acid has been the focus of intense research due to its function as an endogenous signal mediating local and systemic plant defense responses against pathogens.

Salicylic acid (SA) is a phenolic phytohormone that acts as a key regulator of the signaling network in plants under abiotic and biotic stresses. Salicylic acid exerts stimulatory effects on various physiological processes related to plant growth and development. The purpose of this study was to test the hypothesis that exogenous application of SA affects positively the growth, quality and yield. Salicylic acid ($C_7H_6O_3$) discovered as one of the important phenolic compounds in plants (Chandra *et al.* 2007).

This substance naturally is produced in plants in very low amounts. Various physiological and biochemical effects of salicylic acid on plant systems have been documented (Raskin, 1992). Salicylic acid treatment increases or decreases chlorophyll content, depending on the genotype (Chandra and Bhatt 1998). Salicylic acid a natural molecule plays an important role in regulating a number of physiological processes in plants. Its exogenous application has promoted plant performance under biotic and abiotic stresses (Senaratna *et al.*, 2000). Foliar spray of low concentration of salicylic acid promote and influence the growth, development, differentiation of cells, and tissues of plants and enhanced the plant's growth parameters (Helgi and Rolfe 2005).

Considering the above facts, the present investigation entitled "Effect of salicylic acid on onion (*Allium cepa* L.)" was planned to test the effect of salicylic acid as a foliar spray at different time of applications

2. MATERIALS AND METHODS

The present trial entitled "Effect of salicylic acid on onion (*Allium cepa L.*)" was carried out at Scheme for Research on Onion Storage, Department of Horticulture, Mahatma Phule krishi Vidyapeeth, Rahuri, during *rabi* season of 2015-16. The topography of the field was fairly leveled flat beds were prepared for onion transplanting, soil was medium black having moderate in moisture retention capacity. Climatically, this area is in semi-arid, sub-tropical zone, with annual average rainfall 475 mm. The annual mean maximum and minimum temperature are 35.83^0 and 17.82^0, respectively during the period of experimentation.

The onion seed was sown in raised beds in nursery for seedling preparation. Main field was prepared to fine tilth and flat beds of 3 X 2 m were prepared. At the time of land preparation experimental site was applied manure and fertilizers as recommended. The healthy seedlings of onion were transplanted on 12th January, 2015 with spacing of 15 x 10 cm.

Weeding was done manually throughout the growing season. The crop was harvested on 2nd May, 2016. At harvest the growth parameters like plant height, number of leaves and neck thickness observed from ten randomly selected plants and observations recorded. After harvesting of bulb different size bulb, A grade (>60 mm), B grade (40-60 mm) and C grade (<40 mm) were selected and their percentage were computed on weight basis. Total bulb yield (q ha^{-1}) and marketable bulb (%) were calculated.The data recorded for each observation in this present investigation was analyzed statistically as per the procedure described by Panse and Sukhatme (1989).

Treatment details

Factor A – concentration of salicylic acid and water spray (03)

1	:	Salicylic acid @ 100 mg/l
2	:	Salicylic acid @ 150 mg/l
3	:	Water spray

Factor B – Stages of application (07)

1 : 2nd spray at 30 days after transplanting(DAT)
2 : 2nd spray at 45 DAT
3 : 2nd spray at 60 DAT
4 : 2nd spray at 30 DAT and 3rd spray at 45 DAT
5 : 2nd spray at 30 DAT and 3rd spray at 60 DAT
6 2nd spray at 45 DAT and 3rd spray at 60 DAT
7 : 2nd spray at 30 DAT and 3rd spray at 45 DAT and 4th spray at 60 DAT

Note: 1st spray of salicylic acid @ 250 mg/l was given at 30 days after sowing at nursery stage common for all treatments, except water spray treatments.

RESULTS AND DISCUSSION

4.1. Growth parameters

4.1.1. Plant height (cm)

It was revealed that the differences in mean plant height due to salicylic acid treatments were observed to be statistically significant and presented in Table 1.The balance of internal level of natural auxins due to salicylic acid is mainly responsible for maintaining physiological activities in the plant system and that significantly resulted into better growth and more plant height.

Among the conc. of salicylic acid, A_1 recorded maximum plant height (73.73 cm) which was significantly superior over A_2 and A_3. The time of application effect was non-significant. The interactions effects were non-significant, however the combination A_1B_7 (T_7) recorded the maximum plant height (76.45 cm) and the combination A_3B_2 (T_{16}) recorded minimum plant height (62.97 cm).

4.1.2. Number of leaves per plant

The data pertaining to number of leaves per plant as influenced by different salicylic acid treatments and time of application was recorded at harvest and presented in Table 1. It was revealed that the differences in mean number of leaves per plant due to salicylic acid treatments were observed to be statistically significant. The exogenous application of SA had effect on increased photosynthetic activity and cell division which enhances the number of leaves per plant (Gharib, 2006).

Among the conc. of salicylic acid, A_1 recorded maximum number of leaves per plant (14.61) which were significantly superior to A_2 and A_3 treatments. The time of application effects were non-significant. With respect to interactions effect were non-significant, however the combination A_1B_7 (T_7) recorded the maximum number of leaves per plant (15.30) and the combination A_3B_4 (T_{18}) recorded minimum number of leaves per plant (11.64). These findings are close relevant with the result of Jain and Srivastava (1981) in maize, Gutierrez–Coronado *et al.* (1998) in soyabean, Pankaj and Sharma (2003) in okra, Amin *et al.* (2007) in onion, Jeyakumar *et al.* (2008) in black gram, Pradhan *et al.* (2016) and Prajapati *et al.* (2016) in onion.

4.1.3. Neck thickness (cm)

It was revealed that the differences in mean neck thickness of plant due to salicylic acid treatments were observed to be statistically significant and results are presented in Table 1. Neck thickness of onion is important parameter since it is the neck which is ultimately going to be converted into bulb. Hence, more the neck thickness more will be size of bulb and yield (Shashikumar and Shashidhar, 2015). Neck thickness rapidly reduced 90 days after transplanting in onion due to maturity.

Among the conc. of salicylic acid, A_3 recorded minimum neck thickness (0.75 cm) which was significantly higher than A_1 and A_2 treatments. With respect to time of applications effect was non-significant. The interactions effect were non-significant, however the combination A_3B_5 (T_{19}) recorded minimum neck thickness (0.71 cm). The combination A_1B_7 (T_7) recorded the maximum neck thickness (1.07 cm). The result obtained are in close

agreement with the observation recorded by Sakhabutdinova *et al.* (2003) in wheat, Pankaj and Sharma (2003) in okra, Amin *et al.* (2007), Pradhan *et al.* (2016), Prajapati *et al.* (2016) in onion.

4.4. Yield and yield contributing characters

The data pertaining to yield contributing characters *viz.,* polar and equatorial diameter, average weight of bulb (g) and grades of bulbs (%) was recorded during the present investigation and result data presented in Table 2.

4.2.5. Polar diameter (cm)

Among SA conc., the maximum polar diameter of bulb (4.82 cm) recorded in A_1 which was significantly higher than A_2 and A_3. Among the time of application effect was non-significant, however the maximum polar diameter of bulb (4.63 cm) was recorded in B_7. However, the minimum polar diameter of bulb (4.48 cm) was recorded in B_1. The interaction effect were significant, however the combination A_1B_7 (T_7) recorded the maximum polar diameter of bulb (5.02 cm) was at par with the combination A_1B_4 (T_4) (4.90 cm), A_1B_3 (T_3), (4.86 cm), A_1B_5 (T_5) (4.86 cm) A_1B_6 (T_6) (4.86 cm). Thus resulting higher values of polar diameter in onion bulbs similar findings reported by Ibrahim and Sanna (2005), Amin *et al.* (2007), Prajapati *et al.* (2016) and Pradhan *et al.* (2016) in onion and Bideshki Arvin (2010) in garlic.

4.2.6. Equatorial diameter (cm)

With respect to the concentrations of salicylic acid, the maximum equatorial diameter of bulb (5.62 cm) recorded in A_1 which was significantly superior to A_2 and A_3 treatments. Among the time of application effect was non-significant.

The interaction effect were significant, however the combination A_1B_7 (T_7) recorded the maximum equatorial diameter of bulb (5.85 cm) was at par with the combination A_1B_5 (T_5) (5.71 cm), A_1B_4 (T_4) (5.69 cm), A_1B_6 (T_6) (5.67 cm) and A_1B_3 (T_3) (5.65 cm). These findings are close agreement with Amin *et al.* (2007) in onion and Bideshki and Arvin (2010) in garlic and Prajapati *et al.* (2016) and Pradhan *et al.* (2016) in onion Meena *et al.* (2016) in garlic.

4.2.7. Average weight of bulb (g)

It was revealed that the differences in mean average weight of bulbs due to salicylic acid treatments were observed to be statistically significant.

Considering the conc. of salicylic acid the maximum average weight of bulb (81.74 g) recorded in A_1 which was significantly superior over A_2 and A_3 treatments. The interaction effects were significant, however the combination A_1B_7 recorded the maximum average weight of bulb (86.16 g) significantly. These results are in close agreement with Amin *et al.* (2007), Pradhan *et al.* (2016) and Prajapati *et al.* (2016) in onion.

4.2.8. Total bulb yield (kg plot^{-1})

The data regarding to total bulb yield per plot as influenced by different salicylic acid treatments and time of application and presented in Table 3. It is revealed that the differences in regard of total bulb yield due to various treatments of salicylic acid were observed to be statistically significant. Considering the concentration of salicylic acid effects was significant and the highest total bulb yield (27.95 kg plot^{-1}) was recorded in which was at par with A_2 (27.10 kg plot^{-1}). Among the time of application, the maximum total bulb yield kg plot^{-1} (24.91 kg plot^{-1}) was recorded in B_1 which was significantly superior to all the remaining except B_2 (24.54 kg plot^{-1}) and B_7 (24.10 kg plot^{-1}) which was at par with it. With respect to interactions, the combination A_1B_7 (T_7) recorded the maximum total bulb yield (29.72 kg plot^{-1}) was at par with A_1B_5 (T_5) (28.88 kg plot^{-1}), A_1B_3 (T_3) (28.00 kg plot^{-1}), A_1B_4 (T_4) (27.98 kg plot^{-1}) and A_1B_1 (T_1) (27.95 kg plot^{-1}). These findings are closely related with Ibrahim and Sanaa (2005) in onion, Amin *et al.* (2007) in onion, Yildirim and A. Dursun (2009) in

Table 1
Effect of salicylic acid concentrations and time of applications on plant height (cm), number of leaves, neck thickness (cm)

Treatment	*Plant height (cm)*	*Number of leaves*	*Neck thickness (cm)*
Factor A			
A_1	73.73	14.61	0.99
A_2	70.37	13.56	0.92
A_3	65.42	12.04	0.75
Factor B			
B_1	70.09	13.25	0.85
B_2	68.66	13.38	0.87
B_3	69.31	13.42	0.90
B_4	69.87	13.15	0.91
B_5	70.57	13.58	0.87
B_6	70.08	13.52	0.88
B_7	70.29	13.53	0.92
Interaction			
A_1B_1	74.50	13.95	0.92
A_1B_2	72.46	14.10	0.99
A_1B_3	71.31	14.70	0.98
A_1B_4	73.32	14.10	0.99
A_1B_5	73.72	14.85	1.02
A_1B_6	74.33	15.25	0.98
A_1B_7	76.45	15.30	1.07
A_2B_1	71.91	13.70	0.86
A_2B_2	70.55	13.85	0.84
A_2B_3	70.40	13.70	0.97
A_2B_4	69.97	13.70	0.98
A_2B_5	71.09	13.65	0.89
A_2B_6	70.38	13.15	0.92
A_2B_7	68.28	13.20	0.96
A_3B_1	63.87	12.10	0.78
A_3B_2	62.97	12.20	0.79
A_3B_3	66.23	11.85	0.77
A_3B_4	66.31	11.64	0.76
A_3B_5	66.91	12.26	0.71
A_3B_6	65.55	12.15	0.73
A_3B_7	66.13	12.10	0.75

	S.E.+	*CD at 5 %*	*S.E.+*	*CD at 5 %*	*S.E.+*	*CD at 5 %*
Factor A	0.51	1.52	0.11	0.34	0.012	0.037
Factor B	0.79	NS	0.18	NS	0.019	NS
Interaction	1.37	NS	0.31	NS	0.033	NS

Table 2
Effect of salicylic acid concentrations and time of applications on polar diameter (cm), equatorial diameter (cm) and average weight of bulb (g)

Treatment	*Polar diameter (cm)*	*Equatorial diameter (cm)*	*Average weight of bulb(g)*
Factor A			
A_1	4.82	5.62	81.74
A_2	4.56	5.32	77.80
A_3	4.23	4.91	73.07
Factor B			
B_1	4.48	5.22	76.68
B_2	4.50	5.24	76.88
B_3	4.51	5.25	76.99
B_4	4.55	5.30	77.62
B_5	4.52	5.29	77.42
B_6	4.55	5.32	77.86
B_7	4.63	5.39	79.30
Interaction			
A_1B_1	4.61	5.38	78.52
A_1B_2	4.65	5.42	78.98
A_1B_3	4.86	5.65	81.76
A_1B_4	4.90	5.69	82.32
A_1B_5	4.86	5.71	82.48
A_1B_6	4.86	5.67	81.98
A_1B_7	5.02	5.85	86.16
A_2B_1	4.49	5.23	76.78
A_2B_2	4.47	5.20	76.43
A_2B_3	4.55	5.28	77.42
A_2B_4	4.55	5.31	77.66
A_2B_5	4.52	5.30	77.55
A_2B_6	4.65	5.43	79.15
A_2B_7	4.67	5.46	79.58
A_3B_1	4.35	5.06	74.75
A_3B_2	4.38	5.10	75.22
A_3B_3	4.12	4.81	71.78
A_3B_4	4.20	4.91	72.87
A_3B_5	4.18	4.85	72.23
A_3B_6	4.16	4.87	72.44
A_3B_7	4.21	4.85	72.17

	S.E.+	*CD at 5 %*	*S.E.+*	*CD at 5 %*	*S.E.+*	*CD at 5 %*
Factor A	0.02	0.07	0.03	0.09	0.43	1.27
Factor B	0.03	NS	0.04	NS	0.66	NS
Interaction	0.06	0.19	0.08	0.24	1.14	3.37

Table 3
Effect of salicylic acid concentrations and time of applications on total bulb yield and marketable bulb (%)

Treatment	*Total bulb yield (kg plot^{-1})*	*Total bulb yield (qha^{-1})*	*Marketable bulb (%)*
Factor A			
A_1	27.95	463.01	93.24
A_2	27.10	384.01	90.17
A_3	19.69	318.82	87.24
Factor B			
B_1	24.91	413.55	92.33
B_2	24.54	407.34	90.22
B_3	21.98	364.79	89.21
B_4	23.19	384.98	89.49
B_5	23.07	382.95	89.11
B_6	22.09	366.71	91.28
B_7	24.10	400.00	89.86
Interaction			
A_1B_1	27.95	464.00	92.87
A_1B_2	26.83	445.35	93.69
A_1B_3	28.00	464.79	93.39
A_1B_4	27.98	464.51	92.77
A_1B_5	28.88	479.42	91.81
A_1B_6	25.89	429.75	93.48
A_1B_7	29.72	493.27	94.64
A_2B_1	27.10	449.78	93.53
A_2B_2	27.25	452.34	92.58
A_2B_3	19.15	317.82	88.14
A_2B_4	22.59	374.98	90.40
A_2B_5	21.57	358.13	88.12
A_2B_6	21.60	358.56	90.38
A_2B_7	22.68	376.47	88.03
A_3B_1	19.69	326.87	90.59
A_3B_2	19.54	324.31	84.39
A_3B_3	18.78	311.76	86.11
A_3B_4	19.00	315.44	85.30
A_3B_5	18.75	311.29	87.41
A_3B_6	18.78	311.81	89.97
A_3B_7	19.90	330.27	86.92

	S.E.+	*CD at 5 %*	*S.E.+*	*CD at 5 %*	*S.E.+*	*CD at 5 %*
Factor A	0.29	0.85	4.82	14.18	0.50	1.47
Factor B	0.44	1.30	7.36	21.67	0.76	NS
Interaction	0.76	2.26	12.7	37.54	1.32	NS

tomato, Bideshki and Arvin (2010) and Meena *et al.* (2016) in garlic, Prajapati *et al.* (2016) and Pradhan *et al.* (2016) in onion.

4.2.9. Marketable bulb (%)

The data regarding to marketable bulb (%) as influenced by different salicylic acid treatments and time of application are presented in Table 3.

Considering the concentrations of salicylic acid, effect was significant and the highest marketable bulb percentage (93.24 %) was recorded in A_1. Among the time of application, the highest marketable bulb percentage (92.33 %) was recorded in B_1 and lowest marketable bulb percentage (89.11 %) recorded in B_5. The interaction effect were non-significant, however the combination A_1B_7 (T_7) recorded the maximum marketable bulb percentage (94.64 %). The minimum marketable bulb percentage (84.39 %) recorded in A_3B_2 (T_{16}).

4. CONCLUSION

From the foregoing results and discussion, it could be concluded as:

1. The foliar application of salicylic acid at lower concentration (100 mg/l) gives significantly maximum plant height, number of leaves per plant, total chlorophyll content, bulb diameter, average weight of bulb, total bulb yield, marketable bulb yield with significantly minimum purple blotch incidence and thrips incidence as compare to higher dose (150 mg/l) and water spray.
2. Foliar application of salicylic acid at 30 DAS during nursery stage and subsequently 2nd spray at 30 DAT, 3rd spray at 45 DAT and 4th spray at 60 DAT during crop growth stage gives more growth, quality and yield parameters than single spray.
3. The combination A_1B_7 (T_7) (1st spray of 250 mg/l, 2nd spray SA @ 100 mg /lit at 30 DAT, 3rd spray SA @ 100 mg/lit at 45 DAT and 4th spray @ 100 mg/lit at 60 DAT) not only recorded maximum growth parameters but also recorded the highest total bulb yield of 493.27 q ha^{-1} and marketable bulb percentage (94.64%) with minimum storage losses.

Summing the present investigation, it can be concluded that, foliar application of SA as 1st spray of 250 mg/l at 30 days after sowing in nursery stage, 2nd spray SA @ 100 mg /lit at 30 DAT and 3rd spray SA @ 100 mg /lit at 45 DAT and 4th spray SA @ 100 mg /lit at 60 DAT was found beneficial for obtaining maximum yield, quality and storability of onion.

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