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Influence of salicylic acid on the quality and storage in onion cv. (Akola safed)

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Abstract
An experiment entitled "Influence of salicylic acid on the growth, yield and quality in onion Cv. (Akola safed)" was carried out during *rabi* season of academic year 2016-2017, at Chilli and Vegetable Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was conducted in Factorial Randomized Block Design, with three replications and 13 treatment combinations with control treatment. There were two factors, main factor being stages of application with 3 levels *viz.* 30 DAT, 60 DAT, 30 and 60 DAT and another sub factor was concentration of salicylic acid with 4 levels viz. 50, 100, 150, 200 mg l^{-1}. The results of present investigation indicated that, polar diameter (cm), equatorial diameter (cm), TSS (^{0}Brix), ascorbic acid content (mg 100^{-1} g) in onion bulbs were recorded maximum, wherein the treatment combination consisting of two applications of salicylic acid at 30 and 60 DAT along with salicylic acid @ 100 mg l^{-1} (A_3C_2). As regards to the influence of treatment combination on storage parameters *viz*., physiological loss in weight, sprouting and rottening loss were concerned, they depicted numerically minimum values in the treatment combination consisting of two applications of salicylic acid at 30 and 60 DAT with salicylic acid @ 100 mg l^{-1} (A_3C_2).

Keywords: influence, salicylic acid, onion, Akola safed

Introduction
Onion (*Allium cepa* L.) is being extensively cultivated all over the world. India is the second 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 lakh tonnes. The export of onion during 2013-14 was 14.82 lakh MT with a value of Rs 316.961 crores (Anon. 2014) [2]. It is originated in central Asia. It is valued for its distinct pungent flavour and is an essential ingredient for the cuisine of many regions, hence known as "Queen of the kitchen" (Selvaraj, 1976) [7]. The onion is preferred mainly because of its green leaves; immature as well as mature bulbs are either eaten raw or cooked as a vegetable. A distinct characteristic of onion is its alliaceous odour, which accounts for their use as food. The pungency in onion is due to a volatile compound known as *Allyl-propyl disulphide*.

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 salicylic acid affects positively the growth, quality and yield. In general, salicylic acid is an endogenous growth regulator with phenolic nature, which participates in regulation of several physiological processes in crop plants such as stomata closure, ion uptake, inhibition of ethylene biosynthesis and transpiration (Khan *et al.*, 2003 and Shakirova *et al.*, 2003) [4, 8]. It has already established that, many phenolic compounds play an essential role in the regulation of different physiological processes, including plant growth and development, ion uptake and photosynthesis (Popova *et al.*, 1997; Singh and Usha, 2003) [6, 9]. Phenolic molecules produced by plant roots are essential for generation and plant development (Lynn and Chrag, 1991) [5]. Subsequently, the beneficial effect of salicylic acid was demonstrated in other plant species and this was the basis for suggestions salicylic acid functions as an endogenous growth regulator for induction of flowering. Considering the above facts, the present investigation entitled "Influence of salicylic acid on the quality and storage in onion Cv. (Akola safed)" was planned to test the effect of salicylic acid as a foliar spray at different stages of applications.

Material and Methods

The field experiment was conducted in the farm of Chilli and Vegetable Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *rabi* season of 2016-17. Akola is situated in sub-tropical region between 22.20 N latitude and 77.02 E longitude. The altitude of place is 307.2 m above mean sea level. The climate of Akola is semi arid and charactereried by three distinct seasons. Hot and dry summer from March to May, warm humid and rainy mansoon from July to November, and mild cold winter from November to February. To ascertain physio-chemical characteristics of soil, soil samples were collected from different spots of the experiment field to a depth of 0-30 cm, before layout and composite soil sample was prepared and analysed for physico-chemical properties of soil. The soil analysis indicated that, the soil of experimental plot is medium black soil with uniform texture and structure having good drainage, low in organic carbon and available nitrogen, medium in available phosphorus and available potash. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications and thirteen treatments combination. The variety of onion used for the present study was Akola safed, which was developed by Chilli and Vegetable Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2016 - 17.

Treatment details

Factor A – Stages of application (03)

A1	:	Single application of salicylic acid at 30 days after transplanting.
A2	:	Single application of salicylic acid at 60 days after transplanting.
A3	:	Two applications of salicylic acid at 30 and 60 days after transplanting.

Factor B – Concentration of salicylic acid (04)

C1	:	50mg/lit
C2	:	100mg/lit
C3	:	150mg/lit
C4	:	200mg/lit

Results and Discussion

Quality parameters

Polar Diameter (cm)

The data pertaining to the polar diameter of onion bulbs as influenced by different salicylic acid treatments and time of application is presented in Table 1 and revealed significant difference due to various treatments. The data indicated that due to application of salicylic acid at different stages revealed significant results on polar diameter of the bulbs. Maximum polar diameter was observed in A_3 (4.64 cm). However considering to the various concentrations of salicylic acid C_2 recorded maximum polar diameter (4.76 cm). The interaction effect was also found to be significant. The combination A_3C_2 recorded maximum polar diameter of bulbs (5.24 cm).

Equatorial Diameter (cm)

The data pertaining to the equatorial diameter of onion bulbs as influenced by different salicylic acid treatments and time of application is presented in Table 1 and revealed significant difference due to various treatments. The data indicated that application of salicylic acid at different stages revealed significant results on equatorial diameter of the bulbs. Maximum equatorial diameter was observed in A_3 (5.45 cm). However considering to the various concentrations of salicylic acid C_2 recorded maximum equatorial diameter (5.49 cm). The interaction effect was also found to be significant. The combination A_3C_2 recorded maximum equatorial diameter of bulbs (6.33 cm).

Bolters (%)

The data in respect to bolting percentage in onion crop was recorded in Table 1. The data indicated that application of salicylic acid at different stages revealed non-significant results on bolters. Considering to the various concentrations of salicylic acid, minimum bolters were observed in C_2 (0.06 %). However C_4 recorded maximum bolters (0.48 %). The interaction effect was found to be non-significant.

Double Bulbs (%)

The splitted or double bulbs of onion were reported in percentage in Table 1. The data indicated that, due to an application of salicylic acid at different stages, doubles in onion bulbs were not influenced significantly. The effects of various concentrations of salicylic acid on doubles of onion bulbs were statistically significant. The minimum (0.27 %) double bulbs were recorded in C_2 which was found statistically at par with C_1. The maximum double bulbs (0.71 %) were produced due to an application of salicylic acid @ 200 mg l^{-1}(C_4). The interaction effect between stage of application and concentration of salicylic acid along with and without control were found statistically non-significant.

Rotten bulbs (%)

The result indicates that, due to an application of salicylic acid at different stages, rotten bulbs in onion were not influenced significantly. The effect of various concentrations of salicylic acid on rotten bulbs of onion was statistically significant. The minimum (1.54 %) rotten bulbs were obtained in C_2, which was found statistically at par (1.64 %) with C_1. The interaction effect between stages of application and concentrations of salicylic acid with and without control was found statistically non-significant.

Total soluble solids (^{0}Brix)

From the data presented in Table 1, it is observed that, the maximum (12.33 ^{0}Brix) TSS was recorded, in A_3 but it was found minimum (12.00 ^{0}Brix), in A_2. The application of salicylic acid with different concentrations showed statistically significant difference towards TSS content in onion bulbs. Significantly the maximum (12.32 ^{0}Brix) TSS was recorded in C_2. However, significantly the minimum (11.98 ^{0}Brix) TSS was noticed in C_1. The interaction effect between stage of application and concentrations of salicylic acid was found statistically significant. The maximum (12.67 ^{0}Brix) TSS was recorded in the combination A_3C_2. Whereas, it was recorded minimum (11.67 ^{0}Brix), in treatment combination A_2C_1.

Ascorbic acid (mg 100^{-1} g)

Data indicated that, significantly the maximum (12.39 mg 100^{-1} g) ascorbic acid was obtained in A_1. Whereas, it was recorded minimum (11.69 mg 100^{-1} g) in A_2. The different concentration of salicylic acid maximum (12.43 mg 100^{-1} g) ascorbic acid in the treatment C_2. The interaction effect significant the maximum (13.07 mg 100^{-1} g) ascorbic acid in the treatment combination A_3C_2. However, it was recorded minimum (11.10 mg 100^{-1} g), in A_0C_0 combination.

Table 1: Effect of salicylic acid concentrations and time of applications on quality parameters in onion Cv. (Akola safed)

Treatment	Polar diameter (cm)		Equatorial diameter (cm)		Bolters (%)		Double bulbs (%)		Rotten bulb (%)		TSS (^{0}Brix)		Ascorbic acid (mg 100-1 g)	
Factor A														
A_1	4.52		4.98		0.27(0.85)		0.42(0.95)		2.67(1.73)		12.05		12.39	
A_2	4.37		4.58		0.32(0.90)		0.58(1.03)		3.36(1.91)		12.00		11.69	
A_3	4.64		5.45		0.19(0.82)		0.39(0.93)		2.33(1.64)		12.33		12.28	
Factor B														
C_1	4.52		5.09		0.28(0.87)^		0.36(0.92)		1.64(1.44)		11.98		11.77	
C_2	4.76		5.49		0.06(0.75)		0.27(0.87)		1.54(1.41)		12.32		12.43	
C_3	4.37		5.08		0.22(0.84)		0.51(1.00)		3.19(1.91)		12.18		11.89	
C_4	4.39		4.34		0.48(0.97)		0.71(1.09)		4.78(2.29)		12.02		12.39	
Interaction														
A_1C_1	4.52		4.68		0.47(0.96)^		0.35(0.90)^		1.47(1.39)^		11.77		12.20	
A_2C_1	4.44		4.32		0.19(0.82)^		0.44(0.97)^		2.19(1.61)^		11.67		11.47	
A_3C_1	4.58		6.28		0.17(0.82)^		0.29(0.88)^		1.27(1.33)^		12.50		11.63	
A_1C_2	4.55		5.05		0.00(0.71)		0.28(0.88)		1.52(1.40)		12.03		12.60	
A_2C_2	4.49		5.08		0.19(0.83)		0.39(0.94)		1.92(1.52)		12.24		11.63	
A_3C_2	5.24		6.33		0.00(0.71)		0.14(0.80)		1.19(1.30)		12.67		13.07	
A_1C_3	4.37		5.64		0.00(0.71)		0.42(0.96)		3.03(1.85)		12.20		12.40	
A_2C_3	4.32		4.73		0.54(1.02)		0.64(1.07)		3.63(2.03)		12.23		11.53	
A_3C_3	4.43		4.88		0.12(0.79)		0.45(0.98)		2.91(1.85)		12.10		11.73	
A_1C_4	4.64		4.54		0.61(1.02)		0.62(1.06)		4.66(2.26)		12.20		12.37	
A_2C_4	4.22		4.18		0.36(0.92)		0.84(1.16)		5.71(2.49)		11.83		12.13	
A_3C_4	4.32		4.30		0.47(0.96)		0.69(1.05)		3.97(2.11)		12.03		12.67	
A_0C_0	3.79		3.97		0.64(1.07)		0.98(1.22)		7.14(2.75)		11.80		11.10	
	S.E.	CD at 5%	S.E.	CD at 5%	S.E.	CD at 5%	S.E.	CD at 5%	S.E.	CD at 5%	S.E.	CD at 5%	S.E.	CD at 5%
Factor A	0.07	0.20	0.11	0.32	0.04	NS	0.03	NS	0.07	NS	0.07	0.21	0.11	0.33
Factor B	0.08	0.23	0.13	0.37	0.04	0.12	0.04	0.10	0.09	0.25	0.08	0.24	0.13	0.38
Interaction	0.14	0.41	0.22	0.63	0.07	NS	0.06	NS	0.15	NS	0.14	0.41	0.22	0.55
Control (A_0C_0)	0.10	0.31	0.16	0.47	0.05	NS	0.04	NS	0.11	NS	0.10	0.28	0.16	0.48

#Figures in parentheses are arc sin value transformation
^Figures in parentheses are square root transformation

Table 2: Effect of salicylic acid concentrations and time of applications on storage parameters in onion Cv. (Akola safed)

Treatment	PLW (%)		Sprouting losses (%)		Rottening losses (%)		Total losses (%)	
Factor A								
A_1	29.44 (32.83)#		0.00 (2.13)^		7.66 (2.86)^		37.10 (37.51)#	
A_2	28.42 (32.20)		1.50 (2.77)		8.04 (2.92)		36.96 (37.43)	
A_3	22.66 (28.29)		0.00 (2.13)		7.36 (2.80)		30.02 (33.12)	
Factor B								
C_1	27.67 (31.69)		0.00 (2.13)		7.56 (2.84)		35.23 (36.38)#	
C_2	23.51 (28.78)		0.00 (2.13)		7.11 (2.76)		30.62 (34.45)	
C_3	27.57 (31.66)		0.00 (2.13)		7.79 (2.88)		35.36 (36.48)	
C_4	28.61 (32.30)		2.00 (2.98)		8.28 (2.96)		37.56 (37.78)	
Interaction								
A_1C_1	30.21 (33.34)#		0.00 (0.71)^		7.54 (2.83)^		37.75 (37.91)#	
A_2C_1	30.32 (33.41)		0.00 (0.71)		7.75 (2.87)		38.07 (38.10)	
A_3C_1	22.49 (28.31)		0.00 (0.71)		7.39 (2.81)		29.88 (33.13)	
A_1C_2	25.07 (30.03)		0.00 (0.71)		7.40 (2.81)		32.47(34.73)	
A_2C_2	30.26(33.37)		0.00(0.71)		7.63(2.85)		37.89 (37.99)	
A_3C_2	15.19(22.93)		7.63(2.85)		6.30(2.61)		21.49(27.62)	
A_1C_3	30.38(33.45)		7.87(2.89)		7.80(2.88)		38.18(38.16)	
A_2C_3	25.32(30.21)		8.90(3.07)		7.87(2.89)		33.19(35.17)	
A_3C_3	27.01(31.31)		7.39(2.81)		7.71(2.87)		34.72(36.10)	
A_1C_4	32.11(34.51)		6.30(2.61)		7.89(2.90)		40.00(39.23)	
A_2C_4	27.79(31.81)		7.71(2.87)		8.90(3.07)		38.69(38.46)	
A_3C_4	25.94(30.59)		8.05(2.92)		8.05(2.92)		33.99(35.64)	
A_0C_0	37.62(37.83)		9.38(3.14)		9.38(3.14)		51.15(45.66)	
	S.E.	CD at 5%	S.E.	CD at 5%	S.E.	CD at 5%	S.E.	CD at 5%
Factor A	0.27	0.77	0.04	0.12	0.01	0.03	0.28	0.82
Factor B	0.31	0.89	0.05	0.13	0.01	0.04	0.33	0.95
Interaction	0.53	1.55	0.08	0.23	0.02	0.07	0.56	1.65
Control (A_0C_0)	0.39	1.14	0.06	0.17	0.02	0.05	0.42	1.25

#Figures in parentheses are arc sin value transformation
^Figures in parentheses are square root transformation

Storage parameters

Physiological loss in weight (%)

At 120 days after storage (DAS), physiological loss in weight influenced significantly. Considering to the stage of application the minimum physiological loss in weight at 120 DAS was recorded in A_3 (22.66 %). As far as application of salicylic acid with different concentrations is concerned, significantly the minimum C_2 (23.51 %). The interaction effect was significant, the minimum physiological loss in weight of onion bulbs at 120 DAS was recorded in the treatment combination A_3C_2 (15.19 %). This could be attributed due to the fact that, the protection action of salicylic acid would directly associated with the reduction of transpiration rate. These results are supportive to the finding of Dat *et al*. (1998) + in mustard, Singh and Usha (2003) [9] in onion.

Sprouting losses (%)

It is to note herewith that, there were no sprouting had been reported in onion bulbs up to 90 days from the date of initial of stage. At 120 DAS, significantly the maximum (1.50 %) sprouting loss was recorded in A_2. As far as the application of salicylic acid with different concentrations is concerned, significantly the maximum (2.00 %) sprouting loss was recorded in C_4. However, sprouting loss was not noticed in C_1, C_2 and C_3, in onion bulbs with salicylic acid during storage.

The interaction effect was significant. The maximum (4.15 %) sprouting of onion bulbs were obtained in the forms of storage loss.

Rottening losses (%)

At 120 days after storage (DAS), rottening losses were influenced significantly. The stage of application the minimum rottening losses at 120 DAS was recorded in A_3 (7.36%). As far as application of salicylic acid with different concentrations is concerned, the minimum rottening losses at 120 DAS were recorded in C_2 (7.11%). The interaction effect to be non-significant. The minimum rottening losses of onion bulbs at 120 DAS was recorded in the treatment combination (7.63 %) A_3C_2.

Total losses (%)

Considering to the stage of application the minimum total losses at 120 DAS was recorded in A_3 (30.02 %). As far as application of salicylic acid with different concentrations is concerned, the minimum total losses at 120 DAS were recorded in C_2 (30.62 %). The interaction effect to be non-significant. The minimum total losses of onion bulbs at 120 DAS were recorded in the treatment combination A_3C_2 (21.49 %).

Naturally the application of salicylic acid twice with moderate concentration *viz*. 100 mg l^{-1} are responsible for reduction in the rate of transpiration with enhance anti-oxidant activities in the bulbs crop like onion. These results are in close agreement with the findings of Singh and Usha (2003) [9] and Amin *et al*. (2007) [1] in onion.

Conclusion

On the basis of results obtained from the present experiment, following conclusions could be drawn Stage of application of salicylic acid at 30 and 60 DAT (A_3) significantly TSS, ascorbic acid content and reduced storage losses when compare to single application at 30 and 60 DAT. Application of salicylic acid @ 100 mg l^{-1} (C_2) significantly reduced storage losses as compare to the other levels of the concentration. As regards to the interaction effect, out of the total 13 treatment combinations along with the control treatment, the treatment combination consisting of two application at 30 and 60 DAT along with the concentration of salicylic acid 100 mg l^{-1} (A_3C_2) significantly increased the quality parameters like TSS, ascorbic content in onion bulbs and also it reduced storage losses *viz*. physiological loss in weight, sprouting losses and rottening losses during 120 days storage period during present investigation.

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