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Effect of salicylic acid on growth and yield of late *kharif* Onion (*Allium cepa* L.)

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Abstract
The field experiment was conducted at the instruction cum research field of Scheme for Research on onion Storage, Department of Horticulture, MPKV, Rahuri, Dist. Ahmednagar; during late *kharif* season of 2016-17. Design of experiment is Factorial Randomized Block Design. Variety Phule Samarth, Plot Size and Spacing 3 X 2 m^2, 15 x 10 cm.

Present investigation late *kharif* season same treatment A_7 recorded significantly highest plant height (73.19 cm), number of leaves (13.12), polar diameter (5.09 cm), equatorial diameter (5.05 cm) and lowest neck thickness (1.06 cm). The treatment B_4 among the concentration levels of SA recorded significantly highest plant height (71.10 cm), number of leaves (12.27), polar diameter (5.16 cm), equatorial diameter (5.11 cm).The interaction found non-significant effect on above growth parameters during late *kharif* the seasons. whereas during late *kharif* season highest significant average bulb weight (105.90 g), total bulb yield (32.84 t/ha), marketable bulb yield (30.19 t/ha). during late *kharif* season.

In overall the present investigation concluded that, foliar application of SA as 1st spray of 250 mg/lit at 30 days after sowing in nursery stage, 2nd spray, 3rd spray and 4th spray SA @ 250 mg /lit at 30,45 and 60 DAT was found beneficial for obtaining maximum yield improving quality and increasing yield of onion during late *kharif* season.

Keywords: Onion, salicylic, acid, *kharif*, *Allium cepa* L.

Introduction
In India, onion is predominantly cultivated during winter (60%) followed by 20% each in *kharif* and late *kharif* season. The lower productivity of Indian onion is primarily due to cultivation of low yield potential varieties having susceptibility to both biotic (pests, diseases and weeds) as well as abiotic factors (i.e. moisture stress, high temperature, imbalance nutrition etc.). Commercial crops are exposed to a wide array of damaging agents, including biotic (viroids, viruses, bacteria, fungi, insects) and abiotic (drought, salinity, heat, cold and soil toxicity) environmental aggressions. To cope with these continuous challenges under field conditions, plants have evolved broad and efficient mechanisms to obtain an adequate defence. One prominent defensive response of plants against pathogen attack is the synthesis of a remarkably vast array of low molecular weight compounds with disparate functions in plant-pathogen interactions (Dixon, 2001) [4].

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) [25, 33]. Phenolic molecules produced by plant roots are essential for generation and plant development (Lynn and Charg, 1991) [19]. The first induction for the physiological effect of SA was the discovery of flower inducing action and bud formation in tobacco cell culture (Eberhord *et al*., 1989) [6]. Subsequently, the beneficial effect of SA was demonstrated in other plant species and this was the basis for suggestions SA functions as an endogenous growth regulator for induction of flowering. Salicylic Acid (SA) recently included in the class of phytohormones for proper plant growth development and induction of tolerance to both biotic as well as abiotic stresses. The word "Salicylic Acid" (SA) was derived from Latin word "Salix" meaning willow tree, distributed in the whole plant kingdom and is classified under the group of plant hormone (Raskin *et al*., 1990) [29]. In general, SA is an important defensive signal in plants that is essential for elicitor triggered immunity and the establishment of Systemic Acquired Resistance (SAR) (Mur *et al*., 1997 and Carr *et al*., 2010) [22, 3]. Thus, SA 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) [16, 31].

Salicylic acid a natural molecule has been play 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) [30]. 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) [12].

Salicylic acid is recently included in the class of phytohormones for proper plant growth and development and induction of tolerance to both biotic as well as abiotic stresses. In general, salicylic acid (SA) is a phenolic group which plays an important role in plant defence. In the plant tissue, salicylic acid is a transduction signal molecule in plant resistance mechanisms (Malamy and Klessig, 1992; Vlot *et al*., 2009) [20, 36]. To study the effect of salicylic acid on growth and yield of late *kharif* season of onion.

Materials and Methods

The field experiment was conducted at the instruction cum research field of Scheme for Research on onion Storage, Department of Horticulture, MPKV, Rahuri, Dist. Ahmednagar; during late *kharif* season of 2016-17. Design of experiment is Factorial Randomized Block Design. Variety Phule Samarth, Plot Size and Spacing 3 X 2 m^2, 15 x 10 cm.

Treatment details

Factor A- Growth stages

A_1- 30 days after transplanting (DAT)
A_2- 45 days after transplanting (DAT)
A_3- 60 days after transplanting (DAT)
A_4- 30 & 45 days after transplanting (DAT)
A_5- 30 & 60 days after transplanting (DAT)
A_6- 45 & 60 days after transplanting (DAT)
A_7- 30, 45 & 60 days after transplanting (DAT)

Factor – B – Spray Concentration of Salicylic acid

B_1- 100 mg/lit of water
B_2- 150 mg/lit of water
B_3- 200 mg/lit of water
B_4- 250 mg/lit of water

With Additional treatment

C_1- Recommended dose for plant protection
C_2- Control (water spray)

Note

1. Common treatment 30 days of sowing foliar application 250 mg/lit salicylic acid after nursery stage.
2. Recommended dose of NPK and FYM was apply to all treatments
3. Recommended dose of plant protection measures was apply to C_1 treatments only. All others treatments have no plant protection measures.

Results and Discussion

Growth parameters

The data pertaining to plant height as influenced by different concentration levels of salicylic acid, time of application, treatments and combination of treatments were significantly differed during late *kharif* season of 2016 and are presented in Table 1.1.

The plant height recorded for late *kharif* season 2016 was statistically significant due to effect of time of application and recorded highest for treatment A_7 (73.19 cm). It was also significant due to concentration levels of SA and recorded highest significant in treatment B_4 (71.10 cm). The treatment recommended dose C_1 also recorded significant (71.97 cm) over the control C_2 (51.26 cm). The interactions effect was non-significant and treatment A_7B_4 recorded the maximum (75.40 cm) followed by A_7B_3 (73.74 cm).

The plant height was significantly influenced by time of application, concentrations and interactions except late *kharif* 2016. The application of different concentration of salicylic acid exerted a significantly increase in plant height. It might be due to balancing of internal level of natural auxins through salicylic acid which is responsible for proper physiological activities in the plant system which response significantly better growth and ultimately improve plant height.

The high concentration of salicylic acid (SA), A_7B_4 recorded maximum plant height which was significantly superior. These findings are close relevant with the result of Nangare *et al*. (2017) [23], Amin *et al.* (2007) [1] Pradhan *et al.* (2014) [26] and Prajapati *et al*. (2016) [28] in onion; Kopad *et al*. (2017) [18]; Jeyakumar *et al.* (2008) [14] in black gram. (13.42). It was significant due to concentration levels of SA and recorded significant in treatment B_4 (12.64). The treatment recommended dose C_1 also found significant (13.56) over the control C_2 (9.03). The interactions effects were non-significant. The combination A_7B_4 recorded the maximum (13.98) followed by combination A_7B_3 (13.84), A_6B_4 (13.75) and A_4B_4 (13.71).

The number of leaves recorded for late *kharif* season 2016 was statistically significant due to effect of time of application and recorded highest in treatment A_7 (13.12). The number of leaves found significant due to concentration levels of SA in treatment B_4 (12.27). The treatment recommended dose C_1 also found significant number of leaves (12.92) over the control. The interactions effect were non-significant and combination A_7B_4 (13.86) recorded the maximum number of leaves per plant followed by A_4B_4 (13.68).

The number of leaves per plant increased up to 100 days and stopped thereafter due to maturity. Onion leaves possesses a uniseriate epidermis with thickened outer wall adcrusted with the cuticular layer. Peridinal division and enlargement of central cell in leaf axis in combination with adaxial meristematic activity contributes to the increase in thickness in the central portion of the leaf leads to increase in number of leaves (Jones and Mann, 1963) [15]. The exogenous application of SA had effect on increased photosynthetic activity and cell division which enhances the number of leaves per plant. (Gharib, 2006) [10].

Neck thickness rapidly reduced 90 days after transplanting in onion due to maturity (Shashikumar and Shashidhar, 2015) [32].

The concentration of salicylic acid in treatment A_1 (1st spray @ 250 mg/l and 2nd spray @100 mg/l) recorded maximum which was significantly higher than all the SA treatments. These finding are close agreement with Prajapati *et al.* (2016) [28], Kopad *et al*. (2017) [18], Nangare *et al*. (2017) [23] and Dixit *et al*., (2018) [5] in onion.

Neck thickness (cm)

The neck thickness recorded for late *kharif* season 2016 was statistically significant due to effect of time of application and recorded lowest for treatment A_7 (1.06 cm). It was significant due to concentration levels of SA and recorded minimum in

treatment B_4 (1.09 cm). The treatment recommended dose C_1 also found significant lowest (1.22 cm) over the control C_2 (1.36 cm). The interactions effect were non-significant and treatment A_7B_3 recorded the minimum (1.01 cm) followed by A_6B_4 (1.03 cm).

Further, SA at more times of spraying showed significant effect than less number of spraying. The present study clearly also indicated the beneficial impact of SA on crop growth, which might be due to the involvement SA in regulation of several physiological processes in plants such as stomata closure, ion uptake, inhibition of biosynthesis and transpiration (Khan *et al*., 2003 and Shakirova *et al*., 2003) [31].

SA had also prolific effects on both morphology and physiology of plants (Piperpoint, 1996). Increased plant height of onion with exogenous application of SA might be due to directly or indirectly influences on the activity of certain enzymes such as Sucrose –P- Synthase, Sucrose Synthase and amylases. These metabolic affect such as changing carbohydrate metabolism in plants, so that soluble sugars, especially non- reducing sugars accumulated to function on osmotic regulators. Additionally, the accumulated reducing sugars (glucose and fructose) could be used the initial precursors for the synthesis of other osmolytes such as proline and polyamines (Tari *et al*., 2004; Szepsi *et al*., 2009) [35,]. Exogenous application of SA had effect on increased photosynthetic activity which enhances the number of leaves plant-1 and chlorophyll content, there by plant height (Gharib, 2006) [10]. Similar report on beneficial effects of SA on vegetative growth in form of plant height, number of leaves per plant, chlorophyll content of leaves have also been reported by Amin *et al*. (2007) [1] and Dixit *et al*., (2018) [5] in onion; and in several crops by El- Tayeb (2005) [8] in chilli; Elshraiy and Hegazi (2009) [7] in pea; Gawade and Sirohi (2011) [9] in brinjal.

Yield and quality parameters

Equatorial diameter of bulb (cm)

The equatorial diameter of bulb recorded for late *kharif* season 2016 and recorded highest for treatment A_7 (5.05 cm). The equatorial diameter of bulb found significant due to concentration levels of SA (B) and recorded highest in treatment B_4 (5.11 cm). The treatment recommended dose C_1 also found significant (4.77 cm) over the control C_2 (4.20 cm). The interactions effect were non-significant and treatment A_7B_3 recorded the highest (5.32 cm) followed by A_7B_4 (5.18 cm).

The interactions effect were non-significant and highest equatorial diameter of bulb recorded in combination A_7B_3 (5.64 cm) followed by treatment A_4B_4 (5.43 cm) and A_7B_4 (5.16 cm). The treatment recommended dose C_1 found non-significant equatorial diameter of bulb (4.32cm) over the control C_2 (3.93 cm).

Polar diameter of bulb (cm)

The polar diameter of bulb recorded for late *kharif* season 2016 was statistically significant due to effect of time of application and recorded highest for treatment A_7 (5.09 cm). The polar diameter of bulb found significant due to concentration levels of SA and recorded highest in treatment B_4 (5.16 cm) The treatment recommended dose C_1 also found significant polar diameter of bulb (4.32 cm) over the control C_2 (3.80 cm). The interactions effect were non-significant in treatment combination A_7B_4 recorded the highest (5.77 cm).

The results of significant increased in polar and equatorial diameter may be due to better photosynthesis efficacy with SA application and increased chlorophyll content of leaves (Amin *et al.* 2007) [1]. The better efficiency of SA increasing the effective photosynthetic area in terms of plant height, number of leaves per plant significantly enhance the assimilation of photosynthates in the bulb. Due to increased deposition of photosynthes in the scales of each bulb, the diameter was found increased due to application of SA as compare to recommended dose and control. It resulted higher values of polar and equatorial diameter in onion bulbs.

The comparatively significant increase in height, number of leaves and photosynthetic pigments due to effect salicylic acid at different time of application might have helped to accumulate more carbohydrates resulting in increased bulb diameter because bulb is storage organ in onion Salicylic acid application drastically increases bulb diameter in case of onion. The SA application increased diameter in onion was due to increased deposition of photosynthtes in scale of onion. This might be due to external application of SA as foliar spray and that leads to more thickness of scales in bulbs and thereby increasing the diameter of onion bulb as compare to control. These findings are close agreement with Ibrahim and Sanna (2005) [13], Amin *et al.* (2007) [1], Prajapati *et al.* (2016) [28], Pradhan *et al.* (2016) [27], Nangare *et al.* (2017) [23], Kopad *et al.* (2017) [18] and Dixit *et al.*, (2018) [5] in onion. Bideshki and Arvin (2010) [2], Meena *et al.* (2016) [21] in garlic where the clove diameters was increased due to SA application was reported.

Average weight of bulb (g)

The weight of bulb found significant due to time of application for late *kharif* season 2016 and recorded highest in treatment A_7 (105.90 g). The weight of bulb found significant due to concentration levels of SA and recorded highest in treatment B_4(103.82 g). The treatment recommended dose C_1 also recorded significant (87.56 g) over the control C_2 (63.78 g). The interactions effect were non-significant in treatment A_7B_4 recorded (115.50 g) followed by A_7B_3 (111.25 g).

The increased bulb weight in the present study by application of salicylic acid might be due to the better utilization of photosynthetic pigment and increased allocation of photosynthetic pigment towards the bulb. The average of bulb might be increased due to increased polar diameters of bulb and that leaves to increased weight of bulb as compare to control due application of SA to onion. These results are in close agreement with Amin *et al.* (2007) [1], Pradhan *et al.* (2016) [27] and Prajapati *et al.* (2016) [28], Nangare *et al.* (2017) [23], Kopad *et al.* (2017) [18] and Dixit *et al.*, (2018) [5] in onion.

Table 1: Effect of salicylic acid on plant height (cm), Neck thickness (cm), Equatorial diameter of bulb (cm), Polar diameter of bulb (cm), Average weight of bulb (g), Total bulb yield (kg/plot), Total bulb yield (t/ha) and Marketable bulb yield (t/ha) late *kharif* 2016.

Treatment	PH	NOL	NT	ED	PD	AWB	TBYP	TBY	MBY
A_1	64.49	11.10	1.16	4.82	4.77	86.23	14.51	24.18	21.63
A_2	66.21	11.01	1.24	4.87	4.72	85.83	14.64	24.39	21.73
A_3	64.46	10.54	1.32	4.69	4.63	81.83	13.24	22.06	19.31
A_4	67.96	12.98	1.06	4.84	4.84	103.93	18.01	30.00	27.76
A_5	67.35	12.27	1.17	4.73	4.76	97.44	16.56	27.59	25.32
A_6	71.89	12.44	1.16	4.71	4.69	101.91	17.62	29.35	26.72
A_7	73.19	13.12	1.06	5.05	5.09	105.90	19.71	32.84	30.19
S.E. (±)	0.90	0.28	0.02	0.09	0.07	1.44	0.19	0.31	0.31
CD at 5%	2.60	0.81	0.07	NS	0.20	4.16	0.55	0.91	0.90
B_1	63.48	11.56	1.24	4.50	4.39	86.55	15.52	25.85	22.97
B_2	67.34	11.61	1.20	4.67	4.67	89.50	16.03	26.71	23.99
B_3	69.82	12.25	1.14	4.97	4.93	99.02	16.40	27.32	24.96
B_4	71.10	12.27	1.09	5.11	5.16	103.82	17.36	28.92	26.73
S.E. (±)	0.68	0.21	0.02	0.07	0.05	1.09	0.14	0.24	0.24
CD at 5%	1.97	0.61	0.05	0.19	0.15	3.14	0.41	0.69	0.68
A_1B_1	56.10	10.75	1.25	4.60	4.31	74.33	14.11	23.50	20.54
A_1B_2	64.03	10.86	1.16	4.59	4.59	78.00	14.80	24.65	21.73
A_1B_3	68.48	11.76	1.17	4.99	4.99	94.48	14.57	24.28	21.92
A_1B_4	69.37	11.05	1.05	5.09	5.20	98.10	14.57	24.28	22.32
A_2B_1	62.40	10.81	1.30	4.65	4.29	72.89	13.84	23.06	20.07
A_2B_2	65.86	10.85	1.26	4.67	4.57	83.21	14.62	24.35	21.53
A_2B_3	67.82	10.99	1.23	5.02	4.94	89.32	14.94	24.89	22.31
A_2B_4	68.79	11.39	1.20	5.15	5.09	97.93	15.17	25.28	23.01
A_3B_1	58.67	10.00	1.35	4.43	4.20	78.58	12.45	20.75	17.60
A_3B_2	62.40	10.74	1.33	4.50	4.78	79.85	13.09	21.80	18.84
A_3B_3	66.94	10.87	1.31	4.78	4.50	82.75	13.47	22.44	19.80
A_3B_4	69.82	10.55	1.29	5.05	5.05	86.15	13.95	23.24	20.99
A_4B_1	58.67	13.02	1.17	4.68	4.68	95.33	16.27	27.11	24.52
A_4B_2	68.35	12.14	1.12	4.70	4.70	103.50	17.78	29.62	27.22
A_4B_3	71.89	13.10	1.03	4.82	4.82	106.63	17.82	29.68	27.68
A_4B_4	72.95	13.68	0.92	5.16	5.16	110.25	20.16	33.59	31.60
A_5B_1	65.86	11.60	1.31	4.49	4.56	85.35	15.97	26.61	24.11
A_5B_2	66.94	12.07	1.20	4.54	4.49	92.77	16.11	26.84	24.56
A_5B_3	67.82	13.13	1.11	4.83	5.16	101.64	16.65	27.73	25.59
A_5B_4	68.79	12.26	1.07	5.06	4.84	110.00	17.51	29.16	27.01
A_6B_1	71.11	12.44	1.24	4.06	4.06	97.38	17.43	29.04	26.13
A_6B_2	71.77	11.72	1.26	4.65	4.65	94.35	17.18	28.62	25.89
A_6B_3	72.10	12.47	1.11	5.08	5.03	107.11	17.31	28.83	26.30
A_6B_4	72.59	13.13	1.03	5.08	5.05	108.82	18.56	30.93	28.56
A_7B_1	71.58	12.33	1.10	4.63	4.63	102.00	18.55	30.90	27.81
A_7B_2	72.04	12.88	1.06	5.09	4.91	94.85	18.68	31.11	28.18
A_7B_3	73.74	13.44	1.01	5.32	5.08	111.25	20.06	33.42	31.15
A_7B_4	75.40	13.86	1.07	5.18	5.77	115.50	21.57	35.94	33.61
S.E. (±)	1.80	0.56	0.05	0.17	0.14	2.88	0.38	0.63	0.63
CD at 5%	NS	NS	NS	NS	NS	NS	1.09	1.82	1.81
C_1	71.97	12.92	1.22	4.77	4.32	87.56	18.36	30.59	27.66
C_2	51.26	10.10	1.36	4.20	3.80	63.78	12.32	20.52	17.23
S.E. (±)	1.80	0.56	0.05	0.17	0.14	2.88	0.38	0.63	0.63
CD at 5%	5.20	1.62	0.14	0.50	0.41	8.32	1.09	1.82	1.81

Total bulb yield (kg/plot)

The data regarding to total bulb yield as influenced by time of application, different concentration levels of salicylic acid and recommended dose C_1 treatments were recorded for late *kharif* season of 2016 was presented in Table 4.1.

The total bulb yield recorded for late *kharif* season 2016 and recorded highest in treatment A_7 (19.71 kg/plot). The total bulb yield found significant due to concentration levels of SA (B) and recorded highest in treatment B_4 (17.36 kg/plot). The treatment recommended dose C_1 also recorded significant (18.36 kg/plot) over the control C_2 (12.32 kg/plot). The interactions effects were also found significant and treatment A_7B_4 recorded the highest (21.57 kg/plot).

Better efficacy of SA in garlic for increasing yield was also reported by Bideshki and Arvin (2010) [2]. Report on application of SA with increased final yield in Safflower also been reported by Zeid *et al.* (2009) [38], Hayat and Ahmad, (2007) [11], which might be due to accumulation of more chlorophyll content in SA treated plants, responsible for the improved fresh and dry matter accumulation there by final bulb yield (Bideshki and Arvin, 2010) [2].

Total bulb yield (t/ha)

The total bulb yield recorded for late *kharif* season 2016 and recorded highest in treatment A_7 (32.84 t/ha). The total bulb yield found significant due to concentration levels of SA (B)

and recorded highest in treatment B_4 (28.92 t/ha). The treatment recommended dose C_1 also recorded significant (30.59 t/ha) over the control C_2 (20.52 t/ha). The interactions effect were also found significant in combination A_7B_4 recorded (35.94 t/ha) at par with combination A_7B_3 (33.42 t/ha).

Marketable bulb yield (t/ha)

The marketable bulb yield found significant for late *kharif* season 2016 and recorded highest for treatment A_7 (30.19 t/ha). The marketable bulb yield found significant due to concentration levels of SA (B) and recorded highest in treatment B_4 (26.73 t/ha). The treatment recommended dose C_1 also recorded significant (27.66 t/ha) over the control C_2 (17.23 t/ha). The interactions effect were also found significant and treatment A_7B_4 recorded the highest (33.61 t/ha).

The increase in yield could be due to enhanced assimilation of nutrient uptake, better photosynthetic pigments and increased cell integrity which may contribute to increased plant height, number of leaves, bulb diameter and weight of bulb ultimately enhance the yield. The total yield in onion in increased as compare to control due to application of SA as foliar spry on leaves of onion. The deposited photosynthtes was responsible for increased average weight of bulb and also polar and equatorial diameter of bulb that leads to be increased total yield in onion as compared to control. Thus the SA application is beneficial to onion crop. These findings was also supported by various scientist *viz*., Ibrahim and Sanna (2005) [13], Amin *et al*., (2007) [1], Prajapati *et al.* (2016) [28], Pradhan *et al.* (2016) [27] and Nangare (2017) [23] and Dixit *et al.*, (2018) [5] in onion. Similar results were also reported in garlic crop by Bideshki and Arvin (2010) [2], Meena *et al.* (2016) [21] in garlic. The increased weight in tomato fruit were also reported by Yildirim and Dursun (2009) [37].

Marketable yield depends upon how much less losses in total yield were observed due to premature bolting, twin bulb, rotten bulb and undersized bulb. Apart from total yield the marketable bulb yield is the most vital character on which income is mainly dependent. The higher marketable bulb in salicylic acid treated plot than the water spray might be due to lower percentage of premature bolters, doubles, rotten bulbs and undersized bulbs. Salicylic acid treatment gives higher marketable yield, these findings are closely related with Amin *et al.* (2007) [1] and Prajapati *et al.* (2016) [28] and Pradhan *et al.* (2016) [27] Nangare *et al.* (2017) [23] and Dixit *et al.*, (2018) [5] in onion, Bideshki and Arvin (2010) [2] and Meena *et al.* (2016) [21] in garlic

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