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Original Research Article

Effect of Salicylic Acid on Growth, Yield and Storage Quality of Onion (*Allium cepa* L.)

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A B S T R A C T

In order to study the effect of salicylic acid on yield and quality of onion, an experiment was carried out based on randomized blocks design (RBD) with four replications at the Department of Vegetable Crops, Horticulture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during the three consecutive season of 2012-2013, 2013- 2014 and 2014- 2015. Foliar application of Salicylic acid (AR grade) at the rate of 250 mg / lit of water at different days intervals were used to study difference in plant height (cm), number of leaves, neck thickness, polar diameter (cm), equatorial diameter (cm), average bulb weight (g), percentage of A grade bulb (above 5.5 cm), B grade bulb (4.5 to 5.5 cm), C grade bulb (3.5 to 4.5 cm), % of doubles, total yield (t/ha) and marketable yield (t/ha) of onion. The result showed that significant increases in vegetative growth and yield of onion were observed due to the application of salicylic acid. Foliar application of salicylic acid at 30 days after sowing (DAS), II spray at 30 days after transplanting (30 DAT) and III spray at 45 days after transplanting (DAT) recorded significant increase in most growth and yield characters *viz.*, plant height (62.7 cm), number of leaves/plant (11.6), neck thickness (8.62 mm), polar diameter (6.69 cm), equatorial diameter (4.33 cm), total yield (26.5 t/ha) and marketable yield (24.7 t/ha) with 36.5 % of A grade bulb and total dry matter content (5.52 t/ha) compared to other treatments. The least percentage of doubles (0.74%) and total storage loss (22.2 %) was also observed in the aforementioned treatment. These results suggest that foliar application of salicylic acid may improve the growth and yield of onion.

Keywords

Onion, Growth, yield; salicylic acid (SA)

Introduction

Onion (*Allium cepa* L.) is one of the important commercial vegetable crops grown in India and being used as vegetables, spices or as medicines. India is the second largest producer of onion, the first being China. The total annual production in India is 18.73 million tonnes from an area of 0.88 million hectares and the productivity is 21.2 t/ha (Anon., 2015-16). The major onion growing states of India are Maharashtra, Bihar, Karnataka, Gujarat, Andhra Pradesh, Uttar Pradesh, Orissa and Madhya Pradesh. It is an export oriented crop earning valuable foreign exchange to the country. In the year 2013-14, India exported about 1482498.58 metric tonnes of fresh onion fetching about Rs. 316961.25 lakhs besides meeting the demand for internal consumption.

Salicylic acid (SA) or ortho-hydroxy benzoic acid is a common plant-produced phenolic compound. It is an endogenous growth regulator, which contributes in the regulation of physiological, biochemical and molecular processes and there and therefore it affects the plant growth, development and productivity (Hayat *et al.,* 2010). Numerous studies have documented the influence of endo- and exogenous SA on stomata closure (Saaverda, 1979), ion uptake and transport (Khadiga and Bebars, 1993), inhibition of ethylene biosynthesis, transpiration and stress tolerance (Waseem *et al.,* 2006), photosynthetic pigments in leaves (Yildirim *et al.,* 2008), plant photosynthesis (Fariduddin *et al.,* 2003) and on nitrogen metabolism owing to SA producing a positive impact on the activity of nitrate reductase (Fariduddin *et al.,* 2003), synthesis of secondary plant metabolites and on antioxidant activity (Eraslan *et al.,* 2007) or the improved plant tolerance to heavy metals (Guo *et al.,* 2009; Popova *et al.,* 2008).

Eraslan *et al.,* (2007) also reported that exogenous application of salicylic acid, enhanced growth, physiological process and antioxidant activity of carrot plants grown under salinity stress. However, higher concentrations of salicylic acid had an inhibitory effect. Salicylic acid has been reported to induce flowering in a number of plants. Different plant species including ornamental plant *Sinningia speciosa* flowered much earlier as compared to the untreated control, when they received an exogenous foliar spray of salicylic acid (Martin *et al.,* 2005).

In cucumber and tomato, the fruit yield enhanced significantly when the plants were sprayed with lower concentrations of salicylic acid (Larque and Martin, 2007; Javaheri *et al.,* 2012). The results of previous studies showed that production of soluble carbohydrates, sugars and secondary metabolites enhanced in plants exposed to SA. Shraiy and Hegazi (2005) reported positive effects of SA application were correlated with significant increase in total soluble proteins, phenol, total soluble carbohydrates and sugars in pea (*Pisum Sativum* L.) seeds. Keeping the foregoing point in view, a field experiment was conducted to observe and determine the effect of Salicylic acid (SA) on growth and yield of onion.

Materials and Methods

An experiment was undertaken to study the effect of Salicylic acid (SA) on Onion variety Agri found Light Red during three consecutive years of 2012-2013, 2013- 2014 and 2014- 2015 in rabi season at the College Orchard, Department of Vegetable Crops, Horticulture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore (11^0 N latitude, 77^0 E longitudes and an altitude of 426.26 m above mean sea level). The experiment was laid out in a Randomized Block Design with four replications.

The seeds of Agri found Light Red were sown in early September to raise seedlings for transplanting. 45-50 days old seedlings were transplanted in the plots of 12 x 1 m at 45 cm apart. Recommended package of practices were carried out as per the suggestion given in the crop production guide (Anon, 2013). Salicylic acid (AR grade) at the rate of 250 mg / lit of water were given as foliar spray at different days intervals.

Ten plants from each plot were selected randomly and tagged for recording observations. The growth parameters *viz.,* plant height (cm) and number of leaves were recorded 45 days after transplanting. At

harvest time (120 days after transplanting), ten bulbs were chosen at random from every plot and the following data were recorded; neck thickness, polar diameter (cm), equatorial diameter (cm), average bulb weight (g).

The percentage of A grade bulb (above 5.5 cm), B grade bulb (4.5 to 5.5 cm), C grade bulb (3.5 to 4.5 cm), % of doubles, total yield (t/ha), marketable yield (t/ha), total dry matter content and total storage loss were recorded at the end of the harvest. The data for all characters were analyzed using the analysis of variance procedure suggested by Panse and Sukatme (1989).

The treatment details are

T_1 : Foliar application of Salicylic Acid at 30 DAS & II spray at 30 DAT
T_2 : Foliar application of Salicylic Acid at 30 DAS & II spray at 45 DAT
T_3 : Foliar application of Salicylic Acid at 30 DAS & II spray at 60 DAT
T_4 : Foliar application of Salicylic Acid at 30 DAS, II spray at 30 DAT & III spray at 45 DAT
T_5 : Foliar application of Salicylic Acid at 30 DAS, II spray at 30 DAT & III spray at 60 DAT

T_6 : Control

* DAS days after sowing; *DAT days after transplanting

Results and Discussion

The results of the preset study showed that foliar application of salicylic acid significantly affected the growth of onion. The effect of salicylic acid on the growth, yield and storage components were described hereunder.

Data presented in the Table 1 indicated that plant height was significantly increased due to foliar application of salicylic acid (SA). Among the treatment components, foliar application of salicylic acid at 30 days after sowing (DAS), II spray at 30 days after transplanting (30 DAT) and III spray at 45 days after transplanting (DAT) recorded the highest plant height of 58.1cm in 2012-13, 58.0 cm in 2013-14 and 59.2 cm in 2014-15 along with pooled mean value of 62.7 cm followed by foliar application of salicylic Acid at 30 days after sowing (DAS) and II spray at 45 days after transplanting (DAT) which recorded the plant height of 55.1 cm in 2012-13, 55.2 cm in 2013-14 and 2014-15 along with pooled mean value of 59.8 cm respectively (Table 1). This increase might be due to stimulating dry mass production through enhancement of cell division and cell enlargement (Hayat *et al.*, 2005) and chlorophyll accumulation which reflected on vegetative growth of onion plants. According to Shakirova *et al.*, (2003), the positive effect of salicylic acid on growth and yield can be due to its influence on other plant hormones.

Salicylic acid altered the auxin, cytokinin and ABA balances in wheat and increased the growth and yield under both normal and saline conditions. These results are in agreement with Bideshki and Arvin (2010).

Onion leaves are storage organ of the food materials and it get translocated into the bulbs at the time of maturity. Hence the number of leaves play a major role in bulb yield and quality. In the present study, number of leaves per plant varied significantly among the treatments in three seasons (Table 1).

Table.1 Effect of salicylic acid on growth and yield related character of onion (2012-13, 2013-14, and 2014-15)

Treatment	Plant height (cm)				No. of leaves / plant				Neck thickness (mm)				Polar diameter(cm)			
	2012-13	2013-14	2014-15	Pooled	2012-13	2013-14	2014-15	Pooled	2012-13	2013-14	2014-15	Pooled	2012-13	2013-14	2014-15	Pooled
T_1	54.4	54.5	56.9	59.3	9.33	9.50	9.25	10.4	5.70	9.52	9.43	8.21	6.06	6.05	6.28	6.13
T_2	55.1	55.2	55.2	59.8	10.0	10.0	9.60	10.9	5.42	9.29	9.08	7.93	6.35	6.40	6.54	6.43
T_3	52.6	53.1	51.7	56.4	9.00	8.90	9.10	10.0	5.77	9.78	9.65	8.40	6.14	6.24	5.98	6.12
T_4	58.1	58.0	59.2	62.7	10.3	10.4	10.8	11.6	5.29	8.93	8.55	7.59	6.55	6.58	6.96	6.69
T_5	51.7	51.9	53.6	56.3	9.00	9.00	8.60	9.89	5.83	9.99	10.05	8.62	6.30	6.34	6.14	6.26
T_6	53.7	53.9	52.9	57.5	9.67	9.60	9.80	10.7	5.30	9.18	9.36	7.94	5.94	5.95	5.88	5.92
SE.d	0.66	0.75	0.35	0.22	0.31	0.28	0.09	0.05	0.33	0.28	0.06	0.06	0.08	0.03	0.05	0.04
CD : P=05	1.32	1.6	0.76	0.45	0.63	0.60	0.20	0.09	0.67	0.60	0.14	0.13	0.17	0.06	0.10	0.09
CV (%)		7.3	10.9	3.89		4.23	7.44	4.93	5.14	4.23	8.00	0.97	3.81	4.59	10.1	0.93

Table.2 Effect of salicylic acid on yield and yield contributing character of onion (2012-2013, 2013-2014, 2014-2015)

Treatment	Equatorial diameter (cm)				A grade bulb (%)				B grade bulb (%)				C grade bulb (%)			
	2012-13	2013-14	2014-15	Pooled	2012-13	2013-14	2014-15	Pooled	2012-13	2013-14	2014-15	Pooled	2012-13	2013-14	2014-15	Pooled
T_1	4.02	3.98	4.18	4.06	28.7	27.0	23.8	26.5	36.5	37.5	39.66	37.8	33.6	31.2	36.45	33.7
T_2	4.15	4.13	4.72	4.33	31.0	31.0	25.6	29.2	40.2	40.6	44.25	41.6	28.6	24.0	30.1	27.5
T_3	4.05	4.03	3.98	4.02	32.0	32.9	23.1	29.3	44.3	42.7	28.65	38.5	23.6	20.2	48.2	30.6
T_4	4.30	4.31	4.26	4.29	41.0	38.0	30.6	36.5	32.2	33.5	23.13	29.6	25.7	23.5	46.22	31.8
T_5	4.10	3.98	4.01	4.03	24.3	26.0	25.9	25.4	32.5	32.4	38.97	34.6	42.1	37.9	35.05	38.3
T_6	3.80	3.97	4.12	3.96	25.1	26.6	25.2	25.6	44.2	42.2	46.11	44.1	29.6	26.9	28.64	28.3
SE.d	0.08	0.10	0.03	0.03	1.52	1.44	0.33	0.76	1.70	1.75	0.27	1.07	1.32	1.47	1.05	1.15
CD : P=05	0.16	0.21	0.07	0.06	3.13	3.07	0.72	1.55	3.66	3.74	0.57	2.20	2.97	3.14	2.23	2.36
CV (%)	6.28	7.90	6.17	0.94	7.04	6.75	6.86	3.24	7.12	6.52	7.68	3.49	5.10	7.63	6.97	4.46

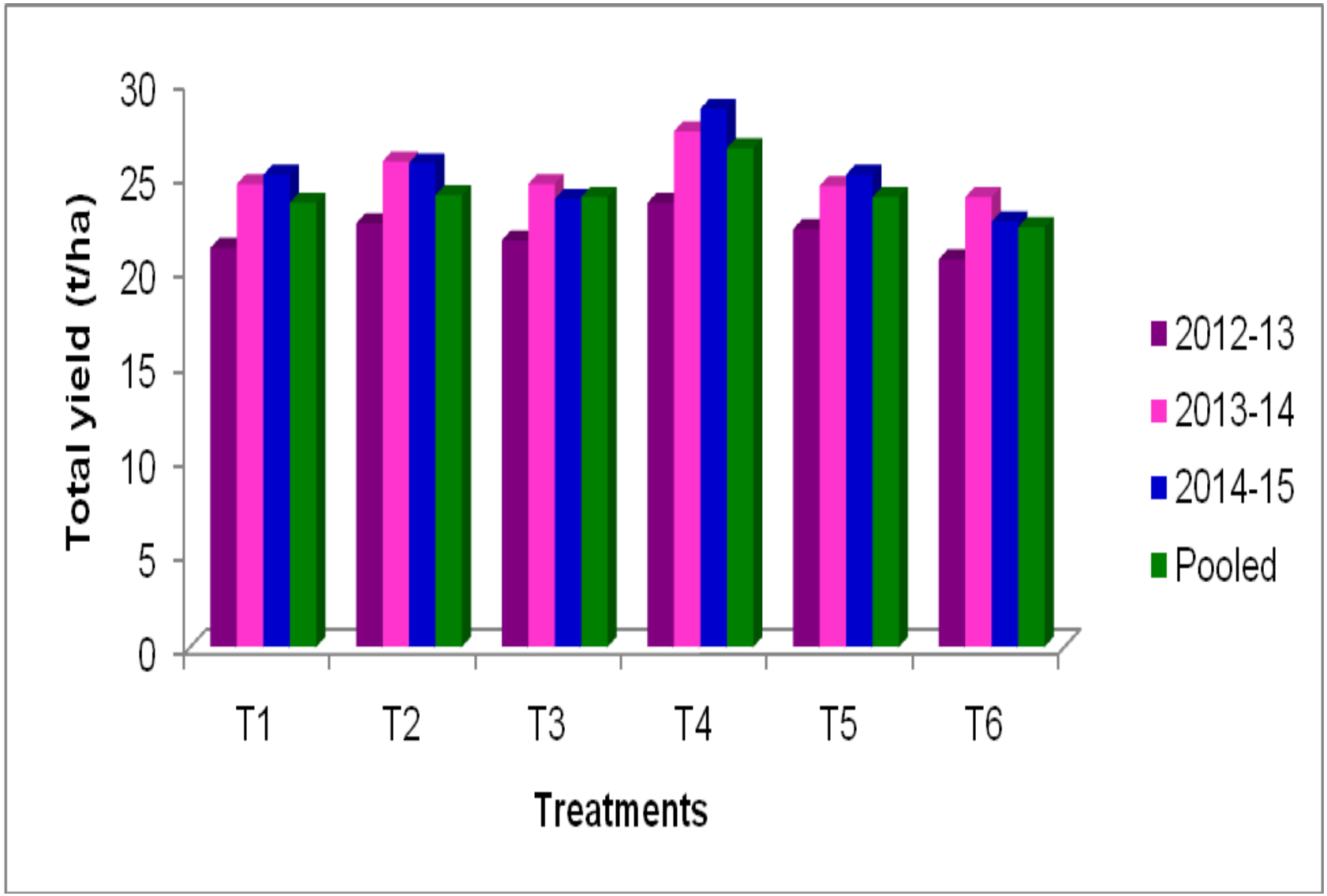
Table.3 Effect of salicylic acid on Doubles (%), total yield (t/ha) and marketable yield (t/ha) of onion (2012-13, 2013-14, 2014-15)

Treatment	Doubles (%)				Total yield (t/ha)				Marketable yield (t/ha)			
	2012-13	2013-14	2014-15	Pooled	2012-13	2013-14	2014-15	Pooled	2012-13	2013-14	2014-15	Pooled
T_1	1.2	2.40	1.63	1.35	21.2	24.6	25.1	23.6	19.9	23.6	22.9	22.5
T_2	0.8	1.30	2.55	2.01	22.5	25.8	25.7	24.0	20.5	24.7	24.0	22.7
T_3	1.0	1.50	1.68	1.09	21.6	24.6	23.8	23.9	19	23.5	23.9	22.1
T_4	0.6	1.24	1.40	0.97	23.6	27.4	28.6	26.5	21.2	26.0	27.0	24.7
T_5	1.4	1.60	1.46	1.38	22.2	24.5	25.1	23.9	20	23.6	23.8	22.4
T_6	1.0	1.90	1.42	1.43	20.6	23.9	22.6	22.3	19	22.9	21.1	21.0
SE.d	NS	NS	NS	NS	0.65	0.79	0.26	0.24	0.62	0.80	0.24	0.22
CD : P=05					1.30	1.69	0.55	0.50	1.24	1.71	0.52	0.45
CV (%)					4.45	6.49	7.46	1.25	4.82	6.73	8.77	1.21

Table.4 Effect of salicylic acid on total dry matter (t/ha) and total storage loss (%) of onion (2012-13, 2013-14, 2014-15)

Treatment	Total dry matter (t/ha)				Total storage loss (%)			
	2012-13	2013-14	2014-15	Pooled	2012-13	2013-14	2014-15	Pooled
T_1	3.18	4.74	4.92	4.81	25.7	23.8	20.2	22.9
T_2	3.62	5.20	5.10	5.24	25.3	27.3	26.9	24.1
T_3	3.50	5.10	4.38	5.40	27.2	25.3	24.1	25.4
T_4	3.74	5.64	5.86	5.52	23.4	20.4	19.8	22.2
T_5	3.00	4.44	5.34	4.60	26.5	24.3	21.9	23.7
T_6	3.50	4.68	4.77	4.51	29.0	26.8	24.3	25.4
SE.d	0.45	0.92	0.36	0.31	0.68	0.65	0.44	0.23
CD : P=05	2.10	1.16	0.63	0.65	1.28	1.31	0.89	0.56
CV (%)	4.31	5.39	5.62	4.32	5.62	6.32	5.11	4.98

Fig.1 Effect of salicylic acid on total yield (t/ha) of onion



The highest number of leaves per plant (10.30 in 2012-13, 10.4 in 2013-14 and 10.8 in 2014-15 was observed in foliar application of salicylic acid at 30 days after sowing (DAS), II spray at 30 days after transplanting (30 DAT) and III spray at 45 days after transplanting (DAT). Amin *et al.*, (2007) reported that foliar application of salicylic acid at the lower and the moderate concentrations (50 and 100 mg/l) significantly increased the number of leaves per plant in onion. Similar results were also reported by Gutierrez-Coronado *et al.*, (1998) and Shehata *et al.,* (2001) in maize and Iqbal and Ashraf (2006) in soy bean.

The yield and yield components *viz.,* neck thickness, polar and equatorial diameter of the bulb was significantly affected by foliar application of salicylic acid in three consecutive seasons (Table 1& 2). The bulbs with less neck thickness fetch premium price in the market. Among the treatment combination, spraying of salicylic acid at 30 days after sowing (DAS), II spray at 30 days after transplanting (30 DAT) and III spray at 45 days after transplanting (DAT) recorded the lowest values (5.29 mm in 2012-13, 8.93 mm in 2013-14 and 8.55 mm in 2014-15) in all the three seasons for the same.

Foliar application of salicylic acid at 30 days after sowing (DAS), II spray at 30 days after transplanting (30 DAT) and III spray at 45 days after transplanting (DAT) recorded the highest value for polar diameter (6.55 cm in 2012-13, 6.58 cm in 2013-14 and 6.96 cm in 2014-15) and equatorial diameter (4.30 cm in 2012-13, 4.31 cm in 2013-14 and 4.26 cm in 2014-15) compared to other treatment combinations and control (Table 1& 2).

Amin *et al.,* (2007) and Bideshki and Arvin (2010) were also observed similar results in onion and garlic respectively.

Grading of bulbs is an important operation to fetch premium prize in the market.

Among the treatment combination, foliar application of salicylic acid at 30 days after sowing (DAS), II spray at 30 days after transplanting (30 DAT) and III spray at 45 days after transplanting recorded 38.0, 30.6 and 36.5 % of A grade bulbs in 2012-13, 2013-14 and 2014-15 respectively.

The percentage of B grade bulbs (32.2% in 2012-13, 33.5 % in 2013-14 and 23.13 % in 2014-15) also high in the aforementioned treatment in all the three seasons (Table 2).

To get high prize in the market, the percentage of double bulbs should be minimum. The lowest per cent of doubles (0.6 % in 2012-13, 1.24 % in 2013-14 and 1.40 % in 2014-15) were observed in T_4 treatment (foliar application of salicylic acid at 30 days after sowing (DAS), II spray at 30 days after transplanting (30 DAT) and III spray at 45 days after transplanting) (Table 3). The maximum significant values for total yield (26.5 t/ha) and marketable yield (24.7 t/ha) were obtained as a result of foliar application of salicylic acid at 30 days after sowing (DAS), II spray at 30 days after transplanting (30 DAT) and III spray at 45 days after transplanting followed by foliar application of salicylic Acid at 30 DAS & II spray at 45 DAT with 24 t/ha of total yield (Figure 1) and 22.7 t/ha of marketable yield compared to other treatments (Table 3).

Amin *et al.,* (2007) and Bideshki and Arvin (2010) were also observed similar results in onion and garlic respectively. Javaheri *et al.,* (2007) also reported that foliar application of salicylic Acid (SA) significantly increased the yield of tomato by increasing the number of bunch per plant.

The storage quality of onion depends on the total dry matter content and total loss by weight at the time of marketing. Foliar application of salicylic acid at 30 days after sowing (DAS), II spray at 30 days after transplanting (30 DAT) and III spray at 45 days after transplanting) recorded the highest dry matter content (3.74, 5.64 and 5.86 t/ha) and least percentage of total loss by weight (23.4, 20.4 and 19.8 %) in three successive seasons respectively (Table 4).

The increase in qualitative parameters of bulb may be due to increased carbohydrates production during photosynthesis.

From the above mentioned results, it could be concluded that foliar application of Salicylic Acid at 30 days after sowing (DAS), II spray at 30 days after transplanting (DAT) and III spray at 45 DAT (days after transplanting) significantly improved the growth and yield parameters of onion.

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