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Studies on effect of foliar application of salicylic acid, azoxystrobin and cycocel on physiological loss in weight and quality traits of onion cv. Arka Kalyan

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Abstract
Onion is a commercial vegetable crop, demands storage to meet off season requirement during which the quality traits were lost in addition to this huge post harvest losses interms of physiological loss in weight, sprouting and rotting are noticed. Thus an attempt has been made at College of Horticulture, Bagalkot, to test efficacy of salicylic acid, azoxystrobin and cycocel on physical and quality traits of onion cv. Arka Kalyan. The experiment was laid out in Randomized Complete Block Design, with 12 treatments and 3 replication. The combined application of chemicals *viz.*, salicylic acid @ 2 mM, azoxystrobin @ 0.1%, at 60 and 90 DAT and CCC @ 2500 ppm at 90 DAT resulted in reduced physiological loss in weight (11.62%) and maximum sensory scores. Application salicylic acid (2 mM) reduced respiration rate of stored onion bulbs and improved quality traits like firmness, moisture and dry matter of stored onion bulbs. The combined application of chemicals was effective in reducing the physiological loss in weight and improving the quality traits in onion cv. Arka Kalyan.

Keywords: onion, cycocel, salicylic acid and azoxystrobin

Introduction
Onion (*Allium cepa* L.) belongs to family Alliaceae which is one of the oldest known vegetables to human beings. It is an important commercial vegetable crop of India contributing great share to the national economy among the horticultural commodities both for internal consumption and export. India is the second largest producer of onion after china with area of 11.67 lakhs ha with production of 202.14 lakhs metric tons and productivity of 17.32 t/ha (Anon., 2016) [1].

It has acquired the status of "queen of the kitchen" due to its versatile usage. It has been used extensively to improve the taste of food and curry as it has special qualities, which add taste and flavour to food. Hence, it is used in all the traditional cooking and culinary preparations. In addition, it is also consumed as salad with meals. Onions are preferred for their green leaves, immature and mature bulbs are either eaten raw or cooked as a vegetable. Mild flavoured or colour ful bulbs are often chosen for salads. The bulbs are used in soups, sauces, condiments, spice, medicine, seasoning of many foods and for the preparation of value added edible products like powder and flakes. 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. The onion bulb contains 88 per cent water. A 100 g edible portion contains energy, 31 cal; protein, 1.5g; fat, 0.6g; total sugar, 7.2g; other carbohydrates, 0.3g; thiamin, 0.04 mg; riboflavin, 0.02 mg ; niacin, 0.1 mg; Vitamin C, 7 mg, 30 mg; Fe, 0.5 mg; Mg, 16.5 mg; K, 150 mg; and Na, 7 mg (Obeng-Ofori *et al*., 2007) [9].

Due to its seasonal nature onion are stored to use them in the off season. During prolonged storage period various quality attributes such as firmness, moisture, dry matter and sensory attributes are negatively affected. On the other hand the harvested bulbs even after harvest possess respiration and transpiration. The increased rate of respiration and transpiration results in physiological loss in weight which affects the profit of the grower/retailers. Thus an attempt is made in the present experiment to know the effect of field application of salicylic acid, azoxystrobin and cycocel on quality traits and physiological loss in weight of the onion bulbs

kept in prolonged storage of 120 days.

Materials and Methods

The present investigation was carried at College of Horticulture, Bagalkot located in the main campus of University of Horticultural Sciences, Bagalkot. The cultivar Arka Kalyan released from IIHR was selected for the study. The seedlings were raised on the raised nursery beds of size 4.0 m x 1 m and are transplanted to the main field of size 1.8 m × 1.8 m with spacing of 10 cm x 15 cm. The experiment was carried using Randomized Complete Block Design, with 12 treatments and 3 replication and the treatments are T_1 as control, SA 2 mM @ 60 + 90 DAT (T_2), seedling dip in SA 2 mM and @ 60 + 90 DAT (T_3), (T_4) azoxystrobin (0.1%) at 60 + 90 DAT, (T_5) SA 2 mM + azoxystrobin 0.1% @ 60 + 90 DAT, seedling dip in SA 2 mM and SA 2 mM and azoxystrobin (0.1%) @ 60 + 90 DAT (T_6), cycocel @ 2500 ppm at 90 DAT (T_7), SA 2 mM @ 60 + 90 DAT and cycocel 2500 ppm @ 90 DAT (T_8), seedling dip in SA 2 mM and @ 60 + 90 DAT and cycocel @ 2500 ppm at 90 DAT (T_9), azoxystrobin @ 0.1% at 60 + 90 DAT followed by cycocel 2500 ppm at 90 DAT (T_{10}), T_{11} (SA @ 2mM and azoxystrobin @ 0.1% at 60 + 90 DAT and cycocel 2500 ppm @ 90 DAT) and (T_{12}) seedling dip in SA 2 mM, SA @ 2mM and azoxystrobin @ 0.1% at 60 + 90 DAT and cycocel 2500 ppm @ 90 DAT.

The bulbs are harvested after 120 DAT at 50 per cent neck fall stage followed by proper curing then are packed in thin gunny bag of size 45 cm x 60 cm and kept under ambient condition for prolonged storage of 120 days. During this period various quality traits like moisture, dry matter, firmness and sensory analysis of the stored onion bulbs was carried out. In addition to this physical parameters like respiration rate and physiological loss in weight were also analysed.

Physiological loss in weight (%): The physiological loss in weight is determined following the procedure adopted by Kukanoor, L., 2005 [5]. The weight of the bulbs was recorded on 30, 60, 90 and 120 days after storage using an electronic balance. The cumulative loss in weight of bulbs was calculated and expressed as per cent physiological loss in weight using the formula given below.

$$\text{Physiological loss in weight (\%)} = \frac{P_0 - P_1 \text{ or } P_2 \text{ or } P_3 \text{ or } P_4}{P_0} \times 100$$

Where,

P_o= initial weight, P_1= weight after 30 days, P_2= weight after 60 days, P_3= weight after 90 days

P_4= weight after 120 days

Respiration rate (ml CO_2/kg/hr): Respiration rate was measured with a CO_2 gas analyzer (Make: Quantek Instruments, Model: 902 D Dual Trak) in static method. The bulbs were weighed and placed in a hermetically sealed container of 1325 ml capacity for 45 minutes. At the end of incubation period, gas sample was drawn from the head space using a gas tight syringe and injected into the CO_2 gas analyzer. The time allowed for change in CO_2 gas concentration in the head space of the sample container was recorded in hour. The respiration rate of the bulbs was calculated using the following formula and expressed as ml CO_2/kg/hr.

$$\text{Respiration rate (\%)} = \frac{CO_2 \text{ concentration x volume of container (ml)}}{100 \text{ x weight of the tissue (kg) x time (g)}} \times 100$$

Moisture content (%): Moisture content was determined using the moisture analyzer (Make: RADWAG Wagi Elektroniczne, Model: MAC 50) which gives the final moisture content in per cent.

Per cent dry matter: The per cent dry matter is determined by following the procedure adopted by Kukanoor, L., 2005. The bulbs were randomly selected from each treatment and cut into small pieces with the help of stainless steel knife. A known weight of the sample was dried in hot air oven at 55°C temperature till a constant weight was obtained. The per cent dry matter is calculated using formula.

$$\text{Per cent dry matter (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

Bulb firmness (N): Bulb firmness was recorded using TA-XT-Plus texture analyser (Stable Micro Systems, London, England). The force required to shear the bulb was recorded and readings were expressed in Newton (N).

Sensory evaluation: Sensory evaluation of bulbs was carried out by a panel of 6 semi-trained judges at monthly intervals from the beginning of storage up to 4 months. The sensory characters *viz*., skin color, texture, flavour and taste and overall acceptability were evaluated using 9 point hedonic scale. The mean of scores given by the judges were used for statistical analysis.

Results and Discussion

Physiological loss in weight (PLW): The pre harvest foliar application of SA, CCC and azoxystrobin significantly affected the PLW of the onion bulbs during prolonged storage of 120 days (Table 1). The bulbs subjected to foliar application of SA (2 mM) and azoxystrobin (0.1%) at 60 + 90 DAT followed by CCC 2500 ppm at 90 DAT (T_{11}) exhibited least PLW (11.62%) which was followed by seedling dip in SA @ 2 mM and SA @ 2 mM and azoxystrobin @ 0.1% at 60 + 90 DAT (12.43%) (T_6) and seedling dip in SA @ 2 mM and SA @ 2 mM, azoxystrobin @ 0.1% at 60 + 90 DAT followed by foliar spray of CCC @ 2500 ppm at 90 DAT (T_{12}) (12.88%) have shown reduction in physiological loss in weight. This might be due to the combined effect of SA, azoxystrobin and CCC. The elicitor molecule SA is an electron donor produces free radical which prevents normal respiration and SA can also decrease respiration rate and bulb weight loss by stoma closing (Freddo *et al*. 2013) [4]. It also decreases the rate of transpiration which is associated with reduction in hydrolytic cell wall enzyme activity which in turn is greatly influenced by SA. Similar results were obtained by Barman and Asrey (2014) [3] in mango and Awad (2013) [2] in peach. Whereas the fungicide azoxystrobin remain effective in controlling the black mould responsible for decay of onion bulbs and the growth retardant CCC which reduces the respiration rate of bulbs, in turn reduces the loss of moisture from the bulbs. This chemical might have helped in modifying the rate of gaseous exchange that takes place through the surface of the bulbs by changing the ratio of carbon dioxide and oxygen inside the bulbs, thus minimising

the respiration and transpiration rate of the bulbs in turn might have reduced the rate of moisture loss and ultimately prevented the loss in weight (Vijayakumar *et al*., 1987) [13]. Similar findings were obtained by Singh and Dhankhar (1995) [11] in onion.

Respiration rate: Pre harvest application of chemicals was significantly affected the respiration rate of the onion bulbs during prolonged storage of 120 days (Table 1). The bulbs imposed with seedling dip in SA @ 2 mM, SA @ 2 mM at 60 + 90 DAT (15.29 ml/CO_2/kg/h) (T_3), seedling dip in SA @ 2 mM, SA @ 2 mM and azoxystrobin @ 0.1% at 60 + 90 DAT (T_6) (15.37 ml/CO_2/kg/h), SA @ 2mM and azoxystrobin @ 0.1% at 60 + 90 DAT followed by CCC @ 2500 ppm at 90 DAT (T_{11}) (15.37 ml/CO_2/kg/h) and seedling dip SA @ 2 mM, SA @ 2 mM at 60 + 90 DAT and CCC @ 2500 ppm at 90 DAT (T_9) (15.38 ml/CO_2/kg/h) have showed relatively reduced respiration rate. From the Table 1 it is clear that treatments containing SA are able to decrease the respiration rate of onions with prolonged storage. The application of SA is well known to reduce the respiration rate in several fruit such as banana and apple (Srivatsava and Dwivedi, 2000; Mo *et al*., 2008) [12, 7]. The SA affects alternative oxidase (AOX) activity leading to decrease in the harmful effects of different post-harvest oxidative stresses such as chilling injury, prevents fermentation and maintains low respiration rates and decreases fruit ripening and senescence rates. Effect of SA in decreasing the respiration rate is mainly due to its negative effects on enzymes like 1-aminocyclopropane-1-carboxylic aid (ACC), 1-aminocyclopropane-1-carboxylate oxidase (ACO), poly galactouranase (PG), pectin methyal estarase (PME), cellulase and antioxidant enzymes leading to decrease in ethylene production and action (Mohammadreza and Morteza, 2010) [8]. Zhang *et al*, 2003 [15] reported a similar effect on kiwi fruit treated with acetyl salicylic acid (ASA).

Moisture content: In general moisture content and drymatter in plant are inversely related higher the quantum of dry matter lesser the quantity of moisture in the bulbs (Lazić *et al*., 2000) [6] which was clear from figure 1. In the present investigation mean moisture content decreased from 84.71 per cent to 80.35 per cent during 120 DAS (Table 2). Among various treatments bulbs subjected to pre-harvest spray of azoxystrobin @ 0.1% at 60 + 90 DAT (T_4) (81.60%), exhibited least moisture content which might be due to the presence of high dry matter content in same treatment.

Dry matter: The mean increase in drymatter content from 15.25 per cent to 19.63 per cent was observed during storage period of 120 days (Table 2). The highest mean drymatter content was noticed in the treatment T_4 (Pre-harvest spray of azoxystrobin @ 0.1% at 60 + 90 DAT) (18.38%) followed by treatment T_9 (Seedling dip in salicylic acid @ 2 mM + Pre-harvest spray of salicylic acid (2 mM) at 60 + 90 DAT and foliar spray CCC 2500 ppm 90 DAT) (17.59%). The increase in dry matter content during the storage period could be attributed to the increase in chemical constituents and also decrease in the moisture content of the bulbs. Reduction in moisture content of the bulb and thereby the hydrolysis of sugar minimises and ultimately resulted in highest dry matter content due to accumulation of more sugar. The results obtained are in agreement with the results obtained by Singh and Dhankar (1995) [11] in onion.

Firmness: The effect of foliar application of salicylic acid, azoxystrobin and cycocel on firmness of the stored onion bulbs cv. Arka Kalyan was significantly affected (Table 2) from 30 days after storage. In the present investigation bulbs imposed with SA @ 2mM, azoxystrobin @ 0.1% at 60 + 90 DAT followed by CCC @ 2500 ppm at 90 DAT (T_{11}) (123.98 N), seedling dip SA @ 2 mM, SA @ 2 mM at 60 + 90 DAT and CCC @ 2500 ppm at 90 DAT (T_9) (122.80 N), seedling dip SA @ 2 mM, SA @ 2 mM and azoxystrobin @ 0.1% at 60 + 90 DAT followed by CCC 2500 ppm at 90 DAT (T_{12}) (122.72 N), seedling dip SA @ 2 mM, SA@ 2 mM at 60 + 90 DAT (T_3) (121.29 N), seedling dip SA @ 2 mM, SA @ 2 mM and azoxystrobin @ 0.1% at 60 + 90 DAT (T_6) (121.84 N), SA @ 2 mM and azoxystrobin @ 0.1% at 60 + 90 DAT (T_5) (121.09 N), SA @ 2 mM at 60 + 90 DAT and cycocel @ 2500 ppm at 90 DAT (T_8) (120.02 N), and SA @ 2 mM at 60 + 90 DAT (T_2) (121.57 N) are the treatments retained the firmness of the stored onion bulbs. From the Table 3 it is clear that treatments containing SA are able to retain bulb firmness with prolonged storage. This may be due to the reduced hydrolysis of soluble starch. SA is well known for retaining the fruit firmness in several crops. It has been demonstrated that SA decreases ethylene production and inhibits cell wall and membrane degrading enzymes such as polygalacturonase (PG), lipoxygenase (LOX), cellulase and pectin methyl esterase (PME) leading to decreasing the fruit softening rate (Srivastava and Dwivedi, 2000) [12] thus maintaining firmness. SA prevents fruit softening according to Srivastava and Dwivedi (2000) [12], Zhang *et al*. (2003) [16] and Wang *et al*. (2006) [15]. The authours found that rapid softening of fruits during ripening was simultaneous with rapid decrease in endogenous SA of fruits. SA affects cell swelling which leads to higher firmness of fruits (Zhang *et al*., 2003 and Shafiee *et al*., 2010) [16, 10].

Sensory evaluation: Sensory evaluation of onion bulbs during prolonged storage of 120 days was done at monthly interval. Bulbs imposed with SA @ 2 mM at 60 + 90 DAT and cycocel @ 2500 ppm at 90 DAT (T_8) (8.08 out of 9) and azoxystrobin @ 0.1% at 60 + 90 DAT and CCC @ 2500 ppm at 90 DAT (T_{10}) (7.95 out of 9) exhibited better colour (Table 4). This might due to the effect of salicylic acid, azoxystrobin and cycocel in retaining the firmness, reducing the water loss and checking growth of pathogenic microorganism thus making bulbs healthier and attractive.

With respect to texture, mean maximum score (Table 4) was recorded by bulbs which are subjected to foliar application of SA @ 2mM, azoxystrobin @ 0.1% at 60 + 90 DAT followed by CCC @ 2500 ppm at 90 DAT (T_{11}) (7.88 out of 9) and SA @ 2 mM at 60 + 90 DAT and cycocel @ 2500 ppm at 90 DAT (T_8) (7.81 out of 9) this may be due to the effect of SA which plays a major role in maintaining the firmness of the fruits by decreasing the ethylene production in most of the crops like apple (Mo *et al*., 2008) [7]. As it reduces senescent changes, which may consequently increase the fruit shelf life.

The intensity of onion flavor can be attributed to genetic, environmental and post-harvest factors (Randle and Lancaster 2002) [5] mean maximum score (Table 5) was recorded by in bulbs which are subjected to foliar application of SA @ 2mM, azoxystrobin @ 0.1% at 60 + 90 DAT followed by CCC @ 2500 ppm at 90 DAT (T_{11}) (7.79) followed by SA @ 2 mM at 60 + 90 DAT and cycocel @ 2500 ppm at 90 DAT (T_8) (7.83 out of 9) are showing best scores for flavour and taste

attributes with prolong storage of 120 days.

Overall acceptability scores reflect better quality retention during storage (Thakur *et al.*, 2012) [13]. Overall acceptability score based on bulb color, flavor, taste and texture decreased during extended storage in all treatments. The maximum score (Table 5) for overall acceptability was obtained Treatments T_{11} (Pre-harvest spray of salicylic acid @ 2 mM and azoxystrobin @ 0.1% at 60 + 90 DAT followed by CCC 2500 ppm foliar spray 90 DAT) (7.90 out of 9) and T_8 (Pre-harvest spray of salicylic acid @ 2 mM at 60 + 90 DAT and foliar spray of CCC 2500 ppm 90 DAT) (7.81 out of 9). Consumer acceptance of any product is determined by sensory attributes perceived by the main senses of human as color, appearance, flavor, taste and texture. The sum of all sensory characters decides the overall acceptability of the product.

Conclusion: From the present investigation it is found that the combined application of salicylic acid, azoxystrobin and cycocel was effective in reducing the respiration rate, physiological loss in weight (PLW). In addition to this pre harvest foliar application of these chemicals also known to affect the quality traits such as moisture, dry matter, bulb firmness and sensory traits of onion cv. Arka Kalyan.

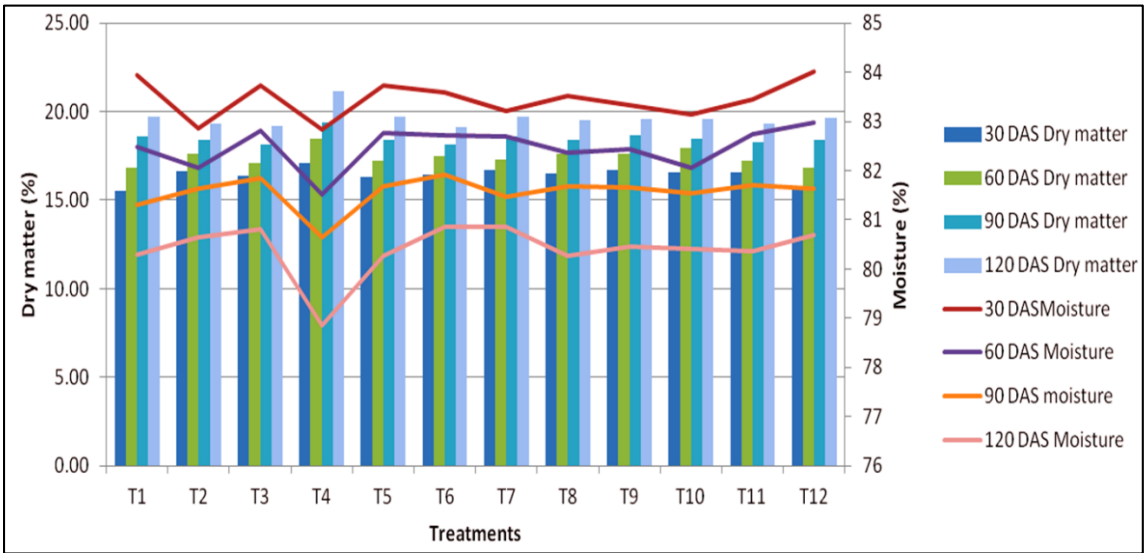

Fig 1: Graph demonstrating relationship between dry matter and moisture content of onions during storage as influenced by field application of SA, azoxystrobin and cycocel

Table 1: Effect of field application of salicylic acid, azoxystrobin and cycocel on physiological loss in weight (%) and respiration rate (ml CO_2/kg/h) of onion bulbs (cv. Arka Kalyan) stored under ambient condition.

Treatments	PLW				Mean	Treatments	Respiration rate (ml CO_2/kg/h)					Mean
	Storage (Days)						Storage (Days)					
	30	60	90	120			Initial	30	60	90	120	
T_1	6.04^{a}	15.28^{a}	21.29^{a}	26.15^{a}	17.19	T_1	14.81^{a}	16.67^{a}	20.25^{a}	21.84^{a}	23.14^{a}	19.34
T_2	4.33^{de}	12.54^{bcd}	17.21^{c}	21.01^{d}	13.76	T_2	12.90^{cd}	13.60^{efg}	15.07^{f}	17.90^{ef}	19.29^{efg}	15.75
T_3	4.41^{cd}	11.37 ^{def}	15.72^{e}	20.23^{e}	12.93	T_3	12.02^{ef}	13.18^{fgh}	15.30^{f}	17.22^{gh}	18.74^{fg}	15.29
T_4	5.01^{bc}	13.41^{b}	18.23^{b}	24.08^{b}	15.18	T_4	13.74^{b}	15.40^{b}	18.99^{ab}	19.50^{b}	21.47^{b}	17.82
T_5	4.28^{de}	12.08^{bcde}	16.33^{d}	20.13^{e}	13.09	T_5	11.64^{ef}	12.81^{ghi}	17.30^{cde}	17.96^{ef}	18.65^{fg}	15.67
T_6	4.04^{de}	10.99^{ef}	15.14^{e}	19.55^{e}	12.43	T_6	11.52^{ef}	12.22^{i}	16.29^{def}	17.64^{fg}	19.18^{efg}	15.37
T_7	4.61^{cd}	11.68^{cdef}	17.28^{c}	24.41^{b}	14.49	T_7	12.83^{cd}	14.77^{bc}	17.39^{cde}	19.31^{b}	20.81^{bc}	17.05
T_8	4.45^{cd}	11.97^{bcde}	16.71^{cd}	23.12^{c}	14.06	T_8	11.53^{ef}	13.78^{def}	16.64^{cdef}	18.40^{de}	20.65^{bcd}	16.20
T_9	4.09^{de}	10.40^{f}	16.35^{d}	22.77^{c}	13.40	T_9	11.25^{f}	12.44^{hi}	15.21^{f}	18.09^{ef}	19.92^{cde}	15.38
T_{10}	5.45^{ab}	12.96^{bc}	17.18^{c}	23.09^{c}	14.67	T_{10}	13.17^{bc}	14.29^{cde}	17.78^{bcd}	19.01^{bc}	20.44^{bcd}	16.93
T_{11}	3.80^{e}	10.29^{f}	14.10^{f}	17.76^{f}	11.62	T_{11}	12.30^{de}	13.45^{efg}	15.95^{ef}	16.80^{h}	18.35^{g}	15.37
T_{12}	4.49^{cd}	12.00^{bcde}	15.11 ^{e}	19.93^{e}	12.88	T_{12}	12.90^{cd}	14.65^{bcd}	17.93^{bc}	18.74^{cd}	19.62^{def}	16.75
Mean	4.58	12.08	16.72	21.85	13.81	Mean	12.55	13.95	17.00	18.53	20.02	16.41
S. Em±	0.20	0.48	0.20	0.26	0.29	S. Em±	0.27	0.30	0.54	0.18	0.36	0.33
CD@5%	0.60	1.45	0.61	0.75	0.85	CD@5%	0.81	0.90	1.59	0.54	1.10	0.99

Note: Values with the same superscripts in same column are not significantly different by Duncan Multiple Range Test at $p \leq 0.05$.

Table 2: Effect of field application of salicylic acid, azoxystrobin and cycocel on moisture (%) and drymatter (%) of onion bulbs (cv. Arka Kalyan) stored under ambient condition.

Treatments	Moisture content (%)					Mean	Treatments	Dry matter (%)					Mean
	Storage (Days)							Storage (Days)					
	Initial	30	60	90	120			Initial	30	60	90	120	
T_1	85.70	83.94	82.47^{bc}	81.31^{d}	80.28^{c}	82.74	T_1	14.30^{d}	15.52^{d}	16.86	18.61^{bc}	19.72^{bc}	17.00
T_2	84.44	82.85	82.07^{c}	81.63^{abc}	80.65^{abc}	82.33	T_2	15.55^{a}	16.63^{ab}	17.61	18.37^{d}	19.31^{d}	17.49
T_3	84.55	83.74	82.82^{ab}	81.84^{ab}	80.81^{ab}	82.75	T_3	15.40^{ab}	16.35^{bc}	17.07	18.16^{e}	19.20^{d}	17.24
T_4	84.16	82.83	81.52^{d}	80.65^{e}	78.85^{d}	81.60	T_4	15.83^{a}	17.09^{a}	18.45	19.35^{a}	21.16^{a}	18.38
T_5	84.43	83.72	82.77^{ab}	81.68^{abc}	80.28^{c}	82.58	T_5	15.51^{ab}	16.29^{bc}	17.23	18.41^{d}	19.69^{bc}	17.52

T_6	84.27	83.60	82.72^{ab}	81.91^{a}	80.85^{a}	82.67	T_6	15.61^{a}	16.47^{ab}	17.51	18.13^{e}	19.15^{d}	17.37
T_7	85.15	83.21	82.69^{ab}	81.4^{cd}	80.26^{c}	82.56	T_7	14.77^{cd}	16.69^{ab}	17.32	18.60^{bc}	19.74^{b}	17.42
T_8	84.62	83.52	82.38^{bc}	81.67^{abc}	80.46^{abc}	82.53	T_8	15.34^{ab}	16.49^{ab}	17.61	18.42^{d}	19.54^{c}	17.48
T_9	84.23	83.33	82.43^{bc}	81.65^{abc}	80.40^{abc}	82.41	T_9	15.66^{a}	16.70^{ab}	17.60	18.65^{bc}	19.60^{bc}	17.59
T_{10}	84.99	83.15	82.06^{c}	81.54^{bcd}	80.37^{bc}	82.42	T_{10}	15.01^{ab}	16.55^{ab}	17.94	18.46^{de}	19.61^{bc}	17.47
T_{11}	84.47	83.45	82.75^{ab}	81.72^{abc}	80.69^{abc}	82.61	T_{11}	15.53^{a}	16.54^{ab}	17.25	18.28^{d}	19.29^{d}	17.38
T_{12}	85.48	84.01	82.99^{a}	81.63^{abc}	80.29^{c}	82.88	T_{12}	14.53^{cd}	15.74^{cd}	16.82	18.37^{b}	19.63^{bc}	17.02
Mean	84.71	83.45	82.47	81.56	80.35	82.51	Mean	15.25	16.42	17.44	18.48	19.64	17.45
S. Em±	0.53	0.35	0.15	0.10	0.15	0.26	S. Em±	0.17	0.24	0.64	0.07	0.06	0.23
CD@5%	NS	NS	0.45	0.31	0.47	0.25	CD@5%	0.50	0.72	NS	0.18	0.18	0.32

Note: Values with the same superscripts in same column are not significantly different by Duncan Multiple Range Test at $p \leq 0.05$.

Table 3: Effect of field application of salicylic acid, azoxystrobin and cycocel on firmness (N) of onion bulbs (cv.Arka Kalyan) stored under ambient condition

Treatments	Bulb firmness(N)					Mean
	Storage (Days)					
	Initial	30	60	90	120	
T_1	125.21	120.09^{c}	117.09^{i}	114.26^{g}	110.62^{c}	117.45
T_2	126.66	123.44^{abc}	121.74^{de}	119.27^{bcde}	116.74^{ab}	121.57
T_3	126.66	124.15^{ab}	121.38^{de}	118.41^{cdef}	115.84^{ab}	121.29
T_4	123.89	120.37^{c}	118.79^{h}	117.19^{f}	113.95^{bc}	118.84
T_5	125.92	122.54^{bc}	120.90^{ef}	119.00^{bcdef}	117.08^{ab}	121.09
T_6	126.16	124.05^{ab}	122.34^{cd}	119.92^{abcd}	116.72^{ab}	121.84
T_7	124.39	122.37^{bc}	119.45^{gh}	117.36^{ef}	115.63^{ab}	119.84
T_8	124.68	122.92^{abc}	121.23^{ef}	117.85^{def}	113.43^{bc}	120.02
T_9	127.94	125.00^{ab}	123.10^{bc}	120.67^{ab}	117.31^{ab}	122.80
T_{10}	128.05	122.55^{bc}	120.22^{fg}	118.45^{cdef}	115.51^{ab}	120.96
T_{11}	128.08	126.31^{a}	124.17^{a}	121.83^{a}	119.52^{a}	123.98
T_{12}	127.53	125.41^{ab}	123.85^{ab}	120.13^{abc}	116.68^{ab}	122.72
Mean	126.26	123.27	121.19	118.69	115.75	121.03
S. Em±	1.76	1.21	0.34	0.70	1.47	1.10
CD@5%	NS	3.58	1.03	2.07	4.34	2.20

Note: Values with the same superscripts in same column are not significantly different by Duncan Multiple Range Test at $p \leq 0.05$.

Table 4: Effect of field application of salicylic acid, azoxystrobin and cycocel on colour and texture of onion bulbs (cv. Arka Kalyan) stored under ambient condition.

Treatments	Colour					Mean	Treatments	Texture					Mean
	Storage (Days)							Storage (Days)					
	Initial	30	60	90	120			Initial	30	60	90	120	
T_1	8.12^{cde}	7.92^{d}	7.80^{de}	7.57	7.13^{cde}	7.71	T_1	7.93^{c}	7.78^{cd}	7.60	7.53^{bc}	7.13^{d}	7.60
T_2	7.90^{fgh}	7.88^{d}	7.77^{e}	7.53	7.53^{a}	7.72	T_2	7.78^{c}	7.82^{bcd}	7.73	7.58^{ab}	7.43^{abc}	7.67
T_3	8.00^{def}	7.95^{d}	7.90^{cde}	7.73	7.37^{ab}	7.79	T_3	7.88^{c}	7.83^{bc}	7.60	7.63^{ab}	7.47^{ab}	7.68
T_4	7.82^{fgh}	8.05^{c}	7.77^{e}	7.60	7.33^{abc}	7.71	T_4	7.78^{c}	7.70^{cd}	7.67	7.53^{bc}	7.23^{bcd}	7.58
T_5	7.95^{efg}	8.19^{b}	7.97^{bc}	7.80	7.40^{ab}	7.86	T_5	8.03^{bc}	7.82^{bcd}	7.70	7.63^{ab}	7.33^{abcd}	7.70
T_6	7.80^{gh}	8.05^{c}	7.93^{bcd}	7.56	7.23^{bcd}	7.72	T_6	7.95^{c}	7.80^{cd}	7.63	7.50^{bc}	7.23^{bcd}	7.62
T_7	8.28^{abc}	7.77^{e}	7.93^{bcd}	7.65	7.40^{ab}	7.81	T_7	7.97^{c}	7.67^{d}	7.47	7.37^{c}	7.40^{abcd}	7.57
T_8	8.40^{a}	8.37^{a}	8.33^{a}	7.79	7.50^{a}	8.08	T_8	8.33^{a}	8.02^{a}	7.70	7.55^{bc}	7.43^{abc}	7.81
T_9	7.73^{h}	7.89^{d}	7.90^{cde}	7.69	7.47^{a}	7.74	T_9	7.93^{c}	7.67^{d}	7.57	7.37^{c}	7.17^{cd}	7.54
T_{10}	8.17^{bcd}	8.19^{b}	8.07^{b}	7.78	7.53^{a}	7.95	T_{10}	7.93^{c}	7.85^{bc}	7.67	7.58^{ab}	7.13^{d}	7.63
T_{11}	8.33^{ab}	8.09^{bc}	7.87^{cde}	7.47	7.10^{de}	7.77	T_{11}	8.27^{ab}	7.97^{ab}	7.80	7.75^{a}	7.60^{a}	7.88
T_{12}	7.77^{gh}	7.93^{d}	7.80^{de}	7.60	7.00^{e}	7.62	T_{12}	7.78^{c}	7.67^{d}	7.60	7.58^{ab}	7.20^{bcd}	7.57
Mean	8.02	8.02	7.92	7.65	7.33	7.79	Mean	7.96	7.80	7.64	7.55	7.31	7.65
S. Em±	0.06	0.04	0.03	0.08	0.06	0.05	S. Em±	0.08	0.04	0.57	0.07	0.09	0.17
CD@5%	0.18	0.10	0.16	NS	0.21	0.13	CD@5%	0.27	0.16	NS	0.20	0.28	0.18

Note: Values with the same superscripts in same column are not significantly different by Duncan Multiple Range Test at $p \leq 0.05$.

Table 5: Effect of field application of salicylic acid, azoxystrobin and cycocel on colour and texture of onion bulbs (cv. Arka Kalyan) stored under ambient condition.

Treatments	Taste and flavour					Mean	Treatments	Overall acceptability					Mean
	Storage (Days)							Storage (Days)					
	Initial	30	60	90	120			Initial	30	60	90	120	
T_1	7.80	7.68	7.53	7.58	7.43	7.61	T_1	7.95^{bcd}	7.79^{de}	7.63^{de}	7.56	7.23^{b}	7.63
T_2	7.85	7.80	5.13	7.63	7.60	7.20	T_2	7.84^{de}	7.83^{de}	7.73^{bcd}	7.56	7.53^{a}	7.70
T_3	7.83	7.78	7.63	7.53	7.47	7.65	T_3	7.91^{cde}	7.85^{cde}	7.70^{bcd}	7.61	7.40^{ab}	7.69
T_4	7.87	7.73	7.60	7.57	7.27	7.61	T_4	7.82^{de}	7.83^{de}	7.67^{cde}	7.57	7.23^{b}	7.62
T_5	7.78	7.67	7.53	7.50	7.37	7.57	T_5	7.92^{cd}	7.89^{cd}	7.73^{bcd}	7.64	7.33^{b}	7.70
T_6	7.90	7.77	7.60	7.43	7.43	7.63	T_6	7.87^{cde}	7.87^{cde}	7.73^{bcd}	7.48	7.30^{b}	7.65

T_7	7.95	7.80	7.63	7.53	7.23	7.63	T_7	8.06^{b}	7.78^{de}	7.70^{bcd}	7.49	7.37^{ab}	7.68
T_8	8.02	7.90	7.80	7.78	7.63	7.83	T_8	8.20^{a}	8.00^{ab}	7.80^{ab}	7.63	7.40^{ab}	7.81
T_9	7.68	7.40	7.37	7.38	7.47	7.46	T_9	7.79^{e}	7.65^{f}	7.57^{e}	7.49	7.37^{ab}	7.57
T_{10}	7.87	7.85	7.67	7.55	7.50	7.69	T_{10}	7.99^{bc}	7.96^{bc}	7.77^{bc}	7.64	7.33^{b}	7.74
T_{11}	8.00	7.95	7.73	7.68	7.57	7.79	T_{11}	8.25^{a}	8.09^{a}	7.90^{a}	7.71	7.53^{a}	7.90
T_{12}	7.82	7.68	7.57	7.55	7.10	7.54	T_{12}	7.78^{e}	7.76^{ef}	7.63^{de}	7.57	7.23^{b}	7.60
Mean	7.86	7.75	7.40	7.56	7.42	7.60	Mean	7.95	7.86	7.71	7.58	7.36	7.69
S. Em±	0.08	0.10	0.73	0.06	0.15	0.22	S. Em±	0.00	0.05	0.02	0.02	0.06	0.03
CD@5%	7.80	7.68	7.53	7.58	7.43	7.61	CD@5%	0.13	0.11	0.11	NS	0.19	0.11

Note: Values with the same superscripts in same column are not significantly different by Duncan Multiple Range Test at $p \leq 0.05$.

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