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Supriya AT
Department of Post Harvest Technology, College of Horticulture, Bagalkot U.H.S., Bagalkot, Udyangiri, Karnataka, India

Jagadeesh SL
Department of Post Harvest Technology, College of Horticulture, Bagalkot U.H.S., Bagalkot, Udyangiri, Karnataka, India

Mansur CP
Department of Post Harvest Technology, College of Horticulture, Bagalkot U.H.S., Bagalkot, Udyangiri, Karnataka, India

Correspondence
Supriya AT
Department of Post Harvest Technology, College of Horticulture, Bagalkot U.H.S., Bagalkot, Udyangiri, Karnataka, India

Effect of pre-harvest foliar sprays on bulb yield, number of bulbs per kg, bulb diameter, and marketable bulbs of onion var. Arka Kalyan

Supriya AT, Jagadeesh SL and Mansur CP

Abstract
Onion *var*. Arka Kalyan was imposed with different pre-harvest foliar sprays 15 days prior to harvest. Bulbs were cured after harvesting and stored under ambient condition for 3 months to study black mould disease incidence and marketable life as influenced by treatments. Observations were recorded for bulb yield, number of bulbs per kg and bulb diameter to understand the impact of foliar sprays on these parameters. Black mould disease incidence and marketable bulbs were recorded at monthly intervals for 3 months. Pre-harvest application of carbendazim @ 0.1 per cent contained minimum black mould disease incidence (2.24%), maximum (61.87 %) marketable bulbs followed by azoxystrobin @ 0.05 per cent (2.46%, 57.00% respectively) at the end of 90 days storage. Among different pre-harvest foliar sprays, carbendazim and azoxystrobin were found helpful in maintaining the storage life of onion.

Keywords: Onion, salicylic acid, azoxystrobin, carbendazim

1. Introduction
Onion (*Allium cepa* L.) belongs to the family alliaceae (2n = 16) and it is the most widely used bulb crop. India is the second largest producer of onion in the world after China. In India, the crop occupies an area of 10.5 lakh ha with production of 168.3 lakh tons and productivity of 16t/ha (Anon., 2013) [2]. It is valued for its bulbs having characteristic flavour, taste and pungency. Many medicinal uses are reported for bulbs and are commonly used as diuretic and applied on wounds and boils. Onion contains phenolics and flavonoids that have potential anti-inflammatory, anti-cholesterol properties (Gopalakrishnan, 2010) [7]. It is used as a salad and cooked in many ways in curries, fried, boiled, baked food items and also used in making soups, pickles *etc*.

Being high in water content, onion is a delicate commodity to store. Serious losses occur due to rotting, sprouting, physiological loss in weight and moisture evaporation. Therefore, the crop requires special procedure and conditions for storage. But due to non-availability of appropriate post-harvest storage facilities, 25-30% of the total onions produced are wasted and it amounts to crores of rupees (Chopra, 2010) [6]. In tropical and subtropical countries like India, Pakistan and Bangladesh, farmers unwilling to go for cold storage facility due to the cost and scarcity of electricity. Although improved storage structures for onion are developed, they are not popular among the farmers probably again because of the higher cost of construction. Pre-harvest and postharvest treatments could applied to reduce post harvest losses without impairing the quality of onion. A pre-harvest spray of maleic hydrazide (2000-2500 ppm) 15 days before harvest prevented rotting and sprouting of bulbs (Sharma, 2012). However, maleic hydrazide has been banned for use from 2014.

Alternatively, other chemicals and some new molecules could be employed as pre-harvest foliar spray to extend the shelf life and reduce spoilage in onions in view of more scientific understanding of their action today. Salicylic acid is being applied for delaying the processes related to ripening and senescence, alleviating chilling injury, enhancing antioxidant capacity, and controlling post harvest decay (Mohammadreza and Morteza, 2010) [6]. The antifungal action of borate is said to be associated with antioxidant enzymes and oxidative damage to the fungal pathogen (Xuequn *et al.*, 2012) [22]. Calcium application maintains cell turgor, membrane integrity, tissue firmness and delays membrane lipid catabolism, thus extending storage life (Chaplin and Scott, 1980) [5]. Carbendazim acts on fungal cells by inhibiting beta-tubulin synthesis, inhibiting development of germ tubes and the growth of mycelia

(Srinivasan and Shanmugam, 2006) [18]. Azoxystrobin is known to bring about the cessation of normal energy production (ATP production) within the cell. Evidence of this effect on fungi can be observed in spore mortality, mycelial collapse and inhibition of sporulation or disruption of other vital stages of fungal development (Harrison and Tedford, 2002) [8].

These chemicals treatments are cost effective for the farmers and thought to be beneficial in maintaining the quality of onion bulbs in storage when applied as pre-harvest sprays. The investigation aims at reducing the losses under traditional storage method, where supplementary expenses to the farmers are minimum. Keeping all these aspects in view, the present investigation was planned to study the effect of pre-harvest foliar sprays on bulb yield, diameter, number of bulbs per kg and marketable bulbs of onion variety Arka Kalyan.

Material and methods

Field experiment was conducted at College of Horticulture, Bagalkot in Karnataka state during the *kharif* season of 2014-15. The experimental site is situated in northern dry zone of Karnataka (Zone-3) located at 16^0 10^0 North latitude, 74^0 42^0 East longitude and at an altitude of 542.0 meters above the mean sea level. The annual rainfall of 543mm, mean temperature of 23.04 ^{0} C to 28.80 ^{0} C and the relative humidity of 64.16%. The experiment was laid out in Randomized Complete Block Design (RCBD) with ten treatments and three replications. The size of each experimental plot was 1.8m X 1.8m. In the present study, Arka Kalyan a popular variety of onion grown in Karnataka was used. The cultural practices followed were as per the standard package of practices. Various spray chemicals and their concentrations that formed treatments in the present investigation are as follows: T_1-Control, T_2-Salicylic acid (2 mM), T_3-Salicylic acid (4 mM), T_4- Boric acid (0.25%), T_5-Boric acid (0.5%), T_6-Calcium chloride (0.5%), T_7-Calcium chloride (1.0 %), T_8-Azoxystrobin (0.05%), T_9 -Carbendazim (0.1 %) and T_{10}-Putrescine (8 mM). The chemicals were sprayed using a hand sprayer to the onion crop foliage three weeks before harvest. The crop was harvested at 120 days after transplanting. Onions with foliage were cured in the field for one week and later separated bulbs in the shade for 15 days. The observations were recorded on bulb yield, bulb diameter and number of bulbs per kg. From each treatment, 5kg of cured onion bulbs were selected and replicated thrice for storage study. Onions from each treatment were packed in gunny bags simulating traditional practice and kept under ambient condition for storage studies. The observations on black mould disease incidence and marketable bulbs were recorded at 30, 60 and 90 days after storage (DAS).

Yield, number of bulbs/kg and bulb diameter

Yield and number of bulbs per kg was observed using weighing balance and bulb diameter was recorded in centimetre using vernier calipers.

Incidence of black mould (%)

The incidence of black mould, a major storage disease caused by *Aspergillus niger* was recorded at monthly interval up to 3 months. The incidence of black mould was calculated using the following formula.

$$\text{Black mould disease incidence (\%)} = \frac{\text{Weight of the black mould infected bulbs}}{\text{Initial weight of bulbs stored}} \text{x } 100$$

Marketable bulbs (%)

At monthly interval (30, 60 and 90 DAS), the rotten and sprouted bulbs were separated and the weight of healthy bulbs was recorded. The recovery of marketable bulbs was calculated by using the following formula.

$$\text{Marketable bulbs (\%)} = \frac{\text{Weight of the healthy bulbs obtained}}{\text{Initial weight of bulbs stored}} \text{x } 100$$

Statistical analysis

Statistical analysis was performed using Web Agri Stat Package (WASP) version 2.0 (Jangam and Thali, 2010). The data collected were analysed by one-way analysis of variance (ANOVA). Significant differences among means at p=0.05 were determined by post hoc tests using Duncan's multiple range test.

Results and discussion

The data on yield in weight (q) of onion variety Arka Kalyan as influenced by different pre-harvest foliar sprays are presented in Table 1. The effect of pre-harvest foliar sprays on yield of bulbs was found to be non significant. However, maximum yield was recorded in treatment T_2 (Salicylic acid-2mM) (261.79 q/ha). The positive effect of salicylic acid on growth and yield can be due to its influence on other plant hormones. In a previous report, salicylic acid altered the auxin, cytokinin and ABA balances in wheat and increased the growth and yield under both normal and saline conditions. The authors have ascribed the increase in yield by foliar application of salicylic acid to the well-known roles of salicylic acid on photosynthetic parameters and plant water relations (Shakirova *et al.* 2007) [17]. In the present study, the effect of salicylic acid on yield was not significant over other treatments mainly due to the fact that the chemical was sprayed only two weeks before the harvest of onions, almost when the photosynthetic and growth activity was coming to an end. The minimum yield was recorded in treatment T_6 ($CaCl_2$ - 0.5%) (253.04 q/ha) was simply a numerically lower value.

With respect to number of bulbs per kg, treatments differed non-significantly among themselves (Table 1). However, maximum number of bulbs per kg were observed in the treatment T_2 (Salicylic acid-2 mM) (17.33) and minimum number of bulbs were noted in the treatment T_1 (Control) (16.0) and T_9 (Carbendazim - 0.1 %) (16.00). Similar to yield and number of bulbs per kg, the treatments did not show significant differences for onion bulb diameter among themselves (Table 1). However, the maximum diameter (5.64 cm) was seen in T_2 (Salicylic acid - 2mM). Similar results were obtained in the experiment of Ali *et al.* (2014) in peach fruit where salicylic acid increased the fruit diameter. Application of salicylic acid (10^{-2} M) doubled the skin thickness in tomato (Javaheri *et al*., 2012) [11]. Nevertheless, the minimum bulb diameter (5.23 cm) observed in T_9 (Carbendazim - 0.1%) was just a numerical difference but not the statistical difference when compared to the treatment T_2 with maximum diameter.

The data related to effects of pre harvest foliar sprays on black mould disease incidence of onion bulbs during ambient storage are presented in Table 2. In the present investigation, the black mould disease incidence showed an increasing trend over the storage period. The maximum black mould incidence was noted in the control (T_1) throughout the storage period. Various pre-harvest treatments employed in present investigation showed varying degree of effectiveness in

controlling the disease over the untreated bulbs. The values for disease incidence at the end of 90 days of storage were lower in T_9 (Carbendazim - 0.1 %) (2.24%) followed by T_8 (Azoxystrobin-0.05%) (2.46%), T_5 (Boric acid - 0.5%) (2.69%) and T_{10} (Putrescine - 8mM) (3.00%). However, the treatment with carbendazim (0.1%) was found more effective numerically in reducing black mould when sprayed two weeks prior to harvest. The reduction in rotting per cent could be attributed to positive effect of carbendazim, a broad spectrum fungicide, in controlling black mould rot (*Aspergillus niger*) responsible for decay of bulbs. Similar findings were reported by Patel and Patel (1991) [15], Srivastava *et al.* (1997) [19] and Srinivasan and Shanmugam (2006) [18] in onion.

Azoxystrobin has a novel mode of action (Hewitt, 1998) [9]. Its fungicidal activity results from the inhibiting mitochondrial respiration of higher fungi, which is achieved by the prevention of electron transfer between cytochrome-b & cytochrome-c (Becker *et al.,* 1981) [3]. Alphanso trees sprayed with Azoxystrobin (2ml/L) witnessed suppreression in the development of both panicle and leaf anthracnose (Sundaravadana *et al.,* 2006). Similar results were obtained in studies of Xuequn *et al.* (2012) [22] in mango, and Robak and Adamicki (2007) [16] in root crops.

The data related to effects of pre harvest foliar sprays on marketable onion bulbs during ambient storage are presented in Table 3. The mean marketable bulbs percentage decreased from 84.19 per cent at 30 days of storage to 52.67 per cent at the end of 90 days of storage with 67.14 per cent at 60 days of storage. The maximum percentage of marketable bulbs at the end of 90 days of storage was obtained in the treatment T_9 (Carbendazim - 0.1 %) (61.87%), followed by T_8 (Azoxystrobin-0.05%) (57.00%) and T_5 (Boric acid -0.5%) (55.03%). This may be attributed to reduction of rotting in these treatments. These results are in conformity with the findings of Robak and Adamicki, (2007) [16] in carrot, Wedge *et al.* (2007) [21] in strawberry and Kukanoor (2005) [13] in onion.

In contrast, minimum per cent marketable bulbs at the end of 90 days of storage were obtained in treatment T_6 ($CaCl_2$ - 0.5%) (43.30%), T_7 ($CaCl_2$ -1%) (47.37%) and T_4 (Boric acid-0.25%) (49.73%). Most of the unmarketable bulbs in these treatments exhibited the damage caused by onion bulb maggot (*Delia antiqua*). According to Brewster (2008) [4], maggots of the second and third generations of *Delia antique,* burrow in to the bases of large plants and developing bulbs and thereby predispose them to rotting by secondary infections of fungi and bacteria. Female flies oviposit maximally in a substrate at about 20°C, a temperature that also favours egg survival and development (Keller and Miller, 1990) [12]. Hence, the lower percentage of marketable bulbs in these treatments might be due primarily to the damage inflicted by the insect followed by infection. This observation points to the need for intervention to in terms of an insecticide spray in onion crop management specifically to take care of onion bulb maggot.

Table1: Effect of pre-harvest sprays on yield, number of bulbs/kg and bulb diameter of onions (variety Arka Kalyan)

Treatments	Parameters		
	Yield (q/ha)	Number of bulbs/kg	Diameter (cm)
T_1	259.46	16.00	5.50
T_2	261.79	17.33	5.64
T_3	258.16	17.00	5.36
T_4	255.50	16.67	5.33
T_5	253.51	17.00	5.48
T_6	253.04	16.33	5.55
T_7	254.37	16.67	5.49
T_8	258.65	17.00	5.43
T_9	259.19	16.00	5.23
T_{10}	261.75	17.00	5.26
Mean	257.54	16.70	5.43
S. Em±	13.39	0.51	0.12
CD@5%	NS	NS	NS

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 pre-harvest sprays on marketable bulbs in onions (variety Arka Kalyan) stored under ambient condition

Treatments	Marketable bulbs (%)		
	Storage (Days)		
	30	60	90
T_1	83.63^{ef}	68.43^{b}	53.20^{bcd}
T_2	85.53^{c}	69.37^{b}	54.37^{bc}
T_3	83.03^{f}	64.33^{d}	51.23^{bcd}
T_4	84.40^{de}	69.20^{b}	49.73^{cde}
T_5	81.63^{g}	67.93^{bc}	55.03^{abc}
T_6	77.83^{h}	56.93^{e}	43.30^{e}
T_7	82.73^{f}	66.20^{cd}	47.37^{de}
T_8	89.43^{a}	71.97^{a}	57.00^{ab}
T_9	88.43^{b}	69.50^{b}	61.87^{a}
T_{10}	85.23^{cd}	67.53^{bc}	53.60^{bcd}
Mean	84.19	67.14	52.67
S.Em±	0.302	0.690	2.353
CD@5%	0.903	2.055	6.995

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 pre-harvest sprays on black mould incidence in onion (variety Arka Kalyan) stored under ambient condition

Treatments	Black mould (%)		
	Days		
	30	60	90
T_1	2.14 (8.17)^{a}	3.75 (11.12)^{a}	5.38 (13.35)^{a}
T_2	0.57 (4.32)^{bc}	1.70 (7.41)^{bc}	3.16 (10.21)^{bc}
T_3	0.65 (4.62)^{bc}	2.06 (8.23)^{bc}	3.20 (10.29)^{bc}
T_4	0.89 (5.42)^{b}	2.63 (8.98)^{ab}	4.99 (12.91)^{a}
T_5	0.67 (4.70)^{bc}	1.85 (7.81)^{bc}	2.69 (9.40)^{bcd}
T_6	1.71 (7.42)^{a}	3.92 (11.34)^{a}	5.28 (13.27)^{a}
T_7	0.62 (4.51)^{bc}	1.88 (7.89)^{bc}	3.50 (10.79)^{b}
T_8	0.40 (3.62)^{c}	1.55 (7.11)^{bc}	2.46 (8.95)^{cd}
T_9	0.28 (3.00)^{c}	1.18 (6.23)^{c}	2.24 (8.60)^{d}
T_{10}	0.53 (4.14)^{bc}	1.82 (7.58)^{bc}	3.00 (9.98)^{bcd}
Mean	0.85 (4.99)	2.23 (8.37)	3.59 (10.77)
S.Em±	0.569	0.882	0.5147
CD@5%	1.696	2.637	1.530

Figures in the parentheses are the arc sin transformed values.

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

T_1 - Control
T_2 - Foliar spray of salicylic acid (2 Mm
T_3 - Foliar spray of salicylic acid (4 mM)
T_4 - Foliar spray of boric acid (0.25%)
T_5 - Foliar spray of boric acid (0.5%)
T_6 - Foliar spray of calcium chloride (0.5%)
T_7 - Foliar spray of calcium chloride (1.0 %)
T_8 - Foliar spray of azoxystrobin (0.05%)
T_9 - Foliar spray of carbendazim (0.1 %)
T_{10} - Foliar spray of putrescine (8mM)

Conclusion

The current investigation reveals that the pre-harvest foliar sprays employed in the study do not have any negative impact on yield, diameter and number of bulbs per kg. Further, pre-harvest spray of azoxystrobin (0.05%) and carbendazim (0.1%) resulted in minimum black mould disease incidence and higher marketable bulbs indicating superior performance of the treatments.

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