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Beneficial effects of pre-harvest carbendazim and calcium nitrate sprays in kinnow (*Citrus nobilis* × *C. deliciosa*) storage*

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Kinnow (*Citrus nobilis*×*C. deliciosa* Frost) was introduced to India from USA at Regional Fruit Research Station, Abohar (Punjab) in 1940 from where it spread to many parts of India. Now, it has become the most favourite citrus cultivar among citrus growers of Punjab, Haryana, Rajsthan, Jammu and Kashmir and Himachal Pradesh because it has adapted very well under semi-arid and sub-mountainous foot hill conditions where other citrus varieties have failed. Unfortunately, its production season is very limited and hence there is glut of fruit during December to January as a result farmers get very low price for the produce. Hence, kinnow fruits are stored for some time under cold store conditions but post-harvest diseases affect it adversely (Singh and Jain 2004). Initiation of these diseases start at the field level due to direct infection or latent phase of pathogen survive on the fruit and become active when the fruits are injured during harvesting and cleaning. Many techniques are employed to control these diseases, but fungicide application is commonly used. However, use of higher doses of fungicides has long-term dietary effects. In addition, development of resistance by major post harvest pathogens is also a constraint to control these diseases. Thus low doses of fungicides are used along with calcium salts to avoid losses caused by pathogens. Pre-harvest spraying with fungicides can prevent spore germination and the formation of appressorium of deep-seated infections in the lenticels and floral remnants on the fruits. Further, field sprays may be the best means to reduce decay of fruits during storage and transportation (Sonkar and Ladaniya 1999). Protective sprays have been used to prevent several post-harvest diseases of citrus, like stem-end rot, Phytophthora brown rot and Penicillium mould. The use of calcium compounds has been reported to enhance the shelf-life of fruits by reduced respiration rate, delayed ripening and reduced decay loss (Sonkar and Ladaniya 1999). Application of fungicides, such as carbendazim, benomyl and Topsin-M, has been studied on various crops (Sonkar and Ladaniya 1999, Blackarski *et al*. 2001).

Hence, the present studies were conducted to find out the effect of pre-harvest spray of fungicides alone and in combination with calcium nitrate on post-harvest behaviour of kinnow fruits during storage under cold store conditions.

Fifteen-year-old kinnow plants of uniform size and vigour, spaced at 6.5 m × 6.5 m on sandy loam soil were selected for the studies during 2003–04 and 2004–05. These kinnow plants were sprayed with carbendazim (0.1% *ai*), copper oxychloride (0.2% *ai)*, calcium nitrate (1.0%), carbendazim (0.1% *ai)* + calcium nitrate 1.0% and copper oxychloride (0.2% *ai*) + calcium nitrate (1.0%) with three replications considering single plant as a unit of replication. The plants sprayed only with water served as control. Three sprays were done starting from 15 December at an interval of 15 days. The fruits were harvested on 30 January after 15 days of last spray. Fruits were harvested by pedicel cutting with the help of a clipper and collected in high density polyethylene crates separately. Unwashed fruits were packed in corrugated fibre board boxes (5 ply; 0.5% ventilation) in two layers containing 30 fruits in each box and a single box was treated as one replication. The packed fruits were stored in cold condition at temperature 5°C±1°C and 85–90% relative humidity. The whole experiment was framed in a factorial randomized block design with six treatments including one set of control. The experiment was conducted during 2003–04 and repeated in same manner in 2004–05.

Observations on physiological loss in weight, spoilage and physico- chemical parameters like juice recovery, total soluble solids, acidity, vitamin C (ascorbic acid) were determined before storage and an at 15 days of interval during storage. Physiological loss in weight was determined by periodical weighing of fruits, and the differential weight loss was expressed in percentage. Visible symptoms of spoilage were recorded and cumulative percentage of spoilage occurred with respect to advancement of storage period was

*Short note

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calculated. Juice extracted from the kinnow fruit by screw type hand-operated juicer and juice recovery was expressed in percentage on weight basis. Total soluble solids (TSS), acidity and ascorbic acid of juice were determined by using standard procedure (Ranganna 2000). The data obtained from all the parameters of both the years were averaged and subjected to analysis as per standard procedures. The data, which were obtained in percentage, were first transformed to arc sine values before analysis. Analysis of variance (ANOVA) was applied by using factorial ramdomized block design (Panse and Shukatme 1984).

Minimum loss in weight (10.48%) after 60 days of storage was found in fruits treated with carbendazim (0.1% *ai*) concentration, followed by carbendazim (0.1% *ai*) + calcium nitrate (1%) treatment under cold store condition (Fig 1). A significant difference in weight loss was recorded in all the treatments over control. Further, physiological loss in weight of the fruits in all the treatments was significantly reduced as the storage period increased. However, there was no significant effect of interaction, treatment and duration of storage on physiological loss in weight. Pre-harvest spraying of fungicide in combination with calcium nitrate significantly reduced the spoilage during storage (Fig 2). Minimum fruit rot (7.78%) after 60 days of storage under cold store condition was recorded with carbendazim (0.1% a i) + calcium nitrate (1%). Significant variation in fruit rot found in all the treatments over control. Probable reason for reduction in physiological loss in weight and fruit spoilage loss may be due to higher evapo -transpiration and respiration rates due to metabolic activities appeared to be responsible as it was reported in kinnow and peaches (Singh and Sharma 2009). Such activities also lead to over ripening and senescence of the fruits which become susceptible to microbial attack causing high spoilage losses. Treatment with fungicide either alone or in combination with calcium nitrate (1%) was most effective to control post-harvest spoilage caused by fungi (Singh and Thakur 2003). This may pertain to fungicidal check on microbial activity and thickening of middle lamella of cell wall due to increased formation and deposition of calcium pectate.

Juice content of the fruits was reduced significantly with the increase in duration of storage period in all the treatments. Similar, significant variation in juice content was recorded within all the treatments, (Table 1). Maximum juice content (48.18%) was found in carbendazim (0.1% a i) + calcium nitrate (1%) treatment followed by carbendazim alone (46.08%). Total soluble solids in the fruit were increased significantly in all the treatments up to 45 days and declined thereafter except copper oxychloride (0.2% a i) + calcium nitrate (1%). Such an increase in total soluble solids may be due to conversion of starch and polysaccharides into simple sugars with the progress of storage, whereas their higher utilization in metabolic activities may be responsible for lowering their levels thereafter. Maximum acidity retention (0.84%) after 60 days of storage was observed in copper oxychloride (0.2% a i) + calcium nitrate (1%) treatment. Calcium nitrate either alone or in combination with fungicide retained acidity in fruits better than fungicide alone. Conversely, the acidity of fruits declined throughout the storage period. It may be due to utilization of organic acids in metabolic activities, which reduced the level of acidity with the progress in storage period. Ascorbic acid content of the fruit was decreased in all the treatments throughout the storage. However, maximum ascorbic acid content was observed in calcium nitrate (1%) treated fruits (25.84 mg/100 ml juice), followed by carbendazim (0.1% a i) + calcium nitrate (1%) treated fruits (25.29 mg/100 ml juice). It may be due to utilization of lesser amount of organic acids as reported

Table 1 Effect of pre – harvest spraying of fungicide and calcium nitrate on juice recovery, total soluble socids, acidity and ascorbic acid content of kinnow fruits during storage under cold store conditions

Treatment	Juice (%)			TSS (°B)			Acidity (%)			Ascorbic acid (mg/100 ml juice)		
	30 days	45 days	60 days	30 days	45 days	60 days	30 days	45 days	60 days	30 days	45 days	60 days
Carbendazim (0.1%)	46.56	45.77	46.08	11.1	11.6	11.5	0.73	0.72	0.73	27.17	23.61	23.80
Carbendazim (0.1% a i) + calcium nitrate (1%)	48.22	46.42	48.18	11.7	12.2	11.7	0.72	0.72	0.69	26.30	24.76	25.29
Copper oxychloride (0.2% a i)	43.51	44.65	43.65	11.4	12.1	11.9	0.80	0.83	0.78	24.57	24.36	23.10
Copper oxychloride (0.2% a i) + calcium nitrate (1%)	46.42	45.24	44.59	11.7	12.1	12.3	0.82	0.81	0.79	26.29	23.59	25.04
Calcium nitrate (1%)	48.96	45.41	45.33	11.8	11.9	11.7	0.78	0.75	0.72	27.00	26.79	25.84
Control	45.15	42.20	43.75	10.6	11.6	11.3	0.75	0.65	0.65	27.46	25.21	24.47
CD ($P = 0.05$)	Treatment = 1.84 Duration = 1.65 Treatment×duration = NS			Treatment = 0.40 Duration = 0.32 Treatment×duration = NS			Treatment = 0.05 Duration = 0.03 Treatment × duration = NS			Treatment = NS Duration = 1.83 Treatment×duration = NS		

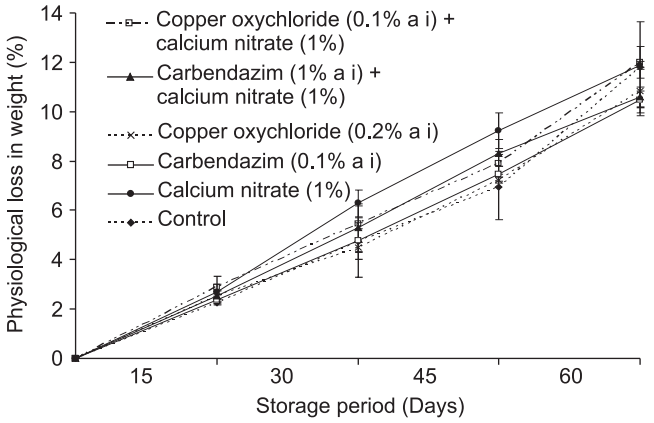

Fig 1 Effect of pre- harvest spraying of fungicides and calcium nitrate on physiological loss in weight of kinnow fruits during storage under cold store conditions

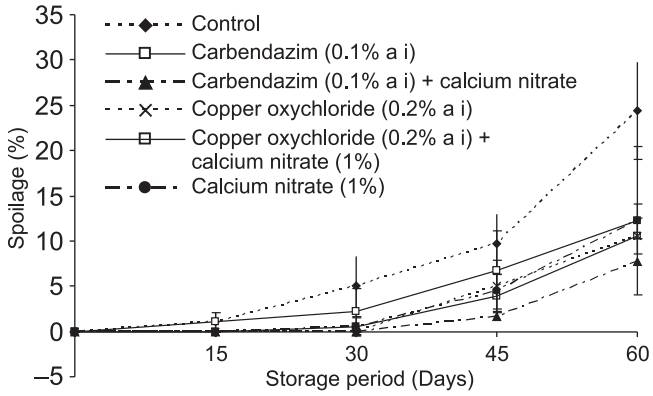

Fig 2 Effect of pre- harvest spraying of fungicides and calcium nitrate on spoilage of kinnow fruits during storage under cold store conditions

in kinnow fruits (Singh and Thakur 2003).

Thus, it can be concluded that pre-harvest spraying of kinnow plants with carbendazim (0.1% *ai*) + calcium nitrate (1%), 15 days before fruit harvest was most effective treatment to control post-harvest spoilage and maintaining fruit quality and retaining marketability of fruits for 50 days.

SUMMARY

An experiment was conducted during 2003–05 to study the effect of pre-harvest sprays of fungicides alone or in combination with calcium nitrate on post-harvest fruit spoilage and quality of kinnow (*Citrus nobilis* × *C. deliciosa* Frost) fruits under cold storage. Treatment consisted of carbendazim (0.1% *ai*), copper oxychloride (0.2% *ai*) and calcium nitrate (1%), carbendazim (0.1% *ai*) + calcium nitrate (1%), copper oxychloride (0.2% *ai*) + calcium nitrate (1%), and control (spray only water). After 15 days of last spray, the fruits were harvested from the tree and packed 30 fruits in each corrugated fiber board boxes (5 ply with 0.5% ventilation). The fruits were stored under cold store conditions (5±1°C; relative humidity 85–90%). Carbendazim (0.1% *ai*) alone or in combination with calcium nitrate 1% reduced the physiological loss in weight significantly during storage. Minimum fruit rot (7.78%) after 60 days of storage was recorded in treatment combination of carbendazim (0.1% ai) + calcium nitrate (1%). The treatment also retained fruit quality like, total soluble solids, acidity, ascorbic acid content better than untreated control during storage.

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