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Role of preharvest spray of nutrients on the shelf life improvement of apple (*Malus domestica* Borkh.) in Uttarakhand

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Abstract
The experiment was conducted to study the responses of preharvest spray of nutrients on shelf life improvement of apple cv Royal Delicious in the Research Block of Department of Horticulture Uttarakhand University of Horticulture and Forestry, Ranichauri, Tehri Garhwal,. The experiment was laid out in RBD with three replications and 11 treatments namely; T_1 (foliar application of borax @ 0.5%), T_2 (foliar application of borax @ 1%), T_3 (foliar application of $CaCl_2$ @ 0.4%), T_4 (foliar application of $CaCl_2$ @ 0.6%), T_5 (foliar application of K_2SO_4 @ 1%), T_6 (foliar application of K_2SO_4 @ 1.5%), T_7 (foliar application of 20:20:20 NPK mixture @1%), T_8 (foliar application of 20:20:20 NPK mixture @ 1.5%), T_9 (foliar application of micronutrient @ 0.5%), T_{10} (foliar application of micronutrients @ 1%) and T_{11} (control). After harvesting of fruits from different treatments they were stored upto 90 days and physico-chemical analysis was done at an interval of 30 days viz., first day, 30 days, 60 days and 90 days of storage. The investigation clearly revealed that minimum physiological loss in weight, minimum rotting percentage and maximum firmness was found with foliar application of $CaCl_2$ @ 0.6% (T_4) followed by foliar application of 20:20: NPK mixture @ 1.5% (T_8) after 90 days of storage.

Keywords: Apple**,** nutrients, calcium, spray, shelf life

Introduction
Apple (*Malus domestica* Borkh.) is an important member of family Rosaceae and grown widely throughout the world. Among the fruits, apples have occupied a very special place in our affection, both as a symbol and as one of the delicious fruits. Delicious and crunchy apple fruit is one of the most popular fruits, favourite of health conscious and fitness lovers who believe in the concept "health is wealth". This wonderful fruit is packed with rich phyto-nutrients that in the true sense are indispensable for optimal health. The antioxidants in apple have much health promoting and disease prevention properties thus truly justifying the adage, *"an apple a day keeps the doctor away.* Nutrition plays a very important role for increasing the quality and shelf life of apple. Calcium plays a key role in a wide range of physiological process. Calcium in adequate amounts helps to maintain apple fruit firmness and decreases the incidence of physiological disorders such as water core, bitter pit and internal breakdown. Postharvest decay may also be reduced by increasing the calcium content of apple fruit. The major problem is getting enough calcium into the fruit to have the desired effects. The role of calcium is well known as a constituent of cell wall in the form of calcium pectate. Its role has also been implicated in guard cell physiology and certain enzymes are activated by calcium. \
Calcium (Ca) is particularly essential to plants as its deficiency reduces the growth of meristem and deforms the youngest leaves. Insufficient Ca levels lead to deterioration of cell walls, with the consequent death of plant cells and tissues [1]. (Calcium is also used to reduce many postharvest disorders in fruits, such as bitter pit in apple [2]. It has been estimated that only limited amounts of the Ca absorbed by roots (around 10%) are transported to fruit tissues [3]. Generally, fruits with low Ca content are poor in quality and less suitable for storage [4]. Limited translocation of calcium to the fruit as well as lack of calcium migration from leaves makes it difficult to elevate its concentration in fruit through soil application. To increase fruit calcium by spray, calcium must directly penetrate the fruit. Foliar application of calcium deposited on the fruit to be effective in decreasing the occurrence of physiological disorders.

Materials and methods
The experimental site is located at Ranichauri about 11 Kms from chamba at an altitude of about 2000 m above mean sea level. Geographic position of experimental site is between latitude 30˚15' N and longitude 78˚02' E under mid hills of Garhwal region of Uttarakhand.

The region represents a humid temperate climate with an annual rainfall of 1278.40 mm. The experiment was conducted on apple tree cv. Royal Delicious. In this experiment three sprays of different treatments were applied at an interval of thirty days after fruit set. First spray was done 1st May 2013, second spray on 1st June 2013 and third on 1st July 2013. Each treatments has one tree per replication. The lab parameters were analysed by using Factorial Randomized Block Design with 11 treatments namely T_1 (foliar application of borax @ 0.5%), T_2 (foliar application of borax @ 1%), T_3 (foliar application of $CaCl_2$ @ 0.4%), T_4 (foliar application of $CaCl_2$ @ 0.6%), T_5 (foliar application of K_2SO_4 @ 1%), T_6 (foliar application of K_2SO_4 @ 1.5%), T_7 (foliar application of macronutrient NPK @ 1%), T_8 (foliar application of macronutrient @ 1.5%), T_9 (foliar application of micronutrient @ 0.5%), T_{10} (foliar application of micronutrients @ 1%) and T_{11} (control). Fruit harvested from different treatments were brought to the Horticulture Lab after proper sorting and grading fruits were selected at random from different treatments and were stored upto 90 days and the physico-chemical analysis were done at an interval of 30 days. The quality parameter recorded as follows:

Physiological Loss in Weight (PLW): It was recorded as cumulative loss in weight of fruits under various treatments based on the initial fruit weight (before storage). The fruit were weighed at different intervals and the loss in weight was calculated at the time of periodical sampling during.

Fruit Firmness: The fruit firmness was determined with the help of penetrometer after removing about one square cm of skin from three sides of the fruit at shoulder end. The firmness was expressed in lb/inch2.

Decay/ Rotting: The number of fruits showing sign of decay or rotting were counted separately in different treatment at different storage intervals. The cumulative number of rotten fruits was calculated at the end of storage period and expressed as per cent. The data were computed for statistical analysis following the procedure described by [5].

Results and discussion

Physiological Loss in Weight (PLW)

The data presented in fig.1 shows that PLW was significantly varies among different treatments and storage intervals. Among the treatments the highest PLW (8.43%) was recorded in T_{11} (control) and lowest (5.17%) in T_4 (foliar application of $CaCl_2$ @ 0.6%) which was at par (5.23%) with T_6 treatment (foliar application of K_2SO_4 @ 1.5%). While at different storage intervals PLW per cent increases ranging from 3.40 percent to 13.57 per cent from 30 days to 90 days of storage. The data also predicts that there was significant difference in treatment among the interactions. Minimum PLW (2.16%) was observed in T_3 (foliar application of $CaCl_2$ @ 0.4%) at 30 days interval while maximum (17.06%) in T_{11} (Control) at 90 days of intervals. It was observed that PLW per cent was minimum by foliar application of calcium to the plants. It is because the calcium application usually leads to an increase in calcium concentration that may affect the structure and functions of cell walls and membranes and cell metabolism event. Calcium plays an important role as an activator for phosphatase enzyme and work as a pH regulator by forming salts with plasma protein. The Calcium is involved in plant cell wall integrity and has been reported in its role in improving storage life of the fruits. Similarly reported in plum [5], guava [6, 7] and grape [8].

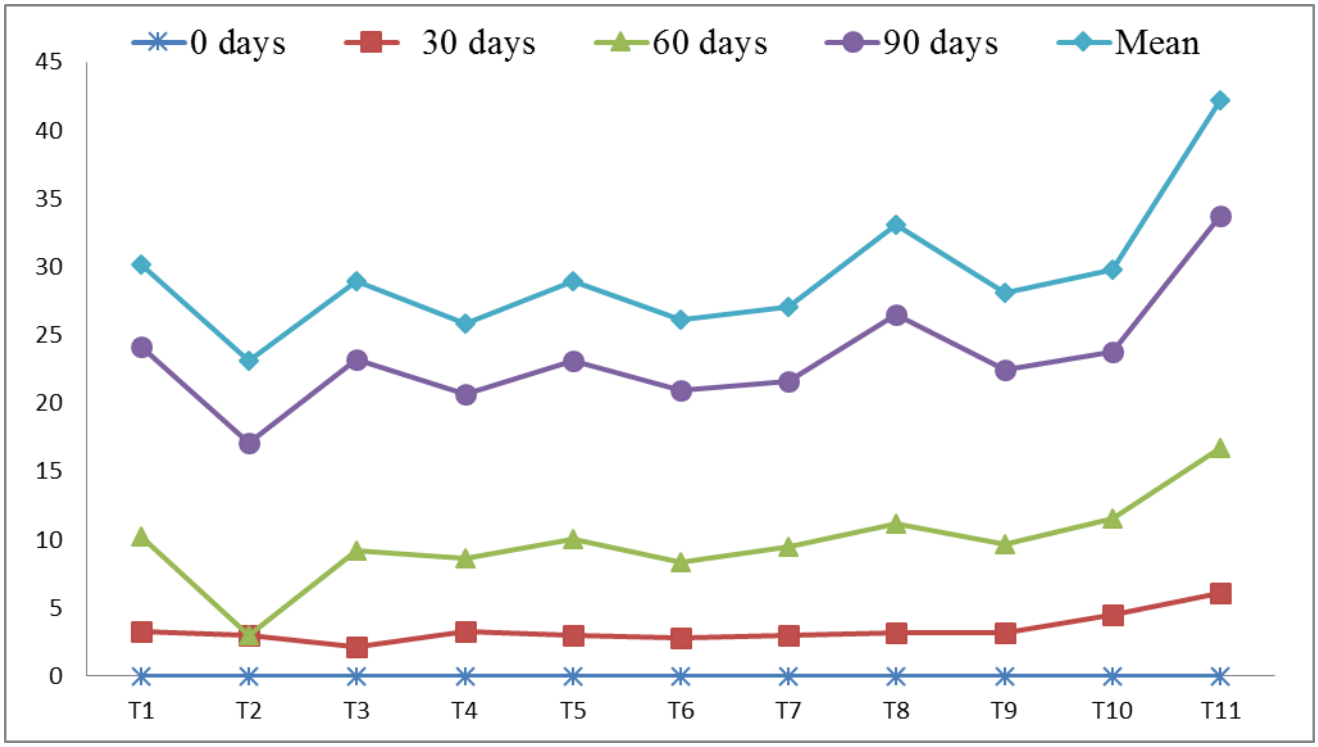

Fig 1: Effect of pre harvest foliar spray of nutrients on fruit P L W (%) of Apple cv. Royal Delicious during storage

Fruit Firmness

The perusal of data in table 1 clearly indicates that fruit firmness was significantly varies among different treatments and storage intervals. Among the treatments maximum fruit firmness was recorded (5.93 lb/inch2) in T_4 (foliar application of $CaCl_2$ @ 0.6%) followed by T_8 and minimum (4.82 lb/inch2) in T_{11}. While at different storage intervals the fruit firmness decreased ranging from 6.52 to 4.03 lb/inch2 from 0 days to 90 days of storage. The data also shows that there was significant difference in treatments among the interactions.

Maximum fruit firmness was observed (7.60 lb/inch2) in T_4 at 0 days interval while minimum (3.60 lb/ inch2) in T_{11} at 90 days of intervals. Fruit firmness was decreased probably due to the breakdown of insoluble protopectins (a major component of cell wall) into water soluble pectin compounds during storage, which ultimately affected the cell wall consistency or softening of fruit skin. Maximum fruit firmness was observed in the fruits treated with $CaCl_2$ @ 0.6%. It might be due to higher availability of calcium to fruit. Calcium is the plant nutrient most closely related to fruit quality and firmness in particular. Calcium appears to be involved in maintaining firmness due to its role as a major component of pectins and in strengthening cell wall and membrane structures. The Calcium application usually leads to an increase in calcium concentration that may affect the structure, functions of cell walls, membranes and cell metabolism events. These results agreement in apple [9, 10, 11], plum [5], mango [12, 13] and guava [14].

Table 1: Effect of pre harvest foliar spray of nutrients on fruit firmness (lb/inch^2) of Apple cv. Royal Delicious during storage.

	Storage Intervals (D)				
Treatments	**0 days**	**30 days**	**60 days**	**90 days**	**Mean**
T_1	6.49	6.13	5.93	4.03	5.64
T_2	6.66	5.60	5.40	3.90	5.39
T_3	6.43	6.06	5.63	4.40	5.63
T_4	7.60	6.23	5.50	4.40	5.93
T_5	5.76	5.30	5.06	3.96	5.02
T_6	6.70	6.13	5.63	4.03	5.62
T_7	6.60	5.96	4.80	3.66	5.25
T_8	7.00	6.06	5.80	4.30	5.79
T_9	6.46	6.13	5.73	4.26	5.65
T_{10}	6.40	5.90	5.46	3.76	5.38
T_{11}	5.69	5.16	4.83	3.60	4.82
Mean	6.52	5.88	5.43	4.03	
	Treatment (T)	Storage interval (D)		Interaction (T×D)	
SE±	0.40	0.24		0.80	
$CD_{0.05}$	0.11	0. 68		0.22	

Rotting/ Decay

The perusal of data in table 2 clearly indicates that fruit rotting percentage was significantly varies among different treatments and storage intervals. Among the treatments maximum rotting (5.52%) was recorded in T_{11} (control) and minimum (3.28%) in T_4 (foliar application of $CaCl_2$ @ 0.6%), which was at par with T3 (3.33%) treatment (foliar application of $CaCl_2$ @ 0.4%) followed by T_8 (3.54%). While at different storage intervals rotting percentage increases and it ranges from 2.08% to 9.56% from 30 days to 90 days of storage. It was also evident from data that there was significant difference among the interactions. Minimum rotting (1.30%) was observed in T_8 (foliar application of macronutrients @ 1.5%) at 30 days interval while maximum (12.43%) in T_{11} (Control) at 90 days of intervals.

Table 2: Effect of pre harvest foliar spray of nutrients on fruit rotting/ decay (%) of Apple cv. Royal Delicious during storage.

	Storage Intervals (D)				
Treatments	**0 days**	**30 days**	**60 days**	**90 days**	**Mean**
T_1	0.00	2.13	5.10	10.03	4.31
T_2	0.00	2.40	5.13	11.00	4.63
T_3	0.00	1.63	3.83	7.86	3.33
T_4	0.00	1.80	3.56	7.76	3.28
T_5	0.00	2.63	5.86	11.13	4.90
T_6	0.00	1.53	4.70	9.36	3.90
T_7	0.00	1.83	4.66	8.0 6	3.64
T_8	0.00	1.30	4.00	8.50	3.54
T_9	0.00	2.80	5.60	10.06	4.61
T_{10}	0.00	1.70	4.53	9.03	3.81
T_{11}	0.00	3.20	6.46	12.43	5.52
Mean	0.00	2.08	4.86	9.56	
	Treatment (T)	Storage interval (D)		Interaction (T×D)	
SE±	0.46	0.28		0.93	
$CD_{0.05}$	0.13	0.79		0.26	

Minimum rotting of fruits by application of $CaCl_2$ @ 0.6% might be due to the higher availability of Ca to the fruit plants. Calcium has been associated with firmness and plant disease resistance. Addition of calcium to fruit can either enhance resistance of fruits to postharvest pathogens or reduce susceptibility to postharvest diseases and disorders. The additional calcium may cause a reduction of pathogen conidia germination and germ tube elongation by limiting nutrients available to pathogens on the fruits surface. The calcium may enhance resistance of fruits to pathogens by interacting with cell walls components. Postharvest pathogens produce pectolyticenzymes, which cause softening of host tissues. Calcium ions bind tightly to the pectins in the cell walls and produce cationic bridges between pectic acids and other acidic polysaccharides. These bridges make the cell walls less accessible to the action of pectolytic enzymes. Those are concord with apple [15, 16, 17], plum [5], guava [14, 18, 19], ber [20] and dragon fruit [21].

Plate 1: Fruits of apple cv. Royal Delicious from control plots with no treatment

Conclusion

On the basis of results obtained it can be concluded that preharvest foliar application of calcium on apple fruits cv. Royal Delicious were found best among the nutrients in terms of reducing the physiological loss in weight, decay and rotting percent. Thus three pre harvest foliar spray of $CaCl_2$ @ 0.6% is helpful for disease management, reducing the physiological loss in weight of apple during storage period.

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