Effect of Calcium formulations to increase yield and shelf life of Manjri Naveen Grapes

Abstract:

The investigation was carried out to know the effect calcium formulations to increase the shelf life of Manjri Naveen grapes. The experiment was designed as randomized block design (RBD) having seven treatments and 4 replication (1 replicate = 4 vines). Three calcium formulations were used i.e. $CaCl_2$, CaO, $Ca(No_3)_2$ as a dose of (2.5 g/l) and (5 g/l). Foliar application of calcium was done 10 days before harvest at veraison stage. Results obtained from the experiment showed the lowest weight loss was found in bunches of calcium oxide and calcium chloride spray treatments (8.14 %), (8.61 %) respectively, while the highest weight loss (10.36 %) occurred in untreated control. The PLW increased significantly at successive from 1.32 % on 1st day to 10.36 % on 7th day of storage at room temperature. CaO at 5 g/l recorded the lowest fallen berries 2.70 (%), followed by $Ca(NO_3)_2$ at 2.5 g/l recorded 3.38 (%). It is might be due to calcium accumulated mostly in the rachis and less in the flesh during grape berry development. Yield and quality components like bunch weight, berry weight, total yield/vine, TSS, TSS/Acidity ratio were significantly influenced by calcium spray. Foliar application of CaO at 5 g/l was found to be effective for increasing the shelf life and yield of Manjri Naveen grapes.

Key Words: PLW, Yield, Quality, Calcium

Introduction:

The grape (*Vitis vinifera* L.) is the most important crop grown in the world. Mostly it grown for making wines and preparation of raisin & then as a table fresh fruit. In India, it is mainly grown for table use. India's major grape growing states are Maharashtra, Karnataka, Andhra Pradesh, Telangana, and Tamil Nadu. Among the grape-growing states, Karnataka stands second in the area after Maharashtra.

Manjari Naveen is the clonal selection developed at ICAR- National Research Centre for Grapes, Pune, from Centennial Seedless. Normally the veraison start after 90 days from pruning and require 25 to 30 days for harvest. The fruit will be ready to harvest between 115 to 120 days after pruning being early maturing variety. But the ripe berries are sensitive to hot climates and keeping qualities (shelf life).To regulate the market supply and to reduce the losses, pre and - post-harvest applications with plant growth regulators, chemicals and wrappers have been useful, in extending the shelf life of grapes during storage, enabling to reduce post-harvest losses. (1). Grape quality depends on a variety of factors, including mineral nutrition and macro and micronutrients balance in the different parts of the grapevine. Calcium (Ca) is a nutrient considered important in determining the storage quality of fruit (2).

Calcium is an essential and major plant nutrient, and it is required in a variety roles, such as structural function in the cell wall and membranes, as a counter ion for inorganic and organic anions in the vacuole, as a cytoplasmic secondary messenger related to environmental or developmental stimuli to their physiological responses (3, 4). The effects of Ca application might also depend on the dose or chemical form, i.e., calcium chloride ($CaCl_2$) or calcium nitrate ($Ca(NO_3)_2$ (5). When the nitrate form is applied, nitrogen might interact with Ca or have an effect by itself (6). When chloride is applied an osmotic stress can be caused, if concentrations are high in spite of plants osmoregulatory mechanisms (7).

Calcium regulates the ripening of fruits and stimulates their colouring, ethylene production, and flesh firmness (8). Grapes with optimum Ca concentrations had improved fruit quality (9), and increase resistance to Botrytis cinerea and delayed senescence (10). It is an important component of the plant cell wall, and binds together the strands of pectin helping to maintain fruit firmness. Calcium binding to cell wall components may also reduce the accessibility of cell wall degrading enzymes to their substrates (11) and by this way storage and shelf life of fruits can be enhanced. Monitoring Ca absorption and accumulation in the fruit tissue is an effective approach to manage and improve fruit quality (12). Hence, the investigation was carried out to know the effect of calcium formulations to increase yield and shelf life of grapes.

Materials and Methods:

Experimental Site

The experiment was conducted at research and developmental vineyards of ICAR- National Research Centre of Grapes, Pune during the year 2020-2021. Pune is located in Midwest Maharashtra state (India) at an altitude of 559 m above the mean sea level. It lies in 18.32° N latitude and 73.51° E longitude. Twelve (12) year-old vines of Manjri Naveen grafted on 110-R rootstock were selected for the study. The vines were planted at a spacing of 2.5 m between rows and 1.2 m between vines within a row. The row orientation was in the direction of North – South. The vines were trained to double cordon Y system. The experiment was designed as randomized Block design (RBD) having Seven treatments and 4 replication (1 replicate = 4 vines). Application of calcium formulations were done 10 days before harvest at veraison stage.

Table no 1. Treatment Details:

Treatments	Treatment Details
T_1	$CaCl_2$ @ 2.5 g/l
T_2	$Ca(NO_3)_2$ @ 2.5 g/l
T_3	CaO @ 2.5 g/l
T_4	$CaCl_2$ @ 5 g/l
T_5	$Ca(NO_3)_2$ @ 5g/l
T_6	CaO @ 5g /l
T_7	Control

$CaCl_2$: Calcium chloride, $Ca(NO_3)_2$: Calcium nitrate, CaO : Calcium Oxide

Yield and Yield Components

Yield and berry quality of Manjri Naveen grapes were recorded at harvest. At harvesting stage parameters such as average bunch weight (g) was calculated from average weight of 15 bunches while yield per vine (kg) was recorded at the time of harvest. Randomly selected berries from bunches at harvest were used for 10 berry weight. To measure average berry length and berry diameter, 10 berries were selected randomly from different bunches from a given replication and were measured using Digital Vernier Caliper (0–300 mm RSK™) and were expressed in millimeter.

Biochemical Analysis

Total soluble solids (TSS) were measured using hand refractometer and expressed as degree Brix. Acidity was measured by titrating the sample with 0.1 N sodium hydroxide using phenolphthalein indicator. The total phenol and Tannins content of the berry were determined using the Folin- Ciocalteu method (13) using Catechol, as the standard. Total flavonoid content (TFC) was determined using the aluminum chloride assay described by (14). Total reducing sugar from berries was determined by Dinitro salicylic Acid (DNSA) method.

Physiological loss in weight (PLW):

The PLW was calculated on initial weight basis. The physiological loss in weight of bunch was recorded on the basis of initial fresh weight of the fruit and subsequent loss in weight occurred during postharvest storage and expressed as percentage value.

$$\textbf{PLW (\%)} = \frac{\text{Initial weight of fruit} - \text{Finial weight of fruit}}{\text{Initial weight of fruit}} \times 100$$

Fallen and Rotten Berries (%) :

Fallen and rotten berry percentage was recorded from each box by dividing the weight of fallen berries and total weight of packed bunch.

$$\textbf{Fallen berry (\%)} = \frac{\text{Weight of free berries inside each box}}{\text{Total bunch weight}} \times 100$$

$$\textbf{Rotten berries (\%)} = \frac{\text{Total weight of bunch} - \text{Bunch weight after removing defected Berries}}{} \times 100$$

Total weight of bunch

Statistical Analysis:

The experiment was conducted in randomized block design consisting of seven treatments with four replications. All calculations were performed using the GLM procedure of SAS System software, (version 9.3.)

Results and Discussion:

Yield and Quality parameters

Table 2 shows the yield and yield-attributing factors of Manjari Naveen, where significant changes were noted. The highest bunch weight (393.63 g), berry weight (3.56 g) and yield per vine (18.88 kg) were recorded with CaO @ 5 g/lit followed by its lower dose CaO @ 2.5 g/lit bunch weight (385.85 g), berry weight (2.88 g) and yield per vine (18.49 kg) while minimum bunch weight (342.69 g), berry weight (2.48 g) and yield per vine (13.04 kg) with untreated control. Calcium chloride and calcium nitrate treated plant showed the statistically at par result. Similar results were observed by (15) when calcium salts were sprayed, with calcium nitrate having a somewhat better effect than calcium chloride. The findings are opposite to the (5) they found no effects on strawberry yield, berry weight and berry sucrose content when adding $Ca(NO_3)_2$ as foliar and soil applications. The outcomes found in this investigation could be caused by the request a greater dose of Calcium Oxide in an increase in yield, berry weight, and cluster weight each vine. Calcium plays a pivotal role in developmental processes in plants ranging from the regulation of development of phytochrome to the regulation of stomatal guard cell by abscisic acid. Hence, calcium might have brought about changes in accumulation of food constituents in the fruit resulting in its increased weight (16).

Result in table 2 indicates that highest TA was found in T_4 followed by T_5 and T_1. Titratable acidity is directly related to the concentration of organic acids present in the fruit, which are an important parameter in maintaining the quality of fruits. TSS/ Acidity ratio showed the quality of grape. TSS/TA ratio was significantly decreased in calcium treated parameter in maintaining the quality of fruits. Lowest TSS/Acidity ratio was found in calcium chloride @ 5 g/L (T_4) treatment. Highest TSS were recorded in T_1 which is statistically at par with T_5. Whereas, the minimum total soluble solid content was recorded under control.

Table 2: Effect of Calcium on bunch and berry quality parameters of Manjri Naveen grapes.

Treatment	**Bunch Weight (g)**	**Berry Weight (g)**	**Berry diameter (mm)**	**Berry length (mm)**	**Pedicel thickness (mm)**	**TSS (°B)**	**Acidity (%)**	**TSS/Acidity Ratio (%)**	**Yield /Vine (kg)**
T1	355.12	3.24	16.63	23.83	1.69	19.77	0.63	31.38	17.68
T2	377.14	3.23	16.43	24.30	1.59	18.40	0.58	30.98	16.01

T3	385.85	2.88	16.50	23.17	1.50	19.10	0.60	32.04	18.49
T4	385.22	2.71	16.07	23.80	1.67	18.70	0.68	27.52	15.81
T5	381.57	2.87	16.33	24.21	1.42	18.97	0.66	28.76	17.44
T6	393.63	3.56	16.60	23.80	1.47	19.33	0.56	34.51	18.88
T7	342.69	2.48	16.17	22.97	1.78	18.07	0.57	32.17	13.04
SEm (±)	**10.64**	**0.26**	**0.31**	**0.31**	**0.10**	**0.34**	**0.01**	**0.99**	**1.07**
C.D @ 5 %	**33.15**	**0.78**	**0.95**	**0.93**	**0.3**	**1.04**	**0.03**	**3.07**	**3.34**

Biochemical parameters

The data recorded on biochemical changes of Manjri Naveen vines were presented in Table 3. The result obtained from the study revealed that the application of calcium at different concentration does not affect the phenolic properties of berry. This result might be just due to the time of application of calcium and its chemical properties. Calcium is applied to increase the shelf life of grapes at pre veraison stage. The result in hand confirm the finding of (17) reported that white Superior Seedless table grapes stored for 7 days at 0 ^{0}C, followed by 4 days at 8 ^{0}C under modified atmosphere packaging, did not change their total phenolic content. Further slight decreases were seen during their subsequent shelf-life.

Table 3: Effect of Calcium on biochemical parameters of Manjri Naveen Grapes

Treatment	**Phenol (mg/g)**	**Tannin (mg/g)**	**Flavonoids (mg/g)**	**Reducing Sugar (mg/g)**
T1	1.95	0.99	77.18	263.07
T2	2.39	0.84	81.13	268.73
T3	2.78	2.14	77.00	243.43
T4	1.87	1.30	76.18	282.61
T5	2.42	1.13	78.47	241.09
T6	2.38	1.03	79.66	216.11
T7	1.85	0.69	75.99	200.00
SEm (±)	**0.25**	**0.12**	**3.03**	**14.36**
C.D @ 5 %	**0.77**	**0.37**	**NS**	**44.73**

Physiological loss in weight (PLW %)

The data on physiological loss in weight (PLW %) of grapes bunches an influenced by the pre- harvest treatments of calcium are presented in table 4. Weight loss is an easy and objective measure often used for valid evaluation of the response of horticultural commodities to treatments (18). In the current study, calcium application and storage duration significantly influenced weight loss of grapes. At the end of storage, the lowest weight loss was found in bunches of calcium oxide and calcium chloride spray treatments (8.14 %), (8.61 %) respectively while the greatest weight loss (10.36 %) occurred in untreated control (table 2). CaO at 5 g/l recorded the lowest fallen berry (%) of 2.70 (%) which was on par with its lower dose i.e. CaO at 2.5 g/l (3.38 %). The results obtained from this study might be due to the calcium sprays markedly retarded the weight loss of clusters, most probably owing to its protective effects on cell wall. While working on calcium formulations, (19) reported that calcium, as a constituent of the cell wall, plays an essential role in forming cross-bridges which influence cell wall strength and is regarded as the last barrier before cell separation. Studies revealed that pre-harvest calcium treatment increases tissue firmness in perishable horticultural produces (20, 21). The postharvest life of table grape is limited by quality deterioration between harvest and retail, mainly due to weight loss, rachis desiccation and accelerated softening and senescence (22). (16) Observed the same in litchi fruit that calcium chloride and boric acid positively improved the storage life of litchi.

Table 4: Effect of Calcium on Shelf life of Manjri Naveen Grapes at 7th day after storage

Treatment	PLW (%)	Fallen Berry (%)	Rotten Berry (%)

T1	8.61	5.83	4.11
T2	9.37	6.49	3.23
T3	8.36	3.38	2.36
T4	8.67	4.64	5.26
T5	9.81	5.55	3.63
T6	8.14	2.70	0.83
T7	10.36	8.30	7.35
SEm (±)	**0.30**	**0.27**	**0.47**
C.D @ 5 %	**0.95**	**0.84**	**1.47**

Fig. No. 1: Effect of Calcium Formulations on Shelf Life of grapes

Correlations between different Parameters

The positive and negative correlations between different morphological and biochemical parameters due to the use of different concentrations of Calcium formulations presented in table 5. Among all parameters, bunch weight has the strongest correlation with yield per vine. Total acidity was negatively correlated with TSS. Berry length had a significant positive relationship with berry weight and bunch weight. PLW (%) correlated positively with fallen and rotten berry (%).

	Bunch Weight (g)	Berry Weight (g)	Berry diameter (mm)	Berry length (mm)	Yield /Vine (kg)	TSS (°B)	Acidity (%)
Bunch Weight (g)	1						
Berry Weight (g)	0.437	1					
Berry diameter (mm)	0.164	0.826	1				
Berry length (mm)	0.417	0.526	0.184	1			
Yield /Vine (kg)	0.689	0.712	0.748	0.324	1		
TSS (°B)	0.268	0.627	0.746	0.218	0.836	1	
Acidity (%)	0.163	-0.341	-0.417	0.337	0.061	-0.198	1
TSS/Acidity Ratio (%)	-0.073	0.514	0.657	-0.367	0.253	0.204	-0.903
PLW (%)	-0.617	-0.624	-0.548	-0.080	-0.787	-0.720	-0.030
Fallen Berry (%)	-0.722	-0.792	-0.342	-0.727	-0.520	-0.275	-0.062
Rotten Berry (%)	-0.774	-0.825	-0.742	-0.384	-0.908	-0.595	-0.237

Table 5: Correlations between different parameters

Conclusion:

Among the different pre-harvest treatments of calcium formulations (calcium chloride, calcium nitrate and calcium oxide), Calcium oxide and calcium chloride positively improved the storage life and yield of grapes. Hence, from this study, it is concluded that calcium oxide @5 g/lit and calcium chloride @2.5 g/lit recommended as pre- harvest spray to maintain quality of berry during postharvest storage.

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