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Study on the effect of pre harvest sprays of calcium chloride and organic acids on yield and shelf life of grape (*Vitis vinifera* L.) cv. thompson seedless

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Abstract
A study titled effect of pre harvest sprays of calcium chloride and organic acids on yield and shelf life of grape (*Vitis vinifera* L.) cv. Thompson Seedless was conducted on 2023-2024 at Grape Research Station, Rajendranagar, Hyderabad. The research aimed to access the effect of calcium chloride and organic acids on yield and shelf life of grape (*Vitis vinifera* L.) cv. Thompson Seedless. The experiment followed a Randomized Block Design (RBD). Notably the study found that pre harvest sprays of fruits with calcium chloride T_2 - $CaCl_2$ @ 1.0% recorded highest berry length (19.55 mm), berry diameter (14.25 mm), number of berries per bunch (102.3), average berry weight (2.23 g), average bunch weight (205.80 g), number of bunches per vine (55.67) and yield (11.46 kg/vine) compared to other treatments. The results on physical parameters revealed that, among all the treatments T_2 - $CaCl_2$ @ 1.0% recorded lowest physiological loss in weight on 1st day (0.96%), 3rd day (3.59%), 5th day (9.04%), 7th day (15.92%), 9th day (27.92%) of storage and lowest decay (%) on 1st day (0%), 3rd day (2.18%), 5th day (6.47%), 7th day (14.93%), 9th day (29.33%) of storage. Among all the treatments T_2 - $CaCl_2$ @ 1.0% recorded highest shelf life (8.00 days). From this study it can be concluded that among all the treatments T_2 - $CaCl_2$ @ 1.0% recorded significantly highest berry and yield parameters, lowest physiological loss in weight and decay (%) and highest shelf life (days).

Keywords: Calcium chloride, ascorbic acid, oxalic acid, berry, yield and shelf life.

Introduction
Grape is one of the significant fruit crops in the Vitaceae family. Every grape that is grown belongs to the genus Muscadinia (2n = 40 chromosomes) or Vitis (2n = 38 chromosomes) and Asia Minor is the place where grapes first appeared. Grape is a highly perishable, non-climacteric fruit and the quality of fruit is affected by a variety of biotic and abiotic factors (Yahia et al., 2019) [26]. Thompson Seedless is the most widely used table grape cultivar for export market among the white seedless cultivars. The homogeneity of the colour as well as the size and shape of the berries and clusters, determine its market value. It is considered as a highly perishable cultivar and also bunches rapidly lose their quality after harvesting (Loay, 2007) [16]. Pre-harvest sprays of calcium chloride enhance fruit quality and reduces the need for fungicide sprays during the harvest season by strengthening the fruit resistance to brown rot in grapes (Conway et al., 1994) [5]. It also keeps the cells that synthesize proteins intact reducing the rate of respiration, protein breakdown, disease incidence and also calcium compounds prolong the shelf life of fruits (Conway and Sams, 1985) [4]. Ascorbic acid is a natural antioxidant which plays an important role in improving growth, reducing browning, increasing storage period and productivity of fruits (KasS.Em et al., 2011) [18]. It contributes to a variety of developmental activities, such as cell wall expansion and division, which enhance plant growth, photosynthesis, and crop yield (Foyer and Pignocchi, 2003) [7]. In addition to being a potential anti-browning agent, oxalic acid, a metabolic product of plants, has also been demonstrated to be a naturally occurring antioxidant for the artificial preservation of oxidized materials (Kayashima and Katayama, 2002) [14]. This antioxidant can reduce enzymatic browning, control postharvest infections of fruits, and delay aging (Zheng and Brecht, 2017) [27]. The application of oxalic acid

shown to induce systematic resistance against diseases caused by bacteria, fungi or viruses to affect antioxidant systems in plants (Malencic et al., 2004) [17]. Previously, numerous attempts have been made to extend the yield and storage life of grapes with the use of pre- harvest sprays of chemicals like GA3, ethephon (Ibrahim and Gaser, 2005) [10]. However, limited information is available regarding the effect of pre harvest application of calcium chloride sprays and organic acids like ascorbic acid and oxalic acid on fruit yield and shelf life of Thompson Seedless grapes.

Materials and Methods

The experiment was conducted during the year 2023-24 at Grape Research Station, Rajendranagar, Hyderabad, Telangana. The experimental site comes under S.Emi-arid tropical climate located at an altitude of 542.8 m above sea level at latitude of 17.87° N and longitude of 79.01° E with an average rainfall of 614.9 mm. The field experiment was laid out in randomized block design (RBD) with three replications i.e. T_1 - $CaCl_2$ @ 0.5%, T_2 - $CaCl_2$ @1.0%, T_3 - $CaCl_2$ @ 1.5%, T_4 - Ascorbic acid @ 500 ppm, T_5 - Ascorbic acid @ 700 ppm, T_6- Ascorbic acid @ 900 ppm, T_7 - Oxalic acid @ 3 mM, T_8 - Oxalic acid @ 5 mM, T_9 - Oxalic acid @ 7 mM, T_{10} - Control (water spray). Data on berry length (mm), berry diameter (mm), number of berries per bunch, average berry weight (g), average bunch weight (g), number of bunches per vines, yield (kg/vine), physiological loss in weight (%), decay (%) and shelf life (days) were recorded and subjected to statistical analysis, the test of significance (F-test) and critical difference (C.D.) at 0.05 probability (Panse and Sukhatme 1985) [19].

Results and Discussion

A. Berry and Yield parameters

Berry length (mm): The data revealed that there was significant variation among treatments with respect to berry length. The highest berry length was observed with T_2 - $CaCl_2$ @ 1.0% (19.55 mm) which was on par with T_3 - $CaCl_2$ @ 1.5% (19.26 mm) and T_6 - AA @ 900 ppm (18.73 mm) followed by T_1 - $CaCl_2$ @ 0.5% (17.96 mm). Significantly lowest berry length (15.34 mm) was noted with T_{10} - Control. The increase in berry length might be due to the calcium chloride ($CaCl_2$) involving in binding up cell to cell by the action of calcium pectate causing optimal increase in cell elongation and division (Vidya et al., 2014) [24], which might have further helped in increasing surface area resulting in more berry length (Kumar et al., 2005). Similar results were reported by Marzouk and Kaseem (2011) [18] and El Abassi et al. (2015) [6] in Thompson Seedless grape.

Berry diameter (mm): A critical examination of data stated that all the treatments had significant effect on berry diameter. Highest berry diameter was noted with T_2- $CaCl_2$ @ 1.0% (14.25 mm) which was on par with T_3 - $CaCl_2$ @1.5% (13.96 mm) and T_6 - AA @ 900 ppm (13.64 mm) followed by T_8 - OA @ 5 mM (13.01 mm). T_{10} - Control (11.36 mm) recorded significantly lowest berry diameter. The increase in berry diameter might be due to involvement of $CaCl_2$ 1% in forming cross bridges and influencing cell wall strength causing optimal increase in the surface area resulting in more berry diameter and volume (Marzouk and Kaseem, 2011) [18].

Number of berries per bunch: The data revealed that there was significant variation among the treatments with respect to number of berries per bunch. The highest number of berries per bunch (102.3) was noted with T_2 - $CaCl_2$ @ 1.0% which was on par with T_3 - $CaCl_2$ @ 1.5% (97.0) followed by T_6 - AA@ 900 ppm (89.0). And the lowest number of berries per bunch (67.7) was recorded with T_{10} - Control. The difference in those attributes among the treatments may be affected by variety, size of the berry, volume of the berry and also environmental conditions (Joshi et al. 2015) [11]. Marzouk and Kaseem (2011) [18] reported similar observations in grape.

Average berry weight (g): Results indicated that there was a significant difference among the treatments with respect to average berry weight (g). Highest average berry weight was recorded with T_2 - $CaCl_2$ @ 1.0% (2.23 g) which was on par with T_3 - $CaCl_2$ @ 1.5% (2.15 g), T_6 - AA@ 900 ppm (2.03 g) followed by T_8 - OA @ 5 mM (1.94 g). Significantly lowest berry weight was noted with T_{10} - Control (1.61 g). The persistent increase in berry weight by $CaCl_2$ @ 1.0% might be due to calcium chloride promoting cell division and optimal increase in water uptake which might have helped in increasing the berry weight (Marzouk and Kaseem, 2011) [18].

Average bunch weight (g): A perusal of data revealed that there was a significant difference among the treatments on average bunch weight. Treatment T_2 - $CaCl_2$ @ 1.0% recorded highest average bunch weight (205.80 g) which was on par with T_3 - $CaCl_2$ @ 1.5% (198.67 g) followed by T_6 - AA @ 900 ppm (198.00 g). Treatment T_{10}- Control (158.50 g) recorded lowest average bunch weight significantly. The highest average bunch weight with $CaCl_2$ @ 1.0% (T_2) might be due to increased productivity due to the decrease of abscission (Kumar et al., 2005) [15] and the calcium might have involved in maintaining the middle lamella of cells and also for enlargement and division of cells, leading to an increase in fruit weight and volume, which are directly proportional to fruit weight (Sankar et al., 2013). The results of this investigation can be compared to those obtained by Wahdan et al. (2011) [25] in mango, Amiri et al. (2009) [1] in 'Asgari' grape and Kaseem et al. (2011) [18] in Flame Seedless grape.

Number of bunches per vine: Significantly treatment T_2 - $CaCl_2$ @ 1.0% (55.67) recorded highest number of bunches per vine and was on par with T_3 - $CaCl_2$ @ 1.5% (51.33) followed by T_6 - AA @ 900 ppm (50.67). Significantly lowest number of bunches per vine (41.67) was recorded with T_{10} - Control. The total number of bunches on each vine might be varied due to soil and nutrition, weather and climate, age and health of the vine. Similar observations were reported by Kaseem et al. (2011) [18] and El Abassi et al. (2015) [6] in grape.

Yield (kg/vine): The data revealed that there was significant variation among treatments with respect to yield (kg/vine). The treatment T_2 - $CaCl_2$ @ 1.0% (11.46 kg/vine) noted highest yield per vine followed by T_3 - $CaCl_2$ @ 1.5% (10.20 kg/vine) and superior to other treatments. Significantly lowest yield (6.61 kg/vine) was recorded with T_{10} - Control. The persistent increased yield might be due calcium chloride helping in the growth, yield, metabolism, structural development of the fruit and physiology of crops (Swathi et al., 2019) [23]. Also, the yield per vine is directly correlated with the bunch weight and number of bunches per vine. Similar findings were also reported by Marzouk and Kaseem (2011) [18], Bonomelli and Ruiz (2010) [3] in Thompson Seedless grape and Amiri et al. (2009) [1] in Asgari grape.

Table 1: Effect of pre harvest sprays of calcium chloride and organic acids on berry length (mm), berry diameter (mm), number of berries per bunch, average berry weight (g), average bunch weight (g), number of bunches per vines and yield (kg/vine) of grape (*Vitis vinifera* L.) cv. Thompson Seedless

Treatments	Berry length	Berry diameter	Number of berries per bunch	Average berry weight	Average bunch weight	Number of bunches per vine	Yield
T_1- $CaCl_2$ 0.5%	17.96bcd	12.97bc	84.3cd	1.90cd	194.90bcd	48.67bcde	9.48bc
T_2- $CaCl_2$ 1.0%	19.55a	14.25a	102.3a	2.23a	205.80a	55.67a	11.46a
T_3- $CaCl_2$ 1.5%	19.26ab	13.96ab	97.0ab	2.15ab	198.67ab	51.33ab	10.20b
T_4- AA 500 ppm	17.31cde	12.34def	77.7de	1.79de	185.33d	46.67cd	8.65d
T_5- AA 700 ppm	17.15de	12.09def	77.3de	1.71de	169.23e	45.67de	7.73e
T_6- AA 900 ppm	18.73abc	13.64abc	89.0bc	2.03abc	198.00b	50.67bc	10.03b
T_7- OA 3 mM	16.35ef	11.78ef	70.03e	1.66e	175.33e	44.67de	7.82e
T_8- OA 5 mM	17.82bcd	13.01bcd	85.7cd	1.94bcd	195.63bc	49.00bcd	9.59bc
T_9- OA 7 mM	17.41cde	12.70cde	82.0cd	1.82cde	190.00cd	48.00bcde	9.12cd
T_{10} - Control	15.34f	11.36f	67.7e	1.61e	158.50f	41.67e	6.61f
S.Em ±	0.52	0.35	3.64	0.07	2.60	1.53	0.26
C.D at 5%	1.56	1.06	10.82	0.23	7.75	4.56	0.79

B. Physical parameters

Physiological loss in weight (%): The data revealed that there was significant variation among treatments with respect to physiological loss in weight (%). T_2 - $CaCl_2$ @ 1.0% recorded lowest physiological loss in weight on 1st day (0.96%), 3rd day (3.59%), 5th day (9.04%), 7th day (15.92%), 9th day (27.92%) of storage whereas highest physiological loss in weight was recorded in T_{10} - Control on 1st day (1.64%), 3rd day (5.49%), 5th day (15.41%), 7th day (25.24%), 9th day (41.83%). The decrease in physiological loss in weight by calcium chloride might be due to involvement of calcium in preventing the weight loss by preserving the optimal fruit firmness, slowing the respiratory rate and delaying senescence (Purohit et al., 2019) [20]. Also, calcium forming cross-bridges and ionic bridges within and between pectic polysaccharides might have resulted in formation of firmer fruits (Huang et al., 2005) [9].

Table 2: Effect of pre harvest sprays of calcium chloride and organic acids on physiological loss in weight (%) of grape (*Vitis vinifera* L.) cv. Thompson Seedless

Treatments	Physiological loss in weight (%)				
	Day 1	Day 3	Day 5	Day 7	Day 9
T_1- $CaCl_2$ 0.5%	1.10cde	4.05efg	9.99e	16.97de	29.26ef
T_2- $CaCl_2$ 1.0%	0.96e	3.59g	9.04e	15.92e	27.92f
T_3- $CaCl_2$ 1.5%	1.05de	3.76fg	9.72e	16.46de	28.78ef
T_4- AA 500 ppm	1.33bc	4.61bcd	13.02bc	19.00c	34.46bcd
T_5- AA 700 ppm	1.38ab	4.71bc	13.70b	19.34bc	37.09bc
T_6- AA 900 ppm	1.25bcd	4.14def	11.15d	17.82cd	31.92de
T_7- OA 3 mM	1.42ab	4.96b	13.92b	21.07b	38.30ab
T_8- OA 5 mM	1.28bcd	4.33cde	11.89d	17.91cd	32.57de
T_9- OA 7 mM	1.32bcd	4.53bcde	12.13cd	17.96cd	33.84cd
T_{10} - Control	1.64a	5.49a	15.41a	25.24a	41.83a
S.Em ±	0.09	0.16	0.34	0.63	1.30
C.D at 5%	0.28	0.48	1.03	1.88	3.87

Decay (%): The data revealed that there was significant variation among treatments with respect to decay (%). T_2 - $CaCl_2$ @ 1.0% recorded lowest decay (%) on 1st day (0%), 3rd day (2.18%), 5th day (6.47%), 7th day (14.93%), 9th day (29.33%) whereas significantly highest decay (%) was recorded in T_{10} - Control on 1st (0%), 3rd day (4.46%), 5th day (11.81%), 7th day (22.31%), 9th day (43.72%). This might be due to calcium chloride helps in maintaining the cell wall components by binding the carboxyl groups of pectic homogalacturonan, which have might have further resulted in the cell wall becoming more resistant to hydrolytic enzymes produced by decay organisms. It also might be due to formation of ionic bridges between and within pectic polysaccharides by calcium resulting in the formation of firmer fruit (Huang et al., 2005) [9]. Similar results were reported by El Abbasy et al. (2015) [6] in Thompson Seedless grape.

Table 3: Effect of pre harvest sprays of calcium chloride and organic acids on decay (%) of grape (*Vitis vinifera* L.) cv. Thompson Seedless

Treatments	Decay (%)				
	Day 1	Day 3	Day 5	Day 7	Day 9
T_1- $CaCl_2$ 0.5%	-	3.10e	7.81e	16.47cd	30.30fg
T_2- $CaCl_2$ 1.0%	-	2.18g	6.47f	14.93e	29.33g
T_3- $CaCl_2$ 1.5%	-	2.39g	7.12ef	16.11de	29.70fg
T_4- AA 500 ppm	-	3.88cd	10.55bc	17.89b	33.59d
T_5- AA 700 ppm	-	4.01bc	10.97abc	18.15b	36.41c
T_6- AA 900 ppm	-	2.76f	9.10d	16.96bc	31.19ef
T_7- OA 3 mM	-	4.20ab	11.25ab	18.23b	39.08b
T_8- OA 5 mM	-	3.66d	10.28c	17.41bc	32.07de
T_9- OA 7 mM	-	3.76cd	10.44bc	17.64bc	32.95d
T_{10} - Control	-	4.46a	11.81a	22.31a	43.72a
S.Em ±		0.10	0.30	0.45	0.53
C.D at 5%		0.31	0.89	1.36	1.58

Shelf life (days): Significant difference among the treatments on shelf life of grape was observed from the data. Highest shelf life (8.00 days) was recorded with T_2 - $CaCl_2$ (1.0%) which was on par with T_3 - $CaCl_2$ @ 1.5% (7.86 days) followed by T_1 - $CaCl_2$ @ 0.5% (7.33 days). Significantly lowest shelf life was noted with in T_{10} - Control (5.50 days). The data shows that the highest shelf life (8.00 days) was recorded with $CaCl_2$ (1.0%) (T_2). This increase in shelf life of grape by calcium chloride might be due to reason that it might have helped in lowering ethylene production (Babak and Majid, 2011) [2], decreasing the respiration rate and thereby improving the shelf life. (Sakhale et al., 2009) [21]. It might also be due to involvement of calcium in enhancing fruit firmness which might have led to slower hastening and increase in shelf-life. Similar observations were reported by Marzouk and Kaseem (2011) [18] and Hazarika and Marak (2022) [8] in grape, Karemera et al. (2014) [12] and Vidya et al. (2014) [24] in mango.

Table 4: Effect of pre harvest sprays of calcium chloride and organic acids on shelf life (days) of grape (*Vitis vinifera* L.) cv. Thompson Seedless

Treatments	Shelf life (days)
T_1- $CaCl_2$ 0.5%	7.33b
T_2- $CaCl_2$ 1.0%	8.00a
T_3- $CaCl_2$ 1.5%	7.86ab
T_4- AA 500 ppm	6.79cd
T_5- AA 700 ppm	6.45d
T_6- AA 900 ppm	7.05bc
T_7- OA 3 mM	6.53d
T_8- OA 5 mM	6.96bcd
T_9- OA 7 mM	6.80cd
T_{10} - Control	5.50e
S.Em ±	0.17
C.D at 5%	0.51

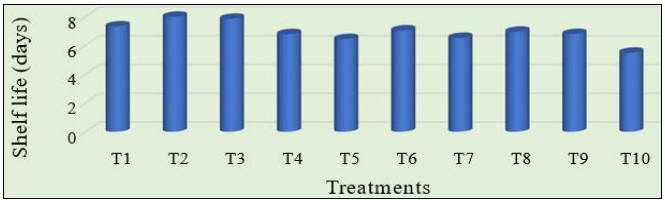

Fig 1: Effect of pre harvest sprays of calcium chloride and organic acids on shelf life (days) of grape cv. Thompson Seedless

T_1 - $CaCl_2$ (0.5%)	T_4 - AA (500 ppm)	T_7 - OA (3 mM)	T_{10} - Control
T_2 - $CaCl_2$ (1.0%)	T_5 - AA (700 ppm)	T_8 - OA (5 mM)	
T_3 - $CaCl_2$ (1.5%)	T_6 - AA (900 ppm)	T_9 - OA (7mM)	

Conclusion

Based on the data acquired it can be concluded that Preharvest sprays of T_2 - $CaCl_2$ @ 1.0% and T_3 - $CaCl_2$ @ 1.5% were found to be best for obtaining higher berry and yield parameters, physical parameters and shelf life (days).

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