IJAAR 6 (2018) 116-121 ISSN 2053-1265

International Journal of Advance Agricultural Research
www.bluepenjournals.org/ijaar

Micronized calcite treatment enhances cluster and berry quality of 'Crimson Seedless' grapes

Sevil Unal[1], Ömer Faruk Bilgin[1], Ferhan Sabir[2] and Ali Sabir[2]*

[1]Selcuk University Graduate School of Natural and Applied Science, 42075, Konya, Turkey.
[2]Selcuk University Agriculture Faculty Horticulture Department, 42075, Konya, Turkey.

Article History
Received 02 November, 2018
Received in revised form 21 November, 2018
Accepted 28 November, 2018

Keywords:
Table grape,
Crimson Seedless,
Calcium treatment,
Quality improvement.

Article Type:
Full Length Research Article

ABSTRACT

Crimson Seedless is one of the globally popular table grape cultivars with its sweet, crispy, seedless and pink berries. This cultivar with its attractive clusters is commonly stored after harvest and its postharvest quality has been a subject of many studies. In the present study, clusters and leaves of soilless grown 'Crimson Seedless' cultivar were sprayed with calcium in micronized calcite form to improve its quality under protected cultivation. Micronized calcite spray of developing green berries along with the leaves noticeably improved the cluster and berry sizes of 'Crimson Seedless' table grapes. In particular, berry detachment force (19.8% increase) and skin rupture force (13.1% increase) were enhanced by calcite spray without impairment in grape maturity process. Findings implied that micronized calcite treatment might be a sustainable practice to improve the harvest quality and to extend postharvest life of table grapes on the face of ever-increasing climate change.

INTRODUCTION

Grapes (*Vitis vinifera* L.) are one of most important crops in the world. The size, color, firmness, chemical and mineral composition of grape berries are key parameters determining the market quality, postharvest life and price of grapes. Mineral composition of fruits is directly related to the harvest quality, transport endurance and resistance to postharvest disorders (Dris and Niskanen, 1996). Among the mineral nutrients, calcium (Ca) has an essential role in affecting the market and storage quality of fruits (Peryea and Neilsen, 2006). This is why Ca fertilization has become as one of standard practices in certain countries for table grapes (Bonomelli and Ruiz, 2013) and apples (Jackson 2003), even if the Ca soil supply is mostly suitable. Ca, as one of the essential major plant nutrients, is required as a divalent cation (Ca^{+2}) in many roles, such as structural function in the plant or fruit cell wall and membranes. It is also 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 (Sugimura et al., 1999; White, 2001). Fruit may be calcium-deficient as the xylem vasculature in fruit undergoes a progressive dysfunction during the season (Drazeta et al. 2001).

While fruits or berries are growing, a continuous Ca absorption by roots is needed as indicated by Ferguson and Watkins (1983). However, Ca absorbed by plant roots might not be necessarily available for the use in the fruit, because a large amount might get tightly bound in solid structural tissue (Saure, 2005). Furthermore, if Ca is sprayed directly to fruits its penetration into the fruit tissue may be very low, as it will depend on cuticle presence and epidermis characteristics which affect the permeability (Wojcik, 2001). Besides, chemical form, i.e. calcium nitrate [Ca(NO3)2] or calcium chloride (CaCl2)as globally common forms, has direct influence on availability of Ca in fruit tissue. As stated by Swietlik, (2006), nitrogen could interact with Ca or have an effect by itself when the nitrate form is applied. On the other hand, when chloride form is used an osmotic stress can be caused (Lea-Cox

*Corresponding author. E-mail: asabir@selcuk.edu.tr.

and Syvertsen, 1993). For this reason, there are contradictory findings on the effect of Ca applications on fruits among the researchers. Recently, micronized calcium produces are promoted as alternative sources, characterized by a high absorption capacity (Sabir et al. 2012), although experimental data regarding quality response of table grapes to preharvest calcium application is relatively insufficient. Therefore, this study was conducted to investigate the effect of calcium fertilizer (in micronized calcite form) sprays on cluster and berry quality of 'Crimson Seedless' table grapes. In particular, berry hardness and skin color properties were evaluated because this cultivar frequently experiences weak coloration and hairline cracking in subtropical climate.

MATERIALS AND METHODS

Cultivation conditions

The study was conducted at the research and implementation glasshouse (38° 01.814 N, 032° 30.546 E, 1158 m above sea level) of Selcuk University, Turkey, in 2017. 'Crimson Seedless' table grape cultivar was selected for the study due to its extensive cultivation worldwide. Four years old vines, grafted on drought tolerant rootstock Richter 99 (V. berlandieri × V. rupestris) (Carbonneau, 1985), were individually cultivated in approximately 70 L (solid volume) pots containing the substrate prepared with sterile peat (1.034% N, 0.94% P_2O_5, 0.64% K_2O, Klassman®) and perlite mixture in equal volume. The experimental vines were in equal vegetative development size with single vertical arm and six canes (one year old shoots). At the beginning of the study, the vines were winter pruning leaving three buds on each cane. A total of six to eight summer shoots per vine were allowed to grow during the study. The vine arm and shoots were tied with thread to wires established about 2.2 m above the ground to let the plants grow on a fence in an upright position, thus ensuring equal benefit from the light. The vines were drip irrigated using one irrigation line for each row equipped with single emitter of 4 L h^{-1} each vine. At the beginning of the study, twelve healthy vines per treatment (four vines for each of three replicates) were selected on the basis of homogeneity in growth.

Experimental design

In order to study the effect of foliar and cluster spraying of calcium on cluster and berry quality attributes of 'Crimson Seedless' an experiment was conducted under glass house condition. For calcium source, micronized calcite product [$CaCO_3$ (40%), SiO_2 (4%), MgO (1%), and Fe_2O_3 (1%)] at 0.5% concentration (Kara and Sabir, 2010) was applied to green clusters and leaves for two times (one berry set when the berries attain 2.0-3.0 mm width) and two fifteen days after berry set). Vines belonging to control group did not receive calcite treatment.

Measurements and analyses

Fifteen clusters representing each treatment (at least one cluster per experimental vine) were used at the commercial maturity when all the experimental vines attain at least 19° Brix juice total soluble solid. Length and diameter of the clusters were determined with using ruler. Cluster weight (g) and berry weight (g) were obtained using digital scales. Length and the diameter of the berry were measured with digital caliper. Vine yield was obtained by simply multiplying the number of clusters per plant and the average number of clusters to estimate the indirect effect of treatment on yield.

Skin color

Skin color of sixty berries collected form fifteen clusters as indicated in OIV (1983) was recorded per treatment using a colorimeter (Minolta® CR-400) to obtain the following variables from two equatorial points of berries: L* (lightness), C (chroma) and h° (hue). Lightness values may range from 0 (black) 100 (white). Chroma indicates the purity or intensity of color, the distance from gray (achromatic) toward a pure chromatic color and is calculated from the a* and b* values of the CIE Lab scale system, starts from zero for a completely neutral color, and does not have an arbitrary end, but intensity increases with magnitude. Hue refers to the color wheel and is measured in angles; green, yellow and red correspond to 180, 90 and 0°, respectively (McGuire, 1992; Peppi et al. 2006).

Skin rupture and berry detachment forces

Thirty representative berries were randomly taken from the top, middle, and bottom of clusters of each replicates. For skin rupture force, a berry was cradled in a jig attached to a force gauge (DPS-11; Imada, Northbrook, IL) and the gauge was gently pulled away from the berry until the skin puncture. The force required to puncture the skin of berry was recorded as the skin rupture force. For berry detachment force, a berry from each section was then cradled in a jig attached to a force gauge and the rachis section was slowly pulled away from the berry until it detached from the pedicel (rachis). The force required to detach each berry from the rachis in N (Newton)-force was recorded as the BDF (Fidelibus et al. 2007).

Chemical analyses of berry juice (must)

Juice from the randomly gathered berries was extracted

Table 1. Changes in cluster growth in response to calcium spray.

	Cluster weight (g)	Cluster diameter (cm)	Cluster length (cm)
Control	205.0±11.8 b	11.7±1.1 b	16.5±1.2 b
Calcite	239.3±7.5 a	14.7±1.6 a	19.0±0.8 a
% change	14.3	20.3	13.2
LSD (%5)	*22.45*	*1.86*	*2.22*

All values are means ± standard error. Levels not connected by same letter are significantly different at 5% level by LSD.

Table 2. Changes in berry growth in response to calcium spray.

	Berry weight (g)	Berry diameter (mm)	Berry length (mm)
Control	2.34±0.02 b	14.0±0.04 b	19.4±0.16 b
Calcite	2.69±0.08 a	14.9±0.60 a	20.4±0.34 a
% change	13.3	6.1	4.7
LSD (%5)	*0.13*	*0.38*	*0.61*

All values are means ± standard error. Levels not connected by same letter are significantly different at 5% level by LSD.

with a hand press and filtered through cheesecloth and the supernatants were collected for juice analysis. SSC (°Brix) was determined with a hand-held temperature compensated refractometer (Atago 9313). TA was quantified by titrating 10 mL of the homogenized berry flesh juice (must) with 0.1 N NaOH to an endpoint of pH 8.1 and expressed as the percentage of tartaric acid (Cefola et al., 2011). Maturity index (MI) was obtained with soluble solid content/acid content while pH was taken by means of a pH-meter (GLP21+, Crison Instruments, Spain). All assays were performed in triplicate.

Statistical analysis

The collected data were subjected to statistical analysis using a randomized factorial design. The mean values were compared using the least significant difference (LSD) test. Statistical tests were performed at $P<0.05$ using SPSS 13.0 for Windows (SPSS Inc., Chicago, IL, USA). Mean values ± standard errors have been displayed in tables.

RESULTS AND DISCUSSION

Weight, diameter and length of clusters were significantly increased by micronized calcite spray (Table 1). Calcite treatment resulted in 14.3, 20.3 and 13.2% enhancements in weight, diameter and length of the clusters, respectively. In our previous study, leaf treatment of micronized calcite resulted in significant increases in cluster weight of nine-year-old 'Narince' wine grape cultivar under vineyard condition (Sabir et al. 2014). In contrast, Bonomelli and Ruiz (2010) found no significant effect of calcium used as 1% $CaCl_2$ on cluster weight of 'Thompson Seedless' grapes in Chile. Such contradictory findings can be due to the genotypic or geographical differences as well as Ca source used by researchers.

Berry size is one of the most important quality parameters affecting market value and cumulative yield in grapes (Bonomelli and Ruiz 2010). As illustrated in Table 2, weight, diameter and length of the berries significantly increased with calcite treatment. Berry weight increased from 2.34 g to 2.69 g with a 13.3% improvement. There were also 6.1 and 4.7% enhances in diameter and length of the berries due to calcite treatment. Using $Ca(NO_3)_2$ form, Lanauskas et al. (2006) found no significant effects of foliar and soil Ca treatment on fruit weight of strawberry.

'Crimson Seedless' grape cultivar has been become a worldwide popular table grape with its crispy and sweet berries. In the present study, the grape berry juice (must) has attained its unique high SSC value, but the calcite treatment did not significantly affected as presented in Table 3. TA and pH values were also not significantly affected by calcite treatment. These findings indicated that micronized calcite did not impair maturity characteristics of grapes.

Table 4 disseminates the changes of different color coordinates as influenced by the calcite treatment.

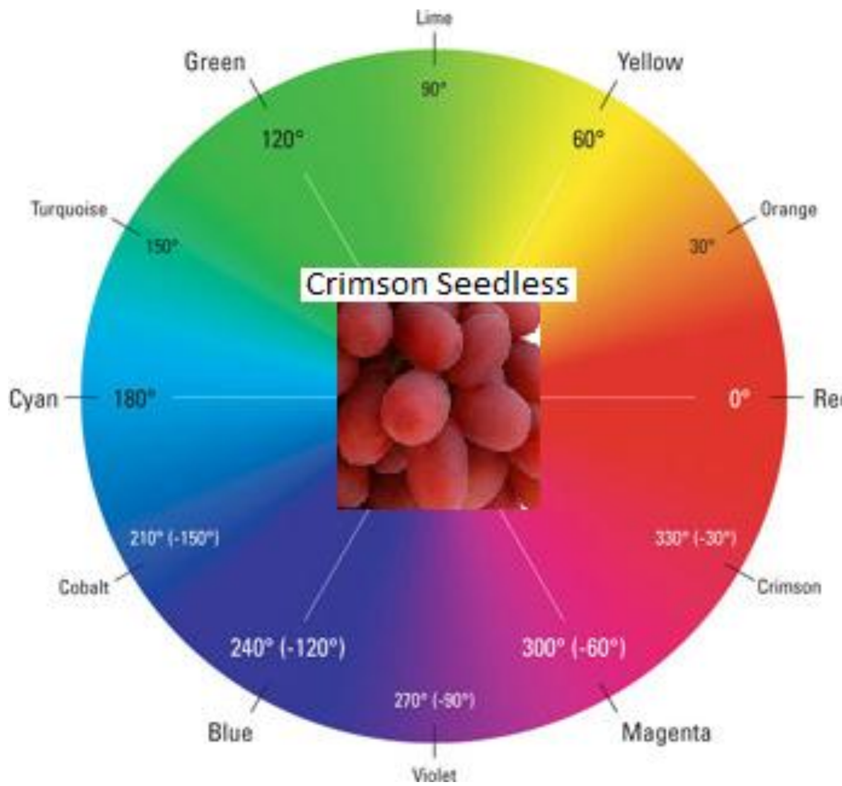

Figure 1. Color wheel of Hue angle.

Table 3. Changes in SSC, TA and pH of must in response to calcium spray.

	SSC	TA	pH
Control	19.3	0.32	3.49
Calcite	19.2	0.33	3.48
% change	-	-	-
LSD (%5)	*n.s.*	*n.s.*	*n.s.*

Table 4. Changes in skin color of berry in response to calcium spray.

	L*	C*	Hue angle
Control	34.7±1.46	10.2±0.74 b	335±7.6 b
Calcite	35.6±1.32	12.4±0.83 a	358±9.8 a
% change	-	14.5	18.3
LSD (%5)	*n.s.*	*1.03*	*2.72*

Treatments lead to significant changes in C* and Hue angle values, although L* did not change significantly. Actually, calcite treatment resulted in 14.5% higher C* value of grapes, indicating the sensitivity of color polar parameters of 'Crimson Seedless' berries to external calcite treatment. Indeed, the word "crimson" means "a rich deep red color inclining to purple". When the findings on Hue angle (color appearance parameter) is considered on color wheel (Fig. 1), it might be understood that micronized calcium treatment resulted in darker red color appearance of the berries. Findings on berry detachment force (BDF), skin rupture force (SRF) and

Table 5. Changes in BDF, N and SRF, N and vine yield (g) in response to calcium spray.

	BDF	SRF	Yield
Control	2.15±0.22 b	2.23±0.11 b	1580
Calcite	2.67±0.09 a	2.57±0.09 a	1786
% change	19.8	13.1	11.5
LSD (%5)	*0.37*	*0.20*	*n.s.*

All values are means ± standard error. For each experimental year, levels not connected by same letter are significantly different at 5% level by LSD.

yield per plant (per 0.5 m^2) are presented in Table 5. BDF and SRF are among the features that directly affect postharvest storage and shelf life of table grapes. The most important findings of the present study may be related with marked positive effects of calcite treatment on improvement of berry and skin hardiness as depicted on Fig. 1. BDF was significantly increased by calcite treatment, with an approximate 20% improvement from 2.15 to 2.68 N. BDF is a significant indicator feature of resistance to berry shattering at postharvest handling processes particularly seen in seedless grapes such as ‘Sultani Cekirdeksiz’ and ‘Crimson Seedless’. A similar effect of calcite treatment on SRF was also determined. With a 14% enhancement, SRF increased from 2.20 to 2.58 N due to calcite treatment. Maintaining the skin hardiness during postharvest handling of table grapes is a key strategy because water loss and pathogen inoculations are favored by hairline cracking on berry skin (Zoffoli et al. 2009). Crimson Seedless is proven as tolerant cultivar to berry crack thus allowing for a longer ripening period and clusters kept in cold storage tends to remain in good conditions (Human, 2010). Micronized calcium can extend the postharvest handling duration with its positive effect on improvement of the BDF and SRF. There was about 12% increase in vine yield after calcite spray although the difference was statistically insignificant.

Conclusion

Micronized calcite had remarkable positive effects on cluster and berry quality of ‘Crimson Seedless’ table grapes. In particular, calcite spray enhanced the berry size, one of the most important quality feature desired in table grapes. Berry detachment resistance, color and rupture force of skin were also improved by calcite spray without impairment in grape maturity. These findings are particularly important for extending postharvest handling life of table grapes. Further investigations under stress conditions in viticulture would yield more detailed knowledge on sustainable improvement of quality of table grapes on the face of ever-increasing climate change.

REFERENCES

Bonomelli C. & Ruiz R. (2010). Effects of foliar and soil calcium application on yield and quality of table grape Cv. ‘Thompson Seedless’. J. Plant Nutr. 33(3):299-314.

Carbonneau A. (1985). The early selection of grapevine rootstocks for resistance to drought conditions. Am. J. Enol. Vitic. 36:195-198.

Cefola M., Pace B., Buttaro D., Santamaria P. & Serio F. (2011). Postharvest evaluation of soilless-grown table grape during storage in modified atmosphere. J. Sci. Food Agric. 91:2153-2159.

Drazeta L., Lang A., Morgan L., Volz R. & Jameson P. E. (2001). Bitter pit and vascular function in apples. Acta Horticulturae. 564:387-392.

Dris R. & Niskanen R. (1996). Effect of calcium on the storage quality of apples grown in Finland. Acta Horticulturae. 448:323-327.

Ferguson I. & Watkins C. (1983). Cation distribution and balance in apple fruit in relation to calcium treatments for bitter pit. Scientia Horticulturae 19:301-310.

Fidelibus M. W., Cathline K. A. & Burns J. (2007). Potential abscission agents for raisin, table, and wine grapes. Hort Sci. 42:1626-1630.

Lanauskas J., Uselis N., Valiuskaite A. & Viskelis P. (2006). Effect of foliar and soil applied fertilizers on strawberry healthiness, yield and berry quality. Agron. Res. 4:247-250.

Lea-Cox J. & Syvertsen J. (1993). Salinity reduces water use and nitrate use efficiency of Citrus. Ann. Bot. 72:47-54.

McGuire R. (1992). Reporting of objective color measurements. Hort Sci. 27:1254-1255.

OIV (1983). Le code des caracte`resdescriptifs des varie´te´setespe´ces de Vitis. Office International de la Vigneet du Vin. Dedon, Paris.

Peppi M. C., Fidelibus M. W. & Dokoozlian N. (2006). Abscisic acid application timing and concentration affect firmness, pigmentation and color of ‘Flame Seedless’ grapes. Hort Sci. 41:1440-1445.

Peryea F. J. & Neilsen G. H. (2006). Effect of very high calcium sprays just before harvest on apple fruit firmness and Calcium concentration. Acta Horticulturae. 721:199-205.

Sabir A., Kara Z. & Yazar K. (2012). Improvement of nursery cane quality, leaf chlorophyll content and cold hardiness of grapevines (*Vitis* spp.) by nano-size calcite pulverization.35th World Congress of Vine and Wine, 10th General Assembly of the OIV, 18-22.06.2012, Izmir, Turkey.

Sabir A., Yazar K., Sabir F. K., Kara Z., Yazici M. A. & Goksu N. (2014). Vine growth, yield, berry quality attributes and leaf nutrient content of grapevines as influenced by seaweed extract (*Ascophyllum nodosum*) and nano size fertilizer pulverizations. Sci. Hortic. 175:1-8.

Saure M. (2005). Calcium translocation to fleshy fruit: Its mechanism and endogenous control. Scientia Horticulturae. 105:65-89.

Sugimura Y., Mori T., Nitta I., Kotani E., Furusawa S., Wada M. & Morita Y. (1999). Calcium deposition in idioblasts of Mulberry leaves. Ann. Bot. 83:543-550.

Swietlik D. (2006). The interaction between $CaCl_2$ and ammonium-

nitrogen on growth, N uptake and translocation in apple and sour orange.Acta Horticulturae. 721:159-164.
White P. (2001). The pathways of calcium movement to the xylem. J. Exp. Bot. 52:891-899.
Wojcik P. (2001). Effect of calcium chloride sprays at different water volumes on apple calcium concentration. Journal of Plant Nutrition. 24: 639-650.
Zoffoli J., Latorre B. A., Rodriguez J. & Aguilera J. M. (2009). Biological indicators to estimate the prevalence of gray mold and hairline cracks on table grapes cv. Thompson Seedless after cold storage. Postharvest Biol. Technol. 52(1):126-133.