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Full Length Research Paper

Effect of Calcium Chloride ($CaCl_2$) on some quality characteristic of apple fruits in Shirvan region

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Consumers demand for high quality fruit is leading to a greater awareness of the need to apply management techniques that enhances the quality of fruits by the fruit growing industry. In order to study the effect of calcium chloride on some characters of apple Sheikh Amir variety fruits, an experiment was conducted during 2010 and 2011 cropping season in apple orchard at Shirvan region. The experimental design in this research was randomized complete block design (RCBD) with four replications. The treatment were comprised of two levels of pre-harvest foliar application of nutrients T_1= Control, T_2= calcium chloride 0.5% foliar application. Results showed that use of calcium chloride had significant effect on fruits yield, fruit firmness, Brix index, acidity and fruit concentration of B and Ca after harvest. Among all measured characters, high amount of fruits yield, fruit firmness, total soluble solids and fruit concentration of B and Ca was recorded in calcium chloride.

Key words: Apple, Brix, calcium chloride, fruit quality, yield.

INTRODUCTION

Improved crop quality and the level of substances and elements existing in it in response to population growth and human nutritional needs is much more important compared with increasing yield per unit of surface. Apple storability and quality in large extent is determined by the genotype of the cultivars and nutrient of apple. The role of balanced nutrition on fruit storability is well known (Terblanche et al., 1980; Dris et al., 1998). Adequate nutrition ensures a balance in fruit mineral composition. Production of apples characterized by a high Ca content is very important for successful storage and handling. Calcium content and its ratio with some other nutrients (N, K, Mg) are a great concern. Apple with Ca deficiency ripen earlier (Tomala, 1997) and loose more weight during storage (Tabatabaie and Malokoti, 1998; Saftner et al., 1998). The desirable Ca content may be different for various cultivars. In general, it is reported that calcium content above 45-60 mg/kg of fresh fruit weight is satisfactory for quality of fruits (Dris et al., 1998). As some other elements content influence apple quality and storability as well, often attention is paid to the ratio of N/Ca, K/Ca, $(K^+Mg)/Ca$, etc. K/Ca ratio above 5.8 in T stage fruitlets is associated with a considerable risk of subsequent bitter bit development (Weibel et al., 2000). Concentration is not uniform across the fruit: greatest concentrations are found in the apple core, decreasing in the apple flesh towards the outer part, and rising again in the apple skin (Perring and Pearson, 1985; Perring, 1986; Aznar et al., 2001). Increases in Ca concentration both in fruit flesh and skin have been found in 'Jonathan' apples (Kadir, 2004), and always, the increase in concentration in the peel was far greater than in the pulp. Increases in the concentrations of other mineral elements in fruit flesh and skin were also noted by Kadir (2004). Several authors (Raese and Drake, 1993; Kadir, 2004; Neilsen et al., 2005) have reported changes in fruit quality traits, particularly flesh firmness, acids and color, associated with increases of Ca concentration in the pulp of fruits. Calcium accumulation in apples is influenced by different management practices and ecological conditions (Tomala, 1999). Direct application of calcium to the fruit is the most effective method for increasing fruit calcium content (Conway et al., 2002). The best way is to spray trees with calcium

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fertilizers. Many calcium fertilizers are proposed to fruit growers. The two generic fertilizer products commonly used for foliar Ca applications are calcium nitrate ($Ca(NO_3)_2$) (15% N, 19.4% Ca), and calcium chloride ($CaCl_2$) (36% Ca). Experimental results indicate different effects of applying calcium fertilizers (Tomala, 1997; Wojcik, 2002). In most part of the world, pre-harvest Ca treatment is generally effective in increasing fruit Ca and reducing spoilage (Benavides et al., 2001; Neilsen and Neilsen, 2002; Kadir, 2004). The favorable effect of calcium obtained by Siddiqui and Bangerth (1995) on Golden Delicious' apples, suggested that the observed effects of $CaCl_2$ on fruit firmness are likely to be associated with the calcium content of the covalently-bound pectin fractions. Also, Benavides et al. (2002) found that the fruit firmness of Golden Smoothee apple increased when calcium was applied. Similar results were obtained by Casero et al. (2004) who indicated that fruit firmness of 'Golden Smoothee' apple shows a positive correlation with fruit Ca content, and bitter pit incidence correlates negatively with this nutrient content ratio.

The objective of this research was to investigate the effectiveness of calcium (Ca) spray programs in Shirvan orchards therefore influencing plant tissue Ca and fruit firmness.

MATERIALS AND METHODS

This experiment was conducted during 2010 and 2011 cropping seasons in an apple orchard at Shirvan region. The site lies at longitude 57°54', and latitude 37°27' and the altit ude of the area is 1047 m above sea level. The soil characteristics of apple orchard is loamy clay soil in texture, pH = 7.64 and EC = 2.12 m S/Cm (The soil properties are shown in Table 1). The experimental design in this research was randomized complete block design (RCBD) with four replications. The treatment was comprised of two levels of pre-harvest foliar application of nutrients T_1 = Control (water spray), T_2 = Calcium chloride ($CaCl_2$). Apple trees (*Malus domestica,* Borkh) in a private orchard at Shirvan region, having ten years old, spaced 4 × 4 m under drip irrigation system, similar in growth and received by common horticulture practices, were selected for this investigation. All selected trees for this research were healthy, nearly uniform in growth vigour and fruiting. All trees had received regularly the same common cultural practices already given to the tree. Selected trees were sprayed 3 times at full bloom, after fruit set (fruit diameters 3 cm) and four weeks after fruit set (Shahin et al., 2010). Foliar sprays were applied using a hand pressure sprayer. Each treatment was surrounded with two rows as guard trees. The treatments were arranged in a randomized complete block design with four replicates for each treatment and three trees per each replicate. The parameters determined in the seasons of the study were fruits dry weight, fruit firmness, total soluble solids, acidity and fruit concentration of B and Ca. Total soluble solids were determined using a hand refractometer, percentage of titratable acidity in fruit juice was determined according to A.O.A.C. (1995), total soluble solid/total acidity ratio were calculated and total sugar in the fruit pulp tissues were also determined by phenol sulfuric method according to Dubois et al. (1956). Samples at twenty leaves from the middle part of the shoots (Chuntanaparb and Cummings, 1981) were randomly selected from each replicate. Fruits were harvested at maturity stage (the first week of June) from each tree of various replicates and yield was recorded as a number of fruits/tree and weight in Kilograms. Samples of 10 randomly mature fruits from each experimental unit were used for measuring various fruit quality attributes. For measuring B content, fruit samples were collected after harvesting time, which were then washed, oven dried ground and extracted with wet acid digestion method and analyzed for elemental content of B by atomic spectrophotometer, model-2380 (Jones and Case, 1990). Total acidity was estimated as malic acid according to A.O.A.C (1995).

The data were analyzed using SAS software; mean comparison was done using Duncan multiple comparison at 5% probability level.

RESULTS AND DISCUSSION

Fruits yield

Higher and lower dry weight of fruits were obtained from application of calcium chloride (T_2) and control (T_1), (16.76 and 15.87) respectively (Table 3). Data (Table 2) show that dry weight of fruit apple was influenced by using calcium spray as pre-harvest. These results are in agreement with the findings of Ashour (2000), who found that spraying Anna apple fruits with 0.5% calcium chloride reduce fruit dry weight losses percentages. In another research, Jafarpour and Poursakhi (2011) stated that foliar application of nutrients in spring along with manure ditch application of nutrients causes significant increase of fruit yield in treated trees compared with control ones. Their results revealed that application of nutrients through manure ditch along with foliar application of nutrients in spring and/or in autumn can be effective on increasing yield and that the impact of foliar application two times (both in autumn and spring) on increasing yield was more than each application done. In addition, Amiri et al. (2008) claimed that foliar application of nutrients is more efficient than soil manuring; however, they recommended a combination of both methods to manage nutrition of trees such that the highest yield and heaviest fruit.

Texture, Brix index and acidity of fruits

Regarding the effect of $CaCl_2$ on texture of apple (Sheikh Amir variety) fruits, an increase in texture of fruit was observed by calcium chloride spray treatment as compare to control. Recorded result in Table 2 showed that calcium chloride spray treatment had significant effect on texture of fruits, and data in Table 3 were shown using calcium chloride spray as a pre-harvest, increased texture of fruits 24.30% in comparison to control. This result corroborated the earlier findings of Siddiqui and Bangerth (1995), who reported that the observed effects of $CaCl_2$ on fruits firmness are likely to be associated with the calcium content of the covalently-bound pectin fractions. Similar results were obtained by Casero et al. (2004) on 'Golden Smoothee' apple who indicated that fruit firmness shows a positive correlation with fruit Ca

Table 1. Chemical analysis of soil.

Zn	Fe	B	Ca	P	K	N	EC	pH
Mg l^{-1}	Mg l^{-1}	PPM	Meq l^{-1}	PPM	PPM	Meq l^{-1}	mS/Cm	-
1.615	0.03	0.45	6.75	27.05	665	0.027	2.12	7.68

Table 2. Analysis of variance on dry weight, texture, acidity, Brix and concentration of B and Ca in apple fruit.

Treatment	df	Dry weight	Texture	Acidity	Brix	B	Ca
Replication	3	11.32^{ns}	0.3^{ns}	0.0002^{ns}	3.08^{ns}	38.03^{ns}	0.00003^{ns}
Foliar application	1	7.90^{**}	4.90^{**}	$0/03^{**}$	62.47^{**}	7.56^{**}	1.18^{**}
Error	3	0.29	2.28	5/71	1.13	0.34	1.96
%CV	-	0.29	0.97	5/71	1.13	0.29	1.96

ns, * and **, non-significant, significant at 5% and 1% probability levels, respectively.

Table 3. Mean comparison for dry weight, texture, acidity, Brix and concentration of B and Ca in apple fruit.

Treatment	Dry weight	Texture	Acidity	Brix	B	Ca
Control	15.87^{b}	2.18^{b}	5.07^{a}	15.22^{b}	23.75^{b}	15.87^{b}
Calcium Chloride	16.76^{a}	2.88^{a}	4.39^{b}	17.72^{a}	24.62^{a}	16.76^{a}

Test mean followed by similar letters in each column, are not significantly different at the 5% level of probability.

content, and bitter pit incidence correlates negatively with this nutrient concentration. Also, Benavides et al. (2002) on Golden Smoothee apple found that the fruit firmness increased when calcium was applied. Furthermore, Saure (2005) on fleshes fruit reported that Ca is known to stabilize cell membranes and in this way may prevent physiological disorders attributed to Ca deficiency. Obtained results in this research showed that calcium fertilizer spray had significance ($P < 0.01$) on Brix index of fruit as shown in Table 2. Main compression in Table 3 shows that lower fruit Brix index (15.22) resulted from control treatment (T_1) and maximum amount of this index (17.22) resulted from calcium chloride spray. Results in this part were shown using calcium chloride spray increased Brix index about 11.61% as compared to control treatment. Foliar application of calcium chloride caused a significance ($p < 0.01$) reduction in acidity of Sheikh Amir apple fruits as shown in Tables 2 and 3. Results in Table 3 showed that calcium chloride treatment (T_2) reduced acidity of fruit about 13.41% in comparison to control treatment (T_1). Similar to our results, Ashour and Mohsen (2000) reported that treated Anna apple fruit with calcium chloride spray or spray plus dipping decreases the acidity during storage.

Calcium and boron content

Calcium and boron content of apple fruit was affected by calcium chloride spray as shown in Table 2. Maximum amount of Ca and B was measured in T_2 (Calcium chloride foliar application) with mean of 0.54 and 24.62 respectively and minimum amount of Ca and B was recorded in control treatment (T1) with mean of 0.20 and 23.75, respectively. Results in this part showed that using calcium chloride increased concentration of Ca in comparison to control of 62.96% and increased B concentration of just 3.53%.

Benavides et al. (2002) applied pre-harvest calcium treatment, 6 or 12 times at rate of 1% (w/v) beginning 60 days after full bloom. The results showed that the calcium applications were equally effective on increasing the calcium content in the fruit. Increases in Ca concentration both in fruit flesh and skin have been found in ‘Jonathan’ apples (Kadir, 2004), and always, the increase in concentration in the peel was far greater than in the pulp. Increases in the concentrations of other mineral elements in fruit flesh and skin were also noted by Kadir (2004). In addition Jafarpour and Poursakhi (2011) stated that calcium application in summer or in autumn increased fruit calcium concentration but their effect was weaker than summer plus autumn calcium applications. The above results are in line with findings found by Wang et al. (1993) 'on Golden Delicious apples' who indicated that Ca and polyamines may be competing for the same binding sites in cell wall. In addition, the improvement of fruit quality during storage by these cations could involve strengthening of the cell wall.

Conclusion

Calcium (Ca) is an important nutrient element, which can affect apple quality after harvest. Ca deficiency expresses itself in the form of cork spot, which develop primarily during the early part of the growing season; bitter pit, which develops during the latter part of the growing season; and senescent breakdown, which forms during and after storage. But it is noted that the sole determinant of fruit quality must be used in conjunction with other indicators. However, it is one of the few quantitative measures that can be made before harvest to give an indication of disorder risk and postharvest behavior. Maximizing calcium concentrations in apple fruit, without incurring damage, will reduce risk of disorders and help in maintaining firmness and other desirable quality properties. We cannot emphasize strongly enough the need to concentrate on the fruit on the tree in efforts to increase postharvest quality. There is increasing information available on the factors that influence fruit growth and quality properties, such that tree management must lie at the heart of quality fruit production. Quantitative measurements, monitoring, and subsequent management are the core of quality production. Calcium sprays have been conclusively shown to increase the yield of fruits, nutrient (Ca and B) concentration of apple and texture and Brix index. While apple fruit firmness is positively related to fruit Ca concentration, the ability of Ca sprays to increase fruit Ca by an amount that can detectably improve fruit firmness is inconsistent.

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