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Original Contribution

EFFECT OF FOLIAR APPLICATION OF AMINO ACID AND CALCIUM CHELATE ON SOME QUALITY AND QUANTITY OF GOLDEN DELICIOUS AND GRANNY SMITH APPLES

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ABSTRACT

In order to investigate the effects of foliar application of amino acid and calcium chelate on 'Golden Delicious' and 'Granny smith' apple trees, a randomized complete block design with four repetitions was conducted. Apple trees were sprayed with (0, 2, 4 mg L^{-1}) of amino acid and (0, 2, 4 mg L^{-1}) calcium chelate and their combination. Fruit weight, fruit firmness, total soluble solids, titretable acidity and calcium content of fruits were determined. All the applied treatments significantly increased quality and quantity traits compared to the control trees in both cultivars. The combination of amino acid and calcium chelate increased weight of both cultivars. Thus, in this study combination of amino acid and calcium chelate foliar spray treatment could be recommended from results as they significantly increased quality and quantity traits of 'Golden delicious' and 'Granny smith' apple trees.

Key words: apple, amino acids, calcium, foliar application

INTRODUCTION

Apple fruit is well characterized for their taste, flavor and dietary values. It is one of the genera of pome fruit trees of the temperate zones belonging to the Rosaceae family and is one of the most important garden crops and due to its high adaptability and it is one of the most extensively fruit trees cultivated in temperate zones (1). Health and superior quality of fruit as one of the most crucial organs of the trees is in direct relation with health of humans (1). Apple storability and quality in large extent is determined by the genotype of the cultivars. Some other factors may influence expression of this peculiarity. The role of balanced nutrition on fruit storability is well known (2, 3). Adequate nutrition ensures a balance in fruit mineral composition (3). Calcium is an important nutrient element, which can affect apple quality after harvest. Calcium 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 (4, 5). Calcium provides cell wall rigidity by cross-linking of pectic chains of the middle lamella (6). Disintegration of cell walls and the collapse of affected tissues are typical symptom of calcium deficiency (5). The proportion of calcium pectate in cell walls is very important for the ripening of fruit. The increase of fruit calcium content leads to the increase fruit firmness of fruit and delays fruit ripening or prevents calcium-related disorders (4, 7, 8). Increases in calcium concentration both in fruit flesh and skin have been found in 'Jonathan' apples (9) and always, the increase in concentration in the peel was far greater than in the pulp. Several authors (9, 10, 11) have reported changes in fruit quality traits, particularly flesh firmness, acids and color, associated with increases of calcium concentration in the pulp of fruits. Calcium accumulation in apples is influenced by different management practices and ecological conditions (12). Experimental results indicated different effects of applying calcium fertilizers (13, 14). In most part of the world, pre-harvest calcium treatment is generally effective in increasing fruit calcium and reducing spoilage (15, 16). The favorable effect of calcium obtained by Siddiqui and Bangerth (17) on 'Golden Delicious' apples, suggested that the observed effects of $CaCl_2$ on fruit firmness are likely to be associated with the calcium

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content of the covalently-bound pectin fractions. When they are applied as inorganic salts to the growing medium, above pH 6, Fe, and above pH 7 Mn, B, Cu and Zn have become insoluble forms, so their absorption by the plants has decrease. However chelates are obtained by the reaction of metallic salts with their synthetic or natural organic complexes has saved the metal cations from undesirable reactions such as precipitation (5, 7). For this reason synthetic precursor which has the ability of making strong chelate is almost used in plant growing medium. EDTA (ethylene diamine tetra acetic acid) and EDDHA (ethylene diamino–hydroxyphenylacetic acid) are well known as synthetic precursors. However, because of the disadvantages mentioned above it has been suggested that micro elements as inorganic or organic complexes should be applied to the leaves instead of adding them to the growing medium in order to solve micro element requirements of the plants (5, 7). The leaf fertilizers which an inorganic mineral structure hardly diffuses from the leaf surface into the plant because of high weight molecular structure. In order to eliminate these negative effects leaf fertilizers with organic structure as synthetic chelates were developed. Foliar fertilizers as chelate should be easily absorbed by the plants rapidly transported and should be easily release their ions to affect the plant (7). Natural chelators as mid molecular weight compounds like amino acids that have long organic chains diffuse easily to cell cytoplasm according to their chemical structure. These chelators are not phytotoxic to plants (4). They make complexes especially with heavy metals and prevent them to uptake by plants in higher ratio (18, 19). The purpose of this study was to investigate using foliar pre-harvest application of amino acid and calcium chelate on some fruit quantity and quality of 'Golden delicious' and 'Granny Smith'.

MATERIAL AND METHODS

The present study was performed on 'Golden delicious' and 'Granny smith' apple trees, budded on MM106 rootstock. All trees were almost uniform in vigor, grown in sandy soil under conventionally accepted practices, using drip irrigation system. A randomized complete block design with four repetitions was conducted in the city Zanjan, Iran. In this experiment, different concentrations (0, 2, 4 mg L^{-1}) of amino acid and calcium chelate and their combination were sprayed on the apple trees. The sprayings at once month intervals started after fruit set until harvest. Foliar sprays were applied using a hand pressure sprayer. Fruit samples were taken to the lab and stored in a refrigerator at 4°C until analyses. Fifteen fruits from each replicate were randomly taken for determining the physical and chemical characteristics. Fruit weights (g) were measured by electronic scale and fruit firmness was measured on two opposite faces of the equatorial zone using a texture analyzer (Stevens-Lfra, Harlow, Essex, UK). The percentage of total soluble solids (TSS %) was determined in fresh fruit juice using a hand refract meter (ATAGO, Tokyo, Japan) at 20°C. The pH values were determined by using a pH meter (JENWAY 351, Staffordshire, UK). Total acidity (TA %) was determined by titration with 0.3 N NaOH up to pH 8.1. calcium was measured by atomic absorption spectrometry (Z8000; Hitachi Ltd., Tokyo, Japan). Results of the measured parameters were subjected to computerized statistical analysis using MSTAT package for analysis of variance (ANOVA) and means of treatments were compared using LSD at 0.05.

RESULTS AND DISCUSSION

Figure 1 shows that, the direct effect of 4 mg L^{-1} amino acids+ 4 mg L^{-1} calcium chelate foliar spray produced the highest significant fruit weight as it resulted in 54.9g in 'Granny smith'. Meanwhile this treatment shows no significant difference with 4 mg L^{-1} amino acids+2 and 0 calcium chelate on 'Granny smith'. A similar response was also evident on the effects of foliar 4 mg L^{-1} amino acids+ 4 mg L^{-1} calcium chelate on 'Golden delicious'. The lowest significant fruit weights were observed in the control trees. Spraying of amino acids and calcium chelate significantly increased the average of fruit weight of 'Golden delicious' and 'Granny Smith' fruits compared with control tress. Texture of the apple fruit is an important factor for the acceptability of the product by the consumer (20). The general positive effects of amino acid foliar spray applications could be attributed to enhanced pollen tube ovule penetration and delayed ovule senescence which increases fruit set and yield. Similar findings were reported on pear (21, 22). Data in **Figure 2** indicated that the fruit firmness of 'Golden delicious' was significantly affected by foliar spraying of 2 mg L^{-1} calcium chelate as compared with control and 'Granny smith' apples. The fruit firmness increased with 2 mg L^{-1} calcium chelate from 5.13to 6.83Kg/cm^2 in 'Golden delicious' apple. Also, Benavides *et al.* (15) on 'Golden Smoothee' apple found that the fruit firmness increased when calcium was applied. Similar results were obtained by Casero *et al.* (23) on 'Golden Smoothee' apple who indicated that fruit firmness shows a positive correlation with fruit calcium content and bitter pit incidence correlates negatively with this nutrient concentration. Furthermore, Saure (24) on fleshes fruit reported that calcium is known to stabilize cell membranes and in this way may prevent physiological

disorders attributed to calcium deficiency. 2 mg L^{-1} amino acid +2 mg L^{-1} calcium chelate as foliar spray had a positive significant effect on total soluble solids (TSS %) as compared with the control treatments in 'Golden delicious'.

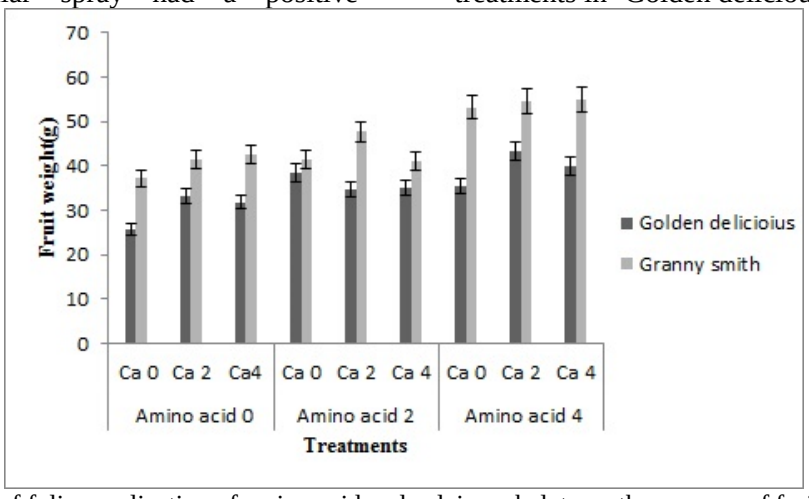

Figure 1. Effects of foliar application of amino acid and calcium chelate on the average of fruit weight. Vertical bars are standard deviations (SD) of means.

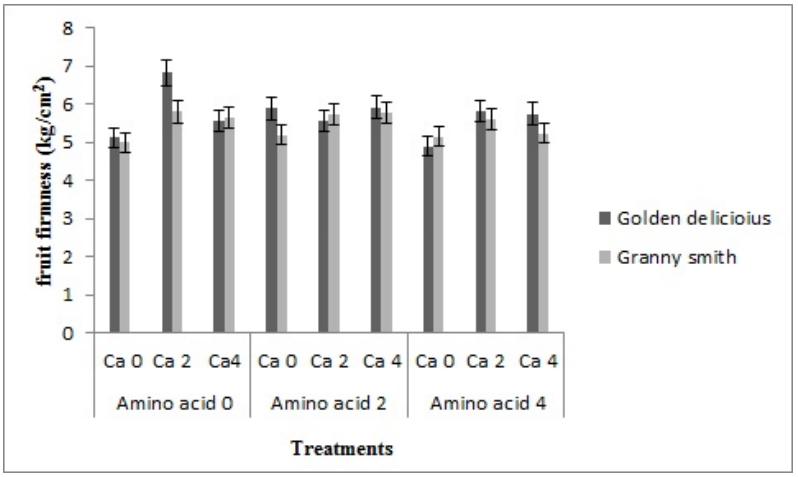

Figure 2. Effects of foliar application of amino acid and calcium chelate on the fruit firmness. Vertical bars are standard deviations (SD) of means.

Whereby these values were not significantly higher than those obtained in the treatments with 2 mg L^{-1} amino acid +0 mg L^{-1} calcium chelate, 2 mg L^{-1} amino acid +4 mg L^{-1} calcium chelate, 0 mg L^{-1} amino acid +4 mg L^{-1} calcium chelate and 4 mg L^{-1} amino acid +4 mg L^{-1} calcium chelate. No significant differences were observed among the values of TSS obtained for 'Granny smith' **(Figure 3).**

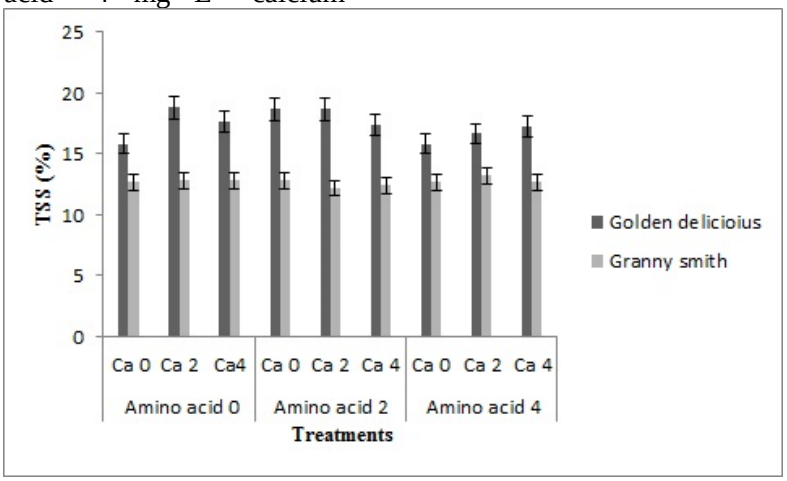

Figure 3. Effects of foliar application of amino acid and calcium chelate on the total soluble solids. Vertical bars are standard deviations (SD) of means.

Amino acid at 4 mg L^{-1} + calcium chelate at 2 mg L^{-1} significantly increased TA% of 'Granny smith' apple fruit as compared with the control and 'Golden delicious'. Whereby these values were not significantly higher than those obtained in the treatments with 0 amino acid+4 mg L^{-1} calcium chelate. while, the lowest value was obtained by the 0 amino acid+2 mg L^{-1} calcium chelate and 4 mg L^{-1} amino acid +0 calcium chelate on 'Golden delicious' apples **(Figure 4).**

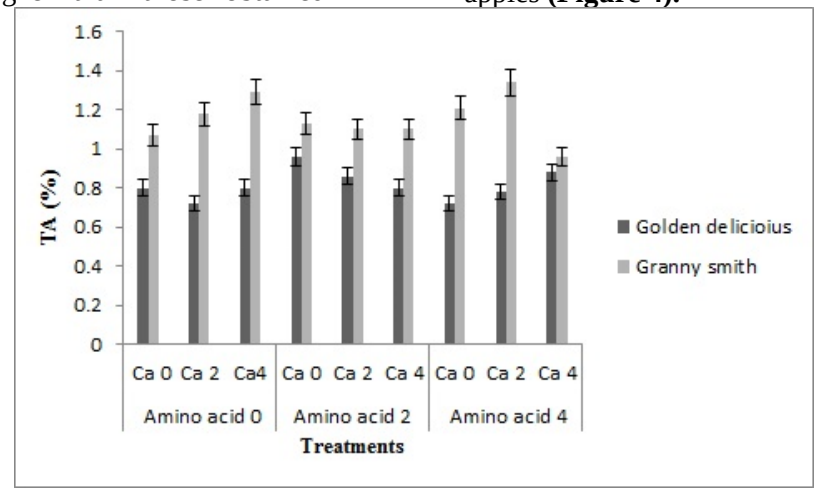

Figure 4. Effects of foliar application of amino acid and calcium chelate on the TA. Vertical bars are standard deviations (SD) of means

No significant differences were found in pH in both cultivars in all of the treatments **(Figure 5)**. Differences in calcium content were statistically significant among treatments for both cultivars. The calcium content in 'Golden delicious' apples analyzed at harvest time ranged between 18 and 52 % of dry matter.

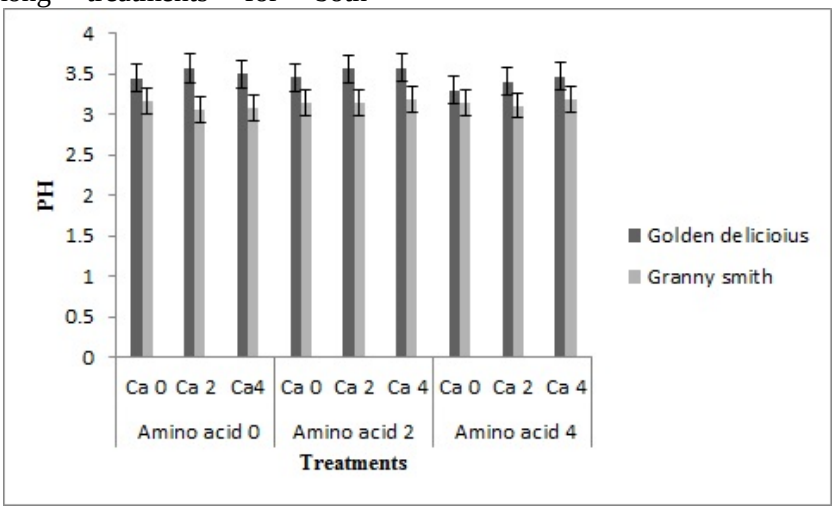

Figure 5. Effects of foliar application of amino acid and calcium chelate on the pH. Vertical bars are standard deviations (SD) of means.

Foliar application of 0 amino acid+4 mg L^{-1} calcium chelate and 4 mg L^{-1} amino acid+2 mg L^{-1} calcium chelate significantly increased the calcium content in 'Golden delicious' fruits. The highest calcium content was provided in 'Golden delicious' apples than 'Granny smith' apples **(Figure 6).** Pre harvest calcium treatments used to increase the calcium content of the cell walls of fruit tissue after harvest. Moreover, it is effective in delaying senescence, resulting in firmer, higher quality fruit (25). The beneficial effect of calcium chloride could be attributed to the physiological role of calcium which plays a binding role in the complex polysaccharides and proteins forming the cell wall (26). Our results are in agreement with those recorded by Asgharzade *et al.* (20) and Casero *et al.* (23) they reported that the enhancement occurred in fruit quality due to foliar application of calcium could be attributed to the effect of calcium in enhancing and

advancing flowering, maturity and the translocation of carbohydrates from leaves to fruits. Benavides *et al.* (15) 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 calcium concentration both in fruit flesh and skin have been found in 'Jonathan' apples (9) 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 (9). In addition Jafarpour and Poursakhi (27) 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.* (28) on 'Golden Delicious' apples who indicated that calcium and polyamines may be competing for the same binding sites in cell wall. In addition, the improvement of fruit quality during storage by these actions could involve strengthening of the cell wall.

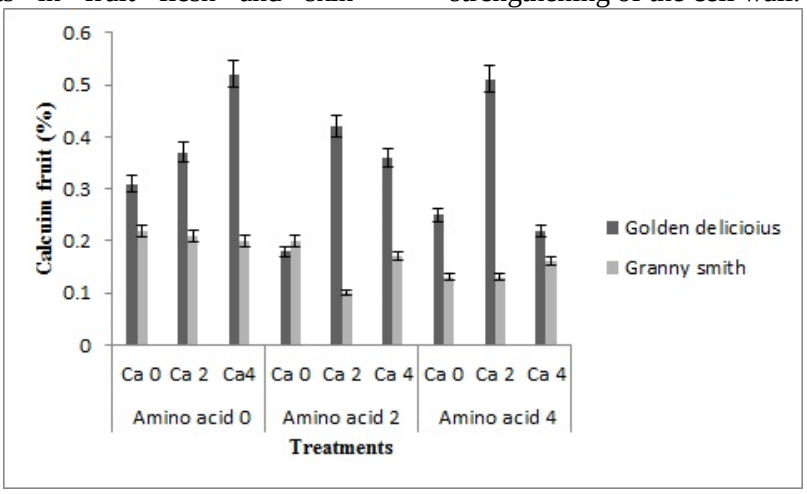

Figure 6. Effects of foliar application of amino acid and calcium chelate on the calcium fruit. Vertical bars are standard deviations (SD) of means.

CONCLUSION

It can be concluded from results of the present study that combination of amino acid and calcium chelate treatments significantly improved fruit quality of 'Granny smith' and 'Golden delicious' apples tress. Consequently they are recommended to be effectively applied in the under same conditions.

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