

Study of concurrent effect of using nutrients through soil and foliar application on yield and quality of the “Red Delicious” apple

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Abstract— To improve quality and quantity of apple fruits, this study conducted in factorial experiment in randomized complete block design with 6 replications. Results showed that foliar application was applied only in the spring, the yield increased. The positive effect of foliar application in spring and fall on the yield increase was superior to the control, but highest yield was obtained in foliar application in the fall+spring. In spite of the increased yield through localized fertilization treatment and foliar application in the fall+spring no decrease was observed in fruit texture firmness. However, the specific weight of fruits and the TSS/TA ratio were increased. Because of the increased yield in fall+spring foliar application, the fruits diameter was decreased. The results showed that in order to avoid alternation and to increase the yield, the foliar application of nutrients will be effective in the spring, fall or both, especially for low yield gardens.

Keywords-apple; fruit set application; fruit quality; Red Delicious; yield

I. INTRODUCTION

Apple 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 it is considered as one of the most extensively fruit trees cultivated in temperate zones. Health and superior quality of fruit as one of the most crucial organs of the trees is in direct relation with health of humans. Therefore, to improve its quality, modern feeding procedures such as spraying and manure ditch should be employed to ensure reaching of target nutrient in appropriate level to the target site i.e. the fruit. 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 is a perennial tree that its annual vegetative growth starts 4 to 8 week following beginning of growth from the terminal vegetative bud. The root of apple trees, at the time of transferring from the plantation to garden due to the primary root being cut, grows in a horizontal direction. The root of these trees is mostly scattered and grows much at a horizontal direction. Apples raised in Iran, due to reasons such as lack of attention to the tree's balanced and proper nutrition, harvest at inappropriate stage, and incorrect storing and packaging, do not enjoy an appropriate quality compared with those produced at standard global levels. The objective

of this research project was to study the effect of concurrent application of nutrients through soil application and foliar application on yield and fruit quality of the Red Delicious cultivar of apple.

II. MATERIALS AND METHODS

The test was performed in one of the orchards of the Semirom city in Isfahan. This region is one of the most important regions of cultivation and raising of apple trees in the country. Trees of the two Golden and Red Delicious trees were such arranged in this orchard that for each three rows of red apples, there was a row of yellow apples and the cultivation system was rectangular, with dimensions of 5 × 6 m. Stripe irrigation method was employed. Soil of the test site had no salinity problem however its lime level was very high. Existence of a full cold period per year and desirable elevation as well as appropriate temperature conditions in spring and summer has led to successful apple tree cultivation in this region. In this research, for the purpose of balancing nutrients and optimizing fertilizer application, except the intended variable, other elements, as described in the following table were uniformly treated and received fertilizer through manure ditch procedure.

For the objective of increasing the number of fruits formed on trees and finally increasing fruit yield and quality, the trees required nutrients were provided via soil application and experimental foliar application. The experiment was conducted in factorial experiment in randomized complete block design with 6 replications. Each Red Delicious apple tree was considered as an experimental unit such that the trees were grown on seedlings and were of almost equal age.

In this experiment, factor A related to optimum use of fertilizer at three levels of a₁: Control, a₂: use of nutrients through surface broadcasting and a₃: manure ditch procedure

TABLE I. AMOUNTS OF FERTILIZER APPLICATION IN OPTIMAL FERTILIZER CONSUMPTION TREATMENT (GR/TREE)

Iron Sulphate	Zinc Sulphate	Copper Sulphate	Manganese Sulphate	Boric Acid	Ammonium Nitrate	Triple Super Phosphate
1000	400	150	250	100	300	400

of applying nutrients and factor B is relevant to foliar application application treatment for the purpose of increasing fruit formation at two levels of b_1 : control (without solution application) and b_2 : solutions of urea, boric acid and zinc sulfate, each at a 0.5% concentration as foliar application on the trees at the rate of 10L/ tree. Application was performed in spring following foliation and prior to anthesis. In the second year two levels b_3 : foliar application in autumn and b_4 : foliar application at two times of autumn and spring were done in addition to b_1 and b_2 levels. Prior to experiment, soil composite samples from the two 0-30 and 31-60 cm depths were taken and their physico-chemical specifications were determined. Also irrigation water samples were taken and were chemically characterized. The garden was irrigated according to the region's routine practice. Following execution of project, necessary cares were taken and appearance of treatments were noted.

Foliar sampling of trees was done in the first half of August. Following drying and preparation, samples were sent to laboratory for analysis and assessment of nitrogen,

phosphorus, potassium, calcium, iron, manganese, zinc, and copper contents. Following harvesting of fruits according to the region's practice, yield of each tree as an experimental unit was determined. Each treatment was sampled and samples were transferred to laboratory. Due to high number of experimental units (72 units), samples of each two replications were mixed and such factors as fruit length, diameter, firmness, density, water content, percentage of soluble solids, pH, titrable acidity and vitamin C content of fruit extract was assessed and concentration of nutrients available in fruits was measured analytically. Sufficient numbers of fruits following storage for 135 and 245 days conservation in cold store were once again evaluated with standard temperature and humidity. No salinity problem of soil was seen however, the soil lime level was very high and the soil texture was rather heavy (loamy-clay) (table 2).

Obtained results were statistically analyzed using the Mstat C software. Means were compared via Duncan test and diagrams were plotted using the Excel software.

TABLE II. SOIL PHYSICO-CHEMICAL ANALYSIS

Depth (cm)	Electron Conductivity (dS/m)	Soil Saturated pH	Organic Carbon (percent)	Total Neutral Value (TNV)	Clay (percent)	Soil Texture	Milligram/Kilogram					
							P	K	Zn	Mn	Cu	Fe
0-30	0.52	7.5	1.03	64.5	39	CL	13.3	320	0.8	6.6	0.7	8.8
31-60	0.33	7.7	0.44	68.5	41	CL	2.5	185	0.8	5.6	0.7	8.4
0-30	0.37	7.6	1.03	56.5	39	CL	4.1	245	0.8	6.0	0.7	9.4
31-60	0.28	7.8	0.58	65	49	CL	1.1	185	0.6	4.8	0.7	7.6

III. RESULTS AND DISCUSSION

A. Effect of treatments on vegetative and reproductive characteristics

Foliar application of nutrients in spring along with manure ditch application of nutrients causal significant increase of fruit yield in treated trees compared with control ones. In another test conducted under boron deficiency conditions by Wojcik [1], post-harvest foliar application of boron, was successful in improvement of generative growth and yield.

Additionally, combined boron and urea foliar application in autumn was proposed for soils suffering sufficient available boron and nitrogen. In spite of increased fruit production level as a result of foliar application of nutrients in spring along with manure ditch application of nutrients Wojcik [2] reported that manuring apple trees with zinc fertilizer alone is not very much effective on improving the tree's yield and growth power. In addition, Amiri [3] 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 was obtained through combined treatment of zinc and nitrogen through foliar application and soil manuring. This report corresponds

with our test results. Amongst applied nitrogenous fertilizers like potassium nitrate, ammonium nitrate levels led to highest yield. In addition, Sotiropoulos [4] indicated that increased level of nitrogen in all treatments, increased yield. In addition, potassium nitrate application compared with ammonium sulfate and urea led to increased yield.

B. Effect of treatment on fruit qualitative specifications

Applied treatments were effective on fruit qualitative specifications such that the TSS content, total ratio of soluble solid substances to acid was increased and the fruit water as a result of application of nutrients in the form of manure ditch and foliar application was reduced. Conformity of increased fruit density and the amount of TSS with each other, as well as lack of reduced fruit tissue firmness indicate superior quality of fruits in this treatment compared with controls Drake [5] as well obtained the best treatment for improved quality of apple fruit through low amounts of nitrogen application in August.

Apple fruit SSC was increased in experiment conducted by Dilmaghani [6] through potassium manuring and storage period, also fruit firmness was at maximum level in samples taken from plots which had calcium application treatment in such a manner that there was a positive relation between fruit calcium content and firmness and there was a converse

relation between K/Ca ratio and fruit firmness at harvest. Wojcik [1] reported that boron and urea solution used as foliar application had no effect on fruit texture firmness, Concentration of soluble solids and blushing of apple fruit. Results of Canesin's research [7] was similar to those reported by Wojcik [1] indicating that foliar application of boron and zinc has no effect on yield, SST and ATT of apple fruits. Wojcik [2] too stated that fruit quality at harvest time including fruit medium size, firmness, color, rot, concentration of soluble solids and acidity was not influenced by zinc fertilizer application. According to the results obtained from the research of Amiri [3] urea and zinc sulphate foliar application led to decreased fruit quality since it led to rot and decreased soluble solids content of fruit however, it increased nitrogen content of leaf and fruit. Regarding fruit quality as a result of nitrogenous fertilizer application experiment of Nava [8] indicated negative effect of that treatment on fruit color, texture firmness and TSS level lower, application of potassium fertilizer had a positive effect on fruit color and TSS level but did not influence fruit texture. Amongst treatments applied in the experiment of Stirooulos [4], level of soluble solids was not significantly influenced by potassium nitrate, urea, and ammonium sulphate treatments. In addition, when the trees were manured with potassium nitrate, compared with ammonium sulphate, fruit texture firmness was significantly increased. Wojcik [9] stated that calcium foliar application had no effect on apple yield, mean fruit weight, fruit skin russeting, firmness, concentration of soluble solids and titrable acidity of fruit at harvest time however, calcium application in summer or in autumn increased fruit calcium concentration but their effects was weaker than summer plus autumn calcium applications.

C. Effect of the storage period on fruit qualitative characteristics

Storage period was effective on fruit qualitative specifications in such a manner that increased TSS amount of fruits, decreased titrable acidity and increased ratio of soluble solids to acid, reduced fruit texture firmness and decreased fruit water content as a result of prolonged storage was observed. As a result of this experiment, increased pH of fruit extract against decreased titrable acidity was seen. In an experiment performed by Drake [5], it was revealed that fruit size, color, firmness, soluble solids and titrable acidity at harvest time and also after 90 days storage at room temperature through 5 low concentrations of nitrogen treatment was not affected. However, in an experiment performed by Dilmaghani [6], fruit firmness at harvest was at maximum level in plots which had received calcium application treatment though in other treatments it was low at harvest and it decreased during the storage period and the difference between treatments following 90 day storage was not high. Also, calcium foliar application in summer + autumn at above said levels by Wojcik [9] could prolonged storage period of the 'Granny Smith' apple cultivar.

D. Effect of treatments on yield

In connection with the effect of various treatments on yield it was revealed that foliar application in autumn is superior to spring treatment and foliar application both in spring and in autumn resulted to highest yield compared with controls. Also, applying various treatment, influenced concentration of nutrients in leaf and fruit except those of calcium and magnesium in such a manner that applied treatments caused increased concentrations of iron and copper though the boron and zinc contents of fruit was not increased by foliar application of such elements.

Application of various treatments, influenced concentration of nutrients in leaf and fruit except those of calcium and magnesium in such a manner that applied treatments resulted to increase concentrations of iron and copper. The fruit boron and zinc content did not increase as a result of foliar application. In an experiment conducted by Sanchez [10], boron foliar application along with urea increased boron content of roots and flower racemes during the full-bloom stage. Also, Wojcik [1] showed that post harvest boron application alone or along with urea improved boron content of flowers, fruit set, and yield. Also in [2], the above said researcher through foliar application of zinc prior and after flowering, was able to increase zinc content of flowers and leaves 28 days post-flowering. Amiri [3], mentioned application of urea and zinc sulphate as a cause of increased nitrogen content of leaf and fruit. In a research conducted by Nava [8], when nitrogen content of fertilizer (potassium nitrate, ammonium sulphate and urea) was increased, nitrogen concentration of leaves was increased as well however this increase was highly significant in the case of potassium nitrate application. Ammonium sulphate increased nitrogen concentration of leaves more than urea. Wojcik [9] performed calcium foliar application both in summer and in autumn which resulted to increased calcium concentration of fruit.

IV. GENERAL CONCLUSION

Regarding the positive and effective role of local placement of nutrients (manure ditch) on improvement of nutritional conditions of trees and preventing the influence of absorptions limiting factors leading to improved quality of fruits and based on our obtained results it can be recommended in that all consumed fertilizers either macro or microelements be applied under manure ditch conditions. Due to the soil limitations for optimal absorption of nutrients, in addition to manure ditch application, foliar application can be employed as well. There are reports on increased fruit formation as a result of foliar application of urea, zinc sulfate and boric acid. Results of our tests 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. On the other hand local placement of nutrients led to increased yield however, the most yield was obtained in combined application of manure ditch and autumnal and vernal foliar application. Therefore combined application of these two

procedures in direction of increasing yield and production level can be recommended. Increased fruit quality as a result of foliar application of nutrients was obtained. Reduced fruit water content and increased soluble solid substances in fruit as a result of autumn-spring foliar application and lack of decreased firmness of fruits following 245 days storage was seen in spite of increased yield as a result of combined application of nutrients through the manure ditch and autumn-spring foliar application methods. Regarding the fact that employment of foliar application procedure of urea, zinc sulphate and boric acid in spring and autumn along with manure ditch while increasing fruit production lead to increased quality and lack of decreased storage life of fruit, this procedure is recommendable.

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