Influence of Foliar Application with Anti-transpiration and Some Nutrients on Some Chemical Characteristics of Apple Fruits cv. Ibrahimi

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Abstract

In 2021 and 2022, we conducted an experiment in Bani Saad district, Diyala Governorate, Iraq, to investigate the effects of foliar application of nutrients and anti-transpiration on the chemical traits of tree apples cv. Ibrahimi. The study included two factors: the first factor was the spraying of three different levels of anti-transpiration were sprayed: kaolinite anti-transpiration AL2Si2O5 (OH)4 at a concentration of 40 mg L-1, potassium silicate anti-transpiration K2SiO3 at a concentration of 7 ml L-1, and distilled water. Also, nutrients at five levels, viz., chelated iron 100 mg L-1, nano-iron 75 mg L-1, calcium chloride 200 mg L-1, nano-calcium carbonate 100 mg L-1, and the spraying with distilled water. The nano iron recorded the highest values for TSS (13.94 and 14.39%), total acidity (0.284 and 0.283%), iron content in fruits (58.33 and 54.66 ppm), chelated iron had the highest value in ascorbic acid (18.01 and 17.17 mg), and nano CaCO3 gave the highest values for calcium content in fruits (1036.7 and 920.2 ppm) for both seasons. Spraying potassium silicate on fruits was the best way to increase their TSS (13.03 and 13.94%), total acidity (0.275 and 0.270%), and calcium content (967.1 and 880.3 ppm). On the other hand, spraying kaolinite on fruits produced the highest values for ascorbic acid (17.32 and 16.73 mg) and iron content (49.53 and 47.06 ppm) for both seasons.

Keywords. Apple fruits, Nutrients, anti-transpiration.

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Introduction

The apple (Malus domestica Borkh) has existed in Mesopotamia since the end of the fifth millennium BC [3]. It belongs to the Rosaceae family. Apples are among the earliest fruit varieties that humans have ever encountered, so apple production has expanded throughout the world's temperate zones [30]. Iraq has planted an estimated 299,632.2 million trees, yielding 79,413 tons of produce annually, with an average tree producing 30.17 kg [9]. One of the essential elements for plant growth is the availability of micro and macronutrients; any shortage of these elements may harm the plant and interfere with its ability to grow and produce. The soil contains large quantities of these elements, but certain conditions that limit their mobility and plant readiness may affect their availability to the plant [2]. [6] states that the direct spraying of these elements on the plant's vegetative parts causes them to absorb directly before they undergo fixation or wash away when added to the soil because the deficiency of any element has a negative impact on all the various processes within the plant. Nano fertilizers are valuable tools in agriculture because they provide micronutrients that are appropriate for the stage at which crops are growing and that are available throughout the growth period. This can increase productivity, quality standards, and crop growth. However, an excessive increase in concentration may hinder crop growth due to nutrient toxicity. Additionally, nano fertilizers give plants more room for a variety of metabolic reactions that speed up photosynthesis, produce more dry matter and crop productivity, and protect the plant from biotic and abiotic stress [28]. Rainfall in Iraq is characterized by irregular distribution and an increase in dust storms, which cause stomata to close and put plants under stress [13]. Due to the lack of research dealing with the local apples, the cv. Ibrahimi, this study aimed to find the best treatments that may increase the chemical characteristics of apple fruits by spraying some nutrients and anti-transpiration on apple trees.

Materials and methods

We conducted the study in one of the apple orchards in Bani Saad district, Diyala Governorate, Iraq, from May 1, 2021, to August 31, 2022, to investigate the impact of foliar spraying anti-transpiration and some nutrients on the chemical characteristics of the apple fruits (Ibrahimi cultivar). The study included two factors: the first factor was the spraying of three different levels of anti-transpiration were sprayed: kaolinite anti-transpiration AL2Si2O5 (OH)4 at a concentration of 40 mg L-1, potassium silicate anti-transpiration K2SiO3 at a concentration of 7 ml L-1, and distilled water. Also, nutrients at five levels, viz., chelated iron 100 mg L-1, nano-iron 75 mg L-1, calcium chloride 200 mg L-1, nano-calcium carbonate 100 mg L-1, and the spraying with distilled water .

We applied three sprays to all treatments on trees that were 6 years old and planted with dimensions of 5 x 5 meters. The first spray was 30 days after the full flowering stage; the second spray was 21 days after the first spray; and the third spray was 21 days after the second spray. We sprayed the plants with nutrients in the early morning until they were completely wet, and used Tween 20 as a surfactant material agent at a rate of 0.1% to reduce surface tension and improve the leaves' absorption of both nutrients and anti-transpiration. During the two plant growth

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seasons, we conducted various agricultural processes, such as irrigation, weeding, and disease control, to serve the trees in the orchard. We applied dab and urea fertilizers to all the trees at the end of August for both seasons. Before the study, we estimated some of the physical and chemical properties of the orchard's soil by taking random samples from the orchard at two depths, the first 0–30 cm and the second 0–60 cm, as shown in Table (1), and conducted the analysis in the Central Soil Laboratory at the College of Agricultural Engineering Sciences, University of Baghdad

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Table 1. Physical and chemical properties of orchard soil

EC	pH	Ca	N	P	K	B	Organic matter	Soil texture	Sand	Silt	clay
ds Siemens \ m^{-1}		millmole/ L^{-1}	mg / kg $^{-1}$	mg / kg $^{-1}$	mg / kg $^{-1}$	mg / kg $^{-1}$	ml/kg^{-1}	Loam	g/kg^{-1}	g/kg^{-1}	g/kg^{-1}
1.39	7.35	8.68	36.5	2.93	35.45	0.36	0.84		297	438	265

Studied traits

Total soluble solids in fruits(%)

The percentage of total soluble solids was calculated by taking the juice of five fruits, mixing and squeezing it, taking a drop of it, placing it on the Hand Refeactometer, and recording the readings.

Total acidity

It was calculated according to the method of [25], where 3 ml of juice was taken and diluted by adding 3 ml of distilled water. After preparing it, a few drops of phenonphthalein dye were added to it, and calibration was carried out with sodium hydroxide (0.1 standard), and the acidity was calculated on the basis of malic acid, which is the dominant acid in apples, as in the following equation:

Total acidity (%) = volume of base x standard (0.1) x equivalent weight of acid x dilution x 100 / sample volume x 1000

Ascorbic acid (V.C) (mg.100 ml-1(

It was estimated according to the method of [1], where 1 ml of juice was taken and diluted to 10 ml by adding 2% metaphosphoric acid. The mixture was shaken well to complete the reaction, then 5 ml of it was taken and 4 ml of blue dye (2,6-dichlorophenol) was added to it. indophenol), and the absorbance was read at a wavelength of 518 nm with a spectrophotometer. The readings were drooped onto a standard curve for pure ascorbic acid, and the following equation was applied.

Ascorbic acid concentration (mg. 100 ml-1) = amount of acid from standard curve x dilution / volume of juice taken x 1000 x 100

Calcium (ppm(

It was estimated according to the AOAC method (1990 .(

Iron (ppm(

It was estimated according to the AOAC method (1990 .(

Experimenta Design and Statistical Analysis

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A factorial experiment was implemented according to a completely randomized block design (CRBD) with two factors (nutrients and anti- transpiration), with three replicates and 45 experimental units. The statistical program SAS (2003) was used, and the data were compared according to Duncan's multinomial test at a probability level of 0.05 [4.[

Results

The results in Tables 2,3,4,5 and 6 showed significant differences between the spraying of nutrients and anti-transpiration and the interaction between them in the TSS, total acidity, ascorbic acid, calcium and iron contents in fruits, where the nano iron gave the highest value in TSS of fruits (13.94 and 14.39%), total acidity (0.284 and 0.283 %), and iron content in fruits (58.33 and 54.66 ppm). The chelated iron recorded the highest value in ascorbic acid (18.01 and 17.17 mg), and the nano CaCO3 got the highest value in the calcium content in fruits (1036.7 and 920.2 ppm) for both seasons, as compared with the spraying of water, which gave the lowest value. Spraying potassium silicate on fruits was the best way to increase their TSS (13.03 and 13.94%), total acidity (0.275 and 0.270%), and calcium content (967.1 and 880.3 ppm). On the other hand, spraying kaolinite on fruits gave the highest values for ascorbic acid (17.32 and 16.73 mg) and iron content (49.53 and 47.06 ppm) for both seasons, while spraying water gave the lowest value. Spraying nano iron and potassium silicate had the highest TSS (14.15 and 14.75%), total acidity (0.289 and 0.290%), and iron content in fruits (61.00 and 57.50 ppm). That's how nutrients and anti-transpiration work together. The chelated iron and kaolinite had the highest levels of ascorbic acid (19.90 and 18.96 mg), and the nano CaCO3 and potassium silicate had the highest levels of calcium in the fruits (1066.0 and 932.0 ppm) for both seasons. This was in contrast to spraying water, which had the lowest value.

Discussion

Spraying with nutrients led to improvements in most of the yield's chemical characteristics. The positive effect of spraying with iron on some of the studied characteristics, such as the percentage of total dissolved solids, vitamin C, and the iron content of fruits, may be due to the important role of iron in improving the process of photosynthesis due to its role in increasing the leaves' content of chlorophyll and iron, as it works to increase the absorption of nutrients, which leads to and increases the production of plant hormones such as gibberellin and auxin and builds other proteins such as cytochrome proteins that are important in improving many vital processes within plant and the formation of Ferrodoxin proteins, which are important in the process of photosynthesis and thus increase the processed food materials, which is reflected in the characteristics of the chemical yield [24]. The high level of iron in fruits may be due to spraying nano-iron on the plant, as its absorption by the plant tissues and its accumulation therein will increase [5]. Spraying fruits with nanocalcium increases the total acidity percentage because calcium plays a crucial role in constructing the cell wall, controlling the permeability of cell membranes due to its structural inclusion [11], facilitating cell division (cell diffusion), constructing new plant tissues, and regulating hormones like auxin [23,8,7]. The increase in the calcium content of fruits is due to the fact that sprinkling nutrients on the plant's foliage can facilitate the process of its absorption by the plant tissues and thus increase its accumulation within them [5]. These results are similar to those of [19,31]. The effect of

anti-transpiration agents (potassium silicates and Kaolinite) on the above chemical yield characteristics may be attributed to the role of silicon in increasing the efficiency of photosynthesis by increasing the chlorophyll content of the leaves [29]. Which is reflected in the provision of materials and compounds that the plant needs for its growth, as well as its role in improving and stimulating the plant's absorption of the necessary nutrients and construction processes such as the work and construction of hormones and enzymes and its role in improving the water condition of the plant [26,18]. It may be attributed to the role of anti-transpiration agents (Kaolinite), as they are an inert material that reflects radiation, which is clay [12,16]. Moreover, it works to mitigate the effects and changes of climate in the short term, by reflecting infrared radiation [17,15] and reducing heat stress [10]. Anti- transpiration may improve plant illumination, reduce leaf scorch, and reduce tree temperature [22,27,14]. It is similar to [21], who explained the role of anti-transpiration in reducing the temperature of the leaves and thus reducing the rate of transpiration and the process of the plant losing water, which will reflect positively on the plant's water content, stimulating the metabolic process, and enhancing the growth rate and productivity of plants. These results were also similar to those of [20,31.[

Conclusion

Most of the chemical properties of apple fruits got better when they were sprayed with nutrients like nano-calcium carbonate, chelated iron, and nano-iron, as well as anti-transpiration chemicals like potassium silicate and kaolinite.

Table 2. Effect of foliar application with anti-transpiration and nutrients and their Interaction on the total soluble solids in fruits (TSS %)

Nutrients	Anti-transpiration							
	First season 2021				Second season 2022			
	Spraying with water	Kaolinite	Potassium silicate	Mean	Spraying with water	Kaolinite	Potassium silicate	Mean
Spraying with d.w	10.45 e	12.49 bc	12.70 b	11.88 B	10.61 f	13.61 bcd	13.23 cde	12.48 C
Chelated iron	13.90 a	13.73 a	13.60 a	13.74 A	13.91 abc	14.50 ab	14.56 ab	14.32 A
Nano iron	13.71 a	13.97 a	14.15 a	13.94 A	13.83 abc	14.60 ab	14.75 a	14.39 A
$CaCl_2$	11.81 cd	12.51 bc	12.31 bc	12.21 B	12.76 de	13.04 cde	13.40 cde	13.06 B
Nano $CaCO_3$	11.30 d	12.25 bc	12.40 bc	11.98 B	12.50 e	12.92 cde	13.80 a-d	13.07 B
Mean	12.23 B	12.99 A	13.03 A		12.72 B	13.73 A	13.94 A	

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Table 3. Effect of foliar application with anti-transpiration and nutrients and their Interaction on the total acidity of fruits (%)

Nutrients	Anti-transpiration							
	First season 2021				Second season 2022			
	Spraying with water	Kaolinite	Potassium silicate	Mean	Spraying with water	Kaolinite	Potassium silicate	Mean
Spraying with d.w	0.225 g	0.248 f	0.277 bc	0.250 D	0.210 g	0.210 g	0.252 f	0.224 C
Chelated iron	0.276 bc	0.277 bc	0.281 abc	0.278 B	0.278 bc	0.285 ab	0.277 bc	0.280 A
Nano iron	0.282 abc	0.283 ab	0.289 a	0.284 A	0.279 bc	0.280 bc	0.290 a	0.283 A
$CaCl_2$	0.260 e	0.264 de	0.261 e	0.261 C	0.259 ef	0.262 de	0.270 cde	0.263 B
Nano $CaCO_3$	0.274 bcd	0.254 f	0.271 cd	0.266 C	0.269 cde	0.271 cd	0.264 de	0.268 B
Mean	0.263 B	0.265 AB	0.275 A		0.259 B	0.261 B	0.270 A	

Table 4. Effect of foliar application with anti-transpiration and nutrients and their Interaction on the ascorbic acid (vitamin c) in fruits (mg.100 ml^{-1})

Nutrients	Anti-transpiration							
	First season 2021				Second season 2022			
	Spraying with water	Kaolinite	Potassium silicate	Mean	Spraying with water	Kaolinite	Potassium silicate	Mean
Spraying with d.w	12.13 i	15.40 fgh	17.53 cd	15.02 C	11.33 g	15.03 ef	16.63 c	14.33 D
Chelated iron	19.23 ab	19.90 a	14.90 gh	18.01 A	18.26 ab	18.96 a	14.30 f	17.17 A
Nano iron	18.36 bc	17.73 cd	16.90 de	17.66 A	16.30 cd	17.40 bc	16.66 c	16.78 A
$CaCl_2$	15.96 efg	15.53 fgh	14.80 gh	15.43 C	15.33 def	15.43 de	14.33 f	15.03 C
Nano $CaCO_3$	14.63 h	18.06 c	16.36 ef	16.35 B	14.63 ef	16.86 c	16.40 cd	15.96 B
Mean	16.06 B	17.32 A	16.09 B		15.17 C	16.73 A	15.66 B	

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Table 5. Effect of foliar application with anti-transpiration and nutrients and their Interaction on the calcium content in fruits (ppm)

Nutrients	Anti-transpiration							
	First season 2021				Second season 2022			
	Spraying with water	Kaolinite	Potassium silicate	Mean	Spraying with water	Kaolinite	Potassium silicate	Mean
Spraying with d.w	833.0 h	890.6 fgh	853.0 gh	858.8 C	801.3 f	826.3 ef	832.3 de	819.9 D
Chelated iron	914.0 efg	928.3 c-f	956.6 c-f	932.9 B	838.3 de	872.3 e	824.3 ef	844.9 C
Nano iron	926.0 c-f	916.6 d-g	998.3 abc	946.9 B	879.0 bc	859 cd	882.3 bc	873.4 B
$CaCl_2$	963.3 c-f	977.0 cde	961.6 c-f	967.3 B	920.0 a	879.3 bc	931.0 a	910.1 A
Nano $CaCO_3$	991.0 bcd	1053.3 ab	1066.0 a	1036.7 A	903.3 bc	925.3 ab	932.0 a	920.2 A
Mean	925.4 B	953.1 AB	967.1 A		868.3 A	872.4 A	880.3 A	

Table 6. Effect of foliar application with anti-transpiration and nutrients and their Interaction on the iron content in fruits (ppm)

Nutrients	Anti-transpiration							
	First season 2021				Second season 2022			
	Spraying with water	Kaolinite	Potassium silicate	Mean	Spraying with water	Kaolinite	Potassium silicate	Mean
Spraying with d.w	32.66 g	39.33 f	37.33 f	36.44 E	35.16 g	40.16 f	40.50 f	38.60 E
Chelated iron	55.66 abc	53.33 bcd	51.66 bcd	53.55 B	50.50 bc	50.33 bc	51.00 bc	50.61 B
Nano iron	57.00 Ab	57.00 ab	61.00 a	58.33 A	53.50 ab	53.00 ab	57.50 a	54.66 A
$CaCl_2$	46.66 de	47.00 bc	42.33 ef	45.33 D	46.50 cde	44.33 e	42.66 def	44.49 D
Nano $CaCO_3$	48.33 de	51.00 bcd	50.00 cd	49.77 C	47.16 cde	47.50 cd	48.00 cd	47.55 C
Mean	48.06 A	49.53 A	48.46 A		46.56 A	47.06 A	47.93 A	

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