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Effect of Foliar Spraying with Potassium Silicate and Some Microelements on the Yield of Apple cv. Ibrahimi

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ABSTRACT

The experiment investigated the effect of foliar spraying of potassium silicate and IQ COMBI Agri-fertilizer which contained some micronutrients, on quality and quantity traits of the yield of apple cultivar Ibrahimi. The foliar spraying was with potassium silicate at levels 0, 1.5, 3 and 4.5 ml/l with symbols S0, S1, S2 and S3 representing the first factor. While the foliar spraying with agri-fertilizer IQ-COMBI at levels 0, 1 and 2 g/l and its symbols were Q0, Q1 and Q2, respectively, representing the second factor. Potassium silicate and IQ COMBI had a significant impact on increasing the yield and improving its quality traits. The S2 level revealed the highest increase in the yield of one tree and the average weight of the fruit, which increased by 11.13 and 9.19%, respectively, compared to the S0 level. Q2 was characterized by the highest increase in the fruits' total sugars and vitamin C content. The yield and the average fruit weight at this level increased by 7.85 and 7.01%, respectively, compared to the Q0 level. The interaction between the factors also significantly impacted the traits. The highest increase in the yield at treatment S2Q1 reached 21.61% compared to the control treatment.

Key words: Foliar spraying, potassium silicate, IQ-COMBI, apple

INTRODUCTION

Apple, *Malus domestica* L., belongs to the Rosaceae family. Apple is considered the most spread deciduous fruit tree. Its original home is the moderate region in East Asia, from where it spread to Europe and other parts of the world. It is considered as an important economic resource, and used as fresh fruits, fruit juice, or fruit pickles (Adriano *et al.*, 2020). Last year cultivar Ibrahimi performed better in middle Iraq. Many researchers referred that adding silicone to the soil as a fertilizer or foliar spraying it on leaves is necessary to enhance the quantity and quality of yield for many horticulture crops. Abdel-Aziz *et al.* (2015) found that spraying palm trees with potassium silicate at 0.4% concentration led to an increase in the total yield, average fruit weight and percentage of soluble solids and total sugars. Similar results were obtained by spraying silicone on palm trees.
Mohammed *et al.* (2015) found that spraying mango trees with 0.2% potassium silicate led to an increase in the yield, reduced fruit acidity and increased the percentage of soluble solids, total sugars and vitamin C. John and Lauren (2018) stated that the foliar spraying of iron sulfate $Fe_2(SO_4)_3$ on pomegranate significantly increased yield. Martin *et al.* (2019) found that spraying apple trees with boron led to increase in the yield of the tree, the total percentage of soluble solids, and reduced the total fruit acidity.

MATERIALS AND METHODS

The experiment was conducted in the spring 2021 in one of the private orchards in Al-Saqlawiya District, Falluja city. It was aimed at studying the effect of foliar spraying with potassium silicate and agricultural fertilizer IQ COMBI that containd (Boron 0.2%, cupper 6%, ferrous 6%, manganese 6%, molybdenum 0.2%, zinc 6%) for yield traits in apple cultivar Ibrahimi. Thirty-six trees, homogeneous in size and shape, five years old, were chosen and cultured at dimensions 3.5 x 4 m, in a factorial experiment according to random complete blocks design (R. C. B. D.) with two factors. First factor was spraying potassium silicate at concentrations of 0, 1.5, 3 and 4.5 g/l designated as S0, S1, S2, and S3. Second factor was spraying microelements at concentrations 0, 1 and 2% g/l designated as Q0, Q1 and Q2. Thus, the experiment included 12 treatments in three replications, and every tree was considered an experimental unit. So, the total trees were 36. The treatments were distributed randomly within a single block, and the results were analyzed using (Genstat program). The average values were compared via the least significant difference test (L.S.D.) at a likelihood level of 5%. Spraying operations were made four times; the first spray was made after the fruit set and then every 20 days.

The number of fruits in 4 branches chosen from different parts of the tree was counted when the fruit set was completed on April 1st, 2021. The remaining fruits were counted at harvesting. The percentage of fallen fruits was calculated as:

$$\text{Fallen fruits percentage} = \frac{\text{Fruits at fruits set - remaining fruits}}{\text{Fruits at fruits set}} \times 100$$

Single tree yield was calculated by weighing the yield of each experimental unit separately on July 01, 2021. Fifty fruits from each experimental unit were chosen, and the average fruit weight was calculated by dividing fruits weight by their number.

Total soluble solids in fruits (% T. S. S.) were measured by Hand Refractometer. The apparatus records were modified according to lab temperature. Total sugar in fruit (%) was estimated by spectrophotometer at 490 nm wavelength. Titratable acidity of fruits (%) was estimated via titrating the fruit juice with 0.1N NaOH using the phenonephthaline. Acidity percentage was measured based on malic acid. Vitamin C (mg/100 g fresh weight) was estimated via titration with 2,6-Dichlorophenol indophenol as mentioned in A.O.A.C.

RESULTS AND DISCUSSION

Foliar spray of potassium silicate led to reducing the percentage of fallen fruits. Treatment S3 had the lowest value of 44.28%, compared to the S0 level, which had the highest value of 55.13% (Table 1). Spray of IQ-COMBI had also significant effect in reducing the percentage of fallen fruits. The Q2 had the lowest value of 46.10%, compared to level Q0 having higher value of 51.29%. Similarly, interaction of potassium silicate and IQ-COMBI spray significantly reduced fallen fruits. S3Q2 had the lowest percentage of 42.67%, compared to the control of 57.77%.

Table 1. Effect of spraying potassium silicate and IQ-COMBI and their interaction in the fallen fruits percentage for apple trees, cv. Ibrahimi

	Q0	Q1	Q2	Ave. S
S_0	57.77	59.62	47.99	55.13
S_1	52.96	56.00	46.00	51.66
S_2	51.61	43.68	47.75	47.68
S_3	42.83	47.33	42.67	44.28
Ave. Q	51.29	51.66	46.10	
LSD S=3.30	LSD Q=2.86		LSD S × Q=5.72	

Spraying potassium silicate had a significant effect on increasing the yield. S2 had the highest average value of 63.59 kg/tree. S0 had the lowest yield of 57.22 kg/tree, didn't differ significantly from level S1, giving 56.44 kg/tree (Table 2). The presence of a significant increase in single tree yield when spraying IQ-COMBI; the two levels, Q1 and Q2, gave the highest value of 60.19 and 60.75 kg/tree with no significant difference between them, while the level Q0 provided the lowest yield of 56.33 kg/tree. Interaction between both study factors significantly increased the yield, so the two treatments, S2Q1 and S2Q2, had the highest yield of 68.10 and 64.66 kg/tree with a significant difference from the most other treatments. In contrast, the control treatment had the lowest yield of 56.00 kg/tree.

Table 2. Effect of spraying potassium silicate and some other microelements and their interaction in the yield (kg/tree) for apple trees cv. Ibrahimi

	Q0	Q1	Q2	Ave. S
S_0	56.00	58.17	57.50	57.22
S_1	55.83	53.67	59.83	56.44
S_2	57.99	68.10	64.66	63.59
S_3	55.50	60.83	61.00	59.11
Ave. Q	56.33	60.19	60.75	
LSD S=2.90	LSD Q=2.51		LSD S × Q=5.02	

Results in Table 3 referred to a significant increase in average fruit weight on spraying with potassium silicate; S2 (40.97 g/fruit) gave the highest average fruit weight with no significant difference from S3 (Table 3). In contrast, S0 gave the lowest average fruit weight 37.52 g/fruit by spraying with IQ-COMBI having a significant effect of increasing the average fruit weight. Q2 gave the highest value of 40.46 g/fruit compared to the level Q0 that gave the lowest value as 37.81 g/fruit. The interaction between both study factors had a significant effect on increasing the average fruit weight. So, the treatment S2Q1 had the highest value of 45.46 g/fruit which differed

Table 3. Effect of spraying potassium silicate and some other microelements and their interaction in the average fruit weight (g/fruit) for apple cv. Ibrahimi

	Q0	Q1	Q2	Ave. S
S_0	37.32	36.24	39.01	37.52
S_1	38.00	36.21	40.10	38.10
S_2	37.10	45.46	40.36	40.97
S_3	38.84	40.67	42.35	40.62
Ave. Q	37.81	39.64	40.46	
LSD S=1.56	LSD Q=1.35		LSD S × Q=2.70	

significantly from all the other treatments. In contrast, the control treatment gave the lowest average fruit weight 37.32 g/fruit.

Total soluble solids (T. S. S.) % in fruit increased with the increase in spray of potassium silicate (Table 4). S3 dominated with the highest average increase of 13.00% with no significant difference from S2. In comparison, S0 gave the lowest value of 12.07%. Spraying of microelements also increased T. S. S. Q1 had the highest percentage of 12.87%, with no significant difference from level Q2. In comparison, the level Q0 had the lowest value of 12.27%, and interaction between both factors significantly affected the studied trait. Thus, the treatment S2Q1 gave the highest percentage of 13.60%, significantly differing from most other treatments. In comparison, the control treatment S0Q0 had the lowest value of 11.97%.

Table 4. Effect of spraying potassium silicate and some other microelements and their interaction in the total soluble solids for apple cv. Ibrahimi

	Q0	Q1	Q2	Ave. S
S_0	11.97	12.00	12.23	12.07
S_1	12.29	12.43	12.74	12.49
S_2	12.37	13.60	12.83	12.93
S_3	12.47	13.43	13.10	13.00
Ave. Q	12.27	12.87	12.73	
LSD S=0.30	LSD Q=0.26		LSD S × Q=0.52	

Foliar spraying with potassium silicate had a significant effect on increasing the percentage of total fruit sugars. S3 had the highest value of 9.01%, compared to S0, which had the lowest value of 8.28% (Table 5). The percentage of total sugars also increased on spraying with microelements. Q1 had the highest value of 8.78%, with no significant difference from Q2. At the same time, the lowest percentage of sugars was at level Q0, which was 8.32%. In addition, the interaction between leaf spray potassium silicate and micronutrients had a significant effect on the studied trait. The two treatments, S3Q1 and S3Q2, had the highest value of 9.54 and 9.06%, and it significantly differed from most other treatments. Still, the lowest value was at the control treatment 8.13%.

Table 5. Effect of spraying potassium silicate and some other microelements and their interaction in the total percentage of sugars in fruit apple cv. Ibrahimi

	Q0	Q1	Q2	Ave. S
S_0	8.13	8.13	8.57	8.28
S_1	8.40	8.57	8.50	8.49
S_2	8.33	8.87	8.47	8.56
S_3	8.41	9.54	9.06	9.01
Ave. Q	8.32	8.78	8.65	
LSD S=0.29	LSD Q=0.25		LSD S × Q=0.51	

The percentage of total fruit acidity significantly decreased with the increased levels of potassium silicate (Table 6). S3 had the lowest rate of 0.37%, while the highest value at level S0 was 0.52%. Spraying with microelements at Q2 had the lowest value of 0.42% compared to the level Q0 which gave the highest value of 0.47%. Also, the interaction between potassium silicate and microelements had a significant effect on the studied trait; the treatment S3Q2 gave the lowest value of 0.34% with no significant difference from S3Q1, which provided 0.36%, while the treatment S0Q1 offered the highest value of 0.57% that did not differ significantly from the control treatment.

Table 6. Effect of spraying potassium silicate and some other microelements and their interaction in the fruit acidity percentage for apple cv. Ibrahimi

	Q0	Q1	Q2	Ave. S
S_0	0.53	0.57	0.44	0.52
S_1	0.52	0.53	0.46	0.50
S_2	0.42	0.41	0.44	0.42
S_3	0.40	0.36	0.34	0.37
Ave. Q	0.47	0.47	0.42	
LSD S=0.03	LSD Q=0.02		LSD S × Q=0.05	

Potassium silicate had a significant effect on increasing fruit vitamin C content. S3 dominated, giving the highest value of 4.54 mg/100 g fresh weights and it differed significantly from all the other levels though there was not a significant difference among them (Table 7). Spraying microelements significantly increased the mentioned trait. So, the treatment Q1 gave the highest value

Table 7. Effect of spraying potassium silicate and some other microelements and their interaction in fruit vitamin C content for apple fruits cv. Ibrahimi

	Q0	Q1	Q2	Ave. S
S_0	3.80	4.00	3.90	3.90
S_1	3.90	4.03	4.13	4.02
S_2	3.73	4.00	4.00	3.91
S_3	3.98	5.00	4.63	4.54
Ave. Q	3.85	4.26	4.17	
LSD S=0.22	LSDQ=0.19		LSD S × Q=0.38	

of 4.26 mg/100 g fresh weight with no significant difference from Q2, while Q0 showed the lowest value of 3.85 mg/100 g fresh weight. Interaction between both study factor had a significant effect on increasing fruit vitamin C content, so the treatment S3Q1 dominated, giving the highest value of 5.00 mg/100 g fresh weight, compared to the control treatment that gave 3.80 mg/100 g fresh weight.

Potassium silicate had a significant effect on increasing fruit's pectin percentage (Table 8). S3 had the highest increase in fruit pectin percentage of 1.24%, compared to S0, which gave 0.93%, followed by treatments S2 and S1 that reached 1.18 and 1.09%, respectively. In contrast, the microelements had not given any significant effect on this trait. The interaction between both study factors had a significant impact on increasing the fruit's pectin percentage; so, the treatment S3Q2 dominated, giving the highest pectin percentage of 1.31%, differing significantly from all the other treatments, while the control treatment made the lowest pectin percentage of 0.8%.

Table 8. Effect of spraying potassium silicate and some other microelements and their interaction in fruit pectin percentage for apple fruits cv. Ibrahimi

	Q0	Q1	Q2	Ave. S
S_0	0.80	1.03	0.97	0.93
S_1	1.12	1.00	1.15	1.09
S_2	1.20	1.24	1.09	1.18
S_3	1.19	1.21	1.31	1.24
Ave. Q	1.08	1.12	1.13	
LSD S=0.06	LSD Q=NS		LSD S × Q=0.11	

The increase in the yield and its quantitative and qualitative traits on spraying potassium silicate and some microelements was attributed to the factors' role in improving the trees' nutritional status. Therefore, it was found that potassium silicate had an essential role in increasing plant resistance to biotic and non-biotic tensions. Liang *et al.* (2015) mentioned that the silicone was absorbed from plant precipitates on dermal tissues, forming a sub-cuticle layer, leading to the hardening of the plant tissues. Also, Ferreira *et al.* (2015) found that silicone formed complexes with compounds in cell walls, leading to an increased cell wall resistance to degradation. The role of silicone in enhancing plant growth could be explained by its participation in organizing and expressing genes responsible for tension resistance. Also, silicone has a role in increasing plant phenol compounds and enzymes responsible for the plant's pathogenic tensions. Silicone also increases the activity of the antioxidant materials; thus, it functions, saving cell membrane vitality.

Potassium, in turn, is a significant macronutrient necessary for plant life as it plays a great role in activating many enzymes associated with photosynthesis and enzymes that participate in synthesizing and constructing carbohydrates and proteins and functions essentially in the synthesized materials like saccharides and proteins, transporting them from manufacturing sites into their saving sites in fruits. It also regulates the opening and closing of the stomata, keeping the cell wall permeability and regulating the cell osmotic pressure. Boron enhances the cell division in root and shoot tips, so its deficiency causes plant growth to fail, forming complicated compounds with saccharides, and facilitating their movement and transport inside plant tissues into fruit storage sites. Also, zinc enhances quantitative and qualitative crop traits because of its function in photosynthesis. Ferron also participates in chlorophyll construction, respiration and chloroplast development, and it's an essential part of many enzymes.

Copper enters the construction of the outer lignin layer that gives shine to plants and fruits. Molybdenum plays a vital role in ferron absorption and transport in the plant. It has an important role in nitrogen assimilation, so it functions as a coenzyme for enzymes that act to reduce nitrate, transforming it into protein. Manganese is necessary to build chlorophyll molecules though it didn't enter its structure. It is involved in constructing many enzymes that enter the oxidation and reduction reactions, and it acts as an enzymatic activator in respiration processes.

It functions as a coenzyme in constructing or degrading proteins and carbohydrates and plays a role in oxidizing IAA and nitrogen assimilation processes. It raises the efficiency of photosynthesis by activating the enzymes responsible for water molecule division to fix water H with CO_2 to form glucose. So, it activates the chemical and biological reactions necessary for photosynthesis. Mosa *et al.* (2015) and Martin *et al.* (2019) found that spraying trees with boron increased the total tree yield and the total soluble solids in fruits and reduced acidity. Sohrab *et al.* (2016) and Harhash *et al.* (2019) could obtain the same results in their pomegranate study as peach research. Moreover, Hafez *et al.* (2018) could gain an increase in yield and rigidity in pear fruits cv. Leconte when spraying with zinc.

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