Response of Dixired Peach Trees to Sulphur and Iron Application

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Abstract

A present study was conducted during 2011 growing season on six year old of peach trees (Prunus persica Batsch) grown in Gr-Rash orchard / Duhok governorate / Iraq, to investigate the effect of Sulphur and Iron on tree yield and some of fruits characters. The experiment was carried out in a Randomized Complete Block Design (R.C.B.D.), including two factors, first was soil application of Sulfur which was applied in the first week of January at four levels (0, 250, 500 and 750 gm S/tree-1), second was foliar spray with three concentrations of iron (0, 50 and 100 mg Fe/L) using Fe-EDDHA (6% Fe) which was sprayed at two equal sprays, first was done after 15 days of full bloom, the second spray was applied after one month of the first spray. Results indicated that Sulphur application especially at a level of 750 gm S/tree-1 and Fe at a concentration of 100 mg Fe/L each alone or with each other significantly increased fruits number per tree, fruit weight, tree yield, TSS, TSS/acidity, fruit juice and peel anthocyanin content, meanwhile fruit acidity was significantly decreased with the increase of the level of Sulfur and Fe application.

1. Introduction

The peach (Prunus persica L. Batsch) is revered as a delicious and healthy summer fruit in most temperate regions of the world and it is known as a species of prunus tree belonging to the family "Rosaceae" and it bear an edible juicy fruit, and it is one of the most important stone fruit, due to heavy loading and dietetic value, the fruit is a good source of carbohydrate, protein and vitamins especially (A, B and C) and mineral nutrient such as phosphorus, potassium, calcium and iron, so that beside the different uses of the fruit, it is often used as table fruits (fresh fruit), juice and jams [1]. Today, peaches are the third largest commercial fruit in Iraqi Kurdistan region, after grapes and apples, Duhok is the major producer of peaches in Iraq. Peaches bear fruits mostly on the previous year wood, which abundantly renovated from terminal and lateral bud growth and as a result, the plant crops grew heavily year after year, this tends to decrease nutrients availability in the soil due to the continuous removal of nutrients from the soil subsequently, the application of fertilizers to improve yield of plant is required [2]. Most soils contain adequate total iron which is ranged from 100 to 100000mg. Kg-1 soil, but amounts that are available to plants might be inadequate dependent on various soil factors, especially in calcareous soils, high pH, CaCO3 content, iron imbalance and poor physical properties such as very high or low soil temperature, high humidity, poor soil aeration, compaction can induce iron deficiency, low organic matter content, acidic soils that rich with zinc, copper and manganese, and excess phosphorus fertilization also exacerbates the chlorosis problem [3]; [4]; [5] and [6].

Calcareous soils typically those of pH ≥ 7.2, so that acidification may be need for crops with a low optimum pH range grown on calcareous soils. To decrease soil pH, elemental S is an effective soil acidulated. While adding the elemental sulfur to the soil, it will be oxidized by the action of Thiobacillus bacteria to form sulfuric acid [7] and [8]. The produced sulfuric acid leads to reduce soil pH and increase its acidity and this acidulate a zone near plant roots (Rhizosphere). This reaction is
very important especially for the Iraqi soils which are basic (pH of most Iraqi soils is over 7). It leads to raise the availability of many nutrient elements in the soil like Fe [9], and the plants required sulfur for the synthesis of S-containing amino acids such as cystine, cysteine, and methionine, which are essential component of protein that comprise about 90% of the S in plants. Sulfur also is needed for the synthesis of co-enzyme A, which is involved in oxidation and synthesis of fatty acids, synthesis of amino acids, and oxidation of intermediates of the citric acid cycle, although S required for the synthesis of chlorophyll, and S is a vital part of the ferredoxin, and Fe-S protein in the chloroplasts [8].

Sulfur can be supplied to peach trees from many sources including fertilizers, soil amendments, pesticides, irrigation water, acidic rains and even atmospheric pollutants. Therefore, S deficiency has seldom been encountered in peach-growing areas and often is not included in nutrient deficiency threshold tables [10]. [11] used a commercial product of Acidam AVC 50 which contains 50% fine granulated sulfur and Thiobacillus genus microorganism on Romeiko vine cultivar by adding this product on February at 0.1 kg/m² in the first season and 0.05kg/m² in the second season and mixing it with soil. [12] showed that the addition to mineral sulfur (250gm S. vine⁻¹) caused a significant increase in total yield of Thompson sedless grapevine as compared with control. [13] studied the effect of slow release nitrogen fertilization such as sulfur coated urea at concentrations of 200, 300 and 400 gm. tree⁻¹ and ammonium sulfate (200gm. tree⁻¹) as control on the fruiting of Guava trees, and they showed that sulfur coated urea fertilizer at all concentrations enhanced tree fruiting and fruit as compared to control. [14] noted that "Mit Ghamr" peach trees that fertilized with 500gm. tree⁻¹ of sulfur coated urea recorded the highest values of fruits number and yield per tree compared to other slow release fertilizers and urea. On the other hand, fruit weight and volume, TSS% and total sugar were positively affected in response to increase of the slow release nitrogen fertilizers especially sulfur coated urea rather than using urea, while the total acidity was reduced.

Iron (Fe) is ranked fourth in abundance after oxygen, silicon and aluminum in the earth's crust. Most soils contain adequate total iron which is ranged from 100 to 100000mg. Kg⁻¹ soil, but amounts that are available to plants might be inadequate dependent on various soil factors, especially in calcareous soils, high pH, CaCO₃ content, ion imbalance and poor physical properties such as very high or low soil temperature, high humidity, poor soil aeration, compaction can induce iron deficiency, low organic matter content, acidic soils that rich with zinc, copper and manganese, and excess phosphorus fertilization also exacerbates the chlorosis problem [3-6].

[15] illustrated that when 'Le-Cont' pear trees were sprayed twice a year with 60mg Fe. L⁻¹ alone or mixed with Mn and Zn at a concentration of 25mg. L⁻¹ for each, enhanced tree fruiting via fruit set and improved most fruit parameters which limited the quality. [16] found that foliar application of 'Le-Cont' pear trees with 36mg Fe. L⁻¹ in the form of Fe-EDDHA alone or mixed with some nutrients (Ca, K, B, Zn and Cu) resulted in a significant increase in tree yield, fruit weight, fruit diameter, TSS, total sugar, reduced sugar and total acidity as compared to the control. [17] observed that foliar application of Fe-sulfate at rate of 0.05% on 'Anna' apple trees alone or in combination with Zn and Mn sulfate at the same concentration substantially increased tree yield, number of fruits per tree, fruit weight and fruit diameter. [18] showed that spraying 'Anna' apple trees grown in calcareous soil with Fe alone or in combination with Zn and Mn significantly improved tree yield, number of fruit per tree, fruit weight, fruit firmness, TSS, acidity and total sugar.

[19] observed that spraying 'Le-Cont' pear trees with chelated iron (Fe-EDDHA) at a concentrations of 30 and 60 mg Fe. L⁻¹ alone or in combination with three levels of Mn (0, 15 and 30mg Mn. L⁻¹) significantly increased fruits number per tree, fruit weight, fruit volume, TSS and yield. However, these concentrations tended to decrease acidity. [20] revealed that foliar sprays with micronutrients like iron enhanced nutritional status and improved the yield and quality of peach trees. [21] found
that there was a significant increase in fruits number per tree, fruit weight and volume, trees yield, fruits length, and diameter, when the trees of apple cv. Barwari were sprayed with 25, 50 and 75 mg Fe. L⁻¹[22] noticed that spraying apple trees cv. Starking Dilicious with 25, 50 and 75 mg Fe. L⁻¹ significantly increased fruits number per trees, fruit weight and volume, trees yield, TSS, carbohydrate concentration, fruit juice contents and significantly decrease fruit acidity as compared with control. Therefore, because there was no study in Iraqi Kurdistan on the effect of soil application of sulfur and foliar spray of iron on fruit trees especially peach trees cv. Dixired. Therefore the aims of this study are Improving the trees yield and fruit quality of Dixired peach trees and limiting the conformity levels of sulfur and iron which were added to peach trees grown in Gr-Rash orchards, to obtain best tree yield with best quality.

2. Materials and Methods

A present study was conducted during 2011 growing season on six year old of peach trees (Prunus persica Batsch) grown in Gr-Rash orchard / Duhuk governorate / Iraq, which were budded on seedling peach rootstock, the trees were similar as it is possible in growth vigor, and trained on open central method, to investigate the effect of Sulfur and Iron on tree yield and some of fruits characters. Trees were spaced at (3.5 x 3.5) meter and irrigated by single cistern method. Full bloom occurred 20th March. The experiment was carried out in a Randomized Complete Block Design (R.C.B.D.), Including two factors, first was soil application of Sulfur which was applied in the first week of January at four levels (0, 250, 500 and 750 gm S. tree⁻¹), second was foliar spray with three concentrations of iron (0, 50 and 100 mg Fe. L⁻¹) using Fe-EDDHA (6% Fe) which was sprayed at two equal sprays, first was done after 15 days of full bloom, the second spray was applied after one month of the first spray. A surfactant agent (Tween 80) was added to all spray treatment solutions at ten drops per holder (0.025 %) to reduce surface tension of solution.

| Characteristics        | Measurement units | Value     |
|------------------------|-------------------|-----------|
| Electrical conductivity | (disysimns.m⁻¹)   | 0.12      |
| pH                     |                   | 7.34      |
| Organic matter         | g. kg⁻¹           | 16.7      |
| Sand                   | g. kg⁻¹           | 397.4     |
| Silt                   | g. kg⁻¹           | 307.7     |
| Clay                   | g. kg⁻¹           | 294.9     |
| Texture                |                   | Clay Loam |
| Total nitrogen         | %                 | 0.235     |
| Available Phosphorus   | mg. kg⁻¹          | 8.40      |
| Available Potassium    | mg. kg⁻¹          | 72.33     |
| Available Sulfur       | mg. kg⁻¹          | 18.99     |
| Available Iron         | mg. kg⁻¹          | 1.788     |
| Available zinc         | mg. kg⁻¹          | 0.387     |
| Available manganese    | mg. kg⁻¹          | 0.760     |
| Calcium carbonate      | %                 | 15.89     |
| Bicarbonate HCO₃⁻      | m mole. L⁻¹       | 3.02      |
The analysis was carried out at Directorate of Research in Erbil Laboratory Division, Agricultural ministry.

During the harvest period of 30/5 to 5/6 /2011), the yield per tree was recorded in kilogram. For determination of fruit characteristics, twenty fruits were picked up randomly from each experimental unit as a composite sample. The studied parameter were Number of Fruits (fruit .tree⁻¹), Fruit Fresh Weight (gm. fruit⁻¹), Fruit Total Soluble Solids (TSS %) by using table refractometer, Fruit Total Acidity (%). It was determined by titration of sodium hydroxide solution 0.1 N with 10ml of fruit juice using phenolphthalein as an indicator [23], Fruit TSS / Acidity Ratio (%), Fruit Juice Volume (ml. fruit⁻¹), it was measured after washing the fruits, grounding them and juice extracting, with the use of a lab-scal fruit juice extractor Juicer/blender, Panasonic, Mj, Japan [24], and Anthocyanin in fruit peel was determined by taking (5 gm) of fruit peel, then diluted in 100ml mixture of (85% alcohol + 15% HCl 1.5 N), and left at 4-5 ºC for 24 hour. Thereafter, they were filtrated with filter paper (Watman No.1) and finally used spectrophotometer reading at wave length of 535nm [25]. All the data were tabulated and statistically analyzed with computer using SAS program [26]. The differences between various treatment means were tested with Duncan Multiple Range test at 5% level [27].

3. Results and Discussion

Results in tables (2 and 3) shows that the soil application of S levels significantly increased Fruits number per tree, Fruit fresh weight, Fruit volium, Tree yield, Fruit TSS, TSS/acidity and Fruit Peel anthocyanin content, especially at 750gm S. tree⁻¹ in comparison with control, meanwhile the heighest Fruit acidity were in the treatment of 250 gm S. tree⁻¹. These results are in accordance with those obtained by [11]; [12]; [13] and [14]. Increasing yield components by soil application of sulfur may be attributed to the role of sulfur in decrease soil pH in rhizosphere [28] and [29] they indicated that decrease of soil pH may be due to sulfur oxidation in soil by Thiobacillus bacteria and then sulfuric acid formation which cause soil pH decrease [30] and [8], an increase of nutrient availability, increase leaf nutrient content, leaf area and total chlorophyll, all this may be led to an increase of carbohydrates which improve buds conversion and formation of flowers, also opening more buds in spring [31], consequently an increase in fruit number, fruit weight, fruit size and finally fruit yield per tree and other yield parameters. An increase of anthocyanin as a result of sulfur application may be due to the role of sulfur in increasing fruit total soluble solids, where [32] indicated that pigments formation needs enough amount of soluble sugars. [33] found that there was liner relation between number of leaves per branch and reducing sugars in fruits and anthocyanin. It is obvious results from tables (2 and 3) that there were significant effects with the foliar spray of Fe concentrations on all studied parameters (Fruits number per tree, Fruit fresh weight, Fruit volium, Tree yield, Fruit TSS, TSS/acidity and Fruit Peel anthocyanin content), while fruit total acidity was decreased, particularly at 100mg Fe. L⁻¹ concentration as compared with control, these results are in agreement.
Table 2. Effect of Sulphur and Iron on fruits number, fruit fresh weight, fruit volume and tree yield of Dixired peach trees in 2011 season.

| Fe conc. (mg Fe. L⁻¹) | Sulphur levels (gm S.tree⁻¹) | Means |
|------------------------|------------------------------|-------|
|                        | 0                            | 250   | 500 | 750 |
| Fruits number (Fruit.tree⁻¹) |                             |       |     |     |
| 0                      | 106.11 c                     | 103.89 c | 109.78 c | 111.33 c | 107.78 b |
| 50                     | 114.89 c                     | 129.33 c | 118.11 c | 121.33 c | 120.92 b |
| 100                    | 195.33 b                     | 195.00 b | 361.33 a | 389.67 a | 285.33a |
| Means                  | 138.78 b                     | 142.74 b | 196.41a  | 207.44 a |       |
| Fruits Fresh weight (gm.Fruit⁻¹) |                     |       |     |     |
| 0                      | 94.19 d                      | 100.74 bcd | 104.37 a-d | 92.25 d | 97.86 b |
| 50                     | 95.84 cd                     | 90.84 d  | 97.45 bcd | 116.65 a | 100.19 ab |
| 100                    | 101.04 bcd                   | 108.47 abc | 100.07 bcd | 110.87 ab | 105.13 a |
| Means                  | 97.01 b                      | 100.02 ab | 100.65 a  | 106.60 a |       |
| Fruit volium (cm³.Fruit⁻¹) |                     |       |     |     |
| 0                      | 81.16 de                     | 77.84 e  | 86.62 cd  | 85.82 cde | 82.86 b |
| 50                     | 87.59 bcd                    | 81.61 cde | 84.08 cde | 87.96 bcd | 85.31 b |
| 100                    | 85.92 cde                    | 89.90 bc | 95.20 ab  | 97.87 a  | 92.22 a |
| Means                  | 84.89 bc                     | 83.12 c  | 88.63 ab  | 90.55 a  |       |
| Tree yield (kg.tree⁻¹) |                     |       |     |     |
| 0                      | 9.88 e                       | 10.41 e  | 11.41 e  | 9.78 e   | 10.37 c |
| 50                     | 10.81 e                      | 11.17 e  | 11.43 e  | 14.09 d  | 11.87 b |
| 100                    | 19.33 c                      | 21.04 c  | 36.10 b  | 42.65 a  | 29.78 a |
| Means                  | 13.34 c                      | 14.21 c  | 19.64 b  | 22.17 a  |       |

*Means of each factor and their interactions for each parameter followed by the same letters are not significantly different from each other according to Duncan's multiple ranges test at 5% level.

Table 3. Effect of Sulphur and Iron on fruit TSS, fruit acidity, TSS/acidity and fruit peel anthocyanin content of Dixired peach trees in 2011 season.

| Fe conc. (mg Fe. L⁻¹) | Sulphur levels (gm S.tree⁻¹) | Means |
|------------------------|------------------------------|-------|
|                        | 0                            | 250   | 500 | 750 |
| Fruit TSS (%)          |                             |       |     |     |
| 0                      | 10.21 f                      | 10.21 f | 10.64 ef | 10.20 f | 10.31 c |
| 50                     | 10.73 def                    | 11.57 d  | 11.35 de | 12.81 c | 11.61 b |
| 100                    | 13.12 bc                     | 13.35 bc | 13.85 b | 15.69 a | 14.00 a |
| Means                  | 11.35 c                      | 11.71 bc | 11.95 b | 12.90 a |       |
| Fruit acidity (mg.L⁻¹) |                             |       |     |     |
| 0                      | 0.566 ab                     | 0.609 a  | 0.582 ab | 0.551 ab | 0.577 a |
|         | 50       | 100      | Means   |
|---------|----------|----------|---------|
| 0.470 cd  | 0.516 bc | 0.454 cd | 0.455 cd |
| 0.438 d   | 0.460 cd | 0.456 cd | 0.435 d  |
| 0.454 cd  | 0.474 b  | 0.497 ab | 0.481 b  |

**Means of each factor and their interactions for each parameter followed by the same letters are not significantly different from each other according to Duncan's multiple ranges test at 5% level.**

With those of [15]; [16]; [19]; [21] and [22]. This may be due to the increase in leaf area and total chlorophyll content (Table, 23) with the increase of iron concentration as it mentioned before which led to an increase in the photosynthesis rates and its products which were used in many processes in the plant such as cell division and enlargement and reducing pre-harvest fruit dropping which surely reflected on improving the tree yield and its characteristics [34]; [35] and [16].

The interaction between Fe and S reveals that there was a significant effect on all studied parameters, the highest means of Fruits number per tree, Fruit fresh weight, Fruit volium, Tree yield, Fruit TSS, TSS/acidity and Fruit Peel anthocyanin content was obtained at the treatment of 750gm S. tree⁻¹ with 100 mg Fe. L⁻¹.

**Acknowledgment**

Thanks to the College of Agriculture, University of Duhok for using its laboratories in chemical analyzes.

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