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Effect of foliar application of Iron and Microgreen fertilizer on vegetative growth, quantitative and berries characteristics of grapevine (*Vitis vinifera* L.) cv. Khoshnaw under non-irrigated condition

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Abstract
This experiment was carried out in a private vineyard located at Wazha village in Shar-Bazher district, Sulaimani governorate, Kurdistan region, Iraq, the elevation of the orchard is 974 m above sea level, during season 2017, to study the effect of foliar application of three concentrations of Iron ($FeSO_4$, 20.5 % Fe) (0, 75, 150 $ml.L^{-1}$) and three concentrations of Microgreen fertilizer (Microgreen) (0, 0.5, 1 $g.L^{-1}$) on grapevine cv. Khoshnaw, 20 years old. The results shows that spraying of Iron or Microgreen had a positive effect on leaf area, leaf fresh and dry weight, total chlorophyll percentage, number of cluster, cluster weight, yield as well as berry length and diameter and weight and size of 100 berries, as such TSS and total sugar as compared to check treatment, whereas the same traits lead to decrease in total acidity percentage. The treatment combination had no effect on number of clusters per vine, juice percentage and juice density.
The interaction between Iron and Microgreen at 150 $m.L^{-1}$ Iron and 1 $g.L^{-1}$ of Microgreen gave the highest values of all growth parameter and yield and grape characteristics except total acidity that obtained in the control.

Introduction

Grape (*Vitis vinifera* L.) belongs to family Vitaceae, is perhaps the most widely cultivated fruit crop of the world in varying climatic zones extending from the temperate to the tropics. It is one of the most delicious, refreshing and nourishing subtropical fruits. The berries are a good source of minerals and vitamins (B1, B2 and C). The fruits are consumed in fresh forms as a table grape and in the processed form as raisin and fresh juice ***[1]***.

Khoshnaw is a late black variety; it is considered as a good table grape and could be used in the juice, wine and raisin industries. The cluster is usually conical in shape, although it is sometimes cylindrical with a small shoulder. Its size is medium to large. The berries are round and in some clones often have some elongation with medium compaction. The color of the berries is dark-black or red-violet.

In plant, micronutrients are playing an important role in the production and productivity. Among Microgreen, Iron plays vital role in synthesis of chlorophyll, carbohydrate production and cell respiration, chemical reduction of nitrate and sulfate and in nitrogen assimilation ***[2]*** and ***[3].***

The importance of Microgreen, particularly (Mg, Cu, Mn, Zn, B and Mo) are well established as the essential plant nutrients. A continuous supply of iron is essential for good plant health ***[4]*** and ***[5],*** Magnesium functions in chlorophyll synthesis, enzyme activation and can play a similar role to Ca in membrane stability.

It also is important in the partitioning of carbohydrates from the leaves to the roots ***[6]***. Copper is a non-protein component of several oxidizing enzymes such as ascorbate oxidize and tyrosinase, and forms an important part of the electron transport chain in photosynthesis ***[7]*** and ***[8]***, Zinc is important in the synthesis of the growth regulator Indole acetic acid, is a component of many different enzymes and plays an important role in pollen and fruit formation ***[9]***, boron is important in cell division and in the normal development of pollen and pollen tube growth, so it follows that boron-deficient vines have poor fruit set. It is an important component of cell walls ***[10]***, Molybdenum is a component of the enzyme systems that carry out reduction oxidation reactions. Enzymes that require Mo include nitrate reductase, which is essential for the incorporation of root-supplied N into cell components and other enzymes involved in cell function ***[11]***.
So, this study is planned to determine the effect of Microgreen fertilizer and Iron on growth, yield, chemical characteristics and fruit quality of grapevine cv. Khoshnaw grown under rain-fed condition.

Material and Method

This study was carried out on a private vineyard located near Shar-Bazher town, Sulaimani governorate, Kurdistan region, Iraq, the elevation of the orchard is 974 m above sea level, during growing season 2017 to investigate the effect of foliar application of Iron ($FeSO_4$, 20.5 % Fe) and Microgreen (EDTA) on the vegetative growth, productivity and berries quality of grapevine cv. Khoshnaw. So this experiment included two factors, the first factor included following three concentrations of Iron (0, 75, 150 $ml.L^{-1}$), while the second factor was the three concentrations of Microgreen (0, 0.5, 1 $g.L^{-1}$). The vines were sprayed twice per season:

1- Once (two weeks before full bloom).
2- Second (two weeks after berry setting).

The Microgreen fertilizer used in this study was in form (EDTA), it is content were as follows:

Chemical composition	
element chelated (EDTA)	*pct (w/w)%*
Iron Fe	*5.00*
Magnesium Mg	*4.50*
Copper Cu	*2.50*
Manganese Mn	*2.50*
Zinc Zn	*1.50*
Boron B	*0.50*
Molybdenum Mo	*0.05*
Do not exceed 6	*pH*
Free from Cl and Na	

Therefore, the experiment consisted of nine treatments with three replications, with one individual vine for each experiment unites and applied as factorial experiment by using (RCBD) design. So the numbers of vines used were 27 vines, the vineyard was 20 years old and the investigated vines were trained of (T) trails and were pruned by leaving seven canes each with five eyes (total eyes lifted on the each vine were 35 eyes). A detergent powder as wetting agent at (1-2 $g.L^{-1}$) was added to all the spraying solution including 0.0 $ml.L^{-1}$ Iron and 0.0 $g.L^{-1}$ Microgreen (control). The vines were sprayed with Iron and Microgreen solutions till run off 2 $L.vine^{-1}$. Horticultural practices except the addition of Iron and Microgreen were used as usual. Potential effects of Iron and Microgreen were evaluated in terms of the change in growth vine, leaf area was calculated by (leaf area meter AM 300), leaf fresh and dry weight, total chlorophyll content according to (SPAD), number of cluster per vine, cluster weight, number of berries per cluster and yield as well as weight and size of 100 berries and length and width of berries as such TSS, total sugar, total acidity percentage, juice percentage and juice density.

All results were analyzed statistically by using SAS programs **[12]**. Duncan's multiple tests at 5% level of probability was to compare the treatment according to **[13].**

Results and discussion

1. Vegetative growth characteristics:

Data presented in table (1) shows that vegetative growth properties for vines sprayed with Iron is superior significantly on the control. Highest leaf area, Leaf fresh and dry weight and total chlorophyll (130.06, 2.631, 1.091 and 52.20) gave by vines spraying with Iron at conc. (150 $ml.L^{-1}$) respectively compared with lowest leaf area (106.24, 2.142, 0.744 and 41.52) at control.

Increasing concentrations of Microgreen were also significantly increased vegetative growth properties. Best values of leaf area, Leaf fresh and dry weight and total chlorophyll (123.86, 2.693, 1.071 and 50.54) gave by vines sprayed 1 $g.L^{-1}$ Microgreen and the lowest values (109.57, 2.058, 0.791 and 41.60) respectively were with vine unsprayed.

Concerning the interaction between spraying different concentrations of Iron and spraying different concentrations of Microgreen on the vegetative growth properties, it is clear from table (1) that the interaction of Iron and Microgreen gave the highest leaf area, Leaf fresh and dry weight and total chlorophyll (138.14, 2.720, 1.301 and 58.93) respectively compared with lowest leaf area, leaf fresh and dry weight and total chlorophyll (98.46, 1.575, 0.576 and 36.03) from the control.

Table-1: Effect of foliar application of Iron and Microgreen and their interactions on vegetative growth characteristics of grapevine (*Vitis vinifera* L.) cv. Khoshnaw.

Treatment			Parameters			
			Leaf area (cm^2)	Leaf fresh weight (g)	Leaf dry weight (g)	Total Chlorophyll (SPAD)
Iron ($ml.L^{-1}$)		0	106.24 c	2.142 b	0.744 b	41.52 c
		75	116.07 b	2.433 a	0.921 ab	45.59 b
		150	130.06 a	2.631 a	1.091a	52.20 a
Microgreen ($g.L^{-1}$)		0	109.57 b	2.058 b	0.791 b	41.60 c
		0.5	118.94 a	2.455 a	0.894 ab	47.17 b
		1	123.86 a	2.693 a	1.071 a	50.54 a
Iron 0	Microgreen	0	98.46 e	1.575 c	0.576 b	36.03 d
		0.5	109.17 de	2.066 b	0.755 b	43.33 c
		1	111.07 ce	2.785 a	0.901 ab	45.20 c
Iron 75	Microgreen	0	106.68 de	1.951 bc	0.850 ab	43.40 c
		0.5	119.18 bd	2.628 a	0.903 ab	45.87 c
		1	122.37 bc	2.720 a	1.010 ab	47.50 bc
Iron 150	Microgreen	0	123.57 bc	2.647 a	0.946 ab	45.37 c
		0.5	128.46 ab	2.670 a	1.025 ab	52.30 b
		1	138.14 a	2.574 a	1.301 a	58.93 a

Means with the same letter in each column for each factor and interaction are not significantly different according to Duncan multiple ranges test at 5% level.

2. Yield characteristics of grape:

It's clear from Table (2) that number of clusters, cluster weight and yield per vine sprayed with Iron ($FeSO_4$) are significantly superior on the control. Highest number of clusters, cluster weight, number of berries per cluster and yield per vine (50.00, 430.01and 21.804) respectively gave by vines sprayed with Iron at conc. (150 $ml.L^{-1}$) compared with lowest value (41.11, 297.05 and 12.451) respectively resulted from the control, whereas spraying Iron had no significant effect on the number of berries per cluster.

Data presented in table (2) also shows that increasing concentration of Microgreen significantly increased number of clusters per vine, cluster weight and yield as compared to the control, the highest values were 50.00, 427.33 and 21.49 respectively obtained from spraying Microgreen with 1 $g.L^{-1}$ which significantly surpassed control treatment, whereas spraying Microgreen had no significant effect on the number of berries per cluster.

Same table shows that the interaction between Iron and Microgreen significantly increased number of clusters per vine, cluster weight and yield, the highest value (55.00, 488.76 and 27.063) respectively were resulted from the interaction of 150 $ml.L^{-1}$ Iron + 1 $g.L^{-1}$ Microgreen, while the lowest value (37.67, 210.85 and 8.076) of number of clusters, cluster weight and yield per vine respectively obtained from the control, Whereas number of berries per vine appeared to be not affected neither by Iron concentrations nor by the Microgreen concentrations.

Table-2: Effect of foliar application of Iron and Microgreen and their interaction on yield characteristics of grape (*Vitis vinifera* L.) cv. Khoshnaw.

Treatment			Parameters			
			Number of Clusters per vine	Cluster weight (g)	Number of Berries (Berries/cluster)	Yield (kg/vine)
Iron ($ml.L^{-1}$)		0	41.11 b	297.05 b	163.78 a	12.451 b
		75	47.22 ab	383.71 a	180.89 a	18.438 a
		150	50.00 a	430.01 a	190.89 a	21.804 a
Microgreen ($g.L^{-1}$)		0	42.22 b	305.17 b	167.78 a	13.227 b
		0.5	46.11 ab	378.28 ab	180.11 a	17.828 ab
		1	50.00 a	427.33 a	187.67 a	21.638 a
Iron 0	Microgreen	0	37.67 c	210.85 c	149.00 a	8.076 c
		0.5	41.33 bc	308.04 bc	161.33 a	12.674 bc
		1	44.33 ac	372.27 ab	181.00 a	16.604 bc
Iron 75	Microgreen	0	44.00 ac	343.73 abc	174.67 a	15.265 bc
		0.5	47.00 ac	386.44 ab	179.00 a	18.802 ab
		1	50.67 ab	420.96 ab	189.00 a	21.248 ab
Iron 150	Microgreen	0	45.00 ac	360.93 ab	179.67 a	16.341 c
		0.5	50.00 ac	440.35 ab	200.00 a	22.008 ab
		1	55.00 a	488.76 a	193.00 a	27.063 a

Means with the same letter in each column for each factor and interaction are not significantly different according to Duncan multiple ranges test at 5% level.

3. Berries characteristics:

Data presented in table (3) shows that berries characteristics represented in term of diameter, berry length, weight and size of 100 berries for vines sprayed with Iron is overtopped significantly on the control. Highest diameter, berry length and weight and size of 100 berries (16.30, 18.22, 236.12 and 208.33) gave by spraying vines with Iron at conc. (150 $ml.L^{-1}$) respectively compared with lowest values (15.00, 16.99, 206.06 and 194.11) at the control.

Increasing the concentrations of Microgreen were significantly increased only weight and size of 100 berries, the best value of property that mentioned above (238.18 and 207.67) respectively gave by vines sprayed Microgreen (1 $g.L^{-1}$) compared with lowest value (207.58 and 192.78) respectively with the control. But increasing the concentrations of Microgreen had no significant effect on the berry diameter and berry length.

For the interaction, data in table (3) shows that the highest value of berry length, weight and size of 100 berries (18.25, 248.87 and 213.00) respectively was obtained in vines sprayed with 150 $ml.L^{-1}$ Iron + 1 $g.L^{-1}$ Microgreen, compared with lowest value in the control. The highest value of berry diameter (16.50) was

obtained in vines sprayed with 150 ml.L^{-1} Iron + 0.5 g.L^{-1} Microgreen and, the lowest value (14.34) was obtained in the control.

Table-3: Effect of foliar application of Iron and Microgreen and their interaction on berries characteristics of grape (*Vitis vinifera* L.) cv. Khoshnaw

Treatment			Parameters			
			Berry diameter (mm)	Berry length (mm)	Weight of 100 berries (g)	Size of 100 berries (cm^3)
Iron ($ml.L^{-1}$)		0	15.00 b	16.99 b	206.06 b	194.11 b
		75	15.95 a	17.80 a	227.03 ab	199.33 ab
		150	16.30 a	18.22 a	236.12 a	208.33 a
Microgreen ($g.L^{-1}$)		0	15.24 a	17.43 a	207.58 b	192.78 b
		0.5	15.99 a	17.72 a	223.46 ab	201.33 ab
		1	16.01 a	17.86 a	238.18 a	207.67 a
Iron 0	Microgreen	0	14.34 b	16.46 c	183.17 b	185.67 b
		0.5	15.24 ab	16.92 bc	211.13 ab	190.67 ab
		1	15.42 ab	17.58 ac	223.87 ab	206.00 ab
Iron 75	Microgreen	0	15.27ab	17.64 ac	218.27 ab	191.67 ab
		0.5	16.24 a	18.00 ab	221.03 ab	202.33 ab
		1	16.34 a	17.75 ab	241.80 a	204.00 ab
Iron 150	Microgreen	0	16.10 a	18.18 a	221.30 ab	201.00 ab
		0.5	16.50 a	18.23 a	238.20 a	211.00 a
		1	16.28 a	18.25 a	248.87 a	213.00 a

Means with the same letter in each column for each factor and interaction are not significantly different according to Duncan multiple ranges test at 5% level.

4. Chemical characteristics of grape:

Concerning the foliar application of Iron, data in table (4) shows that the highest value of TSS and total sugar (18.62 and 17.92) respectively were obtained with vines sprayed with Iron 150 ml.L^{-1} which were surpassed significantly with untreated vine, while the same concentration of Iron significantly reduced total acidity percentage, but had no significant effect on juice percentage and juice density.

For the effect of Microgreen, data in table (4) also shows that Microgreen at concentrations of 0.5 g.L^{-1} and 1 g.L^{-1} significantly increased TSS and total sugar percentage which were (18.47 and 17.40%) respectively and exposed no significant impact on juice percentage and juice density. At the same time foliar application of Microgreen reduced total acidity (220 %).

Table (4) also indicates the interactions between the two factors which gave a significant effect in chemical characteristic of berries. The interaction between sprays of 150 ml.L^{-1} Iron + 1 g.L^{-1} Microgreen gave the highest TSS, total sugar and juice density (20.40, 18.96 and 1.098) respectively, which were superior significantly to most of the other treatment. On the other hand the interaction between sprays 150 ml.L^{-1} Iron + 1 g.L^{-1} Microgreen significantly reduced total acidity percentage and recorded the lowest value (0.162 %) compared to the highest total acidity (0.302 %) from the control. Both factors had no significant effect on juice percentage.

Table-4: Effect of foliar application of Iron and Microgreen and their interaction on chemical characteristics of grape (*Vitis vinifera* L.) cv. Khoshnaw.

Treatment			Parameters				
			TSS (%)	Juice percentage (%)	Total sugars (%)	Total acidity (%)	Juice density (D)
Iron ($ml.L^{-1}$)		0	15.58 c	71.40 a	13.25 c	0.279 a	1.054 a
		75	17.07 b	80.34 a	15.49 b	0.238 b	1.000 a
		150	18.62 a	78.9 a	17.92 a	0.195 c	1.067 a
Microgreen ($g.L^{-1}$)		0	15.74 c	73.90 a	13.41 b	0.262 a	1.012 a
		0.5	17.06 b	76.72 a	15.85 a	0.231 b	1.056 a
		1	18.47 a	80.03 a	17.40 a	0.220 b	1.054 a
Iron 0	Microgreen	0	14.03 e	63.01 a	9.44 c	0.302 a	1.016 ab
		0.5	15.67 de	79.11 a	14.01 b	0.274 ab	1.082 a
		1	17.03 bd	80.03 a	16.31 ab	0.262 ac	1.064 ab
Iron 75	Microgreen	0	16.17 cd	67.11 a	14.41 b	0.262 ac	0.968 b
		0.5	17.07 bd	80.11 a	15.12 ab	0.218 d	1.033 ab
		1	17.97 bc	82.80 a	16.94 ab	0.235 bd	0.999 ab
Iron 150	Microgreen	0	17.03 bd	83.58 a	16.39 ab	0.223 cd	1.053 ab
		0.5	18.43 b	81.61 a	18.42 a	0.201 de	1.051 ab
		1	20.40 a	74.50 a	18.96 a	0.162 e	1.098 a

Means with the same letter in each column for each factor and interaction are not significantly different according to Duncan multiple ranges test at 5% level.

The increase of vegetative growth parameters, yield and its component by the foliar application of Iron may be due to the role of Iron in activation of enzymes system and many metabolism processes, which are related with plant growth, in addition to the response of vegetative growth characteristics to Iron foliar application is usually accompanied with increase in the flowering and yield characteristics ***[14]***. Also may be due to increasing quicker availability of Iron to plants, might have resulted in increase catalase and chlorophyll content, and also manufacture and accumulate of more carbohydrate, which seems to be associated with increase in fruiting and fruit development ***[15]*** and ***[16]***. Iron also increases the berry size by the parenthesis assimilation of reduced nitrogen. Since, it is an element of the nitrite and nitrate reductase enzymes and to increase the yield ***[5]***.

The positive effects of Microgreen on growth and yield characteristics of grapevine may be due to the application of nutrients can be a noteworthy alternative to chemical, and foliar spray application of these products can have prospects for a possible economical use ***[17],*** may be helped in the plant and in turn increase metabolic process in plant ***[5]***.

The reason of increasing vegetative growth characteristics when adding Microgreen during the growing season may also be attributed to the role of Microgreen in many biological and physiological processes in the plant. Also the presence of certain elements substance in Microgreen can have a stimulate effect on the characteristics of vegetative growth of the plant ***[18]*** and the role of these elements to stimulate a number of enzymes important in the process of photosynthesis ***[4]*** and ***[5]*** Also the effect of nutrients on energy transfer through photosynthesis and respiration ***[19]*** and ***[20]*** which in turn leads to improve the vegetative growth characteristics represented by the increase in single leaf area, leaf fresh and dry weight, and leaf chlorophyll content which are positively reflect on grape quality characteristics.

Conclusion

Based on the results obtained from the present study concerning the effect of foliar application of Iron and Microgreen on grapevine cv. Khoshnaw (*Vitis vinifera* L.) at two different growth stages had a positive effect on vegetative growth, yield, berries quality and chemical characteristics of grape, the conclusions can be that foliar application of Iron was more effective in increasing yield characteristics of grape, berries

quality and chemical characteristic of berries especially at concentration 150 ml.L^{-1}, Microgreen at concentration 1 g.L^{-1} increased most of the parameters. The interaction between Iron and Microgreen at 150 m.L^{-1} Iron and 1 g.L^{-1} of Microgreen gave the highest values of all growth parameter and yield and grape characteristics except juice percentage which not affected by the treatments, and the highest values of total acidity were obtained with the control.

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