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EFFECT OF FOLIAR APPLICATION OF CHELATED NANO COPPER ON VEGETATIVE GROWTH AND PRODUCTIVITY OF TAIFI GRAPE CULTIVAR

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ABSTRACT

This research was conducted during the 2022 season to study the effect of foliar application of chelated Nano-Copper , and their interaction with a number of spraying times on vegetative growth of yield of Taifi grape cv. (*Vitis vinifera* L.). Chelated Nano-Copper was sprayed at four concentrations 0, 1 , 1.5 and 2 g l^{-1}. The result showed the superiority of the spraying with 1.5 g l^{-1} in traits of leaf area, total chlorophyll, number of clusters, berry weight, cluster weight and yield of grapevine. Furthermore, spraying three times achieved the best results for the leaf area, total chlorophyll, number of clusters, berry weight, cluster weight and yield of grapevine per vine. Foliar application of Chelated Nano-Copper was and number of spraying times achieved a significant increases in vegetative growth and the yield parameters compare to the control.

INREODUCTION

Grape (*Vitis vinifera* L.) is considered as one of the most popular, favorite fruits and remain the most economically important fruit crop in the world (Keller, 2020 and Mohamed, 2020). Taifi grape cultivar is consider among the table grape varieties distinguished by growth and production due to high ecological adaptation in Iraq (Al-Atrushy, 2018). The spraying of the micor nutrients affect various aspects of vine growth and also enhance better quality production of the fruit. Mineral nutrition is one of the main tools to optimize fruit production (Tagliavini, and Marangoni, 2002). Various mineral elements are essentially required in the form of macro- and micronutrients for proper growth of vegetative and reproductive tissues. Copper (Cu) is one of the micronutrients needed in very small quantities by plants, and is a known to function in regulating plant growth and development, including chlorophyll formation and is involved in several enzyme systems that regulate the rate of many biochemical reactions in plants (Singh *et.al.*, 2017, Viera *et.al.*, 2019). Cu is also required in the process of photosynthesis, and is essential for plant

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respiration and metabolism of carbohydrates and proteins (Ambrosini *et al*., 2018; Din *et al*. 2017). Copper is also an essential micronutrient for normal plant growth and metabolism. In plants, Cu plays a vital role in various metabolic processes, namely cell wall metabolism, also acts as structural element in regulatory proteins, photosynthetic electron transport and mitochondrial respiration, biosynthesis of plant hormones, and as cofactor for a variety of enzymes (Ke, et al. 2007). Copper is an important mineral nutrient found in chloroplasts as a cofactor associated with plastocyanin and Cu/Zn super oxide dismutase (Cu/ZnSOD), (Cohua, et al. 2009). In agriculture, nanotechnology is mainly utilized in the application of nano fertilizers and nano pesticides to track products and nutrient levels for enhancing growth and productivity and increasing plant resistance to insect pests and microbial diseases (Shang *et al*., 2019; Bhatt *et al*., 2020). Nanoparticles (NPs) are tiny materials 1–100 nm in size and have a large surface area-to-volume ratio, high adsorption efficacy, and increased connecting and working efficiencies owing to their extremely small size (Dubchak *et al*., 2010). NPs may affect plant metabolism by delivering micronutrients (Liu and Lal, 2015), gene regulation (Nair and Chung, 2014), and interfering with several oxidative processes in plants (Hossain *et al*., 2015). Copper (Cu) is one of the micronutrients needed in very small quantities by plants, and is a known to function in regulating plant growth and development, including chlo-rophyll formation and seed production (Viera et al. 2019). Cu also is involved in several enzyme systems that regulate the rate of many biochemical reactions in plants (Singh et al. 2017). Cu is also required in the process of photosynthesis, and is essential for plant respiration and metabolism of carbohydrates and proteins (Ambrosini et al. 2018; Din et al. 2017).

This study was aimed to determine the role of foliar fertilization with chelated Nano-copper, to enhancement the vegetative growth and yield production of Taifi grape cultivar.

MATERIALS AND METHODS

This study was carried out during 2023 season in a private vineyard located at Bara-Buhar village, Duhok governorate, Kurdistan Region, Iraq, on Taifi grape cultivar (*Vitis vinifera* L.) , to investigate the effect of foliar nutrition with chelated Nano-Copper (8% pure Cu) at four concentrations (0, 1, 1.5 and 2 $g.l^{-1}$). and their interaction with the number of spray times. spraying once before flowering 25/4/2022. Spraying twice, the first before flowering and the second after setting 1/6/2022. Spraying three times per season , the first was before flowering; the second was after berry setting, and the third sprayed were took place on veraison 1/7/2022. on the vegetative growth and productivity on 16 years old of Taifi grape cultivar. Tween 80 (as wetting agent) was applied at 0.1% to all spray solutions and the vines were sprayed till runoff.

The vines with T- trained Taifi grapevines that were taken in this study were chosen to be as uniform as possible in vigor and were planted at 1.8 × 3 meters apart. Pruning was done in the beginning of March by leaving 48 buds per vine (6 canes per vine each with 8 eyes plus 10 renewals spur each with 2 eyes). The vines were irrigated with a drip-irrigated system. All grapevines undertaken in this study were receiving the regular agricultural and horticultural practices that are usually carried out in vineyard. Full description of the tested soil (1).

Table 1: physical and chemical characteristics of experimental soil samples at 0-50 cm:

Physical analysis of soil samples :					
Sand (%)	Silt (%)	Clay(%)	Organic matter (%)	Texture	
72.7	12.25	15.45	2.779	Sandy loam	
Chemical analysis of soil samples:					
EC dec.m^{-1}	pH	Cation (Meq.L^{-1})		Anions (Meq.L^{-1})	
		Ca^{++}	Mg^{++}	Cl^-	HCO_3^-
0.60	8.3	3	1	2.8	6
Available NPK in soil :					
N (%)		P (ppm)		K (ppm)	
0.0470		16.874		21	

Statistical analysis:

is given in Statistical analysis: the experiment is consist of twelve treatments (four concentrations of Chelated Nano-Copper and nutrients was carrid out three times sprayed per season), with three replication, with two individual grapevine for each experiment unit and applied a factorial experiment within (RCBD) design, observation on different growth parameters were recorded at the end of the experiment. Duncan Multiple Range Test was used for the comparison of treatment means at the 5% level (Roger, and Hasted, 2003). All the data were

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tabulated and statistically analyzed with the computer using SAS system 2017.

RESULTS AND DISCUSSION

Leaf area (cm^2 $leaf^{-1}$) :

It was noted from the results data shown in Table (2) that fertilization with nano-copper at a concentration of 1.5 and 2 g l^{-1} gave the highest leaf area of 13374 and 13286 cm^2 $leaf^{-1}$ respectively, which significantly outperformed the treatments of 1 and 0 g l^{-1} of nano-copper, and the spraying treatment at a concentration of 1.5g l^{-1} was significantly outperformed the control treatment that recorded the lowest area per leaf of 112.23 cm^2 $leaf^{-1}$, and it is also shown that the number of spraying times, especially the three-time spray gave the highest area per leaf of 131.45 cm^2 $leaf^{-1}$ compared to the two spraying treatments once or twice.

Table 2. Effect of foliar application with nano- chelated copper on leaf area of Taify grape cultivar (*Vitis vinifera* L).

Levels of Cu (g l^{-1})	Time			Mean of Cu
	T1	T2	T3	
٠	103.00 h	113.59 g	120.10 f	١١٢.٢٣c
١	120.80 f	126.30 e	130.90 cd	126.00 b
١.٥	127.70 de	135.40 ab	138.13 a	133.74 a
٢	128.00 de	133.90 bc	136.70 ab	132.86 a
Mean of Time	119.87 c	127.29 b	131.45 a	

Means with the same letter are not significantly different according to Duncan multiple ranges test at 5% level.

The results of the same table also show that the bilateral interactions between the studied factors were significantly affected the leaf area , as the treatment of spraying with nano-copper at a concentration of 1.5 g l^{-1} and spraying with three times were significantly outperformed some coefficients, which amounted to 138.13 cm^2 $leaf^{-1}$, while the control treatment was recorded the lowest leaf area.

The reason for the increase in the leaf area may be attributed to the effect of copper in photosynthesis through its role in the formation of chlorophyll (Table 3) and the exploitation of materials manufactured by photosynthesis in increasing leaf growth. In addition to the role of copper in synthesis and activation of enzymes that help in biological processes and the production of chlorophyll and increases the efficiency of photosynthesis, which increases the surface area of the leaves (Vasconcelos and Castagnoli, 2001; Garica, et al, 2004, Singh et al. 2017; Viera et al. 2019).

Total chlorophyll content in the leaves (mg g^{-1} fresh weight):

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The results of Table (3) showed that spraying with nano copper at a concentration of 1.5 and 2 g l-1 gave the highest percentage of total chlorophyll in the leaves of 1.50 and 1.49 g mg-1 soft weight respectively, which significantly outperformed the treatments of 1 and 0 g l-1 of nano-copper, and the spraying with 1.5 g l-1 was significantly superiority the control treatment that recorded the lowest percentage of total chlorophyll in the leaves of 1.19 mg g-1 soft weight. It was also found that the number of sprays, especially the three spray times, gave the highest total chlorophyll content in the leaves of 1.45 mg g-1 fresh weight compared to the one-time spray treatment.

Table 3. Effect of foliar application with nano- chelated copper on the chlorophyll content in the leaves of Taify Grape cultivar (*Vitis vinifera* L).

Levels of Cu (g l^{-1})	Time			Mean of Cu
	T1	T2	T3	
0	1.130 d	1.230 cd	1.236 cd	١.١٩ c
1	1.283 bcd	1.396 abc	1.473 a	1.38 b
1.5	1.450 ab	1.496 a	1.543 a	1.49 a
2	1.430 ab	1.530 a	1.550 a	1.50 a
Mean of Time	1.323 b	1.413 a	1.450 a	

Means with the same letter are not significantly different according to Duncan multiple ranges test at 5% level.

The results of the same table also show that the bilateral interactions between the studied factors were significantly affected in total chlorophyll percentage in the leaves, the treatment of nano-copper spraying at a concentration of 1.5 mg l^{-1} and spray three times was significantly outperformed some of the treayments, which amounted to 1.55 mg g^{-1} fresh weight, while the comparison treatment recorded the lowest total chlorophyll percentage in the leaves of 1.30 mg g^{-1} fresh weight.

The increase in chlorophyll bio metabolism may be attributed to the effect of copper and its contribution to the formation of Iron Porphyrin, which is the basis for the formation of chlorophyll construction, increasing its stability, protecting it from early catabolism and thus increasing the chlorophyll content in the leaves (Arnon, 2002; Viera et al. 2019).

Number of Berries in Cluster:

The data of Table (4) showed that the comparison treatment was significantly exceeded the number of berries in the cluster compared to the rest of

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the treatments amounting to 124.06 berry cluster^{-1}, and the treatment of spraying with nano-copper at a concentration of 1 g l^{-1} was significantly outperformed the treatments of 1.5 and 2 g l^{-1}, while the spraying with 2 g l^{-1} recorded the least number of berries in the cluster amount to 106.80, and it was also found that the number of spraying times did not significantly affect the number of berries in the cluster amount to 113.57 berry cluster^{-1} compared to the three-time spraying treatment that recorded the lowest number of berries in the cluster of 111.9 berry cluster^{-1} .

Table 4. Effect of Foliar Application with Nano- chelated copper on number of berries of Taify grape cultivar (*Vitis vinifera* L).

Levels of Cu (g l^{-1})	Time			Meanof Cu
	T1	T2	T3	
٠	122.40 a	124.80 a	125.00 a	١٢٤.٠٦ a
١	119.00 b	113.80 c	110.60 d	114.46 b
١.٥	106.90 e	105.80 e	104.80 e	105.83 c
٢	106.00 e	107.00 e	107.40 e	106.80 c
Mean of Time	113.57 a	112.85 ab	111.95 b	

Means with the same letter are not significantly different according to Duncan multiple ranges test at 5% level.

The results of the same table also show that the bilateral interactions among the studied factors, in particular the comparison parameter, which was sprayed with distilled water with three times was significantly outperformed most of the treatments in the number of berries in the cluster amount to 125.00 berry cluster^{-1}, while spraying with 1.5 g l-1 of nano-copper with three times recorded the lowest number of berries in the cluster amount to 104.80 berry cluster^{-1}.

Weight of 100 berries (g):

The data of Table (5) showed that the treatment of spraying with nano-copper at a concentration of 1.5 g l^{-1} was significantly exceeded in the weight of 100 berries compared to the rest of the coefficients of 519.36 g, and the treatment of spraying with nano-copper at a concentration of 2 g l^{-1} significantly outperformed the treatments 1 and 0 g L-1, while the comparison treatment recorded the lowest weight of 100 berries amount to 391.73 g.

Table 5. Effect of foliar application with nano- chelated copper on weight of 100 berries of Taify grape cultivar (*Vitis vinifera* L).

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Levels of Cu	Time			Meanof Cu
	T1	T2	T3	
٠	387.10 i	391.30 hi	396.80 h	٣٩١.٧٣ d
١	418.70 g	458.10 f	480.30 e	452.36 c
١.٥	493.90 d	520.10 b	544.10 a	519.36 a
٢	501.10 d	510.30 c	513.90 bc	508.43 b
Mean of Time	450.20 c	469.95 b	483.77 a	

Means with the same letter are not significantly different according to Duncan multiple ranges test at 5% level.

It is also found that the number of spraying times, especially the three-time spraying, gave the highest weight of 100 berries, which amounted to 483.77 g 100 compared to the treatment of spraying once or twice, in addition to the significantly superior spraying treatment twice to the one-time spray treatment, which recorded the lowest weight of 100 berries, amounting to 450.20 g.

The results of the same table also show that the bilateral interactions among the studied factors have significantly affected the weight of 100 berries, the treatment of spraying with nano-copper at a concentration of 1.5 g l^{-1} and spraying with three times were significantly outperformed all the treatments, which amounted to 544.10 g 100 berries^{-1}, while the comparison treatment was recorded the lowest weight of 100 berries amount to 387.10 g.

Number of clusters per vine:

The results data in Table (6) showed that spraying with nano-copper at a concentration of 1.5 and 2 g l^{-1} gave the highest number of clusters in the vine of 33.86 and 31.90 clusters of vine^{-1} respectively, which significantly outperformed the treatments of 1 and 0 mg l^{-1} of nano-copper, and spraying with nano-copper at 1g l^{-1} was significantly outperformed on the comparison treatment that recorded the lowest number clusters in the vine of 23.26 clusters of vines^{-1}, and it is also found that the number of times Spraying, especially three-time spraying, gave the highest number of clusters in the vine, amounting to 31.42 clusters of vine^{-1} compared to the treatment of spraying once or twice, in addition to significantly outperforming the treatment of spraying twice significantly over the treatment of one-time

Table 6. Effect of foliar application with nano- chelated copper on number of clusters in the vine of Taify grape cultivar (*Vitis vinifera* L.)

Levels of Cu (g l^{-1})	Time			Meanof Cu
	T1	T2	T3	
0	20.40 h	23.50 gh	25.90 fg	٢٣.٢٦ c

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1	26.30 efg	29.10 c-f	28.20 def	27.86 b
1.5	30.20 bcd	33.60 b	37.80 a	33.86 a
2	29.80 cde	32.10 bc	33.80 b	31.90 a
Mean of Time	26.67 c	29.57 b	31.42 a	

Means with the same letter are not significantly different according to Duncan multiple ranges test at 5% level.

spraying, which recorded the lowest number of clusters in the vine, which amounted to 26.67 clusters of vine^{-1}.

The results of the same table also show that the bilateral interactions in this study were significantly affected on the number of clusters in the vine, the treatment of spraying with 1.5 g l^{-1} with nano-copper and three times was significantly outperformed all the treatments, which amounted to 37.80 clusters of vine^{-1}, while the comparison treatment recorded the lowest number of clusters in the vine at 20.40 clusters of vine^{-1}.

Cluster weight (g):

It is clear from the data of Table (7) that the treatment of spraying with nano-copper at 1.5 g l^{-1} is significantly superior in the weight of clusters in the vine compared to the rest of the treatments amounted to 555.80 g cluster^{-1}, and the treatment of spraying with nano-copper at 1 g l^{-1} was significantly superior on the treatments of 1 and 0 g l^{-1} ,while the comparison treatment recorded the lowest weight of the cluster of 492.63 g cluster^{-1}, and it is also found that the number of spraying times, especially spraying by three times, gave the highest weight to the cluster of 543.25 g cluster^{-1} compared to the treatment of spraying once or twice, in addition to significantly outperforming the treatment of spraying twice was significantly over the treatment of one-time spraying, which recorded the lowest weight of clusters in the vine, which amounted to 514.60 g cluster^{-1}.

Table 7. Effect of foliar application with nano- chelated copper on weight of cluster in the vine of Taify grape cultivar (*Vitis vinifera* L).

Levels of Cu (g l^{-1})	Time			Meanof Cu
	T1	T2	T3	
٠	480.90 g	495.10 f	501.10 e	٤٩٢.٦٣ d
١	505.60 e	528.00 d	536.80 c	523.46 c
١.٥	534.00 c	556.90 b	576.50 a	555.80 a
٢	537.90 c	552.50 b	557.80 b	549.40 b

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Mean of Time	514.60 c	533.12 b	543.25 a	

Means with the same letter are not significantly different according to Duncan multiple ranges test at 5% level.

The results of the same table also show that the bilateral interactions among the studied workers were significantly affected on the weight of clusters in the vine, the treatment of nano-copper spraying at a concentration of 1.5 g l^{-1} with three times was significantly outperformed all the treatmentss, which amounted to 576.50 g cluster^{-1}, while the comparison treatment recorded the lowest weight of clusters in the vine of 480.90 g cluster^{-1}.

Yield of vine (kg vine^{-1}):

The data of Table (8) confirmed that the treatment of spraying with nano-copper at a concentration of 1.5 g l^{-1} was significantly exceeded the yield of the vine compared to the rest of the coefficients of 18.88 kg vine^{-1}, and the treatment of spraying with nano-copper at a concentration of 2 g l^{-1} was significantly outperformed the treatments 1 and 0 g l^{-1}, while the comparison treatment recorded the lowest the yield of 11.48 kg vine^{-1}.

Table 8. Effect of foliar application with nano- chelated copper on the yield of the vine of Taify grape cultivar (*Vitis vinifera* L).

Levels of Cu (g l^{-1})	Time			Mean of Cu
	T1	T2	T3	
٠	9.818 h	11.641 g	13.006 f	١١.٤٨ d
١	13.304 f	15.371 e	16.755 cd	15.14 c
١.٥	16.133 df	18.719 b	21.799 a	18.88 a
٢	16.036 de	17.742 bc	18.860 b	17.54 b
Mean of Time	13.82 c	15.86 b	17.60 a	

Means with the same letter are not significantly different according to Duncan multiple ranges test at 5% level.

It is also found that the number of spraying times, especially the three-time spraying, gave the highest yield of 17.60 kg vine^{-1} compared to the treatment of spraying once or twice, in addition to significantly outperforming the spraying treatment twice significantly over the one-time spraying treatment, which recorded the lowest yield in the vine, amounted to 13.82 kg vine^{-1}.

The results of the same table also show that the bilateral interactions among the studied workers significantly affected the increase in the yield of the vine, the treatment of nano-copper spraying at a concentration of 1.5 g l^{-1} and spraying with three times were significantly outperformed all the coefficients, which amounted to 21.799 kg $vine^{-1}$, while the comparison treatment recorded the lowest yield of vine amounted to 9.818 kg $vine^{-1}$.

The reason for the increase in the yield and its components may be attributed to the role of copper in increasing the numbers, weights of clusters and the weight of the berries (Tables 6, 7 and 5) in the vine, and the role of copper in improving the growth of the vine and increasing the leaf area (Table, 2) and increasing the area of the vine (Al-Atrushi, 2009) and increasing the content of leaves of chlorophyll (Table, 3), which leads to increasing the efficiency of photosynthesis, increasing the processed food products in the leaves, facilitating their transfer to clusters and berries, increasing the share of berries and clusters of them, thus increasing the yield and its components (Marschner, 1995, and Al-Atrushi, 2009)

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