Effect of coated covers with copper sulfate filtered for infrared radiation in vegetative and flowering traits for the two cultivars of snapdragon (Antirrhinum majus) plant

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ABSTRACT

The study was conducted on the two cultivars of snapdragon (Antirrhinum majus) plant are white Snapdragon and yellow Snapdragon, to compare the covers with concentrations (0, 4, 8%) of copper sulfate. A factorial experiment was conducted according to Complete Randomized Blocks Design, with three replicates and nine plants for each replicate. The results showed significant differences in vegetative and flowering traits for the growing plants under the filtered covers with two copper sulfate concentrations compared to the control plants. where the results of vegetative growth showed a significant decrease in plant length and significant increase in the number of branches, number of leaves, leaf area, the percentage of chlorophyll and the leaves content of carbohydrate, While the results of flowering growth showed a delay in the time of the flowering of the first floret and a decrease in the length of the main inflorescence for the growing plants under the coated covers with both copper sulfate concentrations compared to the control plants.

Keywords: Snapdragon, copper sulfate, infrared.

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تأثير الاغطية المدعمة بكبريتات النحاس المرشحة للأشعة تحت الحمراء في صفات النمو الخضري والزهري لصنفي من نبات حنك السبع *Antirrhinum majus*.

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الخلاصة

اجريت الدراسة على صنفين من نبات حنك السبعAntirrhinum majus هما PALETTE WHITE و PALETTE YELLOW للمقارنة بين الاغطية المدعمة بتراكيز 0 و4 و8% من كبريتات النحاس. ونفذت التجربة العاملية بتصميم القطاعات العشوائية الكاملةRandomized Complete Block Design بثلاث مكررات وتسع نباتات لكل مكرر. اشارت النتائج الى اختلافات معنويه في صفات النمو الخضري والزهري للنباتات النامية تحت الاغطية المرشحة بكلا تركيزي كبريتات النحاس بالمقارنة مع نباتات المقارنة, اذ اظهرت نتائج النمو الخضري انخفاض معنوي في طول النبات وزيادة معنويه في عدد الافرع وعدد الاوراق والمساحة الورقية ونسبة الكلوروفيل والمحتوى الكربوهيدراتي في الاوراق في حين اظهرت نتائج النمو الزهري تأخر في موعد تفتح الزهيرة الاولى وانخفاض في طول النورة الرئيسية للنباتات النامية تحت الاغطية المدعمة بكلا تركيزي كبريتات النحاس بالمقارنة مع نباتات المقارنة.

الكلمات المفتاحية: حنك السبع, كبريتات النحاس, الاشعة تحت الحمراء.

البحث مستل من رسالة ماجستير للباحث الثالث

1. INTRODUCTION

Snapdragon (Antirrhinum majus) is considered a one of the Scrophulariaceae family plants, which is characterized by the beauty of its inflorescence (Dujoi, 2004; Beutle, 2007), the height of the plant varies depending on the cultivars such as the long ones that are suitable for cut flowers, while the short cultivars are used as identification plants. Mohammad et al.,

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(2004) reported that the vegetative and flowering traits for the Snapdragon vary according to changes in the intensity of the surrounding environmental light. The process of producing commercial flowers of flowerpots is considered one of the most important processes of global spread and demand is under specific conditions represented by flowers of bright colors and aromatic, so it is necessary to understand the plant physiology necessary to obtain the desired specifications (Miller, 2017). Light-filtering polyethylene covers are considered non-chemical growth regulators for the production of plants of desirable specifications. Mainard et al., (2016) explained that infrared radiation has the ability to control plant height and other physiological processes. As a result of the scientific evolution in the field of the interaction of environmental factors with phytosanitary processes, many studies have been conducted about the effect of wavelengths for light on the growth and flowering of many ornamental crops and the advantage of using a certain wavelength light to achieve this, which can be considered as alternatives to chemical growth impediments, as well as reducing the permeability of infrared radiation into the plants houses is an important role in reducing the temperature. In dry areas, cooling of greenhouses is necessary to provide the appropriate climate for the growth of plants, where the use of traditional cooling methods face many physical and technical challenges, because of the presence of infrared radiation, which is their dangerous increase in the greenhouse, due to occurrence of heat retention inside the plastic house (Ali and Albayati, 2017). Hassoon, (2013) showed that the process of adding copper sulfate at concentrations of (1, 7%) led to a decrease in infrared spectrum permeability compared to the control membranes, Rajapakse et al., (1993) indicated when studying the effect of pentahydrate copper sulfate at a concentration of 6% on the Chrysanthemum plant (Bright Golden Anne cultivar), showed a decrease in the length of the Internode amounted to (1.3 cm) compared to the control plants which recorded (1.8 cm), Rajapakse and Kelly, (1994) mentioned when studying the effect of copper sulfate covers with concentration of 6% on growth and formation of Rosa x hybrid plant, which reported a decrease in plant height amounted to 16.7 cm compared to the control plants which their height amounted to 20.4 cm, As well as the trait of the internodes height where they decreased to 1.7 cm under the copper sulfate covers, while amounted to 2.1 cm for the control plants, it recorded a decrease in the diameter of flower amounted to 3.7 for plants grown under the copper sulfate cover while amounted to 4.5 cm for the control plants, The average number of flowering days decreased to 32 days for plants growing under copper sulfate covers, while 35 days for the control plants, Rajapakse and Kelly, (1995) showed when studying the effect of adding copper sulfate at 6% concentration on Chrysanthemum plants, found a decrease in the percentage of sucrose in the leaves for the plants growing under the cover coated with copper sulfate , where their value amounted to (5.4 $mg.g^{-1}$) compared to the control plants which amounted to (7.9 $mg.g^{-1}$). The fructose was also decreased in the leaves of the plants grown under covers coated with copper sulfate, where recorded (5.4 $mg.g^{-1}$) compared to the control plants that recorded values amounted to (7.3 $mg.g^{-1}$).

2. MATERIALS AND METHODS

The experiment was conducted at the greenhouse belonging to the Baquba nursery, Directorate of Diyala Agriculture for the period from October 2016 until April 2017 on two cultivars of snapdragon (*Antirrhinum majus*) plant are white and yellow Snapdragon, to study the effect of polyethylene covers coated with three concentrations of copper sulfate are: 0, 4, 8% and their thickness amounted to (0.10, 0.14, 0.14 mm), respectively, and specially designed for experiment at Haven plastic industry in Erbil, using low density polyethylene (Produced by SABIC Saudi Arabia) after recycling it using Granite device

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for the purpose of homogenizing and mixing the granules with copper sulfate and then pour it using a Bdnws device to obtain the polyethylene covers containing the used copper sulfate in the experiment, The permeability values were measured using the UV. Visible 1800 Double beam spectrophotometer device (Labs of the College of Science, Physics Department) as shown in Figure (1). The experiment started on 1 February 2017 by covering the plants with homogeneous height (8-10 cm) and placed within wooden structures, with dimensions of (2 × 1 × 1 m). Plant seeds were cultivated in seedling trays containing peat moss, after germination of the seeds and the arrival of the seedling to the stage of 3 to 4 leaves of real leaf which cultivated into the flowerpots, with a 25 cm diameter containing 12 kg soil with volume ratio of 2 Part riverine mixture: 1 part peat moss, which Its physical and chemical specifications listed in Table (1), The flowerpots soil was sterilized using a 5% fungicide (Beltanol) with a concentration of (1 ml.L^{-1}), the plants were sprayed at a concentration of (1 ml.L^{-1}) with Superserin Pesticide, which is made up of two active substances Chlorpyrephus (500 g. L^{-1}) and Cypermithren (50 g.L^{-1}) When the infection appears, The plants were fertilized with the chemical fertilizer (King Life fruit), made of NPK at a concentration of 6: 9.5: 18% with magnesium concentration of 4%, boron 2%, iron, manganese, molybdenum and zinc each of them with a 0.08% concentration. Where it was added by spraying on the total vegetative of the plant and with the average of (1 g. L^{-1}) as directed by the manufacturer, through a two-week workshop. Manual irrigation was conducted when the surface soils of the soil were dried, as well as the weeding and grinding process for surface soils to remove the growing thicket.

Studied traits:

1- Plant height

2- Number of branches per plant

3 - Number of leaves

4- The relative chlorophyll content in leaves (SPAD)

5- Total carbohydrate in leaves (%)

6- the flowering date of the first floret (day)

7 - height of the inflorescence (cm)

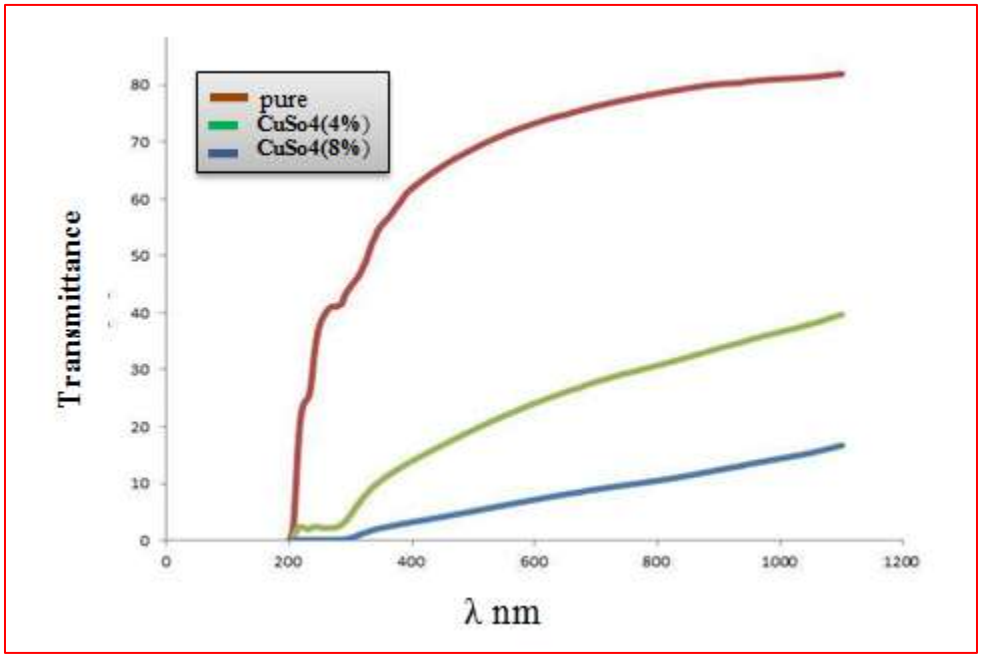

Figure 1: shows the permeability of used plant covers in the experiment.

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Table 1: Some physical and chemical traits of the soil model used in the study.

Soil separates ($g.kg^{-1}$)			Texture	pH of Soil	Electrical conduction EC ($ds.m^{-1}$)	Electrical conduction EC ($ds.m^{-1}$)
Sand	Silt	Clay				
873.3	45.1	81.6		7.634	1.314	0.552
Availability content for macronutrients ($mg.kg^{-1}$)					$CaCO_3$ ($g.kg^{-1}$)	
N		P		K	161.74	
7.62		11.291		196.8		

Table 2: Monthly average of the maximum and minimum temperatures (°C) inside and outside the wooden structures for the second experiment during the months of February to April 2017.

Type of Cover	Month	Max temperature / min-outside structure	Min temperature / min-inside the structure
The control covers	February	6.5 / 26.4	5.8 / 33.4
	March	13.1 / 35.7	13.0 / 35.3
	April	18.1 / 34.3	18.5 / 34.2
Polyethylene covers coated with copper sulfate at a concentration of 4%	February	6.5 / 26.4	5.1 / 29.9
	March	13.1 / 35.7	12.6 / 34.2
	April	18.1 / 34.3	17.8 / 31.7
Polyethylene covers coated with copper sulfate at a concentration of 8%	February	6.5 / 26.4	5.3 / 28.3
	March	13.1 / 35.7	12.6 / 32.0
	April	18.1 / 34.3	17.5 / 30.9

3. RESULTS AND DISCUSSION

1- plant height (cm)

Table (3) shows a significant decrease in the height of the cultivated plants under the concentration of (4, 8%) of the copper sulfate, where their height for both concentrations amounted to (21.75, 18.08 cm), respectively, compared to the control treatment, which amounted to (23.75 cm). Which may be attributed to the fact that the addition of copper sulfate to the manufactured polyethylene covers has led to reduce the average permeability of infrared in the growth environment as shown in Figure (1). Several studies have indicated to the role of copper sulfate in the average permeability of the electromagnetic spectrum. Jwameer, (2015) reported that the permeability of high wavelengths decreases with increasing the concentration of added copper sulfate to the manufactured material, The current study showed that the high concentration of copper sulfate in the plant covers is accompanied by a significant decrease in plant height, This result agree with (Rajapakse and Kelly, 1992) on Chrysanthemum plant, Rajapaks and Kelly, (1994) during their study, the effect of copper sulfate coated on the growth and formation of Rosa x hybrid plant. Rajapakse and Kelly, (1995) When studying the effect of copper sulfate at 6% concentration of Chrysanthemum plants, Li and Rajapakse, (2003) examined the effect of copper sulfate-coated sheets on three cultivars of the Chrysanthemum plant, namely Bright golden Anne, Iridon and Yellow Snowdon. The trait of plant height did not show significant difference between white and yellow cultivar. This result did not agree with the study of (Shafique and Maqbool, 2011) on the plant of the Snapdragon (Antirrhinum majus), where their results showed a significant decrease in the height of white cultivar when compared with the yellow cultivar. The results of the bi-interaction between the concentration of copper sulfate in the polyethylene covers and the cultivar had an effect on the plant height, where the lowest

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values for the plant height under the copper sulfate cover were recorded at a concentration of 8% for the yellow cultivar, which amounted to (18.00 cm). This value rose to amounted the highest amount (24.50 cm) under the control cover of the yellow cultivar, In this direction, both Wilson and Rajapakse, (2001) suggested that reducing the permeability of infrared wavelengths in a growth environment leads to the production of plants with specific height and specific physiological traits, although the amount of response depends on the variety of cultivars.

Table 3: Effect of covering with copper sulfate ($CuSO_4$) and type of cultivar and the interaction between them in plant height (cm) of the Snapdragon (Antirrhinum majus)

Plant cultivar	Concentration of copper sulfate (%)			Effect of cultivar
	0	4	8	
White cultivar	**23.00AB**	**20.50BC**	**18.16C**	**20.55C**
Yellow cultivar	**24.50A**	**23.00AB**	**18.00C**	**21.83C**
Effect of copper sulfate	**23.75A**	**21.75B**	**18.08C**	

* The values that have the identical alphabetic characters for each individual factor and their interactions are not significantly different with each other according to the Duncan's Multiple Range Test at a 5% probability level

2- Number of branches per plant (branch.plant^{-1})

Table (4) shows that Polyethylene covers coated with copper sulfate had a significant effect. Copper sulfate covers at a concentration of 4% have excelled in this trait which amounted to (14.16 branch.plant^{-1}) compared with the control plants amounted to (9.25 branch.plant^{-1}). While the concentration of 8% was not significantly different from the control plants, which amounted to (10.33 branch.plant^{-1}).The increase in the average number of branches per plant may be due to the physiological Effectiveness for cytokines encouraging the lateral branching, Hilali, (2015) noted that cytokines are active in inhibiting the formation of Auxins although the latter decreases their production with decreases the temperatures in the growth environment. This is what indicated to it the temperature data in the growth environment of plants growing under the covers coated with copper sulfate at concentrations of (4, 8%) compared to the growing plants under the structures covered with the control cover as shown in Table (2). These results agree with (Rajapakse and Kelly, 1994) for Rosa x hybrid plants when using copper sulfate with 6% concentration. The different in cultivars did not show any significant differences in the number of branches per plant. These results agree with the study of (Shafique and Maqbool, 2011) on snapdragon (Antirrhinum majus) plant, The results of the bi-interaction for the copper sulfate cover and the plant cultivar showed a clear increase in this trait amounted to (14.83 branch.plant^{-1}) for the plants growing under the polyethylene cover coated with 4% copper sulfate concentration for the yellow cultivar while the lowest average amounted to (8.66 branch.plant^{-1}) compared to the white cultivar.

Table 4: Effect of covering with copper sulfate ($CuSO_4$) and type of cultivar and the interaction between them in the number of branches per plant (branch.plant^{-1}) of the Snapdragon (Antirrhinum majus) plant

Plant cultivar	Concentration of copper sulfate (%)			Effect of cultivar
	0	4	8	
White cultivar	**8.66C**	**13.50AB**	**11.00BC**	**11.05A**
Yellow cultivar	**9.83BC**	**14.83A**	**9.66BC**	**11.44A**
Effect of copper sulfate	**9.25B**	**14.16A**	**10.33B**	

* The values that have the identical alphabetic characters for each individual factor and their interactions are not significantly different with each other according to the Duncan's Multiple Range Test at a 5% probability level

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3- Number of leaves (leaf.plant^{-1})

The trait results of a number of leaves on the plant as shown in Table (5) showed that the plants growing under the copper sulfate cover at a concentration of 4%, a significant increase amounted to (178.58 leaf.plant^{-1}) compared to the plants growing under the control covers which amounted to (117.50 leaf.plant^{-1}). The increase in the average of this trait may be due to the increase in the number of branches on the plant, which indicates to it the relationship correlation with high significant as shown in Table (10), which amounted their value to (0.655) between the two cultivars. The two cultivars did not show a significant difference in the number of leaves on the plant and this result agrees with (Shafique and Maqbool, 2011) on the Snapdragon (Antirrhinum majus) plant. The results of the bi-interaction between the copper sulfate covers and the cultivars showed that the highest value for the number of leaves amounted to (187.17 leaf. plant^{-1}) in the plants covered with a copper sulfate cover at 4% concentration for the white cultivar, and this value was reduced to (107.50 leaf. plant^{-1}) in the white cultivars under the control cover.

Table 5: Effect of covering with copper sulfate ($CuSO_4$) and type of cultivar and the interaction between them in the number of leaves (leaf.plant^{-1}) of the Snapdragon (Antirrhinum majus) plant

Plant cultivar	Concentration of copper sulfate (%)			Effect of cultivar
	0	4	8	
White cultivar	**107.50C**	**187.17A**	**153.33AC**	**149.33A**
Yellow cultivar	**127.50BC**	**170.00AB**	**137.17AC**	**144.89A**
Effect of copper sulfate	**117.50B**	**178.58A**	**145.25AB**	

* The values that have the identical alphabetic characters for each individual factor and their interactions are not significantly different with each other according to the Duncan's Multiple Range Test at a 5% probability level

4- The relative chlorophyll content in the leaves (SPAD)

Table (6) shows that the polyethylene cover coated with copper sulfate at a concentration of 8% has a significant effect on the increase in leaf content of relative chlorophyll, where its value increased to 35.81 SPAD compared to the plants growing under the control cover and growing under the cover coated with 4% copper sulfate concentration amounted to (30.53, 30.99 SPAD), respectively, The reason for the increase in relative chlorophyll content is due to the inhibition of ethylene building. Hilali, (2015) noted that ethylene has an active role in the activation of chlorophylase, which is responsible for chlorophyll oxidation and breakdown. The production of ethylene is increased with increasing the temperature and from Table (2) notice that there is a significant decrease in the rise of the maximum and minimum temperature in the growth environment of plants growing under the covered structures with cover coated by copper sulfate compared to the control covers, While the results of the difference in the cultivar did not show a significant effect on the relative content of chlorophyll in the leaves. The results of the bi-interaction between the polyethylene covers coated with different concentrations of copper sulfate and the different cultivars. The highest values of (36.53 SPAD) were recorded for the grwoing plants under the cover of copper sulfate at a concentration of 8% , While this value declined to (28.90 SPAD) for grwoing plants under the cover of the white cultivar.

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Table 6: Effect of covering with copper sulfate ($CuSO_4$) and type of cultivar and the interaction between them in the relative chlorophyll content in the leaves (SPAD) of the Snapdragon (Antirrhinum majus) plant

Plant cultivar	Concentration of copper sulfate (%)			Effect of cultivar
	0	4	8	
White cultivar	**28.90B**	**29.45B**	**35.08AB**	**31.14A**
Yellow cultivar	**32.16AB**	**32.53AB**	**36.53A**	**33.74A**
Effect of copper sulfate	**30.53B**	**30.99B**	**35.81A**	

* The values that have the identical alphabetic characters for each individual factor and their interactions are not significantly different with each other according to the Duncan's Multiple Range Test at a 5% probability level

Total carbohydrate in leaves (%)

Table (7) shows an increase in carbohydrate content in the leaves for the growing plants under the copper sulfate covers. The results of the statistical analysis showed a significant difference between concentration (4, 8%), which amounted to (46.5, 53.9%), respectively, compared to the control plants which amounted to (44.6%). The increase in the carbohydrate content in the leaves may be due to increase the chlorophyll content in the leaves, which plays an important role in the rising the rate of photosynthesis, which in turn contributes to increasing the production of important compounds within the plant such starch and carbohydrates (Al-Sahaf et al., 2003). This is confirmed by the results of Table (10). The the relationship showed a positive correlation with highly significant between the two cultivars which amounted their value to (0.454) at a significant level of 0.01. On the other hand, the results showed that the white cultivar was significantly excelled and their value amounted to (51.5%) compared to the yellow cultivar, which amounted to 45.1%. This significant difference may be due to the genetic factors that control the difference between different cultivars. Al-Bayati, (2015) noted that genetic factors have a major effect on the results of different cultivars, The results of bi-interaction showed that the highest values were recorded in white cultivars plants growing under the cover of polyethylene coated by 8% concentration of copper sulfate which amounted their value to 59.4%. On the other hand, the lowest values for the yellow cultivars plants growing under the polyethylene covers coated with 4% concentration of copper sulfate, which amounted to 40.8%.

Table 7: Effect of covering with copper sulfate ($CuSO_4$) and type of cultivar and the interaction between them in the total carbohydrate in leaves (%) of the Snapdragon (Antirrhinum majus) plant

Plant cultivar	Concentration of copper sulfate (%)			Effect of cultivar
	0	4	8	
White cultivar	**43.1C**	**52.2AB**	**59.4A**	**51.5A**
Yellow cultivar	**46.2B**	**40.8C**	**48.4B**	**45.1B**
Effect of copper sulfate	**44.6C**	**46.5B**	**53.9A**	

* The values that have the identical alphabetic characters for each individual factor and their interactions are not significantly different with each other according to the Duncan's Multiple Range Test at a 5% probability level

The flowering date of first floret (day)

Table 8: shows that polyethylene covers coated with copper sulfate had a significant effect on the time required for flowering the first floret. The plants growing under the coated covers with the concentration of (4, 8%) copper sulfate lasted (55.00, 50.50 days), respectively, compared to the plants growing under the control cover of 43.66 days, The delay in the flowering of the first floret may be due to the role of Phytochrome red pigment, It is the pigment that encourages the flowering process,

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this pigment activates when exposed to infrared radiation (Hilali, 2015). As shown in Figure (1), the IR penetration rate of the polyethylene cover coated by copper sulfate at a concentration of (4, 8%) compared to the control cover. The variation of the cultivar did not appear to have a significant effect on the flowering date of the first floret. These results agree with (Shafique and Maqbool, 2011) in their study of the snapdragon (Antirrhinum majus) plant. The results of the bi-interaction between polyethylene covers coated with copper sulfate and the cultivars indicated that the highest significant values amounted to 58.66 days were recorded in yellow cultivar plants which growing under the polyethylene cover coated with a concentration of 4% copper sulfate, while the control plants of the yellow cultivar recorded the lowest values amounted to 42.00 days.

Table 8: Effect of covering with copper sulfate ($CuSO_4$) and type of cultivar and the interaction between them in the flowering date of first floret (day) of the Snapdragon (Antirrhinum majus) plant

Plant cultivar	Concentration of copper sulfate (%)			Effect of cultivar
	0	4	8	
White cultivar	**45.33B**	**51.33AB**	**49.00AB**	**48.55A**
Yellow cultivar	**42.00B**	**58.66A**	**52.00AB**	**50.88A**
Effect of copper sulfate	**43.66B**	**55.00A**	**50.50AB**	

* The values that have the identical alphabetic characters for each individual factor and their interactions are not significantly different with each other according to the Duncan's Multiple Range Test at a 5% probability level.

7- Height of the inflorescence (cm)

Table (9) indicates for the height of the main inflorescence showed a significant decrease for the plants growing under the polyethylene cover coated with copper sulfate, where the values of the length of the inflorescence amounted to (6.00, 6.33 cm) in each of the covers coated at the concentration of (8, 4%), respectively, compared to the plants growing under the control covers, which amounted to 14.16 cm. The decrease in the length of the inflorescence may be due to the role of copper sulfate in controlling the infrared permeability in the growth environment as shown in Figure (1). The results showed no significant differences between the two cultivars. Shafique and Maqbool (2011) showed a difference in the ratio of the plants of the seven branches of Majus Antirrhinum. These results agree with (Shafique and Maqbool, 2011) their study of the Snapdragon (Antirrhinum majus) plant, and the results of the bi-interaction between the treatments of polyethylene cover coated with copper sulfate and the different in the cultivar. The lowest values were recorded in the plants growing under the cover coated with copper sulfate at concentrations of (4, 8%) which amounted to 6.00 cm. On the other hand, the highest values amounted to 18.66 cm for the plants growing under the control covers for yellow cultivar.

Table 9: Effect of covering with copper sulfate ($CuSO_4$) and type of cultivar and the interaction between them in the height of the inflorescence (cm) of the Snapdragon (Antirrhinum majus) plant

Plant cultivar	Concentration of copper sulfate (%)			Effect of cultivar
	0	4	8	
White cultivar	9.66B	6.66B	6.00B	7.44A
Yellow cultivar	18.66A	6.00B	6.00B	10.22A
Effect of copper sulfate	14.16A	6.33B	6.00B	

* The values that have the identical alphabetic characters for each individual factor and their interactions are not significantly different with each other according to the Duncan's Multiple Range Test at a 5% probability level.

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Table 10: Correlation analysis for the traits of the vegetative growth.

Traits	Number of branches	Number of leaves	Chlorophyll	Carbohydrate
Plant height	- 0.156	- 0.260	- 0.314	- 0.728**
Number of branches		0.655**	0.037	- 0.074
Number of leaves			0.205	0.501**
Chlorophyll content				0.454**

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