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THE EFFECT OF COBALT FOLIAR NOURISHMENT ON REDUCING WATER STRESS FOR THE SWEET CORN *ZEA MAYS* L. VAR. SACCHARATA AND THE CHARACTERISTICS OF VEGETATIVE GROWTH

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ABSTRACT

A field experiment was carried out with the aim of studying the effect of graduated concentrations of cobalt sprayed on plants on some growth characteristics of sweet corn crops under water stress conditions for the two autumn seasons 2018 and 2019. Use of a Randomized Complete Block Design (R.C.B.D.) according to the spilt-plot arrangement with three replications. The main-plots included three levels of water stress, which are irrigation after depleting 30, 50 and 70% of the available water, with symbols W_1, W_2 and W_3 respectively. While the cobalt solution spraying concentrations represented 0, 4, 8 and 12 mg L^{-1} and symbolized as CO_0, CO_1, CO_2 and CO_3 respectively on the Sub-plots. The results showed that there were no significant differences between the two irrigation treatments after depleting 30 and 50% of the available water, with regard to the number of days to 50% tasseling, plant height, number of leaves, leaf area, plant dry weight and crop growth rate for both seasons. Whereas, irrigation after depleting 70% of the available water led to a decrease in all the studied characteristics. While the cobalt spray concentrations significantly affected most of the studied traits, except for the number of days to 50% tasseling and number of leaves. The treatment of spraying with a concentration of 12 mg L^{-1} significantly outperformed the rest of the treatments with the highest average plant height reaching 148.60 and 148.66 cm, leaf area 3547.00 and 3703.00 cm^2 $plant^{-1}$, plant dry weight 150.63 and 151.30 g $plant^{-1}$ and crop growth rate 2.96 and 2.79 g m^{-2} day^{-1} compared with the comparison treatment CO_0 (distilled water) respectively, For the two seasons. The interaction between water stress and cobalt treatments was significant in the characteristic of plant height, leaf area and plant dry weight for both seasons. Therefore, we recommend the possibility of irrigation after depleting 50% of the available water without a significant effect on the vegetative growth characteristics, as well as the possibility of treating sweet corn plants with cobalt at a concentration of 12 mg L^{-1} to improve their ability to withstand water stress conditions.

Keywords : Sweet corn, Water stress, Cobalt.

Introduction

The problem of water shortage is the important factor at present and in the future to limit the expansion of all social and economic life activities in various fields and their development, especially in the field of agriculture, especially in the arid and semi-arid regions in which Iraq is located, which is currently facing a scarcity in the quantities of water flowing to the Tigris and Euphrates and fluctuation Their level from one season to another, with low or falling rain rates at times other than times needed by the plant, high temperatures and rates of evaporation, and this is accompanied by weakness in the process of managing water and soil resources, as well as the increasing demand for food due to the development in the current and future population growth. All these factors have affected a lot Significant scarcity of this water in recent years.

As for the researchers' point of view, it is expected that by 2025, 65% of the world's population will live under the influence of environments that suffer from lack of water (Nezhadahmadi *et al*., 2013), and this indicates that there is a real risk of distributing the available water resources. Therefore, researchers and specialists in the agricultural field have always sought The use of some appropriate agricultural applications that aim to eliminate or overcome the physiological symptoms that occur on plants growing in harsh environments such as drought or ground water deficit to help them withstand stress (water deficit).

Since recent studies have indicated the importance of using cobalt to give it good results in increasing plant tolerance to water stress, it is considered one of the beneficial nutrients that do not fall within the group of major or minor nutrients (Jayakumar *et al*., 2009) and contributes to reducing the impact of environmental stress on plants through Its positive effect in improving the characteristics of vegetative growth by improving the water balance, readiness and absorption of some nutrients, especially macronutrients and micronutrients, activating a number of necessary enzymes and helping that have an effect in delaying the aging of leaves, inhibiting the action of ethylene and reducing the activity of Peroxidase that have an effect in stopping the action of the growth regulator lAA Gad and Kandil, (2011). The results of Gad and El-Metwally, (2015) indicated that spraying yellow corn plants with cobalt under stress conditions led to a significant increase in plant height, leaf area and plant dry weight, as Chaudhari *et al*. (2017)

indicated that adding cobalt at concentrations of 0, 10, 20, 40, 80 mg L^{-1} caused a significant increase in the height plants of yellow corn, and the increase was more at a concentration of 20 mg L^{-1}. Although this crop is not the focus of attention of producers and researchers in Iraq, the climatic conditions are favorable for the cultivation and production of this crop, as its environmental requirements are completely similar to the conditions of yellow corn, so it is possible to successfully cultivate and produce sweet corn in Iraq as it is of nutritional value for humans, which makes it a possibility. The spread of this crop is featured, and it can also be consumed throughout the year for its various manufacturing uses and thus improve our diet.

Materials and Methods

A field experiment was carried out in the experimental field of the Field Crops Department - College of Agricultural Engineering Sciences - University of Baghdad (Jadriya) for the autumn seasons 2018 and 2019. In order to study the effect of sprayed cobalt concentrations and its correlation with water stress for the 403 KSC sweet corn crop obtained from SPCRI. The experiment was designed according to a Randomized Complete Block Design (R.C.B.D) with a spilt-plot arrangement with three replications. The main-plots included irrigation treatments after depleting 30, 50 and 70% of the available water, and they were symbolized W_1, W_2 and W_3 respectively. While the Sub-plots included the concentrations of cobalt solution sprayed 0, 4, 8, and 12mL^{-1}, symbolized by CO_0, CO_1, CO_2 and CO_3, respectively, by two sprays during the first growing season when the plant reached the stage of 6 leaves and the second until the emergence of 10% of the tasseling. Soil service operations were carried out and the land was divided into slabs with dimensions of 2.5 m * 2 m, with a distance of 70 cm between one line and another, and a distance of 20 cm between one side and another, with a plant density of 71428 plants ha^{-1}. Then urea fertilizer (46% N) was added with an average of 696 kg ha^{-1} in two batches, the first at the stage of 6 true integrated leaves and the second at the beginning of tasseling. Whereas triple superphosphate fertilizer (46% P_2O_5) was added with an average of 436 kg ha^{-1} at once mixed with soil before planting (Ministry of Agriculture, 2011). The bush was also removed by manual weeding whenever needed with the preventive control of plants from infestation by the corn stalk borer insect (*Sesamia cretica* L.) by using liquid diazinon pesticide with an average of 1.5 m L^{-1} water in two batches, the first at the stage of 4-5 leaves and the second at the beginning tasseling (Al-Ameri, 2011). Sweet corn seeds were sown on 7/28/2018 for the first season and 7/15/2019 for the second season.

Soil water retention capacity was estimated by estimating the relationship between the structural tensile strength of the soil sample and the moisture content at the tensile 0, 33, 100, 500, 1000 and 1500 kPa, through which according to the available water content of the soil from the difference between the moisture content at the field capacity and the wilting point. The volumetric method was adopted to measure the moisture content, monitor the soil moisture changes, and determine the date of irrigation according to the level of depletion for the irrigation treatments. By taking soil samples mediated by Auger a day before irrigation and after irrigation two days from a depth of 0-20 cm during the vegetative growth phase, and then increasing the depth of hydration to 40 cm during the flowering phase and the stage of formation of ears and to the end of the experiment and placed in aluminum cans and weighed wet in a Micro water oven For a period of 12 minutes after the drying time was calibrated with samples dried in an electric oven according to the method suggested by (Zein, 2002) to dry the samples, then weighed after drying and the moisture content was measured according to the formula (Hillel, 1980).

$$P_w = (M_{sw} - M_s / M_s) * 100 \quad ...(1)$$

P_w = the percentage of gravitational moisture,

M_{SW} = mass of wet soil (g), Ms = mass of dry soil (g).

Irrigation Method

Irrigation was done by plastic tubes connected to an electric pump. Equal amounts of irrigation water were added when planting to the field capacity of all panels to ensure field emergence. Moisture tightening treatments 30, 50 and 70% of the available water were implemented when the plant reached the stage of 6 true integrated leaves (Hanway, 1971), and the irrigation quantities were at a depth of 20 cm for the depletion treatments W_1, W_2 and W_3 (60, 100 and 140) L/5 m^2, and the amount of water for a depth of 40 cm was (120, 200 and 280) L/5 m^2 and until the last water when the plants reached Physiological maturity stage. The depth of added water was calculated to compensate for the depleted moisture according to an equation (Allen *et al*., 1998).

$$d = (\theta_{fc} - \theta_I) * D \quad ...(2)$$

d = depth of added water (mm), θ_{fc} = volumetric humidity at field capacity (cm^3 cm^{-3}), I = Volumetric humidity before irrigation (cm^3cm^{-3}), D = the depth of the soil which is equal to the depth of the effective root system (mm).

The volumetric water content was calculated based on the bulk density of the soil, as in the following equation:

$$\theta = pw * \ell_b \quad ...(3)$$

θ = moisture content based on volume, Pw = moisture content based on weight, ℓ_b = Soil bulk density (mg m^{-3}).

After that, the volume of water to be added to each plot was calculated according to the following equation:

$$V = d \times A \quad ...(4)$$

V = the volume of water to be added (liters),

A = the irrigated area (m^2).

Prepare a cobalt (CO) solution

The cobalt (CO) solution was prepared in the form of aqueous cobalt sulfate ($COSO_4.7H_2O$) from Riedel-DE haen AG Seelze-Hannover AG (German origin) in the Tissue Culture Laboratory - College of Agricultural Engineering Sciences - University of Baghdad - Jadriya, dissolving 1 g of the powder In distilled water with stirring on a plate Stirrer Magnetic device at a temperature of 50 ° C until the material dissolves homogeneously, then complete the volume to liter to obtain a concentration of 1000 mg L^{-1} as a standard solution (the original solution) and the required spray concentrations were prepared from it 4, 8 and 12 mg L^{-1} according to the following dilution equation:

$$N_1 \times V_1 = N_2 \times V_2 \quad ...(5)$$

N_1 = concentration of the original solution. V_1 = volume of the original solution. N_2 = required concentration. V_2 = required volume.

As for the studied traits:

1. Number of days to 50% tasseling (Days) :

The period was calculated from the date of planting (the date of the first irrigation) to the emergence of tassel until the completion of the emergence of 50% tassel of five plants per experimental unit from the middle lines, according to the field observation.

2. Plant height (cm) :

It was measured from the soil surface level to the lower node of the tassel for an average of five plants randomly selected from the mean lines of each experimental unit after the tassel flowering was completed.

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

The total number of leaves is calculated from the first effective green leaf at the bottom of the plant to the highest leaf in it from the average of five plants taken randomly from the two middle lines for each experimental unit.

4. Leaf area (cm^2):

The leaf area was measured at the stage of 50% tassel from an average of five plants randomly taken from the mean lines of the experimental unit using the following equation:

Leaf area = square of the length of the leaf under the ear * 0.65 (Elsahookie, 1990).

5. Plant dry weight (g plant^{-1}):

calculated from the average weight of five plants at the stage of 50% tassel taken randomly with all its components (except for the root) then it was cut and dried naturally on the air, taking into account its flipping until Weight stability.

6. Crop growth rate (g m^{-2} day^{-1}):

It was extracted from dividing the average dry matter at this stage by the period from planting to 50% tassel.

Statistical analysis

The experiment data were analyzed statistically according to the Randomized Complete Block Design R.C.B.D., with the arrangement of split- plots. The lowest significant difference (L.S.D) was selected at the level of 0.05 for comparison between the arithmetic means of the coefficients using the Genstat statistical program (Steel and Torrie, 1980).

Results

The results of Tables 1, 2, 3, 4, 5 and 6 showed a significant effect of the available water depletion treatments in all the studied traits for two seasons,

The two treatments W_1 and W_2 (after depleting 30 and 50% of the available water) recorded the highest average number of days to 50% tasseling, plant height, number of leaves and leaf area, plant dry weight, and crop growth rate was (53.50 and 56.42) and (51.47 and 54.37) Days, (152.05 and 152.32), (142.55 and 142.80) cm, (13.66 and 14.34), (13.34 and 13.58) leaf plant^{-1}, (3734.25 and 3798.00), (3552.25 and 3698.25) cm^2 , (153.55, 154.32), (146.57 and 146.72) g plant^{-1}, (2.87 and 2.72) and (2.84 and 2.69) g m^{-2} day^{-1} respectively for the two seasons and they did not significantly differ between them. Whereas, W3 (after depleting 70% of the available water) recorded the lowest average for all of the aforementioned characteristics, amounting to (47.45 and 50.52) days, (126.60 and 126.77) cm, (10.24 and 10.62) leaf plant^{-1}, (2740.75 and 2789.50) cm^2 plant^{-1}, (122.10 and 126.35) g plant^{-1} and (2.57 and 2.50) g m^{-2} day^{-1} respectively for the two seasons. The results of the aforementioned tables also indicate the presence of a significant effect of cobalt spray concentrations on all studied traits except for the characteristic of the number of days to 50% tasseling and number of leaves for the two seasons. The results of Tables (2, 4, 5 and 6) respectively showed that spraying the sweet corn plants with cobalt led to the increase of the studied growth characteristics. The CO_3 treatment was significantly superior to the rest of the other treatments in giving it the highest average plant height of 148.60 and 148.66 cm, with an increase of 10.56 and 9.98% compared to the comparison treatment for CO_0 (distilled water) respectively for the two seasons (Table 2). While the results shown in (Table 4) showed that the spraying treatments with cobalt led to a significant increase in the average leaf area compared with the CO_0 comparison treatment, which recorded the lowest average leaf area for plants which amounted to 3148.33 and 3197.66 cm^2 plant^{-1} respectively for the two seasons, while the average leaf area reached its limit, The highest when treated with CO_3 in giving the highest average for this characteristic was 3547.00 and 3703.00 cm^2 plant^{-1}, with an increase of 12.66 and 15.76%, compared to CO_0 treatment respectively for the two seasons. The results of (Table 5) also showed a significant effect of cobalt concentrations in increasing the dry weight of the shoots, and the highest average was 150.63 and 151.30 g plant^{-1} when treated with CO_3 with an increase of 13.68 and 11.99% compared to the CO_0 treatment respectively for the two seasons. While the results indicated in (Table 6) that crop growth rate was affected by the concentrations of spraying with cobalt, as the CO_3 treatment recorded the highest average for this characteristic, which amounted to 2.96 and 2.79 g m^{-2} days^{-1}, with an increase of 14.28 and 11.60% compared to the comparison treatment CO_0 Consecutively for the two seasons. The results of the aforementioned tables also indicated that there was a significant effect of the interaction between the available water depletion treatments and the cobalt spray concentrations in the characteristic of plant height, leaf area and plant dry weight for both seasons. The combination W_1CO_3 was recorded by giving it the highest average plant height of 160.60 and 161.20 cm, leaf area 3817.00 and 3997.00 cm^2 plant^{-1} and plant dry weight 164.60 and 165.20 g plant^{-1} compared to the comparison treatment combination. It was also observed that the combination of W_3CO_3 was significantly higher in plant height, leaf area and plant dry weight compared to the comparison combination W_3CO_3 for both seasons.

Discussion

It is evident from the results of the aforementioned tables (1, 2, 3, 4, 5 and 6) that the higher soil moisture parameters (lower stress) represented by the level W_1 (depletion of 30% of the available water) and the treatment W_2 (depletion of 50% of the available water) did not differ significantly between them. It led to the improvement of all the vegetative growth characteristics of the sweet corn crop, as the availability of appropriate moisture in the soil has a major role in the growth and depth of the roots and then the absorption and distribution of water and nutrients within the parts of the plant and its reflection on the growth and division of plant cells, the activity of enzymes in them, the regularity of the carbon representation process, and from Then increase the accumulation of dry matter for the plant. While the values of all vegetative growth indicators decreased in the aforementioned tables, with a decrease in the amount of water added at the W_3 level (after depleting 70% of the available water), as the number of days to 50% tasseling was reduced (Table 1). This may be due to the lack of water with high temperature, increased wind speed and low relative humidity increased the speed of the physiological processes that take place inside the plant, which induces it to accelerate the early flowering, which is one of the plant mechanisms to withstand water stress and is expressed by the plant's escape from stress, The ability of plants to complete their life cycle before exposure to serious water stress (Fang and Xiong, 2015), It is an indicator of drought tolerance through the acceleration of vital processes that take place within the plant, such as reducing plant height and leaf growth, and this result coincides with the results of Murtadha *et al.* (2018) Abdulameer (2018) and Abdulameer and Ahmed (2019) who found that the number of days to 50% tasseling decreased with decreasing Quantities of irrigation water. It was also noticed that the morphological indicators of growth were affected by water stress, the plant height was reduced (Table 2). This reduction may be attributed to the decrease in the number of days to 50% tasseling (Table 1), within which the stage in which the stem elongates as well as the reduction of the content of Relative water (unpublished data) that determines the division and expansion of cells and the decrease in vegetation density in this treatment as a result of reducing the number and area of leaves (Table 3 and 4), which allowed the penetration of light into the vegetative cover, which led to the failure to give growth hormone (auxin) the opportunity in Work on the elongation of phalanges due to its photo-breaking effect negatively on plant height (Essa, 1990), This result is in agreement with the findings of Wang *et al.* (2018), Jiang *et al.* (2018) and Hassan (2019), who indicated a decrease in the average height of maize plants under water stress conditions. As for the decrease in the number of plant leaves when exposed to water stress, this is due to the apparent decrease in the difference in the period from planting to 50% tasseling (Table 1), in which the growth and expansion of the leaf affected by the lack of soil moisture and the high temperature, which differed between the two seasons, affected the length The length of time allocated to the growth and elongation of phalanges to hold the stem and stimulate the vegetative shoots to produce leaves, so the number of leaves emanating from the plant is reduced (Hakim *et al.*, 2018), as well as the lower plant height (Table 2), This caused a reduction in the number of leaves, as yellow corn plants adopt the mechanism of wilting and falling of the lower leaves during water stress. Majda and Robert (2018), Huang *et al.* (2018) and Peng *et al.* (2018) who indicated the reduction of the number of plant leaves due to the effect of the intensity of water stress treatment $W_{3,}$ This is due to the decrease in the number of days to 50% tasseling (Table 1) and the number of plant leaves and their relative water content that reduced their growth rate and their inability to elongate and expand, and this in turn caused the decrease in the dry weight of the plant (Table 5) represented by the plant height and the number of leaves. (Tables 2 and 3) respectively, and this result confirmed what was mentioned by Ronaghi *et al.* (2017), Abdulameer (2018), Zhao and others (2018), Zhang *et al.* (2018) and Hassan (2019) that reducing plant height, number of leaves and leaf area led to a decrease in Average dry matter gathering of yellow corn plants when exposed to water stress. It was also noted that the morphological indicators of plant growth were negatively affected due to the lack of ready water, which resulted in slow growth and expansion of plant cells, which was reflected in the amount of the intercepting surface of the falling solar radiation, which is an essential part of the carbon representation process, and this in turn negatively led to the accumulation of dry matter (Table 5). And reducing it and then reducing the rate of crop growth, as plant growth and development depend on the shape of plant parts and their growth according to the age of the plant, the growth stage and the level of stress. This result is in agreement with the results of Abduladheem (2017), Abdulameer and Ahmed (2019), and Hassan (2019) who found a lower yield growth rate for yellow maize when subjected to water stress. Through the results in the aforementioned tables, it was also noted that spraying plants with cobalt caused a significant increase in all the studied traits except for the characteristic of the number of days to 50% tasseling and the number of leaves that did not show clear significant differences, that spraying plants with cobalt led to the improvement of vegetative growth characteristics. For the yield of sweet corn, and the reason for the increase may be due to the positive role of cobalt in increasing the content and efficiency of auxins and cytokinins in the plant, which led to an increase in the processes of cell division and elongation (Jayakumar *et al.*, 2013). As well as its role in improving the readiness and transfer of major and minor elements from the root to the vegetative parts through their influence on morphological and physiological characteristics in the vegetative tissue and delaying plant aging (Gad and El-Metwally, 2015 and Sarma *et al.*, 2014 and Chaudhari *et al.*, 2017) This was reflected in the increase in the growth characteristics, including plant height, increased division and elongation of leaf cells, and then increased leaf area, dry weight of the plant and the growth rate of the crop (Tables 2, 4, 5 and 6), respectively, and this appears when spraying plants with cobalt at a concentration of CO_3 (12 mg L^{-1}). Which gave the highest values for the characteristics mentioned in the tables shown later, superior to the rest of the other concentrations of cobalt, which gave the lowest averages for all the studied traits. The results of the experiment also showed the superiority of the interaction coefficients between the study workers by their effect on some characteristics of vegetative growth such as plant height, leaf area and dry weight of the plant. The presence of cobalt has reduced the negative effects of water shortage, because plants treated with cobalt lose less water because it helps to raise the efficiency of water consumption by the events of water balance, which is necessary for the expansion of cells, expanding the leaf area and delaying plant aging because it inhibits ethylene biosynthesis and increases the efficiency of growth regulators and improves The readiness and movement of nutrients from the root to the vegetative parts and vice versa (Gad and El-Metwally, 2015), and as a result, it leads to the formation of an in-depth root system to absorb the largest amount of water and nutrients and transfer them to the plant.

Conclusions

We conclude from this that the treatment of W_2 (depleting 50% of the available water) gave the same effect on the studied characteristics and without significant difference than the treatment of W_1 (depleting 30% of the available water). The growth of the sweet corn crop, and here it becomes clear the functional role of cobalt in reducing the harmful effects of water stress, which led to improving the vegetative growth characteristics of the sweet corn plant.

Table 1 : Effect of irrigation and Cobalt treatments and their interactions on number of days to 50% tasseling (Days) in autumn seasons of 2018 and 2019.

	Irrigation	Cobalt mg L^{-1}				Mean
		CO_0 = 0	CO_1 = 4	CO_2 = 8	CO_3 = 12	
Autumn season 2018	W_1= 30%	53.90	53.20	53.40	53.50	53.50
	W_2 =50%	51.90	51.10	51.40	51.50	51.47
	W_3 =70%	47.60	47.60	47.40	47.20	47.45
	Mean	51.13	50.63	50.73	50.73	
L. S. D. (P = 0.05)		W = 2.23		CO = N.S.	W * CO = N.S.	
Autumn season 2019	Irrigation	Cobalt mg L^{-1}				Mean
		CO_0 = 0	CO_1 = 4	CO_2 = 8	CO_3 = 12	
	W_1 =30%	56.20	56.50	56.20	56.80	56.42
	W_2 =50%	54.20	54.50	54.00	54.80	54.37
	W_3 =70%	50.90	50.10	50.70	50.40	50.52
	Mean	53.76	53.70	53.63	54.00	
L. S. D. (P = 0.05)		W = 2.31		CO = N.S.	W * CO = N.S.	

Table 2 : Effect of irrigation and Cobalt treatments and their interactions on plant height (cm) in autumn seasons of 2018 and 2019.

	Irrigation	Cobalt mg L^{-1}				Mean
		CO_0 = 0	CO_1 = 4	CO_2 = 8	CO_3 = 12	
Autumn season 2018	W_1 =30%	148.00	144.30	155.30	160.60	152.05
	W_2 =50%	135.60	143.00	140.00	151.60	142.55
	W_3 =70%	119.60	123.60	129.60	133.60	126.60
	Mean	134.40	136.96	141.63	148.60	
L. S. D. (P = 0.05)		W = 11.14		CO = 1.93	W * CO = 10.96	
Autumn season 2019	Irrigation	Cobalt mg L^{-1}				Mean
		CO_0 = 0	CO_1 = 4	CO_2 = 8	CO_3 = 12	
	W_1 =30%	150.00	148.90	149.20	161.20	152.32
	W_2 =50%	137.10	139.60	146.10	148.40	142.80
	W_3 =70%	118.40	125.20	127.10	136.40	126.77
	Mean	135.16	137.90	140.80	148.66	
L. S. D. (P = 0.05)		W = 13.63		CO = 2.14	W * CO = 11.72	

Table 3 : Effect of irrigation and Cobalt treatments and their interactions on number of leaves in autumn seasons of 2018 and 2019.

	Irrigation	Cobalt mg L^{-1}				Mean
		CO_0 = 0	CO_1 = 4	CO_2 = 8	CO_3 = 12	
Autumn season 2018	W_1 =30%	13.70	13.73	13.88	13.33	13.66
	W_2 =50%	13.30	13.36	13.46	13.26	13.34
	W_3 =70%	10.10	10.23	10.46	10.20	10.24
	Mean	12.36	12.44	12.60	12.26	
L. S. D. (P = 0.05)		W = 1.16		CO = N.S.	W * CO = N.S.	
Autumn season 2019	Irrigation	Cobalt mg L^{-1}				Mean
		CO_0 = 0	CO_1 = 4	CO_2 = 8	CO_3 = 12	
	W_1 =30%	14.20	14.32	14.46	14.39	14.34
	W_2 =50%	13.53	13.56	13.66	13.57	13.58
	W_3 =70%	10.52	10.63	10.77	10.56	10.62
	Mean	12.75	12.83	12.96	12.84	
L. S. D. (P = 0.05)		W = 1.87		CO = N.S.	W * CO = N.S.	

Table 4 : Effect of irrigation and Cobalt treatments and their interactions on leaf area (cm^2) in autumn seasons of 2018 and 2019.

	Irrigation	Cobalt mg L^{-1}				Mean
		CO_0 = 0	CO_1 = 4	CO_2 = 8	CO_3 = 12	
Autumn season 2018	W_1 =30%	3640.00	3707.00	3773.00	3817.00	3734.25
	W_2 =50%	3385.00	3478.00	3588.00	3758.00	3552.25
	W_3 =70%	2420.00	2530.00	2947.00	3066.00	2740.75
	Mean	3148.33	3238.33	3436.00	3547.00	
L. S. D. (P = 0.05)		W = 238.9	CO = 129.50		W * CO = 270.30	
	Irrigation	Cobalt mg L^{-1}				Mean
		CO_0 = 0	CO_1 = 4	CO_2 = 8	CO_3 = 12	
Autumn season 2019	W_1 =30%	3627.00	3741.00	3827.00	3997.00	3798.00
	W_2 =50%	3508.00	3667.00	3757.00	3861.00	3698.25
	W_3 =70%	2458.00	2546.00	2903.00	3251.00	2789.50
	Mean	3197.66	3318.00	3495.66	3703.00	
L. S. D. (P = 0.05)		W = 110.10	CO = 120.10		W * CO = 195.90	

Table 5 : Effect of irrigation and Cobalt treatments and their interactions on plant dry matter (g) in autumn seasons of 2018 and 2019.

	Irrigation	Cobalt mg L^{-1}				Mean
		CO_0 = 0	CO_1 = 4	CO_2 = 8	CO_3 = 12	
Autumn season 2018	W_1 =30%	146.30	152.00	151.30	164.60	153.55
	W_2 =50%	139.60	144.00	147.00	155.70	146.57
	W_3 =70%	111.60	119.60	125.60	131.60	122.10
	Mean	132.50	138.53	141.30	150.63	
L. S. D. (P = 0.05)		W = 11.14	CO = 1.95		W * CO = 10.93	
	Irrigation	Cobalt mg L^{-1}				Mean
		CO_0 = 0	CO_1 = 4	CO_2 = 8	CO_3 = 12	
Autumn season 2019	W_1 =30%	148.90	149.20	154.00	165.20	154.32
	W_2 =50%	141.00	143.60	150.00	152.30	146.72
	W_3 =70%	115.40	125.20	128.40	136.40	126.35
	Mean	135.10	139.33	144.13	151.30	
L. S. D. (P = 0.05)		W = 10.61	CO = 2.93		W * CO = 10.51	

Table 6 : Effect of irrigation and Cobalt treatments and their interactions on crop growth rate (g m^2 day^{-1}) in autumn seasons of 2018 and 2019.

	Irrigation	Cobalt mg L^{-1}				Mean
		CO_0 = 0	CO_1 = 4	CO_2 = 8	CO_3 = 12	
Autumn season 2018	W_1 =30%	2.75	2.85	2.83	3.08	2.87
	W_2 =50%	2.69	2.81	2.85	3.02	2.84
	W_3 =70%	2.35	2.51	2.65	2.79	2.57
	Mean	2.59	2.72	2.77	2.96	
L. S. D. (P = 0.05)		W = 0.20	CO = 0.16		W * CO = N.S.	
	Irrigation	Cobalt mg L^{-1}				Mean
		CO_0 = 0	CO_1 = 4	CO_2 = 8	CO_3 = 12	
Autumn season 2019	W_1 =30%	2.64	2.64	2.73	2.90	2.72
	W_2 =50%	2.59	2.63	2.77	2.78	2.69
	W_3 =70%	2.27	2.50	2.53	2.70	2.50
	Mean	2.50	2.59	2.67	2.79	
L. S. D. (P = 0.05)		W = 0.13	CO = 0.11		W * CO = N.S.	

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