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Effect of proline foliar spraying and irrigation water salinity on some growth traits of yellow corn *Zea mays* L. crop

Anmar Hamoudi Kadhim[1] Hanoon N.Kadhem Al-Barakat[2] and Mohammed Radwan Mahmoud[3]

[1,2,3] College of Agriculture, University of Al-Muthanna, Iraq.
[3]E-mail: modrn@mu.edu.iq

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Abstract. A field experiment was carried out during the two spring seasons 2020/2021 in an agricultural field, located on the banks of the Euphrates River in Al-Muthanna Governorate, which is 4 km away from Al-Muthanna University, between latitudes 45°14′58″ and longitudes 31°19′33″, to study the effect of foliar spraying with the amino acid (proline) and irrigation water salinity on the growth of corn *Zea mays* L., in an experiment whose treatments included two levels of concentrations of the amino acid (proline), they were 0 and 2, four levels of electrical conductivity of the irrigation water used in the irrigation process, it was less than 2.0 dSiemens m^{-1} using pure water RO mixture with river water, 4.0, 6.0 and 8.0 dSiemens m^{-1} using a mixture of tap water and river water. The results indicated that there were significant differences between the levels of proline acid, as the treatment of adding proline 2% gave the highest value for chlorophyll and leaf area, the results showed a significant superiority between irrigation water salinity levels in plant height, as the treatment of 8.0 dSiemens m^{-1} decreased compared to the control treatment, there were significant differences in the interaction, where B0 x w2 treatment gave the highest value for stem diameter, while B0 x 1w treatment gave the lowest value for stem diameter, a significant superiority between irrigation water salinity levels in dry matter, as the treatment of 6.0 dSiemens m^{-1} decreased and gave the lowest dry matter compared to the treatment of 4.0 dSiemens m^{-1} which gave the highest dry matter.

Keywords. yellow corn, amino acids, proline, salinity of irrigation water.

1. Introduction

Proline is a simple, non-polar, essential amino acid, were included in the formation of proteins that contain an aliphatic or heterocyclic side chain in the rest of the molecule, it differs from the rest of the side chains in other acids, being attached to both the nitrogen atom of the amino group and the carbon atom (alpha), proline accumulates in the stems and leaves of plants exposed to water or salt stress, due to the high tensile (attractive) forces of water inside the soil during drought [1]. The accumulation of proline in stressed plants is a determinant of the effect of water stress, it was also considered an indicator of coping with a particular stress, p Proline keeps the cellular osmotic pressure high, the higher the proline content, it is a protective response of plants to all factors that reduce the percentage of water in the cells [2].

In an experiment carried out by Muhammad [3] in the field of the Directorate of Agriculture of Diyala for the spring season (2011), to find out the effect of spraying proline acid at levels (0, 150 and 200) mg L-1 and spraying abscisic acid at levels (0, 15 and 20) mg L^{-1} on maize plants under the influence of moisture stress, the level of 200 mg L^{-1} of acid gave the highest mean of plant height and leaf area of 179.7 cm and 55.22 dm^2, respectively, the treatment of the interaction between the two acids (20 mg ABA L^{-1} + 200 mg Proline L^{-1}) achieved the highest averages of grain yield and biological yield (Ton ha^{-1}) of 5.07 and 9.54 tons ha^{-1}, respectively, compared with the no-spray treatment.

An experiment was conducted by Hussein *et al*. [4] in a field at the University of Baghdad on wheat crop, to determine the effect of interaction between spraying with proline acid at concentrations (0, 10, 20 and 30) ppm, increasing concentrations of NaCl (0, 50, 100 and 150) mmol L^{-1} in plant nitrogen, phosphorus, potassium and total chlorophyll content, the results showed an increase in proline acid concentration from 0 to 30 ppm.

The results of the experiment conducted by Mosaad *et al*. [5] on a farm belonging to the Agricultural Research Center in Egypt showed, to study the effect of spraying with the amino acid proline at concentrations of 0, 50 and 100 mmol on the yield of maize and the rate of mineral nitrogen representation under the influence of salt stress and for two consecutive agricultural seasons 2016 and 2017, the addition of proline at a concentration of 50 mmol sprayed on the plant was significantly superior in giving it the highest mean of plant height (cm), leaf area (cm^2), grain yield and dry matter yield (ton ha^{-1}), whose values were respectively 207.3 cm, 729.0 cm^2, and 7.479. And 11.198 tons ha^{-1} for the first season 2016, 215.6 cm^2, 754.9 cm^2, 7.523 and 11.167 tons ha^{-1} for the second season 2017 compared to the treatment of no addition (without spraying).

Therefore, the study aimed to find out the effect of foliar application of the amino acid and the salinity of the irrigation water on the growth of the yellow corn crop.

2. Materials and Methods

2.1 Location, treatments and and experience design:

A field experiment was carried out during the two spring seasons 2020/2021, at one of the agricultural fields located on the banks of the Euphrates River in Al-Muthanna Governorate, which is 4 km away from Al-Muthanna University, between latitudes 45°14′58″ and longitudes 31°19′33″, to study the effect of foliar spraying with the amino acid (proline) and irrigation water salinity on the growth of corn, *Zea mays* L., in an experiment whose coefficients included two levels of the concentrations of the amino acid (proline) which were 0 and 2% and denoted by B0 and B1 respectively, and four levels of electrical conductivity of the irrigation water used in the irrigation process were less than 2.0 dSiemens m^{-1} using a mixture pure water (RO with river water), 4.0, 6.0, and 8.0 dSiemens m^{-1} using tap water mixture with river water) and denoted by (W0, W1, W2, and W4), respectively.

After preparing the experimental land for plowing, smoothing and leveling operations, soil samples were taken from a depth of 0-30 cm from different locations in the field, it was mixed well to homogenize, air-dried and smoothed using a polyethylene hammer, passed through a sieve with a diameter of 2 mm. A composite sample was taken from it for the purpose of estimating some of the chemical and physical soil characteristics of the research soil, then the field was divided into three replicates, and the distance between the replicates was 2 meters, each repeater contains 24 experimental units with dimensions of (2 x 3) m^2 for one experimental unit, and the interval between one experimental unit and another was 0.5 meters, each experimental unit included 4 routers, with a distance of 75 cm between replicate, between one furrow and another, this furrow was planted with yellow corn seeds (Fajr) in one holes on 3/15/2021, with (3) seeds per jar, and the distance between one hole and another was 20 cm.

The seeds were obtained from the General Authority for Seed Examination and Certification, two weeks after the emergence of seedlings, the thinning process was carried out to leave only one plant in each hole, earthen drains were made along the experimental units, with the installation of an irrigation system consisting of PVC pipes (Turkish-made) with a diameter of 1 inch, with all its accessories, including connections and locks, it was connected with four tanks of 5000 liters and filled with the required saline levels of irrigation water, then the pipes were extended along the distance between the repeaters and distributed to the experimental units to control the irrigation process with the required saline levels.

Phosphate fertilizer was added in the form of triple superphosphate fertilizer (P_2O_5 45%) and potash fertilizer in the form of potassium sulfate (43% K) at one time when planting at the level of 200 kg P ha^{-1} and the level 120 kg K ha^{-1}, as for the nitrogenous fertilizer, it was added in the form of urea fertilizer (46% N) at the level of 240 kg N ha^{-1}, in three equal batches, the first at planting, the second after 21 days of planting, and the third at the beginning of flowering. Crop servicing operations were carried out on the experimental land by getting rid of the bushes by hand hoeing and watering the crop as needed, according to what was mentioned by Al-Younes *et al*. [6] and continued until the end of the season. Diazinon granulated at a concentration of (10%) was used to control the yellow corn stem borer insect at a rate of (6) kg ha^{-1} by feeding on the growing top of the stem twice, the first after 20-25 days of sowing and the second after two weeks of the first control [7].

The experiment was carried out using split-plot design, using the randomized complete block design (R.C.B.D) with three replicates, the irrigation water salinity levels (less than 2.0, 4.0, 6.0 and 8.0 dSiemens m^{-1}) were distributed on the main plots, as for the concentrations of the mixture of organic acids (humic and fulvic) (0, 20 and 40) liter ha^{-1} on the sub plots, thus the total experimental units were 4 x 3 x 3 = 36.

Table 1. Some chemical and physical properties of field soil before planting.

Items	Value	Unit
pH	8.40	-
EC	5.60	dSc.m
CEC	5.80	Cmol kg^{-1}soil
Organic Mater	8.50	gm kg^{-1}
Gypsum	1.03	
Lime	280.00	
Carbonate	Nill	Cmol kg^{-1}soil
Bicarbonate	0.06	
Available nitrogen	5.30	mg kg^{-1}
Available phosphorus	2.60	
Available potassium	35.60	
Available calcium	9.36	mmol L^{-1}
Available magnesium	5.42	
Available sodium	4.22	
Soil properties		
Clay	239.00	gm kg^{-1}
Silt	477.00	
Sand	284.00	
Soil texture	**Silty loam**	

2.2

Studied traits:

2.2.1 Growth traits:

2.2.1.1 Leaves chlorophyll content (SPAD)

It was calculated when the flowering stage was completed as an average of several readings taken from five leaves of each experimental unit using a Chlorophyll Meter model CCM-200 plus [8].

2.2.1.2 Plant height (cm)

It was estimated as an average of five readings randomly taken from each experimental unit in the 100% flowering stage using a measuring tape graduated from soil surface level to the node below the male inflorescence.

2.2.1.3 leaf area (cm^2)

The leaf area of five plants randomly taken from each experimental unit was calculated using the equation [9], which states:

The leaf area of one plant = (the length of the leaf below the ear leaf) 2 x 0.75

2.2.1.4 stem diameter (mm)

The diameter of the stem was measured for five plants randomly taken from each experimental unit at the flowering stage of 100% using a Vernier meter up to one mm from the second node on the stem, taking into account the removal of the leaf sheath and from the plants themselves that were used to measure the height of the plant and then extract its average [10].

2.2.1.5 Dry matter, plant gm^{-1}:

The plants were dried during the flowering stage in an electric oven at a temperature of 70 m for 48 hours until the weight was stabilized with a sensitive scale.

2.3 Statistical analysis:

After collecting the data, it was analyzed statistically using the electronic calculator and using the Genstat program, according to the method of variance analysis mentioned in Al-Rawi and Khalaf Allah [11], the modified Least Significant Difference (L.S.D.) test was used to compare the averages of the treatments at a probability level of 0.05.

3. Results and Discussion

3.1 Chlorophyll (SPAD):

Table (2) shows a significant differences between the levels of the amino acid proline, and the absence of significant differences between the levels of irrigation water salinity and the levels of the amino acid proline, and the interaction between them in the character of chlorophyll.

Table (2) shows that there are significant differences between proline acid levels, where the treatment of adding proline 2% gave the highest value for chlorophyll 25.01 SPAD, while the comparison treatment gave 20.76 SPAD.

Table 2. Effect of irrigation water salinity and the amino acid proline and the interaction between them on chlorophyll**.**

W	B0	B1	Means
W0	26.42	27.61	27.01
W1	20.84	24.62	22.73
W2	19.80	23.93	21.87
W3	15.99	23.88	19.94
Means	20.76	25.01	
L.S.D 05	**W**	**B**	**W*B**
	N.S	3.022	N.S

3.2

Plant height (cm):

Table (3) shows that there were significant differences between the irrigation water salinity levels, there were no significant differences between the levels of homocysteine and the interaction between them in plant height.

Table (3) shows a significant superiority between irrigation water salinity levels in plant height, where the treatment of 8.0 dSiemens m^{-1} decreased and gave a plant height of 94.1 cm compared to the control treatment that gave the highest height of 112.4 cm. The reason may be due to the increase in salt stress on the crop during the growth stages from branching to completion of flowering, which includes the elongation phase, which affected the shortening of the phalanges, led to a negative effect on plant height, the increase in salinity led to a lack of expansion and elongation of cells, led to a significant reduction in plant height, this result agrees with what was found by Al-Hamdani [12], the reason may be due to the osmotic effect, which leads to a decrease in the amount of water entering the plant and a decrease in the swelling effort of the leaf cells [13].

Table 3. Effect of irrigation water salinity and the amino acid proline and the interaction between them on plant height cm.

W	B0	B1	Means
W0	115.6	109.2	112.4

W1	109.3	102.2	105.8
W2	97.8	107.3	102.6
W3	94.0	94.2	94.1
Means	104.2	103.2	
L.S.D 05	**W**	**B**	**W*B**
	4.21	N.S	N.S

3.3

Leaf area (cm^2):

Table (4) shows a significant differences between the levels of the amino acid proline, there are no significant differences between irrigation water salinity levels and levels of the amino acid proline and the interaction between them in the leaf area.

Table (4) shows that there are significant differences between proline acid levels, where the treatment of adding proline 2% gave the highest value of the leaf area 3699 cm^2, while the comparison treatment gave 3401cm^2.

Table 4. Effect of irrigation water salinity and the amino acid proline and the interaction between them on the leaf area (cm^2).

W	B0	B1	Means
W0	3930.	3383	3656
W1	3484.	3708	3596
W2	3227.	4025	3626
W3	2963.	3681	3322
Means	3401.	3699	
L.S.D 05	**W**	**B**	**W*B**
	N.S	121.5	447.9

3.4

Stem diameter (mm):

Table (5) shows that there were no significant differences between irrigation water salinity and proline levels, there were significant differences in the interaction between them in the characteristic of stem diameter.

Table (5) shows that there were significant differences interaction, where B0 x w2 treatment gave the highest value for stem diameter, it reached 15.22 mm, while the treatment of B0 x 1 w gave the lowest value for the stem diameter as it reached 13.32 mm.

Table 5. Effect of irrigation water salinity and the amino acid proline and the interaction between them on stem diameter (mm).

W	B0	B1	Means
W0	14.22	14.14	14.18
W1	14.00	14.38	14.19
W2	15.22	13.32	14.27
W3	14.16	14.60	14.38
Means	14.40	14.11	
L.S.D 05	**W**	**B**	**W*B**
	N.S	N.S	0.789

3.5

Dry matter(gm plant-1):

Table (6) shows that there were significant differences between irrigation water salinity levels, and there are no significant differences for proline acid and the interaction between them in dry matter.

Table (6) shows a significant superiority between irrigation water salinity levels in dry matter

Where the treatment of 6.0 dSiemens m^{-1} decreased and gave the lowest dry matter 467 gm $plant^{-1}$ compared to the treatment of 4.0 dSiemens m^{-1} which gave the highest dry matter 710 gm $plant^{-1}$. The reason may be due to the increase in salt stress on the crop during the growth stages from branching to completion of flowering, includes the elongation phase, which affected the shortening of the internodes, which led to a negative effect on plant height, the increase in salinity led to a lack of expansion and elongation of cells, led to a significant reduction in plant height. This result was consistent with what was found by Al-Hamdani [12]. The reason may be due to the osmotic effect, which leads to a decrease in the amount of water entering the plant and a decrease in the swelling effort of the leaf cells [13].

Table 6. Effect of salinity of irrigation water and the amino acid proline and the interaction between them on dry matter (gm plant^{-1}).

W	B0	B1	Means
W0	763	550	657
W1	719	701	710
W2	405	528	467
W3	561	467	514
Means	612	562	
L.S.D 05	**W**	**B**	**W*B**
	175.8	N.S	N.S

4. Conclusions

There were significant differences between the levels of the amino acid proline, where the treatment of adding proline 2% gave the highest values for the characteristics of leaf area and chlorophyll. There were significant differences between the irrigation water salinity levels, as the treatment of 8.0 dSiemens m^{-1} decreased and gave the lowest plant height and dry matter. There were significant differences in the overlap, where the treatment of B0 x w2 gave the highest value for the diameter of the stem, reaching 15.22 mm, while the treatment of B0 x 1 w gave the lowest value for the diameter of the stem, reaching 13.32 mm.

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