Effect of Foliar Feeding of Roselle Extract on Some Growth Characteristics and Yield of Five Varieties of Yellow Corn (*Zea mays* L.)

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Abstract
Field experiment was done using two factors in the land of the Department of Field Crops, College of Agriculture, University of Kerbala in the 2025-2026 agricultural season. The experiment included two factors which are; (i) five yellow corn varieties (Fajr, Baghdad, Maha, Buhooth, and 5018) and (ii) foliar application of Roselle extract in three concentrations (0, 4, and 8 g L-1). The method used is RCBD in three replications.
The findings of the experiment showed significant difference among varieties on some parameters. Variety Maha scored superiority as it attained the highest values for leaf area, dry weight, ear length, ear diameter, and the number of grains per row. Variety Buhooth scored superiority on number of rows per ear and total yield while Baghdad variety recorded superiority in the average 100-seed weight.
Foliar sprays of Roselle extract, especially 8 g L-1 concentration, gave better performance for the majority of measured parameters.
With respect to the two way interaction between factors of the study, interaction Maha with 8 g L-1 concentration had superiority in plant height, dry weight, ear length, number of grains per row, and average 100-seed weight. Interaction Maha with 4 g L-1 concentration gave superiority in ear diameter and leaf area. Interaction Buhooth with 8 g L-1 concentration, on the other hand, gave superiority in the number of rows per ear and total yield.

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Keywords: Growth, Roselle, feeding, *Zea mays*, Fajr, Baghdad, Maha, Buhooth, and 5018

1. Introduction

Yellow Corn (Zea mays L.) belongs to the Poaceae family crops and comes first in productivity all over the world and third in terms of consumption following wheat and rice (Ifie *et al*., 2026) [8]. Growing yellow corn is practiced across the globe in extensive geographical locations. Importance of the yellow corn crop is associated with its two main applications, namely food products for humans and animals' food (Revilla *et al*., 2022) [12], which is provided by the structure of the crop's grain, consisting of 4% oil, 10% protein, 71% carbohydrates (Khaeim *et al*., 2022) [9], vitamins A and E (Szulc *et al*., 2022) [14].

In Iraq, although this crop is highly important, its productivity per unit area is lower than the world one. The cultivated area is between 50 and 199 thousand hectares, while the average yield is 20,165 kg ha^-1 (Arab Organization for Agricultural Development, 2017). There are several factors affecting low productivity of the yellow corn crop, including quality of the variety, soil condition and poor crop management practices, fertilization, in particular.

Techniques of fertilization are important means for improvement of crop yield. Introduction of modern techniques, including nano-, organic-, and bio-fertilizers, as well as plant extracts, is designed to reduce chemical fertilizer application and pollution and improve the efficiency of nutrient uptake and reduction of nutrient losses (Gade *et al*., 2023; Ding *et al*., 2023) [5, 4]. Plant extracts as alternatives to conventional fertilizers or biostimulants provide several benefits including precision in plant target and higher

nutrient sensitivity because of easy cellular permeability (Han *et al*., 2024; López-Serrano *et al*., 2026) [10]. One of the most common plant extracts is that of Hibiscus sabdariffa L. (Roselle) that is characterized by high content of vitamins, minerals, organic compounds, and amino acids (Singh & Hailemariam, 2017) [13]. Roselle extract provides stimulation of numerous physiological processes, such as photosynthesis, respiration, chlorophyll biosynthesis, cell division, tissue growth, and plant hormone activation (Mousa, 1999) [11].

Thus, the goals of the present study are as follows:

1. to identify the best-performing yellow corn variety among those tested;
2. to evaluate the effect of the Roselle extract and to find out the most suitable concentration for growth and yield of yellow corn varieties;
3. to find out the most favorable interaction among the study factors.

2. Materials and Methods

2.1. Field Experiment Location

The experiment was done in the Al-Hussainiya region at the College of Agriculture of the University of Kerbala, Department of Field Crops, during the autumn period. The experiment focused on examining the effects of applying Roselle extracts to different growth and production properties of five yellow corns (Fajr, Baghdad, Maha, Buhooth, and 1518).

2.2. Chemical and Physical Analyses of Field Soil

Soil samples were taken randomly from the field at the soil depth of 0-30 cm, mixed to make a composite sample, and air-dried. A portion of the soil sample was brought to the laboratories of the College of Agriculture, University of Kerbala, where soil chemical and physical analysis was carried out as shown in Table 1.

Table 1: Physical and Chemical Properties of the Field Soil

Soil Property	Value	Unit
Soil Reaction (pH)	7.5	—
Electrical Conductivity (EC)	2.4	dS m^{-1}
Available Nitrogen (N)	15.0	mg kg^{-1}
Available Phosphorus (P)	5.6	mg kg^{-1}
Available Potassium (K)	65.8	mg kg^{-1}
Organic Matter	3.9	%
Soil Texture	Sandy loam	—
Soil Separates:		
Clay	1.6	%
Silt	46.0	%
Sand	52.4	%

2.3. Land Preparation

Field Soil preparation was done by ensuring proper ploughing, levelling and softening of the soil. The drip irrigation lines were laid out with a spacing of 30cm laterally and drippers were laid out at a spacing of 15cm.

2.4. Experimental Design

The experiment was designed using the RCBD system where there were two factors. Factor I included five varieties of yellow maize which are: Maha, Buhooth, 5018, Baghdad, and Fajr. Factor II involved the use of three levels of concentration of the extract of Roselle leaves applied on the plants through foliage spraying. The three levels used were 0, 4, and 8 g/L.

2.5. Cultivation and Crop Management

Seeds of yellow corn (Zea mays) have been obtained from the Department of Field Crops, College of Agriculture, University of Kerbala and were sown in the autumn season on September 9, 2025, in row plantation pattern. Intervening distance between rows and plants in each row was 30 cm and 15 cm, respectively. Three seeds were planted per hill at a depth of 5 cm and then drip irrigation was carried out.

The first weed removal around the plants was done on September 18, 2025, which is 9 days after sowing. Granular Diazinon insecticide was used at the rate of 3 granules per whorl of each plant on September 19, 2025, for the purpose of controlling corn stem borer. Thin plantation was also done to maintain one healthy plant per hill in subsequent experiments.

2.6. Extraction Method of Roselle Extract

The extract was obtained using the procedure proposed by Harborne (1984) [7]. Fifty grams of powdered Roselle calyx was mixed in 500 mL of distilled water and kept for shaking for 30 minutes. The mixture was left for another 30 minutes after which it was passed through gauze and centrifuged for 15 minutes at 300 rpm. The extract was concentrated by rotary evaporator. Concentrations of the treatment equivalent to 4 and 8 g L-1 were prepared.

Application of treatments involved three sprays. The first spray was conducted a week after thinning, second spray a week after the first one and third spray was done at the beginning of blooming.

2.7. Studied Characteristics

After achieving full maturity, the following data were collected:

- **Height of the plant (cm):** using a tape measure.
- **Leaf area (cm2):** determined through leaf length and width measurement in relation to tables provided by Al-Sahooki & Jiad (2013).

- **Dry weight (Mg ha-1):** estimated using the average plant weight and multiplying it with plant density (45,000 plants ha-1).
- Length of the ear (cm)
- Diameter of the ear (cm)
- Number of rows in one ear
- Number of grains in one ear
- Weight of 100 grains (g)
- Yield (Mg ha-1)

3. Results and Discussion

3.1. Plant Height (cm)

Table 2 clearly shows that the treatments related to the spraying of Roselle extract and interaction treatments had significant effects on the plant height while there were no significant differences among the varieties for the plant height. Between the treatments related to spraying of the Roselle extract, the concentration of 8 g/L was better by getting the maximum plant height of 171.8 cm and was significantly different from the values of 0 and 4 g/L concentrations, which were 140.7 cm and 161.6 cm, respectively, showing increase percentage of 22.1% and 6.3%, respectively. For the interaction treatments, the statistical results shown in Table 2 show the variety "Maha" as the best one at the concentration of 8 g/L with the maximum plant height of 186.5 cm while the interaction treatment of the variety "Maha" with no-spray (0 g/L) treatment had the minimum value of 116.5 cm.

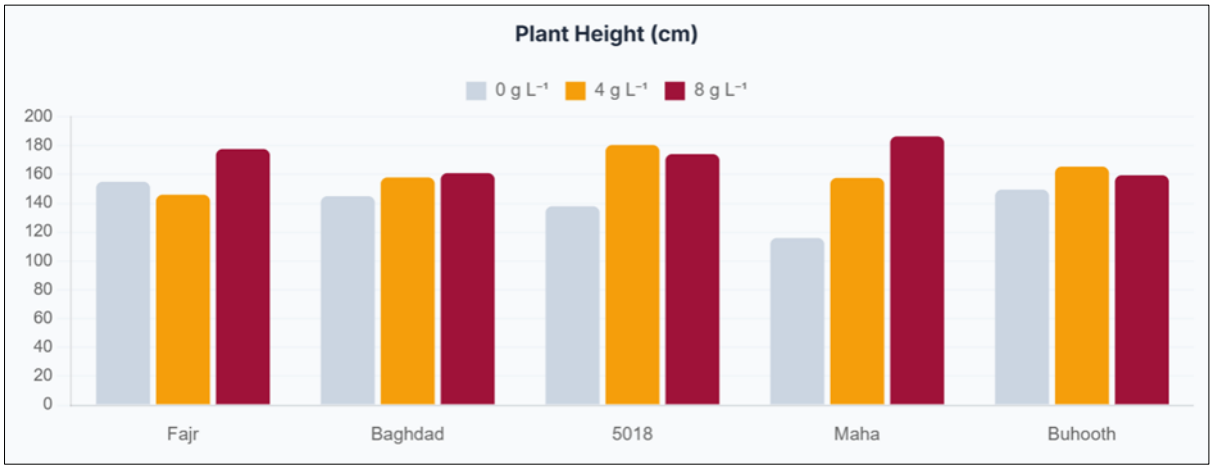

Fig 1: Effect of Foliar Feeding with Roselle Extract on the Average Plant Height (cm) of Five Yellow Corn Varieties.

3.2. Leaf Area (cm^2)

According to Table 3, significant differences were found among varieties and their interactions concerning leaf area, while the foliar spray with Roselle extract had no significant effect. Maha was characterized by the maximum leaf area of 3802 cm2, while the Fajr variety had the minimum leaf area of 2909 cm2; the difference between these two values is 30.69%. Regarding interaction treatment, statistical analysis indicated that the Maha variety at the level of 4 g L-1 was the best, giving the maximum leaf area (4000 cm2). On the other hand, the worst combination of both varieties (Fajr and Baghdad) at the level of 4 g L-1 resulted in the minimum leaf area of 2426 cm2.

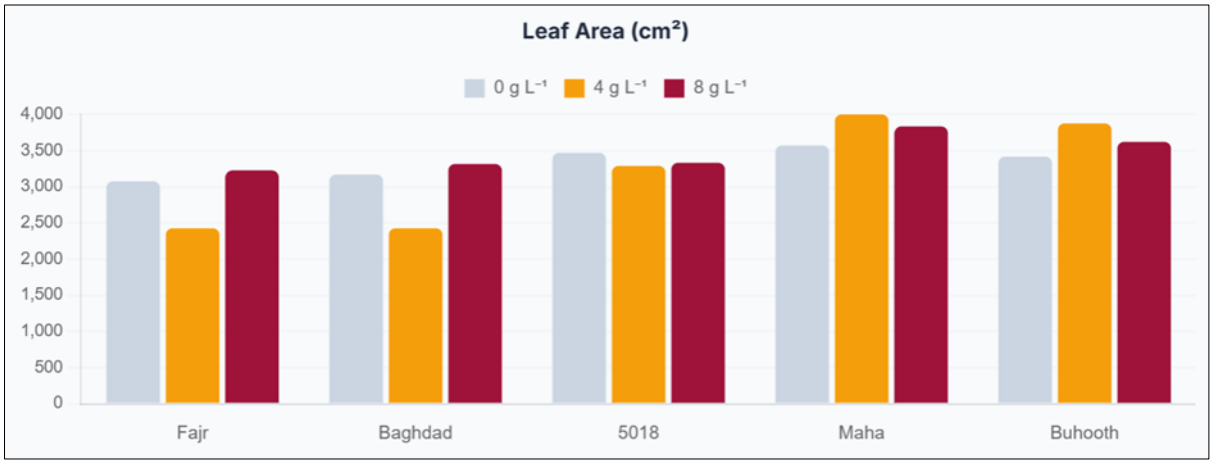

Fig 2: The Effect of Foliar Feeding with Roselle Extract on the Average Leaf Area (cm^2) of Five Yellow Corn Varieties.

3.3. Dry Weight (*Mg* ha^{-1})

From the results shown in figure 4, there are considerable differences in the variety, treatment of spray and their interactions on the dry weight.

Among varieties, the highest dry weight was found in Maha which was 12.800 Mg ha^-1, and the variety 5018 was the variety with the lowest dry weight which was 0.405 Mg ha^-1, a 36.1% increase.

In relation to Roselle extract treatments, the treatment of 8 g L^-1 gave the best result in terms of dry weight with a value of 12.975 Mg ha^-1, which was significantly higher than that of 0 and 4 g L^-1 (8.874 and 12.411 Mg ha^-1 respectively). This was an increase of 46.2% and 4.54% respectively.

Among interaction treatments, the interaction between variety Maha with 8 g L^-1 gave the highest dry matter rate which was 15.450 Mg ha^-1 while interaction between variety 5018 with 8 g L^-1 was 6.975 Mg ha^-1.

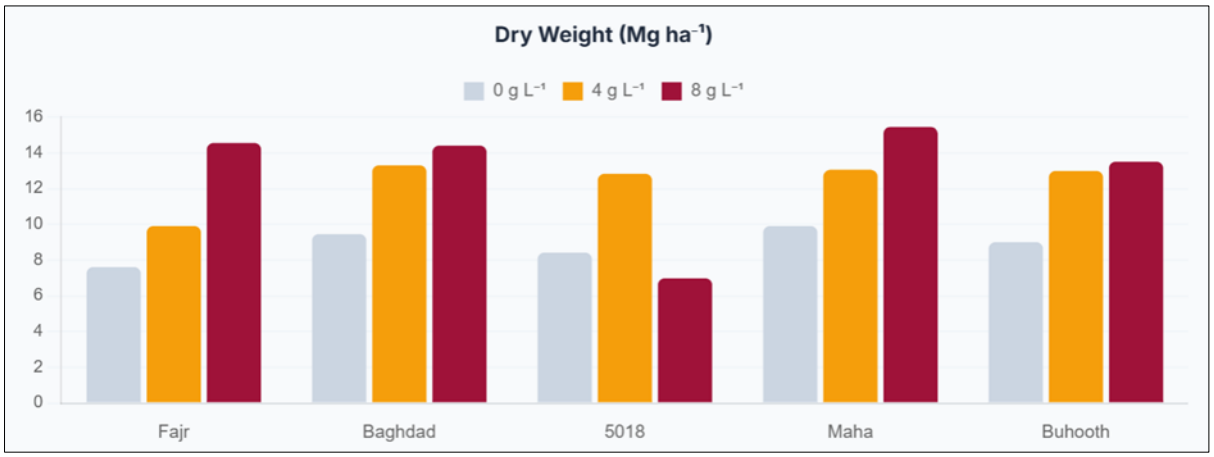

Fig 3: Effect of Foliar Feeding with Roselle Extract on the Average Dry Weight (*Mg* ha^{-1}) of Five Yellow Corn Varieties

3.4. Ear Length (cm)

From the results as shown on figure 5 above, there was statistically significant difference in ear length among the varieties, treatments with Roselle extract and interaction effects. The variety Maha had good performance, having the highest ear length of 15.64 cm, while variety 5018 was having the least ear length value of 14.42 cm, thus resulting in 8.46% increase. In terms of the effect of Roselle extract treatments on ear length, 8g L-1 treatment resulted in the highest ear length of 17.78 cm, which was statistically better than 0 and 4 g L-1 treatments giving values of 11.40 cm and 15.45 cm, respectively, which represent 55.96% and 15.1 % increases. For the interaction effects, variety Maha at 8g L-1 had the highest ear length value of 19.17 cm, while other varieties, namely Fajr, Baghdad, 5018, and Buhooth had the least value of 11.00 cm when control treatment (0 g L-1) was applied.

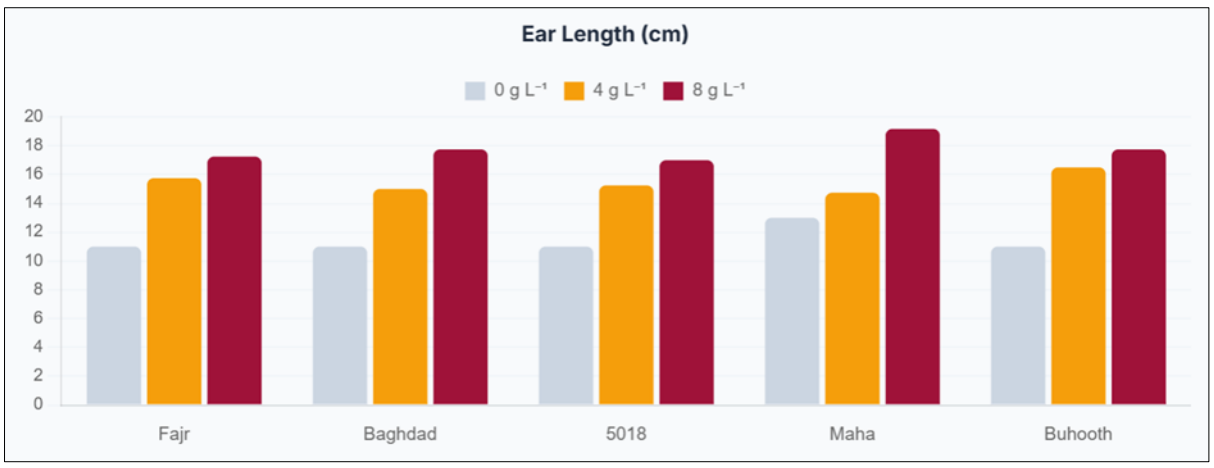

Fig 4: Effect of Foliar Feeding with Roselle Extract on the Average Ear Length (cm) of Five Yellow Corn Varieties

3.5. Ear Diameter (cm)

From the outcomes displayed in Figure 6, it is evident that there are clear variations across the varieties, Roselle extract treatments, and interaction treatments in regards to ear diameter. In regards to the varieties, the Maha variety performed better than the others and achieved a higher diameter value of 22.36 cm, while 5018 variety obtained the lowest diameter value of 14.82 cm, which is a 50.8% improvement. As for Roselle extract treatments, 8 g L-1 concentration treatment had the highest ear diameter of 22.58 cm and was significantly different from the control with an increment of 12.41% (81.9%). In interaction treatments,

interaction between Maha variety and 4 g L-1 treatment had the highest mean ear diameter of 27.78 cm, while the interaction between Baghdad and 5018 varieties and control treatment had the lowest value of 11.90 cm.

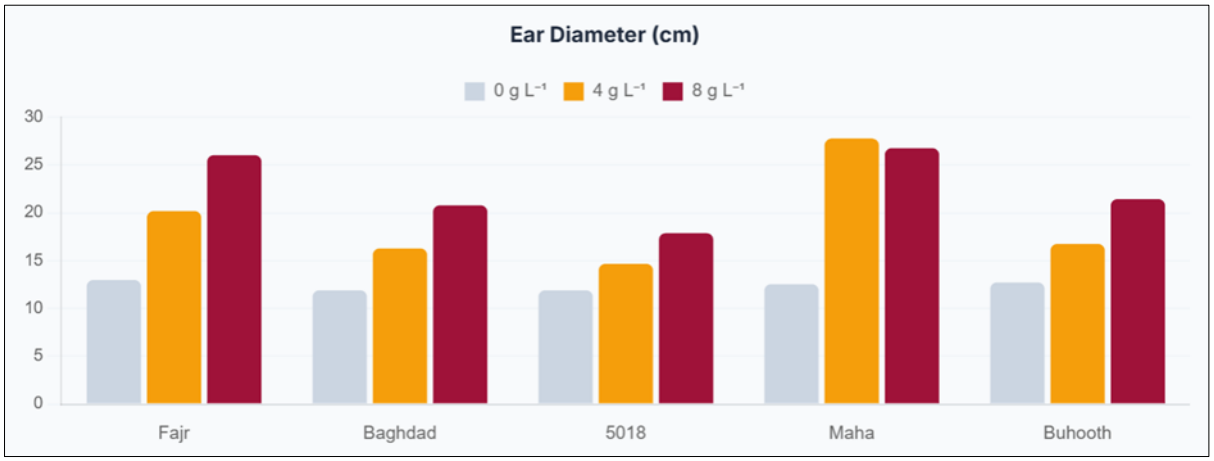

Fig 5: Effect of Foliar Feeding with Roselle Extract on the Average Ear Diameter (cm) of Five Yellow Corn Varieties

3.6. Number of Rows per Ear

From Figure 7, it is clear that there are significant differences between varieties, spraying treatments, and interaction in relation to the rows per ear. From the varieties, the variety Buhooth had the highest number of rows per ear at 18.78 while Baghdad had the least rows at 16.64, which corresponds to an increase of 12.86%. From the Roselle extract treatments, the concentration 8 g L-1 gave the highest rows at 19.13 compared to the concentrations 0 and 4 g L-1, which had 16.30 and 18.05 rows respectively, which corresponded to 17.36% and 5.98% increases. From interaction treatments, Buhooth combined with 8 g L-1 gave the highest number of rows per ear at 21.46 rows while Baghdad under control gave the lowest rows at 14.75.

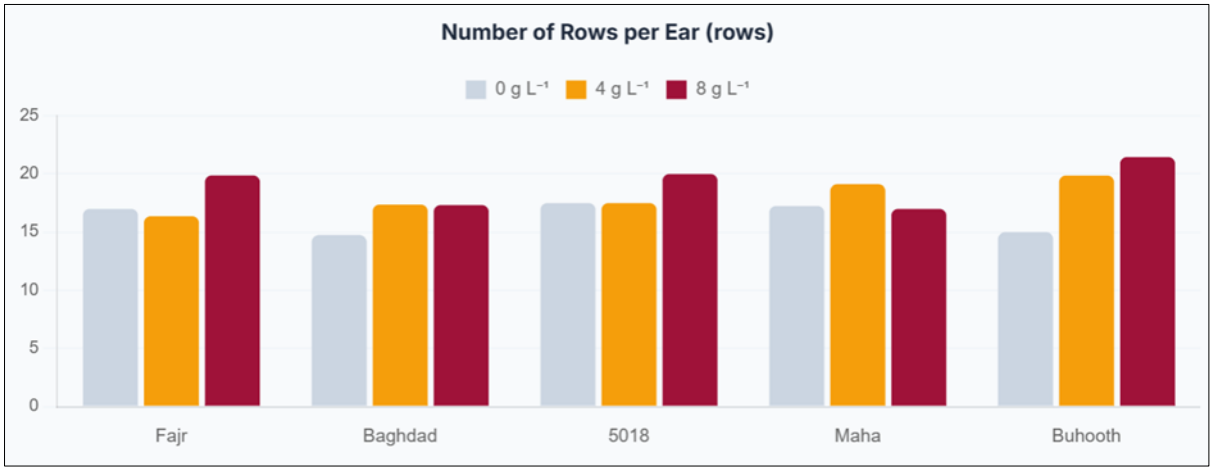

Fig 6: Effect of Foliar Feeding with Roselle Extract on the Average Number of Rows per Ear of Five Yellow Corn Varieties

3.7. Number of Grains per Row

From the results shown in Figure 8, there is a clear difference among varieties, Roselle extract application, and their interaction with regards to grains per row. From the varieties tested, Maha performed very well, recording the highest value of 36.89 while the variety 5018 had the lowest value of 33.83, which showed an improvement of 9.04%. On the other hand, from the Roselle extract application, the amount of 8 g/L-1 recorded the highest value and was statistically better than the amounts of 0 and 4 g/L-1 (which were 32.70 and 34.70 grains, respectively). An improvement of 20.33% and 13.40% were obtained from 0 and 4 g/L-1, respectively.

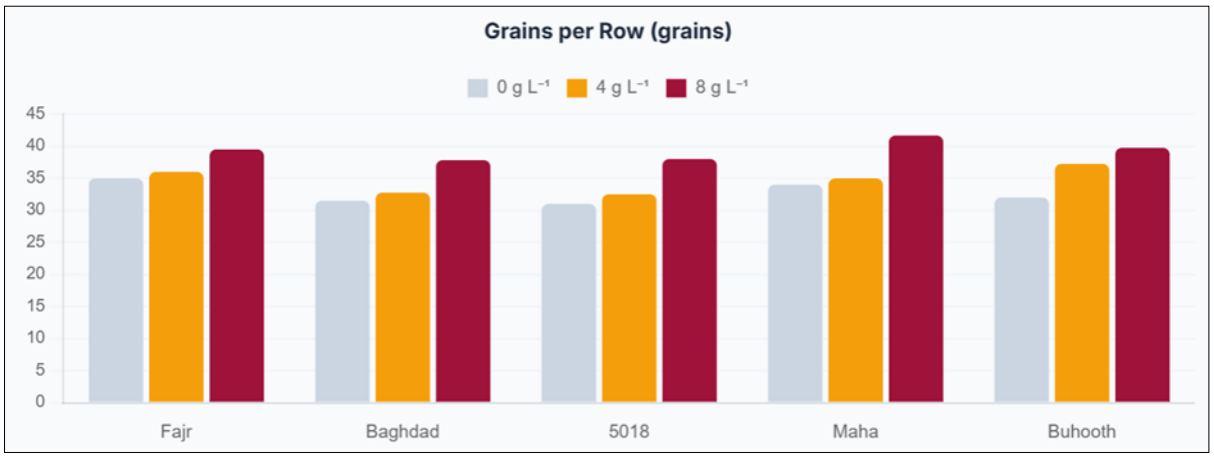

Fig 7: Effect of Foliar Feeding with Roselle Extract on the Average Number of Grains per Row of Five Yellow Corn Varieties

3.8. Average 100-Seed Weight (g)

Figure 9 above shows that there were significant differences between the different varieties, different Roselle extracts and their interactions with respect to 100-seed weight. As far as variety effects are concerned, the Baghdad variety had the highest value at 24.27g while the Fajr variety had the lowest value at 15.57g, which is an increase of 55.87%. As for the Roselle extracts effects, the 8 g L-1 was the best one where it gave the highest mean at 23.27g and was significantly higher than 0 g L-1 and 4 g L-1 with mean values of 17.60g and 20.55g, which is a 33.35% increase. The interaction treatments showed that the variety Maha at 8 g L-1 gave the maximum value at 27.77g while the variety Fajr at the control treatment had the minimum value at 11.50g.

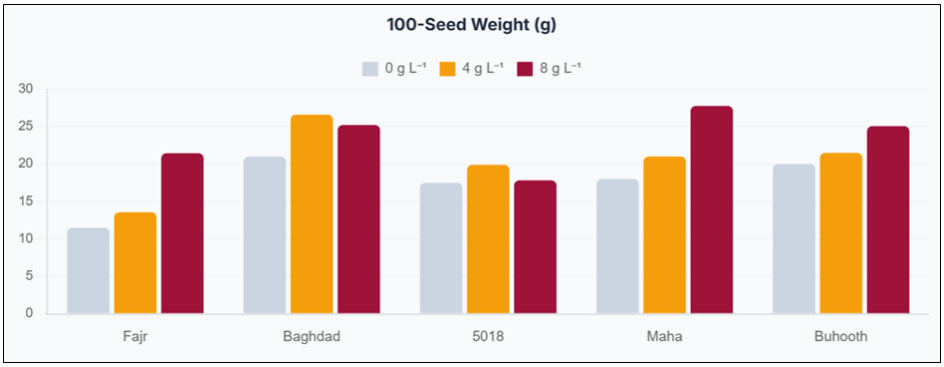

Fig 8: Effect of Foliar Feeding with Roselle Extract on the Average 100-Seed Weight (g) of Five Yellow Corn Varieties

3.9. Yield (Mg ha^{-1})

Data illustrated in figure 10 show that there were statistically significant differences among varieties, Roselle extract treatments and their interactions concerning total yield of plants. As for varieties, Buhooth had the greatest yield of 7.06 Mg ha^-1, while Fajr had the least yield of 4.75 Mg ha^-1, which indicates an increase by 48.63%. Concerning Roselle extract treatments, the greatest yield was obtained using 8 g L^-1 of the extract, having a value of 7.92 Mg ha^-1, with statistical differences from 0 and 4 g L^-1, which gave yields of 4.16 and 5.97 Mg ha^-1, respectively, with an increase of 90.38% and 32.66%. Regarding interaction treatments, the interaction between Buhooth and 8 g L^-1 extract showed the greatest average yield of 9.63 Mg ha^-1, while the interaction of Fajr variety with control treatment showed the least value of 3.08 Mg ha^-1.

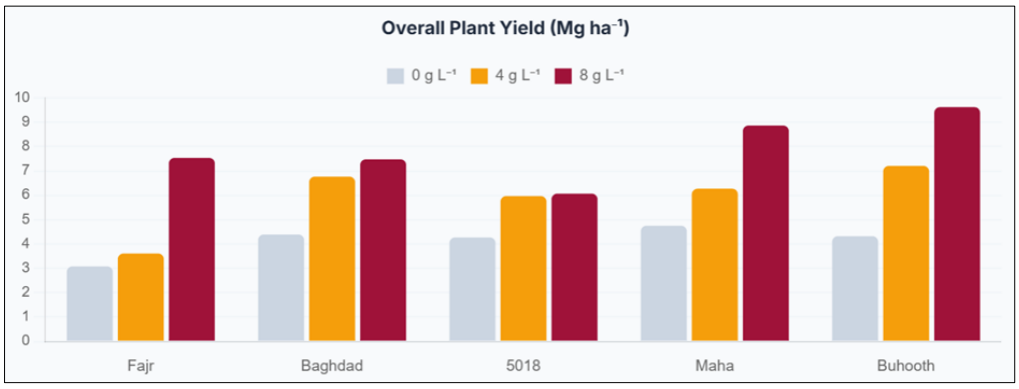

Fig 9: Effect of Foliar Feeding with Roselle Extract on the Average Plant Yield (Mg ha^{-1}) of Five Yellow Corn Varieties

4. Discussion

According to the data represented in figures 2, 3, and 4, variety Maha showed the best results in plant height, leaf area, and dry weight. It is possible to assume that it is related to the particular composition of genes of this variety because it can utilize the full potential of its genetic and physiological characteristics and use photosynthates for the development and extension of stem cells, not storing in other plant tissues. The above results correspond to the conclusion of Al-Hilfi and Al-Tamimi (2017) [1] about growth characteristic improvements in different varieties.

In addition, according to the tables below, the best performance can be observed for Roselle extract in terms of the 8 g L-1 spraying level. This improvement is associated with the high content of ascorbic acid in the extract; it serves as an antioxidant, as well as diphenols. The Roselle extract contains potassium, which can serve as an activator of enzymes, and magnesium, which is responsible for ribosome structure (it is necessary for protein synthesis), as well as for chlorophyll structure. In addition, the extract improves photosynthesis and respiration, regulates activities of plant hormones and causes the cell division.

Among the yield components, variety Buhooth showed the highest total yield (Table 10) and the highest number of rows per ear (Figure 7). This observation can be explained by the genetic architecture of the variety which provides efficient direction of the utilization of photosynthetic assimilates (source) for yield components (sink). This result confirms the statement of Al-Quraishi (2017) [3].

Similar results have been obtained for the 8 g L-1 spraying level of Roselle extract. It is likely to be explained by the constituent parts of the extract (ascorbic acid, diphenols, potassium, and zinc – enzyme activators) as well as by magnesium. Magnesium is important for chlorophyll structure and photosynthesis and respiration, and all these factors positively affect the yellow corn yield components.

Considering the above information, it is possible to recommend using eco-friendly plant extracts (Roselle extract, for example) due to the high content of useful substances and improvement of physiological and biological activity of plants.

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