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E-mail: tjas@tu.edu.iq

Hossam Mamdouh

Hamid ^{1*}

Omar Nazhan Ali ²

Qatada Ibrahim

Abdullah ³

Field Crops Department -
College of Agriculture -
Tikrit University., Iraq

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Effect of foliar application of potassium on growth and yield characteristics of three corn genotypes (*Zea mays* L.)

ABSTRACT

A field experiment was conducted during the autumn season (2019) at the Research Station of Field Crops Department / College of Agriculture, Tikrit University, to study the effect of spraying potassium on the growth characteristics, yield and its components of the three genotypes of corn (*Zea Mays* L.). The first factor contained two concentrations of foliar spraying with potassium (2500 and 5000 ppm) and the second factor was three genotypes of corn (DKC6589, DKC6120, and ZP). The experiment was carried out in a randomized complete block design (R.C.B.D), with three replications. The results showed that foliar spraying with potassium had a significant effect for both levels on the following characteristics: plant height (171.50 cm), leaf area (6157.56 cm²), the weight of 300 grains (104.99 g), and total grain yield (9.134 Mg ha⁻¹).

The genotypes were also significantly affected by the following traits. The genotype (DKC 6120) gave the highest values: Plant height (173.60 cm), leaf area (5992.83 cm²), ear length (18.14 cm), number of days from planting until 50% of tasseling (56.72 days), number of days from planting until 50% of silking (60.54 days), number of rows per ear (15.64 row ear⁻¹), number of seeds per row (27.75), the number of grains in the ear (418.97), the weight of 300 grains (101.50 g), and the total grain yield (9.535 Mg ha⁻¹).

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INTRODUCTION

Corn (*Zea Mays* L.) is one of the most important cereal crops, and it is the most responsive field crop to fertilizers, including potassium, and this response changes according to environmental and genetic conditions (Al-Ma'ini, 2010). The problem of unavailability of nutrients in the soil, including gypsum soil, has clearly affected the productivity of field crops, including maize. The foliar feeding on the shoot system may be a supplement to ground fertilization, especially in the important stages of growth, which need greater nutrition to meet the plant's need for major elements. Potassium has a major role in the vital processes of the plant and increases the physiological processes that have an important impact on the productivity of field crops. (Asses et al., 2016).

In the study of (Ali et al., 2016), it was found that important plant hormones such as auxins and gibberellins are regulated when potassium is sprayed, which in turn works to increase flowering and increase grain in corn. Also, it showed that potassium has a significant effect on leaf area, dry weight of plants, and stability content of phosphorous and nitrogen and potassium (Rafat et al., 2012), (AL-Zubaidi, 2015), (Salih et al., 2012) and (Karpool and AL Delamee, 2017). Al-Moussawi (2013) explained in his study that there was a significant effect of potassium foliar spraying and the number of sprays on plant height, ear length, number of ears per plant, number of rows per ear, number of grains per row, and grain yield. Cultivation of genotypes with high

* Corresponding author: E-mail: hossam1979@tu.edu.iq

productivity contributes broadly to the increase in yield and other characteristics that have a major role in this increase, and this was confirmed by (Younis and Al-Hassan, 2014) that the presence of a significant increase in plant height between the two corn varieties (Bohoth 106 and Rabie). Rapid and consistent emergence is needed across the field and it is necessary for the seed industry to produce high quality corn seed that does this (Ali, 2018). In view of the importance of the potassium element and the role of genotypes in increasing the growth and productivity of corn, this study aims to know the effect of foliar spraying with potassium element on growth and yield characteristics of three corn genotypes.

MATERIALS AND METHODS

A field experiment was carried out during the autumn season (2019) at the research station of the Field Crops Department of the College of Agriculture, Tikrit University in Salah al-Din Governorate. The experimental (6 m²) was planted in each hole (3 grains) with five lines and the distance between line and other was (75 cm) and between one hole and another (25 cm). The randomized complete block design was used to analysis of the studied traits (R.C.B.D) with Duncan's multiple range test at the probability of 1% and 5%. The experiment was watered on 18/7/2019, and after 14 days of planting, the seedlings were reduced to one plant in each hole, and all the agricultural operations were performed according to the recommendations. Urea fertilizer (N 46%) was used as a nitrogen source at a rate of 200 kg h⁻¹ and was added in two batches, the first at planting and the second after 45 days of planting. Triple superphosphate fertilizer (P₂O₅) P 47% was added as a source of phosphorous at a rate of 200 kg h⁻¹ before planting (Regab and Jassim, 2016). Distilled water was used when spraying potassium fertilizer at a concentration of (5 g. L⁻¹ and 10 g. L⁻¹) (K₂O 50%). The corn shoot system was sprayed until fully homogeneously wet with potassium before the evening to avoid the volatilization of the dissolved solution with water and to ensure good absorption from the shoot system. The first factor has three genotypes: (DKC6589 symbolizes H1, DKC6120: H2, and ZP: H3). The second factor was spraying two concentrations of high-potash fertilizer that contains 50% of K₂O, and the composition of the fertilizer was (0-0-50), the first concentration was 2500 ppm, 5 grams of powder / 1 liter of water was dissolved, symbolized by K1, the second concentration was 5000 ppm. 10 grams of powder / 1 liter of water has the symbol K2. The studied traits were (plant height, leaf area, ear length, number of days from planting until 50% of tasseling, number of days from planting until 50% of silking, number of rows per ear, number of grains per row, number of grains per ear, weight 300 grain, and the total yield kg.h⁻¹).

RESULTS AND DISCUSSION

1. Plant height (cm)

The results of Table (1) indicate that there were significant differences among potassium fertilization and the genotypes of corn and the interaction between them. Where the mean of potassium foliar spraying k1 gave the highest rate for this trait reached (171.50 cm), while the H2 genotype gave the highest rate for this trait amounted to (173.60 cm), while the interaction between genotype H2 and K1 potassium fertilization gave the tallest plant (174.81 cm). This is consistent with the findings of Farhan and Sharif (2020) that there were significant differences in potassium foliar feeding among corn varieties. The reason may be that potassium led to an increase in the rates of photosynthesis and the necessary food preparation (Harlin et al., 2005). Al-Asadi (2015) also confirmed the existence of significant differences between the corn genotypes included in his study of the plant height trait.

Table (1): The effect of foliar application of potassium of three corn genotypes on plant height (cm)

Foliar fertilization levels	Genotypes			Mean of Foliar fertilization
	H1	H2	H3	
K1	174.81 a	171.10 c	173.12 b	171.50 a
K2	174.08 a	166.58 d	154.12 e	166.43 b
Mean of genotypes	172.96 b	173.60 a	160.35 c	

The means with the same letters are not significantly different at $P > 0.01$ and 0.05 using Duncan (DMRT).

K1 = Potassium (2500 ppm), K2 = Potassium (5000 ppm), H1 = genotype: (DKC6589), H2 = genotype: (DKC6120), H3 = genotype: (ZP).

2. Leaf area (cm²)

The results of (Table 2) show that there are significant differences among the means and the interaction among them, where the K2 concentration gave the highest rate for the trait (6157.56 cm²), while the H2 hybrid gave the highest mean of leaf area (5992.83 cm²). The dual interaction between potassium foliar spraying and the hybrid H2 had a significant effect by obtaining the highest rate of this trait amounted to (6194.33 cm²), so this is consistent with what was found by (Farhan and Sharif, 2020) that there were significant differences when the concentration of potassium foliar spray increases, the leaf area increases. This confirms that potassium has an effect by providing the needs of the plant and because potassium is a fast-moving element (Ali et al., 2005). Al-Asadi (2015) showed that the genotypes of corn have a significant effect on the mean leaf area in the spring and fall seasons.

Table (2): The effect of foliar application of potassium of three corn genotypes on Leaf area (cm²)

Foliar fertilization levels	Genotypes			Mean of Foliar fertilization
	H1	H2	H3	
K1	5588.00 c	6194.33 a	5854.67 b	5617.22 b
K2	6131.00 a	5409.00 c	6147.33 a	6157.56 a
Mean of genotypes	5891.17 ab	5992.83 a	5778.17 b	

The means with the same letters are not significantly different at $P > 0.01$ and 0.05 using Duncan (DMRT).

K1 = Potassium (2500 ppm), K2 = Potassium (5000 ppm), H1 = genotype: (DKC6589), H2 = genotype: (DKC6120), H3 = genotype: (ZP).

3. Ear length (cm)

Table (3) indicated that there were no significant differences among the levels of potassium fertilization, while the results indicated that there were significant differences among the genotypes and the interaction. H2 genotype gave the highest rate of the trait (18.14 cm), while the interaction between genotype H1 and K2 level gave the highest amount of the trait reached (18.15 cm). The reason for this may be due to the role of potassium and its positive effect on genotypes because it is

one of the major important elements in the growth rate, and its role in maintaining water balance through the process of opening and closing stomata (Yassin, 2001).

Table (3): The effect of foliar application of potassium of three corn genotypes on Ear length (cm)

Foliar fertilization levels	Genotypes			Mean of Foliar fertilization
	H1	H2	H3	
K1	17.30 b	16.87 c	18.13 a	17.06 a
K2	18.15 a	15.76 d	15.73 d	16.92 a
Mean of genotypes	17.09 b	18.14 a	15.74 c	

The means with the same letters are not significantly different at $P > 0.01$ and 0.05 using Duncan (DMRT).

K1 = Potassium (2500 ppm), K2 = Potassium (5000 ppm), H1 = genotype: (DKC6589),
H2 = genotype: (DKC6120), H3 = genotype: (ZP).

4. Number of days from planting until 50% of tasseling

The results of (Table 4) indicated that there were no differences among the levels of potassium fertilization, but the effect was significant between the genotypes and the bilateral interaction. The H2 genotype gave the lowest average (56.72 days), while the bilateral interaction between K1 and H3 potassium fertilization gave the least number of days (56.56 days). The reason may be due to the short height of the H3 genotype plant, which leads to reduced competition for nutrients because the stems are estuaries for a short period for nutrients, so they are competitive for the male organs. This was confirmed by (Al-Jubouri and Anwar, 2009) and (Koberlo, 2004) that the varieties vary with each other in the number of days of tasseling. In a study (Ibrahim, 2013) showed a decrease in the number of tasseling days with fertilization compared to treatment without fertilization.

Table (4): The effect of foliar application of potassium of three corn genotypes on number of days from planting until 50% of tasseling

Foliar fertilization levels	Genotypes			Mean of Foliar fertilization
	H1	H2	H3	
K1	57.04 bc	57.12 bc	56.56 c	57.35 a
K2	56.88 c	58.44 a	57.99 ab	57.33 a
Mean of genotypes	57.08 b	56.72 b	58.22 a	

The means with the same letters are not significantly different at $P > 0.01$ and 0.05 using Duncan (DMRT).

K1 = Potassium (2500 ppm), K2 = Potassium (5000 ppm), H1 = genotype: (DKC6589),
H2 = genotype: (DKC6120), H3 = genotype: (ZP).

5. Number of days from planting until 50% of silking

The results obtained from (Table 5) showed that there were no significant differences among the levels of foliar spraying of potassium while confirming the presence of significant differences

among the genotypes and the interaction between the genotypes and potassium foliar spraying. The H2 genotype gave the lowest number of days to reach 50% of silking (60.54 days), which did not differ significantly from the H3 genotype (60.80 days). The reason may be due to the genotypes that have a role in determining the character of silking by being affected by the photoperiod that affects flowering in general. This is consistent with (Al-Tai, 2013), who showed that the genotypes differ in the time required to reach silking, as well as (Ibrahim, 2013) showed that fertilization has a role in reducing the number of days for flowering.

Table (5): The effect of foliar application of potassium of three corn genotypes on number of days from planting until 50% of silking

Foliar fertilization levels	Genotypes			Mean of Foliar fertilization
	H1	H2	H3	
K1	62.15 a	61.51 ab	60.50 c	61.21 a
K2	60.57 c	60.98 bc	60.61 c	60.90 a
Mean of genotypes	61.83 a	60.54 b	60.80 b	

The means with the same letters are not significantly different at $P > 0.01$ and 0.05 using Duncan (DMRT).

K1 = Potassium (2500 ppm), K2 = Potassium (5000 ppm), H1 = genotype: (DKC6589), H2 = genotype: (DKC6120), H3 = genotype: (ZP).

6. Number of rows. ear⁻¹

The results of Table (6) indicated that there were no significant differences among the potassium levels, but there were significant differences among the corn genotypes and the binary interaction, where the H2 genotype had the highest mean of this trait (15.64 row. ear⁻¹). On the other hand, the highest value of the interaction between K1 and genotype H3 was (16.57 rows. ear⁻¹). The reason may be due to the superiority of the H2 hybrid in the growth characteristics (plant height, ear length, and leaf area), which distinguished it in giving the highest capacity in flowering and more rows in the ear in order to increase the vital activities. This is consistent with what was mentioned by (Aziz and Muhammad, 2012), who showed that the corn varieties had a significant effect on the number of rows per ear. Al-Moussawi (2013) as well as emphasized in his study the role of potassium foliar spraying in the growth and yield of corn and its moral effect on the number of rows per ear.

Table (6): The effect of foliar application of potassium of three corn genotypes on Number of rows. ear⁻¹

Foliar fertilization levels	Genotypes			Mean of Foliar fertilization
	H1	H2	H3	
K1	14.66 b	15.16 b	16.57 a	15.28 a
K2	14.71 b	14.62 b	15.10 b	14.99 a
Mean of genotypes	14.91 b	15.64 a	14.86 b	

The means with the same letters are not significantly different at $P > 0.01$ and 0.05 using Duncan (DMRT).

K1 = Potassium (2500 ppm), K2 = Potassium (5000 ppm), H1 = genotype: (DKC6589), H2 = genotype: (DKC6120), H3 = genotype: (ZP).

7. Number of grains. row⁻¹

The results of Table (7) found that there were no significant differences among the potassium fertilization concentrations, but the means of corn genotypes and the binary interaction between them had a significant effect. The H2 genotype was superior and recorded the highest rate of the number of grains. row⁻¹ (27.75), and the two-way interaction between genotype H1 and K2 fertilization level gave the highest rate of this trait (28.43). The reason for the superiority of H2 genotype for this trait may be due to the genetic difference between the genotypes. Given the superiority of this genotype (H2) in most of the studied traits, it may make it the earliest in flowering as it is from the maturity group FAO200. In addition, the vegetative growth period is short and increases the accumulation of dry matter, which is reflected in the large size of the ear and thus increasing the number of grains per row (Rejab and Jassim 2016). Regarding the role of potassium in its significant effect with the H2 genotype, Al-Mousawi (2013) confirmed in his study that foliar spray has a significant effect in increasing the number of grains. Row⁻¹ and this is consistent with what (Irrak and Al-Amir, 2017) found.

Table (7): The effect of foliar application of potassium of three corn genotypes on Number of grains. row⁻¹

Foliar fertilization levels	Genotypes			Mean of Foliar fertilization
	H1	H2	H3	
K1	24.54 e	25.27 d	27.08 b	25.93 a
K2	28.43 a	26.16 c	24.22 e	25.97 a
Mean of genotypes	24.90 b	27.75 a	25.19 b	

The means with the same letters are not significantly different at $P > 0.01$ and 0.05 using Duncan (DMRT).

K1 = Potassium (2500 ppm), K2 = Potassium (5000 ppm), H1 = genotype: (DKC6589),
H2 = genotype: (DKC6120), H3 = genotype: (ZP).

8. Number of grains. ear⁻¹

Table (8) indicated that there were no significant differences among the levels of potassium foliar spraying, while the table shows that there were significant differences among the means of the genotypes. Genotype H2 gave the highest rate of this trait amounted to (418.97) compared to the genotype H1 and H3, who recorded the lowest rate (328.29 and 347.25) respectively. This is consistent with (Al-Hamid, 2009) who showed in his study the response of some corn varieties for foliar fertilization with nutrients significantly on the the number of grains per ear⁻¹ through its effect on pollen tube growth and flower fertilization (Laszewski and Blevins, 1998). The interaction between K1 potassium concentration and H3 genotype gave the highest rate of the trait amounted to (422.33) and this was confirmed by (Al-Bayrouti et al., 2008) that foliar fertilizers are added to encourage growth and increase the accumulation of dry matter in the plant by spraying its solutions on the vegetative parts. Where they showed that spraying with potassium is positively reflected in increasing the absorption of phosphorous, which led to an increase in the number of grains per ear.

Table (8): The effect of foliar application of potassium of three corn genotypes on Number of grains. ear⁻¹

Foliar fertilization levels	Genotypes			Mean of Foliar fertilization
	H1	H2	H3	
K1	333.70 c	360.81 b	422.33 a	360.57 a
K2	415.61 a	325.68 c	330.90 c	369.10 a
Mean of genotypes	347.25 b	418.97 a	328.29 c	

The means with the same letters are not significantly different at $P > 0.01$ and 0.05 using Duncan (DMRT).

K1 = Potassium (2500 ppm), K2 = Potassium (5000 ppm), H1 = genotype: (DKC6589),
H2 = genotype: (DKC6120), H3 = genotype: (ZP).

9. Weight of 300 grains (g)

The results of Table (9) showed that there were significant differences among the means of potassium foliar spraying, genotypes, and the interaction between them. The potassium fertilization K2 gave the highest weight of 300 grains (g) amounted to (104.99 g), while the concentration K1 gave the lowest mean (93.41 g). This result may be due to the use of potassium foliar spraying on the leaves is an important stage of the plant led to increasing the efficiency of the photosynthesis process in the plant, which has a role in building proteins that have a role in increasing nitrogen absorption (Kirby and Maugel, 1989). Potassium also has a role in increasing the period of filling the grain while the leaves continue to be active and thus increasing the amount of manufactured substances that collect in the grains (Krauss, 1993). H2 genotypes recorded the highest value for the trait (101.50 g), while the results of the bilateral interaction between K2 and H1 genotype had the highest amount (109.37 g). These results are in agreement with (Al-Mashhadani, 2010), (Hamdan and Yektaş, 2011), and (Aziz and Muhammad, 2012) who indicated that there were significant differences among the experimental factors for the weight of 300 grains. The reason may be due to the genetic nature of the genotypes, which excelled in all the studied traits, which was positively reflected in the weight of 300 grains (g). This is consistent with (Al-Hadidi, 2007), also confirmed by (Al-Moussawi, 2013) when studying the effect of potassium spraying on the corn crop, his results showed that it had a significant effect on this trait. As well as similar to the results of (Jabbar et al., 2018) when they study the effect of spraying foliar fertilizer on the growth and the productivity of corn, where it was shown that the application of foliar fertilizer had a significant effect on the weight of 500 grains (g).

Table (9): The effect of foliar application of potassium of three corn genotypes on Weight of 300 grains (g)

Foliar fertilization levels	Genotypes			Mean of Foliar fertilization
	H1	H2	H3	
K1	92.72 c	108.34 a	93.63 c	93.41 b
K2	109.37 a	93.88 c	97.25 b	104.99 a
Mean of genotypes	100.53 a	101.50 a	95.56 b	

The means with the same letters are not significantly different at $P > 0.01$ and 0.05 using Duncan (DMRT).

K1 = Potassium (2500 ppm), K2 = Potassium (5000 ppm), H1 = genotype: (DKC6589),
H2 = genotype: (DKC6120), H3 = genotype: (ZP).

10. Total grain yield (Mg ha^{-1})

Table (10) indicated that there were significant differences among the means of potassium levels, genotypes, and the interaction between potassium fertilization and genotypes. The potassium concentration K2 recorded the highest grain yield (Mg ha^{-1}) amounting to (9.134 Mg ha^{-1}) and the highest rate for this trait for the genotype H2 reached (9.535 Mg ha^{-1}). The bilateral interaction between K2 potassium concentration and H1 genotype recorded the highest grain yield (9.673 Mg ha^{-1}) compared with the binary interaction between K2 and genotype H2 potassium fertilization, which did not differ significantly from K2 and genotype H3 potassium fertilization, which recorded the lowest rate for this trait (8.530 and 8.536 Mg ha^{-1}) respectively. These results were confirmed by (Al-Moussawi, 2013) and (Ramhelda and AL-fouly, 2002) that foliar spray has a significant effect on grain yield. Potassium has an important role in the formation of chlorenchyma cells that increase the diameter of the plant stem and thus increase the dry weight of corn plants, as well as in increasing the leaf area through the high value of carbohydrates that stimulate enzymes and their storage in the endosperm of grains. These results are in agreement with (Arrak and Al-Amir, 2017) and (Rajab and Jassim, 2016). The reason for the increase in the grain yield of genotype may be due to the autumn planting (18/7/2019), which in turn increased the percentage of fertilization, moderate temperatures, and a lot of moisture during flowering, which increased the growth period of the shoot system. As well as, the superiority of the H2 genotype in all the studied traits, which was positively reflected in the total grain yield of corn. This agrees with (Ahmed, 2001), (Al Hadidi, 2007), (Al Jubouri and Anwar, 2009), and (Bakht et al., 2011).

Table (10): The effect of foliar application of potassium of three corn genotypes on total grain yield (Mg ha^{-1})

Foliar fertilization levels	Genotypes			Mean of Foliar fertilization
	H1	H2	H3	
K1	8.730 c	9.193 b	9.396 ab	8.885 b
K2	9.673 a	8.530 c	8.536 c	9.134 a
Mean of genotypes	8.961 b	9.535 a	8.533 c	

The means with the same letters are not significantly different at $P > 0.01$ and 0.05 using Duncan (DMRT).

K1 = Potassium (2500 ppm), K2 = Potassium (5000 ppm), H1 = genotype: (DKC6589),
H2 = genotype: (DKC6120), H3 = genotype: (ZP).

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تأثير الرش الورقي للبيوتاسيوم في صفات النمو والحاصل لثلاثة تراكيب وراثية من الذرة الصفراء *Zea Mays L.*

حسام ممدوح حميد (1) عمر نزهان علي (2) قتادة أبراهيم عبدالله (3)

قسم المحاصيل الحقلية - كلية الزراعة - جامعة تكريت - تكريت - العراق

الخلاصة

نفذت تجربة حقلية خلال موسم الخريف (2019) في محطة ابحاث قسم المحاصيل الحقلية لكلية الزراعة جامعة تكريت، لدراسة تأثير رش عنصر البيوتاسيوم في صفات النمو والحاصل ومكوناته لثلاثة تراكيب وراثية من الذرة الصفراء (*Zea Mays L.*) ، اذ تضمنت العامل الأول تركيزين من الرش الورقي بالبيوتاسيوم (2500 و 5000 ملغم . لتر-1) والعامل الثاني ثلاثة تراكيب وراثية من الذرة الصفراء (, DKC6120 , ZP , DKC6589). نفذت التجربة بتصميم القطاعات العشوائية الكاملة (R.C.B.D) ، وبثلاثة مكررات . اظهرت النتائج ان الرش الورقي بالبيوتاسيوم قد اثر معنوياً في الصفات التالية : ارتفاع النبات (171.50 سم) والمساحة الورقية (6157.56 سم²) و وزن 300 حبة (104.99 غم) والحاصل الكلي (9.134 طن هـ -1). كما اثرت التراكيب الوراثية معنوياً بالصفات التالية: إذ أتفوق التركيب الوراثي (DKC6120) في ارتفاع النبات (173.60 سم) والمساحة الورقية (5992.83 سم²) وطول العرنوص (18.14 سم) وعدد الأيام من الزراعة لغاية 50% تزهير ذكري (56.72 يوم) وعدد الأيام من الزراعة لغاية 50% تزهير انثوي (60.54 يوم) وعدد الصفوف بالعرنوص (15.64 صف عرنوص-1) وعدد الحبوب بالصف (27.75) وعدد الحبوب بالعرنوص (418.97) ووزن 300 حبة (101.50 غم) وحاصل الحبوب الكلي (9.535 طن هـ -1).

الكلمات المفتاحية:
تراكيب وراثية ، ذرة صفراء ، الرش الورقي بالبيوتاسيوم