



Article

Evaluation of Some Maize Genotype's Performance and Their Susceptibility to Corn Stem Borer Under The Effect of Potassium Spraying

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ABSTRACT

This study took a close look at different types of corn plants (*Zea mays* L.) to see how well they stood up against the corn stem borer, *Sesamia cretica*. We also explored how applying potassium to the leaves affected their resistance. The experiment happened during the summer growing season of 2024 at the University of Kirkuk's Agricultural Research and Experiment Station. We used a standard experimental setup, repeating our tests three times. We tried three different potassium concentrations (0, 15, and 30 grams per liter) and tested six distinct corn varieties: KONSENS, DKC777, DKC666, AGN720, GAMESON, and GOLDEN. We measured several things: how much the plants got infected, the number of holes, larvae, and tunnels in each plant, and how much of the stem was eaten away. Our statistical analysis showed that both the potassium application and the type of corn plant, as well as their combination, had a big impact on most of the traits we measured. The only exceptions were the infection rate, the number of larvae, and the excavated distance when considering the interaction between the plant type and potassium. Interestingly, the 'GAMESON' corn variety consistently showed the best resistance. It had the lowest infection rate (15.94%), the fewest holes (5.31), larvae (1.51), tunnels (2.18), and the least stem damage (17.36%). Applying potassium at 30 grams per liter also significantly helped, reducing the infection rate to 16.38%, holes to 2.73, tunnels to 2.52, and stem damage to 16.80%. The best results came from combining the 'GAMESON' variety with the 30 gm/L potassium treatment, leading to the absolute minimum number of holes (1.86) and tunnels (1.46). This really highlights how much this combination boosts resistance. Our findings strongly suggest that using resistant corn varieties like 'GAMESON' along with smart potassium fertilization can significantly protect corn crops from the stem borer.

INTRODUCTION

Maize is one of the most important agricultural crops in the world, it is considered a major source of food and fodder and is characterized by its ability to adapt to different climatic and soil conditions. Maize is used in many applications, including food production for humans, animal feed and biofuel [1]. It is rich in nutrients, such as carbohydrates, vitamins and minerals. Maize cultivation is an important tributary to the agricultural economy in many countries, which makes it a focus of great interest by farmers and researchers, makes it an energy-rich food. Maize is also used in the manufacture of many food products such as flour and oils, and also in non-food industries such as biofuel [2].

Statistics and estimates for 2023 showed that the United States is one of the largest countries in maize production, with production reaching 389.6 million tons [3]. Maize production for the spring and fall seasons reached 538.3 thousand tons, an increase of 42.2 over the production in 2022, which was estimated at 496, by 8.5%, while the production of the fall crop was estimated at 99.9% of the total of the two seasons [4].

Genotype evaluation is the basic material on which plant breeders build to improve quantitative and qualitative traits [5]. Interest has increased in studying the components of variances for quantitative traits, because they are important in estimating the coefficients of phenotypic and genetic variation, the heritability rate, and the expected genetic improvement [6]. In addition, in selection programs [7], it depends primarily on genetic variation and understanding the genetic behavior, that determining the most influential traits as a criterion for selection [1].

The importance of potassium and the extent of its response in Iraq are still limited studies, it is believed that all Iraqi soils have a high potassium content [8]. Potassium is considered one of the essential nutrients that play a vital role in the growth and development of the maize crop [9]. Potassium directly affects the physiological processes of the plant, including regulating water balance, enhancing corn resistance to drought and harsh weather conditions. Potassium also contributes to improving water use efficiency, which increases crop productivity in non-ideal conditions [10]. Potassium is considered an important factor in enhancing vital processes, such as photosynthesis and carbohydrate formation, which leads to improving grain quality [11]. Potassium also helps increase plant resistance to diseases and pests, reduces the need to use pesticides [12].

Studies show that potassium deficiency, can lead to reduced plant growth, reduced grain yield, and increased stem fragility, causing harvesting problems [13]. Therefore, good potassium fertilization is considered an essential factor to achieve high productivity and excellent quality of agricultural crops, including maize [14]. by paying attention to the balance of nutrients, especially potassium is essential to ensure the sustainability of corn cultivation and achieve food security [15].

Corn stem borer infestation is one of the important agricultural problems, facing maize farmers in many agricultural areas around the world, this borer is considered a harmful insect, that attacks corn plants and causes severe damage, directly affecting growth and yield. This insect is widely spread in areas where corn is intensively grown, which leads to a deterioration in productivity and crop quality [16]. The effect of the maize stem borer is that the larvae penetrate the stem and feed on the internal tissues of the plant, which leads to damage to plant tissues and weakens the plant's ability to absorb nutrients and water. Severe infestation may cause tissue rot and loss of water balance within the plant, leads to a decline in the crop. Infestation may weaken the structure of the plant and make it more vulnerable to winds and other environmental factors, which increases the chances of it breaking and falling [17].

There are many ways to combat the corn stalk borer, some agricultural treatments such as potassium spraying can be used and applied to enhance plant resistance to this insect. Also, improving some genotypes of plants, can contribute to reducing the impact of infection on growth and yield, this problem poses a major challenge to farmers, which calls for continuous research to find effective and integrated solutions, to reduce the impact of this insect on agricultural production [18].

This study aims to evaluate the sensitivity of some genotypes of maize to infection with the corn stalk borer under the influence of potassium spraying.

MATERIALS AND METHODS

The experiment was carried out at the Agricultural Research and Experiment Station (Al-Sayyadah area), College of Agriculture, University of Kirkuk, during the summer agricultural season (2024).

The soil prepared for planting the field experiment was plowed with a drill plow twice perpendicularly.

Leveling and smoothing operations were carried out on it. Triple superphosphate fertilizer P_2O_5 was added as a source of phosphorus at a rate of 200 kg. ha⁻¹ all at planting. Nitrogen fertilizer in the form of urea fertilizer (46% nitrogen) as a source of nitrogen at a rate of 200 kg. ha⁻¹, by two batches, the first at planting and the second after a month of planting [19].

The study factors were as follows:

The first factor: Foliar spraying of potassium on the plant at the stage of 7-8 leaves of the plant's age with potassium element in the form of potassium sulphate K_2O (52%), with three concentrations of 0, 15 and 30 gm. L⁻¹, symbolized by K0, K1 and K2 respectively.

The second factor: Includes 6 cultivars of maize, were KONSENS, DKC777, DKC666, AGN720, GAMESON and GOLDEN.

The experiment was implemented according to the split plot system within the complete randomized block design and with three replicates, each replicate included three main plots on which potassium spray levels were distributed, each replicate contained 18 experimental units on which the treatments resulting from the compatibility between the levels of the two study factors were randomly distributed, each main plot was divided into 6 sub-plots on which the maize cultivars were randomly distributed, each experimental unit included 4 lines with a length of 3 m. The distance among one line and another was 0.75 m, among one plant and another was 20 cm. A distance of 1 m was left among each experimental unit and the other, also 1 m between the main plots and the blocks [20]

The cultivation was done by placing 2-3 grains in each hole, then it was thinned to one plant after one week of germination.

The following traits were studied: Infection rate (%), holes number/ plant, larvae number/ plant, tunnels number/ plant and percentage of the excavated area of the stem (%).

Statistical analysis: The results of the experiment were statistically analyzed according to the Randomized Complete Block Design (R.C.B.D) and the split plot arrangement. The means were compared by Duncan's multiple range test based on the (SAS) program [21].

RESULTS

Analysis of variance for corn stem borer infestation on growth, yield and its components in maize:

Table (1) shows that the mean squares of potassium spraying, genotypes and their interaction, on the corn stem borer infection on growth, yield and its components in maize, was significant ($P \leq 0.05$) for all the studied characteristics under study, except for the larvae number/ plant in the effect of genotypes and the interaction between genotypes, and potassium on the infection percentage, the larvae number/ plant and the distance dug/ plant did not reach the level of significance.

Table (1) Analysis of variance for corn stem borer infestation on growth, yield and its components in maize

S.O. V	d.f	Mean Square				
		Infection rate (%)	Holes No. / plant	Larvae No. / plant	Tunnels No./ plants	Excavated distance/plant
Replicates	2	2442.04	16.04	17.24	42.53	1020.03
Genotypes	2	1480.14**	14.70**	16.00**	63.12**	1211.76**
Error A	4	40.53	0.10	5.08	3.06	31.57
Potassium	5	329.67**	7.91**	29.84**	10.19**	244.85**
Genotypes× Potassium	10	26.22 ^{n.s}	1.67**	0.74 ^{n.s}	1.91**	12.75 ^{n.s}
Error B	30	15.12	0.48	1.66	0.69	8.73

Infection rate (%)

Table (2) shows significant differences between the averages of genotypes compositions in the infection rate, DKC777 genotypes, gave the highest rate (34.63 %), while the lowest rate was recorded for GAMESON genotype (15.94 %).

Table (2) Average effect of genotypes, potassium spraying and their interactions on the trait of infection rate

Genotypes	Potassium (gm. L ⁻¹)			Cultivar mean
	0	15	30	
KONSENS	37.30 abc	26.56 def	16.36h	26.74b
DKC777	43.26 a	38.83ab	21.80fgh	34.63 a
DKC666	35.13bc	31.43code	18.40gh	28.32 b
AGN720	32.00 b-e	34.43 bc	15.76h	27.40 b
GAMESON	23.80 fg	15.26h	8.76 i	15.94 c
GOLDEN	32.96 bcd	25.66ef	17.23gh	25.28 b
Potassium means	a34.07	28.70 a	16.38b	

Holes No./ plant

Table (4) show that there are significant differences between the averages of the genotypes in the trait of the amount of larvae / plant. The DKC777 genotype gave the highest rate (6.75), while the lowest rate was recorded for the GAMESON genotype (1.51).

Table (3) Average effect of genotypes, potassium spraying and their interactions on the number of holes/plant trait

Genotypes	Potassium (gm. L ⁻¹)			Cultivar mean
	0	15	30	
KONSENS	4.96 bc	3.23def	3.26def	3.82 b
DKC777	6.26 a	6.20a	3.46de	a5.31
DKC666	5.13 ab	3.10d-g	2.53efg	3.58bc
AGN720	2.76 efg	3.76cde	2.66efg	3.06 bc
GAMESON	3.80cde	2.06fg	1.86g	2.57d
GOLDEN	4.30cde	3.00d-g	2.60 efg	3.30bc
Potassium means	4.53a	3.56b	2.73c	

Larvae number/ plant

Table (4) show that there are significant differences between the averages of the genotypes in the trait of the amount of larvae / plant. The DKC777 genotype gave the highest rate (6.75), while the lowest rate was recorded for the GAMESON genotype (1.51).

Table (4) Average effect of genotypes, potassium spraying and their interactions on the number of larvae/plant trait

Genotypes	Potassium (gm. L ⁻¹)			Cultivar mean
	0	15	30	
KONSENS	4.23bc	3.30cde	1.60de	3.04 b
DKC777	7.86a	6.26ab	6.13ab	6.75a
DKC666	3.76cd	3.46cde	1.50de	2.91b
AGN720	3.43cde	2.43 cde	1.60de	2.48 bc
GAMESON	2.06cde	1.13e	1.33de	1.51c
GOLDEN	3.33cde	2.96 cde	1.23de	bc2.51
Potassium means	4.11a	3.26 a	2.23a	

Tunnels Number/ plant

Table (5) indicates the presence of significant differences between the averages of genotypes in the trait of amount of tunnels / plant. The DKC777 genotype gave the highest number (5.35), while the lowest rate was recorded for the GAMESON genotype (2.18).

Table (5) Average effect of genotypes, potassium spraying and their interactions on the number of tunnels/plants

Genotypes	Potassium (gm. L ⁻¹)			Cultivar mean
	0	15	30	
KONSENS	7.00 ab	4.10c	2.33ef	4.47b
DKC777	7.96a	4.10c	4.00cd	5.35a
DKC666	6.43b	4.10c	2.53c-f	4.35b
AGN720	6.53b	3.73cde	2.46def	4.24 b
GAMESON	2.66c-f	2.43ef	1.46f	2.18c
GOLDEN	6.20b	2.33ef	2.33ef	3.62b
Potassium means	6.13a	3.46b	2.52b	

The excavated area ratio of the stem (%)

Table (6) shows significant differences between the averages of the genotypes in the trait of the percentage of the excavated area of the stem. The DKC777 genotype gave the highest ratio (33.73%), while the lowest percentage was recorded for the GAMESON genotype (17.36%).

Table (6) Average effect of genotypes, potassium spraying and their interactions on the percentage of the excavated area of the stem

Genotypes	Potassium (gm. L ⁻¹)			Cultivar mean
	0	15	30	
KONSENS	34.93ab	24.71c	15.43d	25.02b
DKC777	39.68a	35.35ab	26.16c	33.73a
DKC666	33.33b	25.00c	14.97d	24.43 b
AGN720	32.96b	22.84c	16.20d	24.00 b
GAMESON	22.95c	16.60d	12.53d	17.36c
GOLDEN	35.40ab	24.96c	15.50d	25.28b
Potassium means	33.21 a	24.91b	16.80c	

DISCUSSION

The significant differences between the studied characteristics when infected with corn stem borer on growth, yield and its components, highlight the significant negative impact of this pest on the productivity of maize plants. The differences appear clearly in the decrease in growth indicators [22] as a result of stem damage and weak flow of water and nutrients, which hinders the basic physiological processes to [23].

The infection also causes a reduction on the grains number/ per ear, an increase in the damaged ears number, and a decrease in the grains weight, leads to a significant decrease in the total yield, these changes are directly related to the size of the infection and the level of damage caused by the pest in different parts of the plant.

The infection also affected the components of the yield in varying ways; for example, significant differences may be greater in grain weight than in grain number, because of the effect of infection on the grain filling and formation process. Also, the response of different genetic makeup to infection varies based on their genotype, where differences appear between resistant and susceptible genotype to infection, significant differences resulting from infection, were scientific evidence of the importance of developing effective control strategies and using resistant varieties [24]. Understanding these differences contributes

to improving agricultural management programs, reducing losses resulting from the corn stalk borer, which enhanced production efficiency [25]. These differences highlight the importance of choosing the appropriate genotype in breeding programs to improve corn resistance to stem borer, contributes to reducing losses and increasing productivity [22].

The results also showed significant differences between potassium averages in the infection rate trait, as the 0 gm. L⁻¹ treatment recorded the highest rate (34.07%), and a non-significant difference from the 15 gm. L⁻¹ treatment was 28.70%, while 30 gm. L⁻¹ treatment recorded the lowest rate (16.38%). Potassium spraying contributed to reducing the infection rate of corn stem borer on yellow corn plants, by enhancing plant health and natural immunity. Potassium helped strengthen cell walls and improve stem hardness, made it difficult for the pest to dig or feed on the stem and enhanced the efficiency of physiological processes, such as photosynthesis and nutrient transport, which supports the rapid and strong growth of the plant. In addition, potassium stimulated the production of natural defensive compounds in the plant such as phenols and anti-enzymes [20]. It hinders the activity of the borer, these combined effects reduce the severity of the infestation, it improves the plant's ability to tolerate the stress caused by the pest [26]. While the data of the same table showed that there were no significant differences when interacting between genotypes and potassium spray concentrations on the infection rate trait.

The genotypes greatly affect the number of holes trait in the maize plant as a result of infection with the corn stem borer [27]. The resistant genotype has defensive properties such as stem thickness or the formation of chemical compounds that hinder the feeding of the pest or reduce its effectiveness, these properties reduce the number of holes resulting from the feeding of the borer on the stem, as for the sensitive genotype, it is more susceptible to infection [20]. which leads to an increase in the number of holes on the stem as a result of the borer's digging. Therefore, the number of holes trait can be improved by selecting resistant cultivars or from hybridization programs that enhance plant resistance to this pest [23].

The results also showed significant differences between potassium averages in the holes number/plant. The treatment 0 gm.L⁻¹ recorded the highest number (4.53), while the treatment 30 gm.L⁻¹ recorded the lowest number (2.73). Potassium spraying contributed to reducing the number of holes in the yellow corn plant when infected with the corn stem borer, by enhancing the plant's resistance to pests. Potassium enhances the strength of the plant cell walls and increases the hardness of the stem, which makes it difficult for the borer to effectively dig the stem, it also improves the health of the plant in general, which enhances its ability to withstand infection, when applying potassium spraying. The production of defensive compounds such as phenols and anti-pest enzymes increased, reduced the chances of infection and limited the number of holes resulting from digging, this leads to reducing the negative impact on the plant and thus improving productivity [28].

While the data of the same table showed significant differences when interacting between genotypes and potassium spray concentrations on the number of holes/plant trait, as the interaction in this trait gave the highest number when interacting between DKC777 genotype and the spray treatment 0 gm. L⁻¹, which amounted to 6.26, with a non-significant difference from the interaction between DKC777 genotype and the spray treatment (15 gm. L⁻¹), which amounted to 6.20, while the interaction between GAMESON genotype and the comparison treatment had the lowest rate (1.86). The genotype with resistant genes shows a greater ability to tolerate infection, as it has defensive properties such as increasing the thickness of the stem or secreting chemical compounds that prevent the borer from easily penetrating the stem, these properties reduce the holes resulting from drilling, while the genotype sensitive to infection, it suffers from increased holes due to weakness Its genetic defenses against the pest. Genetic improvement in the resistant genotypic is an effective way to reduce its impact on productivity [28].

The genotype with resistant genes has strong defense mechanisms, such as increasing the thickness

of the stem or secreting chemicals that hinder the development of larvae inside the plant [27], this reduces the number of larvae that feed on the stem, as for the sensitive genotype, it lacks these defenses [17]. which leads to increased larval reproduction inside the stem and causes more damage. Therefore, choosing resistant genotypes is considered an effective strategy to reduce the number of larvae and reduce the impact of infection on the crop [25].

The results also showed significant differences between potassium averages in the amount of tunnels/plant. The treatment 0 gm. L⁻¹ recorded the highest number (6.13), while the treatment 30 gm. L⁻¹ recorded the lowest number (2.52). Spraying with potassium reduced the number of tunnels when infected with the corn stem borer on the yellow corn plant, by improving plant health and increasing its resistance to pests, it enhanced the strength of plant cell walls and gave strength to the stem, which made it difficult for the borer to penetrate the stem and form tunnels. Potassium also stimulated the increased production of defensive compounds, such as phenols that work to hinder the borer's feeding, led to a reduction in tunnels and mitigated the impact of infection, which enhanced plant health and increased the chances of improving the crop [21].

There are significant differences when interacting between genotypes and potassium spray concentrations on the number of tunnels/plant trait. The interaction in this trait gave the highest number when interacting between the DKC777 genotype and the spray treatment 0 gm. L⁻¹ (7.96), while the interaction between the GAMESON genotype and the comparison treatment 30 gm. L⁻¹ had the lowest rate (1.46). Potassium improved the plant's ability to resist pests by strengthening cell walls and increasing the production of defensive compounds, which reduced the chances of feeding the borer when potassium spraying is combined with the genotype [26].

The genotype with resistant genotypes, has defensive properties such as increasing the thickness of the stem or secreting chemical compounds, lead to reducing the ability of the excavator to excavate the stem, these defenses prevent the excavator from penetrating deeply, thus reducing the affected area [20]. As for the sensitive genotype, it is less able to resist the excavator, which leads to an increase in the excavated area of the stem. Therefore, through genetic improvement, resistant genotypes can be selected that reduce these damages and increase production efficiency [29].

The results showed significant differences between the potassium averages in the characteristic of the percentage of the excavated area of the stem, as the treatment 0 gm. L⁻¹ recorded the highest ratio (33.21%), while the treatment 30 gm. L⁻¹ recorded the lowest ratio (16.80%). Potassium spraying contributed to reducing the percentage of the excavated area of the stem when infected with the corn stem borer, by enhancing plant health and increasing its resistance to infection, it enhanced the strength of cell walls, making the stem more solid and less susceptible to excavation. Potassium also stimulated the production of defensive compounds in the plant, such as phenols, which work to reduce the activity of the borer and prevent its feeding, this improvement in immunity reduces the deep penetration of borer into the stem [22], which leads to a reduction in the excavated area [20]. Therefore, spraying with potassium contributes to reducing the damage caused by infection and improves the general health of the plant [30].

CONCLUSION

The study demonstrated a significant effect of potassium spraying and genetic compositions on maize stem borer resistance, except for certain traits that did not reach the significance level in their interaction. The GAMESON genotype exhibited superior resistance across all studied traits. Additionally, potassium concentration at 30 g/L played a clear role in reducing infestation and enhancing resistance. The interaction between GAMESON and the 30 g/L potassium treatment achieved the best results in minimizing the number of holes and tunnels per plant. The study recommends using GAMESON combined with a high potassium concentration to enhance maize resistance to stem borer.

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