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ORIGINAL STUDY

Effect of Spry of Potassium Ratio and Cycocel on Physiological Traits of Maize (Zea mays L)

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ABSTRACT

The aim of this work was to investigating the effect of foliar application of potassium (K) and the growth regulator Cycocel (CCC) on the physiological traits of maize (Zea mays L). The experiment was designed using a split-plot arrangement within a randomized complete block design (RCBD) with three replicates. The treatments included foliar application of potassium at concentrations of 500, 1000, and 1500 mg.L^{-1}, as well as three concentrations of the growth regulator Cycocel (0, 150, and 200 mg.L^{-1}). The results indicated a significant increase in Protein (P), phosphorus, and carbohydrate contents at the concentration of 200 mg.L^{-1} of Cycocel, reaching 8.22%, 0.71%, and 199.46 mg g^{-1}, respectively. Biological reason for the observed decrease in leaf nitrogen percentage with increasing Cycocel concentrations by spry ratio. A significant decrease in nitrogen percentage in the leaves was observed with increasing concentrations. The results also showed no significant differences due to potassium application in all physiological traits except for carbohydrate content, which significantly increased at the concentration of 1500 mg.L^{-1}, reaching 214.35 mg.L^{-1}. For future work use different concentrations of K and the growth regulator CCC, depend on the spry ration, apply both to soil and as foliar sprays on different maize cultivars, investigate the effects of potassium and CCC on other cereal crops.

Keywords: Maize (Zea mays L), Spry potassium, Cycocel, Potassium, Carbohydrate, Phosphorus

1. Introduction

Maize (Zea mays L.) is one of the most important field crops, ranking third in importance after wheat and rice. It belongs to the family Poaceae (Gramineae). It is also considered one of the most prominent strategic crops of great importance in Iraq, playing a significant role in human nutrition [1]. Maize is of considerable importance due to its diverse uses, including food and industrial applications, in addition to its use as animal feed for livestock production systems. Despite its great importance, its productivity levels remain relatively low [2]. Maize is also a rich source of complex fibers, vitamins, proteins, and complex carbohydrates [3]. Central America is where maize (Zea mays L.) [4], the most extensively farmed cereal in the world, was domesticated. In terms of its development as a crop and its application in a range of food products, maize has moved quickly from its center of origin in Mexico to different regions of the world [5]. One of the most versatile crops grown in a variety of agro climatic zones is maize. Another name for it is “the poor man’s nutricereal” [6]. It provides about 30% of the daily caloric needs of about 4.5 billion people in 94 poor countries. 63% of the maize farmed globally is used as animal feed in addition to being a major source of oil, starch, biofuel, etc [7].

Potassium is one of the essential macronutrients required by plants in large quantities. It activates enzymatic reactions within the plant, reduces the adverse effects of abiotic stresses, and plays a key role

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in the regulation of stomatal opening and closing [8]. Furthermore, K has a central role in protein and carbohydrate synthesis, as well as in activating enzymes involved in photosynthesis, thereby enhancing plant resistance to diseases and pests [9]. One synthetic growth retardant that may be used to increase crop productivity under environmental stressors like salt is chlormequat chloride (CCC), also known as Cycocel. Cycocel is a plant growth retardant used for various purposes; it reduces plant height, thickens stems, and enhances leaf greenness [10].

The challenge faced this work were different ratios of growth regulator Cycocel, their interaction on Chlorophyll (Chl) content, Cycocel, as well as their interaction, on carbohydrate content, regulator Cycocel, as well as their interaction, on the Nitrogen percentage, Cycocel, as well as their interaction, on Phosphorus percentage, Cycocel, as well as their interaction, on K percentage, Cycocel, as well as their interaction, on estimation of Protein percentage of maize plants, then the percentage of spry [11]. The study involved the assessment of Chl content, carbohydrate percentage, nitrogen percentage, phosphorus percentage, K percentage, and protein percentage in maize leaves. This study aims to investigate the effect of foliar application of K and the growth regulator CCC on physiological traits of maize (Zea mays L).

2. Materials and methods

2.1. Study area

This study was conducted at the Technical Institute located in Al-Hawija District, within Kirkuk Governorate, during the summer growing season of 2025. The experiment was designed using a Randomized Complete Block Design (RCBD) and included a field trial to investigate the effect of four concentrations of K, applied in the form of K sulfate (K_2O) (K1, K2, K3, and K4), and three concentrations of the growth regulator Cycocel (C1, C2, and C3) on the physiological traits of maize (Zea mays L). The experiment was designed using a Randomized Complete Block Design (RCBD). The soil used in this study from the Hawija Technical Institute. It is prepared soil and was analyzed according to the results in Table 1.

Table 1. The soil physicochemical characteristics.

Analysis	Values	Unites
pH	7.06	-
E.C	o.79	dS/m
N	8.9	$mg.kg^{-1}$
P	5.2	$mg.kg^{-1}$
K	1.8	$mg.kg^{-1}$

2.2. Methodology

Determination of total Chl content in the flag leaf (mg/100 g). Five flag leaves were randomly collected from plants within the experimental units. Total Chl content was estimated according to the method described in [12]. Determination of Carbohydrate percentage in leaves (%) Carbohydrate content in maize leaves was measured according to the method described in [13]. Determination of Nitrogen percentage (N %) in leaves the percentage of nitrogen in the leaves was determined using the Micro-Kjeldahl method as described in [14]. Determination of phosphorus percentage (P %) in maize leaves phosphorus percentage in maize leaves was determined using a spectrophotometer at a wavelength of 880 nm, following the method described in [15]. Statistical Analysis was performed using Duncan's multiple range test (DMRT) at a significance level of 0.05. The analysis was conducted using Excel and SAS studio software. Determination of percentage (K %) in Maize Leaves K content in maize leaves was determined using a flame photometer according to the method described in [16]. Determination of P percentage in leaves(P %). The P percentage was calculated using the Eq. (1) [17]:

$$\text{Protein (\%)} = \text{Total Nitrogen} \times 6.25 \quad (1)$$

3. Results and discussions

3.1. Effect of K/CCC on Chl content in maize plants

The results presented in Table 2 indicate that there are no significant differences among the effects of foliar application of different concentrations of K and the growth regulator Cycocel on Chl content in the flag leaf ($mg.L^{-1}$) of maize plants. However, the results shown that the interaction between different concentrations of K and the growth regulator Cycocel resulted in significant differences among the studied factors. The highest value was recorded at concentrations (0, 0) $mg.L^{-1}$, reaching 62.42, whereas lowest value (42.11 $mg.L^{-1}$) was observed at potassium concentration of 500 $mg.L^{-1}$ combined with Cycocel concentration of 150 $mg.L^{-1}$ [18]. Values sharing the same letters are not significantly different from each other according to Duncan's Multiple range test at the 0.05 probability level.

3.2. Effect of K/CCC on Carbohydrate content in maize plants

The results as shown in Table 3 indicate that foliar application of different concentrations of potassium

Table 2. Effect of foliar application of different concentrations of K, growth regulator CCC, their interaction on Chl content of maize plants.

Effect of K concentrations mg.L^{-1}	Effect of foliar application of the growth regulator CCC mg.L^{-1} 0 mg.L^{-1}	150 mg.L^{-1}	200 mg.L^{-1}	Effects of K concentrations
0	62.42ab	47.89cd	46.13de	48.81a
500	42.41e	42.11e	54.18a	46.23a
1000	45.68dc	52.2ab	45.15de	47.66a
1500	50.16bc	47.79cd	43.33e	47.09a
Effects of growth regulator CCC	47.20a	47.5a	47.61a	

Table 3. Effect of foliar application of different concentrations of P, growth regulator CCC, as well as their interaction, on carbohydrate content of maize plants.

Effect of K concentrations mg.L^{-1}	Effect of foliar application of growth regulator CCC mg.L^{-1} 0 mg.L^{-1}	150 mg.L^{-1}	200 mg.L^{-1}	Effects of K concentrations
0	209.84bcd	199.22bcd	189.14de	199.40a
500	144.31f	194.37bcde	203.98bcd	180.88c
1000	172.47e	229.88a	190.38cde	197.57b
1500	216.95ab	211.75abcd	214.36abc	214.35a
Effects of growth regulator CCC	185.89b	208.80a	199.46a	

on maize plants had a significant effect on the carbohydrate percentage in leaves. The highest value (214.35%) was recorded at the concentration of 1500 mg.L^{-1}, whereas the lowest value (180.88%) was observed at the concentration of 500 mg.L^{-1}. Regarding the effect of foliar application of the growth regulator Cycocel on carbohydrate percentage, significant differences were observed. The concentration of 0 mg.L^{-1} recorded a value of 185.89%, which differed significantly from the concentrations of 150 and 200 mg.L^{-1}, which recorded 208.80% and 199.46%, respectively. As for the interaction between the studied factors, the results showed significant differences in carbohydrate percentage due to the interaction between potassium and Cycocel concentrations. The highest value (229.88 %) was obtained at 1000 mg.L^{-1} Potassium combined with 150 mg.L^{-1} Cycocel, whereas the lowest value (144.31 %) was recorded at 500 mg.L^{-1} potassium combined with 0 mg.L^{-1} Cycocel. The increase in carbohydrate percentage may be attributed to the role of potassium in improving photosynthetic efficiency, enhancing sugar transport, and promoting starch formation. This result is consistent with the findings reported in [19]. Values sharing the same letters are not significantly different from each other according to Duncan's multiple range test at the 0.05 probability level.

3.3. Effect of K/CCC on Nitrogen percentage in maize plants

The results presented in Table 4 indicate the presence of significant differences among the mean effects of foliar application of potassium between the control treatment (0 mg.L^{-1}) and the 1500 mg.L^{-1} concentration on nitrogen percentage. The highest value (1.156 %) was recorded in the control treatment, whereas the lowest value (1.034%) was observed at the 1500 mg.L^{-1} potassium concentration. Regarding the mean effects of foliar application of the growth regulator CCC on nitrogen percentage, significant differences were observed between the control treatment and the concentrations of 150 and 200 mg.L^{-1} [5]. As for the interaction effect between potassium and Cycocel concentrations, the results showed a significant effect on nitrogen percentage. The highest value (1.363 %) was recorded in the control treatment of both factors, whereas the lowest value (0.896 %) was observed at 1500 mg.L^{-1} potassium combined with 150 mg.L^{-1} Cycocel. The reduction in nitrogen percentage

Table 4. Effect of foliar application of different concentrations of K and the growth regulator CCC, as well as their interaction, on the N percentage of maize plants.

Effect of K concentrations mg·L^{-1}	Effect of foliar application of the growth regulator CCC mg L^{-1} 0 mg.L^{-1}	150 mg.L^{-1}	200 mg.L^{-1}	Effects of K concentrations
0	1.363 a	1.086 bcd	0.998 de	1.156 a
500	1.086 bcd	1.046 cd	1.195 b	1.111 ab
1000	1.076 bcd	1.173 bc	1.066b cd	1.105 ab
1500	1.211 b	0.896 e	0.998 de	1.03 4b
Effects of growth regulator CCC	1.184 a	1.056 b	1.064 b	

Table 5. Effect of foliar application of different concentrations of K, growth regulator CCC, as well as their interaction, on Phosphorus percentage of maize plants.

	Effect of foliar application of the growth regulator CCC mg L^{-1}			
Effect of K concentrations mg.L^{-1}	0 mg.L^{-1}	150 mg.L^{-1}	200 mg.L^{-1}	Effects of K concentrations
0	0.84 a	0.63 cd	0.55 cd	0.676 a
500	0.51d e	0.58 cde	0.88 a	0.656 a
1000	0.78 ab	0.58 cde	0.68 cd	0.678 a
1500	0.46 a	0.58 cde	0.77 b	0.605 a
Effects of growth regulator CCC	0.65 b	0.59 b	0.71 a	

under Cycocel application may be attributed to its inhibitory effect on plant growth, as it restricts stem elongation and delays cell division, thereby reducing leaf area. This reduction negatively affects photosynthetic activity, which in turn leads to a decrease in nitrogen content [20]. Values sharing the same letters are not significantly different from each other according to Duncan's multiple range test at the 0.05 probability level.

3.4. Effect of K/CCC on Phosphorus percentage in maize plants

The results presented in Table 5 indicate that there were no statistically significant differences among the mean effects of foliar application of potassium on phosphorus percentage. However, the table shows significant differences in the mean effects of foliar application of the growth regulator CCC on phosphorus percentage in maize plants. The highest value was recorded in the control treatment (200 mg.L^{-1}), reaching 0.71%, compared with the concentrations of 0 and 150 mg L^{-1}, which recorded 0.65% and 0.59%, respectively [5]. Regarding the interaction between the two studied factors, the highest value (0.88%) was recorded at 500 mg.L^{-1} potassium combined with 200 mg.L^{-1} Cycocel. This value did not differ significantly from the treatment of 1500 mg.L^{-1} potassium combined with the control treatment of Cycocel in phosphorus percentage in maize leaves. The lowest value (0.46%) was recorded under the same conditions. The increase in phosphorus percentage in maize leaves may be attributed to the availability of phosphorus in the soil in its plant-available forms [21]. Values sharing the same letters are not significantly different from each other according to Duncan's multiple range test at the 0.05 probability level.

3.5. Effect of K/CCC on K percentage in maize plants

The statistical results presented in Table 6 indicate that there were no significant differences among the mean effects of foliar spraying treatments with different concentrations of potassium and Cycocel on the percentage of potassium in the leaves of maize plants. Regarding the two-way interaction between the two factors, the results showed significant differences among the applied concentrations. The highest value was recorded at the treatment combination of (0) mg.L^{-1} potassium with 200 mg.L^{-1} of the growth regulator Cycocel, reaching 1.243%. In contrast, the lowest value was observed at the treatment of 500 mg.L^{-1} potassium with (0) mg.L^{-1} Cycocel (control treatment), where the potassium percentage in the leaves was 0.83%. The reduction in potassium percentage may be attributed to stomatal closure, which reduces water loss through transpiration [5]. This, in turn, negatively affects the photosynthesis process and consequently reduces the production of energy required for nutrient uptake through the roots. In addition, metabolic changes within the plant may occur, affecting the production of organic compounds that facilitate potassium transport within plant cells. These results are consistent with those reported by [22]. Values with identical letters do not differ significantly from each other according to Duncan's multiple range test at a probability level of 0.05.

Table 6. Effect of foliar application of different concentrations of K, growth regulator CCC, as well as their interaction, on K percentage of maize plants.

	Effect of foliar application of the growth regulator CCC mg.L^{-1}			
Effect of K concentrations (mg.L^{-1})	0 mg.L^{-1}	150 mg.L^{-1}	200 mg.L^{-1}	Effects of K concentrations
0	1.13 abcd	0.983 bcdef	1.243 ab	1.11 a
500	0.83 ef	0.916 daf	1.216 abc	0.99 a
1000	0.91 def	0.94 cdef	0.983 bcdf	0.94 a
1500	1.286 a	1.1abede	0.983 bcdef	1.05 a
Effects of growth regulator CCC	1.040 a	0.98 a	1.05 a	

Table 7. Effect of foliar spraying with different concentrations of K, growth regulator CCC, as well as their interaction, on estimation of P percentage of maize plants.

Effect of K concentrations mg·L^{-1}	Effect of foliar application of the growth regulator CCC mg L^{-1}			Effects of K concentrations
	0 mg.L^{-1}	150 mg.L^{-1}	200 mg.L^{-1}	
0	8.14 bc	6.80 dc	7.72 cd	7.55 a
500	6.44 e	7.68 cd	9.44 a	7.85 a
1000	6.48 e	9.99 a	8.38 bc	8.28 a
1500	9.11 ab	7.88 c	7.34 cde	7.85 a
Effects of growth regulator CCC	7.54 b	8.09 a	8.22 a	

3.6. Effect of K/CCC on Protein percentage in maize plants

The results presented in Table 7 indicate that there were no significant differences among the mean effects of potassium foliar spraying on the percentage of protein in the leaves of maize plants. In contrast, the effect of foliar application of the growth regulator Cycocel showed significant differences between the concentrations (0 and 150 mg.L^{-1}), which recorded values of 7.54 and 8.09, respectively. However, no significant differences were observed between the concentrations (150 and 200 mg·L^{-1}). Regarding the two-way interaction between the two factors, the results revealed significant differences. The highest value was recorded at the treatment combination of 1000 mg·L^{-1} potassium with 150 mg·L^{-1} Cycocel, reaching 9.99%. In contrast, the lowest value was observed at 500 mg·L^{-1} potassium with (0) mg·L^{-1} Cycocel (control treatment), which recorded 6.44% [23]. The increase in protein percentage in maize leaves may be attributed to several factors, including the role of potassium as an activator of many enzymes involved in protein synthesis. In addition, potassium facilitates the transport of essential amino acids required for protein formation within plant cells. These findings are consistent with those reported by [24]. Values with identical letters do not differ significantly from each other according to Duncan's multiple range test at a probability level of 0.05.

4. Conclusion

The study of physiological traits of maize plants (Zea mays L), effect of foliar application of K and CCC were detailed in this work. The foliar application of potassium at a concentration of (1500 mg.L^{-1}) showed a significant superiority in carbohydrate content. Foliar spraying with the growth regulator CCC at concentrations of (150 and 200 mg.L^{-1}) had a positive effect on carbohydrate content, phosphorus content, and protein content. The interaction between potassium and Cycocel concentrations had a positive effect, where the treatment of 1000 mg.L^{-1} potassium combined with 150 mg.L^{-1} Cycocel achieved the best results in improving both carbohydrate and protein contents. A significant reduction in nitrogen content was observed with increasing potassium concentrations compared to the control treatment. Regarding the interaction between the two factors, a significant increase in carbohydrate and protein contents was recorded at the combination of 1000 mg L^{-1} potassium and 150 mg L^{-1} CCC, reaching 229.88 mg g^{-1} and 9.99 %, respectively. Additionally, the interaction between 500 mg L^{-1} potassium and 200 mg L^{-1} Cycocel also showed significant effects. This work recommended to use different concentrations of potassium and the growth regulator Cycocel, and to apply them both to the soil and as foliar sprays on different maize cultivars.. Further future studies are recommended to investigate the effects of potassium and Cycocel on other cereal crops.

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Conflict of interest

The author declares no conflict interest.

Ethical approval

Not applicable.

Data availability

The data will be available upon request.

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Author contributions

Asmaa Mohamed Husaeen: data curation, writing-original, Abdulaah Yassin Ali: methodology, conceptualization, writing review and editing, supervision.

References

1. Bukhsh MAA, Ahmad R, Malik AU, Hussain S, Ishaque M. Agrophysiological traits of three maize hybrids as influenced by varying potassium application. *Life Sci. Int. J.* 2010;4(2):1487–1496.
2. Amanjyoti *et al.* Maize. in *Cereals and nutraceuticals*. Springer, 2024;47–80.
3. Saritha A, Ramanjaneyulu AV, Sainath N, Umarani E. Nutritional importance and value addition in maize. *Biot. Res. Today*. 2020;2(9):974–977.
4. Abdullah HI, Al-Joboury WMR, Aljoboury IFO, Hameed IK, Al-Badrany KA, Abdulqader MA. Synthesis and Characterization of Schiff base Compounds Produced from 6-Bromo-4-Fluoro-2 Aminobenzothazol Assessment against Antibacterial Activity. *AUIQ Complement. Biol. Syst.* 2025;2(1):118–130.
5. Khalaf NI *et al.* Conversion of Algal Biomass via Pyrolysis Process into Pyro-Char Production at Wastewater Treatment Nrc Baiji. *J. Chem. Technol. Metall.* 2026;61(2):249–257.
6. Abdulqader MA. Thermochemical Conversion of Oily Sludge, Composition, Hazards, and Treatment Strategies: An Overview. *AUIQ Complement. Biol. Syst.* 2025;2(2):10–36.
7. Pratikantam S *et al.* The nutritional, phytochemical composition, and utilisation of different parts of maize: A comparative analysis. *Open Agric.* 2024;9(1).
8. Torabian S *et al.* Potassium: A vital macronutrient in potato production—A review. *Agronomy*. 2021;11(3):543.
9. Cui J, Tcherkez G. Potassium dependency of enzymes in plant primary metabolism. *Plant Physiol. Biochem.* 2021;166:522–530.
10. Pandey GK, Mahiwal S. *Role of potassium in plants*. vol. 49. Springer, 2020.
11. Ghaffari NS, Shokuhfar A, Mojaddam M, Lak S, Afrinesh A. Cycocel and micronutrients on yield of (Zea mays L.). *J. Selva Andin. Res. Soc.* 2024;15(1):14–28.
12. Racz I *et al.* The influence of flag leaf removal and its characteristics on main yield components and yield quality indices on wheat. *Agronomy*. 2022;12(10):2545.
13. DuBois M, Gilles KA, Hamilton JK, Rebers PA, Smith F. Colorimetric method for determination of sugars and related substances. *Anal. Chem.* 1956;28(3):350–356.
14. Miller L, Houghton JA. The micro-Kjeldahl determination of the nitrogen content of amino acids and proteins. *J. biol. Chem.* 1945;159(2):373–383.
15. John MK. Colorimetric determination of phosphorus in soil and plant materials with ascorbic acid. *Soil Sci.* 1970;109(4):214–220.
16. Al-Sahaf FH. Applied plant nutrition. *Al-Hikma House*. *Baghdad*. 1989.
17. Al-Zobiady RA, Habeeb Al-mamoori A, Alkhafagi KFH, Abakah AJS. The Role of Proline Concentrations in Improving the Yield of Maize (ZEA MAYS L.) Plant Under Water Stress Conditions.
18. Ghareeb BA, Sharbazhery AOM, Fattah MA. Effect of Plant Growth Regulator (Cyccocel) and Irrigation on some Vegetative Characteristics of Turffgrass. *Migr. Lett.* 2023;20(S2):222–232.
19. Ibrahim MI, Amin MA, Ali AA. Effect of potassium fertilization on the field soil characters and productivity of yellow maize plant. *J. Educ. Sci.* 2023;32(4):26–33.
20. Cai F *et al.* Maize (Zea mays L.) physiological responses to drought and rewatering, and the associations with water stress degree. *Agric. Water Manag.* 2020;241:106379.
21. MUTAHI WS. Customized Potassium Foliar Feed for Optimum Yield of Maize. *Kenyatta University*. 2022.
22. Abbas M, Abdel-Lattif H, Shahba M. Ameliorative effects of calcium sprays on yield and grain nutritional composition of maize (Zea mays L.) cultivars under drought stress. *Agriculture*. 2021;11(4):285.
23. Abdulqader MA, Mohammed MM, Saeed LI, Habeeb OA. Co-pyrolysis of oily sludge and algal biomass. *J. Environ. Manage.* 2025;394:127617.
24. Mirtaleb SH, Niknejad Y, Fallah H. Foliar spray of amino acids and potassic fertilizer improves the nutritional quality of rice. *J. Plant Nutr.* 2021;44(14):2029–2041.