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# EFFECT OF DRIP IRRIGATION WITH FOLIAR DRESSING OF MINERAL FERTILIZER KRISTALON AND THEIR IMPACT ON MAIZE GRAIN YIELD IN SOUTHERN KAZAKHSTAN

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## SUMMARY

Nowadays, drip irrigation is a promising technology for optimizing plant development conditions and allowing the introduction of necessary nutrients to plants. The study aimed to establish the effects of drip irrigation with various levels of foliar dressing of mineral fertilizer Kristalon on maize (*Zea mays* L.) and achieve its maximum genetic potential for grain yield to enhance overall production. A field experiment implies exploratory research and quantifies the effects of drip irrigation with foliar Kristalon dressing to validate and introduce scientific achievements in agricultural production. Various technological methods applied to corn cultivation sought to increase its green mass and yield. In the experimental treatments, the corn crop irrigation engaged drip irrigation with different foliar dressings of Kristalon in the phases of the 5th and 11th tillering leaf and stem elongation with the norms of 2, 4, and 6 kg Kristalon ha$^{-1}$, respectively, in comparison with the control treatment (no Kristalon foliar dressing). Corn foliar treatment with fertilizer Kristalon preparation with a norm of 2, 4, and 6 kg ha$^{-1}$ produced grain yields of 11.43, 12.27, and 12.33 t ha$^{-1}$, respectively, compared with the control treatment (9.67 t ha$^{-1}$). The fertilizer Kristalon at 2, 4, and 6 kg ha$^{-1}$ produced 18.2%, 26.9%, and 27.5% more grain yield than the control. However, the Kristalon foliar dressing at 6 kg ha$^{-1}$ did not significantly increase the maize grain yield, and there was an increase of 0.6% compared with the 4 kg ha$^{-1}$ level. Therefore, corn foliar dressing with fertilizer Kristalon at 4 kg ha$^{-1}$ is an option for better production under the environmental conditions of South Kazakhstan.

**Keywords:** Maize (*Zea mays* L.), grain corn, drip irrigation, foliar dressing, mineral fertilizer Kristalon, yield components, grain yield

**Key findings:** Assessment of drip irrigation with mineral fertilizer Kristalon foliar dressing revealed that Kristalon preparation at 4 kg ha$^{-1}$ in the phases of 5th and 9th leaf tillering and stem elongation is recommendable for getting maximum grain yield at the Zhambyl Region, South Kazakhstan.

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## INTRODUCTION

Maize (*Zea mays* L.) is one of the most common and valuable annual crops grown in South Kazakhstan. Even though corn is a drought-resistant crop, its yield sharply declines in dry seasons. In addition, an accurate accounting of the vegetative demand of the plant for water is limited, which consistently varies depending on the phenological phases of development. Therefore, increasing corn yield significantly can reach high values with proper agricultural technology. In the arid conditions of South Kazakhstan, the rational use of water resources using modern irrigation methods can ensure stable and high yields of crops while maintaining soil fertility, which is also of particular relevance (Abdreshov *et al*., 2019).

In corn cultivation for grains, irrigation traditionally entails sprinkling and surface irrigation. However, using these irrigation methods is often less technologically convenient and feasible. The main factors for the inexpediency of sprinkling and surface irrigation methods may be fields with rough terrain, saline soils, and grounds with low water permeability, with such irrigation systems spending more water. Therefore, in times of water resource scarcity, it is necessary to consider drip irrigation as an alternative, which is the most innovative and promising irrigation method (Angold and Zharkov, 2014; Balgabaev *et al*., 2017; Kenenbaev *et al*., 2023).

Drip irrigation makes it possible to supply water directly to the root zone of plants and flexibly manage the water regime of the soil in the local humidification zone. In assessing the effects of drip irrigation and sprinkling on corn grain yield, a discovery showed that drip irrigation helped obtain the highest corn yield (Abd-El-Wahed and Alib, 2013). Corn drip irrigation allows for the optimal use of irrigation water, considering the prevailing climatic conditions and the required irrigation regime. The corn yield gains direct effects from the values of the irrigation norm for the growing season. A lack of water caused a decrease in the leaf surface index, the concentration of Fe, Zn, and Cu, and increased root dry matter (Oktem, 2008).

During irrigation, corn consumes water cautiously, associating a reduced transpiration coefficient and increased responsiveness of corn to irrigation with its productivity (Tsarev *et al*., 1996; Murley *et al*., 2018; Gusev *et al*., 2022; Bugubaeva *et al*. 2023). In corn, the lowest water consumption was notable at the germination stage in the 7–8 leaf phases, and later, it gradually increased until the heading of panicles, with the maximum water consumption observed until the milk-wax ripeness phase (Pandey *et al*., 2000). Afterward, water consumption decreased until the full ripeness of corn ears (Motazedian *et al*., 2019).

Studies in arid and semi-arid regions for spring corn production revealed that fertilizer application is crucial to improve corn yields with optimal water use. The best indicators of corn yield, dry matter, and water use efficiency were visible with optimal water supply, and the traits plant height, stem diameter, and leaf area index were the highest by applying the recommended dose of NPK fertilizers (Xiao *et al*., 2021). Employing effective organic fertilizers combined with nitrogen fertilizers increased the soil organic matter content, total nitrogen and phosphorus, available potassium and phosphorus, dry matter accumulation, and corn grain yield (Wang *et al*., 2019).

In Pakistan, previously conducted studies have assessed water productivity and corn yield at different watering frequencies, and they concluded that drip irrigation needs daily employment in combination with 100% provision of balanced fertigation standards for economically viable corn production (Chauhdary *et al*., 2019). Recently, the noted increase in groundwater pollution was due to the improper use of nitrogen fertilizers in irrigation systems. Therefore, the most appropriate approach is the timely application of water and fertilizers to enhance plants' nutrient absorption, minimize water loss, and dissolve substances in the field by optimizing the management of drip fertigation with drip irrigation (Azad *et al*., 2018).

A report stated that an optimal level of irrigation was a 14-day interval combined with a dose of fertilizers exceeding the recommended one by 25% to increase the efficiency of water and nitrogen use for increasing agricultural productivity, allowing the highest corn yield, with the same recommended for farms with low water availability (Tefera, 2020). The use of nitrogen fertigation not only maximizes the corn grain yield but also ensures the highest efficiency of nitrogen and water use (Lamm and Trooien, 2003). In the northeastern semi-arid region of Brazil, drip irrigation with fertigation units for fertilization has become widespread to ensure maximum economic production of corn (Souza *et al*., 2021). A study also established that under certain water conditions, an increase in fertilizer quantity cannot significantly increase grain yield or water productivity and can negatively affect those (Cao *et al*., 2022).

Based on the previous discussions, a possible conclusion can be that with optimal use of water for corn drip irrigation, providing plants with the necessary fertilizers is also crucial to have a significant impact on maize productivity. In addition to these prime plant nutrition elements, trace elements such as sulfur (S), zinc (Zn), magnesium (Mg), boron (B), iron (Fe), molybdenum (Mo), copper (Cu), and manganese (Mn) are likewise necessary, as they contribute to the growth and development of corn, participate in the synthesis of chlorophyll and metabolism, and increase plants' resistance to adverse environmental conditions. The presented study assessed the effects of grain corn foliar treatment with mineral fertilizer Kristalon (containing macro and microelements) during the drip irrigation on the growth and productivity of maize in South Kazakhstan.

## MATERIALS AND METHODS

In maize, the studies on drip irrigation with foliar dressing of mineral fertilizer Kristalon began in 2017–2019, assessing the chief growth indicators and recording the soil moisture levels in various phenological phases at the Experiment and Production Site (EPS), Samgau Farm, District Kordai, Zhambyl Region, South Kazakhstan. The climate of the study area has a pronounced continental characteristic of Southern Kazakhstan due to the influence of deserts and the high mountains. Continentality is defined by the frequent and abrupt changes in daily and annual air temperatures, harsh and relatively short winters, and long, hot, and intense dry summers.

The soils of the studied area were ordinary gray dirt. The thickness of the humus horizon was 35–50 cm; humus content in the 0.3 m layer has a range of 1.5%–1.9%, and gross nitrogen is at 0.120%–0.134%. Concerning the mechanical composition of the soil, it was a heavy loam containing sand (19.6%), dust (52.0%), clay (28.4%), and soil density (1.20 g $cm^3$ in a layer of 0–50 cm). The soil layer's field moisture capacity (FMC) of 0–50 cm was 21.3%, and the soils were not saline (salts amount to 0.114 g $l^{-1}$). The experiments ran in four-fold repetitions. The experiments were short-term, lasting only three years, in compliance with the methodology of Dospekhov (2014).

The study sought to assess the effects of foliar dressing of mineral fertilizer Kristalon on corn grain yield with drip irrigation under the environmental conditions of Southern Kazakhstan. Irrigation at the corn cultivation site transpired by drip method, based on maintaining soil moisture at an optimal level, considering the prevailing climatic conditions during the plant's growing season. The irrigation regime maintained the soil moisture level according to the phases of plant development. Soil moisture recording from the beginning of vegetation to the stage of the 9th leaf was at the level of 75% FMC, from the phase of the 9th leaf to the flowering and grain-filling stages at the level of 85% FMC, and from the milk ripeness to the grain maturation period at the level of 75% FMC. The initial soil moisture acquired had the condition that during this period, with insignificant transpiration and higher physical evaporation from the soil surface, plant support comes from enough reserves from autumn and winter precipitation. During the period of growth of the above-ground part, which grows much faster than the root system, the observed progress from the phase of the 9th leaf to the flowering and grain-filling stages had the pre-watering moisture threshold maintained at 85% FMC. In the milk-wax ripeness phase, the total water consumption of corn decreased, and the root system growth stabilized. During the growing season, soil moisture dropped to 75% FMC. The full ripeness phase of the grain required corn harvesting.

Adjusting irrigation norms and the operating time of drip irrigation systems ensued, if necessary, based on the indicators of soil moisture and the performance of the drip irrigation system. Accounting of the supplied water to the areas of corn cultivation went on daily by water measuring devices. The study methodology at the Experiment and Production Site, considering the climatic characteristics of the region, provided for technological operations for cultivation and requirements for the moisture availability of grain corn. Planning for September and October of the previous year included dehulling after harvesting the previous crop, applying mineral fertilizers in the form of ammonium sulfate ($[NH_4]_2SO_4$), 63 kg of the active ingredient/ha, and superphosphate ($Ca[H_2PO_4]_2*H_2O$), 75 kg of the active ingredient/ha, as well as, beardless plowing of the soil to a depth of 30–35 cm. Planned soil harrowing over the years of the study was in March and April, with pre-sowing cultivation in 7–8 cm depth on the third day of April.

An approximate target for corn sowing was from the third day of April up to the first day of May, with simultaneous application of fertilizers, i.e., nitrogen (N), phosphorus (P), and potassium (K) at the ratio of 16:16:16 kg $ha^{-1}$, respectively, to a depth of 7–8 cm. The first cultivation of the soil to a depth of 7–8 cm targeted the corn development phase (4th–5th leaf). Weed control started from May to June using the Biceps-Garant herbicide with a dose of 1 l/ha at the 3–4 true leaf stage, with the additional use of the Hacker herbicide for eliminating thistles at a rate of 0.02 l/ha on the 1st day of June. The second cultivation continued in the 7th leaf phase, applying fertilizer with ammonium nitrate ($NH_4NO_3$) at a dose of 52.5 kg of the active ingredient/ha. Beginning irrigation with drip irrigation occurred on the second to the third days of May when the upper soil horizon dried up to 7 cm.

During the study, the effects of foliar dressing of mineral fertilizer Kristalon under drip irrigation on the corn grain yield underwent evaluation with the following variants:

Variant 1: Drip irrigation with Kristalon foliar dressing at the rate of 2 kg $ha^{-1}$

Variant 2: Drip irrigation with Kristalon foliar dressing at the rate of 4 kg $ha^{-1}$

Variant 3: Drip irrigation with Kristalon foliar dressing at the rate of 6 kg $ha^{-1}$

Control: Drip irrigation with no Kristalon foliar dressing

The Kristalon foliar dressing occurred in the 5th and 9th leaf tillering phases and at the stem elongation stage. The presented study established 12 experimental plots, three for each variant of the experiment, in compliance with the principle of randomization. The area of the experimental plots was 56 $m^2$ (20 m × 2.8 m). The number of rows following the technical characteristics of the seeder was four. Providing protective and end strips with a width of 2.8 m helped protect the accounting part of the plots from accidental damage. The Borja F1 corn cultivar served as the specimen for sowing carried out by tape. The sowing scheme was 0.7 m × 0.2 m (Figure 1), and the corn seeding rate was 71,000 seeds/ha.

Corn foliar treatment applied the Kristalon universal preparation, which belonged to the line of water-soluble complex fertilizers containing nitrogen, phosphorus, potassium, and trace elements in chelated form, with no chlorine. The fertilizer is suitable for plants of any kind and on all soil types. The nitrogen,

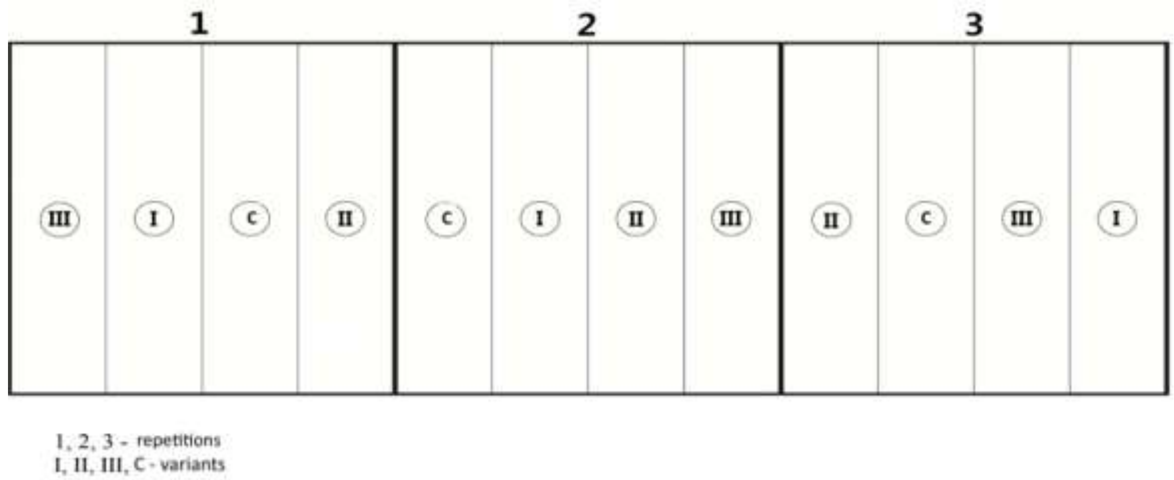


**Figure 1.** A diagram of the field experiment plot with a randomized placement of four variants with three repetitions.

phosphorus, and potassium (NPK) fertilizer formula is 15:5:30, with the content of magnesium (3%), sulfur (6%), iron (0.07%), boron (0.025%), molybdenum (0.004%), manganese (0.04%), copper (0.01%), and zinc (0.025%). Its application was at a rate of 2 to 6 kg/ha (the concentration of the solution ranges from 0.05% to 0.02%), considering the soil agrochemical parameters and cultural requirements. The consumption per ha equals 500–1,000 l. It is used for root treatment and foliar dressing (Zarechny, 2022).

Soil moisture monitoring in each variant transpired using the thermostatic weighing method before sowing, before and after watering, on the date of fixing the phases of growth and development, and after precipitation (Golovanov *et al*., 1986; Gilev, 2012). Observations on layers after 0.1 m to 1.0 m and soil sampling up to the depth of the active soil layer ensued in all experimental variants in three-fold repetition.

Phenological observations on the experimental variants progressed by repetition, considering the phases of corn development. The terms of harvesting corn for the grain schedule were according to the full ripeness of the ears. The corn harvest accounting employed a continuous method, weighing the yield from all experimental plants. A weight accounting of the removable crop assessed the effectiveness of the studied variants of the experiment. The development of technological methods for cultivating corn for grain when using drip irrigation technology in the conditions of the Zhambyl region implied the referencing of all the agrotechnical measures carried out during the cultivation of the crop, considering the peculiarities of its cultivation. The system of care for corn crops consisted of the following basic techniques: pre-emergence harrowing, destruction of the soil crust, shallow loosening of the soil in the initial phases of plant growth, formation of plant seedlings, or thinning, loosening of the earth in the space between the rows or rigs with the removal of weeds, plant fertilizing, plant disease, and pest control.

Statistical analysis of the experiments ran using data analysis of variance. The methodology involved the processing of data analyses for each year and total harvests for the entire period of the experiment according to the variants of the experiment, considering repetitions, using the Excel software.

## RESULTS

Field studies to assess the effects of Kristalon foliar dressing with drip irrigation on corn grain yield have materialized under the environmental conditions of Southern Kazakhstan. The studies have established the main factors of the water balance at the accepted moisture level for the various phases of corn development, the timing of the onset of the main stages, indicators of plant growth and development, and an assessment of foliar dressing effects on maize plant productivity.

In 2017, the corn sowing took place on April 20. Given the better moisture content of the soil and the air temperature, the seedlings appeared on April 30. Afterward, the growth and development of plants emerged following biological standards and the varietal characteristics of the corn. The phases of flowering and grain filling were visible on July 15. In 2018, sowing the grain corn ensued on April 21, and the corn seedlings were notable on May 1. Recording the flowering and grain filling proceeded on July 13. The corn sowing in 2019 transpired on April 20, and the seedlings appeared on the 10th day April 29), with the grain filling recorded on July 16.

The first watering occurred based on the moisture availability of the crop season and when 0–10 cm of the specified humidity surfaced in the soil layer. Watering began on June 2, 2017; in 2018, on May 10; and in 2019, on May 14. Subsequent watering continued depending on weather conditions, and the irrigation interval was one to five days. The irrigation norms for the experimental variants varied from 16 to 115 $m^3$ $ha^{-1}$. Determining the irrigation time followed the values of irrigation standards and technical characteristics of the irrigation system based on crop productivity.

Determining the total water consumption characterizing the water input to create a grain corn crop took account of three factors, i.e., the used reserves of soil moisture, atmospheric precipitation in the growing season, and the irrigation rate. Groundwater at the Experiment and Production Site lay at a depth of 3 m, which did not participate in feeding the root layer. In the irrigation of corn for grain, the main factors of the water balance, plus the drip irrigation method, are shown in Table 1.

In the studied years, atmospheric precipitation compensated moisture consumption by the crop by an average of 15%, and soil moisture reserves were at 7%. The irrigation rate was 78%, considering the accepted soil moisture level. According to the results of accounting for the supplied water, irrigation rates for the periods from the beginning of irrigation to the harvesting of grain corn according to the years of the study were 6,154, 5,465, and 6,780 $m^3$ $ha^{-1}$ during 2017, 2018, and 2019, respectively.

The mineral fertilizer Kristalon foliar dressing treatments in corn proceeded with universal preparation in the 5th and $9^{th}$ leaf tillering phases and at stem elongation. Following the onset of these phases, foliar dressing transpired on May 29, June 25, and July 8, 2017; on June 1, June 28, and July 8, 2018; and on June 3, June 29, and July 09, 2019, respectively.

The results of phenological observations of corn appear in Table 2. The Kristalon foliar dressing positively impacted the grain corn crops' growth and development traits. On average, in the first variant crop, the plant height over the years of the study varied from 246 to 248 cm, 252 to 268 cm in the 2nd variant, and 252 to 268 cm in the 3rd. In control (with no Kristalon dressing), the plant height varied from 225 to 241 cm.

The mass of one plant in the experimental variants with a three-time treatment of plants with Kristalon dressing during the observation period increased by 9.1% to 16.9% compared with the control variant (variant 1: 204.8 to 930.7 g; variant 2: 210.0 to 997.5 g; variant 3: 207.9 to 944.9 g; and control: 184.0 to 853.3 g). The diameter of the plant stems in the experimental variants in the full ripeness phase exceeded their diameter in the control variant by 8.8%–17.0% (variant 1: 2.95 cm; variant 2: 3.17 cm; variant 3: 3.08 cm; control: 2.71 cm). Corn harvesting for grain happened on September 25, 2017, September 26, 2018, and also in 2019. The corn grain yield under the adopted irrigation regime and the introduction of Kristalon foliar dressing gave the following

**Table 1.** The main factors of the water balance in the irrigation of corn for grain with drip irrigation.

| Humidity level in the experiment variants | Year of the study | Moisture used for irrigation | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Total water consumption | Irrigation rate | | Atmospheric precipitation | | Soil moisture reserves | |
| | | $m^3$/ha | $m^3$/ha | % | $m^3$/ha | % | $m^3$/ha | % |
| 75%-85%-75% FMC | 2017 | 7,953 | 6,154 | 77.4 | 1,267 | 15.9 | 532 | 6.7 |
| | 2018 | 7,048 | 5,465 | 77.7 | 1,040 | 14.8 | 525 | 7.5 |
| | 2019 | 8,503 | 6,780 | 79.8 | 1,193 | 14.0 | 529 | 6.2 |
| | Average | 7,835 | 6,136 | 78 | 1,167 | 15 | 529 | 7 |

**Table 2.** The timing of the passage of phases in experiments at the Experiment and Production Site.

| Phenological phases of development | 2017 | | 2018 | | 2019 | |
|---|---|---|---|---|---|---|
| | Beginning | End | Beginning | End | Beginning | End |
| Sowing | 21.04 | 30.04 | 21.04 | 01.05 | 21.04 | 29.04 |
| Seedlings | 1.05 | 15.05 | 02.05 | 13.05 | 30.04 | 14.05 |
| 5th leaf phase | 16.05 | 10.06 | 14.05 | 10.06 | 15.05 | 10.06 |
| 9th leaf phase | 11.06 | 5.07 | 11.06 | 5.07 | 11.06 | 5.07 |
| Heading of panicles | 6.07 | 10.07 | 6.07 | 10.07 | 6.07 | 10.07 |
| Flowering and grain filling phase | 11.07 | 3.08 | 11.07 | 29.07 | 11.07 | 31.07 |
| Milk ripeness phase | 4.08 | 20.08 | 30.07 | 10.08 | 1.08 | 10.08 |
| Wax ripeness phase | 21.08 | 10.09 | 11.08 | 31.08 | 11.08 | 31.08 |
| Full ripeness | 11.09 | 25.09 | 01.09 | 26.09 | 01.09 | 26.09 |

**Table 3.** Corn grain yield at the Experiment and Production Site during 2017–2019.

| Years of the study | Variants | Plant height (cm) | Average ear weight (g) | Average grain weight $ear^{-1}$ (g) | Plant population (pcs $ha^{-1}$) | Actual yield (t $ha^{-1}$) | Increase in grain yield (%) |
|---|---|---|---|---|---|---|---|
| 2017 | Variant 1 | 248 | 330.2 | 154.5 | 70,560 | 10.9 | 26.7 |
| | Variant 2 | 265 | 370.4 | 171.3 | 70,650 | 12.1 | 40.7 |
| | Variant 3 | 267 | 380.5 | 172.3 | 70,800 | 12.2 | 41.9 |
| | Control | 225 | 302.0 | 122.5 | 70,200 | 8.6 | – |
| 2018 | Variant 1 | 247 | 320.3 | 162.4 | 70,200 | 11.4 | 14 |
| | Variant 2 | 252 | 368.4 | 174.0 | 70,100 | 12.2 | 22 |
| | Variant 3 | 252 | 375.0 | 175.4 | 70,100 | 12.3 | 23 |
| | Control | 241 | 305.0 | 142.4 | 70,230 | 10.0 | – |
| 2019 | Variant 1 | 246 | 339.6 | 170.1 | 70,560 | 12.0 | 15.4 |
| | Variant 2 | 266 | 374.5 | 176.9 | 70,650 | 12.5 | 20.2 |
| | Variant 3 | 268 | 378.1 | 176.9 | 70,800 | 12.5 | 20.2 |
| | Control | 225 | 310.6 | 147.9 | 70,300 | 10.4 | – |
| 2017–2019 | Variant 1 | 247 | 330.0 | 162.3 | 70,440 | 11.43 | 18.2 |
| | Variant 2 | 261 | 371.1 | 174.2 | 70,437 | 12.27 | 26.9 |
| | Variant 3 | 262.3 | 377.9 | 174.9 | 70,567 | 12.33 | 27.5 |
| | Control | 230.3 | 305.9 | 137.7 | 70,243 | 9.67 | – |

results over three years: at the rate of 2 kg $ha^{-1}$ (variant 1 - averaged 11.43 t $ha^{-1}$ ); 4 kg $ha^{-1}$ (variant 2 - averaged 12.27 t $ha^{-1}$); and 6 kg $ha^{-1}$ (variant 3 – averaged 12.33 t $ha^{-1}$). In control (with no Kristalon foliar dressing), the grain yield was 9.67 t $ha^{-1}$ (Table 3). The actual grain corn yield determination ensued at the grain moisture content of 14%.

The results of the experiments indicated a significant positive effect of Kristalon foliar dressing (with three levels) on corn yield. Plant foliar dressing at three levels increased the corn grain yield (at 2 kg $ha^{-1}$ by 18.2%, 4 kg $ha^{-1}$ by 26.9%, and 6 kg $ha^{-1}$ by 27.5%). Results also revealed that an increase in the rate of Kristalon foliar dressing with the preparation from 4 to 6 kg $ha^{-1}$ led to an increase in grain yield only up to 0.6%. Employing corn foliar treatment with the Kristalon preparation at a rate of 4 kg $ha^{-1}$ is highly recommendable for better corn productivity since an increase in preparing the corn foliar treatment dosage also increases the cost of purchasing and preparation use.

## DISCUSSION

The field experiment results, aiming to assess the effects of grain corn foliar dressing with mineral fertilizer Kristalon preparation at a rate of 2, 4, and 6 kg $ha^{-1}$, proved to increase the grain yield. With the optimal water supply of plants, additional preparations were necessary for the phases of plant development, such as, the 3rd leaf, beginning of tillering, and stem elongation at the rate of 4 kg $ha^{-1}$. Kristalon foliar dressing of the maize plants at the Experiment and Production Site of the Samgau, District Kordai, Zhambyl Region, Southern Kazakhstan during 2017–2019, on average, increased the grain corn yield by 26.9% compared with the control treatment. Generally, the corn foliar dressing contributed to the corn's growth and development, increasing its grain yield.

The effect of putting fertilizers in drip irrigation, increasing corn yield, has had past studies in China confirming it (Xiao *et al*., 2021). In conditions of low fertility and poor land productivity in Ningxia Province (China), the use of fertilizers increased the content of total nitrogen, total phosphorus, available potassium, and available phosphorus, as well as dry matter accumulation and corn grain yield (Wang *et al*., 2019). The importance of nitrogen fertilizer application has its establishment in the Northeastern semi-arid region of Brazil, with the nitrogen content estimated by leaves, grain yield, gross and net income, profit margin, and profitability index (Souza *et al*., 2021).

The studies on foliar treatment effects with organic and mineral fertilizers on grain crops' productivity and quality in dark chestnut soil conditions of the Saratov Left Bank (Russia) showed that using an organic trace element complex contributed to an additional increase in corn yield by 0.23 t $ha^{-1}$ (Denisov *et al*., 2022). It has also been evident that micronutrient use in crop cultivation is necessary for several reasons, i.e., in high-yielding hybrids, an increase in the yield of which can lead to a decrease in the content of trace elements in the productive mass, improved grain quality, increased resistance to diseases and adverse factors, balanced nutrition of plants, and enriched crop production with trace elements (Enakiev *et al*., 2018).

A field experiment at the Qlyasan Agricultural Research Farm in the Suleimani Governorate of Kurdistan in Iraq, carried out from April to August 2019, showed that non-root fertilization with some trace elements significantly affected the corn grain yield and the absorption of the introduced trace elements by the corn kernels (Bakr and Ghafoor, 2020). Thus, foliar dressing contributes to an increase in the corn grain yield and can also be suitable for use on irrigated areas.

## CONCLUSIONS

According to the results, the Kristalon preparation at a rate of 4 kg $ha^{-1}$ in the 5th and 9th leaf tillering phases and stem elongation proved beneficial for use in corn grain crops in the Zhambyl Region, Southern Kazakhstan. The practical significance of grain corn foliar dressing with drip irrigation is its provision of an increase in corn yield of 26.9% compared with the control variant without plant foliar treatment. The study's theoretical significance is because the need for additional treatment of plants by the Kristalon universal preparation (a complex fertilizer containing nitrogen, phosphorus, potassium, and trace elements in chelated form with no chlorine) was recognizable. The application of nitrogen eliminates the delay in plant growth; phosphorus eliminates the possible formation of ears with underdeveloped rows of grains; and potassium enhances the development of the corn root system and increases the movement of carbohydrates. Further research in this area will allow the establishment of crop productivity in the conditions of South Kazakhstan and assess the impact of foliar dressing on plants in irrigated agriculture.

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