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Examination of the Interactive Effects of Seed Magnetic Priming and Zeolite Application on Yield and Physiological Characteristics of Super Sweet Corn Under Water Stress

Negin Zaryan[1], Behnam Habibi Khaniani*[2], Ali Afrous[2], Mehdi Sadeghi[2]

1. PhD. Student, Department of Agronomy, Dezful branch, Islamic Azad University, Dezful, Iran.
2. Department of Agronomy, Dezful Branch, Islamic Azad University, Dezful, Iran.

RESEARCH ARTICLE

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ABSTRACT

BACKGROUND: Sweet corn faces challenges such as drought stress, which can significantly reduce yield. Zeolite and magnetic fields are emerging methods proposed to enhance plant growth and yield.

OBJECTIVES: This study investigates the combined effects of zeolite and magnetic fields on sweet corn to develop optimal strategies for addressing drought stress, with a focus on yield and physiological characteristics.

METHODS: A split-plot factorial experiment was conducted within a randomized complete block (RCBD), featuring three replications. The experimental factors included three levels of drought stress (60%, 80%, and 100% of crop water requirement), two levels of zeolite application (0 and 5 Ton.ha^{-1}), and five magnetic field treatments (50 and 100 milliTesla for 15 and 30 minutes, plus an untreated control).

RESULT: Results demonstrated that the maximum cob length and thousand-grain weight were achieved under 100% drought stress with zeolite application and a magnetic field intensity of 15-100 milliTesla. Fresh yield and canned product yield were optimized under 80% drought stress with a magnetic field intensity of 15-100 milliTesla. The highest leaf area index (LAI) and crop growth rate (CGR) were recorded in the treatment involving 80% drought stress, zeolite, and a magnetic field intensity of 15-50 milliTesla. Net assimilation rate (NAR) and the percentages of starch and protein were significantly influenced by the interactions among drought stress, zeolite, and magnetic fields.

CONCLUSION: These findings highlight the positive effects of zeolite and magnetic field treatments on both quantitative and qualitative traits of sweet corn under varying water stress conditions, suggesting their potential for optimizing sweet corn cultivation practices.

KEYWORDS: *Drought stress, Growth parameters, Magnetic field, Sweet corn, Zeolite.*

***Corresponding Author:** Behnam Habibi Khaniani ✉ BehnamHabibi2001@yahoo.com

1. BACKGROUND

Sweet corn (*Zea mays* var. saccharata) is a key agricultural crop with significant roles in food security and economic development. However, optimal production of this crop is increasingly challenged by environmental stresses, particularly drought, which can substantially impact its yield and quality (Garcia *et al*., 2017). Zeolites, as porous minerals with high water absorption and retention capacities, have emerged as effective solutions for improving plant growth conditions under drought stress (Jones and Miller, 2021). These materials enhance soil water retention and physical properties, thereby mitigating the adverse effects of drought and improving plant growth and performance (Taylor *et al*., 2022). In addition to zeolites, magnetic fields have been investigated as a novel method for enhancing plant growth under drought conditions (Wang and Li, 2023). Recent studies have demonstrated that magnetic fields can positively influence plant performance by improving seed germination, root and stem growth, and biomass production. These fields affect physiological processes and increase the efficiency of water use, helping plants better adapt to drought stress (Hafeez *et al*., 2022). The combined use of zeolites and magnetic fields under drought conditions can effectively improve the growth and yield of sweet corn. This combination can enhance growth parameters such as cob length, thousand-kernel weight, starch percentage, Leaf Area Index (LAI), and Crop Growth Rate (CGR), while also improving kernel quality and reducing the negative impacts of drought stress (Kim and Park, 2020; Zhang *et al*., 2023).

2. OBJECTIVES

This research investigates the simultaneous effects of zeolite and magnetic fields to develop optimal strategies for managing drought stress and enhancing sweet corn yield.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This study was conducted during the 2021 and 2022 growing seasons at the campus of Azad University of Dezful, located at 32 degrees and 22 minutes North latitude, 48 degrees and 24 minutes East longitude, and 140 meters above sea level. The experiment was designed as a split-plot factorial within a randomized complete block design with three replications. The main treatments consisted of three levels of irrigation stress: 60%, 80%, and 100% of the crop's water requirement. The sub-treatments included magnetic field exposures with different intensities and durations: 50 millitesla for 15 minutes, 50 millitesla for 30 minutes, 100 millitesla for 15 minutes, and 100 millitesla for 30 minutes, in addition to non-treated seeds (control) and application of zeolite at 5 $t.ha^{-1}$ versus no zeolite application. Each plot included 10 rows of planting, each 15 meters long, with a row spacing of 75 centimeters.

3.2. Lab Management

Prior to planting, the seeds were exposed to the designated magnetic field intensities in laboratory cups for the required duration. In plots where zeolite was applied, the required amount of zeolite was precisely calculated and spread over the soil surface before discing, and then mixed into the soil to a depth of 20 centimeters. Planting was carried out manually on September 1, 2021, and 2022, using 7 to 8 kilograms of seeds at a depth of 1.5 centimeters, resulting in a plant density of 8 plants per square meter. Immediately after planting, the first irrigation was performed. Following germination, thinning and weed control were carried out using herbicides.

3.3. *Measured Traits*

The initial crop yield (kg) and the gross volume of irrigation water applied (m^3) for crop production were measured. For this purpose, the water flow rate into the plots was measured using a flowmeter, and the irrigation duration was recorded for each irrigation event. After determining the total volume of water used and measuring the plot area, the water use efficiency (kg per m^3) was calculated. Finally, the water use efficiency across different stress treatments and their combinations was assessed and compared.

Table 1. Characteristics of Climatic Factors in Dezful, 2021 and 2022

Month	Evaporation (mm)	Sunshine Hours	Min. Relative Humidity (%)	Max. Relative Humidity (%)	Max. Tem. (°C)	Min. Temp. (°C)	Mean Tem. (°C)
September 2021	303.4	323.8	3	86	49.8	18.8	34.7
October 2021	240.3	293.6	6	80	43.3	19.0	29.1
November 2021	108.3	203.9	13	98	35.1	14.0	21.9
September 2022	264.2	292.3	7	90	46.3	16.3	34.3
October 2022	194.2	278.3	7	79	44.2	9.5	29.1
November 2022	97.5	192.9	18	100	37.0	10.7	23.0

Table 2. Physical and Chemical Properties of the Soil at 0-30 cm Depth

EC ($ds.m^{-1}$)	pH (Saturation)	N ($mg.kg^{-1}$)	P ($mg.kg^{-1}$)	K ($mg.kg^{-1}$)	O.C (%)	Clay (%)	Silt (%)	Sand (%)	Soil texture
1.7	7.35	39	6	95	0.44	26	54	20	Loam Soil

During the assessment stage, 5 plants were randomly selected from each plot, and the following traits were measured: ear length, number of kernels per row, number of rows, leaf area index (LAI), crop growth rate (CGR), net water uptake (NAR), and yield components including fresh ear yield, canning yield, thousand-kernel weight, and percentages of protein and starch in the kernels. For harvesting operations, after removing two side rows and half a meter from the beginning and end of each row as margins, the remaining plants in each plot were separately harvested. The plants were dried in an oven at approximately 70°C for 48 hours and then weighed. After separating the kernels, the kernel yield was calculated based on tons per hectare. To determine the thousand-kernel weight, two samples of 500 kernels each were separated using a seed counter, and their combined weight was recorded as the thousand-kernel weight. The percentage of kernel protein was determined by measuring the total nitrogen content using the micro-Kjeldahl method, which was then converted to the percentage of kernel protein. Starch content was measured using a spectrophotometer set at a wavelength of 510 nm according to the Megazyme method (2016). The leaf area index (LAI) was calculated based on the following formula (LAI), Crop Growth Rate (CGR) and Net Assimilation Rate (NAR) (Alizadeh *et al.*, 2010):

Equ.1. LAI = LA / GA

Equ.2. $CGR = \frac{W2 - W1}{T2 - T1} \times \frac{1}{GA}$

Equ.3. NAR= CGR \ LAI

In these equations, W1 and W2 are respectively the initial total dry weight. Secondary ($g.m^{-2}$), T1 and T2, primary and secondary sampling time and LA is the leaf area and GA is the ground area.

3.4. *Statistical Analysis*

Data analysis was performed using SAS software (Ver.9), and mean comparisons were conducted using Duncan's multiple range test at a 5% significance level. Graphs were created using EXCEL software (2016).

4. RESULT AND DISCUSSION

The results of the combined analysis of variance indicated that the effect of the year was not significant for any of the traits studied. Therefore, there was no statistical difference between the two years of the study in terms of their impact on the outcomes of the experimental design.

4.1. *Cob length*

The analysis of variance table (Table 3) indicated that the two-way interactions of stress × zeolite and stress × magnetism were significant at the 5% probability level, while the interaction of zeolite × magnetism and the three-way interaction of stress × zeolite × magnetism on the cob length trait were significant at the 1% probability level. The results of the three-way interactions demonstrated that the maximum cob length was observed in the treatment with 100% stress and zeolite application without magnetism (41 cm), which did not significantly differ from the treatment with 100% stress without zeolite application but with 15-100 magnetism. The minimum cob length was recorded in the treatment with 60% stress without zeolite application and without magnetism (22.5 cm) (Table 4). These findings indicate that the utilization of zeolite and magnetic fields under different stress conditions can significantly impact the cob length of sweet corn. The concurrent application of both factors can enhance growth and increase cob length effectively. Water deficit stress can adversely affect the cob length of sweet corn. However, the application of zeolite can mitigate this effect and improve cob length under drought conditions, as zeolite enhances cob growth by retaining soil moisture and improving nutrient uptake (Nikkpour *et al.*, 2021). Furthermore, magnetic fields can contribute to an increase in the cob length of sweet corn by enhancing photosynthetic processes and improving the efficiency of water and nutrient utilization, thereby promoting better cob growth (Yuan and Zhang, 2021). Khan and Ahmad (2021) reported that under water deficit stress conditions, the use of zeolite and magnetic fields significantly increased the cob length of sweet corn. The findings of their study suggest that the combined application of zeolite and magnetic fields can enhance cob length by approximately 18%, which is consistent with the results of the present study.

4.2. *1000 Kernel Weight*

The interactions of zeolite × magnetism and stress × magnetism, as well as the three-way interaction of stress × zeolite × magnetism, significantly impacted the thousand kernel weight at the 5% probability level (Table 3). The highest thousand kernel weight was observed in the treatment with 100% stress, zeolite application, and magnetic field (15-100), with an average of 380.83 grams. In contrast, the lowest weight was recorded in the treatment with 60% stress, without zeolite application, and without a magnetic field, averaging 163.33 grams (Table 4). Water deficit stress can adversely affect the thousand kernel weight of corn, as water scarcity leads to reduced kernel size and consequently lower thousand kernel weight (Khan and Ahmad, 2021). The application of zeolite as a soil amendment can increase the thousand kernel weight of corn by improving soil moisture retention and enhancing nutrient uptake, which leads to improved kernel size and weight (Nikkpour, Rezaei, and Hosseini, 2021). Ranjbar and Ghorbani (2022) demonstrated that the use of zeolite could increase the thousand kernel weight of corn to an average of 270 grams, a significant improvement compared to conditions without zeolite under water deficit stress. Additionally, magnetic fields can significantly enhance the thousand kernel weight of corn by improving photosynthetic processes and increasing the efficiency of water and nutrient utilization, contributing to increased kernel weight (Ali and Khan, 2020). In this context, Jafari and Eslami (2020) reported that the use of magnetic fields increased the thousand kernel weight of corn by approximately 250 grams, a relative improvement compared to the absence of magnetic fields.

4.3. *Fresh Ear Yield*

According to the results, the interaction of stress × magnetism significantly impacted the fresh ear yield at the 5% probability level (Table 3). The treatment with 80% stress combined with a 15-100 magnetic field produced the highest fresh ear yield (42.460), while the treatment with 60% stress without magnetism resulted in the lowest yield (25.573) (Fig. 1). Water deficit stress can markedly affect the fresh ear yield of sweet corn, as water scarcity reduces ear growth and development, leading to a decrease in both the quantity and quality of the final product (Khan and Ahmad, 2020). The application of a magnetic field can enhance fresh ear yield by positively influencing photosynthetic processes and improving water and nutrient uptake, thereby increasing both the quantity and quality of the final product (Yuan and Zhang, 2021).

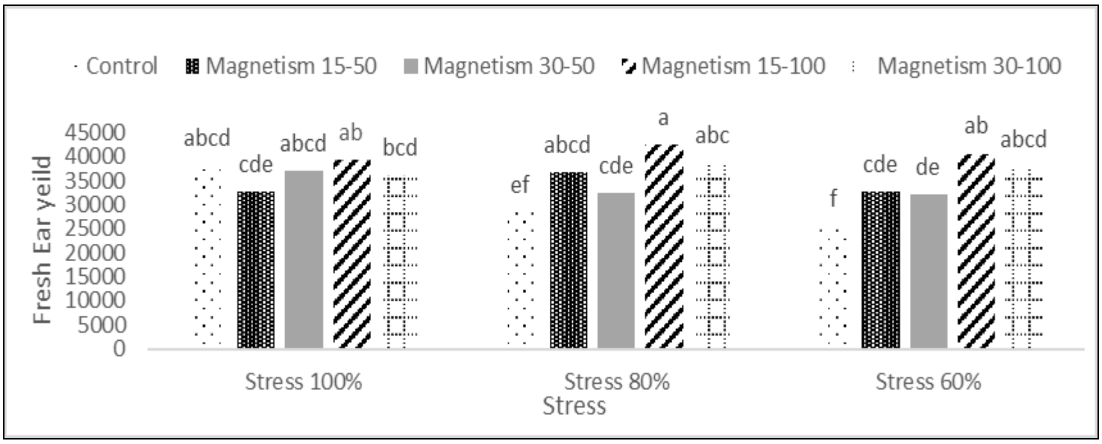

Fig. 1. Effect of the Interaction between Stress × Magnetism on Fresh Ear Yield of Sweet Corn.

4.4. *Conservable grain Yield*

The interaction between stress and zeolite significantly affected the Conservable grain Yield at the 5% probability level (Table 3). As detailed in Fig. 2, the treatment with 80% stress and no zeolite yielded the highest canning performance, averaging 20,484 g/h^{-1}. This was not significantly different from the treatment with 100% stress and zeolite, which had a yield of 20.034 g.h^{-1}. Conversely, the treatment with 60% stress without zeolite recorded the lowest Conservable grain Yield, averaging 1196.33 g.ha^{-1}. Environmental stresses such as water scarcity can adversely affect the Conservable grain Yield of sweet corn by diminishing both the quality and quantity of the final product (Ghosh and Singh, 2019). The application of zeolite as a soil amendment can improve Conservable grain Yield by enhancing soil moisture retention and increasing nutrient availability, thereby leading to improved quality and quantity of the final yield (Khan and Ali, 2021).

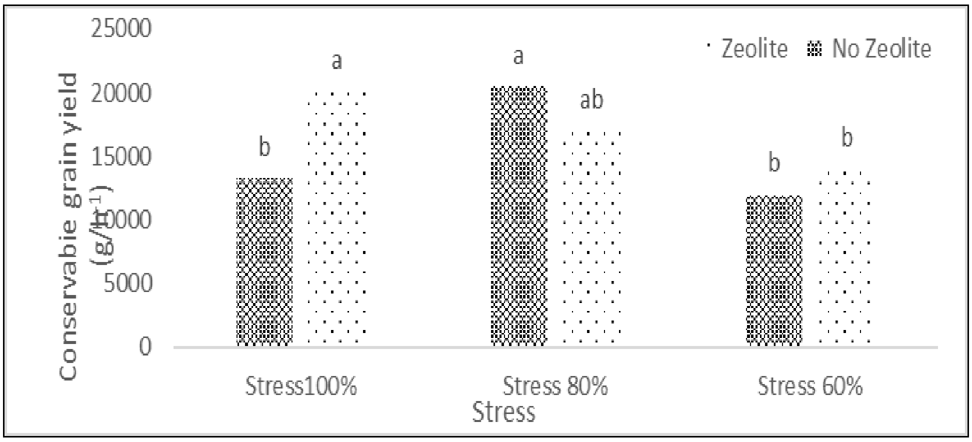

Fig. 2. The Effect of the Interaction between Stress × Zeolite on the Canning Yield of Super Sweet Corn.

4.5. *Number of Kernels per Row*

The findings of this study revealed that the interactions between zeolite and magnetic field significantly affected the number of kernels per row at the 1% probability level (Table 3). The highest number of kernels per row (39.38) was observed in the treatment with a magnetic field of 30-100 combined with zeolite, while the lowest number of kernels per row (29.16) was found in the treatment with a magnetic field of 15-100 without zeolite (Fig. 3). The application of zeolite as a soil amendment can enhance the number of kernels per row in corn, as zeolite improves soil moisture conditions and nutrient availability, leading to better growth and increased kernel production (Nikkpour *et al.*, 2021). Additionally, magnetic fields can contribute to an increased number of kernels per row by enhancing photosynthetic processes and improving resource utilization efficiency, which promotes better kernel growth and increased kernel production (Abbasi *et al.*, 2022).

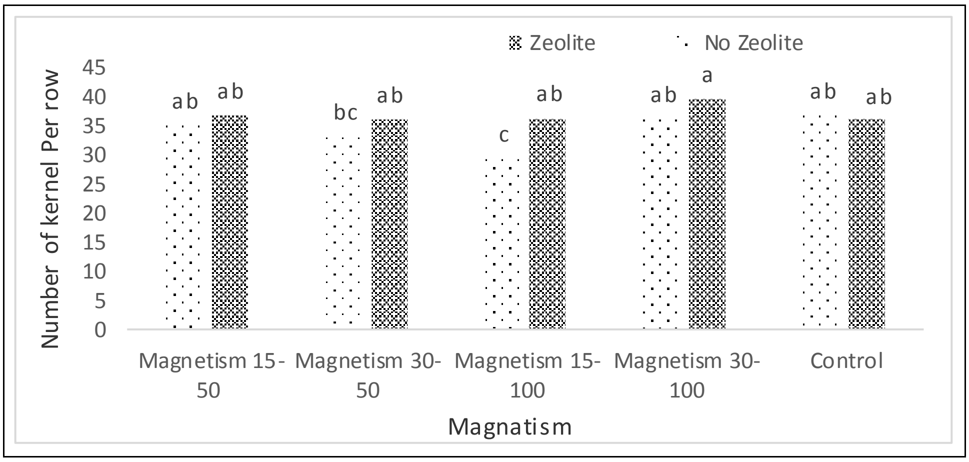

Fig. 3. Effect of the Interaction between Magnetic Field × Zeolite on the Number of Kernels per Row in Sweet Corn.

4.6. *Leaf Area Index* (*LAI*)

The Leaf Area Index (LAI) represents the ratio of the leaf area to the ground area occupied by the plant and indicates the plant's capacity to intercept solar radiation (Hajirad *et al*., 2021). The highest LAI (2.64) was observed in the treatment with 80% stress combined with zeolite and a magnetic field of 15-50, whereas the lowest LAI (0.65) was recorded in the treatment with 60% stress, without zeolite and without a magnetic field (Table 4). Water deficit stress typically results in a significant reduction in LAI in corn. This decline is attributed to restricted water availability, which adversely affects leaf growth and development. Consequently, water scarcity can lead to smaller leaf size, fewer leaves, reduced photosynthetic activity, and a lower LAI (Hosseini *et al.*, 2021). The application of zeolite can alleviate the negative impacts of water stress on LAI by improving soil moisture retention, thus supporting the maintenance and increase of leaf area (Mohammad and Ali, 2020). Furthermore, Ali and Khan (2022) reported that magnetic fields could enhance LAI by improving water and nutrient uptake, optimizing photosynthetic processes, and increasing enzymatic activity in plants. This enhancement in photosynthetic efficiency results in a larger active leaf area and improved light capture for photosynthesis. The research indicates a significant increase in LAI in corn when exposed to magnetic fields, demonstrating the positive impact of magnetic fields on leaf growth and development.

4.7. *Crop Growth Rate* (*CGR*)

Crop growth rate (CGR) refers to the increase in the weight of a plant population per unit area over time. The interaction between stress and magnetic field, as well as the three-way interaction between stress, zeolite, and magnetic field, significantly affected CGR at the 1% probability level (Table 3). According to Table 4-5, the highest CGR (1.70) was observed in the treatment with 80% stress combined with zeolite and a magnetic field of 15-50, whereas the lowest CGR (0.77) was recorded in the treatment with 60% stress without zeolite and magnetic field (Table 4). A study by Ahmadi *et al.* (2021) indicates that the application of zeolite under drought stress conditions can enhance CGR in corn. Drought stress typically reduces CGR due to decreased photosynthesis, stomatal closure, and reduced water availability. However, zeolite as a soil amendment can mitigate these negative impacts by improving soil moisture retention and increasing water availability for plants. Zeolites, with their high water-holding capacity and cation exchange capacity, enhance soil moisture conditions and improve plant access to water, thereby minimizing reductions in CGR under drought stress. Furthermore, Abbasi *et al.* (2022) reported that magnetic fields could increase CGR in corn. Their research demonstrated that magnetic fields improve CGR by enhancing photosynthetic activity and optimizing water and nutrient uptake, contributing to better crop growth.

4.8. *Net Assimilation Rate (NAR)*

The analysis of Net Assimilation Rate (NAR) in this study demonstrated that the interaction effect of stress × magnetic field was significantly different at the 1% probability level (Table 3). The highest NAR was recorded under 60% stress conditions without the application of a magnetic field, while the lowest NAR was observed under 60% stress combined with a 30-100 magnetic field (Fig. 4). Specifically, the maximum NAR was achieved in the 60% stress treatment without a magnetic field, suggesting enhanced absorption capability due to the absence of adverse magnetic field effects. In contrast, the minimum NAR was found in the 60% stress treatment with the 30-100 magnetic field, which indicates a detrimental impact of the magnetic field in conjunction with stress conditions, leading to reduced water absorption efficiency. These findings suggest that the exclusion of magnetic fields under stress conditions can potentially improve water absorption, whereas the combination of magnetic fields with stress conditions may negatively affect water absorption. Drought stress typically leads to a decrease in Net Assimilation Rate (NAR) as it adversely affects photosynthetic efficiency and water uptake, resulting in a negative impact on NAR (Zhang *et al.,* 2020). Additionally, Li *et al.* (2021) have found that magnetic fields can influence plant physiological processes, potentially altering NAR due to their effects on water absorption and resource utilization efficiency. Zhou *et al.* (2022) further reported that magnetic fields can affect NAR, with these effects varying depending on environmental conditions and the intensity of the magnetic field, which aligns with the findings of the current study.

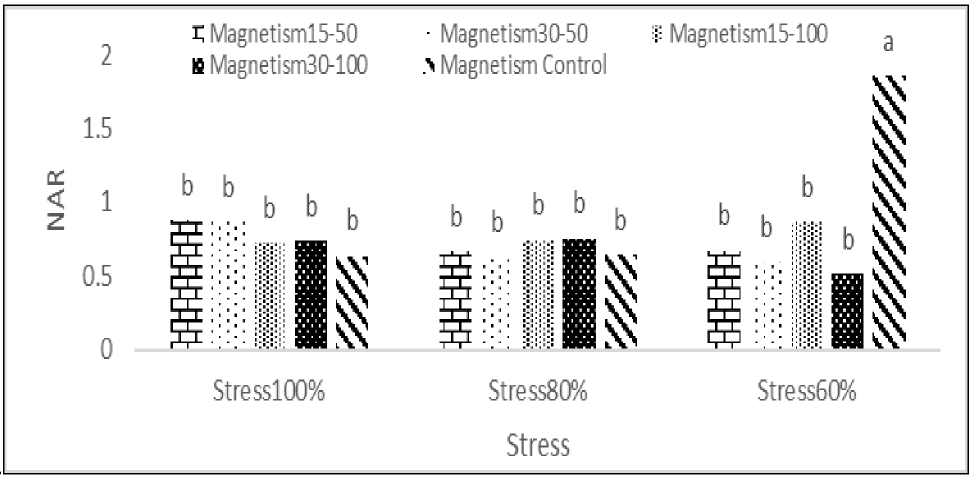

Fig. 4. illustrates the interactive effect of stress × magnetic field on net water absorption (NAR) in sweet corn and starch percentage.

4.9. *Kernel starch percentage*

The interaction effects of stress × magnetic field and the three-way interaction of stress × zeolite × magnetic field had a significant impact on starch percentage at the 1% probability level (Table 3). The highest and lowest starch percentages were observed in treatments with 80% stress combined with zeolite and magnetic field 50-15, and 60% stress without zeolite and magnetic field 100-30, with average values of 46.93% and 52.56%, respectively (Table 4). Research indicates that the use of zeolite as a soil amendment can enhance water management in the soil and mitigate the adverse effects of drought stress. Due to its unique properties, such as highwater retention capacity and cation exchange capability, zeolite can increase the amount of available water for plants, thereby reducing the impact of drought stress on starch percentage. For instance, a study by Nikkpour *et al*. (2021) demonstrated that the application of zeolite under drought stress conditions leads to an increase in starch percentage in maize kernels. This research indicates that zeolite, by improving soil moisture status and reducing drought stress severity, indirectly positively affects the chemical composition of maize grains (Nikkpour *et al.*, 2021). Additionally, a study by Abbasi *et al.* (2022) showed that the application of a magnetic field under drought stress conditions increases the starch percentage in maize kernels. This research suggests that the magnetic field enhances the activity of enzymes involved in starch synthesis, thereby improving the quality of maize grains (Abbasi *et al.*, 2022).

4.10. *Kernel protein percentage*

According to Table 3, the interactions between stress × zeolite, stress × magnetic field, zeolite × magnetic field, and the three-way interaction of stress × zeolite × magnetic field significantly affected the kernel protein percentage at the 1% probability level. The highest kernel protein percentage (9.65%) was recorded in the treatment with 60% stress combined with zeolite and magnetic field 100-15, while the lowest protein percentage (5.80%) was observed in the treatment with 60% stress without zeolite and magnetic field (Table 4). Research by Ahmadi *et al*. (2021) indicates that the use of zeolite under drought stress conditions significantly increases the kernel protein percentage in maize kernels. This study highlights that zeolite enhances soil moisture retention and mitigates the adverse effects of drought stress, thus improving the protein content of maize grains. Additionally demonstrated that magnetic field application under drought stress conditions leads to an increase in kernel protein percentage in maize kernels. This study suggests that magnetic fields enhance the activity of protein synthesis enzymes, thereby improving the protein quality of maize grains (Abbasi *et al.*, 2022).

5. CONCLUSION

This study shows that zeolite and magnetic fields positively impact corn traits under water stress. Cob length and thousand-kernel weight were highest under 100% stress with zeolite and a magnetic field of 15-100. Fresh and canned product yields peaked at 80% stress with a magnetic field of 15-100. Leaf area index and growth rate were highest at 80% stress, zeolite, and a magnetic field of 15-50. Additionally, net water absorption and starch and protein content were affected by the interactions of stress, zeolite, and magnetic fields. These findings suggest that zeolite and magnetic fields can optimize corn cultivation under water stress, improving both yield and quality.

6. ACKNOWLEDGMENT

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Table 3. Analysis of Variance for the Effects of Zeolite and Magnetic Field on Growth Parameters and Quantitative and Qualitative yield of Sweet Corn under Drought Conditions

Treatments	df	Cob length	1000 kernel weight	Fresh cob yield	Canned Kernel yield	Kernel per row	LAI	CGR	NAR	Strach	Protein
Year	1	0.55^{ns}	2.68^{ns}	2164820^{ns}	734211^{ns}	0.005^{ns}	0.05^{ns}	0.29^{ns}	0.0004^{ns}	0.09^{ns}	0.10^{ns}
Year *Rep	4	5.80	4478	22861971	210589584	31.27	0.06	0.20	0.11	302.27	0.25
Stress	2	6.15^{ns}	9757^{ns}	72105308**	349350913^{ns}	13.95^{ns}	4.03**	2.37**	0.71*	443.62**	16.86**
Year * Stress	2	1.48^{ns}	0.87^{ns}	1191486^{ns}	825843^{ns}	0.83^{ns}	0.01^{ns}	0.03^{ns}	0.03^{ns}	22.12^{ns}	0.02^{ns}
Error (a)	8	3.01	1341	5790978	167128866	43.9	0.13	0.16	0.12	232.50	0.90
Zeolite	1	57*	19653*	110544020^{ns}	195919164*	95.33*	4.42**	2.47**	0.0009^{ns}	266.45^{ns}	2.81**
Year * Zeolite	1	1.18^{ns}	0.55^{ns}	480500^{ns}	719975^{ns}	0.05^{ns}	0.0001^{ns}	0.05^{ns}	0.14^{ns}	280.75^{ns}	0.34^{ns}
Stress * Zeolite	2	1.26*	8765^{ns}	35589247^{ns}	1727780140*	29.9*	0.31*	0.27^{ns}	0.32^{ns}	106.93^{ns}	47.97**
Year * Stress * Zeolite	2	0.0007^{ns}	1.48^{ns}	2230607^{ns}	787201^{ns}	0.15^{ns}	0.0007^{ns}	0.01^{ns}	0.06^{ns}	130.03^{ns}	1.18*
Magnetism	4	10.6^{ns}	5401^{ns}	272808956**	647765857^{ns}	58.79^{ns}	1.33**	0.65**	0.86**	518.96**	7.11**
Year * Magnetism	4	0.79^{ns}	2.28^{ns}	1349442^{ns}	481273^{ns}	0.43^{ns}	0.08^{ns}	0.10^{ns}	0.2^{ns}	67.53^{ns}	0.83*
Stress * Magnetism	8	31.5*	3259*	185106042*	357098911^{ns}	29.47^{ns}	0.55**	0.35**	1.45**	397.14**	2.74**
Year * Stress * Magnetism	8	0.47^{ns}	1.96^{ns}	1605776^{ns}	529539^{ns}	1.33^{ns}	0.14^{ns}	0.05^{ns}	0.13^{ns}	20.07^{ns}	0.48^{ns}
Zeolite * Magnetism	4	60.75**	9134*	93768376*	515443669^{ns}	42.10**	0.14^{ns}	0.19^{ns}	0.05^{ns}	138.41^{ns}	1.31**
Year * Zeolite * Magnetism	4	0.36^{ns}	1.18^{ns}	1841733^{ns}	472353^{ns}	1.03^{ns}	0.05^{ns}	0.12^{ns}	0.09^{ns}	49.43^{ns}	0.28^{ns}
Stress * Zeolite * Magnetism	8	7.8**	7541**	65341336^{ns}	482902325^{ns}	22.98^{ns}	0.91**	0.57**	0.06^{ns}	576.11**	2.32**
Year * Stress * Zeolite * Magnetism	8	0.6^{ns}	1.98^{ns}	1427407^{ns}	549706^{ns}	0.61^{ns}	0.12^{ns}	0.07^{ns}	0.13^{ns}	46.39^{ns}	0.43^{ns}
Error (b)	108	13.3	3598	75625734	441131257	28.10	0.08	0.09	0.20	106.15	0.32
CV (%)		9.5	18.07	23.09	18.07	13.07	20.28	33.58	57.62	14.18	7.23

^{ns}, * and **: no significant, significant at 5% and 1% probability level, respectability.

Table 4. Comparison of Mean Effects of Stress × Zeolite × Magnetic Field Interactions on Various Growth Parameters and Quantitative and Qualitative yield of Sweet Corn under Drought Conditions

Treatments	Cob length (cm)	1000 kernel weight (g)	LAI	CGR	Strach(%)	Protein (%)
S1× Z× M1	36.16^{bcdef}	281.67^{defg}	1.25^{fg}	1.07^{gbcdefhi}	64.48^{jfghi}	7.23^{ikhj}
S1× Z× M2	38.33 ^{abcdef}	369.5^{ab}	1.81^{c}	1.5^{ab}	77.63^{ebcdfgh}	6.68^{ikj}
S1× Z× M3	37^{abcdef}	380.83^{a}	1.74^{cd}	1.34^{abcde}	67.18 ^{efghi}	7.03^{ikhj}
St1× Z× M4	34.83^{ef}	373.33^{ab}	1.84^{c}	1.46^{abc}	72.76 ^{cdefghi}	6.53^{ikm}
Stress1× Z× M5	41^{a}	313.33^{abcdefg}	1.77^{cd}	1.36^{abcd}	70.96^{cdefghi}	6.96^{ikhj}
S1× NZ× M1	36.66 ^{bcdef}	323.33^{abcdef}	1.51^{cdef}	1.16^{gbcdefh}	76.38^{bcdefghi}	6.81ikj
S1× NZ × M2	38.66 ^{bcdef}	337^{abcdef}	1.14^{fg}	0.84^{gjhi}	63.65^{jhi}	8.96^{Abcd}
S1× NZ × M3	41^{a}	344.17^{abcd}	1.75^{cd}	1.11^{gbcdefhi}	73.1 ^{cdefghi}	9.13 ^{abc}
S1× NZ × M4	38.66 ^{bcdef}	280^{defg}	1.77^{cd}	1.22^{gbcdef}	74.31 ^{cdefghi}	9.05 ^{abc}
S1× NZ × M5l	38.66 ^{bcdef}	333.33^{abcdef}	1.47^{cdef}	0.74^{jhi}	67.33edfghi	8.08^{fge}
S2× Z× M1	39.33 ^{abCd}	351.67^{abcd}	2.64^{a}	1.70a	93.46^{a}	9.37^{ab}
S2× Z× M2	39.66^{abc}	296.67^{cdefg}	1.45^{cdefg}	0.87^{gjhi}	71.36^{ecdfghi}	8.93 ^{abcd}
S2× Z× M3	34.66^{ef}	371^{ab}	1.80^{c}	1.01^{gdefhi}	87.78^{ab}	8.63 ^{bcde}
S2× Z× M4	36.66 ^{bcdef}	339.67^{abCde}	1.87^{b}	1.38^{abcd}	64.66^{jfghi}	8.2^{defg}
S2× Z× M5	35fd^{e}	266.67^{fg}	1.44^{cdefg}	0.73^{jhi}	73.98 ^{cdefghi}	7.71^{fgh}
S2× NZ × M1	38.66^{bcdef}	270^{efg}	1.26^{fg}	0.83^{gjhi}	79.78 ^{bcde}	8.8^{bcde}
S2× NZ × M2	36.33 ^{bcdef}	350^{abcd}	1.53^{cdef}	1.03^{gcdefhi}	78.58 ^{bcdef}	9.05^{abc}
S2× NZ × M3	38.33 ^{bcdef}	336.67^{abcdef}	1.49^{cdef}	1.34^{abcde}	78.68 ^{bcdef}	8.86^{abcde}
S2× NZ × M4	40.33^{ab}	333.67^{abcdef}	1.68^{cde}	1.316^{abcdef}	65.35jfghi	7.43^{ighj}
S2× NZ ×M5	35.66^{cdef}	313.33^{abcdefg}	1.05^{g}	0.77^{jhi}	64jghi	7.65^{igh}
S3× Z× M1	34.33^{f}	313.33^{abcdefg}	1.32^{efg}	0.9233^{gjefhi}	68.66 ^{cdefghi}	8.46 ^{cdef}
S3× Z× M2	40.33^{ab}	337^{abcdef}	1.55^{cdef}	0.7283^{jhi}	73 ^{cdefghi}	8.5^{cdef}
S3× Z× M3	37 ^{abcdef}	327.33^{abcdef}	1.42^{cdefg}	1.165^{gbcdefh}	77.98 ^{cdefgh}	9.65^{a}
S3× Z× M4	35fd^{e}	357.5^{abc}	1.82^{c}	1.09^{gbcdefhi}	81.5^{abcd}	8.66^{bcde}
S3× Z× M5	39.33cadb	313.33^{abcdefg}	0.58^{i}	0.853gjhi	62.5^{ji}	7.216^{ikhj}
S3× NZ × M1	37.83 ^{bcdef}	303.67^{bcdefg}	1.37^{defg}	0.89gjfhi	70.66 ^{cdefghi}	6.86^{ikj}
S3× NZ × M2	37.83 ^{bcdef}	243.33^{g}	0.87^{i}	0.52^{j}	82.63^{abc}	6.53^{ikm}
S3× NZ × M3	40.33 ^{ab}	306.67^{bcdefg}	1.27^{efg}	1.04^{gcdefhi}	71.9 ^{cdefghi}	5.95^{im}
S3× NZ × M4	38.83 ^{abcde}	250.83^{g}	0.80^{i}	0.15^{K}	52.56^{j}	7.06^{ikhj}
S3×NZ× M5	22.5^{g}	163.33^{h}	0.65^{i}	0.67^{ji}	72.5 ^{cdefghi}	5.8^{m}

Mean followed by similar letters in each column are not significant different at 1% according to duncan Multiple Rang Test. (S1:Stress100, S2:Stress100, S3:Stress100, Z: Zeolite, NZ: No Zeolite, M1: Magnetism 15-50, M2: Magnetism 30-50, M3: Magnetism 15-100,M4: Magnetism 30-100, M5:Control)

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