The effects of applying agricultural polymers and altering watering frequency on the availability of iron and zinc in the soil, as well as the growth characteristics of wheat plants (*Triticum aestivum* L.) grown in sandy soil.

Zainab Nafeh Awwad Al-Amiri [1] **Hanoun N. Kadhem Al-Baraka[2]**

[1,2]Soil and Water Resources Department / College of Agriculture / Al-Muthanna University

E.mail: [1] zainabnafie98@gmail.com , [2] reda@mu.edu.iq

Abstract

The purpose of this study was to examine the effects of agricultural polymer application and irrigation frequency on soil nutrient levels and wheat yield in sandy soil. The research was conducted at the Al-Bandar Research Station of the College of Agriculture - Al-Muthanna University during the agricultural season of 2022-23. The study employed a split-plot design with three replications. The experimental design comprised five levels of agricultural polymer, labeled as P0, P1, P2, P3, and P4, which were administered at rates of 0, 25, 50, 75, and 100 kg ha-1, correspondingly. The secondary plot was assigned these levels of irrigation. labeled as R1, R2, R3, and R4, representing 6, 7, 8, and 9 instances of watering, respectively.

The findings of the statistical analysis indicate that the inclusion of varying amounts of agricultural polymer resulted in enhanced plant characteristics. Specifically, when the polymer level exceeded P3 (75) kg polymer ha-1, there was a significant increase in plant height, chlorophyll content, iron content, and zinc content. The average values for these characteristics were 104.03 cm, 51.19 spad, 2.51 mg Fe kg-1 soil, and 0.600 mg Zn kg-1 soil, respectively.

The observed traits were significantly influenced by the bilateral relationship between the levels of the agricultural polymer and the frequency of irrigation.

Keywords: agricultural polymer, SAP, irrigation number, Zn, Fe, wheat.

Introduction

Iraq is a nation that experiences water scarcity and severe climate change, resulting in adverse effects on plant growth (1). The situation is further exacerbated by the escalating water resource crisis in arid and semi-arid regions, including Iraq. This crisis is characterized by a rise in drought conditions caused by reduced rainfall retention, elevated temperature levels, and decreased water availability. Given the significant volumes of water present in the Tigris and Euphrates rivers, it becomes imperative to employ rigorous scientific approaches in order to enhance the efficacy of water utilization by plants. This can be achieved through the implementation of economic irrigation techniques aimed at conserving water or by augmenting the capacity of plants to withstand periods of drought (2).

The wheat crop, scientifically known as *Triticum aestivum* L., is a significant agricultural commodity that holds nutritional significance and has a substantial impact on global economies. Wheat grains, which belong to the Poaceae family, are widely consumed and rank as the top food commodity for consumers. This is primarily due to their ability to fulfill over 50% of an adult's energy requirements and provide approximately 25% of their protein intake (3).

A variety of soil conditioners have been employed in agricultural practices to enhance specific soil attributes, with agricultural polymers emerging as particularly significant (4,5). Agricultural polymers refer to synthetic organic compounds that exhibit white crystalline properties reminiscent of table sugar. These compounds possess hydrophilic characteristics and demonstrate resistance to biological degradation in natural environments. The phenomenon under consideration leads to the build-up of gaseous emissions (6).

The objective of our study was to investigate the impact of agricultural polymer application and irrigation frequency on wheat and the concentration of Fe, Zn nutrients in soil.

Materials and methods

The Al-Bandar research station of the College of Agriculture, Al-Muthanna University, served as the location for a field experiment conducted during the agricultural season of 2022-2023. The purpose of this study was to examine the effects of applying agricultural polymers and altering irrigation frequencies on specific characteristics and the growth of wheat.

Soil samples were collected from the field at a depth ranging from 0 to 30 cm. The aforementioned samples were subsequently subjected to a drying and grinding process in order to evaluate specific soil properties prior to the commencement of planting activities. Table 1 provides a comprehensive overview of the distinct attributes of the soil.

The study employed an experimental design that utilized a split-plate S.P.D design, which incorporated a split-plate system. The experimental design comprised of three replications, wherein each replication was composed of 20 experimental units. As a result, the overall quantity of experimental units reached a total of 60. The primary panels were specifically designated for the purpose of facilitating irrigation, whereas the secondary panels were allocated for the application of agricultural polymers. The experimental design encompassed five distinct levels of agricultural polymer (P) combined Mixed with soil (0, 25, 50, 75, and 100 kg ha-1 polymer), referred to as P0, P1, P2, P3, and P4, correspondingly, Table 2 displays the attributes of the agricultural polymer.

In conjunction with four discrete irrigation levels (6, 7, 8, and 9) and their corresponding symbols (R1, R2, R3, and R4).

Table 1 the chemical and physical properties exhibited by the soil sample prior to the commencement of planting.

chemical properties	**pH**	**ECe(dS m-1)**	**CEC (C mole kg-1)**	**O.G**	**N(mg kg-1)**	**P(mg kg-1)**	**K(mg kg-1)**	**Zn**	**I**
	7.8	4.14	13.5	0.86	21.8	13.53	174	0.32	1.98
physical properties	**Sand**	**silt**	**clay**	**Soil texture**					
	67.15	18.54	14.31	sandy loam					

The planting occurred on November 20, 2022. Nitrogen fertilizer was applied at 150 kg N-1 as 46% urea. The first batch was administered ten days after planting for germination, and the second one and a half months later. For phosphorus, triple super phosphate fertilizer with 20% phosphorus was administered at 100 kg P ha-1 during planting. Potassium was also supplied with 120 kg K ha-1 of 42% potassium sulphate fertilizer during planting(7).

ISSN 2072-3857

Studied traits: plant height (cm), leaf area (cm2):according to (8)**, chlorophyll levels:** were measured using a Spad 520-meter (Special Production Analysis Division) during the flowering stage, **Iron in the soil at the harvest stage (mg Fe kg-1 of soil)**: Extraction of ready iron according to (9) method (using Atomic Absorption Spectrophotometric), **The concentration of zinc in the soil at the harvest stage (mg Zn kg^{-1} soil).**: using atomic absorption spectroscopy (9).

The statistical analysis of the data was conducted using the software program Genstat. The mean values were compared using the least significant difference (L.S.D) test at a significance level of 0.05, as described by (10)

Table (2) Characteristics of agricultural polymers**.**

product name	SOCO Polymer SAP (Polyacrylate Potassium)
Chemical formula	(C3H5KO2)n (C3H6O2)m
exterior	White granular powder
Molecular main chain	carbon chain polymer
physical property	Non-toxic, harmless, non-polluting
Function	Drought control, soil improvement, water retention
water adsorption	350-1200 times
size	5-20 , 20-80 , 30-100 mesh
pH	6-8
EC	0.05
K	18.3 %

Results and discussion

Plant height (cm)

The findings from Table 3 demonstrate that the introduction of agricultural polymer at various levels had a significant impact on plant height. Notably, when the polymer addition exceeded 75 kg per hectare (ha-1), the plant height increased to 104.03 cm, representing a 4.9% increase compared to the control group (P0) which had a height of 98.63 cm. The potential cause can be attributed to the incorporation of the polymer, which contributed to the preservation of nutrients and enhanced their availability. This includes nitrogen, a crucial element responsible for cellular elongation and division, consequently influencing plant height (11, 12).

The findings presented in Table 3 indicate that there were statistically significant variations in the overlap coefficients pertaining to the levels of agricultural polymer and the frequency of watering with respect to the plant height characteristic. Specifically, the overlap treatment R4P1 yielded the highest average plant height of 107.33 cm, whereas the lowest average was observed in the overlap treatment R4P4 at a rate of 94.80 cm.

ISSN 2072-3857

This discrepancy may be attributed to a certain factor or factors. The provision of diverse polymer concentrations and the occurrence of balanced watering intervals between each concentration create favorable environmental conditions for plant development. This phenomenon can be attributed to the role of agricultural polymers, which serve as a source of nutrients for plants due to their moisture-retaining properties. Additionally, these polymers help preserve essential nutrients that facilitate cell division and elongation, ultimately contributing to increased plant height.

Table 3 the impact of varying levels of agricultural polymer, the number of irrigation events, and their interaction on the concentration of plant height (cm)

Treatment	polymer					Average
irrigation	P0	P1	P2	P3	P4	
R1	98.60	96.63	101.33	103.20	101.80	100.31
R2	102.53	97.13	103.80	105.53	106.40	103.08
R3	96.20	104.53	99.67	105.40	103.87	101.93
R4	97.20	107.33	101.93	102.00	94.80	100.65
Average	98.63	101.41	101.68	104.03	101.72	
L.S.D. 0.05	P=4.393		P*R=9.794		R=N.S	

Leaf area (cm2)

The data presented in Table 4 indicates that the inclusion of agricultural polymer at various concentrations did not have a statistically significant impact on the measurements of the flag leaf's area. Regarding the correlation between the coefficients of agricultural polymer levels and the frequency of watering, it is observed from the aforementioned table that there exist notable variations in this aspect. Specifically, the R1P4 treatment exhibited superior performance compared to R1P2, with an average of 73.42 cm2 for each treatment. Conversely, the R3P4 treatment displayed the lowest level of overlap, with an average of 57.23 cm2.

The observed significant effect may be attributed to the polymer's function as a nutrient-releasing agent, serving as a preservative for the elements present in the soil solution. Additionally, certain nutrients play a crucial role in root development, particularly in the growth of root hairs which possess a heightened capacity for water and nutrient absorption, including various elements. This positive impact on plant growth is well-documented (11).

ISSN 2072-3857

Table 4 the impact of varying levels of agricultural polymer, the number of irrigation events, and their interaction on the concentration of leaf area (cm2)

Treatment	polymer					Average
irrigation	P0	P1	P2	P3	P4	
R1	71.26	62.09	73.42	70.20	73.42	70.08
R2	67.13	62.12	61.10	73.03	72.31	67.14
R3	57.32	71.24	63.90	60.79	57.23	62.10
R4	61.33	70.38	61.81	67.10	63.94	64.91
Average	64.26	66.46	65.06	67.78	66.73	
L.S.D. 0.05	P=N.S		P*R=13.838		R=N.S	

Chlorophyll (SPAD).

According to the findings presented in Table 5, it can be observed that the application of the agricultural polymer had a notable impact on the chlorophyll content values. Specifically, the agricultural polymer resulted in the highest chlorophyll content values, with average readings of 51.19 and SPAD 49.21. These values exhibited an increase rate of 10.2% and 5.9% respectively, when compared to the treatment P0, which did not involve the addition of any substances and yielded the lowest average chlorophyll content reading of 46.45 SPAD.

The potential explanation for this phenomenon may be attributed to the polymer's function in facilitating the retention of essential plant nutrients and water, thereby creating an optimal growth environment. Additionally, the presence of inspiration plays a crucial role in promoting vegetative growth and enhancing the efficiency of photosynthesis processes. Furthermore, inspiration stimulates growth and division processes by serving as a valuable source of carbon and energy required for constructing photosynthetic components (13).

Based on the data presented in the table, it can be observed that the interaction between the levels of agricultural polymer and the frequency of watering had a statistically significant impact on the chlorophyll content values in the plant. Specifically, the treatment involving the overlap of agricultural polymer level R1P1 yielded the highest average chlorophyll content value of 51.83 SPAD, while the lowest value of 40.23 SPAD was recorded for the chlorophyll content in the R1P0 overlap treatment.

Table 5 the impact of varying levels of agricultural polymer, the number of irrigation events, and their interaction on the concentration of Chlorophyll (SPAD)

Treatment	polymer					Average
irrigation	P0	P1	P2	P3	P4	
R1	40.23	51.83	49.74	49.71	47.73	47.85
R2	50.14	51.31	47.75	48.92	46.61	48.95
R3	46.04	50.39	42.83	48.72	50.30	47.66
R4	49.39	51.23	51.27	49.50	47.09	49.70
Average	46.45	51.19	47.90	49.21	47.93	
L.S.D. 0.05	P=3.085		P*R=6.379		R=N.S	

ISSN 2072-3857

Iron (mg Fe kg^{-1} of soil)

The findings presented in Table 6 demonstrate statistically significant variations in the levels of soluble iron in the soil when an agricultural polymer is introduced at a rate of 2.51 mg Fe kg-1 soil in treatment P3 (75 kg ha-1), as compared to treatment P0 (no addition) which yielded a lower value of 2.09 mg Fe kg-1 soil.

The potential explanation for this phenomenon may be attributed to the capacity of the agricultural polymer to deliver water in close proximity to the root zone. The presence of hydrogen ions in abundance, and their subsequent concentration increase, can sustain the extent of soil interaction. Consequently, this can enhance the availability of microelements, such as iron. Alternatively, the favorable moisture conditions facilitated by the polymer may contribute to improved root growth, thereby aiding acid secretion. The use of organic materials in soil management aims to decrease the level of soil interaction, which subsequently affects the availability of iron in the soil (14).

Based on the findings presented in Table 6, it is evident that the interplay between the agricultural polymer and the frequency of irrigations has resulted in an augmentation of the soil's iron availability post-harvest. Specifically, the treatment denoted as overlap R2P3 exhibited the highest average value of 2.69 mg Fe kg-1 soil, while the lowest average amount of available iron in the soil was observed in a different treatment. The data was acquired from the two interactions, R2P2 and R4P1, resulting in Fe concentrations of 1.97 and 1.94 mg Fe kg-1 soil, respectively.

The potential explanation for this phenomenon may lie in the utilization of agricultural polymers, which possess the capacity to retain moisture (table 2), coupled with the judicious application of irrigation. These practices are believed to contribute positively to the enhancement of soil nutrient availability, including the element of iron.

Table 6 the impact of varying levels of agricultural polymer, the number of irrigation events, and their interaction on the concentration of Iron (mg Fe kg-1 of soil)

Treatment	polymer					Average
irrigation	P0	P1	P2	P3	P4	
R1	2.08	2.15	2.44	2.40	2.45	2.31
R2	2.14	2.21	1.97	2.69	2.49	2.30
R3	2.13	2.13	2.06	2.42	2.42	2.23
R4	2.01	1.94	2.18	2.53	2.27	2.18
Average	2.09	2.11	2.16	2.51	2.41	
L.S.D. 0.05	P=0.222		P*R=0.455		R=N.S	

Zinc (mg Zn kg^{-1} soil)

The findings presented in Table 7 demonstrate that the inclusion of varying concentrations of agricultural polymer resulted in notable variations in the soil's zinc availability. Specifically, the P1 treatment exhibited a superior performance, with a rate of 0.776 mg Zn kg-1 of available zinc in the soil, in contrast to the P0 level which displayed the lowest average quantity. The concentration of zinc in the soil was measured to be 0.509 mg Zn kg-1 soil.

The potential cause for this phenomenon can be attributed to the incorporation of agricultural polymers, which have enhanced the physical and chemical characteristics of

ISSN 2072-3857

the soil, as well as its fertility. Additionally, these polymers possess a high capacity for moisture retention, thereby reducing soil compaction and subsequently facilitating the release of various nutrients in the soil, particularly zinc (11).

Based on the findings presented in Table 7, it is evident that the interaction between the agricultural polymer and the frequency of irrigations has resulted in an elevation of zinc levels in the soil post-harvest. Specifically, the treatment labeled as "overlap R4P1" exhibited the highest average zinc content of 0.924 mg Zn kg-1 soil, while the lowest average zinc content of 0.118 mg Zn kg-1 soil was observed in the treatment labeled as "Interference R2P4".

One possible explanation for this phenomenon could be attributed to the efficacy of the agricultural polymer in water retention, soil aeration, enhancement of soil structure, and reduction of apparent density. Alternatively, the presence of the agricultural polymer may be responsible for facilitating a favorable pH environment for zinc, as its availability in the soil is contingent upon pH levels. In addition to its function in the process of conserving elements within the soil (15).

Table 7 the impact of varying levels of agricultural polymer, the number of irrigation events, and their interaction on the concentration of Zinc (mg Zn kg- 1 soil)

Treatment	polymer					Average
irrigation	P0	P1	P2	P3	P4	
R1	0.650	0.603	0.627	0.660	0.684	0.645
R2	0.695	0.836	0.839	0.844	0.118	0.666
R3	0.234	0.740	0.549	0.760	0.795	0.616
R4	0.455	0.924	0.765	0.135	0.642	0.584
Average	0.509	0.776	0.695	0.600	0.560	
L.S.D. 0.05	P=0.1883		P*R=0.3654		R=N.S	

Conclusions

Based on the findings of this research, it can be inferred that the incorporation of the agricultural polymer, along with an increased frequency of irrigation, positively influenced the growth and yield attributes of plants. This effect was observed when the agricultural polymer was applied at a rate of 75 kg per hectare.

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ISSN 2072-3857