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Article

Effect of Irrigation Methods and potassium spray on the growth, yield, and water use efficiency of Sorghum Grown in degraded soil

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ABSTRACT

A factorial field experiment was implemented using a randomized complete block design (RCBD)[1] with three replicates To study the effect of the interaction between different irrigation methods and potassium spraying on the productivity of sorghum bicolor L in silty loam at the experiment station of the Agricultural Research Department, Ministry of Agriculture located in the Abu Ghraib area for the autumn season 2021. The experiment included five treatments for different irrigation methods: Cultivation of seeds in the underside of furrow and drip irrigation l1, Cultivation of seeds in tops of furrow and drip irrigation l2, Cultivation on the surface and irrigation inside the plot with drip irrigation l3, cultivation of seeds in the underside of furrow and surface irrigation l4, Cultivation of seeds in tops of furrow and surface irrigation l5. As for the subplot, it included three treatments: one spray of potassium in the eight-leaved stage (K1), two sprays, the first at the eight-leaved stage and the second at the eight-leaved stage, and the spraying was repeated at the ten-leaved stage (K2), as well as a control treatment without spraying (K0) that was sprayed With distilled water only. It uses potassium sulfate fertilizer (K2SO4) as a source of potassium. The results indicate the excellence of the irrigation treatment of cultivation of seeds in the underside of the furrow and surface irrigation l4, and two sprays of potassium (K2) to give it the highest average plant height (147.17) cm. The number of grains per plant (3100), the weight of 500 grains (15.27) g, the grain yield (3.31) tons ha-1 and the biological yield (18.80) tons ha^{-1}. The treatment of cultivation of seeds in the tops of furrow and drip irrigation l2had the highest mean leaf area (665.8) cm^2 and harvest index (17.84)% and the treatment of cultivation on the surface and irrigation inside the drip plots(l3)) recorded the highest efficiency of water use amounted to (0.689) kg m^{-3}.

Keywords: irrigation methods, potassium, growth, yield and water, sorghum grown, degraded soil

INTRODUCTION

Large areas of Iraqi lands are exposed to soil deterioration due to natural factors such as drought, high temperatures and increased evaporation rates or human factors resulting from mismanagement and use of these lands 2. The deterioration is physical, as if there is a deterioration in the composition of the soil, its exposure to erosion, or chemical deterioration, such as a high degree of salinity or the interaction of the soil. Therefore, the cultivation of field crops in such soils needs to control the practices of the field factors of production in proportion to the surrounding conditions (climate and soil factors). Field practices include choosing the appropriate crop that bears and responds to the surrounding environmental factors better than others, as well as the appropriate selection of the cultivar, cultivation method, irrigation method, and fertilization method. Since salinity deterioration is the prevailing name for most of the Iraqi soils, the selection of sorghum, which is characterized by its tolerance to salinity conditions, drought, and high temperatures compared to other summer grain crops such as corn and millet, and its tolerance for cultivation in degraded lands, has a higher comparative advantage than other crops[4] Choosing an appropriate method for irrigating sorghum in light of the acute crisis of water shortage, high temperatures and recurring droughts as a result of climate change. The selection of the irrigation method that includes a homogeneous distribution of soil moisture in the root zone and reducing the losses to the least possible in order to achieve the best growth and the highest efficiency of water use, which is the main source of the irrigation process in the dry and semi-arid areas [5]. The drip irrigation method is widely used in producing field crops such as sorghum, corn, cotton, and soybeans [6, 7]. However, its use by farmers in Iraq is still limited, so traditional irrigation is practiced (Tourist irrigation or Palmroz), The latter is less control over water management, which increases the percentage of waste and may cause problems to the soil such as salinization and waterlogging [7, 8]. [9] found that the use of drip irrigation method in sorghum cultivation causes an increase in growth traits such as leaf area, plant height, grain yield and its components, biological yield and harvest index compared to the traditional irrigation method [10]. while other researchers obtained a higher efficiency of water use with drip irrigation compared to conventional[11]. Potassium is an essential nutrient for the growth and yield of most field crops, including sorghum, as the plant needs relatively large quantities [12]. Because of its physiological and nutritional role for the plant [13], especially in stimulating many enzymatic reactions in the plant, controlling the movement of closing and opening stomata, and encouraging the transport process inside the plant [12]. Therefore, supplying the plant with potassium in the right quantity, time, and method requires knowledge and control. As potassium fertilizers are characterized by high prices compared to nitrogen and phosphate fertilizers, their availability may decrease when added to the soil, especially under high salinity conditions 15. Several researchers have used potassium by spraying on plants and given encouraging results in increasing the growth and yield [16]. Based on what was mentioned above, the importance of this study is to know the effect of irrigation method and water distribution in the root zone of the plant and the possibility of adding potassium as a spray on plants in the growth, yield and efficiency of water use of sorghum grown in saline soil using well water under the conditions of the central region in Iraq.

MATERIALS AND METHODS

To know the effect of irrigation method and potassium spray on the growth, yield and water efficiency of sorghum (Sorghum bicolor L), A field experiment was conducted in the season 2021 at the experiment station of the General Authority for Agricultural Research / Ministry of Agriculture located in the Abu Ghraib region, located at latitude of 33 17" 31 north, length 44 03" 56 east, and 35 meters above sea level in silty loam soil. The experiment had left Bora for several years, contributing to the high salinity rate, which may reach more than 6 $ds.m^{-1}$ The experimental land was tillage using Moldboard plows for one time and smoothed with disc harrows. DAP fertilizer (18-46-0) was added before cultivation in 160

$kg.ha^{-1}$ As it was mixed with the soil, as for nitrogen fertilizer, it was added in the form of urea (46% N) at an average of 200 kg ha-1, and in two batches, the first after the completion of field emergence and the second after (30) days from the emergence stage [17]. The experiment land was divided into plots according to the aandomized complete block design (RCBD)[1] aarrangement with three replicates. The experiment included five treatments for different irrigation methods:

- Cultivation of seeds in the underside of furrow and drip irrigation l1
- Cultivation of seeds in tops of furrow and drip irrigation l2
- Cultivation on the surface and irrigation inside the plot with drip irrigation l3
- Cultivation of seeds in the underside of furrow and surface irrigation l4
- Cultivation of seeds in tops of furrow and surface irrigation l5

The Alkhair cultivar's sorghum seeds were cultivated and sown in the pits methods line at the top or underside of the furrow or in the plots (according to the irrigation method proven in this study). The distance was 25 cm between one pit and 75 cm between one line and another. For all treatments, three seeds were placed in each pit, their seedlings thinning to one plant two weeks after emergence. As for the subplot, it included three treatments: one spray of potassium in the eight-leaf stage (K1), two sprays, the first at the eight-leaf stage and the second at the ten-leaf stage (K2), as well as a control treatment without spraying (K0), which was sprayed with distilled water only. The area of the experimental unit was 3 * 3 m, and these units were separated from each other by a distance of 1.5 m to prevent water leakage between the experimental units. Samples were taken from field soil at depths 0-10, 10-20, and 20-40, and a composite sample was made from it to analyze it and determine some of the soil's physical and chemical properties, as shown in Table (1).

units	values	Traits
$g.kg^{-1}$ soil	30.80	**sand**
	52.40	**silt**
	16.8	**clay**
-	Silty loam	**texture**
ds/m	6.10	**Electrical conductivity (EC)**
-	7.40	**Soil pH**
mg/kg	10.60	**available phosphorus**
	21.00	**available Nitrogen**
	302.00	**available potassium**
cm^{-3} cm^{-3}	32.74	**Volumetric moisture content at 0.3 bar (field capacity**
	17.63	**Volumetric moisture content at 15 bar (wilting point)**
	14.84	**available water**
mg/cm^{-3}	1.32	**Soil bulk density**

Table 1. Some physical and chemical properties of field soil before cultivation:

Using a network of pipes equipped with a counter to calculate the water used for each experimental unit, the irrigation process was conducted based on the depletion of 50% of the prepared water.
According to the equation in (Hassan, 1990)

$$P_w = \left(\frac{M_{sw} - M_s}{M_s} \right) 100 \quad (1)$$

Where:
Pw = weight moisture percentage %

Msw = mass of wet soil mg
Ms = mass of dry soil, mg

	Amounts of water added (m3 h^{-1})						
Drip irrigation for plants cultivated in the underside of furrow	Drip irrigation for plants cultivated in the upper third of the furrow	Drip irrigation for plants cultivated in lines inside flat plots	Irrigation by furrow for plants cultivated in the underside of furrow	Irrigation by furrow for plants cultivated in the upper third of the furrow	irrigation sequence	**Amount of irrigation water added (m3 h-1)**
200	200	200	400	400	1	
200	200	200				
200	200	200	400	400	2	
200	200	200				
200	200	200	450	450	3	
200	200	200				
200	200	200	450	450	4	
200	200	200				
1600	1600	1600	1700	1700	-	The volume of used water from cultivation to the stage of vegetative growth (m3 h-1)
200	200	200	500	500	5	
200	200	200				
200	200	200	500	500	6	
200	200	200				
200	200	200	500	500	7	
200	200	200				
1200	1200	1200	1500	1500	-	The volume of used water from the stage of vegetative growth to the stage of flow-ering (m3 h-1)
200	200	200	550	550	8	
200	200	200				
200	200	200	600	600	9	
200	200	200				
200	200	200	600	600	10	
200	200	200				
200	200	200	600	600	11	
200	200	200				
200	200	200	600	600	12	
200	200	200				
2000	2000	2000	2950	2950	-	The volume of water used from the flowering stage to physiological maturity (m3 h-1)
4800	4800	4800	6150	6150	-	The volume of water used for irrigation for the season (M3H-1)
24	24	24	12	12	_	Total irrigation during the season

Table 2. The number of irrigations and the quantities of water added (m3 h-1) for the experiment treatment during the crop's growing season.

The weighted method was adopted to calculate the moisture percentage and to determine the amount of water to be added to each irrigation for a depth of 40 cm. Table (2) shows the number of irrigations and the amount of irrigation added in the season and for each treatment.

The experiment included 0 and 1000 mg K L-1 (K0, K1, K2). They were added by spraying on the vegetative growth at the six-leaf stage (K1), and the spray was repeated when the (K2) treatment was sprayed at the six-leaf stage, and the spraying process was repeated In the ten-leaf stage, its source is potassium sulfate (K2SO4). As for K0, it was sprayed with distilled water only. Thus, the required concentrations were prepared by dissolving 4.46 (K2SO4) in each liter to obtain the concentrations of 1000 mg K L-1 for each spray. It showed plants' height, leaf area and chlorophyll index at the stage of completion of head emergence. Ten plants were randomly selected from the middle lines after obtaining complete dryness. The number of grains per head was calculated, the weight of 500 grains was calculated, and the average was extracted for the ten plants. The plants of each experimental unit were harvested to calculate the biological yield. The total yield of the experimental unit was extracted by discarding the heads of the plants of each plot. The yield of the ten plots previously taken was added to it. The harvest index was extracted by dividing the grain yield by the biological yield of each experimental unit. As for the efficiency of field water use (WUE f), it was calculated from the product of dividing the grain yield by the amount of water used for each experimental unit, as in the following equation mentioned in [18].

$$WUE\ f = Y / WA \tag{2}$$

Since:
WUE f = Field Water Use Efficiency (kg m^{-3})
Y = grain yield (kg ha^{-1})
WA = Total seasonal water amount added to irrigate the crop (m^3 ha^{-1}) WA

2.1. Statistical analysis.

The data were statistically analyzed using the analysis method of variance. The statistical program Genstat (2012) V.12 was adopted according to the design used, and the averages were compared using the Least Significant Difference (LSD) test at the 0.05 level [19].

3. Results

3.1. Field Water Use Efficiency (WUE f).

The amount of water used to produce one gram of dry matter is expressed by the water use efficiency, and [18] defined the water use efficiency (WUE f) as the yield of each volume of water used to produce that yield. Results in Table (3) showed a significant effect of irrigation methods on water use efficiency. At the same time, there was no significant interaction between spraying potassium fertilizer and the interaction between irrigation methods and potassium fertilizer. The results in Table (3) show that the highest efficiency of water use was obtained from the drip irrigation method (I3), which amounted to 0.689 kg m^{-3}, which differed significantly from treatment (I2) which gave 0.641 kg m^{-3} and from treatment (I1) which gave 0.630 kg m^{-3}, Whereas, the irrigation treatments with farrows(I4) and (I5) gave the lowest mean, which was 0.537 kg m^{-3} and 0.521 kg m^{-3}, and they did not differ significantly. This agrees with [20 and 21], who indicated that drip irrigation increases the efficiency of water use by the crop. The results are also consistent with the results of [22] and [11], which showed that irrigation water use efficiency was higher when using the drip irrigation method. [6] also found that water use efficiency is at its best when using the drip irrigation method.

potassium fertilization				irrigation methods
averages	K_2	K_1	K_0	
0.630	0.725	0.633	0.532	**I_1**
0.641	0.714	0.640	0.570	**I_2**
0.689	0.758	0.712	0.588	**I_3**
0.537	0.615	0.537	0.490	**I_4**
0.521	0.615	0.560	0.389	**I_5**
0.03	NS			**LSD 0.05**
	0.725	0.618	0.507	**average**
	NS			**LSD 0.05**

Table 3. The effect of irrigation methods and potassium spray on the efficiency of water use for sorghum (kg m-3) 2022

Plant height (cm)

The statistical analysis results showed that the height of sorghum plants had a significant effect on the method of irrigation and spraying with potassium and the interaction between them. Table (4) indicates that the irrigation treatment of sorghum plants grown on the underside of furrow (l4) gave the highest average plant height of 147.17 cm. In comparison, drip irrigation for plants grown in the underside of the furrow (l1) gave the lowest average of 114.53 cm. These results were consistent with what was mentioned in [11, 23, and 24,] that the height of sorghum plants is affected by different irrigation methods. Also, two sprays of potassium (K2) gave the highest average plant height of 145.01 cm compared to no spraying (K0), which gave the lowest average for the trait, 116.27 cm. As the increase was about 20%, [25,26, 27, 28, 29] stated that the height of maize plants White increases significantly with increasing potassium concentration and number of sprays. Table (4) shows that the highest response to potassium spray was with the irrigation treatment (I5), as the plant height increased from 108.20 cm under no spraying (K0) to 135.7 cm under one spray (K1), and the highest response to two sprays treatment with potassium was to the I4 irrigation treatment. It increased from 142.4 cm under (K1) to 161.70 cm under (K2).

potassium fertilization				irrigation methods
averages	K_2	K_1	K_0	
114.53	115.50	117.47	110.53	**I_1**
124.53	142.07	124.60	106.93	**I_2**
137.72	155.73	139.27	118.33	**I_3**
147.17	161.70	142.4	137.33	**I_4**
131.29	149.93	135.7	108.20	**I_5**
4.353	6.956			**LSD 0.05**
	145.01	131.91	116.27	**averages**
	3.188			**LSD 0.05**

Table 4 . Effect of irrigation methods and potassium spray on the height of sorghum plant (cm) for the autumn season 2022

Leaf area cm²:

The statistical analysis results showed a significant effect of irrigation methods and potassium spray and the interaction between them on the leaf area of sorghum plants. Table (5) shows that the drip irrigation method for plants grown at the top of Al-Merz (I2) gave the highest mean leaf area of 665.8 cm2. This did not differ significantly from treatment (I4), which gave an average of 649.3 cm2, and these results confirmed what was mentioned by [11, 23, and 24], that the leaf area of sorghum is significantly affected by the used irrigation method. Table (5) shows that two sprays of potassium (K2) gave the highest mean of leaf area of 700.4 cm2, while treatment (k0) gave the lowest mean of the trait, which was 513.3 cm2. These results are consistent with what [30 and 31] mentioned, that the leaf area of sorghum increases by increasing the number of sprays with potassium and up to three sprays or by increasing the potassium concentration.

potassium fertilization				irrigation methods
averages	K_2	K_1	K_0	
612.3	669.9	626.6	540.5	**I_1**
665.8	710.1	698.6	588.9	**I_2**
612.6	691.0	612.6	534.3	**I_3**
616.0	712.1	664.3	471.6	**I_4**
618.4	718.9	615.2	521.1	**I_5**
27.22	NS			**LSD 0.05**
	700.4	643.5	513.3	**averages**
	43.73			**LSD 0.05**

Table 5. Effect of irrigation methods and potassium spray on the leaf area of sorghum (cm2)

Weight 500 grain(g).

The statistical analysis results showed that the weight of 500 grains of sorghum had a significant effect on irrigation methods and potassium fertilizer spraying and the interaction between them. Table (6) shows that the highest average weight of 500 grains was obtained from the irrigation method (l4), which was 15.27 g, followed by the irrigation method (3 (I 14.92 g and I5 (14.70 g). While treatment (l1) gave the lowest average of 13.12 g, [11] mentioned that the weight of the grain in sorghum is often affected by the irrigation method used. Table (6) shows that potassium spraying caused a significant increase in grain weight, where the (K2) treatment gave an average of 18.00 g, compared to the non-spray (K0), which gave the lowest average of 11.49 g. This is what [32] indicated: the weight of the grain is determined by the activity of the plant and the amount of metabolites available to grains. [33, 34, and 35] agreed with this result. The Table shows that the highest response was for the irrigation method (I3) under two sprays of potassium (I3K2), which gave 19.08 g, and the responses to the other treatments were close.

potassium fertilization				irrigation methods
averages	K_2	K_1	K_0	
13.12	16.74	12.79	9.84	**I_1**
13.70	17.15	12.57	11.38	**I_2**
14.92	19.08	13.70	11.97	**I_3**
15.27	18.70	14.97	12.14	**I_4**
14.70	18.31	13.68	12.12	**I_5**
0.60	1.02			**LSD 0.05**
	18.00	13.54	11.49	**averages**
	0.47			**LSD 0.05**

Table 6. Effect of irrigation methods and potassium spray on the weight of 500 grains (g)

Number of grains in inflorescence

The statistical analysis results showed that the number of grains per head was not affected by the irrigation method. In contrast, the effect of potassium spray and the interaction between irrigation methods and potassium spray was significant. Table (7) shows that the treatment of two sprays with potassium (K2) gave the highest average number of grains per head, which amounted to (3401 grains). While the control treatment (K0) gave the lowest average for the trait, amounting to (2539 grains), this result is consistent with what was mentioned (2000 IPI) that potassium spray leads to an increase in the number of grains per head in sorghum and that the increase in the number of sprays has a positive effect in increasing the number of grains per head, Where the results of some studies indicated that the use of potassium led to an increase in the rate of flowering and fertilization and this was positively reflected in the number of grains [36], and agrees with [37, 38]. Table (7) shows that drip irrigation of corn grown in the underside of the furrow gave the highest increase in the number of grains under the treatment of potassium (K2) spray compared to no spray, While the irrigation treatment (I2) gave the highest response in the number of grains for the head under the potassium spray (I2 K2) treatment, and this confirms the different irrigation methods in they responded to the potassium spray.

potassium fertilization				irrigation methods
averages	K_2	K_1	K_0	
2900	3267	2850	2583	**I_1**
2889	3217	2883	2567	**I_2**
3106	3417	3250	2650	**I_3**
3100	3555	3100	2645	**I_4**
3011	3550	3233	2250	**I_5**
NS	229.4			**LSD 0.05**
	3401	3063	2539	**averages**
	88.2			**LSD 0.05**

Table 7. Effect of irrigation methods and potassium spray on the number of grains in the inflorescence of the plant.

Grain yield (ton ha^{-1})

The results of the statistical analysis showed that the grain yield of sorghum had a significant effect on the irrigation methods and the spraying of potassium fertilizers and the interaction between them. Irrigation methods I3 and I4 gave the highest average grain yield of 3.31 (ton ha-1) each, followed by method I5, which gave 3.21 ton ha-1. Table (8) shows that the highest grain yield was obtained from two sprays of potassium (K2), which amounted to 3.69 tons ha^{-1}, compared to no spray, which gave the lowest average (2.59 tons ha^{-1}). These results confirm what was mentioned [39, 40]; these results are in agreement with the findings of [31, 37], who indicated that potassium spraying improved growth traits and increased yield components and then increased grain yield and that three sprays are better than Two or one sprayer. Table (8) showed that the highest yield obtained from (I4K2) treatment, which amounted to 3.802 tons ha-1, did not differ significantly from (I4K2) and (I3K2) treatments, which indicates that irrigation methods differed in their response to potassium spray treatments.

potassium fertilization				irrigation methods
averages	K_2	K_1	K_0	
3.027	3.484	3.039	2.559	**I_1**
3.083	3.430	3.081	2.737	**I_2**
3.312	3.644	3.466	2.826	**I_3**
3.306	3.802	3.306	2.810	**I_4**
3.211	3.786	3.448	2.399	**I_5**
0.1683	0.2138			**LSD 0.05**
	3.692	3.268	2.593	**averages**
	0.0816			**LSD 0.05**

Table 8. Effect of irrigation methods and potassium spray on the average grain yield per unit area (ton ha^{-1})

Biological yield (tons ha^{-1}):

The results of the analysis of statistical variance showed that there was a significant effect between the treatments of irrigation methods and the spraying of potassium fertilizers, and there was no significant effect on the interaction between them. Table (9) shows that the biological yield of sorghum plants excelled on treatment (l3) by giving it the highest average of 18.86 tons ha-1 that did not differ significantly from the two treatments (I4 and I1) compared with irrigation treatment (l2) which gave the lowest average of 17.37 ton ha^{-1}, These results were consistent with everything mentioned by [41, 2]. These results are in agreement with [42 and 43,] who confirmed that water stress affects reducing plant biological yield. The results showed in Table (9) that treatment (K2) excelled on the highest mean of the cultivar, reached 21.11 (ton ha-1) with an estimated increase rate of 25.9% over treatment (K0), which gave the lowest mean of the cultivar reached 15.58 (ton ha-1). This result is consistent with the findings of [37 and 29], who found an increase in plants' biological yield due to increased potassium fertilization.

potassium fertilization				irrigation methods
averages	K_2	K_1	K_0	
18.79	20.80	19.25	16.32	**I_1**
17.37	20.59	16.71	14.83	**I_2**
18.86	21.78	18.47	16.34	**I_3**
18.80	21.15	19.64	15.61	**I_4**
18.38	21.24	18.83	15.08	**I_5**
0.394	NS			**LSD 0.05**
	21.11	18.58	15.63	**averages**
	0.692			**LSD 0.05**

Table 9. Effect of irrigation methods and potassium spray on the biological yield of the plant (ton ha^{-1})

Harvest Index (%)

The harvest index is defined as a measure of the efficiency of converting the products of the carbonization process into an economic yield, and the higher its value in grain crops, the better because this is evidence of the high efficiency in converting the largest amount of dry matter produced into a grain yield by the effect of different treatments. The statistical analysis of variance showed significant differences in the effect of irrigation methods and the interaction between irrigation methods and potassium fertilizer. In contrast, no significant differences were observed in the effect of potassium fertilizer. Table (10) in the harvest index for sorghum plants shows the superiority of the irrigation treatment (l2) with the highest mean of 17.84% and the youngest effect of I3, I4, and I5. Meanwhile, treatment (l1) gave the lowest mean of the trait, which was 16.14%. These results agree with the findings of [23 24] that different irrigation methods lead to a difference in harvest index about the interaction. The treatment of potassium fertilizer (K1) in the treatment of irrigation (3l) gave the highest mean for the characteristic that reached 18.77%, While the treatment of potassium fertilizer (K0) in the treatment of irrigation (I1) gave the lowest mean of the trait amounted to 15.67% that the difference in irrigation methods according to the different amount of potassium fertilizer added is evidence of the different response of the sorghum crop to the addition of potassium fertilizer and irrigation methods in the harvest index.

potassium fertilization				irrigation methods
averages	K_2	K_1	K_0	
16.14	16.85	15.90	15.67	**I_1**
17.84	16.67	18.42	18.45	**I_2**
17.61	16.73	18.77	17.34	**I_3**
17.62	17.90	16.85	18.11	**I_4**
17.34	17.91	18.31	15.88	**I_5**
1.005	1.636			**LSD 0.05**
	17.19	17.65	17.09	**averages**
	NS			**LSD 0.05**

Table 10. Effect of irrigation methods and potassium spray on average harvest index (%)

DISCUSSION

The highest grain yield was obtained from the irrigation treatments, whether for corn planted in the top (I4) or underside (I5)of furrow or drip irrigation for the sorghum seeds planted on lines inside the plates (I3), as shown in Table (8). The increase in grain yield for these treatments came from an increase in (yield components, number of grains per head, Table (7), and weight of 500 grains (Table (6)). The increase in the number of grains is related to the number of grain sites that arise and are formed in the early stages of the plant's life between the six-leaf and ten-leaf stages. It increases with age until it reaches the final size (Potentrel for cvly). The height between the source (leaves) and the estuary (the heads) governs the amount of processed materials in the leaves, and this depends on the size of the light interception associated with the leaf area of the plant, as the results in Table (5) indicate that the treatments that excelled the yield are those that gave the highest leaf area. Studies have indicated that the amount of manufactured materials in the leaf depends on the anatomical characteristics of the leaf, leaf angle, specific weight, amount of chlorophyll, and the number and size of stomata [38, 43]. As for the weight of the grains, it comes by increasing the amount of manufactured material in the leaves transferred to the grain sites from the fullness period extended in pollination to physiological maturity. Table (6) showed that the treatments that excelled on the grain weight were the ones that gave the highest average plant height. The increase in the dry matter for the treatments that matched the yield showed the total dry matter quantity (biological yield) shown in Table (9) that the higher biological yield means the largest dry matter that has accumulated, part of which is transmitted to the grain direction, which is observed through the harvest index(10). The improvement in growth in the treatments that gave the highest yield may be related to the quantity and distribution of the lag phase in the root zone, as well as the displacement of salinity in the root zone in the irrigation treatments (I4 and I5) or the drip inside the plots (I3). The increase in grain yield (8) in the treatment of two sprays with potassium (K2) is due to the virtue of potassium in increasing the yield components (number of grains and grain weight), as shown in Table (6,7).

CONCLUSIONS

The increase in the number and weight of grains comes from the role of potassium in increasing growth (leaf area and plant height), biological yield and transportation processes (harvest index).

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