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Effect of irrigation systems and planting spacing in growth and yield wheat

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Abstract

Abstract:

Aimed the study impassive of three irrigation systems (surface, drip and sprinkler), and four planting distances (10, 20, 30 and 40 cm). Main-plots are occupied by irrigation systems, while sub-plots are occupied by the spacing between planting lines. The results indicated that surface irrigation significantly outperformed drip irrigation in terms of plant height and flag leaf area. Despite the low-mean of drip irrigation, it was superior in terms of the greatest average number of grains per spike. The biological yield and grain yield were not significantly affected by the irrigation systems, while the traditional irrigation system recorded the lowest average. The plant height and number of grains per spike were significantly superior at a distance of 40 cm between the planting line, whereas the flag leaf area was superior at a distance of 30 cm. The biological yield was significantly superior, despite the fact that the distance of 10 cm resulted in the lowest average for these characteristics. Ultimately, the biological yield was superior at a distance of 20 cm. The results of the two-way interaction among irrigation systems and planting distances indicated that the combination (drip irrigation × 20 cm distance) had the highest average biological yield.

Keywords: irrigation systems, row spacing, growth, productivity, wheat *Triticum aestivum* L.

Introduction:

Wheat is a grain commodity that is of varying economic and nutritional significance. It is the most significant crop in the world in terms of both importance and cultivated area, and it is a staple diet for over two-thirds of the global population. This is due to the fact that its grains contain carbohydrates and proteins in balanced amounts. The availability of production factors, including soil, water, and suitable climate conditions, has facilitated the widespread cultivation of wheat in Iraq. However, production per unit area is still low compared to the global average, due to the lack of use of modern means to increase production, including the use of modern irrigation methods, appropriate distances between planting rows, and the application of fertilizers in the appropriate quantities and at the appropriate time, which are significant agricultural factors that affect the quality and production of a variety of commodities, including winter grain crops [1].

The employment of modern irrigation techniques, such as drip irrigation and sprinkler irrigation, has become increasingly popular among farmers in wealthy countries in recent years. Because irrigation water has a certain amount of salts, which play a key role in regulating the time and quantities of water, these approaches have become commonly employed in dry and semi-arid regions where water is a determining factor. This is especially true for the fact that irrigation water contains salts. Drip irrigation is a modern method, saves a lot of irrigation water, reduces the spread of weeds, saves labor, and time, and eliminating the need to level the land. In addition, it maintains a constant percentage of moisture in the root zone., which improve growth and agricultural production. The efficiency of irrigation with this method reaches more than 90% [2].

Sprinkler irrigation system is one of the modern irrigation systems used in desert areas with sandy soil, that cannot retain water for a long time, this system uses a high-altitude oscillating sprinkler above the crop, This method has a greater ability to control the distribution of water on the soil surface based on the distribution of the soil, which reduces water runoff on its surface. The irrigation efficiency in this method reaches 80%.

The surface irrigation method is an old traditional method and one of the most common irrigation methods, and the rewrite simplest formula for adding water to the soil, where water is added directly to the soil surface from a canal located on the upper side of the surface. In this method, the amount of water used for the plant cannot be controlled, so water losses are high. Water negatively affects the physical properties of the soil, the irrigation efficiency in this way reaches 60% [3].

It affects the efficiency of plant production from shoots and spikes in addition to its impact on the weight of the grain [4]. Due to the fact that it influences the quantity of light and heat that is accessible, the plant density population in the field plays a significant part in selecting the appropriate number of plants and achieving high levels of productivity. This is because it influences the majority of the physiological processes that are carried out by the plant[5].

The study aimed to determine the best combination of irrigation systems and plant spacing to increase the productivity of the unit area.

Materials and Methods:

In the winter agricultural season of 2023-2024, a field experiment was carried out at the College of Agriculture Research Station, which is located at the College of Al-Muthanna University. This station is situated northeast of Al-Muthanna Governorate, three kilometers away from the center of Samawah city, and is situated at a combination of longitude 45.12 and latitude 31.24

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Table (1) Some physical and chemical properties of the soil of the experimental field before planting.

Properties	Items	Unit	Value
Physical	**Clay**	gm. kg^{-1}	16.67
	Silt		45.83
	Sand		37.50
	Soil texture		Silty loam
Chemical	**pH**	--	7.64
	EC (1:1)	ds. m-1	2.05
	Organic Matter	gm. kg^{-1}	1.86
	Available Nitrogen	mg. kg^{-1}	0.73
	Available Phosphorus		29.87
	Available potassium		170.00

* Analyzed in the laboratory of the Department of Soil and Water Resources, College of Agriculture, Al-Muthanna University.

The experiment included studying two factors:-

The first factor:-

- Surface irrigation method, symbolized by the symbol K0.

- Strip irrigation method (drip), symbolized by the symbol K1.

- Sprinkler irrigation method, symbolized by the symbol K2.

Second factor:-

- plant spacing10 cm, symbolized by the symbol B1.

- plant spacing 20 cm, symbolized by the symbol B2.

- plant spacing 30 cm, symbolized by the symbol B3.

- plant spacing 40 cm, symbolized by the symbol B4.

The experiment was carried out using Split – Blok designs The irrigation systems represented main-plots and the space among the lines represented sub-plots with wheat crops. The combinations were distributed randomly within each plot. The total experimental units were 36 experimental units resulting from 3 irrigation methods × 4 agricultural distances × 3 replicates =.

The land was divided into slabs with an area of (2 m x 2 m = 4 m^2), and plowing, flattening, and leveling operations were conducted in accordance with the design employed. The blocks were separated by a distance of 2 m to prevent overlap between treatments. The wheat (Wafiya variety) was planted on 18/11/2023, with a seed quantity of 180 kg ha^{-1} [6], with lines of 2 m length and with plant spacing between lines (10, 20, 30 and 40 cm). Urea fertilizer (N = 46%) was used as a source of nitrogen, at a level of 150 kg N ha^{-1}. added in three batches, at the emergence stage, at the elongation stage, and at the 50% flowering stage [7]. triple superphosphate (P=43%) in one batch at planting, according to the fertilizer recommendation [8].

Weeding was conducted as necessary, and plants were harvested at achieving full maturity on April 12, 2024.

Studied Traits:

Vegetative Growth:

Plant Height (cm): Ten plants were randomly selected from the median lines of each experimental unit, and the height of the plants at maturity was measured from the base to the apex of the primary stem spikes, excluding the tip. The average height was calculated.

Leaf Area (cm^2): A total of 10 plants were selected at random from the median lines of each experimental unit, and the following equation was used to calculate the average leaf area at flowering for each of those plants:

Leaf area = Leaf Length * Maximum Width * 0.95. [9].

Yield and its components:

Grains per spike number (grain per spike^{-1}): Calculated by averaging the number of granules in ten spikes that were randomly selected from the center lines of each experimental unit.

Biological yield (Mg h^{-1}): After drying the plants until the weight was constant, all plant portions above the soil surface (grains + straw) for the two middle lines of each experimental unit were weighed and subsequently converted to Mg h^{-1}.

Grain yield (Mg h^{-1}): The seed yield of the harvested plants for two lines of the central rows of each experimental unit was used to determine the grain yield, and the total output was then converted to Mg h^{-1}. This process was repeated for each of the experimental units.

Results and discussion

Plant height (cm):

Table (2) illustrates that the surface irrigation system achieved the highest average plant height of 75.34 cm, with no significant difference from the sprinkler irrigation system, which recorded an average of 74.26 cm. In contrast, the drip irrigation method yielded the lowest average of 72.27 cm. The reason may be due to the availability of water in large quantities in the surface irrigation method, unlike supplying the plant and soil with water in the form of drops, or spray, which is positively reflected on plant growth, these results agree with Al-Moelhem [11] and Naif [12], who shown a substantial impact of irrigation systems on the mean plant height.

The results indicated that the optimal planting distance was 40 cm, resulting in the greatest average plant height of 75.24 cm. This was followed by distances of 20 cm and 30 cm, which produced average heights of 74.71 cm and 73.16 cm, respectively. The increase in plant numbers, resulting from a greater quantity of seeds, led to competition for light, thereby enhancing their average heights. This result agreed with Al-Hasnawi [13], They demonstrated that employing wider spacing resulted in the greatest average plant height in comparison to narrower spacing. This result differed from the results of Al-Anbari *et al.* [14] and Shabib [15], They indicated that planting spacing had no meaningful effect on average plant height.

Table (2) The impact of irrigation systems, planting spacing, and their interaction on plant height.

Planting spacing (B) (cm)	Irrigation systems (K) Surface (K0)	Strip (K1)	Sprinkler (K2)	Mean
B1	73.38	69.51	75.24	72.71
B2	77.75	73.52	72.87	74.71
B3	74.30	71.57	73.60	73.16
B4	75.91	74.47	75.33	75.24
Mean	75.34	72.27	74.26	
L.S.D$_{0.05}$	**B**	**K**	**K×B**	
	1.64	1.94	N.S	

Flag leaf area (cm^2):

Table (3) indicates that the surface irrigation system produced the highest average flag leaf area of 29.34 cm², whereas the drip irrigation system yielded the lowest average of 23.80 cm², which was not statistically different from the sprinkler irrigation system's average of 24.14 cm². The plant's maximal water intake resulted in an increase in branch quantity, positively influencing the expansion of leaf area. This result is consistent with Al-Molhem [11] who confirmed the increase in flag leaf area when water consumption was 100%.

The results indicated that a single line was particularly responsible for enhancing the opportunity to receive light and stimulate chlorophyll, which in turn led to an increase in the process of photosynthesis and, as a consequence, an increase in the leaf area. This is what Al-Hasnawi [13], which indicated the superiority of the leaf area of oats planted at a distance of 20 cm compared to the large area among planting lines of 30 cm.

As for the interaction between the two factors, it is noted that there are highly significant differences, the combination (surface irrigation× 30 cm distance) while the combination (drip irrigation× 10 cm distance) gave the lowest average for this trait, which reached 16.04 cm^2.

Table (3) The impact of plant spacing, irrigation systems, and their interaction on the area of flag leaves (cm^2).

Planting spacing (B) (cm)	Irrigation systems (K)			
	Surface (K0)	Strip (K1)	Sprinkler (K2)	Mean
B1	23.62	16.04	19.77	19.81
B2	23.24	22.62	22.05	22.64
B3	44.82	22.05	27.80	31.56
B4	25.69	34.48	26.94	29.04
Mean	29.34	23.80	24.14	
L.S.D$_{0.05}$	**B**	**K**	**K×B**	
	4.93	4.04	4.93	

Yield and its components:

Number Grains per spike (grain per spike^{-1}):

Table (4) indicates that the drip irrigation system achieved the highest average number of grains per spike, totaling 48.96 grains per spike, whereas the traditional irrigation system exhibited the lowest average at 44.51 grains per spike. The concentration of water in the root zone, supplied in adequate amounts during crop growth and emergence, resulted in enhanced photosynthetic output, thereby augmenting the number of spikelets constituting the grains. This increase in spikelet quantity was correlated with a rise in the number of tillers in the plant, facilitated by drip irrigation, this result differed from the results of Al-Molhem [11], They determined that substantial disparities existed in the quantity of grains per spike at 100% water consumption.

The plant spacing of 20 cm and 30 cm did not exhibit a significant difference, yielding averages of 49.16 and 48.74 grains per spike, respectively. However, it significantly differed from the 10 cm spacing, which averaged 38.77 grains per spike. This variation is attributed to reduced competition among plants as the distance between planting lines increased, facilitating enhanced spike growth and consequently a greater grain count. This result agreed with Al-Hasnawi [13] on the oat crop and Al-Jubouri *et al*. [16] on the wheat crop, who showed that increasing the distance between the planting lines led to an increase in the number of grains in the spike, it did not agree with the results of Al-Zubaidy and Al-Jubory [17] and Shabib [15], They came to the conclusion that the distance between planting each spike did not have a significant effect on the amount of grains produced by each spike.

Table (4) The impact of irrigation methods, planting distances, and their interaction on the grain count per spike.

Plant spacing (B) (cm)	Irrigation systems (K) Surface (K0)	Strip (K1)	Sprinkler (K2)	Mean
B1	44.23	36.00	36.07	38.77
B2	46.53	53.93	47.00	49.16
B3	42.43	50.73	53.07	48.74
B4	44.83	55.17	49.83	49.94
Mean	44.51	48.96	46.49	
$L.S.D_{0.05}$	**B**	**K**	**K×B**	
	5.51	NS	N.S	

Biological yield (Mg. ha^{-1}):

A distance of 30 cm resulted in the lowest average of 9.546 Mg ha^{-1}. The increase may be attributed to the reduction of spacing between planting lines while maintaining the same seed quantity, which decreases the number of plants per line. This adjustment optimizes the utilization of available light energy and soil nutrients, resulting in a greater accumulation of nutrients within the plant's structures, ultimately enhancing the biological yield, this result is with Al-Hasnawi [13] a substantial enhancement in bio-yield by the reduction of spacing between planting rows.

Regarding the interaction between the two factors, the combination (drip irrigation x 20 cm distance) produced the highest average for this trait, reaching 13.729 Mg ha^{-1}. Conversely, the combination (surface irrigation x 40 cm distance) produced the lowest average, reaching 8.781 Mg ha^{-1}, without a significant difference from a number of combinations.

Table (5) The impact of irrigation systems, plant spacing, and their relationship on biological yield (Mg ha^{-1}).

Planting spacing (B) (cm)	Irrigation systems (K) Surface (K0)	Strip (K1)	Sprinkler (K2)	Mean
B1	12.666	11.708	11.333	11.903
B2	11.750	13.729	9.667	11.715
B3	9.250	8.667	10.722	9.546
B4	8.781	10.923	10.333	10.014
Mean	10.612	11.258	10.514	
$L.S.D_{0.05}$	**B**	**K**	**K×B**	
	1.48	N.S	NS	

Grain yield (Mg. ha^{-1}):

A significant difference from the distance of 40 cm, which averaged 3.518 Mg ha^{-1}, this was due to the fact that the proximity of the planting lines led to a better distribution of plants and thus optimal exploitation of the available growth requirements, this result differed from the results of Al-Zubaidy and Al-Jubory [17] and Shabib [15] who did not find significant effects on grain yield due to the effect of planting distances, but it agreed with the results of Al-Hasnawi [13] and Aziz and Nassir [18], who demonstrated the intestinal increase in grain yield at narrow planting distances.

Table (6) Impact of irrigation systems, planting distances, and their interaction on grain yield (Mg ha^{-1}).

Planting spacing (B) (cm)	Irrigation systems (K)			
	Surface (K0)	Strip (K1)	Sprinkler (K2)	Mean
B1	4.554	4.689	4.039	4.427
B2	4.837	4.506	4.043	4.462
B3	2.980	3.111	4.143	3.411
B4	2.609	4.098	3.847	3.518
Mean	3.745	4.101	4.018	
L.S.D$_{0.05}$	**B**	**K**	**K×B**	
	0.730	N.S	N.S	

Conclusions:

The drip irrigation approach surpassed other irrigation techniques in terms of grains per spike, averaging 48.96 grains per spike. The maximum grain yield of 4.462 Mg ha^{-1} was obtained at a distance of 20 cm. No significant changes in productivity were seen among irrigation systems, despite substantial variations in water usage; nonetheless, the drip irrigation approach yielded higher output compared to sprinkler and traditional irrigation methods.

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