Response of Wheat (*Triticum eastivum* L.) Crop to Planting Dates and Different Levels of Potassium Fertilizer on Yield Characteristics and Components

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DOI: 10.56201/ijaes.v10.no10.2024.pg1.8

Abstract
This experiment was conducted in Al-Khader area, Al-Muthanna Governorate, during the winter season 2023-2024, with the aim of studying the response of wheat to planting dates and levels of potassium fertilization on the crop and its components. The experiment was applied using split-plots and three replicates. The planting dates occupied the main plots, included three dates (20/11, 30/11 and 10/12-2022), while the levels of adding potassium levels in Sub-plot, included three levels (100, 140 and 180 kg ha^{-1}). The results showed that the dates were significantly superior in some of the study traits, were the first date was superior on the biological yield (13.869 kg ha^{-1}), and the grain yield (4.260 kg ha^{-1}), while the third date was superior in the number of grains per spike (51.27 grains spike^{-1}), and the harvest index (31.98%), which did not differ significantly from the first date, which amounted to 30.90%. As for potassium levels, the third level of potassium fertilizer addition was superior, by giving the highest average number of spikes (361.7 spikes m^{2}), while there was no significant effect for the rest of the studied traits. As for the interaction, the interaction treatment between the first date and the second level of potassium gave the highest average for biological yield and grain yield, reaching 14.688 and 4.550 kg ha^{-1}, while the interaction treatment of the third date and the third level of potassium gave the highest averages for grains number and harvest index, reaching 57.23 grains spike^{-1} and 39.16%.

Keywords: *wheat (Triticum eastivum L.), planting dates, potassium fertilizer, yield.*

Introduction:

Wheat is one of the world's major crops, it contributes to providing 20% of human food needs, which represents a staple food for more than 35% of its population (El-Lethy *et al*., 2013).

Wheat in Iraq ranks first in terms of cultivated area, the wheat crop in Iraq suffers from low productivity, despite the availability of factors for the success of its cultivation, the reason may be attributed to not choosing the appropriate planting dates, due to the difference in environmental conditions from one year to another, and the variation in temperatures (Wahid *et al*., 2017).

The appropriate planting date, provides the varieties with the appropriate requirements, of temperature and light period, for the different stages of plant growth, despite the existence of some differences in the behavior of varieties on growth and production due to the effect of different planting dates (Shirinzadeh *et al*., 2017; Al-Qadi *et al*., 2018).

Potassium fertilizers are added to wheat crops and many crops, as it plays a major role in most vital activities within the plant. The importance of potassium comes from its role in many physiological processes, especially the transfer and storage of metabolites and water relations within the plant (Havlin *et al*., 2003). It helps plants tolerate high salinity, potassium is one of the essential elements that must be available in the plant, to carry out the photosynthesis process with a high degree of efficiency, it stimulates the plant to transfer and store the manufactured materials in the leaves to their storage places in the fruits. The positive functions of potassium for the plant are not limited to this amount of functions, but rather go beyond it to other functions, stimulate root growth in the plant, improves the plant's ability to tolerate drought and thirst, increases the plant's ability to resist harsh winter conditions of extreme cold and freezing, improve the plant's efficiency in absorbing nitrogen, and it increases the plant's ability to not lie down (Al-Hujairi, 2013).

The role of potassium and its importance in various metabolic activities of the plant justifies the need for potassium fertilization, especially under dry conditions, high temperatures, and fluctuations in the amount of rainfall. The necessity of potassium for the plant is not only evident in the early stages of its growth, but also extends to the stage of maturity (Al-Ugaidi *et al*., 2022).

This study aimed to response of wheat (*Triticum eastivum* L.) crop to planting dates and different levels of potassium fertilizer on yield characteristics and components.

Materials and Methods:
Experiment site:
A field experiment was carried out in Al-Khader district, Muthanna Governorate, during the agricultural season 2022-2023, in a Loamy soil (Table 1). Taken at a depth of 30 cm, where a composite sample was collected from the field and analyzed in the soil laboratory of Al-Diwaniyah Agriculture Directorate, with the aim of knowing the response of the wheat crop to planting dates and adding levels of potassium to the characteristics of the crop and its components.

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

Properties		Unit	Value
Physical	**Sand**	gm kg^{-1} soil	500.00
	Silt		341.00
	Clay		123.00
	Soil texture	Loamy	
Chemical	**Ece**	Ds m^{-1}	4.30
	pH		7.00
	Organic mater	gm kg^{-1} soil	3.20
	Available Nitrogen	mg kg^{-1} soil	26.45
	Available Phosphorus		17.90

Available Potassium	129.67

Experimental factors:
The experiment included studying two factors:-

The first factor (planting dates) and the dates were:

1. First date (A1) = 20/11. 2. Second date (A2) = 30/11. 3. Third date (A3) = 10/12

The second factor included the levels of potassium addition and the levels are:-

1. First level (K1) = 100 kg K_2O h^{-1}. 2. Second level (K2) = 140 kg K_2O h^{-1}

3. Third level (K3) = 180 kg K_2O h^{-1}

Experimental design:
The experiment was carried out using a split-plot design with three replicates, where planting dates occupied the main plots and included three dates, while potassium addition levels occupied the sub-plots and included three levels, the total experimental units became (3×3) with three replicates = 27 experimental units. The wheat variety Wafia was used for planting.

Field operations:
Land preparation and soil service operations were carried out before planting, cleaning and removing the remains of the previous crop. The land designated for the experiment was plowed twice perpendicularly using a rotary plough, after the tamping process was carried out, it was left for a period to dry, then the soil was smoothed with disc harrows. The land was leveled, it was divided into panels according to the design used. The canals were opened, shoulders were made among plots, a distance of 50 cm was left among sub-plots, a distance of 2 m among main plots, to maintain no interactions among the levels and the experimental units. The area of the experimental unit was 2 m width x 2 m length, each experimental unit included 10 lines, with a planting distance of 20 cm between one line and another, with a planting depth of 4 cm. Planting was done in rows.

The experimental land was fertilized with nitrogen fertilizer at a rate of 180 kg h^{-1} (46%N) in two batches. The triple superphosphate fertilizer (46% P_2O_5) before planting at a quantity of 100 kg P h^{-1} was added in one batch before planting (Jadoua, 1995). Potassium sulfate (K_2O 50%) was added according to the experimental parameters in one batch. The first harvest date was on 21/4/2023, where the two middle lines were harvested. The second harvest date was on 29/4/2023. Finally, the third harvest date was on 6/5/2023.

Studied traits:
Total number of spikes m^{-2}: According to the total number of spikes by harvesting the two middle lines of the experimental units and converted to square meters.

Grains number in the spike (grain $spike^{-1}$): It was calculated from the average number of grains for ten spikes after manually removing these spikes and calculating the number of grains $spike^{-1}$.

Grain yield (ton ha^{-1}): The grain yield of the group of plants harvested from the two middle lines was estimated after the threshing process of the spikes from each experimental unit, then the straw was isolated from the grains and the total grain weight was taken and the grain yield was extracted and converted on the basis of tons ha^{-1}.

Biological yield (ton ha^{-1}): Calculated from the harvest of the plants of the two middle lines for each experimental unit by taking the weight of the completely harvested plants (grains + straw), and then converted the weight from gm m^{-2} to tons ha^{-1}.

Harvest index (%): The harvest index was calculated using the following equation:

Harvest index = (grain yield / biological yield) × 100 (Donald, 1962).

Statistical analysis:
The data were analyzed statistically using the statistical program Genestat. The averages of the coefficients were compared according to the Least Significant Difference (L.S.D) test at a probability level of 0.05 (Al-Rawi and Khalaf Allah, 2000).

Results and Discussion:
Number of spikes (m^2):
The results of the statistical analysis showed significant differences for potassium fertilizer and the interaction. The results showed that there was no significant effect of dates (Table 2).

There was a significant effect of potassium fertilization levels on the number of spikes. The third level outperformed in giving the highest average (361.7 spikes m^2), while the first level gave the lowest average (328.1 spikes m^2), this was attributed to its effect in increasing plant height and the number of nodes, improving the absorption of nutrients, the most important of which was nitrogen, which encourages increased plant growth, it was positively reflected in increasing the number of spikes, agree with Al-Dumai (2015) who showed an increase in the number of spikes with increasing potassium levels.

As for the interaction, the interaction between the first date and the third level of potassium was significantly superior in giving the highest average (396.2 spikes m^2).

Table (2) shows the effect of planting dates and levels of potassium fertilizer on the number of spikes (spikes m^2).

Planting dates	Potassium		
	P1	**P2**	**P3**
T1	396.2	314.4	324.4
T2	361.3	353.8	326.9
T3	327.5	342.3	333.1
Potassium mean	361.7	336.8	328.1
Planting date mean	334.3	347.3	345.0
L.S.D$_{0.05}$	**Planting dates**	**Potassium**	**Interaction**
	N.S	19.07	28.91

Grains number in the spike (grain per spike^{-1}):
The results of the statistical analysis showed that there were significant differences in dates and the interaction, while there was no significant effect of potassium fertilizer (Table 3). The dates were significantly superior, the third date was superior in giving the highest average (51.27 grains spike^{-1}), while the second date gave the lowest average (44.31 grains spike^{-1}), this may be attributed to the environmental conditions, which may be unsuitable for pollination and fertilization, reducing the period required to reach flowering, lack of green space and decreased photosynthesis, shortening the period of formation of spikelets and decreasing the number of grains per spike depending on the planting date (Al-Mohammadi, 2011; Noah *et al*., 2009).

The results showed that there was no significant effect of potassium fertilization levels on the number of grains per spike.

As for the interaction, it was significantly superior and the interaction treatment between the third date and the third level of potassium was superior in giving the highest average (57.23 grains spike^{-1}).

Table (3) shows the effect of planting dates and levels of potassium fertilizer on the trait of number of grains in the spike (grain spike^{-1}).

Planting dates	Potassium		
	P1	**P2**	**P3**
T1	49.27	47.27	36.40
T2	50.37	46.47	42.85
T3	50.03	46.53	57.23
Potassium mean	49.89	46.76	45.49
Planting date mean	46.56	44.31	51.27
L.S.D$_{0.05}$	**Planting dates**	**Potassium**	**Interaction**
	3.942	N.S	6.151

Biological yield (ton h^{-1}):
Table (4) shows the results of the statistical analysis that there were significant differences between dates and interaction, while there was no significant effect of potassium fertilizer.

The results showed that the dates were significantly superior in this characteristic, as the first date was superior in giving the highest average (13,868 ton h^{-1}), while the third date gave the lowest average (9,037 ton h^{-1}). The reason for the decrease in the biological yield in the third date is due to the low plant height and the low number of spikes per square meter, this result agreed with Al-Qadi *et al.* (2018)

As for the interaction, it was significantly superior and the interaction treatment between the first date and the second level of potassium was superior in giving the highest average (14,688 ton h^{-1}).

Table (4) shows the effect of planting dates and potassium fertilizer levels on the biological yield (tons ha^{-1}).

Planting dates	Potassium		
	P1	**P2**	**P3**
T1	13,167	14,688	13,750
T2	10,938	13,438	12,438
T3	10,125	8,250	8,735
Potassium mean	11,410	12,125	11,641
Planting date mean	13,868	12,271	9,037
L.S.D$_{0.05}$	**Planting dates**	**Potassium**	**Interaction**
	1,363.4	N.S	1,664.9

Grain yield (ton h^{-1}):

The results of the statistical analysis showed significant differences between dates and their interaction, while there was no significant effect of potassium fertilizer (Table 5). The results showed that dates were significantly superior in this trait, as the first date was superior in giving the highest average (4.260 tons h^{-1}), while the third date gave the lowest average (2.846 tons h^{-1}). This can be attributed to the delay in planting date, leading to a decrease in leaf area, increase and production of dry matter, decrease in the number of spikes and biological yield, it was negatively reflected in increasing grain yield, this result agreed with Al-Qadi *et al*. (2018).

The results showed that there was no significant effect of potassium fertilization levels on biological yield.

As for the interaction, the interaction between the first date and the second level of potassium was significantly superior in giving the highest average (4.550 tons ha^{-1}). This may be attributed to the superiority of this treatment in the biological yield.

Table (5) shows the effect of planting dates and levels of potassium fertilizer on the grain yield (tons ha^{-1}).

Planting dates	Potassium		
	P1	**P2**	**P3**
T1	4,244	4,550	3,988
T2	3,329	3,250	3,056
T3	2,419	2,706	3,412
Potassium mean	3,331	3,502	3,485
Planting date mean	4,260	3,212	2,846
L.S.D$_{0.05}$	**Planting dates**	**Potassium**	**Interaction**
	399.1	N.S	471.5

Harvest index (%):

The results of the statistical analysis showed significant differences for dates and interaction, while there was no significant effect of potassium fertilizer (Table 6).

The results showed that dates were significantly superior, as the third date was superior in giving the highest average (31.98%), which did not differ significantly from the first date (30.90%), while the second date gave the lowest average (26.49%). This can be attributed to the fact that the source efficiency was sufficient to produce a strong outlet, as the scarcity of spikes and biological yield, compared to other treatments, it prevented competition for photosynthesis products and directed them towards the outlet

The results showed that there was no significant effect of potassium fertilization levels on the biological yield.

As for the interaction, it was significantly superior, and the interaction treatment between the third date and the third level of potassium was superior in giving the highest average (39.16%).

Table (6) shows the effect of planting dates and potassium fertilizer levels on the harvest index (%).

Planting dates	Potassium		
	P1	P2	P3
T1	32.39	31.08	29.24
T2	30.59	24.22	24.66
T3	23.87	32.91	39.16
Potassium mean	28.95	29.40	31.02
Planting date mean	30.90	26.49	31.98
$L.S.D_{0.05}$	**Planting dates**	**Potassium**	**Interaction**
	4.293	N.S	5.503

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