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The effect of potassium fertilizer and planting dates on growth, yield, and quality of wheat (*Triticum aestivum* L.).

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Abstract

The field experiment was conducted during the winter season of 2021-2022 in one of the farmers' fields in the village of Al-Budayab, affiliated Ramadi city . The study aimed to investigate the effect of potassium fertilizer levels (120, 160, and 200) kg K ha^{-1} and planting dates (November 15th, December 1st, December 15th) on the growth, yield, and quality characteristics of wheat . The experiment was carried out using a randomized complete block design (RCBD). Statistical analysis revealed significant differences among the levels of potassium fertilizer, with the 200 kg K ha^{-1} level superior to other levels in plant height 94.25 cm, leaf area 48.16 cm², number of spikes per square meter 285.60 m^{-2}, number of grains per spike 65.50 grains, 1000-grain weight 34.10 g and grain yield 6.40 ton ha^{-1} . Additionally, the planting dates showed significant differences, where 15th of December record a significant yield significantly higher results for the above-mentioned characteristics, measuring plant height 82.30 cm, leaf area 43.31 cm², number of spikes per square meter 270.94 m^{-2}, number of grains per spike 58.94 grains, 1000-grain weight 32.64 g and 5.36 tons. The interaction between the level of potassium fertilizer and planting dates also had a significant effect on grain yield, as the 200 kg K ha^{-1} level combined with the December 15th planting date resulted in the highest grain yield of 7.30 tons ha^{-1}. Regarding the grains protein content in, the 120 kg K ha^{-1}level recorded the highest percentage of 12.57%, and the November 15th yielded the highest percentage of 12.12% compared to the other planting dates.

Key words: Potassium, planting dates, yield, yield components, bread wheat

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Introduction

Bread wheat (*Triticum aestivum* L.) belongs to the group of energy-rich foods, as white bread contains 9.7% protein, 1.3% fat, and 53.1% carbohydrates[1]. The human requirement for grains is estimated to be around 75% [2]. Mesopotamia is one of the first homes for the emergence of wheat. However, the crop suffers from low productivity and grain quality despite the availability of favorable cultivation factors. The optimal use of potassium fertilizers, along with choosing the appropriate planting date, is one of the important scientific measures that farmers must take in order to obtain high grain yields of good quality Potassium contributes to the activation of many vital processes within the plant, including photosynthesis, sugar synthesis, activation of at least 80 enzymes, transportation of photosynthetic products to storage sites, and enhancing the plant's ability to withstand drought and stimulate growth [3]. Additionally, the plant's potassium requirement exceeds its requirement for any other nutrient except nitrogen. It was commonly believed that Iraqi soils are rich in potassium and do not require the addition of potassium fertilizers[4]. However, studies have indicated that 25-30% of Iraqi soils had potassium content below the critical threshold of 160 mg kg^{-1}, and Iraqi soils have the ability to fix potassium [5]. [6] Reported that the addition of potassium fertilizer led to a significant increase in wheat grain yield About 200 kg. h^{-1} .

The planting date has an important role in providing suitable temperatures and the optimal photoperiod for plant growth [7]. A group of studies indicated that planting dates have a significant impact on wheat growth and yield [8] found that plant height was significantly affected by different planting dates, with the 14^{th} of November planting date resulting in the highest plant height of 100.48 cm compared to 82.48 cm when planted on 23^{rd} of December. In a study conducted by [9] to determine the effect of three planting dates (1^{st} of November, 15^{th} of November, and November 30th), the November 15th planting date recorded the highest number of tillers with 435 and 420 compared to the other two dates in the same seasons. [10] reached that the November 20th planting date outperformed in terms of grain yield, while the December 25th planting date had the lowest average for this characteristic.

Based on the above, this research aims to investigate the effect of varying levels of potassium fertilizer and planting dates on the growth, yield, and quality traits of bread wheat, Al-Rasheed variety.

Materials and methods

This experiment was conducted in one of the at a farmer field the Al-Budayab - Ramadi Region during the winter season of 2021-2022. Random soil samples were taken at depth of 30 cm and analyzed at the laboratories of the Desert Studies Center at Anbar University to determine their physical and chemical properties (Table1). The experimental design used was a randomized complete block design (RCBD) with three replications, aiming to study the effect of potassium fertilizer add as K (120, 160, 200 kg K ha^{-1}) in the form of potassium sulfate (K_2SO_4), and three planting dates symbolizes it T (November 15th, December 1st, December 15th). Each experimental unit had an area of 2 x 3 m with a distance of 2 m between replications and 1.5 m between treatments. The experimental unit consisted of 13 rows, each with a length of 3 m, with a spacing of 15 cm between rows, and a seeding rate of 120 kg ha^{-1}. Nitrogen fertilizer in the form of urea (46% N) was added at a rate of 200 kg N ha^{-1} in 2 times, the first at seedling emergence and the second at the tillering stage. Phosphorus fertilizer (P_2O_5 45%) in the form of triple superphosphate was added at a rate of 160 kg P_2O_5 ha^{-1} in at once during planting. Soil and crop management practices were performed as needed. Data were recorded for the following studied traits.

1. **Plant height (cm):** It was measured as the average height of ten randomly selected plants from the base of the plant to terminal spikelet top, excluding awns.
2. **Flag leaf area (cm^2):** It was calculated from the average area of random flag leaves from the main stems of each experimental unit in

the study season, according to the following equation:

Flag leaf area = Length of the flag leaf x Width of the widest area x correction factor 0.95 [11].

3. **Number of spikes per square meter at harvest**: One square meter was harvested from the middle rows of each plot, and the number of spikes in it was recorded.
4. **Number of grains per spike**: The average number of grains was taken from ten spikes for each experimental unit after threshing and manually cleaning the spikes.
5. **1000-grain weight (grams):** A random sample of grains, consisting of 1000 grains, was taken, and their weight was determined.
6. **Grain yield (tons ha^{-1}):** The weight of the harvested area was converted to tons ha^{-1}.
7. **grains Protein percentage in**: the total nitrogen content of the grain was calculated using the modified Kjeldahl method according to [12] and converted to crude protein by multiplying the result by 5.7.

Statistical analysis was performed for all studied traits using a randomized complete block design (RCBD), using the Genstat statistical software. A least significant difference (LSD) test was used to compare the means at a significance level of 0.05.

Table (1) Some physical and chemical properties of the soil of the experimental field before planting for the season 2021-2022.

PH	7.1
Electrical conductivity	5.2
Available phosphorus (mg kg^{-1})	2.39
Available potassium (mg/kg^{-1})	20.78
Available nitrogen (mg/kg^{-1})	20.11
Clay percentage (%)	34.25
Sand percentage (%)	47.32
Silt percentage (%)	20. 38
Soil texture	Silty clay

Results and discussion

Plant Height (cm):

The results indicate significant differences among the levels of potassium fertilizer in their effect on plant height (Table 2). The level of potassium fertilizer at 200 kg Kha^{-1} The highest significant plant height, reaching 94.25 cm, whiles the level at 120 kg K ha^{-1} recorded the lowest average height of 66.57 cm. This increase in plant height may be attributed to the stimulation of factors that promote cell division and elongation through the role of potassium in activating plant hormones, particularly gibberellins and auxins [13]. Additionally, potassium plays a role in providing the balanced nutrition necessary for cell division and elongation, as well as its effectiveness in regulating stomata opening and CO_2 entry, thereby increasing carbon assimilation rates and providing necessary food [14]. This reduces competition between the vegetative and reproductive parts during the initiation of floral and fruiting primordia. Furthermore, the activation of material transport processes due to potassium effects also contributes to the rapid provision of growth requirements and increased plant height[15] .

The results indicate significant differences among the levels of planting dates in their effect (Table 2). The planting date of December 15th outperformed the other dates, giving the maximum plant height of 82.30 cm compared to the dates of November 15th and December 1st, which recorded 80.56 cm and 78.38 cm, respectively. This may be attributed to the higher temperature, leading to increased internode elongation and consequently resulting in an increase in plant height [16].

Furthermore, significant interaction was also observed between the levels of potassium fertilizer and planting dates in their effect on this trait. The level of 200 kg K ha^{-1} combined with the planting date of December 15th recorded the highest average of 98.15 cm. These results are consistent with [17].

Table (2). Effect of potassium fertilizer levels and sowing dates on the plant height (cm) of wheat

Potassium fertilizer	Sowing dates			Mean potassium
	T1	T2	T3	
K1	70.23	66.36	63.12	66.57
K2	80.19	75.44	85.63	80.42
K3	91.26	93.33	98.15	94.25
Mean sowing dates	80.56	78.38	82.30	
LSD Sowing date 0.028	LSD Potassium x sowing dates 0.048			LSD Potassium 0.028

Leaf Area (cm²)

The results indicate significant differences among the levels of potassium fertilizer on the leaf area (Table 3). The results show that by increasing the level of potassium addition to the soil, it leads to a direct increase in the leaf area The treatment with 200 kg K ha^{1-} had the highest leaf area at 48.16 cm², while the level of 120 kg K ha recorded the lowest average leaf area at 33.30 cm² (Table 3). This can be attributed to the role of potassium in promoting cell division and elongation in leaf cells through the stimulation of gibberellins and auxins production and its interaction with these hormones in increasing the flexibility and elasticity of cell walls, as well as increasing the osmotic pressure, which encourages water uptake and the formation of high turgor pressure, contributing to leaf cell elongation [18]. Additionally, potassium contributes to increasing the leaf area exposed to light by promoting the production of proteins and carbohydrates and the synthesis of chlorophyll, which is essential for photosynthesis and providing food and energy, thereby sustaining leaf greenness and extending leaf growth duration and expansion [19]. The results also demonstrate that the variation in planting dates has a significant effect on leaf area. 15th of December outperformed by recording the highest leaf area of 43.31 cm² compared to the first and second dates with 39.16 cm² and 40.57 cm², respectively. This may be attributed to the temperature in the later planting date, which contributed to cell building and elongation, thus increasing the leaf area [15].

The results indicate a significant interaction effect between the potassium fertilizer concentrations and planting dates on leaf area. The potassium level of 200 kg K ha^{-1} combined with the planting date of December 15th showed the highest leaf area of 49.92 cm². These findings are consistent with the results obtained by [20].

Table (3). Effect of potassium fertilizer levels and planting dates on the flag leaf area (cm^2) of wheat

Potassium fertilizer	Sowing dates			Mean potassium
	T1	T2	T3	
K1	30.13	33.34	36.42	33.30
K2	39.64	41.55	43.60	41.60
K3	47.73	46.84	49.92	48.16
Mean sowing dates	39.16	40.57	43.31	
LSD Sowing date 0.027	LSD Potassium x sowing dates 0.047			LSD Potassium 0.027

Number of spikes per square meter:

Significant differences were observed among the levels of potassium fertilizer in their effect on this trait (Table 4). The highest number of spikes per square meter was recorded at the potassium level of 200 kg K ha^{-1}, reaching 285.60, while the lowest average was 228.26 spike m^{-2} at the concentration of 120 kg K ha^{-1} (Table 4). This may be attributed to the role of potassium in promoting the success and development of tillers, which carries the spikes. As a result, the total number of spikes per unit area increases, due to its role in improving the efficiency of photosynthesis [21].

The results indicate significant differences among the planting dates in their effect on the number of spikes per square meter (Table 4). The date of December 15th recorded the highest average of 270.94 spikes m^{-2}, while the other dates, November 15th and December 1st, recorded 251.84 spikes m^{-2}, and 256.72 spikes m^{-2},, respectively. This may be attributed to favorable environmental conditions and temperatures that were conducive to the transformation of a greater number of vegetative tillers into spike-bspikeing tillers. This was associated with a good leaf biomass and a high level of photosynthetic representation, providing an adequate amount of nutrients for distribution between the vegetative and root mass, resulting in an increased number of formed spikes [22].

The interaction between the levels of potassium fertilizer and planting dates had a significant effect on the average of this trait. The potassium level of 200 kg K ha^{-1} combined with the December 15th planting date, recorded the highest value of 301.63 spikes m^{-2} (Table 4). These results are consistent with the findings of [23].

Table (4). Effect of potassium fertilizer levels and sowing dates on number of spikes per square meter of wheat

Potassium fertilizer	Sowing dates			Mean potassium
	T1	T2	T3	
K1	220.13	223.23	241.42	228.26
K2	260.54	266.60	269.75	265.63
K3	274.85	280.32	301.63	285.60
Mean sowing dates	251.84	256.72	270.94	
LSD Sowing date 0.019	LSD Potassium x sowing dates 0.034			LSD Potassium 0.019

Number of grains per spike

The results indicate that potassium levels have a significant effect on the number of grains spike-1 (Table 5). The high fertilizer level of 200 kg K ha^{-1} recorded the highest number of grains spike-1, reaching 65.50 grains, surpassing the levels of 120 kg K/ha and 160 kg K/ha, which yielded 45.31 and 57.34 grains, respectively. This can be attributed to the role of potassium in controlling plant hormones that are involved in the initiation, growth, pollination, and fertilization of florets. Additionally, potassium plays a crucial role in the synthesis of proteins necessary for plant tissue building and in the process of photosynthesis [24].

The results demonstrate significant differences among the planting dates in terms of the average number of grains $spike^{-1}$. The planting date of December 15th recorded the highest number of grains spike-1, reaching 58.94 grains, while the November 15th planting date had the lowest average of 53.60 grains $spike^{-1}$. This can be attributed to the higher temperatures, which were favorable for flowering, fertilization, increased green area, enhanced photosynthesis, and an extended period for grain and floret formation [25]. Moreover, a significant interaction effect was observed between the studied factors. The highest average value achieved when the fertilizer level of 200 kg K ha^{-1} combined with the planting date of December 15th, with 69.14 grains $spike^{-1}$ (Table 5). These results are consistent with the findings of [26].

Table (5). Effect of potassium fertilizer levels and sowing dates on number of grains spike^{-1} of wheat

Potassium fertilizer	Sowing dates			Mean potassium
	T1	T2	T3	
K1	42.24	45.33	48.35	45.31
K2	55.45	57.25	59.34	57.34
K3	63.10	64.27	69.14	65.50
Mean sowing dates	53.60	55.62	58.94	
LSD Sowing date 0.018	LSD Potassium x sowing dates 0.032			LSD Potassium 0.018

Weight of 1000 grain (g)

The results indicate significant differences among the potassium concentrations in the average weight of 1000 grain (Table 6). The highest mean value of 34.10 g was recorded at the fertilizer level of 200 kg K ha^{-1}, whiles the level of 120 kg K ha^{-1} recorded 28.92 g. The reason may be attributed to the role of potassium in delaying leaf senescence in plants and maintaining their activity in photosynthesis for a longer period, which increases the amount of manufactured substances in the leaves and their transfer to storage sites in the grains, resulting in an increase in their weight due to carbohydrate and protein accumulation [27]. The result also demonstrates that planting dates have a significant effect on the average value of this trait. The planting date of December 15th recorded the highest value of 32.64 g. While, the dates November 15th and December 1st recorded 30.58 g and 31.71 g, respectively. This can be attributed to the higher temperature during the third date, which resulted in the utilization of photosynthetic products by the plant and the production of a larger quantity of dry matter, which was allocated to flowers and grains, leading to an increase in the number of grains, their size, and their filling rate [28]. A significant interaction was found between the levels of potassium fertilizer and planting dates. The fertilizer level of 200 kg K/ha combined with the planting date of December 15th showed a significant effect, at 34.91 g. These results are consistent with the findings of [29].

Table (6). Effect of potassium fertilizer levels and sowing dates on weight of 1000 grain of wheat

Potassium fertilizer	Sowing dates			Mean potassium
	T1	T2	T3	
K1	27.23	29.33	30.21	28.92
K2	30.95	31.96	32.81	31.91
K3	33.56	33.85	34.91	34.10
Mead sowing dates	30.58	31.71	32.64	
LSD Sowing date 0.034	LSD Potassium x sowing dates 0.059			LSD Potassium 0.034

Grain yield (ton. ha^{-1})

The fertilizer treatment of 200 kg K ha^{1-} significantly outperformed the other treatments with the highest grain yield of 6.40 tons/ha, compared to 120 kg K ha^{-1} and 160 kg K/ha, which recorded yields of 3.00 tons ha^{-1}and 4.85 tons ha^{1-}, respectively (Table 7). This can be attributed to the role of potassium in the plant's vital functions and metabolic processes of carbohydrates and proteins, as well as its regulation of essential nutrient activities. Additionally, potassium contributes to extending the grain filling period, increasing the efficiency of converting light energy into chemical energy, and enhancing the efficiency of transporting the products of photosynthesis from the leaves to grain storage sites [30].

Furthermore, the planting dates varied significantly in this characteristic. The planting date of December 15th recorded the highest grain yield of 5.36 tons ha^{-1}, while the November 15th date produced the lowest grain yield of 4.25 tons ha^{-1}. This difference can be attributed to the superiority of the December date in terms of spike number per square meter, number of grains $spike^{-1}$, and the weight of 1000 grains, which positively influenced the grain yield. These results align with the findings of [31, 32].

Table (7). Effect of potassium fertilizer levels and sowing dates on grain yield (ton. ha^{-1}) wheat

Potassium fertilizer	Sowing dates			Mean potassium
	T1	T2	T3	
K1	2.52	2.95	3.53	3.00
K2	4.44	4.86	5.26	4.85
K3	5.79	6.12	7.30	6.40
Mead sowing dates	4.25	4.64	5.36	
LSD Sowing date 0.012	LSD Potassium x sowing dates 0.020			LSD Potassium 0.012

Protein Content in Grains

The results of the statistical analysis in Table 8 indicated significant differences among fertilizer treatments in their effect on protein content. The treatment of 120 kg K ha^{-1} yielded the highest protein content in grains, reaching 12.57%, compared to the two treatments of 160 kg K ha^{-1} and 200 kg K ha^{-1}, which recorded 11.84% and 11.33%, respectively. This may be due to the fact that the low concentration of potassium has led to an increase in plant efficiency in nutrient uptake from the soil (nitrogen) and subsequently increased its concentration in the grains [3] . Additionally, the increase in chlorophyll concentration in the flag leaf due to nitrogen, which is an important component in chlorophyll synthesis, led to the plant's efficient photosynthesis process. As a result, the products of this process were transferred to the spike, facilitating fertilization, grain formation, and the transfer of nitrogen from the leaves to the seeds, where it accumulates [33].

The results also indicate a significant effect of planting dates on this characteristic (Table 8). The highest protein content of 12.12% was observed for the November 15th planting date. Additionally, the interaction between the studied factors had an effect on increasing the average protein content. The first potassium fertilizer level, combined with the early planting date, resulted in the highest protein content of 12.82%. These findings align with the results reported by [34].

Table (8). Effect of potassium fertilizer levels and sowing dates on protein content (%) wheat

Potassium fertilizer	Sowing dates			Mean potassium
	T1	T2	T3	
K1	12.82	12.61	12.28	12.57
K2	12.03	11.83	11.67	11.84
K3	11.51	11.32	11.17	11.33
Mead sowing dates	12.12	11.92	11.71	
LSD Sowing date 0.022	LSD Potassium x sowing dates 0.039			LSD Potassium 0.022

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مجلة جامعة كركوك للعلوم الزراعية

تأثير مستويات مختلفة من السماد البوتاسي وعدة مواعيد من الزراعة في نمو وحاصل ونوعية الحنطة *Triticum aestivum L.*

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- تاريخ استلام البحث 2023/06/11 وتاريخ قبوله 2023/07/09

المستخلص

نفذت التجربة الحقلية خلال الموسم الشتوي 2021 - 2022 في احد حقول المزارعين في قرية البوذياب التابعة لمدينة الرمادي . لدراسة تأثير ثلاث مستويات من السماد البوتاسي (200 ,160 ,120) كغم K . هكتار وثلاث مواعيد زراعة (15 تشرين الثاني و1 كانون الأول و 15 كانون الأول) في صفات النمو والحاصل والنوعية لنبات الحنطة . طبق نظام التجارب العاملية بتصميم القطاعات العشوائية الكاملة (R.C.B.D) . أظهرت نتائج التحليل الاحصائي وجود فروقات معنوية بين مستويات السماد البوتاسي حيث تفوق مستوى السماد البوتاسي 200 كغم K . هكتار على المستويات الأخرى في صفات ارتفاع النبات 94.25 سم ومساحة ورقة العلم 48.16 سم^{2} و عدد السنابل بالمتر المربع285.60 م^{2} وعدد الحبوب بالسنبلة65.50 حبة ووزن 1000 حبة 34.10 غم وحاصل الحبوب 6.40 طن .هـ$^{-1}$. كذلك لوحظ ان مواعيد الزراعة قد اختلفت هي الاخرى فيما بينها معنويا فقد تفوق موعد الزراعة 15 كانون الاول معنويا على باقي المواعيد لنفس الصفات اعلاه اذ اعطى ارتفاع نبات 82.30 سم ومساحة ورقة علم43.31 سم^{2} وعدد سنابل بالمتر المربع270.94 م^{2} وعدد الحبوب بالسنبلة 58.94 حبة ووزن1000 حبة 32.64 غم وحاصل حبوب5.36 طن .هـ$^{-1}$. كان للتداخل بين مستوى السماد البوتاسي ومواعيد الزراعة تأثيرا معنويا في صفة حاصل الحبوب، اذ حقق مستوى السماد 200 كغم K . هكتار مع موعد الزراعة 15 كانون الأول اعلى حاصل حبوب بلغ 7.30 طن .هـ$^{-1}$. وفيما يخص صفة نسبة البروتين في الحبوب فقد سجل المستوى السمادي 120 كغم K . هكتار اعلى نسبة بلغت 12.57 %، ايضا اعطى الموعد الزراعي 15 تشرين الثاني اكبر نسبة 12.12 % مقارنة بباقي المواعيد.

الكلمات المفتاحية: بوتاسيوم، مواعيد زراعة، الحاصل، مكونات الحاصل، حنطة الخبز .