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**The Effect of Spraying Cytokinin and Planting Dates on
Barley Growth and yield**

ABSTRACT

A field experiment was carried out during the winter season 2020-2021 in the AL-Sufia area, east of Ramadi, to estimate effect of spraying cytokinin on the growth and yield of barley (*Hordeum vulgare* L.). By using the split plot plate arrangement by randomized complete block design (RCBD) with three replications, the study included two factors, the first factor, three concentrations of cytokinin 0 (K1), 30 (K2) and 60 (K3) mg L⁻¹ taken and sprayed on the vegetative part in equal parts for two sprays, each spraying 0, 15 and 30 mg L⁻¹ when the first vegetative branch appeared. The second factor is the planting dates and they were Oct 25th, Nov 10th, Nov 25th and Dec 10th, and the symbols (D1, D2, D3, D4) were taken. Concentration of 60 mg L⁻¹ of cytokinin significantly affected the yield characteristics and its components, as this concentration recorded the highest average in the characteristics number of grains in the spike, weight of 1000 grains, and grain yield was 26.20 grains in the spike-1 and 53.77 g and 5.633 ton H-1 respectively. The planting dates also had a significant effect on the yield characteristics and its components, second date superior Nov 10th in most of the studied traits, and the yield traits recorded the highest rates in the trait of the number of spikes 402.7 spikes m⁻² and number of grains spike 26.17 grain spike-1, and grain yield amounted to 6.198 ton h-1

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INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the important cereal crops in the world because it is used in human nutrition, as its grain contains about 10% protein, 70% carbohydrates, and a high percentage of essential amino acids for humans, fibers, and vitamins, especially vitamin B (Mani et al., 2008). The globally cultivated area of this crop reached 51.14 million hectares and produced 158.9 million tons with average productivity of 3.11 tons ha⁻¹, while the cultivated area reached 897.2 thousand hectares produced 1.51 million tons, with an average productivity of 1.69 ton ha⁻¹ in Iraq (FAO.2018). One of the most important problems facing the cultivation of this crop in Iraq, which prevents the achievement of good productivity, is how to understand the appropriate conditions for the growth phases of this crop and the physiological processes related to the integrated service of the soil and the crop from planting to harvest, especially determining the appropriate date for its cultivation because it is one of the important and essential factors in achieving the best yield of the crop (Al-Kinani, 2019). Recently, researchers and scientists have directed attention to using growth regulators like cytokinin to the regulation of physiological processes, which is positively reflected on the growth and increased the yield of the plant cytokine. The date of planting has an effect on the environmental conditions and the resulting Heat Accumulation with the length of the photoperiod, and this is, of course, reflected in the formation of the tillers because the planting dates lead to a change in the response of varieties and species to the

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photoperiod and temperature (Al-Mohammadi, 2011). Therefore, and based on the foregoing, the aim of this study is to know the effect of planting date on the studied characteristics of barley and its reflection on the pattern of riparian formation, growth characteristics, and yield. As well as determining the most appropriate concentration of cytokinin and its important role in the characteristics of the yield and its components. Determining the best interaction between planting dates and cytokinin concentrations to obtain the best combination that gives the highest rate of the studied traits.

MATERIALS AND METHODS

A field experiment was carried out in the winter season 2020-2021 in the field of a farmer in the AL-Sufia area, east of Ramadi, in Anbar Governorate, in order to determine the effect of planting date barley and spraying with different concentrations of kinetin on the growth characteristics and yield of this crop. The experiment included a study of two factors, planting dates, which included Oct 25th, Nov 10th, Nov 25th and Dec 10th, which took the symbols D1, D2, D3, D4 sequentially, which represented the main plots. The concentrations of kinetin (0, 30 and 60 mg L⁻¹), which were by symbols (K1, K2, K3) represented sub-plots in the RCBD design with the split plot arrangement with three replicates. The experimental land was divided into boards with an area of 2x2m. Each experimental unit included 10 lines, the distance between one line and another was 20 cm. Barley variety (Aksad) seeds were sown at a seeding rate of 120 kg H⁻¹. The nitrogen fertilizer was added at a rate of 120 kg N ha⁻¹ in the form of urea fertilizer (46 %N) according to the experiment treatments. Phosphate fertilizers were added with an amount of 80 kg K. h⁻¹ in the form of triple superphosphate (46% P₂O₅) in one batch during the preparation of the soil for planting. Potassium fertilizer was added in the form of potassium sulfate (42%K) in the branching stage with an amount of 40 kg K.h⁻¹. The following traits were studied: leaf area cm² (length*max width*0.95). plant⁻¹, dry weight (gm. plant⁻¹), number of spikes m⁻², number of grains (grain spike⁻¹), weight of 1000 g grains and grain yield (ton ha⁻¹). 10 plants were taken from the median lines and studied on them. The data were statistically analyzed using the computer within the program Genstat Version12 according to the method of analysis of variance in the arrangement of the split-plots by design of the randomized complete block design R.C.B.D and the averages were compared using the least significant difference L.S.D at the probability level of 0.05 (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Leaf Area

The second date (Nov 10th) in leaf area superior the other dates and recorded the highest value of (232.6) cm², while in the fourth date recorded the lowest value leaf area (191.3) cm² (Table 1). The reason for the superiority of the second date may be due to the beginning of the formation of tillers was delayed compared to the first date, and that the arrival of the plants to the maximum formation of the tillers was after mid-January and near the start of high temperatures, so the conditions were more suitable for the growth and expansion of leaves on the second date. This result is in agreement with what was reached by Abu Hadma and et. Al. (2015) and Jassim et al. (2016). The results of the same table showed the superiority of plants treated with a concentration of 60 mg L⁻¹ of kinetin with the highest average leaf area of 217.0 cm² and a percentage greater than the comparison by 5.4%, but non significantly from spraying with a concentration of 30 mg L⁻¹, which amounted to 215.4 cm² while the area decreased Foliage of plants in the control treatment (spraying with water) to the lowest average of 205.8 cm². The reason for the increase in leaf area when treated with kinetin may be due to its role in increasing the process of cell division and activating the action of auxin, which has an important role in division and elongation, as well as its role in delaying the aging of leaves and save proteins and nucleic acids in the leaves as well as a cycle in the construction of kрана discs in the plastids and perpetuation Nutrient access to leaves (Al-Sabbagh, 2016) and this agrees with by Al-Alizadeh (2010), Hussain (2015) and Al-Fayyadh (2018). A significant interaction was observed between the two factors of the study, as the interaction between the concentration of kinetin 60 mg L⁻¹ and the second date (Nov 10th) was significantly (249.0) cm² compared to the least average leaf area (192.3) cm² with the interaction between spraying treatment with a concentration of 60 mg L⁻¹ on the fourth date.

Table (1): The effect of planting date, cytokinin spraying, and their interaction on barley leaf area (cm²)

Cytokinin concentration mg. L ⁻¹	Data				Average
	Oct 25 th	Nov 10 th	Nov 25 th	Dec 10 th	
0	216.3	210.3	205.7	191.2	205.8
30	217.2	238.6	215.5	190.3	215.4
60	227.8	249.0	199.1	192.3	217.0
Average	220.4	232.6	206.7	191.3	
LSD 0.05					
Date x Cytokinin	3.265	Cytokinin	1.632	Date	2.128

Dry weight (g. plant⁻¹)

The planting date on Nov 10th superior in trait of plant dry weight, as it reached the highest average of (6.71) g. plant⁻¹ compared to the first date which recorded the lowest average of 6.096 g. plant⁻¹, non-significant statistical between the Nov 10th and Nov 25th plants (Table 2). The superiority of the Nov 10th was due to the superiority of the plants of this date in the characteristics of leaf area (Table 1) and the activation of photosynthesis and accumulation of dry matter resulting from the appropriate environmental conditions that the plant experienced during the stages of growth and the periods that the plant went through and which occurred in which it was The reference to it in the trait of leaf area, as well as the superiority of the second date in the trait of leaf area, the increase in dry matter was known at the end of the plant growing season, and then dried and weighed Table-1 (Al-Jiashi, 2020 and Liu et al., 2021). The results of (Table-2) also showed the superiority of plants treated with a concentration of 60 mg L⁻¹ of kinetin with the highest average dry weight of 6.82 g plant⁻¹, which differed significantly from spraying with a concentration of 30 g.L⁻¹ and the control treatment (6.272 and 6.225) g. plant⁻¹ respectively, The reason for this superiority is due to the role of kinetin with its physiological effectiveness and increasing the leaf area by encouraging division, elongation and building chlorophyll, leading to an increase in photosynthesis per unit leaf area and the accumulation of total dry matter in plant parts, and this in turn increases the dry weight of plants (Attiya, 2010 and Saadi, 2013) this result agree with (Zalewski et al, 2014). The results of (Table -2) showed that there were significant differences from the interaction of the effect of planting date and the concentration of kinetin in this trait, and the superiority of the interaction between the concentration of kinetin 60 g. L⁻¹ and the third date (Nov 25th), which recorded the highest rate of 7.28 g. plant⁻¹ compared to the treatment between Water spray treatment (comparison) and the first date (Oct 25th), which reached the lowest recorded rate of 5.45 g. plant⁻¹

Table (2): The effect of planting date, cytokinin spraying, and their interaction on barley dry weight of g. plant⁻¹

Cytokinin concentration mg. L ⁻¹	Data				Average
	Oct 25 th	Nov 10 th	Nov 25 th	Dec 10 th	
0	5.45	6.73	6.60	6.12	6.225
30	6.37	6.27	6.13	6.32	6.272
60	6.47	7.13	7.28	6.38	6.815
Average	6.096	6.71	6.67	6.27	
LSD 0.05					
Date x Cytokinin	0.0451	Cytokinin	0.0225	Date	0.0710

Number of spikes (spike m⁻²)

The results of table 3 indicated that second date (Nov 10th) significantly increased the number of spikes and gave the highest value of,402.7 spikes m⁻², Compared to the fourth date, which recorded the least number of spikes (316.7) spikes. m⁻², The reason for the increase in the number of spikes in the second date is due to the superiority of this date in leaf area, dry weight and other growth characteristics, which allowed the formation of the flowering and fruiting parts for a sufficient period with the availability of growth requirements from the leaf area (Table 1). Which activity photosynthesis and the accumulation of the appropriate dry matter during the different stages of growth, all of which led to the formation of the fruiting parts in a manner that accompanied the active growth and with the least competition between the vegetative and fruiting parts of the plant, On the first date (Oct 25th), the barley plant is resistant to inappropriate environmental conditions because the environment is considered an effect in characteristics growth of the plant which is reflected on the characteristics of the yield and its components, and competition occurs between the main stem and the tillers, and the demand for manufactured materials produced by the plant increases. As for the third and fourth dates, this delay led to a short period of time required for the growth and formation of spikes to effective which in turn negatively affected the number of spikes (Baladezaie ,2011) and Al Kafai ,2018). The two treatments 30 and 60 g .L⁻¹ non- significantly in terms of their effect on this trait, as recorded 377.7 and 374.2 spikes. m⁻², and they were superior to the comparison treatment in which the number of spikes decreased to 345.2 spikes. m⁻² (Table 3). This positive effect of spraying with kinetin is due to the superiority of these two treatments in the characteristics of leaf area and dry weight (Tables 1 and 2) because of the effect of kinetin in breaking the apical dominance as well as its role in activity and transfer of nutrients to their areas of presence by reducing competition between the vegetative and fruiting parts during the emergence of the fruiting parts of the plant(Ali et al. 2015 and Chen et al., 2021). The results of (Table 3) showed that there were non- significant from the interaction effect of planting date and kinetin concentrations in this trait.

Table (3): The effect of planting date, cytokinin spraying, and their interaction on barley of the number spikes (spike m⁻²)

Cytokinin concentration mg. L ⁻¹	Data				Average
	Oct 25 th	Nov 10 th	Nov 25 th	Dec 10 th	
0	363.7	383.3	323.7	310.7	345.2
30	392.0	410.7	384.3	323.7	377.7
60	400.0	414.0	367.3	315.7	374.2
Average	385.2	402.7	358.4	316.7	
LSD 0.05					
Date x Cytokinin	N.S	Cytokinin	10.36	Date	12.11

Number of grains.spike⁻¹

The superiority of the second date (Nov 10th) in the number of grains and gave the highest value (26.17) grain spike⁻¹ compared with the fourth date, which gave the lowest number of grain (24.75) grain spike⁻¹ (Table 4), The reason for the superiority of the second date is due to the appropriate temperature during the emergence and development stage of the spike, which led to the increase of the development period of the growth apical in the spikes and the reduction in the rates of abortion of the florets and spike during the emergence phase of the spike. This is due to the superiority of this date in the growth characteristics, which provided a vegetation cover that intercepts the light sun and encourages the increase of photosynthesis and the dry matter formed and associated with the formation of a vegetative group ability of intercepting the light to perform photosynthesis (Girish et al. 2018) This finding agreed with Chaudhary et al. (2017).

The results of the same table also showed the superiority of plants treated with a concentration of 60 mg L⁻¹ of kinetin in this trait two treatments, and the highest average number of grains was 26.20 spikes⁻¹. Which differed from the plants of the control treatment (spraying with water), the lowest value amounted to 24.33 grains of spike⁻¹, The reason is the increase in the number of grains in the spike to increase the leaf area, the dry weight of the plant and the number of spikes, This increases the products of photosynthesis, which is positively reflected in the number of spikelets (Holubova et al., 2018) agreed with the findings of many researchers (Javid et al., 2011 and Al-Obaidi et al., 2017).

It was shown from (Table 4) that the interaction treatment between 60 mg L⁻¹ concentration in the third date (Nov 25th) was superior. The highest number of grains was recorded (26.85) grain spike⁻¹ compared to the lowest number of grains (22.59) grain spike⁻¹.

Table (4): The effect of planting date, cytokinin spraying, and their interaction on barley Number of grains spike⁻¹

Cytokinin concentration mg. L ⁻¹	Data				Average
	Oct 25 th	Nov 10 th	Nov 25 th	Dec 10 th	
0	22.59	25.32	24.74	24.67	24.33
30	26.83	26.65	25.24	24.62	25.83
60	26.43	26.55	26.85	24.97	26.20
Average	25.28	26.17	25.61	24.75	
LSD 0.05					
Date x Cytokinin	0.360	Cytokinin	0.180	Date	0.161

Weight of 1000 grain (gm.)

The results of (Table 5) showed the superiority of the second date (Nov 10th) in the trait of 1000 grains, and the highest value was recorded (55.12) g. compared with the treatment of the first date (Oct 25th), which recorded the lowest 1000 grains, which amounted to 51.53 g. This may be due to the superiority of the second date in growth characteristics, especially leaf area and chlorophyll, and an increase in dry weight. In addition, the appropriate environmental conditions are appropriate in the stages of growth, especially temperatures. results agreed with the findings of (Tabarzad et al., 2016). The results in (Table 5) showed a significant superiority of plants treated with 60 mg L⁻¹ of kinetin over the control treatment and sprayed with a concentration of 30 mg L⁻¹, which gave the highest average weight of 1000 grains which was 53.77 g. This is due to the effective role of kinetin at a concentration of 60 mg L⁻¹ in improving growth characteristics and its role in increasing leaf area and dry weight (Tables 1, 2) and increase the accumulation of dry matter inside the plant (Salam *et.al*, 2019). This finding is agree with (Yang et al., 2016) and (Chen et al., 2021). The interaction treatment between the concentration of kinetin 60 mg L⁻¹ in the second date (10/11) was superior, giving the highest grain weight, which amounted to 56.88 g, compared to the lowest number of grains 50.55 g by the interaction between the comparison treatment in the first date (Oct 25th).

Table (5): The effect of planting date, cytokinin spraying, and their interaction on barley weight 1000 grain (g.)

Cytokinin concentration mg. L ⁻¹	Data				Average
	Oct 25 th	Nov 10 th	Nov 25 th	Dec 10 th	
0	50.55	53.43	54.27	55.08	53.33
30	52.08	55.07	52.29	54.55	53.50
60	51.95	56.88	53.66	52.60	53.77
Average	51.53	55.12	53.12	54.08	
LSD 0.05					
Date x Cytokinin	0.444	Cytokinin	0.222	Date	0.181

Grain yield (ton ha⁻¹)

The results of (Table 6) indicated the superiority of the plants of the second date (Nov 10th) in the number of spikes, the number of grains spike⁻¹ and the weight of 1000 grains. It was significantly superior to the comparison treatment with a grain yield of 6.198 ton ha⁻¹ with a percentage of 16% with the other components of the yield and significant other dates as well the difference in grain yield due to the effect of the variance in the planting date and the negative effect of delaying planting, especially in the month of December, (Yadi et al. ,2016) and (Reddy et al.,2018) Table (6) shows a significant superiority of plants treated with a concentration of 60 mg L⁻¹ of kinetin with the highest mean grain yield of 5.633 ton ha⁻¹. While the comparison treatment that recorded the lowest rate amounted to 4.723 ton ha⁻¹, this increasing in the yield was due to the positive effect of kinetin by increasing the leaf area and dry weight and increasing the yield components (the number of grains spike and weight 1000 grains). These results are in agreement with the findings of (Ali ,2015) and (Chen et al., 2021). The results of (Table 6) for the interaction between kinetin concentrations and planting dates non-significant effect on the characteristic of grain yield.

Table (6): The effect of planting date, cytokinin spraying, and their interaction on barley grain yield (ton ha⁻¹)

Cytokinin concentration mg. L ⁻¹	Data				Average
	Oct 25 th	Nov 10 th	Nov 25 th	Dec 10 th	
0	4.406	5.502	4.587	4.396	4.723
30	5.801	6.355	5.370	4.646	5.543
60	5.807	6.738	5.590	4.396	5.633
Average	5.338	6.198	5.182	4.480	
LSD 0.05					
Date x Cytokinin	N.S	Cytokinin	0.303	Date	0.646

CONCLUSION

The consults showed that concentration of 60 mg L⁻¹ of cytokinin had a significant effect on the characteristics of the yield and its components, which indicates the possibility of using higher concentrations of cytokinin as it gave a significant increase in the desired direction. We also note from the previous results that planting dates caused a difference in the direct response to the yield and its components depending on the prevailing environmental conditions, second date Nov 10th superior in growth characteristics, yield and its components, so the second date Nov 10th can be considered as one of the most suitable planting dates for growth barley, variety of Iksad in the conditions of the region. The results also gave the best combination of 1000 weight and grain yield in the treatment of the second date with a concentration of 60 mg L⁻¹.

We recommend the adoption of early planting of barley for its superiority over the late dates and the use of concentrations higher than 60 mg L⁻¹ of kinetin to obtain higher rates of the yield and its components

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تأثير رش الساييتوكاينين ومواعيد الزراعة في نمو وحاصل الشعير

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الخلاصة

نفذت تجربة حقلية خلال الموسم الشتوي 2020-2021 في منطقة الصوفية شرق الرمادي لمعرفة تأثير الرش بالساييتوكاينين على نمو وحاصل الشعير (*Hordeum vulgare L.*) وباستخدام ترتيب الألواح المنشقة بتصميم القطاعات الكاملة المعشاة (RCBD) بثلاث مكررات وتضمنت عوامل الدراسة عاملين العامل الأول ثلاثة تراكيز من الساييتوكاينين 0 (K1) و 30 (K2) و 60 (K3) ملغم لتر-1 تضاف رشا على الجزء الخضري عند ظهور أول فرع خضري. العامل الثاني المواعيد الزراعية وكانت 10/25 و 11/10 و 11/25 و 12/10 واخذت الرموز (D1, D2, D3, D4). اثر التركيز 60 ملغم لتر-1 من الساييتوكاينين معنويا في صفات الحاصل ومكوناته اذ سجل هذا التركيز اعلى معدل في صفات عدد الحبوب بالسنبلة ووزن 1000 حبة وحاصل الحبوب بلغ 26.20 حبة سنبلة-1 و 53.77 غم. و 5.633 طن هـ-1 بالتتابع.

كما اثرت مواعيد الزراعة معنويا في صفات الحاصل ومكوناته اذ تفوق الموعد الثاني 11/10 في معظم الصفات المدروسة وسجلت صفات الحاصل اعلى المعدلات في صفة عدد سنابل 402.7 سنبلة م2 وعدد حبوب بالسنبلة 26.17 حبة سنبلة-1 و حاصل الحبوب بلغ 6.198 طن هـ-1

الكلمات المفتاحية:

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