RESPONSE OF OAT CULTIVARS TO DIFFERENT SEEDING RATES

Basheer A. Abraheem[1] **Bushra SH. J. ALobaidy[2]**
Assist. Prof. **Assist. Prof.**
[1] Dept. of Field Crop Sc., Coll. of Agric. Eng. Sci., University of Baghdad, Iraq.
[2] Dept. of Field Crop Sc., Coll. of Agric., University of Anbar, Iraq.
Basher.abd@coagri.oubaghdad.edu.iq **ag.Bushra.shaker@uoanbar.edu.iq**

ABSTRACT

This study was aimed to investigate vegetative growth indicators of four oat cultivars (Genzania, Shefa, Carrolup, and Hamel) at seeding rates of 80, 100, and 120 kg ha⁻¹ in a factorial experiment within a randomized block design during the winter season 2022-2023. Genzania showed significant superiority in leaf area, relative growth rate (0.0707 g g⁻¹ day⁻¹), and total dry mass (21.54 tons ha⁻¹). Shefa excelled in tiller count (365.10 tillers m⁻²), while Hamel exhibited superiority in stem diameter (5.68 mm), lower lodging index (39.90), and fewer effective tillers (88.10%). Seeding rate effects included increased plant height and total dry mass, with a rise in lodging index. The highest seeding rate (120 kg ha⁻¹) significantly outperformed in tiller count. Conversely, leaf area and effective tiller percentage decreased with higher seeding rates. The 80 kg ha⁻¹ seeding rate showed superiority in relative growth rate. Interaction between factors was significant for total dry mass and lodging index, with Genzania × 120 kg ha⁻¹ performing the best. Cultivars varied in vegetative growth responses to seeding rates.

Keywords: lodging index, relative growth rate, food security, active tillers.

استجابة اصناف من الشوفان لمعدلات بذار مختلفة

بشير عبد الله ابراهيم[1] بشرى شاكر العبيدي[2]
استاذ مساعد استاذ مساعد
[1] قسم علوم المحاصيل، كلية علوم الهندسة الزراعية، جامعة بغداد، العراق
[2] قسم المحاصيل، كلية الزراعة، جامعة الانبار، العراق

المستخلص

اجريت تجربة عاملية في الموسم الشتوي 2022–2023 بهدف دراسة استجابة بعض مؤشرات النمو الخضري في اربعة اصناف من الشوفان(Genzania وShefa وCarrolup وHamel) لمعدلات بذار مختلفة (80 و100 و120 كغم هـ$^{-1}$). بينت النتائج تفوق الصنف Genzania معنوياً في المساحة الورقية ومعدل النمو النسبي والكتلة الجافة الكلية، في حين تفوق الصنف Shefa بعدد الاشطاء، والصنف Hamel بقطر الساق ودليل الاضطجاع واقل نسبة اشطاء فعالة. واشارت نتائج معدلات البذار الى زيادة كل من ارتفاع النبات والكتلة الجافة الكلية و دليل الاضطجاع زيادة معنوية مع كل زيادة في مستوى معدل البذار. وتفوق معدل البذار الاعلى (120 كغم هـ$^{-1}$) تفوقاً معنوياً في عدد الاشطاء م$^{-2}$. وحصل العكس مع مساحة ورقة العلم ونسبة الاشطاء الفعالة فانخفضت معنوياً بزيادة مستوى معدل البذار، وتفوق معدل البذار80كغم هـ$^{-1}$ معنوياً في معدل النمو النسبي. اشارت النتائج الى معنوية التداخل بين عاملي الدراسة في في الكتلة الجافة الكلية ودليل الاضطجاع، اذ تفوقت توليفة Genzania×120 كغم هـ$^{-1}$ على التوليفات الاخرى كلها. وعليه فان الاصناف قيد الدراسة اختلفت في مؤشرات النمو الخضري مما انعكس في اختلاف استجابتها لمعدلات البذار التي بزيادتها ازدادت الكتلة الجافة للاصناف Carrolup و Genzania وHamel.

الكلمات المفتاحية: دليل الاضطجاع، معدل النمو النسبي، الأمن الغذائي، الاشطاء الفعالة

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INTRODUCTION

Oats (*Avena sativa* L.), related to the Poaceae grass family, are considered one of the important cereal crop worldwide. Their significance lies in their diverse uses, as they contribute to human nutrition with grains rich in essential nutrients. Oats contain important nutritional elements, with their grains comprising approximately 60% carbohydrates, 14% protein, 4% β-glucan, and 7% fat (23). Oat plants serve as a natural source of β-D-glucan, a compound known for its health-enhancing effects, such as reducing cholesterol levels and maintaining blood sugar levels (18). Oat extract is rich in antioxidants and is used to boost immunity against diseases caused by free radicals (16). The use of oat grains in human nutrition has increased due to their content of antioxidants, carotenes, vitamins such as E, and minerals such as Fe, Ca, P (10). The global production of oats reached 25.18 million tons, cultivated on an area of 9.77 million hectares, with a yield of 2.57 tons per hectare (9**).** Agricultural represents the most important method for harvesting solar energy, and determining the seeding rate is a crucial factor in increasing the efficiency of this process and, consequently, crop growth. Optimal plant density achieves the highest values for growth indicators for cultivars with different tillering tendencies. Therefore, it is important to find the appropriate relationship between cultivated cultivars and the suitable plant density that balances the potential of these cultivars to produce tillers without compromising their strength through competition for growth factors when exceeding the optimal plant density. Seeding rates were depending on the location, planting date, cultivar, soil type, fertility, moisture, and seed germination rate. Cultivars with high tillering tendencies can compensate for the number of tillers per unit area when planted at low seeding rates; however, the opposite is not true. Low-tillering cultivars cannot compensate for the shortage in the number of tillers per unit area at low seeding rates. In high seeding rates, competition between tillers appears early in cultivars with high tillering tendencies. Previous studies have shown variations in the response of different oat cultivars to different plant densities. According to Naser and Al-mothefer (14), a plant density of 120 kg/ha resulted in the highest plant height and the lower leaf area. Sumaya and Khalaf (20) used three seeding rates (200, 250 and 300 seeds m^{-2}) and found that the seeding rate of 200 seeds m^{-2} achieved the best results. Abed and Al-essawi (1) found that the Genzania variety was significantly superior to the Shefa variety in the area of the flag leaf. In another study, Addaheri et al. (3) observed the superiority of Genzania and Carrolup over Shefa in plant height, while in total dry matter, Genzania and Shefa outperformed Carrolup. Kanwal *et al.,* (11) found that the highest seeding rate (90 kg ha^{-1}) increased plant height, number of tillers, leaf area, and total dry weight. Therefore, this study was conducted to explore the impact of different seeding rates on the studied cultivars.

MATERIALS AND METHODS

A field experiment was conducted at the village of Khazraj, west of the city of Ramadi, in the winter season of 2022-2023, A randomized complete block design (RCBD) The experiment conducted using split plot arrangement within three replicates. The experiment included four oat cultivars (Genzania, Shefa, Carrolup, and Hamel) as main plots, and three seeding rates (100, 120, and 140 kg ha^{-1}) as sub-plots. Each experimental unit had a 2 × 2 m area, and the seeds were sown on November 22, 2022 (3; 14). Each experimental unit comprised 10 rows, each 2 m long, with a spacing of 20 cm between rows. The experimental soil was fertilized with triple superphosphate (46% P_2O_5) at a rate of 100 kg ha^{-1}(2), potassium fertilizer at rate of 100 kg ha^{-1}, and urea (46% N) at a rate of 120 kg ha^{-1} (15). The urea was applied in two doses, the first at the beginning of tiller formation (ZGS21), and the second at the beginning of the booting stage (ZGS41). Crop management operations included irrigation and weeding was performed as needed until harvest.

Statistical analysis: was conducted on the obtained data for vegetative growth traits using Analysis of Variance (ANOVA) through the GenStat software. The Least Significant Difference (LSD) test was employed for mean comparison at a significance level of 5%.

RESULTS AND DISCUSSION

Plant height(cm): The results in Table (1) indicate significant differences among oat cultivars. Both Hamel and Genzania significantly outperformed Shefa and Carrolup in plant height, with no significant differences between them. The differences among cultivars in plant height may be attributed to the fact that plant height is primarily controlled by additive genes to a significant degree (8). Additionally, Table (1) shows a significant increase in plant height with each increase, in seeding rate level. The percentage increase, in plant height reached 7.00% and 13.81% at the second seeding rate (100 kg ha^{-1}) and the third seeding rate (120 kg ha^{-1}), respectively, compared to the first seeding rate level (80 kg ha^{-1}). This can be explained by the fact that an increases in seeding rate leads to an increases in the number of plants growing in a unit area, intensifying competition among the plants. The heightened competition results in increased shading between the plants (reduced light penetration through the plant canopy), leading to a decrease in the photodegradation of auxin produced in the apical meristem. This implies a reduced regulation of auxin levels, with a proportion of it being broken down in response to light intensity. Consequently, a substantial amount of auxin reaches the stem, causing elongation. Additionally, there is a decrease in the ratio of red light to far-red light (R:FR), impacting the transformation of phytochrome pigment, which plays a role in plant responses to environmental conditions, leading to a decrease in the Pr: Pfr ratio (19). This stimulates the production of gibberellins or increases the activity of existing gibberellins to elongate stem cells in collaboration with auxin, thus increasing plant height. Consequently, the increases in seeding rate leads to more shading, ultimately resulting in elevated levels of hormones responsible for stem elongation, this result is consistent with the results of Baktash, and Naes (7). As for interactions, no significant effects were observed between cultivar combinations and seeding rates.

Table 1. Effect of seeding rates and varieties on plant height (cm).

Cultivars	Seeding rate (kg ha^{-1})			Mean
	80	100	120	
Carrolup	103.00	107.30	115.30	108.60
Genzania	112.70	125.80	130.70	123.00
Hamel	121.40	125.80	140.00	129.10
Shefa	103.00	112.00	114.70	109.90
Mean	110.00	117.70	125.20	
L.S.D 5%	Cultivars	Seeding rate	Interaction	
	8.67	7.51	N.S.	

Stem diameter (mm)

Data in Table (2) shows that the cultivar Hamel exhibited the highest stem diameter, significantly outperforming to other cultivars. Genzania followed with a significant superiority over the cultivars Carrolup and Shefa, which had the lowest average stem diameters. It is noteworthy that the cultivar Shefa, which had the smallest stem diameter with a non-significant differences from the cultivar Carrolup, also yielded the highest number of tillers (Table 4). This aligns with the compensatory principle, where tillers with a higher count tend to have smaller stem diameters due to the distribution of dry matter across more units. Additionally, the cultivars Carrolup and Shefa obtained the lowest total dry mass (Table 6), exhibiting a significant decreases compared to the cultivars Genzania and Hamel. Consequently, the limited total dry mass was distributed among the tillers, resulting in smaller diameters and, consequently, shorter heights (Table 1). Neither the seeding rate nor the interaction between the factors had a significant effect on stem diameter.

Table 2. Effect of seeding rates and varieties on stem diameter (mm).

Cultivars	Seeding rate (kg ha^{-1})			Mean
	80	100	120	
Carrolup	4.01	3.38	3.77	3.72
Genzania	4.80	5.33	5.14	5.09
Hamel	5.56	5.76	5.73	5.68
Shefa	3.66	3.15	3.33	3.38
Mean	4.51	4.41	4.49	
L.S.D 5%	Cultivars	Seeding rate	Interaction	
	0.457	N.S.	N.S.	

Flag leaf area (cm^2)

Results of Table (3) show that the cultivar Genzania significantly outperformed all other cultivars with a highest flag leaf area, followed by the cultivars Shefa and Hamel, which did not differ significantly from each other but outperformed the cultivar Carrolup. The percentage increases in flag leaf area for Genzania exceeded three-quarters (76.17%) of Carrolup's flag leaf area. Genzania's superiority in flag leaf area correlated with an increase in plant height (Table 1), relative growth rate (Table 5), and total dry mass (Table 6), underscoring the significance of this trait. Results of Table (3) also indicate that any increases in the seeding rate was accompanied by a significant decrease in flag leaf area. The percentage decreases in treatments with seeding rates of 100 and 140 kg ha^{-1} was 14.50% and 31.76%, respectively, compared to the 80 kg ha^{-1} treatment. This suggests that an increases in seeding rate, leading to higher plant density, intensifies competition among plants for growth factors such as nutrients, water, and sunlight. On the other hand, increased shading (due to higher plant density) results in smaller flag leaf areas compared to those growing under full light. Consequently, flag leaf area, along with certain indicators of vegetative growth such as relative growth rate (Table 5) and total dry mass (Table 6), decreases., No significant interaction were observed between the seeding rates and cultivars during the study season.

Table 3. Effect of seeding rates and varieties on flag leaf area (cm^2).

Cultivars	Seeding rate (kg ha^{-1})			Mean
	80	100	120	
Carrolup	4.01	3.38	3.77	3.72
Genzania	4.80	5.33	5.14	5.09
Hamel	5.56	5.76	5.73	5.68
Shefa	3.66	3.15	3.33	3.38
Mean	4.51	4.41	4.49	
L.S.D 5%	Cultivars	Seeding rate	Interaction	
	0.457	N.S.	N.S.	

Number of Tillers (m^{-2})

The results illustrate that the cultivar Shefa had the highest number of tillers, significantly outperforming other cultivars in this study (Table 4), which did not differ significantly from each other. This finding aligns with Odib and Dahal (15), who observed that the Shefa cultivar possesses a higher number of tillers. It appears that the Shefa cultivar has the genetic capacity to produce this large number of tillers. However, despite the increase in tiller count for this cultivar, it did not elevate the relative growth rate (Table 5), and the Hamel cultivar gave the lowest average for total dry mass (Table 6). Therefore, the priority is to keep tillers alive and not increase dry matter (4), as observed in the Carrolup cultivar, which obtained the lowest rate. Regarding seeding rates, Table (4) shows that the number of tillers increased numerically with the increases in seeding rate until reaching significance with the highest seeding rate (120 kg ha^{-1}), surpassing the 80 and 100 kg ha^{-1} seeding rates. The increase in tiller count with higher seeding rates can be explained by the higher seeding rate increasing plant density, leading to more tillers per unit area. This aligns with the results of Alshugeairy *et al*. (5), Mahmood and Al-hassan (13), Sumaya and Khalaf (21). Despite the intensified competition among plant tillers, the overall tiller count increases per unit area due to the cumulative effect of tiller numbers. A significant superiority of the highest seeding rate in total dry mass (Table 6) observed, supporting the results that increased plant density is followed by an increase in tiller count. Notably, all cultivars exhibited this behavior (Table 4), suggesting that these cultivars could be tolerated higher seeding rates (plant density) than those applied in this study. The interaction between the study factors did not statistically significant.

Table 4. Effect of seeding rates and varieties on number of tillers (m^{-2}).

Cultivars	Seeding rate (kg ha^{-1})			Mean
	80	100	120	
Carrolup	339.30	348.00	362.70	350.00
Genzania	328.00	340.70	344.00	337.60
Hamel	323.30	338.00	364.70	342.00
Shefa	355.30	363.30	376.70	365.10
Mean	336.50	347.50	362.00	
L.S.D 5%	Cultivars	Seeding rate	Interaction	
	14.96	12.96	N.S.	

Relative growth rate (g $g^{-1}day^{-1}$)

The results show that the Genzania cultivar significantly outperformed other cultivars in Relative Growth Rate (RGR), while the Carrolup cultivar did not differ significantly from the Hamel cultivar, surpassing the Shefa cultivar significantly (Table 5). The superior RGR of the Genzania cultivar is consistent with its significant advantages in plant height (Table 1), flag leaf area (Table 4), and total dry mass (Table 6), indicating its ability to accumulate dry matter through photosynthetic processes and maintain the produced biomass. Results also reveal that the seeding rate of 80 kg ha^{-1} significantly outperformed the seeding rates of 100 and 120 kg ha^{-1}. The highest seeding rate (120 kg/ha^{-1}) exhibited a lower RGR compared to the moderate seeding rate (100 kg ha^{-1}), although it did not reach statistical significance. The increase in plant density with seeding rates in the studied cultivars seemed to reduce the RGR of oat plants, potentially due to increased competition among plants for various growth factors such as nutrients, water, and sunlight. Consequently, limiting growth factors became the determining factor for plant growth. The third seeding rate (120 kg ha^{-1}) reduced RGR in all cultivars, and cultivars can be ranked in descending order of tolerance to this seeding rate as follows: Genzania, Hamel, Carrolup, and Shefa. This suggests that Genzania is the most tolerant cultivar to this seeding density (based on the RGR index). This might indicate the potential for further increasing the seeding rate for Genzania beyond what was used in this study. As for the Shefa cultivar, the seeding rate of 120 kg ha^{-1} may pose a challenge in maintaining a relative growth rate not significantly different from the other cultivars. Referring to Table (4), reveal that Shefa significantly outperformed other cultivars in tiller count, which contributed to the reduction in RGR due to early competition among the high number of tillers per unit area, affecting the relative growth rate by competing for growth factors. From Table 5 there is a significant interaction between the study factors, as the combinations Genzania×80 kg ha^{-1} and Hamel×80 kg ha^{-1} significantly outperformed all other combinations. This indicates that these two cultivars exploited the lower plant density to achieve the highest relative growth rate among all studied cultivars.

Table 5. Effect of seeding rates and varieties on relative growth rate (g $g^{-1}day^{-1}$).

Cultivars	Seeding rate (kg ha^{-1})			Mean
	80	100	120	
Carrolup	0.0669	0.0680	0.0645	0.0665
Genzania	0.0804	0.0697	0.0621	0.0707
Hamel	0.0802	0.0580	0.0607	0.0663
Shefa	0.0683	0.0644	0.0565	0.0631
Mean	0.0740	0.0650	0.0610	
L.S.D 5%	Cultivars	Seeding rate	Interaction	
	0.0033	0.0036	0.0064.	

Total dry matter (ton ha^{-1})

Results of Table (6) indicate that the Genzania cultivar significantly outperformed other cultivars in the study with the highest total dry matter, followed by Hamel cultivar with a significant advantage over the Shefa and Carrolup cultivars, which did not exhibit a significant difference from each other. Total dry matter can serve as a measure of a cultivar's efficiency in the photosynthetic process and its ability to preserve this mass against potential decreases due to respiratory losses, leaf shedding, or tillers mortality. By referring to the flag leaf area (Table 3) and relative growth rate (Table 5), it becomes apparent that the Genzania cultivar has demonstrated a significant superiority in both aspects compared to the other studied cultivars. This reveals high genetic capacity for active growth and the ability to maintain the produced dry matter. Despite not excelling in the number of tillers (Table 4), the Genzania cultivar yielded the lowest average among the other cultivars (although the difference is not statistically significant) when compared to the Carrolup and Hamel cultivars. Nevertheless, it provided the highest total dry matter among the cultivars studied. Additionally, Table 6 reveals that any increase in seeding rate significantly increases the total dry matter. It is noteworthy that the relative growth rate (Table 5) significantly decreased with an increase in seeding rate for all cultivars due to intensified competition among plants and individual plant tillers for growth factors. However, this did not prevent plants from accumulating live biomass that increased with higher plant density. The higher plant density overcame the decrease in the relative growth rate for individual plants, resulting in the highest density having the highest total dry matter, these results are similar to those of Khorshid (12). Table (6) indicates a significant interaction between the study factors. Genzania×120 kg ha^{-1} outperformed all other combinations, highlighting Genzania's ability to yield a large total dry matter despite the increased seeding rate, distinguishing it from other cultivars in this study. Returning to the trait of relative growth rate (Table 5), we observe the superiority of Genzania and Hamel at the lower seeding rate, with Hamel lagging in total dry matter (Table 6) at the higher seeding rate. This may indicate Genzania's ability to keep tillers alive for later stages of plant growth, thus retaining the total dry matter produced through the photosynthetic process, in contrast to Hamel. An increase in seeding rate increases the total dry matter for Carrolup, Genzania, and Hamel, except for the Shefa cultivar. For Shefa, it seems that a seeding rate of 100 kg ha^{-1} achieved a balance between the numbers of tillers produced per unit area while maintaining ineffective competition to reduce the total dry matter. However, this competition became effective at the higher seeding rate (120 kg/ha), leading to a decrease in total dry matter due to intense competition among tillers (this cultivar exhibited significant superiority in the number of tillers - Table (4) for growth factors, resulting in a weakening of each other.

Table 6. Effect of seeding rates and varieties on total dry matter (ton ha^{-1})

Cultivars	Seeding rate (kg ha^{-1})			Mean
	80	100	120	
Carrolup	17.58	19.31	19.93	18.94
Genzania	19.40	21.32	23.90	21.54
Hamel	18.70	19.90	21.10	19.90
Shefa	17.57	20.18	19.77	19.17
Mean	18.31	20.18	21.17	
L.S.D 5%	Cultivars	Seeding rate	Interaction	
	0.44	0.64	1.10	

Lodging index

Results show that the Hamel cultivar provided the lowest lodging index among the cultivars in this study (Table 7). On the other hand, the Genzania cultivar exhibited significant superiority in giving the highest lodging index. When linking the stem diameter (Table 2) with the lodging index (Table 7), we find that the Hamel cultivar, which had the highest stem diameter and a significant superiority over other cultivars, reflected this with the lowest lodging index among the cultivars in this study. This emphasizes the importance of stem diameter in lodging resistance, this is similar to the results of Shah et al (17). Regarding the Genzania cultivar, despite its superiority with the Hamel cultivar in plant height (Table 1) and no significant difference in the number of tillers (Table 4), the Genzania cultivar excelled in leaf area (Table 3) and total dry matter (Table 6). These two traits may play a role in the higher lodging index for this cultivar compared to other cultivars in this study. It appears that any increase in seeding rate significantly increases the lodging index. From Table (1), we find that each increase in seeding rate significantly increases plant height, as well as with the number of tillers (Table 4) and total dry matter (Table 6). The increase in these traits combined with no increase in stem diameter (Table 2) or even its numerical decrease may be reflected in an increased likelihood of lodging occurrence, leading to a higher lodging index. The combination Genzania × 120 kg ha^{-1} gave the highest lodging index, as this combination combined the highest cultivar with the highest seeding rate in the lodging index, providing the highest value for interaction among the other combinations.

Table 7. Effect of seeding rates and varieties on lodging Index

Cultivars	Seeding rate (kg ha^{-1})			Mean
	80	100	120	
Carrolup	41.10	42.30	50.10	44.50
Genzania	43.10	48.60	54.30	48.70
Hamel	32.40	38.10	49.20	39.90
Shefa	40.40	44.20	48.90	44.50
Mean	39.30	43.30	50.62	
L.S.D 5%	Cultivars	Seeding rate	Interaction	
	4.03	3.43	7.55	

Percentage of active tillers

Results of Table (8) show that the Shefa cultivar, which gave the highest number of tillers (Table 4), exhibited a numerical increase (non-significant) in the percentage of active tillers compared to the Carrolup and Genzania cultivars. On the other hand, the Hamel cultivar gave the lowest average with a significant decrease in the percentage of active tillers compared to other cultivars in this study, except for the Genzania cultivar. This could be explained by the fact that in densely tillered cultivars, there is early competition between tillers, making the duration of tiller growth shorter than the duration required by less branched cultivars. This simultaneous growth of tillers in the Shefa cultivar allows most tillers to reach the heading stage almost simultaneously. In contrast, less tillering cultivars show competition occurring later, which means the possibility of late-emerging tillers that cannot reach the heading stage, resulting in an increase in the total number of tillers without an increase in the number of active tillers. Support for this claim can be found in the seeding rate, where the percentage of active tillers significantly decreased at the lowest seeding rate (80 kg ha^{-1}) compared to the two higher seeding rates. This means that an increase in the seeding rate, which increases plant density, increased the percentage of active tillers. This could be due to the synchronicity in the growth of these tillers and early competition among them for growth resources such as light, water, and nutrients. Thus, it reduced the opportunity for the emergence of late tillers, which may find it nearly impossible to reach the heading stage. We can observe that the increase in the seeding rate to 120 kg ha^{-1} resulted in the highest percentage of active tillers, even though the numerical increase over the average seeding rate still aligns with the same context. Similarly, with the interaction of varieties with seeding rates, all varieties followed the same pattern in increasing the percentage of active tillers with an increase in the seeding rate, This is consistent with the results of Baktash and Naes (6). It seems that the interaction between cultivars and seeding rates has taken the same behavior. In the seeding rate of 120 kg ha^{-1}, the Shefa variety outperformed (with the highest combination at 96.49), surpassing the Hamel variety and showing no significant difference from the Carrolup and Genzania varieties with*in* this seeding rate. While, the Genzania×80 kg ha^{-1} treatment gave the lowest value for the percentage of active tiller.

Table 8. Effect of seeding rates and varieties on percentage of active tillers

Cultivars	Seeding rate (kg ha^{-1})			Mean
	80	100	120	
Carrolup	90.55	91.23	93.84	91.87
Genzania	84.88	94.28	93.23	90.80
Hamel	85.78	87.54	90.98	88.10
Shefa	90.02	93.33	96.49	93.28
Mean	87.81	91.59	93.63	
L.S.D 5%	Cultivars	Seeding rate	Interaction	
	3.57	3.44	6.28	

REFERENCES

1. Abed, Nadhum Y. and H. K. Sh. Al-essawi. 2024. evaluation of oat varieties under sufficient and insufficient irrigation. Iraqi Journal of Agricultural Sciences, 55(3), 1251-1258. https://doi.org/10.36103/j5f16091

2. Abood, N. M. and Sh. S. Mirare. 2024. effect of seed soaking with a growth regulator (atonik) and seeding dates on the vegetative growth characteristics of sorghum bicolor l. Iraqi Journal of Agricultural Sciences, 55(3), 951-961. https://doi.org/10.36103/242f4j91

3. Addaheri A. M. S., O. M Hassan., Q. S Khalf., M. Athab U.,and O. S. Meshal 2021. Potential role of cutting date in lodging and yield of three oat cultivars. IOP Conf. Ser.: Earth Environ. Sci. 904(2021)012021, 1-8. doi:10.1088/1755-1315/904/1/012021.

4. Ali, Zainab Adnan, and Basheer Abdala Abraheem. 2023. The role of selected treatments in the parameters of leaf growth and yield of stevia plants under deficit irrigation system. IOP Conf. Series: Earth and Environmental Science.1-13. doi:10.1088/1755-1315/1225/1/012083.

5. Alshugeairy, Z.K., F.F Alogaidi, B.H Hadi, and W.A Hassan,. 2023. Path coefficient analyses of introduced rice varieties under different planting distances. sabrao J. Breed. Genet, 55(2), 516-524. doi.org/10.54910/sabrao2023.55.2.23

6. Baktash, F.Y. and M. A. Naes. 2016. Evaluation bread wheat pure lines under effect of different seeding rates for grain yield and it's component Iraqi Journal of Agricultural Sciences, 47(5):1132-1140. https://doi.org/10.36103/ijas.v47i5.488

7. Baktash, F. Y. and M.A. Naes. 2016. evaluation bread wheat pure lines under effect of different seeding rates. Iraqi Journal of Agricultural Sciences, 47(5). 1141-1150. https://doi.org/10.36103/ijas.v47i5.489

8. Baktash, F.Y. and A. M. Dhahi. 2018. evaluation performance genotypes of bread wheat to yield, yield components, biological yield and harvest index. Iraqi Journal of Agricultural Sciences, 49(1):11-20. https://doi.org/10.36103/ijas.v49i1.199

9. FAO. 2020. www. FAOSTAT @fao. org.com.

10. Finnan, J.; B. Burke, and J. Spink,. 2019. The effect of nitrogen timing and rate on radiation interception, grain yield and grain quality in autumn sown oats. Field Crops Res. 231, 130–140. doi: 10.1016/j.fcr.2018.12.001.

11. Kanwal, A., D. R. Zubair, A. Mehboob Rehman, M. Ibrahim, M. A. Bashir, M. M. Maqbool, M. Imran, Ubaid ur Rehman, O. Nasif, and M. J. Ansari. 2022. the impact of seeding density and nitrogen rates on forage yield and quality of *Avena sativa* L. BioMed Research International. 2022, 1-9.

12. Khurshid, F. F. 2022. effect of sowing methods on the yield and yield components of wheat under two seed rates at sulaimani region. Iraqi Journal of Agricultural Sciences, 53(1), 99-110. https://doi.org/10.36103/ijas.v53i1.1513

13. Mahmood, J. W. and M. F. Al-hassan. 2023. Effect of hierarchy of the production of tillers in wheat (*Triticum aestivum* L.) cultivar (KM5180) under the influence of planting dates. Research on Crops, 24 (2): 236-240. https://doi.org/10.36103/ijas.v54i6.1878.

14. Naser, A. F., and A. A. Al-mothefer. 2018. Effect of seeding quantity and chemical fertilizer on growth and grain yield of oats (*Avena sativa* L.). Al-Muthanna Journal for Agriculture Sciences., 6(1), 77-84. doi 10.1088/1755-1315/1262/4/042060

15. Odib, Rafid. K. and E. N. Dahal. 2020. Evaluation of the biological response of salicylic acid on growth and yield of oat. Plant Archives Vol. 20, Supplement 1, 1563-1569.

16. Salim F.D., S. H. Ahmed, A. M. Abd, S.Z. Skben,and N. A. Ramadhan. 2014. Determination of total phenol, antioxidant and

antimicrobial activities of *Avena sativa* L. and *Ocimum basilicum*. Baghdad Sciences Journal, 11(2), 1062-6. doi.org/10.21123/bsj.2014.11.2.1062-1066

17. Shah et al. 2017. Effect of dose and timing of application of different plant growth regulators on lodging and grain yield of a Scottish landrace of barley (Bere) in Orkney, Scotland. International Journal of Environment, Agriculture and Biotechnology (IJEAB). 2(4).2010-2019. doi.org/10.22161/ijeab/2.4.59

18. Singla, A.; Gupta, O.P.; Sagwal, V.; Kumar, A.; Patwa, N.; Mohan, N.; Ankush; Kumar, D.; Vir, O.; Singh, J.; et al. Beta-Glucan as a Soluble Dietary Fiber Source: Origins, Biosynthesis, Extraction, Purification, Structural Characteristics, Bioavailability, Biofunctional Attributes, Industrial Utilization, and Global Trade. *Nutrients* 2024, *16*, 900. https://doi.org/10.3390/nu16060900

19. Smith, Harry. 2000. Phytochromes and light signal perception by plants—an emerging synthesis. Nature, 407 (6804). 585-591. doi:10.1038/35036500

20. Sumaya A. A. and A. S. Khalaf. 2023. Effect of seed size and seeding rates on yield attributes of triticale Var. admiral. Iraqi Journal of Agricultural Sciences, 54(3), 820-836. https://doi.org/10.36103/ijas.v54i3.1766

21. Sumaya A. A. and A. S. Khalaf. 2024. Influence of target seeding rates based on thousand kernel weight on vegetative growth traits of triticale, variety admiral- Part I., Iraqi Journal of Agricultural Sciences, 55(5), 1838–1847. https://doi.org/10.36103/77kmp732

22. Thomas, T. C. 1975. Visual quantification of wheat development. Agron.J., 65:116- 119.

USDA. 2018. Software Developed by the National Agricultural Library. V.3.9.5, 2018-08-24.

23. Zhang, Kailong, Rui Dong, Xinzhong Hu, Changzhong Ren, and Yuwei Li. 2021. "Oat-Based Foods: Chemical Constituents, Glycemic Index, and the Effect of Processing" *Foods* 10, no. 6: 1304. https://doi.org/10.3390/foods10061304