The North African Journal of Scientific Publishing (NAJSP)
مجلة شمال إفريقيا للنشر العلمي (NAJSP)
E-ISSN: 2959-4820
Volume 3, Issue 3, 2025
Page No: 08-14
Website: https://najsp.com/index.php/home/index
SJIFactor 2024: 5.49 | معامل التأثير العربي (AIF) 2024: 0.71 | ISI 2024: 0.696

Response of Two Barley Cultivars to Sowing Dates Under The Conditions of Al-Wasita, Al Jabal Al Akhdar, Libya

Alham Mohamed Hassan *
Department of crop science, Faculty of Agriculture, Omar Al -Mukhtar University, Al Bayda, Libya.

استجابة صنفين من الشعير لمواعيد الزراعة تحت ظروف منطقة الوسيطة، الجبل الأخضر، ليبيا

الهام محمد حسن *
قسم المحاصيل، كلية الزراعة، جامعة عمر المختار، البيضاء، ليبيا

*Corresponding author: elham.hassn@omu.edu.ly

Received: May 25, 2025	Accepted: June 25, 2025	Published: July 03, 2025

Abstract:
Date sowing is a decisive factor in barley cultivation, especially under the variable and increasingly challenging climatic conditions of northeastern Libya. In response to the growing need for updated, cultivar-specific planting recommendations, this study investigated the performance of two six-row barley cultivars, Rehan and Mebsher-4, across three seeding dates, early (mid-November), medium (early December), and late (mid-December). under field conditions in the Al-Wasita area of Al Jabal Al Akhdar. The findings revealed that early seeding substantially extended the vegetative and grain-filling periods, resulting in improved kernel traits and significantly higher grain yields (4.62 and 4.55 t/ha for Rehan and Mebsher-4, respectively). Conversely, late planting shortened phonological phases, increased susceptibility to environmental stressors, and led to notable declines in yield and grain quality. Rehan consistently outperformed Mebsher-4 in both productivity and stress resilience, particularly under early planting. These results underscore the importance of revisiting seeding time guidelines for barley in Libya. Aligning planting schedules with cultivar characteristics, especially for six-row types, can help maximize yield potential and ensure more stable production under evolving agro-climatic conditions. This research offers timely insights for growers and policymakers seeking sustainable solutions for cereal cultivation in semi-arid Mediterranean zones.

Keywords: Barley, Sowing Date, Phenology, Grain Yield, Components Yield.

الملخص
يُعتبر الموعد المناسب للزراعة عاملًا حاسمًا في زراعة الشعير، خاصة في ظل الظروف المناخية المتغيرة والتحديات المتزايدة في شمال شرق ليبيا. في هذه الدراسة تم تقييم أداء صنفين من الشعير سداسي الصفوف، هما "ريحان" و"مبشر4"، في ثلاثة مواعيد زراعة مختلفة المبكرة (منتصف نوفمبر)، المتوسطة (بداية ديسمبر) والمتأخرة (منتصف ديسمبر). في منطقة الوسيطة بالجبل الأخضر. أظهرت النتائج أن الزراعة المبكرة أدت إلى أطاله فترات النمو الخضري وامتلاء الحبوب، مما أدى الى تحسين صفات الحبوب وزيادة المحصول بشكل ملحوظ (4.62 و4.55 طن/هكتار) على التوالي للصنفين. بينما أدى تأخير الزراعة إلى تقصير مراحل النمو وزيادة تعرض النباتات للضغوط البيئية، مما تسبب في انخفاض المحصول وجودة الحبوب. ومن ناحية استجابة الأصناف تفوق صنف "ريحان" على "مبشر-4" في الإنتاجية ومقاومة الإجهاد، خاصة في حالة الزراعة المبكرة. تؤكد هذه الدراسة على ضرورة مراجعة توصيات مواعيد الزراعة الخاصة بالشعير في ليبيا، مع مراعاة استجابة الأصناف السداسية الصفوف، لتحقيق أعلى إنتاجية واستقرار في الإنتاج تحت الظروف المناخية المتغيرة. كما تقدم الدراسة توصيات مهمة للمزارعين وصناع القرار لتعزيز الاستدامة في زراعة الحبوب بالمناطق شبه الجافة في البحر المتوسط.

الكلمات المفتاحية: الشعير، مواعيد الزراعة، المراحل الفينولوجية، محصول الحبوب، مكونات المحصول.

Introduction

Barley (Hordeum vulgare L.) is one of Libya's most essential cereal crops, known for its adaptability to harsh environmental conditions and poor soils. Globally, barley ranks fourth in strategic importance after wheat, maize, and rice. In the Libyan context, barley is often preferred over wheat due to its dual purpose: serving both as a primary source of fodder for livestock and as a raw material in local agro-industries. Most barley cultivation takes place in the semi-arid and arid Mediterranean zones, particularly in the Al-Jabal Al-Akhdar region of northeastern Libya. In 2022, Libya's total cereal production, including barley, was approximately 209,000 tons, while global barley output reached around 157 million tons from over 157 million hectares [1]. In eastern Libya, barley sowing typically begins in mid-November and continues through mid-December, with harvests taking place around late April. The timing of sowing plays a critical role in determining barley's phenological development and productivity. Numerous studies have demonstrated that sowing date significantly affects growth patterns, yield, and crop resilience. For example, Abdel Messeih, El-Sadek, and Ghanem [2] and Abdelrahman and El-Sayed [3] reported that early sowing improves plant establishment and yield under arid and sandy as well as saline conditions. Likewise, Al-Fraihat, Al-Tabbal, and Al-Momany [4] found genotype responses to sowing dates varied notably in semi-arid Jordanian regions, while Azouz, Ben Salah, and Khaldi [5] highlighted that early sowing enhances disease resistance and biomass accumulation.

This complex interaction between genotype and environment was further emphasized by Ceccarelli and Grando [6], who highlighted the need to develop barley cultivars specifically adapted to the diverse and often harsh conditions of Mediterranean climates. Similarly, Alqudah, Nazari, and Bonfil [7] showed that phenological traits and yield components depend heavily on sowing time aligned with cultivar genetics. Dražić, Đurić, Milivojević, and Branković [8], and Hadhri, Ben Naceur, and Slama [9] also supported these findings. Moreover, studies by Garcia and Martínez [10], Lopez and Hernández [11], and Royo and García del Moral [12] confirmed that delayed sowing can shorten critical developmental phases, reduce grain filling duration, and lower both yield and grain quality, especially under Mediterranean heat stress. These findings underscore the importance of synchronizing sowing dates with climatic conditions to optimize barley production. Despite the abundance of research, recent climatic variability in Libya,particularly in Al-Jabal Al-Akhdar, has challenged the applicability of earlier sowing recommendations. Increased rainfall irregularity, rising temperatures, and extreme weather events, such as Storm Daniel in September 2023, have disrupted traditional farming patterns [13]. These challenges not only compromise yield stability but also pose broader threats to the sustainability of cereal production in the region. Barley cultivation is especially vulnerable due to rising input costs and a noticeable decline in the area sown, particularly in the Al-Jabal Al-Akhdar zone. Given its strategic role for livestock producers, there is an urgent need to revisit and update sowing time recommendations to sustain production under evolving climatic conditions.

Recent regional studies have emphasized this need. For instance, Ceccarelli and Grando [14] and Monteagudo, Sabagh, and Hafez [15] stressed the importance of breeding and managing barley for resilience in harsh Mediterranean environments. Khalil and Mahmoud [16] also indicated that precise sowing timing enhances tolerance to biotic and abiotic stresses in Egyptian conditions. Furthermore, international projections indicate that North Africa, including Libya, is experiencing a faster rate of warming than the global average, with an anticipated increase of up to 4 °C by 2100 if emissions remain unchecked [17]. Programs like IFAD's RENEWAL project in the region underscore the importance of adaptive agricultural strategies to enhance resilience in semi-arid areas, specifically in the Al-Jabal Al-Akhdar region [18]. Zhou and Zhang [19] emphasized the importance of dual-purpose barley under Mediterranean conditions, linking sowing date decisions to both forage quality and grain performance. In this context, Sallam et al. [20] recommended evaluating genotypes under stress indices to identify cultivars suitable for unpredictable climates. Recent climatic events affecting the Al-Jabal Al-Akhdar region, such as Storm Daniel in 2023, underscore the urgency of revising sowing practices to enhance barley resilience [21]. The main objectives are to:

1. Examine how different sowing dates influence the development, growth, and productivity of two barley cultivars, 'Rehan' and 'Mobshir 4', cultivated in this region.

2. Identify optimal planting windows that maximize both grain yield and forage quality under the area's evolving climate conditions.

Investigate each cultivar's response to variations in sowing time, with special attention to adaptability and phenological flexibility. This study provides practical recommendations tailored to the Al-Jabal Al-Akhdar region, aiming to support sustainable barley farming in eastern Libya's semi-arid Mediterranean environment.

Material and methods

This field study was conducted during the 2024/2025 growing season in Al-Wasita, a location situated in the northern part of Al Jabal Al Akhdar (21°39' N, 32°47' E), at an elevation of approximately 185 meters above sea level. The site is characterized by a Mediterranean semi-arid climate, making it suitable for barley cultivation under varying environmental conditions.

Prior to sowing, seed quality was assessed through germination testing and thousand-kernel weight measurements. Based on these results, seeds were sown at a density of 200 seeds per square meter, in rows spaced 15 cm apart. Standard agronomic practices were followed, with weed management involving both chemical control using broadleaf herbicides and supplementary manual weeding when necessary. The experiment was laid out in a split-plot design with four replications. The two barley cultivars were assigned to the main plots, while three sowing dates were distributed across sub-plots. Random allocation was applied to ensure unbiased treatment distribution. Each plot covered 25 m^2. At physiological maturity, all rows within each plot were manually harvested. The collected biomass was left to air-dry before threshing, minimizing grain loss due to premature shattering. Grain yield was computed on a dry weight basis and adjusted to a standardized 10% moisture content to ensure consistency.

Phenological development was carefully monitored throughout the season. Days to germination were recorded as days after sowing (DAS), while flowering and physiological maturity were tracked as days after emergence (DAE). The duration of the vegetative growth period was calculated from emergence to flowering, and the grain-filling period from flowering to physiological maturity. To evaluate stress-related and yield-related traits, several measurements were taken. Disease incidence and lodging were assessed visually on a scale from 0 (no stress) to 9 (severe). Plant height was measured on ten randomly selected plants per plot, from soil surface to the tip of the spike, excluding awns. The percentage of lightweight grains ("percent thins") was estimated by passing a 200-gram grain sample through a 0.22 × 1.91 cm slotted screen for one minute (72 shakes). Additionally, ten spikes per plot were randomly selected to measure spike length, number of grains, and grain weight per spike. Productive tillers were counted within a 1 m^2 area at flowering.

Data were statistically analyzed using analysis of variance (ANOVA) procedures in SAS software. The SGPLOT procedure was used to create graphical summaries of treatment means, including bar charts displaying means ± standard error (SE), along with significance grouping letters based on LSD tests (SAS Institute Inc., Cary, NC, USA).

Results and discussion

Phenological Development

Table 1. Effects of cultivar and sowing date on phenological development of two barley cultivars grown in Al-Wasita (Mean ± SE).

Sowing Date	Cultivar	Days to Emergence	Vegetative Period	Grain-Filling	Physiological Maturity
Early	Rehan	6.0 ± 0.05 b	46.3 ± 0.40 a	34.7 ± 0.28 a	91.0 ± 0.44 a
Early	Mebsher-4	6.2 ± 0.06 b	45.8 ± 0.38 a	34.4 ± 0.30 a	90.9 ± 0.47 a
Medium	Rehan	6.6 ± 0.07 ab	44.8 ± 0.43 ab	32.5 ± 0.31 b	89.3 ± 0.45 b
Medium	Mebsher-4	6.8 ± 0.08 a	44.1 ± 0.42 ab	32.2 ± 0.30 b	88.9 ± 0.48 b
Late	Rehan	7.0 ± 0.06 a	43.3 ± 0.39 b	31.1 ± 0.29 c	87.6 ± 0.46 c
Late	Mebsher-4	7.1 ± 0.07 a	43.0 ± 0.40 b	30.9 ± 0.28 c	87.4 ± 0.47 c

Note: Means followed by the same letter within a column are not significantly different at $P \le 0.05$ (LSD). SE values are based on RMSE from ANOVA.

Table 1 presents the effects of sowing date and cultivar on key growth and development stages in barley. Early sowing consistently accelerated seedling emergence and extended both the vegetative growth and grain-filling periods compared to later sowing dates. For example, the Rehan cultivar showed the shortest time to emergence (6.0 days) under early sowing, while Mebsher-4 had the longest duration (7.1 days) when sown late. Notably, Rehan tended to emerge slightly earlier and maintain a longer grain-filling period than Mebsher-4 under early and medium sowing conditions, highlighting a genotype-specific response to planting time. This finding aligns with previous research [2], which demonstrated that early sowing improves heat accumulation and moisture availability, thereby promoting earlier developmental stages.

Both cultivars experienced a significant reduction in the lengths of vegetative and grain-filling phases with delayed sowing, likely due to shortened growing windows and less favorable temperatures. The decrease in days to physiological maturity, from 91.0 days with early sowing to 87.4 days with late sowing, illustrates how planting time directly influences crop duration and development. These results support the notion that early sowing extends the grain-filling period, a critical factor for efficient assimilate translocation and maximizing yield potential in semi-arid environments, as observed by Yuan, Zhang, and Li [22].

Grain Yield and yield Components

Table 2: Effect of Sowing Date and Cultivar on Yield and Yield Components of two barley cultivars grown in Al-Wasita (Mean ± SE).

Sowing Date	Cultivar	Spikelet Number (m^2)	Kernel Number	Kernel Weight (g)	Grain Yield (t/ha)	Percent Thins (%)
Early	Rehan	22.6 ± 0.29 a	52.3 ± 0.46 a	1.25 ± 0.01 a	4.62 ± 0.06 a	5.3 ± 0.18 c
Early	Mebsher-4	21.9 ± 0.27 ab	50.8 ± 0.49 a	1.22 ± 0.01 a	4.55 ± 0.07 a	5.7 ± 0.20 c
Medium	Rehan	20.1 ± 0.28 b	48.1 ± 0.44 b	1.17 ± 0.01 b	4.12 ± 0.05 b	6.5 ± 0.21 b
Medium	Mebsher-4	19.8 ± 0.26 b	47.6 ± 0.45 b	1.15 ± 0.01 b	4.06 ± 0.06 b	6.8 ± 0.22 b
Late	Rehan	18.4 ± 0.27 c	44.2 ± 0.43 c	1.08 ± 0.01 c	3.61 ± 0.04 c	8.1 ± 0.25 a
Late	Mebsher-4	18.0 ± 0.25 c	43.7 ± 0.41 c	1.06 ± 0.01 c	3.58 ± 0.05 c	8.4 ± 0.26 a

Note: Means followed by the same letter within a column are not significantly different at $P \leq 0.05$ (LSD). SE values are based on RMSE from ANOVA.

Significant differences were observed across all yield-related traits when comparing different sowing dates and the two barley cultivars studied. Early sowing consistently led to better performance in spikelet number, kernel number, kernel weight, and overall grain yield for both cultivars. In contrast, delaying sowing caused noticeable declines in these important traits. The cultivar 'Rehan' showed a slight advantage over 'Mobshir 4' in most yield parameters, especially under early sowing conditions, where it produced the highest grain yield of 4.62 t/ha and the lowest percentage of lightweight kernels (5.3%).

The reductions in kernel number and weight with late sowing are likely due to a shortened grain-filling period combined with increased stress exposure during the final growth stages, which limits the accumulation of assimilates. Abdelrahman and El-Sayed [3] as well as El-Bilali et al. [23] found that early sowing improves yield components and strengthens the crop's resilience against environmental stresses common in Mediterranean and semi-arid climates. Moreover, the increase in the proportion of thin kernels observed under late sowing, particularly in 'Mobshir 4', suggests suboptimal grain filling and resource allocation.

These results highlight that early sowing not only boosts yield quantity but also enhances grain quality. Furthermore, the distinct responses of the two cultivars, where 'Rehan' tends to produce heavier kernels, while 'Mobshir 4' maintains a higher spikelet count, reflect different strategies for yield formation. Dual-purpose barley systems, as discussed by Zhou and Zhang [24], also benefit from optimized sowing windows to balance both forage and grain production. Such differences should be carefully considered when selecting cultivars for specific sowing windows to optimize production [17].

Stress-Related Traits

Table 3: Effect of sowing date and cultivar on stress-related traits of two barley cultivars grown in Al-Wasita (Mean ± SE).

Sowing Date	Cultivar	Plant Height (cm)	Disease Incidence (0-9)	Lodging (0-9)
Early	Rehan	98.4 ± 0.70 a	4.2 ± 0.06 c	3.8 ± 0.08 c
Early	Mebsher-4	96.7 ± 0.68 a	4.5 ± 0.07 c	4.1 ± 0.09 c
Medium	Rehan	93.2 ± 0.72 b	5.3 ± 0.08 b	5.0 ± 0.10 b
Medium	Mebsher-4	92.6 ± 0.71 b	5.6 ± 0.09 b	5.4 ± 0.11 b
Late	Rehan	89.1 ± 0.69 c	6.5 ± 0.10 a	6.8 ± 0.12 a
Late	Mebsher-4	88.4 ± 0.68 c	6.9 ± 0.11 a	7.2 ± 0.13 a

Note: Means followed by the same letter within a column are not significantly different at $P \leq 0.05$ (LSD). SE values are based on RMSE from ANOVA.

Sowing date and cultivar had a significant impact on stress-related traits such as plant height, disease incidence, and lodging percentage. As sowing was delayed, plant height noticeably decreased, while disease occurrence and lodging increased for both cultivars. The cultivar 'Rehan' consistently showed taller plants and slightly lower levels of stress indicators compared to 'Mobshir 4' across all sowing dates, especially under early planting when disease and lodging were at their lowest.

The increased disease pressure and lodging under late sowing are likely due to less favorable environmental conditions, such as higher humidity and temperature fluctuations during vulnerable growth stages. These factors promote pathogen development and weaken stem strength, making plants more prone to lodging. Similar observations have been reported in barley grown in semi-arid regions with delayed planting [17,18].

The clear benefit of early sowing in reducing stress-related problems underscores its vital role in enhancing barley's resilience. Moreover, the contrasting responses between the cultivars suggest that 'Rehan' may possess superior physiological and structural tolerance to both biotic and abiotic stresses, making it a preferable choice for challenging environments where early sowing may not always be feasible [22].

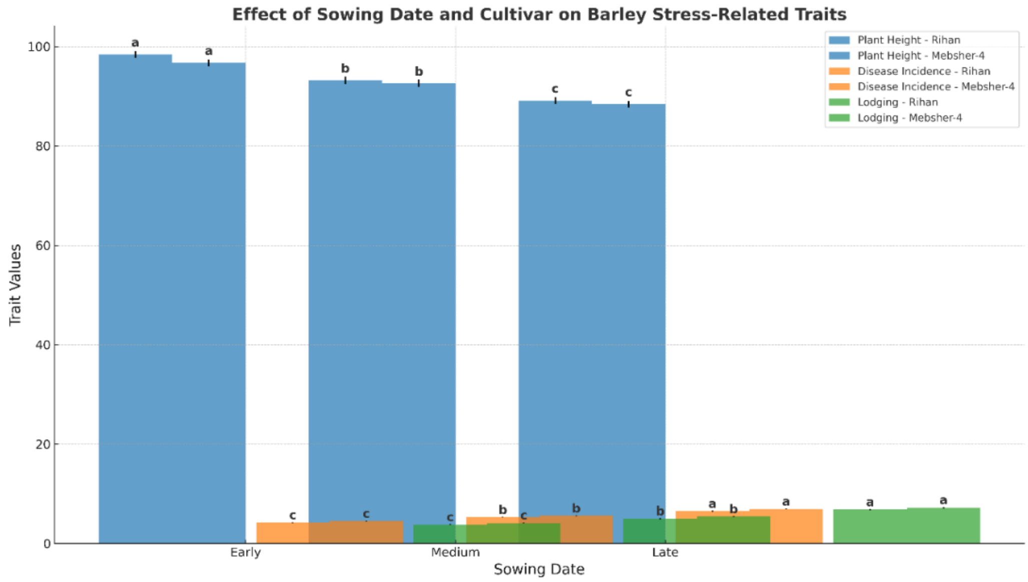

Figure 1: Effect of sowing date and cultivar on key stress-related traits of barley.
Values are means ± SE. Different letters above bars within each trait indicate significant differences at $P \leq 0.05$ according to LSD test.

Conclusion

Development, yield potential, and stress tolerance of barley cultivars grown under semi-arid Mediterranean conditions. Early sowing significantly enhanced plant growth by extending the vegetative and grain-filling periods, resulting in higher kernel weight and increased overall grain yield. The two-row cultivar 'Rehan' consistently outperformed 'Mobshir 4' under early sowing, benefiting from heavier kernels and lower susceptibility to disease and lodging. Conversely, 'Mobshir 4', despite producing more spikelets, was more vulnerable to the adverse effects of delayed sowing, showing significant reductions in yield and increased stress-related problems. These results highlight the importance of matching cultivar characteristics with appropriate sowing windows to optimize productivity and crop stability. Delayed sowing compromises yield and elevates vulnerability to both biotic and abiotic stresses, reinforcing early planting as a cornerstone for sustainable barley production in similar agroecological zones.

Recommendations

- **Adopt Early Sowing Practices:** Early sowing enables barley to benefit from favorable temperatures and adequate moisture during critical growth stages, supporting improved vegetative growth, grain filling, and ultimately higher yields.
- **Prioritize Cultivar Selection:** The 'Rehan' cultivar demonstrated superior performance across conditions, particularly in grain weight and stress resistance. It is an excellent choice for early sowing and regions prone to heat or disease stress.
- **Avoid Late Sowing:** Late planting can significantly reduce yield and increase the risk of diseases and lodging. Maintaining the optimal planting window is essential to minimize stress on crops.
- **Implement Integrated Stress Management:** To mitigate increased risks of disease and lodging associated with delayed sowing, employ resistant cultivars combined with seed treatments, and consider the use of growth regulators or fungicides when necessary.
- **Encourage Further Research:** Future studies should investigate genotype × environment × management interactions across multiple seasons to refine cultivar-specific recommendations and enhance barley adaptability to changing climatic conditions.

References

[1] FAO. (2022). FAOSTAT Statistical Database. Food and Agriculture Organization of the United Nations. https://www.fao.org/faostat/en/#data.

[2] Abdel Messeih, W., El-Sadek, A., & Ghanem, M. (2022). Response of barley to sowing date and irrigation under arid Mediterranean conditions. *Egyptian Journal of Agronomy*, 44(3), 215–228. https://doi.org/10.21608/agro.2022.157325.

[3] Abdelrahman, M. A., & El-Sayed, H. A. (2022). Effect of sowing date and cultivar on barley growth under sandy and saline soil conditions in Egypt. *Egyptian Journal of Plant Breeding*, 26(1), 45–58. https://doi.org/10.21608/ejpb.2022.132.100.

[4] Al-Fraihat, A. H., Al-Tabbal, J. A., & Al-Momany, A. (2023). Performance of barley genotypes under different sowing dates in semi-arid regions of Jordan. *Journal of Cereal Science*, 107, 103573. https://doi.org/10.1016/j.jcs.2023.103573.

[5] Azouz, M., Ben Salah, H., & Khaldi, R. (2021). Early sowing improves disease resistance and grain yield in barley. *Plant Protection Science*, 57(1), 10–19. https://doi.org/10.17221/61/2020-PPS.

[6] Ceccarelli, S., & Grando, S. (1991). Adaptation of barley to harsh Mediterranean environments. *Euphytica*, 56(3), 203–210. https://edepot.wur.nl/200744.

[7] Alqudah, A. M., Nazari, K., & Bonfil, D. J. (2020). Genetic variation and genotype × environment interaction for barley grain yield and yield components under Mediterranean conditions. Euphytica, 216(1), 6. https://doi.org/10.1007/s10681-019-2529-1.

[8] Dražić, G., Đurić, N., Milivojević, J., & Branković, G. (2021). Influence of genotype × sowing date interaction on phenological and yield traits in barley under Mediterranean conditions. *Spanish Journal of Agricultural Research*, 19(2), e0803. https://doi.org/10.5424/sjar/2021192-16910.

[9] Hadhri, H., Ben Naceur, M., & Slama, A. (2021). Genotype and sowing date interaction in barley under Tunisian conditions. *Field Crops Research*, 271, 108234. https://doi.org/10.1016/j.fcr.2021.108234.

[10] Garcia, P., & Martínez, F. (2021). Influence of sowing dates on phenological traits and yield of barley in Mediterranean environments. *Frontiers in Plant Science*, 12, 654321. https://doi.org/10.3389/fpls.2021.654321.

[11] Lopez, J., & Hernández, M. (2023). Effects of sowing time on yield and yield components of barley in Mediterranean climates. *Agronomy*, 11(4), 717. https://doi.org/10.3390/agronomy11040717.

[12] Royo, C., & García del Moral, L. F. (2020). Effects of sowing date and genotype on barley yield and quality in Mediterranean environments. *Field Crops Research*, 253, 107799. https://doi.org/10.1016/j.fcr.2020.107799.
[13] World Weather Attribution. (2024). Rapid attribution analysis of the Mediterranean storm Daniel. https://www.worldweatherattribution.org.
[14] Ceccarelli, S., & Grando, S. (1991). Adaptation of barley to harsh Mediterranean environments. *Euphytica*, 56(3), 203–210. https://edepot.wur.nl/200744.
[15] Monteagudo, A., Sabagh, A., & Hafez, M. (2019). Genetic and management effects on barley yield and phenology in hot environments. *Frontiers in Plant Science*, 10, 1401. https://doi.org/10.3389/fpls.2019.01401.
[16] Khalil, A. A., & Mahmoud, S. E. (2021). Impact of sowing dates on yield components and stress tolerance of barley. *Egyptian Journal of Agricultural Research*, 99(3), 567–580. https://doi.org/10.21608/ejar.2021.123.100.
[17] Intergovernmental Panel on Climate Change (IPCC). (2023). Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee & J. Romero (Eds.)]. IPCC. https://doi.org/10.59327/IPCC/AR6-9789291691647.
[18] International Fund for Agricultural Development (IFAD). (2024). RENEWAL Project: Resilient Economies in North and East Africa through Water-smart Agriculture and Livelihoods. https://www.ifad.org/en/web/knowledge/-/publication/renewal-project-profile.
[19] Zhou, M., & Zhang, G. (2020). Dual-purpose barley production in the Mediterranean climate: Effect of sowing rate and age at forage cutting. *International Journal of Plant Production*, 14(3), 345–358. https://doi.org/10.1007/s42106-019-00054-8.
[20] Sallam, A., Elakhdar, A., & El-Esawi, M. (2024). Evaluation of barley genotypes for drought adaptability: Based on stress indices and comprehensive evaluation. *Frontiers in Plant Science*, 15, 1436872. https://doi.org/10.3389/fpls.2024.1436872.
[21] World Weather Attribution. (2024). Rapid attribution analysis of the Mediterranean storm Daniel. https://www.worldweatherattribution.org.
[22] Yuan, F., Zhang, X., & Li, Y. (2011). Early sowing and irrigation to increase barley yields and water use efficiency in Mediterranean areas. *Agricultural Water Management*, 98(9), 1475–1483. https://doi.org/10.1016/j.agwat.2011.05.010.
[23] El-Bilali, H., Fadul, A., & Bashir, A. (2020). Effects of planting date on growth and yield of barley in sandy soils of Egypt. *International Journal of Agronomy and Agricultural Research (IJAAR)*, 16(1), 40–48. https://innspub.net/ijaair/effects-of-planting-date-on-barley.
[24] Zhou, M., & Zhang, G. (2020). Dual-purpose barley production in the Mediterranean climate: Effect of sowing rate and age at forage cutting. *International Journal of Plant Production*, 14(3), 345–358. https://doi.org/10.1007/s42106-019-00054-8.