Indonesian Journal on Health Science and Medicine

Vol. 3 No. 1 (2026): July
DOI: 10.21070/ijhsm.v3i1.371

ISSN 3063-8186 (online), https://ijhsm.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Indonesian Journal on Health Science and Medicine

Vol. 3 No. 1 (2026): July
DOI: 10.21070/ijhsm.v3i1.371

Table Of Contents

Indonesian Journal on Health Science and Medicine
Vol. 3 No. 1 (2026): July
DOI: 10.21070/ijhsm.v3i1.371

Originality Statement

The author[s] declare that this article is their own work and to the best of their knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the published of any other published materials, except where due acknowledgement is made in the article. Any contribution made to the research by others, with whom author[s] have work, is explicitly acknowledged in the article.

Conflict of Interest Statement

The author[s] declare that this article was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright Statement

Indonesian Journal on Health Science and Medicine

Vol. 3 No. 1 (2026): July
DOI: 10.21070/ijhsm.v3i1.371

Complete list of editorial team (link)

Complete list of indexing services for this journal (link)

How to submit to this journal (link)

ISSN 3063-8186 (online), https://ijhsm.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Indonesian Journal on Health Science and Medicine
Vol. 3 No. 1 (2026): July
DOI: 10.21070/ijhsm.v3i1.371

Article information

Check this article update (crossmark)

Check this article impact (*)

Save this article to Mendeley

(*) Time for indexing process is various, depends on indexing database platform

Indonesian Journal on Health Science and Medicine
Vol. 3 No. 1 (2026): July
DOI: 10.21070/ijhsm.v3i1.371

Irrigation Interval and Ethephon Regimes Shaping Alfalfa Yield and Quality

Sundus Kamel J Alhilfi, sundus.jabar@uobasrah.edu.iq (*)
Department of Field Crop, College of Agriculture, University of Basrah, Iraq

Fatimah Ali Jamel, fatima.chamel@uobasrah.edu.iq
Department of Field Crop, College of Agriculture, University of Basrah, Iraq

Sabreen H. A. Al-Rubaiee, sabreen.hazim@uobasrah.edu.iq
Department of Field Crop, College of Agriculture, University of Basrah, Iraq

(*) Corresponding author

Abstract

General Background: Alfalfa (*Medicago sativa* L.) is a key perennial forage crop valued for high biomass and protein content, yet its productivity is strongly constrained by water scarcity and suboptimal canopy management, particularly in arid regions. **Specific Background:** In southern Iraq, reduced water availability from major rivers necessitates efficient irrigation scheduling alongside agronomic practices that regulate plant architecture. **Knowledge Gap:** Limited field-based evidence integrates irrigation intervals with ethephon application to clarify their combined role in determining forage yield and quality attributes of alfalfa. **Aims:** This study examined growth traits, green and dry forage yield, and protein characteristics of alfalfa under different irrigation intervals and ethephon spray concentrations. **Results:** An intermediate irrigation interval (10 days) combined with moderate ethephon concentration (0.5 ml L^{-1}) consistently produced the highest branch density, forage yields, protein percentage, and protein yield, with significant interaction effects across traits. **Novelty:** The study demonstrates a synergistic irrigation–ethephon management window that optimizes source–sink balance under water-limited conditions. **Implications:** These findings support adaptive irrigation scheduling coupled with growth regulator use to sustain forage productivity and quality in arid and semi-arid agroecosystems.

Highlights:

- Optimal irrigation interval maximized alfalfa biomass and protein yield.
- Moderate ethephon concentration promoted branching and canopy efficiency.
- Combined management improved forage quality under water-limited conditions.

Keywords:

Alfalfa, Irrigation Interval, Ethephon, Forage Yield, Protein Quality

Published date: 2026-01-12

Indonesian Journal on Health Science and Medicine
Vol. 3 No. 1 (2026): July
DOI: 10.21070/ijhsm.v3i1.371

Introduction

Alfalfa (*Medicago sativa* L.), of the Fabaceae family, ranks as one of the most significant perennial plants and forage crops around the world1 owing to its capacity to yield abundant green forage protein and plentiful nutrients, which support animal growth and productivity. Qualitatively and quantitatively hay and silage are prepared out of, it has been name " The king of Fodder" due to its never-ending ability throughout the years 3-4) the time growth period so, in soil just spill out (cruise) for longer or shorter from it depending on the agricultural environment situation which placed with.

Iraq is suffering from a worrying situation about the water scarcity after some of its waters in the Tigris and Euphrates rivers as well as their joints have been reduced due to building dam by neighboring countries, on one hand, and global warming that faces all the world, on the other. The best use of water is very important to manage the number of days between an irrigation and the other according to its stage of growth in order to get a maximum yield. Moreover, water plays a crucial role in the plant body as it acts as a vehicle for nutritive and diluted materials and also facilitates energy transfer required for the process of carbon metabolism involved in the synthesis of organic food, as well as serving to regulate plant temperature [1]. The spread of the root system at its front also depends on water distribution in the soil surface layer, which subsequently affects growth of stem, leaves as well as other organs [2]. This variation in moisture tension at the vicinity of the plant root-system, causes variations on the growth of plants in response to differences in internal differences on this tension [3].

The concept of the inhibition of apical dominance was first developed with growth retardants which provoke or induce one of those processes when applied to appropriate concentrations. Growth regulators of different types are applied, including Ethephon, which has a suppressive effect on growth and controls the source sink relationship by destruction of metabolic products [4] . It decreases the cellular elongation and cell division because of sub-apical meristem region, thus reduce the main stem elongation and reduce vegetative plant. In addition, It is acting as an antagonist for auxins in stem tissues thereby having important role to manage the equilibrium of distribution pattern of photosynthesis products between the source and the sink which gives more yield 5, since plant growth and formation are not happening randomly, there are regulate hormone in plants work to balance source/sink ratio in transfer photosynthesis materials happen and they working on make canopy architecture of plant also influence with rate grow, that make plant feel its environment then interact with it tell be state balance between available factor for grow plant essential water or genetic factor born with it automatic i.e., of course other non-genetic factors but that have huge rule. The removal of apical dominance is associated with the activation of lateral buds and an increase in leaf area, which increases light interception, leads to a higher efficiency for CO(2) assimilation and more accumulation as well. The objective of the current study was to evaluate growth, green forage yield (GFY), and quality of alfalfa under various irrigation intervals and ethephon spray concentrations.(*Medicago sativa* L.).

Materials and Methods

A field experiment was conducted during the winter season of 2022-2023 in Basra Governorate at the Agricultural Research Station affiliated with the College of Agriculture, University of Basra (Karmat Ali site, University of Basra) in a loamy-textured soil. The study aims to know the effect of irrigation periods and ethephon spray concentrations on the growth, green forage yield, and quality of alfalfa (*Medicago sativa* L.). The experiment was conducted as a factorial experiment using a randomized complete block design (RCBD) with three replicates. The different factorial treatments were randomly distributed within each block, resulting in a total of 27 experimental units (3 x 3 x 3).

The experiment included two factors: the first factor was three irrigation periods (5, 10, and 15 days), symbolized I1, I2, and I3. The second factor was three ethephon concentrations (0, 0.5, and 1) ml L^{-1}, symbolized E1, E2, and E3.

A composite sample was also taken from different locations in each replicate from a depth of (0-30 cm), and mixed together. Chemical and physical analyses were carried out on the soil as shown in (Table 1).

Soil Properties	pH	E.C (dS m^{-1})	N Available mg kg^{-1}	P Available mg kg^{-1}	K Available mg kg^{-1}	Soil texture
2023/2022	7.50	12.27	68	19.33	165.4	mixed

Figure 1. Table (1): Shows the physical and chemical characteristics of the study field before planting

The experimental land was harrowed and leveled, then divided then divided into three blocks according to the design used, which were then divided into panels measuring (1.5 x 2). The experimental unit area was 3 m^2, and each sector contained nine experimental units a distance of 1.5 meters was left between each sector.

Planting was carried out in mid-October using the broadcasting method and after which the seeds were covered with a thin

Vol. 3 No. 1 (2026): July
DOI: 10.21070/ijhsm.v3i1.371

soil layer. An initial irrigation was applied for germination, while subsequent irrigations were carried out according to the experimental treatments.Harvesting was carried out based on reaching a flowering rate of 20-22%. This is because harvesting at this stage produces the highest quantity of green forage yield and the best quality, in addition to maintaining the vitality and ability of the plants to regrow from the crown buds in the subsequent stage.

The data were analyzed statistically using the GenStat program, and the averages were compared according to the least significant difference method at the 0.05% level, as stated in [7] . The following traits were measured:

2.1. Plant height (cm):

plant height was measured from the soil surface to the end of the stem for ten random plants from each experimental unit. After that the average plant height for each experimental unit was measured.

2.2. Number of branches (branch m^{-2}) :

It was measured randomly by harvesting 0.5 m2 of each experimental unit and converted to square meters.

2.3. Green forage yield (tons ha^{-1}):

green forage yield was measured from a random 0.5 m2 harvest for each experimental unit. The sample was weighed directly using an automated balance and converted tons ha^{-1}.

2.4. Dry forage yield (tons ha^{-1}):

Dry forage yield (tons ha^{-1}) = Green forage yield (tons ha^{-1}) × % dry matter.

2.5. protein percentage in leaves (%):

= percentage of Nitrogen x 6.25 [8]

2.6. protein yield (tons ha^{-1}) : was calculated using this formula:

Protein yield = % protein × *dry forage yield* (tons ha^{-1})

Results and discussion

3.1. plant height (cm):

The increase in the Ethophon concentrations (shown in table 1) significantly affected the plant height by reducing it in alfalfa. Plants treated with E_3 concentrations recorded the lowest average of 43.78 cm, compared to E_2 treatment which recorded the highest average of 65.11 cm. The decreased rate of 32.75% might be attributed to the action of ethylene released from Ethophon in the plant tissues that specially functions to decrease the auxin rate, reduces its transport, or binds it to other compounds, in order to make it bound. This results in reduced height, as the hormone responsible for apical dominance.

Table (1) shows how the irrigation treatment I recorded the highest average plant height of 55.00 cm. Meanwhile, the irrigation treatment I_3 recorded the lowest height average of alfalfa (52.06 cm). This reduction of plant height might be attributed to water stress, which likely reduced the natural auxin levels that are responsible for cell elongation, thus affecting plant height. These results are consistent with those reported by [9] [10].

Irrigation Intervals (day)	Ethephon spray concentrations ml L^{-1}			mean irrigation Intervals
	E1	E2	E3	
I1	54.00	66.67	44.33	55.00
I2	52.33	65.00	45.33	54.22
I3	50.83	63.67	41.67	52.06
mean concentration of ethephon	52.39	65.11	43.78	
(L.S.D(0.05	E	I	E*I	
	1.190	1.190	N.S	

Indonesian Journal on Health Science and Medicine
Vol. 3 No. 1 (2026): July
DOI: 10.21070/ijhsm.v3i1.371

Figure 2. Table (1) effect of irrigation Intervals Ethophon spray concentration and their interaction on plant height (cm)

3.2. Number of branches (branche m $^{-2}$)

Table 2 shows that the spraying treatment E_2 achieved the highest mean for number of branches per square meter amounting to 434.22 branches m^{-2}, while E_1 recorded the lowest mean of 400.67 branches m^{-2}, which did not differ significantly from the spraying treatment E_3, with an increase percentage of 8.37%.

Irrigation Intervals (day)	Ethephon spray concentrations ml L^{-1}			Mean irrigation Intervals
	E1	E2	E3	
I1	398.33	434.33	403.67	412.11
I2	438.00	455.00	414.00	435.67
I3	365.67	413.33	390.33	389.78
Mean concentration of ethephon	400.67	434.22	402.67	
(L.S.D(0.05	E	I	E*I	
	2.145	2.145	3.715	

Figure 3. Table (2) The effect of irrigation Intervals, ethephon spray concentrations, and their interaction on the number of branches m^{-2}

The reason for that is that spraying with ethephon stimulates the emergence of branches after its application as a result of the occurrence of a state of hormonal balance, as the released ethylene works on hindering the biosynthesis of auxin and inhibiting its movement in the stem tissues, which increased the proportion of cytokinin, so the growth of branch buds was stimulated. These results agree with [11] .

The irrigation treatments differed significantly among themselves in this trait (Table 2), as the irrigation treatment I_2 gave the highest mean for number of branches (435.67 branches), while the irrigation treatment I_3 recorded the lowest mean for number of branches amounting to 389.78 branches, and the reason for the decrease in number of branches is attributed to the decrease in vegetative growth represented by plant height, which leads to inhibition of the photosynthesis process and thus affects the number of branches.

As for the interaction, Table 2 shows the superiority of irrigation treatment I_2 with ethephon spray concentration E_2 over most interactions, recording the highest mean for number of branches amounting to 455.00 branches m^{-2}, while the interaction between irrigation treatment I_3 and ethephon concentration E_1 gave the lowest mean for number of branches amounting to 365.67 branches.

3.3. Green forage yield (tons ha $^{-1}$)

Table 3 shows that ethephon spray concentration E_2 achieved the highest green forage yield amounting to 14.91 tons ha^{-1}, surpassing the other concentrations with an increased percentage of 51.83% compared with E_3. The reason for that is its superiority in number of branches and plant height, which has the greatest effect in increasing green forage yield [12] [13].

DOI: 10.21070/ijhsm.v3i1.371

Irrigation Intervals (day)	Ethephon spray concentrations ml L^{-1}			Mean irrigation Intervals
	E1	E2	E3	
I1	12.80	13.80	11.08	12.56
I2	13.40	17.55	10.40	13.78
I3	12.07	13.37	7.99	11.14
Mean concentration of ethephon	12.76	14.91	9.82	
(L.S.D(0.05	E	I	E*I	
	0.902	0.902	1.563	

Figure 4. Table (3) The effect of irrigation intervals, ethephon spray concentrations, and their interaction on the green forage yield (tons ha^{-1})

And this is confirmed by the highly significant correlation values between green forage yield and plant height and number of branches (r = 0.4112* and r = 0.6535**, respectively) (Table 7). The table also shows the presence of a significant decrease in forage yield with the increase of irrigation intervals, as irrigation treatment I_3 recorded the lowest mean for forage yield amounting to 11.14 tons compared with the other irrigation treatments with a decrease percentage of 19.16, Table 3 shows the significant effect of the interaction between ethephon spray concentrations and irrigation treatments in green forage yield, as concentration E_2 under irrigation treatment I_2 achieved the highest mean for forage yield amounting to 17.55 tons ha^{-1}.

3.4. Dry forage yield (tons ha^{-1})

The results of Table 4 show that ethephon spray concentration E_2 achieved the highest dry forage yield with a mean of 5.14 Mg, surpassing significantly the other concentrations with an increase percentage of 51.62% compared with concentration E_3, which recorded the lowest mean of 3.39 tons for dry forage yield.

Irrigation Intervals (day)	Ethephon spray concentrations ml L^{-1}			Mean irrigation Intervals
	E1	E2	E3	
I1	4.41	4.76	3.82	4.33
I2	4.62	6.05	3.59	4.75
I3	4.16	4.61	2.76	3.84
Mean concentration of ethephon	4.40	5.14	3.39	
(L.S.D(0.05	E	I	E*I	
	0.311	0.311	0.539	

Figure 5. Table (4) The effect of irrigation intervals, ethephon spray concentrations, and the interaction between them on the dry forage yield (tons ha^{-1})

The reason for that is its superiority in increasing green forage yield, and these results are confirmed by the highly significant correlation values between dry forage yield with each of green forage yield, number of branches, and plant height (r = 1.0000, r = 0.6535, and r = 0.4112*, respectively) (Table 7). The table also shows a significant superiority in dry forage yield under irrigation treatment I_2, as it recorded the highest mean for forage yield amounting to 4.75 tons compared with the other irrigation treatments, with an increase percentage of 23.70% over duration I3, which recorded the lowest mean amounting to 3.84 tons' ha^{-1}, and this agrees with what was reached by [14]. As for the effect of the interaction, Table 4 shows that ethephon spray concentration E_2 under irrigation treatment I_2 gave the highest mean for dry forage yield 6.05 tons' ha^{-1}, while ethephon spray concentr

ISSN 3063-8186 (online), https://ijhsm.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

3under irrigation treatment I_3 gave the lowest mean amounting to 2.76 tons ha^{-1}.

3.5. protein percentage%

Table 5 indicates the significant effect of ethephon spray concentrations. E2 achieved the highest protein percentage in the plant, amounting to 21.23%, compared to E_3, which recorded the lowest average protein percentage, amounting to 18.48%. This is due to the role of ethephon, when sprayed at the appropriate concentration, in protein synthesis by controlling RNA synthesis and the production of some protein enzymes, thus increasing the protein percentage.

Irrigation Intervals (day)	Ethephon spray concentrations ml L^{-1}			Mean irrigation Intervals
	E1	E2	E3	
I1	20.30	21.67	18.97	20.31
I2	18.60	24.07	19.37	20.68
I3	16.63	17.97	17.10	17.23
Mean concentration of ethephon	18.51	21.23	18.48	
(L.S.D(0.05	E	I	E*I	
	1.049	1.049	1.817	

Figure 6. Table (5) Effect of irrigation Intervals, ethephon concentrations and their interaction on the protein percentage.

These results are also supported by the highly significant correlation values between protein percentage and dry forage yield (r = 0.6920**) (Table 7). This is consistent with the findings of [15][16] The table also shows a significant effect on protein percentage, as the I_2 irrigation treatment recorded the highest average protein percentage, amounting to 20.68%, compared to the other irrigation durations, and an increase of 20% over the irrigation treatment, which recorded the lowest average, amounting to 17.23%. Table 5 shows the effect of the interaction between ethephon spray concentrations and irrigation treatments on the protein percentage. Concentration E_2 with irrigation treatment I_2 achieved the highest percentage of 24.07%, while the lowest percentage was recorded when interacting between concentration E_1 and irrigation treatment I_3, reaching 16.63%, which did not differ significantly from the interaction between E_3 and irrigation treatment I_3, which gave 17.10%.

3.6. protein yield (tons h^{-1})

E_2 concentration significantly outperformed the other concentrations, yielding 1.107 tons h^{-1}, while E_3 concentration yielded a lower average of 0.632 tons ha^{-1}. This may be due to the superiority of E_2 concentration in dry feed yield (Table 4) and protein percentage (Table 5). These results are confirmed by the correlation values between protein yield and dry feed yield (r = 0.9459) and between protein yield and protein percentage (r = 0.8797).

ISSN 3063-8186 (online), https://ijhsm.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Vol. 3 No. 1 (2026): July
DOI: 10.21070/ijhsm.v3i1.371

Irrigation Intervals (day)	Ethephon spray concentrations ml L^{-1}			Mean irrigation Intervals
	E1	E2	E3	
I1	0.900	1.031	0.772	0.884
I2	**0.861**	1.459	0.703	1.008
I3	**0.692**	0.831	0.470	0.664
Meanconcentration of ethephon	**0.818**	1.107	0.632	
L.S.D 0.05	E	I	E*I	
	0.0902	0.0902	0.1562	

Figure 7. Table (6) Effect of irrigation intervals, ethephon concentrations and their interaction on crude protein yield (tons h^{-1})

Irrigation treatments differed significantly in protein yield, with irrigation treatment I_2 yielding the highest average of 1.008 tons ha^{-1}, a 51.67% increase over the other irrigation treatments, in which irrigation treatment I_3 recorded the lowest average protein yield of 0.664 tons ha^{-1}. Table 6 shows the significant effect of the interaction between spray concentrations and irrigation treatments on protein yield. Concentration E_2 with irrigation treatment I_2 achieved the highest average protein yield of 1.459 tons ha^{-1}, while concentration E_3 and irrigation treatment I_3 gave the lowest average of 0.470 tons ha^{-1}.

conclusion

In conclusion, ethephon was effective in increasing the number of branches, green and dry forage yield, protein percentage, and protein yield. The most important stage for spraying ethephon is the beginning of flowering, as it yielded significant results for most of the study traits. Variations in irrigation treatments also yielded excellent results for growth traits, yield, and protein percentage. Therefore, we recommend spraying ethephon at a concentration of 1 ml per liter at the beginning of flowering to give encouraging results for yield

traits	height	number of branches	green forage yield	dry forage yield	protein percenta %ge	protein yield
height	1.0000					
number of branches	0.0393	1.0000				
green forage yield	*0.4112	**0.6535	1.0000			
dry forage yield	*0.4112	**0.6535	**1.0000	1.0000		
protein %percentage	0.0264	**0.6895	**0.6920	**0.6920	1.0000	
protein yield	0.2466	**0.7263	**0.9459	**0.9459	**0.8797	1.0000

Figure 8. Table (7) Correlation among the studied traits

References

Indonesian Journal on Health Science and Medicine
Vol. 3 No. 1 (2026): July
DOI: 10.21070/ijhsm.v3i1.371

1. [1] H. M. Kareem Al-Oboudi, A. Adnan, A. Mosqat, and K. A. Salman, “Effect of Irrigation Intervals on Some Field Traits and Water Productivity of Maize Crop,” in Proceedings of the First Scientific Conference on Combating Desertification, Iraq, 2017.
2. [2] R. R. H. Al-Azzawi and Q. Y. Khalaf, “The Effect of Using Modern Irrigation Methods on the Water Requirements of Agricultural Crops in Diyala Governorate,” Diyala, Iraq, 2015.
3. [3] A. P. B. Proffitt, P. R. Berliner, and D. M. Oosterhuis, “A Comparative Study of Root Distribution and Water Extraction Efficiency by Wheat Grown under High- and Low-Frequency Irrigation,” Agronomy Journal, vol. 77, no. 5, pp. 655–662, 1985.
4. [4] K. N. Devi et al., “Effect of Bioregulators on Growth, Yield and Chemical Constituents of Soybean (Glycine max),” Journal of Agricultural Science, vol. 3, no. 4, pp. 151–159, 2011.
5. [5] R. A. Al-Zubaidi, I. H. Al-Muaini, and K. A. Jidou, “Effect of Cutting and Treatment with Ethephon on Growth Traits and Yield of Bread Wheat (Triticum aestivum L.) Grown at Early Planting Dates,” Al-Furat Journal of Agricultural Sciences, vol. 8, no. 1, pp. 86–94, 2016.
6. [6] R. N. Roy, A. Finck, G. J. Blair, and H. L. S. Tandon, Plant Nutrition for Food Security: A Guide for Integrated Nutrient Management. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO), 2006.
7. [7] K. M. Al-Rawi and A. A. Khalafallah, Design and Analysis of Agricultural Experiments. Mosul, Iraq: Dar Al-Kutub for Printing and Publishing, Ministry of Higher Education and Scientific Research, University of Mosul, 1980.
8. [8] AOAC, Official Methods of Analysis, 15th ed. Arlington, VA, USA: Association of Official Analytical Chemists, 1990.
9. [9] A. S. Hussein, H. R. Nayyef, and Y. J. Shabeeb, “Effect of Irrigation Periods, Tillage Systems and Their Interactions on Growth Traits of Three Rice (Oryza sativa L.) Cultivars,” International Journal of Agricultural Statistics Sciences, vol. 16, no. 1, pp. 1337–1344, 2020.
10. [10] A. A. Abdullah and N. Hassan, “Isolation and Identification of Vesicular Arbuscular Mycorrhizal Fungi from Various Plant Hosts Growing at Different Agricultural Sites in Salah Al-Din Governorate, Iraq,” Tikrit, Iraq: College of Agriculture, University of Tikrit, 2013.
11. [11] A. K. M. Al-Darraji and J. M. A. Al-Jumaili, “Effect of the Growth Inhibitor Ethephon on Growth and Yield of Soybean,” Journal of Educational and Scientific Studies, vol. 3, no. 13, pp. 1–12, 2022.
12. [12] H. J. Atiya, S. M. Kazem, and B. A. Ibrahim, “Effect of Plant Growth Regulators on Some Vegetative Traits of Black Seed (Nigella sativa L.),” Iraqi Journal of Agricultural Sciences, vol. 41, no. 2, pp. 80–88, 2010.
13. [13] H. Majid and S. Ibrahim, “Effect of Seed Rates and Nitrogen Fertilization on Growth and Green Fodder Yield of Alfalfa (Medicago sativa L.) and Oats (Avena sativa L.) Mixture,” pp. 78–95, 2017.
14. [14] L. S. Pereira, “Irrigation Demand Management to Cope with Drought and Water Scarcity,” in Tools for Drought Mitigation in Mediterranean Regions. Dordrecht, The Netherlands: Springer, pp. 19–33, 2003.
15. [15] M. A. J. Al-Karkhi, “Role of Mycorrhizal Fungi and Irrigation Intervals in Growth and Yield of Mung Bean (Vigna radiata L.),” Journal of Kerbala for Agricultural Sciences, vol. 5, no. 5, pp. 138–151, 2018.
16. [16] Z. A. A. Razzaq et al., “Alfalfa (Medicago sativa L.) Growth and Fodder Yield in Response to Iron and Humic Acid Spraying,” IOP Conference Series: Earth and Environmental Science, vol. 1549, no. 1, Art. no. 012001, 2025.

ISSN 3063-8186 (online), https://ijhsm.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo