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Role of Mycorrhiza and Some Plant Extracts in improving the Germination and Growth of two thyme varieties

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ABSTRACT

The experiment was conducted at a lath house affiliated with the College of Agricultural Engineering Sciences, University of Baghdad, following the Randomized Complete Block Design (RCBD) within aSplit-blocks arrangement with three replicates. The experiment involved two factors: the first factor was planting two thyme varieties Wild thyme and German thyme), while the second factor was combination treatments of mycorrhizae and irrigation with licorice and cumin extracts, with ten treatments including the control treatment, mycorrhizae, mycorrhizae + 1% licorice extract, mycorrhizae + 2% licorice extract, mycorrhizae + 1% cumin extract, mycorrhizae + 2% cumin extract, mycorrhizae + 1% licorice + 1% cumin, mycorrhizae + 1% licorice and 2% cumin, mycorrhizae + 2% licorice and 2% cumin. The experiment results demonstrated that the two interaction treatments of German thyme and mycorrhizae + 2% licorice extract and German thyme and mycorrhizae + 2% licorice + 1% cumin had the highest germination percentages, 86.67% and 82.67%, respectively. Treatment Wild thyme and mycorrhizae + 2% licorice + 1% cumin was superior in germination rapidness, seedling length, and number of leaves, attaining 5.433 day seed^{-1}, 8.000 cm, and 11.467 leaves.plant^{-1}, respectively. Treatment German thyme and mycorrhizae + 2% licorice + 1% cumin was superior in homogeneity, achieving 20.777 seeds.day^{-1}. Treatment mycorrhizae + 2% licorice + 1% cumin was the most rapid in germination and homogeneous and was superior in sapling height and number of leaves, recording 5.466 days.seed^{-1}, 18.472 seeds.day^{-1}, 7.900 cm and 11.033 leaves.plant^{-1}, respectively. Treatment T1Measurement treatment was superior to other treatments by exhibiting the highest germination percentage, which reached 72.50%. The difference between the varieties was insignificant in the number of leaves. The variety German thyme was superior in germination percentage and homogeneity, achieving 53.67% and 13.276 seeds.day^{-1}, respectively.

دور المایاکورایزا وبعض المستخلصات النباتية في تحسين انبات ونمو بذور نوعين من الزعتر

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الخلاصة

نفذت التجربة في احدى الظلل التابعة لكلية علوم الهندسة الزراعية – جامعة بغداد وفقا لتصميم القطاعات الكاملة المعشاة (RCBD) بترتيب القطاعات المنشقة Split plot Design وبثلاث مكررات . شملت التجربة عاملين : العامل الاول زراعة صنفين من الزعتر (البري والزعتر الالماني) أما العامل الثاني فيمثل توليفات من المعاملة بالمايكورايزا والسقي بمستخلصي عرق السوس والكمون وبواقع عشر معاملات تضمنت : معاملة القياس ومايكورايزا ومايكورايزا + ١% مستخلص عرق السوس ومايكورايزا +٢% مستخلص عرق السوس ومايكورايزا +١% مستخلص الكمون و مايكورايزا + ٢% مستخلص الكمون ومايكورايزا + ١% عرق السوس +١% كمون ومايكورايزا +١% عرق السوس و ٢% كمون و مايكورايزا +٢% عرق السوس +١% كمون ومايكورايزا +٢% عرق السوس و٢% كمون.اظهرت نتائج التجربة ان معاملتي التداخل V1T4(الزعتر الالماني والمايكورايزا و٢% مستخلص عرق السوس) وV1T9 (الزعتر الالماني والمايكورايزا و٢% مستخلص عرق السوس و١% مستخلص الكمون) أعطت اعلى نسبة انبات وتجانس والتي بلغت ٨٦.٦٧ و٨٢.٦٧ % و٢٠.٧٧٧ بذرة.يوم$^{-1}$ على التوالي. تفوقت المعاملة V2T9 (الزعتر البري والمايكورايزا و٢% مستخلص عرق السوس و١% مستخلص الكمون)في سرعة الانبات و طول للشتلة وعدد الاوراق والتي بلغت ٥.٤٣٣ يوم .بذرة $^{-1}$و٨.٠٠٠ سم و١١.٤٦٧ورقة .نبات $^{-1}$بالتتابع. ان المعاملةT9 (المايكورايزا و٢% مستخلص عرق السوس و١% مستخلص الكمون) كانت اسرع انباتا واكثر تجاناسا وتفوقت في طول للشتلة وعدد الاوراق والتي بلغت ٥.٤٦٦ يوم.بذرة $^{-1}$ و١٨.٤٧٢ بذرة.يوم$^{-1}$ و٧.٩٠٠ سم و ١١.٠٣٣ ورقة .نبات $^{-1}$بالتتابع وتفوقت المعاملة T1 (معاملة القياس)على بقية المعاملات بأعطاءها اعلى نسبة للانبات والتي بلغت ٧٢.٥٠% . عدم وجود فروق معنوية بين الاصناف في عدد الاوراق.وتفوق الصنف الالماني في نسبة الانبات والتجانس والذي بلغ ٥٣.٦٧ % و١٣.٢٧٦ بذرة.يوم$^{-1}$ بالتتابع.

الكلمات المفتاحية : الزعتر ،عرق السوس ، الكمون ، نسبة الانبات ، سرعة الانبات

INTRODUCTION

Thyme (*Thymus vulgaris* L.) is a perennial flowering plant belonging to the family Lamiaceae, which includes 236 genera and more than 6,000 species. Most of these plants are aromatic and used as a source of essential oils . Thyme is widely cultivated in many world regions, although its original habitat is the western Mediterranean region and southern Italy (Davis, 1992; Halat et al., 2022). It has important medical and functional properties, so it has been involved in many food, cosmetics, perfumes and pharmaceutical industries (Abed Al-Rahman et al., 2007; Abbas, 2017; da Cunha Honorato et al., 2022; Iftikhar et al., 2023). Thyme has been used in traditional medicine to treat chest infections, cough, diabetes and others (Askary et al., 2018) and as an antimicrobial, anti-fungal, anti-parasitic, and antioxidants agents, as well as used for tumour treatment (Al-Jourani and Al-Kanani, 2013 Al-Nasrawi, 2017; Pujante-Galián, 2020; Panagiotopoulos et al., 2021; Abumughaid, 2021; Elbe, 2022; Vassiliou et al., 2023; Hadi and Majeed, 2023). The benefits of thyme plants are not limited to humans but also animals. Giving animals this plant with drinking water increases antibodies and improves animal production performance (Mahbuba et al., 2022). Seed germination is the most important stage in the plant life cycle. Water, air, temperature and light are all required for seed germination (Kumar et al., 2023).

Mycorrhizae are fungi that live in symbiosis with plants. They produce mycelium with a large surface area for resource exchange. Moreover, many fungal genera develop vesicles within the roots, acting as storage organs for fungi and as channels for the exchange of nutrients and energy between plants and the soil (Taha, 2021; Bhardwaj et al., 2023; Kumar et al., 2024). They also play a significant role in soil aggregation, environmental stability and increased plant tolerance to environmental stresses (Diagne et al., 2020; Prisa, 2023).

Researchers have recently become interested in using plant extracts in agriculture as alternatives to pesticides or plant growth regulators. They are environmentally friendly natural substances; they do not harm human health or the ecosystem. Among these extracts is licorice extract, which stimulates enzymes that convert complex compounds into simple ones. It also provides the plant with the energy needed for its growth. Terpenoid compounds in the extract may also stimulate bud formation (Fayyad, 2005; Ayoub, 2018; Sultan et al., 2020). Plant extracts also play a role in increasing the hormonal content of the plant, which is positively reflected in plant growth (Shakir and Al-Rawi, 2017). Fernandez-Zarate et al. (2022) found that the use of mycorrhizae in Cinchona plants had a significant effect on improving seed germination. Al-Shewailly, 2020 found that treating palm seeds with licorice extract at a concentration of 20 mg.L-1 and humic acid at a concentration of 500 mg.L^{-1} displayed the highest values for all studied traits (germination percentage of 99%, germination duration of 6 days, and plant sheath length of32 mm). Al-Mohmadi & Al-Ani, 2019 found a significant effect of spraying with licorice extract on the sorghum growth.Achieving the targets of sustainable development, this study aimed to improve the germination of thyme seeds by utilizing mycorrhizae and spraying them with yeast extract, licorice, and cumin.

MATERIALS AND METHODS

The experiment was conducted at a lath house in the College of Agricultural Engineering Sciences, University of Baghdad during the spring season 2024, based on the randomized complete block design (RCBD) with a split-Blocks arrangement and three replicates. The experiment comprised two factors: the first factor was planting two varieties of thyme (wild Thyme and German thyme symbolized as V1 and V2), while the second factor represented combinations of treatment with mycorrhizae and irrigation with extracts of licorice and cumin, constituting ten treatments as shown below. Licorice and cumin extracts were prepared by dissolving 10 g of each in 100 ml of water and leaving it for a whole day, then filtering it and taking 1% and 2% of each filtrate. The seeds were disinfested with a sodium hypochlorite solution for two minutes, rinsed in distilled water several times, placed in dishes containing mycorrhizae, and moistened with the previously prepared solutions, except for the control treatment of distilled water only. The means were compared using the least significant difference test (LSD 5%).

Treatments :

1- Control treatmentWatering with distilled water (T1)
2- Mycorrhizae(T2)
3- Mycorrhizae + 1% Licorice extract(T3)
4- Mycorrhizae + 2% Licorice extract(T4)
5- Mycorrhizae + 1% Cumin extract(T5)
6- Mycorrhizae + 2% Cumin extract(T6)
7- Mycorrhizae + 1% Licorice + 1% Cumin(T7)
8- Mycorrhizae + 1% Licorice and 2% Cumin(T8)
9- Mycorrhizae + 2% Licorice + 1% Cumin(T9)
10- Mycorrhizae + 2% Licorice + 2% Cumin(T10)

The response to treatments was evaluated by calculating the following parameters:

Germination percentage = number of germinated seeds × 100

Germination rapidity:

1- Germination percentage = number of germinated seeds × 100
2- Germination rapidity (day/seed) = sum of (number of daily germinated seeds × number of days) / number of days of actual germination
3- Germination homogeneity = number of seeds germinated at the end of the test period/ number of days of actual germination
4- Sapling height: It was measured two months after seed germination.
5- Number of leaves: It was counted at the end of the experiment.

RESULT AND DISCUSSION

Results in Table 1 exhibit a significant effect of mycorrhizae and irrigation with licorice and cumin extracts on the germination percentage of the two thyme varieties. The interaction treatments V1T4 and V1T9 displayed the highest germination percentage, reaching 86.67% and 82.67%, respectively, compared to treatment V2T1, which recorded the lowest germination percentage, reaching 9.33%. Treatment T4 outperformed the other treatments by recording the highest germination percentage, attaining 72.50%, compared to treatment T1, which had the lowest germination percentage, reaching 16.33%. Variety V1 outperformed in germination percentage, recording 53.67%.

Table 1. Effect of mycorrhizae and plant extracts on the seed germination percentage of two thyme varieties.

Treatments	varieties		Mean of mycorrhizae and plant extracts
	V1	V2	
T1	23.33	9.33	16.33
T2	56.00	26.33	41.17
T3	60.33	46.00	53.17
T4	86.67	58.33	72.50
T5	49.00	26.67	37.83
T6	27.67	20.67	24.17
T7	66.33	44.00	55.17
T8	42.67	36.67	39.67
T9	82.67	55.00	68.83
T10	42.00	31.33	36.67
Mean of varieties	53.67	35.43	44.55
L.S.D 5%	L.S.D V=1.004	L.S.DT=2.373	L.S.D V*T=3.214

Measurement treatment = T1 and mycorrhizae = T2 and mycorrhizae + 1% licorice extract = T3 and mycorrhizae + 2% licorice extract = T4 and mycorrhizae + 1% cumin extract = T5 and mycorrhizae + 2% cumin extract = T6 and mycorrhizae + 1% licorice + 1% cumin = T7 and mycorrhizae + 1% licorice and 2% cumin = T8 and mycorrhizae + 2% licorice + 1% cumin = T9 and mycorrhizae + 2% licorice and 2% cumin = T10, V1 = German thyme, V2 = Wild thyme

The results illustrated in Table 2 reveal that the treatment of the seeds of the two varieties, the German and wild thyme, with mycorrhizae and irrigation with extracts of licorice at a concentration of 2% and cumin at a concentration of 1%% was significantly superior, recording the most rapid germination, which attained 5.433 and 5.500 days.seed^{-1}, which did not differ significantly from the treatments V2T5, V2T6 and V1T8, which reached 5.567, 5.567 and 5.833 days.seed^{-1}, respectively, compared to the treatment V2T1, which had the slowest germination, elapsing 9.000 days.seed^{-1}. Concerning the treatment with plant extracts, the table clearly shows that the treatment T9 (mycorrhizae at 2% licorice and cumin at 1%) had the most rapid germination, reaching 5.466 days.seed^{-1}, compared to the control treatment, which elapsed a longer time for germination, reaching 8.750 days.seed^{-1}. The table below reveals that differences between the two varieties in germination rapidness were insignificant.

Table ٢. Effect of mycorrhizae and plant extracts on the seed germination rapidness of two thyme varieties.

Treatments	varieties		Mean of mycorrhizae and plant extracts
	V1	V2	
T1	8.500	9.000	8.750
T2	6.900	6.433	6.667
T3	7.700	7.200	7.450
T4	6.200	6.167	6.183
T5	6.433	5.567	6.000
T6	6.433	5.767	6.600
T7	7.767	6.367	7.067
T8	5.833	7.567	6.700
T9	5.500	5.433	5.466
T10	7.900	7.233	7.5665
Mean of varieties	6.917	6.673	6.895
L.S.D 5%	L.S.D V= N.S	L.S.DT=0.4575	L.S.DV*T=0.6239

Measurement treatment = T1 and mycorrhizae = T2 and mycorrhizae + 1% licorice extract = T3 and mycorrhizae + 2% licorice extract = T4 and mycorrhizae + 1% cumin extract = T5 and mycorrhizae + 2% cumin extract = T6 and mycorrhizae + 1% licorice + 1% cumin = T7 and mycorrhizae + 1% licorice and 2% cumin = T8 and mycorrhizae + 2% licorice + 1% cumin = T9 and mycorrhizae + 2% licorice and 2% cumin = T10, V1 = German thyme, V2 = Wild thyme

The results of Table 3 indicate that the seeds of the German thyme variety were more homogeneous than those of the wild variety when treated with mycorrhizae and irrigated with licorice extracts at a concentration of 2% and cumin at a concentration of 1%; this treatment was significantly superior, yet it did not differ from the T4V1 treatment, reaching 20,777 and 19,500 seeds.day^{-1}, respectively, compared to the control treatment T1V2, which was less homogeneous, recording 7,000. The table results also show that the seeds treated with mycorrhizal, licorice extracts at 2%, and cumin extract at 1% were more homogenous than the other treatments, displaying 18,472 seeds. day^{-1}, compared to the control treatment T1, which was less homogenous and recorded 7,410 seeds.day^{-1}. It is also evident that the German variety V1 was more homogeneous than the wild variety V2.

Table 3. Effect of mycorrhizae and plant extracts on the germination homogeneity of two thyme varieties.

Treatments	varieties		Mean of mycorrhizae and plant extracts
	V1	V2	
T1	7.820	7.000	7.410
T2	13.333	9.553	11.443
T3	12.917	6.583	9.750
T4	19.500	15.663	17.582
T5	12.553	9.833	11.193
T6	9.387	9.800	9.593
T7	13.527	8.443	10.985
T8	12.500	11.000	11.750
T9	20.777	16.167	18.472
T10	10.443	11.553	10.998
Mean of varieties	13.276	10.560	11.918
L.S.D 5%	L SDV=0.6058	L SDT=0.5806	L SDV*T=0.8306

Measurement treatment = T1 and mycorrhizae = T2 and mycorrhizae + 1% licorice extract = T3 and mycorrhizae + 2% licorice extract = T4 and mycorrhizae + 1% cumin extract = T5 and mycorrhizae + 2% cumin extract = T6 and mycorrhizae + 1% licorice + 1% cumin = T7 and mycorrhizae + 1% licorice and 2% cumin = T8 and mycorrhizae + 2% licorice + 1% cumin = T9 and mycorrhizae + 2% licorice and 2% cumin = T10, V1 = German thyme, V2 = Wild thyme

Table 4 demonstrates the significant effects of the interaction between mycorrhizae and irrigation with licorice and cumin extracts and the two thyme varieties on sapling height: It was measured two months after seed germination. length. The interaction treatment T9V2 exhibited the highest length, reaching 8.000 cm; however, it did not differ significantly from the interaction treatments T9V1 and T7V1, whose sapling height reached 7.800 and 7.033 cm, respectively, compared to the control treatment T1V1, which produced the lowest length, reaching 2.267 cm.

Table 4. Effect of mycorrhizae and plant extracts on on the sapling height cm of two thyme varieties.

Treatments	varieties		Mean of mycorrhizae and plant extracts
	V1	V2	
T1	2.267	3.433	2.850
T2	3.800	4.133	3.967
T3	2.567	2.800	2.683
T4	6.343	6.843	6.593
T5	2.833	4.367	3.600
T6	3.933	4.033	3.983
T7	7.033	6.267	6.650
T8	6.000	5.800	5.900
T9	7.800	٨.٠٠٠	٧.٩٠٠
T10	3.900	2.767	3.333
Mean of varieties	4.648	4.824	4.745
L.S.D 5%	LSD V= N.S	LSDT=0.394	LSDV*T=0.5900

Measurement treatment = T1 and mycorrhizae = T2 and mycorrhizae + 1% licorice extract = T3 and mycorrhizae + 2% licorice extract = T4 and mycorrhizae + 1% cumin extract = T5 and mycorrhizae + 2% cumin extract = T6 and mycorrhizae + 1% licorice + 1% cumin = T7 and mycorrhizae + 1% licorice and 2% cumin = T8 and mycorrhizae + 2% licorice + 1% cumin = T9 and mycorrhizae + 2% licorice and 2% cumin = T10, V1 = German thyme, V2 = Wild thyme

The table ٤ indicates that treatment T9 resulted in the highest value of 7.900 cm, which did not differ significantly from T7 and T4, which produced 6.650 and 6.593 cm, respectively, compared to the control treatment T1, which gave the lowest value of 2.850 cm. Regarding the varieties, no significant difference was observed between the two of them in the sapling height.

Table 5 shows the superiority of the interaction T9V2 treatment in the number of leaves trait, producing 11,467 leaves.plant^{-1}, compared to the control treatment T1V1, displayed the lowest value of 4,233 leaves.plant^{-1}.

Table 5. Effect of mycorrhizae and plant extracts on the number of leaves of two thyme varieties.

Treatments	varieties		Mean of mycorrhizae and plant extracts
	V1	V2	
T1	4.233	4.387	4.310
T2	6.330	6.900	6.615
T3	5.333	6.100	5.717
T4	7.333	8.887	8.110
T5	5.667	5.733	5.700
T6	6.933	6.400	6.667
T7	10.667	8.443	9.555
T8	7.667	7.233	7.450
T9	10.600	11.467	11.033
T10	5.487	5.333	5.410
Mean of varieties	7.025	7.088	7.057
L.S.D 5%	L SD V =0.3985	L SD T=0.4794	L SD V*T=0.6691

Measurement treatment = T1 and mycorrhizae = T2 and mycorrhizae + 1% licorice extract = T3 and mycorrhizae + 2% licorice extract = T4 and mycorrhizae + 1% cumin extract = T5 and mycorrhizae + 2% cumin extract = T6 and mycorrhizae + 1% licorice + 1% cumin = T7 and mycorrhizae + 1% licorice and 2% cumin = T8 and mycorrhizae + 2% licorice + 1% cumin = T9 and mycorrhizae + 2% licorice and 2% cumin = T10, V1 = German thyme, V2 = Wild thyme

It is noticed from the table ٥ that the treatment T9 is superior in the number of leaves, reaching 11,033 leaves.plant^{-1}, compared to the control treatment, which recorded the lowest value of 4,310 leaves.plant^{-1}. Table 5 demonstrates that differences between the varieties were insignificant in the number of leaves.

Utilizing mycorrhizae increases water and nutrient uptake by increasing the absorption surface area of the mycelium in the soil, allowing the plant to access more soil; this can enhance photosynthesis, boost plant growth, and thus increase leaf area (Huang et al., 2018; Yeh et al., 2019; Wu et al., 2020; Khaledian et al., 2021). These results are consistent with Gutowski (2015) applied on garden cress, Zadeh and Pirzad (2020) on thyme, Tsulsiyah et al. (2021) on orchid, ROSTAMI et al. (2021) on thyme, and Alassady et al. (2022); and Altaai and Saad (2024) on bean.

The significant increase in germination percentage, rapidity, sapling height, and number of leaves in thyme is due to the licorice extract containing Mevalonic acid. Mevalonic acid may be considered the initiator of gibberellin, so it behaves like gibberellin in stimulating enzymes and converting complex compounds into simple ones, thus providing the energy needed for cell growth and division . These results are consistent with Al-Saqaf et al. (2017) on onion, Matter and Al Ajaily (2018) on garlic, Al-Shewailly (2020) using licorice extract, Al-Rawi and Al-Marsoumi (2023) using licorice and mycorrhizae on rose, and Khudhair et al. (2024) on maize. The reason for the significant increase resulting from using some concentrations of cumin extract may be due to its role in activating the production of antioxidants (Farhan and Chechan, 2020), as cumin contains carbohydrates, proteins, and vitamins, in addition to containing lutein and arotine, which play a role

in activating seed germination and growth (Omidbaigi, 2008 and Derakhshan et al., 2010). These results are consistent with those of Abdulhussein (2016) related to the effect of using plant extracts, including cumin, on the plumule length of the dill plant and GEDİK and USLU (2019), who used cumin extract on flax seed germination.Results obtained from the study showed that using mycorrhizal fungi and plant extracts of licorice and cumin on two thyme varieties significantly enhanced many growth parameters, including the germination percentage and rapidness, plant height, and number of leaves when they were used individually or in combination. German thyme outperformed wild thyme in many traits.

CONCLUSIONS

Results obtained from the study showed that using mycorrhizal fungi and plant extracts of licorice and cumin on two thyme varieties significantly enhanced many growth parameters, including the germination percentage and rapidness, plant height, and number of leaves when they were used individually or in combination. German thyme outperformed wild thyme in many traits.

REFERENCES

Abbas, H.A.2017. Thyme Extract as Corrosion Inhibitor for Teeth Filler Alloy in Saliva Media. Iraqi Journal of Science, 2016, Vol. 57, No.4C, pp:2800-2810

Abdul Hussein, T.M.2016.Effect of Water Extracts of Some Medicinal Plants on Germination Percentage and Development of Plumule and Radicle Growth *Anethum graveolens L*. ibn Al-Haitham J. for Pure & Appl. Sci .Vol. 29 (3).

Abo mughaid, M.M.2021. Isolation and Identification of Fungi from Clinical Samples of Diabetic Patients and Studying the Anti-Fungal Activity of Some Natural Oils on Isolated Fungi. Baghdad Science Journal. 18(3):462-470.

AL – Jorany, R.S. and M.A.J. AL – Kinani.2013. Control of American Foul Brood Disease (AFB) in Honey Bee Using Thyme Extracts and Thymol. Ibn Al-Haitham Jour. for Pure & Appl. Sci.26(3).

Al assady, R.A., H.A. Almrani and M.K. Abdul-Hammed.2022.Symbiotic Relationship between Mycorrhizae Fungus, Humic Compost and Seaweed Extract on Vegetative Growth Characteristics and Gel Yield of Aloe vera .Indian Journal of Ecology (2022) 49 Special Issue (18): 531-532.

Al-Mohmadi, S. Y. A. and M. H. I. Al-Ani .2019. Effect Of Spraying with Different Concentration Of Licorice Extract And Plant Densities In Growth And Yield Of Sorghum Bicolor L. Iraqi Journal of Agricultural Sciences :50(6):1478-1485. DOI:10.36103/ijas.v50i6.835.

Al-Nasrawi, H.A.2017. Study of the inhibitory effects of some medicinal plants extracts on growth of Listeria monocytogenes isolated from human, cow and sheep in Al-Qadisiya governorate. The Iraqi Journal of Veterinary Medicine, 41(2):38-47.
DOI: https://doi.org/10.30539/iraqijvm.v41i2.46

Al-Rawi ,L.A.H. , H. G. Al-Marsoumi.2023.The Effect of Shadding Addition of Licorice Extract and Biofertilizers on The Growth and Production of Commercial Cut Flowers of Two Cultivars of Roses.Iraqi Journal of Desert Studies 2023, 13 (2): 18-28. DOI:10.36531/ijds.2023.141492.1040.

Al-Saqaf,N.M., O.S.AL- Haw shabi and M.A.Hussein.201٧.Effect of licorice extract (*Glycyrrhiza glabra L.*) on germination and of seedlings growth of Onion (*Allium cepa L. cv. Bafatiem*).Aden University Journal of Natural and Applied Sciences .21(1).https://doi.org/10.47372/uajnas.2017.n1.a02.

Al-Shewailly,M.S.R.2020. Effect of Aqueous extract of licorice and humic acid on germination of date palm (*Phoenix dactylifera l.)* seeds. Int. J. Agricult. Stat. Sci. Vol. 16, Supplement 1, pp. 1005-1009.DocID: https://connectjournals.com/03899.2021.17.1695.

Al-Shewailly,M.S.R.2020.Effect of Aqueous Extract OF Licorice andD Humic acid on Germination Of Date Palm (*PHOENIX DACTYLIFERA L.*) Seeds.Int. J. Agricult. Stat. Sci. 16(1):, pp. 1005-1009.

Altaai, A.F. and D.A. Saad.2024.Response *Phaseolus vulgaris L.* Plant to Glomus mosseae and Azotobacter chroococcum .Diyala Agricultural Sciences Journal.16(1): 52-55. https://dx.doi.org/10.52951/dasj.24160105.

Askary M., Behdani M.A., Parsa S., Mahmoodi S., Jamialahmadi M.2018. Water stress and manure application affect the quantity and quality of essential oil of *Thymus daenensis* and *Thymus vulgaris*. *Ind. Crops Prod.* 111:336–344.

Ayoub,A.A.2018.Study of the Active Ingredient of Licorice Plant and Applications.This is an open access article under the CC BY 4.0 license http://creativecommons.org/licenses/by/4.

Bhardwaj, A. K., Chandra, K. K., & Kumar, R. 2023.Water stress changes on AMF colonization, stomatal conductance and photosynthesis of Dalbergia sissoo seedlings grown in entisol soil under nursery condition. Forest Science and Technology, 19(1), 47–58.https://doi.org/10.1080/21580103.2023.2167873.

Da Cunha Honorato A., Maciel J.F.A., de Assis R.M.A., Nohara G.A., de Carvalho A.A., Pinto J.E.B.P., Bertolucci S.K.V.2022. Combining green manure and cattle manure to improve biomass, essential oil, and thymol production in *Thymus vulgaris* L. *Ind. Crops Prod.* 2022;187:115469. doi: 10.1016/j.indcrop..115469.

Davis PH. 1992. Flora of Turkey and the East Aegean Islands. Thesis. University Edinburgh, U.K. pp. 32−35.

Derakhshan, S., Sattari, M. and Bigdeli, M. 2010. Effect of cumin (*Cuminum cyminum L.*) seed essential oil on biofilm formation and plasmid integrity by Klebsiella pneumoniae. Pharma. Mag., 6: 57-61. 14. DOI: 10.4103/0973-1296.59967.

Diagne, N., M. Ngom, P. I. Djighaly, D. Fall, V. Hocher, and S. Svistoonoff. 2020.Roles of Arbuscular Mycorrhizal Fungi on Plant Growth and Performance:Importance in Biotic and Abiotic Stressed Regulation. *Diversity* .12 (10): 370. doi:10.3390/d12100370.

Elbe H., Ozturk F., Yigitturk G., Baygar T., Cavusoglu T. Anticancer activity of linalool: Comparative investigation of ultrastructural changes and apoptosis in breast cancer cells. *Ultrastruct. Pathol.*46:348–358. doi: 10.1080/01913123.2022.2091068.

Farhan, E. M. and R. A. Chechan.٢٠٢٠.Evaluting the ability of pleurotus ostreatus aqueous extract to modulate genotoxicity induced by cyclophosphamide in mice bone marrow cells. Iraqi Journal of Agricultural Sciences.51(5):1405-1412. DOI: https://doi.org/10.36103/ijas.v51i5.1150.

Fayad, M.H. 2005. The effect of spraying some growth regulators and plant extracts on the growth and yield of the two plant species: Cucumis melo var. flexuoses Noud. and Cucumis sativus L. Ph.D. Thesis, College of Agriculture, University of Basrah, Iraq.

Fernandez-Zaratea, F.H., A. E. Huaccha-Castillob, S. P. Vaca-Marquinac, T. Sanchez-Santilland Eli Morales-Rojasb , Alejandro Seminario-Cunyaa Luci Magali Barturen-Vegae ,M. G. Santill, and D. C. Bustamante.2022. Effect of arbuscular mycorrhiza on germination and initial growth of *Cinchona officinalis* L. (Rubiaceae). FOREST SCIENCE AND TECHNOLOGY .18(4) 182–189. https://doi.org/10.1080/21580103.2022.2124318.

GEDİK ,O., Ö. S. USLU.2019.Effects of Fennel and Cumin Extracts on Flax Seed Germination Parameters and Mitotic Activity in the Root Tip Cell.BEU Journal of Science10 (1), 197-206. DOI:10.17798/bitlisfen.806250

Gutowski,V.2015.The effect of mycorrhizae on seed germination, development, and reproductive yield of Rapid Gro Radish.ESSAI.13(18). http://dc.cod.edu/essai/vol13/iss1/18.

Hadi, M.M. and M.M. Majeed.2023. PRODUCTION OF GREEN DETTOL AS BACTERIAL INHIBITOR AND DISINFECTANT. Iraqi Journal of Agricultural Sciences – 2023:54(4):1008-1015.DOI: https://doi.org/10.36103/ijas.v54i4.1789.

Halat, D.H. , M. Krayem, S. Khaled and S. Younes.2022.A Focused Insight into Thyme: Biological, Chemical, and Therapeutic Properties of an Indigenous Mediterranean Herb.Nutrients 2022, 14, 2104. https://doi.org/10.3390/nu14102104.

Huang, H., Zi X-M, Lin H, Gao J-Y. 2018. Host-specificity of symbiotic mycorrhizal fungi for enhancing seed germination, protocorm formation and seedling development of over-collected medicinal orchid, J Microbiol. 56(1):42–48. DOI: 10.1007/s12275-018-7225-1

Iftikhar, T., H. Majeed, S.S. Zahra, M. Waheed, M. Niaz, and N. Ban.2023.Thyme.Essentials of Medicinal and Aromatic Crops (pp.399-429).

1. in Labiatae Science,Mahbuba A. M., A. Ab. Jabbar and N. A. Mustafa..٢٠٢٢.The effectiveness of some medicinal plants on body performance, hematological, ileum morphology and immune statue of japanese quail. Iraqi Journal of Agricultural Sciences – 2022:53(4):724-731.DOI: https://doi.org/10.36103/ijas.v53i4.1582

Issraa R. Abed Al-Rahman,1, Fatima J. Jawad, Ekbal H. Alkateeb and Alaa A. Abdulrasool .2007. Preparation of Anise and Thyme Lotion for Topical Use. Iraqi J.Pharm.Sci., Vol.16 (1).DOI: https://doi.org/10.31351/vol16iss1pp8-13.

Khalediyan N, Weisany W, Schenk PM. 2021. Arbuscular mycorrhizae and rhizobacteria improve growth, nutritional status and essential oil production in *Ocimum basilicum* and *Satureja hortensis*. Ind Crops Prod. 160:113163.DOI:10.1016/j.indcrop.2020.113163

Khudhair, M.M. ,M.M., J.H. Hamza and H.Z. Rihan.2024. PLANTING OF STIMULATED CORN SEEDS AT DIFFERENT DATE SPRING SEASONS. Iraqi Journal of Agricultural Sciences –2024:55(2):813-822.DOI: https://doi.org/10.36103/bshasy14.

Kumar, R., A. K. Bhardwaj, K. K. Chandra, B. Dixit, and A.K. Singh.2024. Diverse role of mycorrhiza in plant growth and development: Review. Solovyov Studies ISPU.72(2)..

Kumar, R., Bhardwaj, A. K., & Chandra, K. K. (2023). Levels of natural and anthropogenic disturbances and assessment of their impact on plant community functional diversity. Forestist , 73(1): 108- 116DOI:10.5152/forestist.2022.22025.

Matter, A. M. and A. Al Ajaily.2018. Potassium Poultry Waste and Licorice Extract Effect on Growth , Yield and Substance of Garlic (*Allium atroviolaceum L.*).Tikrit University Journal of Agricultural Sciences .18(2).

Omidbaigi, R. 2008. Production and Processing of Medicinal Plants. 5th ed., Tehran Astan Quds Publication.

Panagiotopoulos A., T. M.,I. Karakasiliotis,D.M. Kotzampasi, V. Daskalakis, N. Kesesidis, G.Notas , C.Lionis , M. Kampa ,and s. Pirintsos.2021. P-cymene impairs SARS-CoV-2 and Influenza A (H1N1) viral replication: In silico predicted interaction with SARS-CoV-2 nucleocapsid protein and H1N1 nucleoprotein. *Pharmacol. Res. Perspect.* 9(4). doi: 10.1002/prp2.798.

Prisa, D.2023.Mycorrhizal Symbioses and Plant Interactions.Karbala International Journal of Modern Science. 9 (2), Article 6.https://doi.org/10.33640/2405-609X.3296.

Pujante-Galián M.A., Pérez S.A., Montalbán M.G., Carissimi G., Fuster M.G., Víllora G., García G. p-Cymene Complexes of Ruthenium (II) as Antitumor Agents. *Molecules.* 25:5063. doi: 10.3390/molecules25215063.

Rostami, R., S.A. HOSSEINI, B.E. POUR, A. ETMINAN and G. SALIMI .2021.Growth, physiological, and biochemical responses of thyme (*Thymus vulgaris*L.) to the application of arbuscular mycorrhizal fungi under cadmium stress conditions.Notulae Botanicae Horti Agrobotanici Cluj-Napoca 49(3):11924.DOI:10.15835/nbha49311924.

Shakir, M.A. and W. A. A. Al-Rawi.2017. Effectof garlic and licorice root extract onleaves mineral and hormonal content of pear transplants. The Iraqi Journal of Agricultural Sciences –48: (Special Issue): 131-143.

Sultan, F.I.; Al-Farha, A.A. and Shaaban, I. 2020. Separation and identification of some fatty acids and phenolic compounds from *Portulaca oleracea* L. and study their biological effect on two types of pathogenic bacteria. Asian Journal of Agriculture and Biology. AJAB. 8(3): 1-1.DOI: 10.35495/ajab.2020.02.119.

Taha,H.H.2021.Mycorrhizae Fungi.Rafidain Journal of Science. 33(3). pp.52-64.DOI: 10.33899/rjs.2021.168914.

Vassiliou,E,O. Awoleye, A. Davis, and S. Mishra.2023. Anti-Inflammatory and Antimicrobial Properties of Thyme Oil and Its Main Constituents. Int J Mol Sci. 2023 Apr; 24(8): 6936.

Wu, L.S. et al., 2020.Endophytic fungi, host genotype, and their interaction influence the growth and production of key chemical components of Dendrobium catenatum.Fungal Biology, 124(10), pp.864-876.https://doi.org/10.1016/j.funbio.2020.07.002.

Yeh, C. M. et al., 2019. New insights into the symbiotic relationship between orchids and fungi. Applied Sciences (Switzerland), 9(3), pp.1-14.**https://doi.org/10.3390/app9030585**.

Zzadeh,Z.M.S. and A. Pirzad.2020.Biochemical responses of mycorrhizal-inoculated Lamiaceae (Lavender, Rosemary and Thyme) plants to drought: a field study.Soil science Plant nutrition.67(1):41-49.https://doi.org/10.1080/00380768.2020.1851144