# Effect of spraying with thiourea and boron on growth parameters of sweet marjoram (*Origanum majorana* L.)

**Rusul F. Nouri[1], Kadum M. Abdullah[1]***

**Horticulture and Landscape Department, College of Agriculture, University of Kerbala, Karbala, Iraq.**
***Corresponding author e-mail: kadum.m@uokerbala.edu.iq**
**https://doi.org/ 10.59658/jkas.v12i1.3283**

**Received**
Jan. 10, 2025

**Accepted**
Feb. 17, 2025

**Published**
Mar. 15, 2025

## Abstract

A pot experiment was carried out in the Horticulture and Landscape Department, College of Agriculture, University of Kerbala during the spring season of 2024. The study aimed to investigate the impact of thiourea spraying at concentrations of 0, 500, 750, and 1000 mg $L^{-1}$ (T0, T1, T2, T3 respectively) and boron spraying at concentrations of 0, 25, 50, and 100 mg $L^{-1}$ (B0, B1, B2, B3 respectively) on the vegetative growth characteristics of sweet marjoram. The study was conducted according to a randomized complete block design with three replications. The results showed the differential effect of adding the study factors individually, as the concentration (1000 mg $L^{-1}$) thiourea had a significant superiority in all traits except for the leaf area trait, while for spraying boron, the significant superiority was for the concentration (100 mg $L^{-1}$) in all traits. The interaction between thiourea and boron was significant, as treatment T1 B3 was superior in plant length and gave (29.45 cm), while treatment T3 B2 was superior in stem diameter and number of branches and gave (2080 mm) and (18.68 branches plant-1) respectively. As for leaf area, the highest average was at the interaction equation T2 B3 and reached (1.134 cm2), and the interaction treatment T3 B3 gave the highest average of dry matter percentage of (24.97%) and the highest total chlorophyll content of (57.91 mg 100 g fresh weight). The important conclusion of this study is the significant effect of the study factors on the growth of this herb of medical importance.

**Keywords**: Medicinal plants, Lamiaceae, SH, marjoram, $NH_2$

## Introduction

The majority of medicinal plants that contain volatile oils were previously employed as condiments to improve the flavour of food. However, today, a significant number of these plants are employed to treat diseases [1]. The potential of plant essential oils as antibacterial, antiseptic, and anti-inflammatory medicines has garnered growing interest [2]. One of these aromatic plants that is widely spread in the world for its therapeutic properties is marjoram (*Origanum majorana* L.), which is a herbaceous plant that belongs to the Lamiaceae family and is native to Cyprus and Antalya and has spread to large parts of the Mediterranean region, especially Egypt and other Arab countries. The genus Origanum is widely used for their effectiveness as home remedies for various conditions such as chest infections, sore throat, rheumatic pain, nervous disorders, cardiovascular diseases, epilepsy, insomnia, skin care, flatulence, and stomach disorders. In addition, it is used as an antioxidant, analgesic, anticancer, and antidepressant [3]. The essential oil was also found to have activity as a natural pesticide for agricultural pests as an alternative to synthetic pesticides [4]. Marjoram is grown mainly for its green, dry aromatic leaves. Although it is a perennial herb, it is treated as an annual and grows to a height of 30-60 cm. It is sensitive to cold. This plant is propagated by seeds or cuttings and is planted in the spring until the summer. The plant is harvested after three to four months. It is usually harvested before the seeds form because the leaves contain a high percentage of oil [5].

Thiourea (TU) is a chemical compound that contains sulfur (42%) and nitrogen (36%) in the form of SH and NH2, respectively. The importance of sulfur is due to its being essential in the formation of proteins, vitamins, enzymes and defensive compounds in the plant, in addition to nitrogen fixation and its optimal use to enhance plant productivity [6]. Nitrogen is a mineral nutrient that is one of the major nutrients that the plant needs greatly because it is essential for plant growth and development. It stimulates vegetative growth in plants, photosynthesis rates and chlorophyll content [7]. Since thiourea is highly soluble in water, it is easily absorbed from the surface of the plant, so it helps the plant to mitigate the damage of prevailing abiotic stresses. It also plays a role in increasing photosynthesis rates, total chlorophyll concentration and starch in the leaves [8].

Boron is regarded as one of the special elements that is significant not only for its chemical characteristics but also for its essential functions in the upkeep of the ecosystem in general and the development of higher plants in particular. Its relevance in agriculture has grown since its role as a nutrient was established, and its presence in the soil or with irrigation water is now one of the elements influencing agricultural output. This element must be continuously supplied for plants to grow healthily and to achieve the best possible production in terms of both quantity and quality [9]. Boron participates in the construction of the cell wall and membranes and the performance of their functions, the flow of ions across membranes, cell division and elongation, the biosynthesis of nitrogen and carbohydrates, the transport of sugars, proteins, enzymes, nucleic acids, indole acetic acid, oleamines, and ascorbic acid, in addition to the biosynthesis and transport of phenols. It also works in combination with sugars as a compound that accelerates the movement of sugars to active areas. This works to move boron across cell membranes easily during growth throughout the stages of plant growth and reproduction [10,11]. Recently, boron-containing compounds have shown high efficacy against many plant pathogens, which encourages the use of these compounds within the integrated pest management program [12]. Unbalanced boron supply, whether in deficiency or excess, leads to negative effects on the growth of various crops and the ecosystem in general, so it has become important to provide this element to plants according to their needs to achieve optimal natural growth and improve production quality [13].

In Iraq, sweet marjoram is an uncommon plant. This study intends to test the cultivation of sweet marjoram under Iraqi climatic conditions, and Karbala Governorate in particular, because of its numerous culinary applications and medical and industrial significance. It also aims to determine the extent to which the growth of sweet marjoram responds to treatment with thiourea and boron separately or in combination by examining the vegetative growth characteristics of this plant.

## Materials and Methods

The study was conducted at the University of Kerbala / College of Agriculture / Horticulture and Landscape Department in a plant canopy covered with Saran with a shading rate of 50% for the period from 25/2/2024 to 1/7/2024. Marjoram seeds were planted in trays containing a mixture of soil and peat moss at a ratio of 2 soil: 1 peat moss on 4/2/2024. Then the seedlings were transferred to plates and then to pots containing soil and peat moss. The study was conducted as a factorial experiment with two factors using a Randomized Complete Blocks Design (R.C.B.D) with three replicates, where each replicate contained 16 treatments resulting from the use of four concentrations of thiourea (0, 500, 750, 1000 mg $L^{-1}$) and four concentrations of boron (0, 25, 50, 100 mg $L^{-1}$). The required concentrations were prepared by dissolving thiourea and boron in distilled water. There were 4 plants in each treatment unit, so the number of plants included in the study was (16 treatments × 4 plants × 3 replicates = 192 plants). The seedlings were sprayed with the study factors successively when the seedlings were two months old, at a rate of four sprays, with two weeks between each spray until the end of the experiment. All agricultural service operations were carried out, such as irrigation, weeding, and pest control. Chemical fertilization was also carried out using neutral NPK fertilizer, which was added at a concentration of 1 ml $L^{-1}$. Measurements of the vegetative parts, including plant length (cm), stem diameter (mm), number of branches (branch $plant^{-1}$), leaf area ($cm^2$) (the leaf area was measured using the Image program in the Windows 7 operating system) [14], and the percentage of dry matter of the vegetative part (%) were made using samples taken from the experimental units. The [15] method was used to estimate the chlorophyll content of the leaves.

## Results and Discussion

### Plant length (cm)

Thiourea and boron spraying, as well as their combination, had a substantial impact on the marjoram plant's length, according to the data in Table (1). According to the findings, the thiourea spray treatment at (1000 mg $L^{-1}$) was the best and produced the greatest average of (27.86 cm), whereas the dosage of (750 mg $L^{-1}$) produced the lowest average of (23.72 cm). The same table's results also showed that the boron spray treatment was preferable at a concentration of (100 mg $L^{-1}$), which produced the greatest average of (28.26 cm), whereas the concentration of (0 mg $L^{-1}$) produced the lowest average of (23.77 cm). The interaction between the concentrations of thiourea and boron spraying was significant, as the interaction treatment outperformed in recording the highest average of (29.45 cm) in treatment T1B3, while treatment T3B1 gave the lowest average of (21.38 cm), as shown in Table (1).

**Table (1):** The effect of spraying with thiourea and boron and their interactions on the length of the marjoram plant.

| Boron (mg L$^{-1}$) | Thiourea (mg L$^{-1}$) | | | | Average of Boron |
|---|---|---|---|---|---|
| | 0 (T0) | 500 (T1) | 750 (T2) | 1000 (T3) | |
| 0 (B0) | 23.35 | 23.28 | 21.94 | 26.50 | 23.77 |
| 25 (B1) | 22.87 | 24.70 | 21.38 | 28.25 | 24.30 |
| 50 (B2) | 23.23 | 23.83 | 24.16 | 27.46 | 24.67 |
| 100 (B3) | 26.91 | 29.45 | 27.42 | 29.25 | 28.26 |
| L.S. D | 3.059 | | | | 1.529 |
| Average of Thiourea | 24.09 | 25.32 | 23.72 | 27.86 | |
| L.S. D | 1.529 | | | | |

**Stem diameter (mm)**

The results of Table (2) show that there is a significant effect of spraying with thiourea and boron and the interaction between them on the stem diameter trait of marjoram plants, as the results indicate the superiority of the spraying treatment with thiourea at a concentration of (1000 mg L$^{-1}$) and recorded the highest average of (1.806 mm), while the concentration (0 mg L$^{-1}$) gave the lowest average of (1.469 mm). The results of the same table also indicate the superiority of the boron spray treatment at a concentration of (100 mg L$^{-1}$), which gave the highest average of (1.737 mm), while the concentration (0 mg L$^{-1}$) gave the lowest average of (1.385 mm). The interaction between the thiourea and boron spray concentrations had a significant effect, as the highest average of (2080 mm) in treatment T3B2, while treatment T0B1 gave the lowest average of (1.240 mm).

**Table (2):** The effect of spraying with thiourea and boron and their interactions on the stem diameter of the marjoram plant.

| Boron (mg L$^{-1}$) | Thiourea (mg L$^{-1}$) | | | | Average of Boron |
|---|---|---|---|---|---|
| | 0 (T0) | 500 (T1) | 750 (T2) | 1000 (T3) | |
| 0 (B0) | 1.380 | 1.277 | 1.353 | 1.530 | 1.385 |
| 25 (B1) | 1.240 | 1.650 | 1.587 | 1.633 | 1.527 |
| 50 (B2) | 1.560 | 1.603 | 1.610 | 2.080 | 1.713 |
| 100 (B3) | 1.697 | 1.757 | 1.513 | 1.980 | 1.737 |
| L.S. D | 0.2714 | | | | 0.1357 |
| Average of Thiourea | 1.469 | 1.572 | 1.516 | 1.806 | |
| L.S. D | 0.1357 | | | | |

**Number of branches in the plant (branch plant$^{-1}$)**

The results presented in Table (3) showed a significant effect of spraying with thiourea and boron and the interaction between them on the number of branches of marjoram plants, as the results indicate the superiority of the spraying treatment with thiourea at a concentration of (1000 mg $L^{-1}$) and recorded the highest average of (17.64 branches plant-1), while the concentration of (0 mg $L^{-1}$) gave the lowest average of (14.38 branches $plant^{-1}$). The results of the same table also indicate the superiority of the boron spray treatment at a concentration of (100 mg $L^{-1}$) as it gave the highest average of (17.26 branches $plant^{-1}$), while the concentration of (0 mg $L^{-1}$) gave the lowest average of (14.39 branches $plant^{-1}$). As for the interaction between the thiourea and boron spray concentrations, it was significant as the interaction treatment outperformed in recording the highest average of (18.68 branches $plant^{-1}$) in the T3B2 treatment, while the T0B1 treatment gave the lowest average of (12.57 branches $plant^{-1}$).

**Table (3):** The effect of spraying with thiourea and boron and their interactions on the number of branches of the marjoram plant.

| Boron (mg $L^{-1}$) | Thiourea (mg $L^{-1}$) | | | | Average of Boron |
|---|---|---|---|---|---|
| | 0 (T0) | 500 (T1) | 750 (T2) | 1000 (T3) | |
| 0 (B0) | 13.99 | 12.60 | 14.08 | 16.90 | 14.39 |
| 25 (B1) | 12.57 | 15.23 | 15.48 | 16.73 | 15.00 |
| 50 (B2) | 14.58 | 13.40 | 16.50 | 18.68 | 15.79 |
| 100 (B3) | 16.38 | 16.40 | 18.02 | 18.23 | 17.26 |
| L.S. D | 1.861 | | | | 0.931 |
| Average of Thiourea | 14.38 | 14.41 | 16.02 | 17.64 | |
| L.S. D | 0.931 | | | | |

## Leaf area ($cm^2$)

After analyzing the data, it was determined that spraying thiourea and boron, as well as their interaction, had a significant impact on the leaf area trait of marjoram plants. The results showed that the thiourea spraying treatment at a concentration of 750 mg $L^{-1}$ was superior and produced the highest average leaf area, measuring 0.938 $cm^2$, while the concentration of 0 mg $L^{-1}$ produced the lowest average, measuring 0.824 cm2. The same table's results also shown that the greatest average (0.955 $cm^2$) was obtained by spraying boron at a concentration of 100 mg $L^{-1}$, while the lowest average (0.774 $cm^2$) was obtained at a concentration of 0 mg $L^{-1}$. The interaction between the concentrations of thiourea and boron sprays was also significant, as the interaction treatment was superior in recording the highest rate, which reached (1.134 $cm^2$) in the T2B3 treatment, while the T0B0 treatment gave the lowest rate, which reached (0.648 $cm^2$).

**Table (4):** The effect of spraying with thiourea and boron and their interactions on the leaf area of the marjoram plant.

| Boron (mg $L^{-1}$) | Thiourea (mg $L^{-1}$) | | | | Average of Boron |
|---|---|---|---|---|---|
| | 0 (T0) | 500 (T1) | 750 (T2) | 1000 (T3) | |
| 0 (B0) | 0.648 | 0.717 | 1.008 | 0.722 | 0.774 |
| 25 (B1) | 0.866 | 0.895 | 0.818 | 0.829 | 0.852 |
| 50 (B2) | 0.797 | 0.859 | 1.137 | 0.952 | 0.936 |
| 100 (B3) | 0.986 | 1.134 | 0.789 | 0.912 | 0.955 |
| L.S. D | 0.2081 | | | | 0.1041 |
| Average of Thiourea | 0.824 | 0.901 | 0.938 | 0.854 | |
| L.S. D | 0.1041 | | | | |

## Dry matter percentage of the vegetative system (%)

The findings demonstrated Table (5) that the percentage of dry matter in marjoram plants was significantly impacted by thiourea and boron spraying as well as their combination. According to the results, the spraying treatment with thiourea at a concentration of 1000 mg $L^{-1}$ was preferable and produced the greatest average of 21.41%, whereas the concentration of 0 mg $L^{-1}$ produced the lowest average of 18.60%. According to the same table's data, the boron spray treatment was best at a concentration of 100 mg $L^{-1}$, which produced the greatest average (21.61%), whereas a concentration of 25 mg $L^{-1}$ produced the lowest average (17.92%). Table (5) indicates that the interaction between the thiourea and boron spraying concentrations was substantial, with the interaction treatment recording the greatest rate (24.97%) in the T3B3 treatment and the T0B0 treatment giving the lowest rate (17.20%).

**Table (5)**: The effect of spraying with thiourea and boron and their interactions on the dry matter percentage of the marjoram plant.

| Boron (mg $L^{-1}$) | Thiourea (mg $L^{-1}$) | | | | Average of Boron |
|---|---|---|---|---|---|
| | 0 (T0) | 500 (T1) | 750 (T2) | 1000 (T3) | |
| 0 (B0) | 17.20 | 18.65 | 18.34 | 18.63 | 18.21 |
| 25 (B1) | 17.68 | 18.53 | 17.80 | 17.68 | 17.92 |
| 50 (B2) | 21.17 | 18.25 | 20.79 | 24.37 | 21.14 |
| 100 (B3) | 18.37 | 21.17 | 21.93 | 24.97 | 21.61 |
| L.S. D | 2.565 | | | | 1.283 |
| Average of Thiourea | 18.60 | 19.15 | 19.72 | 21.41 | |
| L.S. D | 1.283 | | | | |

## Total chlorophyll content in leaves (mg $100g^{-1}$ fresh weight)

The results revealed a significant effect of spraying with thiourea and boron and their interaction on the chlorophyll content of marjoram plants. These results indicated that the thiourea spray treatment was superior at a concentration of (1000 mg $L^{-1}$) which recorded the highest average (44.28 mg $100g^{-1}$ fresh weight), while the concentration of (0 mg $L^{-1}$) gave the lowest average, reaching 24.51 mg $100g^{-1}$ fresh weight (Table

6). According to the same table's data, the boron spray treatment was preferable at a concentration of 100 mg $L^{-1}$, which produced the greatest average of 40.72 mg $100g^{-1}$ fresh weight, while the concentration of 0 mg $L^{-1}$ produced the lowest average of 22.89 mg $100g^{-1}$ fresh weight. Thiourea and boron spraying concentrations interacted significantly, with the interaction treatment recording the highest rate (57.91 mg $100g^{-1}$ fresh weight) in the T3B2 treatment and the T0B0 treatment recording the lowest rate (15.49 mg $100g^{-1}$ fresh weight).

**Table (6):** The effect of spraying with thiourea and boron and their interactions on the chlorophyll content of the marjoram plant.

| Boron (mg $L^{-1}$) | Thiourea (mg $L^{-1}$) | | | | Average of Boron |
|---|---|---|---|---|---|
| | 0 (T0) | 500 (T1) | 750 (T2) | 1000 (T3) | |
| 0 (B0) | 15.49 | 18.56 | 27.70 | 29.83 | 22.89 |
| 25 (B1) | 20.33 | 30.91 | 31.24 | 38.69 | 30.29 |
| 50 (B2) | 30.24 | 31.46 | 23.02 | 57.91 | 35.66 |
| 100 (B3) | 31.98 | 35.93 | 44.26 | 50.70 | 40.72 |
| L.S. D | 7.726 | | | | 3.863 |
| Average of Thiourea | 24.51 | 29.22 | 31.55 | 44.28 | |
| L.S. D | 3.863 | | | | |

The results of the statistical analysis of some vegetative characteristics of marjoram plant under the influence of the study factors represented by thiourea and boron and the interaction between them indicated the presence of a significant response to the concentrations used in the study, as spraying with thiourea had a significant effect on the above characteristics (Tables 1, 2, 3, 4, 5 and 6). The reason behind the positive effect of thiourea is that it consists of two basic elements, nitrogen and sulfur. Nitrogen improves the activity of growth hormones, which is reflected in increased cell division and growth, while sulfur contributes to the formation of protein, which is the main component of the plant's vital structure, as sulfur enters into the formation of some amino acids [16]. The reason for the increase in the percentage of dry matter resulting from spraying thiourea is due to improving growth characteristics, increasing light receptors, and increasing the photosynthesis process. The stable nature of thiourea for enzymes and proteins and its ability to increase the activity of the nitrate reductase enzyme contribute to increasing the accumulation of dry matter in the plant [17]. Thiourea spraying may have led to maintaining the turgor pressure of the cells, which is reflected in increasing the leaf area [16]. Foliar spraying of thiourea helps in the absorption of nutrients, which will have a positive effect on the increase, formation, and content of the plant part of chlorophyll [18]. Results similar to the above results were found by [19, 20, 21]. Boron had a significant effect when sprayed on the vegetative system of the plant, as the concentrations used gave a significant increase in the studied traits (Tables 1, 2, 3, 4, 5 and 6). This is due to the fact that boron is one of the essential elements for the formation of the cell wall and the integrity of membranes, helps in the transport of sugars, and affects at least 16 functions in plants, including cell division, starch formation, carbohydrate synthesis, nucleic acid formation, water relations, and hormone synthesis and movement [10, 22]. Previous studies have also shown the significant effect of boron in encouraging the growth and production of different crops [23, 24].

The results of this study were encouraging for the cultivation of this medicinal herb under the conditions of the region and the possibility of improving its growth and yield by using combinations of growth regulators and mineral elements. Also, the results obtained from this experiment encourage researchers to conduct more research on this medicinal plant or use the combinations of the study on other medicinal plants.

## References

**1)** Özer, Z., Gören, A. C., Kılıç, T., Öncü, M., Çarıkçı, S., & Dirmenci, T. (2020). The phenolic contents, antioxidant and anticholinesterase activity of section Amaracus (Gled.) Vogel and Anatolicon Ietsw. of Origanum L. species. Arabian journal of chemistry, 13(4), 5027-5039.

**2)** Nurzyńska-Wierdak R, Pietrasik D, Walasek-Janusz M (2022) Essential oils in the treatment of various types of acne—a review. Plants 12:90.

**3)** Ouedrhiri, W., Mechchate, H., Moja, S., Mothana, R. A., Noman, O. M., Grafov, A., & Greche, H. (2021). Boosted antioxidant effect using a combinatory approach with essential oils from *origanum compactum*, *origanum majorana*, *thymus serpyllum*, *mentha spicata*, *myrtus communis*, and artemisia herba-alba: mixture design optimization. Plants, 10(12), 2817.

**4)** Kakouri, E., Daferera, D.J., Kanakis, C.D., Revelou, P., Kaparakou, E.H., Dervisoglou, S., Perdikis, D.C., & Tarantilis, P.A. (2022). *Origanum majorana* Essential Oil—A Review of Its Chemical Profile and Pesticide Activity. Life, 12.

**5)** Tripathy, B., Satyanarayana, S., Khan, K. A., Raja, K., & Mohanty, C. (2016). Phytochemical screening and antifungal activity of ethanol and petroleum-ether leaf extracts of *Origanum majorana*. International Journal of Pharmaceutical Research and Health Sciences, 4(4), 1320-1323.

**6)** Maruyama-Nakashita, A. (2017). Metabolic changes sustain the plant life in low-sulfur environments. Current opinion in plant biology, 39, 144-151.

**7)** Sakuraba, Y. (2022). Molecular basis of nitrogen starvation-induced leaf senescence. Frontiers in Plant Science, 13, 1013304.

**8)** Ishfaq, N., Waraich, E. A., Ahmad, M., Hussain, S., Zulfiqar, U., Din, K. U., ... & Ali, H. M. (2024). Mitigating drought-induced oxidative stress in wheat (*Triticum aestivum* L.) through foliar application of sulfhydryl thiourea. Scientific Reports, 14(1), 15985.

**9)** Saleem, M., Khanif, Y. M., Fauziah Ishak, F. I., Samsuri, A. W., & Hafeez, B. (2011). Importance of boron for agriculture productivity: a review. International Research Journal of Agricultural Science and Soil Science, 1(8), p. 293-300.

**10)** Al-Juheishy, W. K. (2020). Effect of boron on some industrial crops: A Review. Mesopotamia Journal of Agriculture, 48(4), 134-145.

**11)** Kohli, S. K., Kaur, H., Khanna, K., Handa, N., Bhardwaj, R., Rinklebe, J., & Ahmad, P. (2023). Boron in plants: Uptake, deficiency and biological potential. Plant Growth Regulation, 100(2), 267-282.

**12)** Du, S.S., Luo, X.F., An, J.X., Zhang, Z.J., Zhang, S.Y., Wang, Y.R., Ding, Y.Y., Jiang, W.Q., Zhang, B.Q., Ma, Y. and Zhou, Y. (2023). Exploring boron applications in modern agriculture: Antifungal activities and mechanisms of phenylboronic acid derivatives. Pest Management Science, 79(8), pp.2748-2761.

**13)** Singh, A. K., Singh, A. K., & Singh, J. P. (2020). Boron in crop production from soil to plant system: a review. Archives of Agriculture and Environmental Science, 5(2), 218-222.

**14)** Easlon, H. M., & Bloom, A. J. (2014). Easy Leaf Area: Automated digital image analysis for rapid and accurate measurement of leaf area. Applications in plant sciences, 2(7).

**15)** Chappelle, E. W., Kim, M. S., & McMurtrey III, J. E. (1992). Ratio analysis of reflectance spectra (RARS): an algorithm for the remote estimation of the concentrations of chlorophyll a, chlorophyll b, and carotenoids in soybean leaves. Remote sensing of environment, 39(3): 239-247.

**16)** Meena, D.K., Sharma, R.K., Kumar, A., Bhatnagar, A., Dawar, R., Glotra, A., Kumar, S. and Singh, T. (2023). Impact of foliar spray of thiourea on growth attributes of two cultivars of soybean. Journal of Agriculture and Ecology, 15, pp.134-139.

**17)** Sachin, A. S., Sivakumar, T., KrishnaSurendar, K., & Senthivelu, M. (2019). Influence of plant growth regulators and nutrients on biometric, growth and yield attributes in Blackgram (*Vigna mungo* L.). Journal of Agriculture and Ecology, 7, 55-63.

**18)** Meena, S., Shivran, A. C., Dhaker, D. L., Karthik, R., & Meena, B. R. (2024). Effect of Irrigation Scheduling and Thiourea on Nutrient Concentration, Uptake and Water Use Efficiency of Mustard. Environment and Ecology, 42(3A), 1212-1218.

**19)** Fiaz, K., Maqsood, M.F., Shahbaz, M., Zulfiqar, U., Naz, N., Gaafar, A.R.Z., Tariq, A., Farhat, F., Haider, F.U. and Shahzad, B. (2024). Application of thiourea ameliorates drought induced oxidative injury in *Linum usitatissimum* L. by regulating antioxidant defense machinery and nutrients absorption. Heliyon, 10(4).

**20)** Ahmad, M., Waraich, E.A., Zulfiqar, U., Yong, J.W.H., Ishfaq, M., Din, K.U., Ullah, A., Abbas, A., Awan, M.I., Moussa, I.M. and Elshikh, M.S. (2024). Thiourea improves yield and quality traits of *Brassica napus* L. by upregulating the antioxidant defense system under high temperature stress. Scientific Reports, 14(1) https://doi.org/10.1038/s41598-024-62257-y.

**21)** Maliha, M., Husna, M. A., Sultana, M.N., Singh, K. and Uddin, A.F.M.J. (2023). Influence of Thiourea Concentrations on Growth and Yield of Light Pink Lisianthus. Int. J. Bus. Soc. Sci. Res. 11(1): 01–06.

**22)** Shireen, F., Nawaz, M.A., Chen, C., Zhang, Q., Zheng, Z., Sohail, H., Sun, J., Cao, H., Huang, Y. & Bie, Z. (2018). Boron: functions and approaches to enhance its availability in plants for sustainable agriculture. International journal of molecular sciences, 19(7), p 1-20.

**23)** Hasan, M., and Massa, R. (2023). Effect of spraying sugar alcohols and boron on some growth parameters, flowering and yield of strawberry (*Fragaria x ananassa* Duch Var. Oso Grande). Arabian Journal of Scientific Research. Volume 4, Issue 1. https://doi.org/10.5339/ajsr.2023.2.

**24)** Shaker, U. B., & Rasool, I. A. (2023). Role of organic fertilizer and boron foliar application on growth and productivity of potato for processing. Iraqi Journal of Agricultural Sciences, 54(5), 1478-1486.