# The Impact of Adding Bio-fertilizer and Spraying Seaweed extract on the Growth and Yield of *Zea mays*

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## Abstract

A study conducted in the Al-abbasiya district, Najaf, during the 2022 agricultural fall season utilized a randomized complete block design (RCBD) and a normal factorial experiment. The objective of this study was to examine the impact of bio-fertilizer addition and seaweed extract spraying on maize yield parameters. The findings indicated that the application of bio-fertilizer, specifically the $B_2$ treatment, outperformed the control treatment in various traits, including plant height, leaf surface area, total chlorophyll, total plant weight, and grain yield. The respective measurements for these traits were 195.1 cm, 0.642 $m^2$ $plant^{-1}$, 2.829 mg $g^{-1}$ plant, 21.75 tons $ha^{-1}$, and 8.74 tons $ha^{-1}$. Similarly, most of the analyzed parameters, such as plant height, leaf surface area, total chlorophyll, total plant weight, and grain yield, were superior to the control treatment, with measurements of 196.3 cm, 0.398 $m^2$ $plant^{-1}$, 2.738 mg $g^{-1}$ plant, 21.32 tons $ha^{-1}$, and 10.68 tons $ha^{-1}$, respectively. The $B_2N_2$ treatment exhibited higher values for several analyzed parameters, including plant height, leaf surface area, total chlorophyll, total plant weight, and grain yield, which measured 203.9 cm, 0.681 $m^2$ $plant^{-1}$, 2.99 mg $g^{-1}$ plant, 23.45 tons $ha^{-1}$, and 11.73 tons $ha^{-1}$, respectively, compared to the control treatment.

**Keywords:** Bio-fertilizer, Seaweed extract, maize.

## Introduction

Maize is one of the most extensively produced cereal crops in the world and is a staple diet in many countries. Farmers are constantly searching for approaches to boost the growth and productivity of maize crops in order to fulfill the ever-increasing demand (16). In recent years, the use of bio-fertilizers and seaweed extracts as a natural alternative to synthetic fertilizers has grown in popularity (5).

*Trichoderma* fungi are free-living and commonly found in soil, They are known to secrete plant growth-promoting compounds that enhance the growth and development of plants(21). *Trichoderma* fungi help improve seedling emergence, root development, and reduce the stress caused by abiotic factors such as drought and salinity (19). Maize plants treated with *Trichoderma* fungi have shown increased shoot and root biomass, higher chlorophyll content, and improved resistance against pathogens (6 and 17). Mycorrhiza fungi form mutualistic associations with the roots of plants by providing them with essential nutrients such as phosphorus, nitrogen, and other micro-nutrients (4 and 8). Mycorrhiza fungi also improve the ability of plants to uptake water, as they extend the root system of plants, In maize plants Mycorrhiza fungi enhanced the growth of the root system and shoot biomass, nutrient uptake, and yield (12 and 20). Maize plants grown in soil supplemented with *Trichoderma* and Mycorrhiza bio-fertilizers had higher biomass, more leaves, and higher grain yield than those grown in soil without the bio-fertilizers (9 and 13)

Seaweed extracts are rich in various micronutrients, plant growth regulators, and other compounds that have positive effects on plant growth and development. Application of seaweed extracts through spraying can stimulate plant growth and enhance overall plant health (7). Seaweed extract, derived from seaweed, serves as a natural plant growth stimulant, containing essential nutrients such as plant hormones, amino acids, and minerals, which contribute to faster and healthier plant growth (11). The use of seaweed extract promotes root system development, increases chlorophyll content, and improves overall growth performance. Furthermore, it functions as an effective foliar fertilizer, allowing direct application to leaves and providing immediate benefits to crops (10). In a study conducted on maize plants, the application of seaweed extract at different growth stages resulted in significant improvements in plant height, leaf area, biomass, and grain yield (3). The findings led the authors to conclude that seaweed extract has the potential to enhance the growth and yield of maize crops (18). The research aims to study the addition of bio-fertilizers and spraying with seaweed extract and their interaction in the growth and production of maize.

## Materials and methods

A field experiment was conducted during the 2022 agricultural fall season in Al-abbasiya district, Najaf governorate. The study aimed to investigate the impact of bio-fertilizer addition and seaweed extract spraying on the growth and yield of maize plants. The experiment followed a randomized complete block design (RCBD) and a normal factorial design. The experimental field was prepared by horizontal plowing, leveling, vertical plowing, and subsequent leveling and smoothing.

The field was divided into three sectors, each containing nine experimental units. In total, there were 27 experimental units, with each unit measuring 3 meters by 2 meters. The distance between adjacent experimental units was 1.5 meters, while the gap between sectors was 2 meters. Within each experimental unit, there were four rows of plants. The spacing between rows was 75 centimeters, and the gap between individual plants within a row was 25 centimeters. Hence, each experimental unit accommodated 32 plants. Soil samples were taken randomly and extracted well. A representative sample was taken from the field for the purpose of analysis before planting, from a depth of 0-30 cm. Some of its chemical and physical properties were studied, as shown in Table 1

The experiment included a study of two factors, the first factor was bio-fertilizer and was added in levels without addition and is denoted by the symbol ($B_0$) and the second level was added *Trichoderma* fungi and denoted by the symbol ($B_1$) and the third level was added *Mycorrhiza* fungi and denoted by the symbol ($B_2$) where the bio-fertilizers were added mixed with the seeds before planting. The second factor is the seaweed extract Its characteristics are shown in Table 2, and it is denoted by the symbol ($N_0$, $N_1$, $N_2$) and at concentrations of (0,3,6) ml / L sequentially as it was sprayed. The urea fertilizer (N 46%) was added at a rate of 100 kg N $ha^{-1}$ in two doses and the phosphate fertilizer was added at a rate of 80 kg P $ha^{-1}$ in the form of triple superphosphate (P 20%). Additionally, the potassium fertilizer was added at a rate of 100 kg K $ha^{-1}$ in the form of potassium sulfate fertilizer one doses before planting.

On the vegetative total and seedlings were planted on 15/06/2022 and the crop was harvested on 15/11/2022, The following characteristics were studied (plant height (cm), leaf area ($m^2$ $plant^{-1}$), total chlorophyll (mg g $plant^{-1}$), total plant dry weight (tons $ha^{-1}$), and grain yield (tons $ha^{-1}$) The statistical analysis of the results was conducted using the SAS software program. According to (1) the Duncan multiplex test was utilized at the 0.05 probability level to determine significant differences between means.

**Table 1.** The soil's chemical and physical qualities before planting

| Parameters | pH | CEC | EC | N | P | K | Sand | Silt | Clay | Texture |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $dsm^{-1}$ | | (mg $kg^{-1}$) | | | (%) | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Amount** | 7.4 | 29.3 | 2.27 | 24 | 17.54 | 232.4 | 38.0 | 19.7 | 42.3 | Clay |

**Table 2.** The Chemical properties of Seaweed extract

| Parameters | Organic matter | Alginate acid | PH (1:10) | EC (ds $m^{-1}$) |
|---|---|---|---|---|
| **Amount** | %5 | %0.3 | 6.5 | 2.9 |

## Results and Discussion

1. height of plant (cm)

According to Figure (1), the inclusion of Bio-fertilizer in the $B_2$ treatment resulted in a significant increase in plant height, measuring 195.1 cm, compared to the control treatment $B_0$ with a height of 181.4 cm. Similarly, the application of Seaweed extract surpassed the control treatment $N_0$, reaching a height of 181.9 cm, while the treatment $N_2$ recorded a height of 196.3 cm. Furthermore, when considering the interaction between the two variables, the $B_2N_2$ treatment exhibited the highest plant height value, measuring 203.9 cm, in contrast to the comparison treatment $B_0N_0$, which yielded a height of 175.0 cm.

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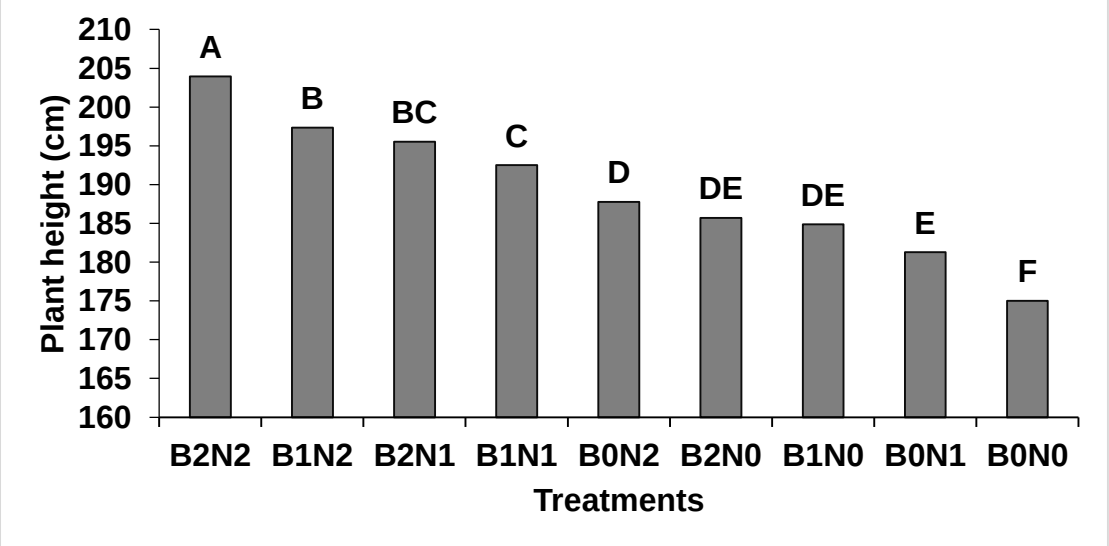
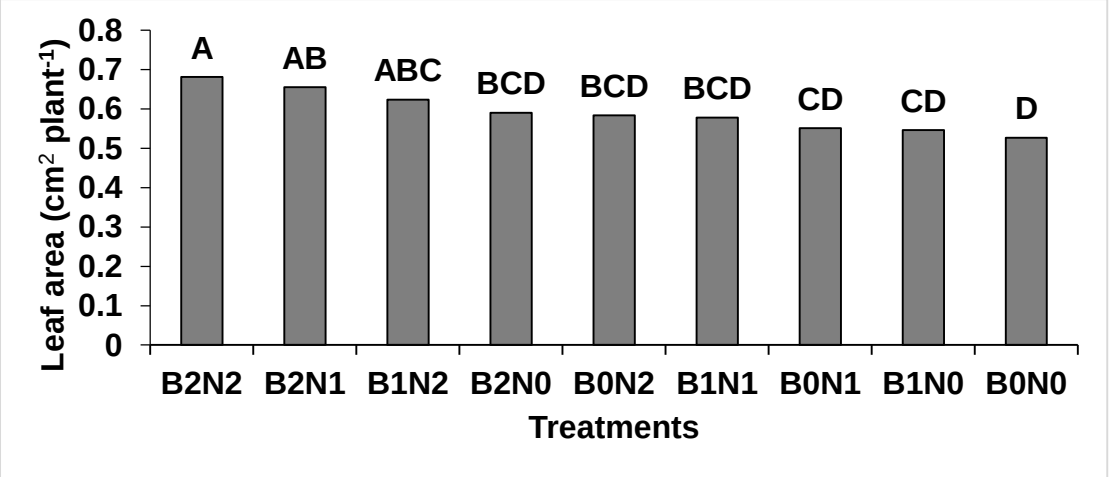



The Duncan polynomial test indicates that at the 0.05 probability level, coefficients with the same letters do not differ substantially

**Figure 1.** The effect of adding bio-fertilizer and spraying with seaweed extract on height of maize (cm)

2. leave surface area ($cm^2$ $plant^{-1}$)

Figure (2) revealed that the addition of bio-fertilizer to the $B_2$ treatment led to a notable increase in plant area, with a significant difference of 0.642 $cm^2$ $plant^{-1}$ compared to the comparison treatment $B_0$, which resulted in a difference of 0.554 $cm^2$ $plant^{-1}$. This suggests that the application of bio-fertilizer positively influenced the growth and development of the plants. Furthermore, when examining the interaction between the $B_2$ treatment and nitrogen (N) application, it was found that $B_2N_2$ had the most substantial interaction effect on plant area, with a value of 0.681 $cm^2$ $plant^{-1}$. In contrast, the $B_0N_0$ treatment exhibited a lower interaction value of 0.527 $cm^2$ $plant^{-1}$. This implies that the combined application of bio-fertilizer and nitrogen had a synergistic effect on promoting plant growth, resulting in a greater increase in plant area compared to the treatment without bio-fertilizer and nitrogen. It is worth noting that all units of measurement provided in the figures remain unchanged, ensuring consistency and accuracy in reporting the results.



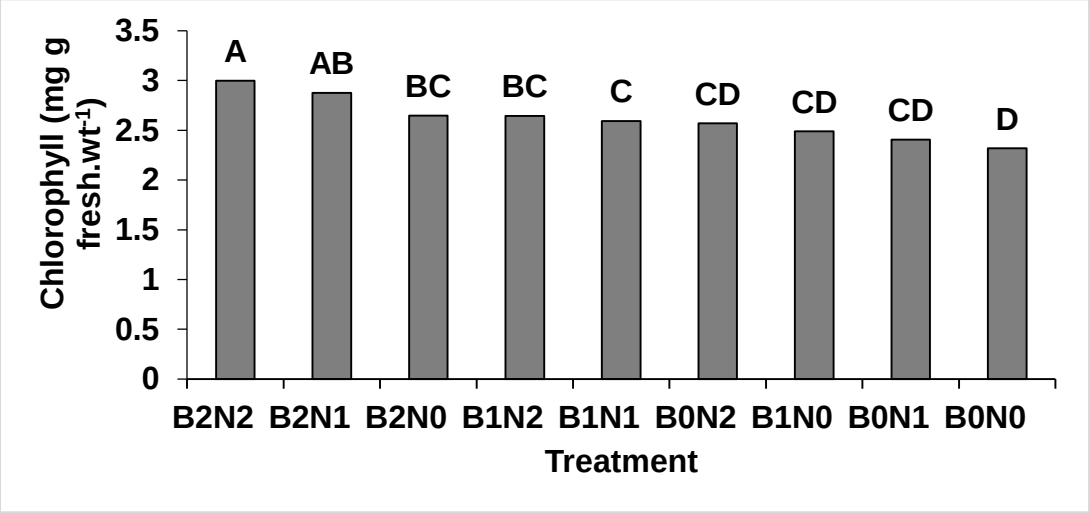

The Duncan polynomial test indicates that at the 0.05 probability level, coefficients with the same letters do not differ substantially.

**Figure 2.** The effect of adding bio-fertilizer and spraying with seaweed extract on leave surface area ($cm^2$ $plant^{-1}$).

3. total chlorophyll (mg g $fresh.wt^{-1}$)

According to figures 3, the addition of bio-fertilizer to treatment $B_2$ resulted in a significant increase of 2.829 mg g $fresh.wt^{-1}$. compared to the comparison treatment $B_0$, which amounted to 2.431 mg g $fresh.wt^{-1}$. Moreover, the supplementation of Seaweed extract outperformed the N2 control treatment by 2.738 mg g $fresh.wt^{-1}$ and the $N_0$ control treatment by 2.473 mg g fresh.wt-1. Among the various treatments, the most significant interaction between the two variables was observed in treatment $B_2N_2$, which resulted in a fresh

weight of 2.999 mg g fresh.wt$^{-1}$. In contrast, the comparative treatment $B_0N_0$ yielded a fresh weight of 2.318 mg g fresh.wt$^{-1}$.

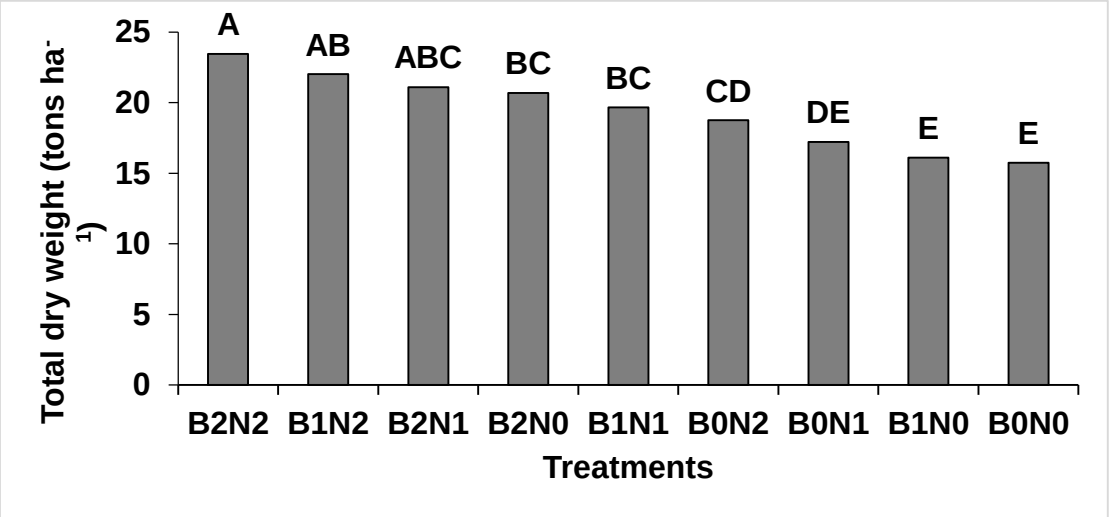



The Duncan polynomial test indicates that at the 0.05 probability level, coefficients with the same letters do not differ substantially.

**Figure 3.** The effect of adding bio-fertilizer and spraying with seaweed extract on total chlorophyll (mg g fresh.wt$^{-1}$).

4. plant dry weight total (tons ha$^{-1}$)

Figure (4) results revealed that the addition of bio-fertilizer to treatment $B_2$ had a significant effect on crop yield, resulting in a substantial increase to 21.75 tons ha$^{-1}$. In comparison, the control treatment $B_0$ yielded 17.16 tons ha$^{-1}$, indicating a noticeable improvement with the addition of bio-fertilizer. Similarly, the inclusion of marine algae in the $N_2$ treatment also had a positive impact on crop yield, resulting in a considerable increase to 21.32 tons ha$^{-1}$. This performance surpassed the $N_0$ control treatment, which yielded 17.52 tons ha$^{-1}$. The addition of marine algae proved to be an effective strategy for enhancing crop productivity. Furthermore, when both bio-fertilizer and marine algae were combined in treatment $B_2N_2$, the interaction between these two variables resulted in the highest yield among all the treatments. The crop yield for $B_2N_2$ was recorded at 23.45 tons ha$^{-1}$, showcasing a substantial improvement compared to the baseline treatment $B_0N_0$. These findings highlight the significant positive effects of incorporating bio-fertilizer and marine algae into agricultural practices. The use of bio-fertilizer can enhance nutrient availability and promote plant growth, while marine algae can provide valuable organic matter and additional nutrients. When these treatments were combined, a synergistic effect was observed, leading to even higher crop yields. These results emphasize the potential of these sustainable and environmentally friendly approaches for optimizing agricultural productivity.

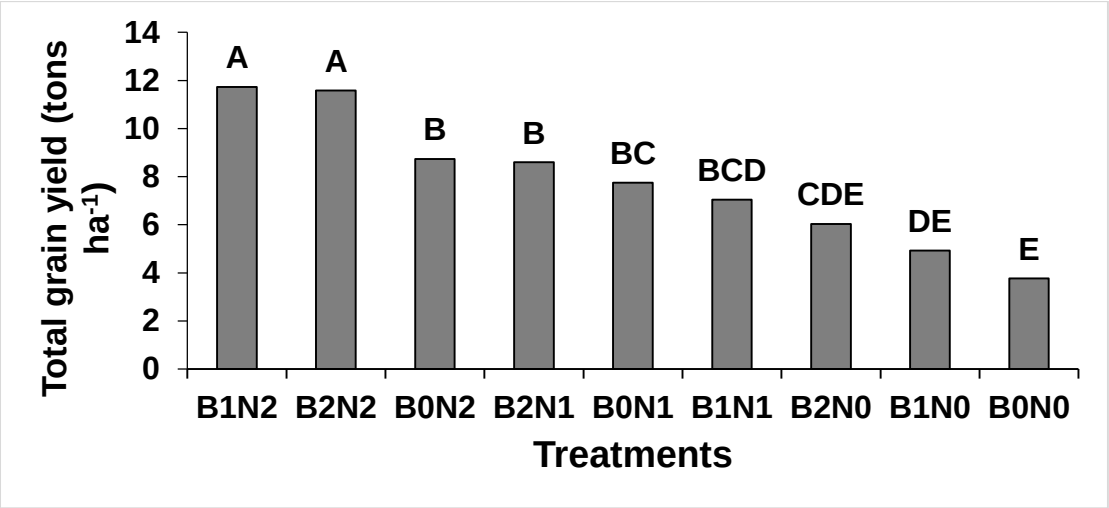



The Duncan polynomial test indicates that at the 0.05 probability level, coefficients with the same letters do not differ substantially.

**Figure 4.** The effect of adding bio-fertilizer and spraying with seaweed extract on plant dry weight total (tons $ha^{-1}$).

5. grain yield total (tons $ha^{-1}$)

Figure (5) revealed that adding bio-fertilizer to treatment $B_2$ resulted in a significant increase in yield, with a value of 8.74 tons $ha^{-1}$. This was in comparison to the comparison treatment $B_0$, which resulted in a yield of 6.75 tons $ha^{-1}$. The addition of marine algae to the $N_2$ treatment further enhanced the yield, reaching 10.68 tons $ha^{-1}$. This was significantly higher than the $N_0$ control treatment, which resulted in a yield of 4.91 tons $ha^{-1}$. When considering the interaction between the two variables, it was observed that the treatment $B_2N_2$ had the highest yield, with a value of 11.73 tons $ha^{-1}$. This was in comparison to the treatment $B_0N_0$, which resulted in a yield of 6.75 tons $ha^{-1}$. The increase in yield due to the combined effect of bio-fertilizer and marine algae was significant, highlighting the positive interaction between these two variables in promoting crop productivity. It is worth noting that all yield values mentioned are in tons per hectare (tons $ha^{-1}$). These results emphasize the potential of using bio-fertilizers and marine algae as effective strategies to enhance agricultural productivity and optimize crop yields.




The Duncan polynomial test indicates that at the 0.05 probability level, coefficients with the same letters do not differ substantially.

**Figure 5.** The effect of adding bio-fertilizer and spraying with seaweed extract on grain yield total (tons $ha^{-1}$).

*Trichoderma* and Mycorrhiza fungi have been recognized for their significant role in enhancing the growth and yield of maize plants. These beneficial fungi establish symbiotic relationships with plants, contributing to improved plant performance. Several studies support the positive effects of Trichoderma and Mycorrhiza fungi on maize plants. Research conducted by Shahzad *et al.* (17) and Ningsih *et al.* (14) highlighted the impact of these fungi on maize growth and yield. One of the notable effects observed after the application of bio-fertilizers containing *Trichoderma* and Mycorrhiza fungi was an increase in leafy area. This can be attributed to the fungi's ability to enhance nutrient absorption, particularly nitrogen, phosphorus, and potassium. The fungi supply plants with hyphae, which increases the absorption area, leading to improved metabolic activities within the plant and enhanced growth, particularly in terms of leaf development. Additionally, bio-fertilizers have been found to increase the content of chlorophyll in plants. Chbani *et al.* (5) and Andrzejak and Janowska., (2) reported that bio-fertilizers play a role in the secretion of cytokines, which facilitate the uptake of essential nutrients like potassium and magnesium, necessary for chlorophyll synthesis and plant metabolism. The application of bio-fertilizers also resulted in an increase in dry matter and grain yield of maize plants. Pujiasmanto *et al.* (15) suggested that this effect is attributed to the role of microorganisms in promoting root system activity and growth. The increased root system enables plants to benefit from microbial secretions and enhances nutrient absorption from the soil, ultimately leading to an increase in grain yield. In addition to the fungi-based bio-fertilizers, the use of seaweed extract has shown positive effects on the growth and yield of maize plants. Basavaraja *et al.* (3) and Tursun (18) reported that spraying maize plants with seaweed extract resulted in increased growth and yield. This growth-promoting potential may be attributed to the presence of specific substances in the

seaweed extract, which facilitate plant growth. Furthermore, seaweed extract contains essential macro and micronutrients that contribute to the overall improvement in plant growth.

## Conclusion

Bio-fertilizers derived from *Trichoderma* and Mycorrhiza fungus, as well as seaweed extract, could enhance maize crop growth and yield. Farmers looking for environmentally responsible and sustainable solutions are increasingly turning to natural alternatives to conventional fertilizers and pesticides. According to the studies stated above, utilizing bio-fertilizers, and spraying with seaweed extract can result in increased biomass, more leaves, thicker stems, and, eventually, higher grain yield. Implementing these tactics in maize farming has the potential to increase output and profitability.

### Conflict of interest

The authors declare no conflict of interest.

## References

1- **Al-Rawi, K. M. and AM Khalaf allah. 2000**. Design and analysis of Agricultural experiments. Baghdad University. Ministry of Higher Education and Scientific Research. Iraq. pp, 561.

2- **Andrzejak, R., and Janowska, B. 2022**. *Trichoderma* spp. Improves Flowering, Quality, and Nutritional Status of Ornamental Plants. International Journal of Molecular Sciences, 23(24): 15662.

3- **Basavaraja, P. K., Yogendra, N. D., Zodape, S. T., Prakash, R., and Ghosh, A. 2018**. Effect of seaweed sap as foliar spray on growth and yield of hybrid maize. Journal of Plant Nutrition, 41(14): 1851-1861.

4- **Begum, N., Qin, C., Ahanger, M. A., Raza, S., Khan, M. I., Ashraf, M., and Zhang, L. 2019**. Role of arbuscular mycorrhizal fungi in plant growth regulation: implications in abiotic stress tolerance. Frontiers in Plant Science, 10: 1068.

5- **Chbani, A., Majed, S., Mawlawi, H., and Kammoun, M. 2015**. The use of seaweed as a bio-fertilizer: Does it influence Proline and Chlorophyll concentration in plants treated? Arabian Journal of Medicinal and Aromatic plants, 1(1): 67-77.

6- **Choudhary, D. K., Johri, B. N., & Prakash, A. 2007.** *Trichoderma*: a multitasking fungus for bio-based economy. African Journal of Biotechnology, 6(6): 623-629.

**7- Choulot, M., Le Guillard, C., Bourgougnon, N., and Michalak, I. 2022**. Seaweed-based fertilizing products. In Algae and Aquatic Macrophytes in Cities (pp. 271-313). Elsevier.

8- **de Sousa, R. N. 2023**. Introductory Chapter: Mycorrhizal Fungi–A Current Overview on Agricultural Productivity and Soil Health. Arbuscular Mycorrhizal Fungi in Agriculture-New Insights.

9- **Gao, C., El-Sawah, A. M., Ali, D. F. I., Alhaj Hamoud, Y., Shaghaleh, H., and Sheteiwy, M. S. 2020**. The integration of

bio and organic fertilizers improve plant growth, grain yield, quality and metabolism of hybrid maize (*Zea mays* L.). Agronomy, 10(3): 319.

10- **Hamouda, M. M., Saad-Allah, K. M., and Gad, D. 2022**. Potential of seaweed extract on growth, physiological, cytological and biochemical parameters of wheat (*Triticum aestivum* L.) seedlings. Journal of Soil Science and Plant Nutrition, 22(2): 1818-1831.

11- **Hernández-Herrera, R. M., Sánchez-Hernández, C. V., Palmeros-Suárez, P. A., Ocampo-Alvarez, H., Santacruz-Ruvalcaba, F., Meza-Canales, I. D., and Becerril-Espinosa, A. 2022**. Seaweed Extract Improves Growth and Productivity of Tomato Plants under Salinity Stress. Agronomy, 12(10): 2495.

12- **Igiehon, N. O., Babalola, O. O., and Aremu, B. R. 2013**. Growth promoting effects of Rhizobium and mycorrhizal fungi inoculation separately and in combination in maize (*Zea mays* L.). International Journal of Agriculture and Biology, 15(6): 1154-1160.

13- **Mahmud, A. A., Upadhyay, S. K., Srivastava, A. K., and Bhojiya, A. A. 2021**. Biofertilizers: A Nexus between soil fertility and crop productivity under abiotic stress. Current Research in Environmental Sustainability, 3: 100063.

14- **Ningsih, E. P., and Hikmah, A. N. 2022**. Effect of drought stress and mycorrhizal dose on growth and yield of maize (*Zea mays* L.). In *IOP Conference Series: Earth and Environmental Science* (Vol. 951, No. 1, p. 012067). IOP Publishing.

15- **Pujiasmanto, B., Putra, I. H., and Mumtazah, H. M. 2018**. The efficiency of Mycorrhiza biofertilizer treatment to the growth and yield of soybean. In IOP Conference Series: Earth and Environmental Science (Vol. 142, No. 1, p. 012073). IOP Publishing.

16- **Ranum, P., Peña-Rosas, J. P., and Garcia-Casal, M. N. 2014**. Global maize production, utilization, and consumption. Annals of the New York Academy of Sciences, 1312(1): 105-112.

17- **Shahzad, R., Waheed, M. F., Ahmad, R. I., Ullah, H., and Hasan, S. A. 2012**. Mitigation of drought stress in maize by Trichoderma spp. Pakistan Journal of Botany, 44(5): 1611-1616.

18- **Tursun, A. O. 2022**. Effect of foliar application of seaweed (organic fertilizer) on yield, essential oil and chemical composition of coriander. PLOS ONE, 17(6), e0269067.

19- **Tyśkiewicz, R., Nowak, A., Ozimek, E., and Jaroszuk-Ściseł, J. 2022.** *Trichoderma*: The current status of its application in agriculture for the biocontrol of fungal phytopathogens and stimulation of plant growth. International Journal of Molecular Sciences, 23(4): 2329.

20- **Wu, Q. S., Liang, J., and Zhang, J. L. 2014**. The role of mycorrhizas in the growth and nutrient uptake of maize in red soil. South African Journal of Botany, 94: 73-78.

21- **Zin, N. A., and Badaluddin, N. A. 2020**. Biological functions of *Trichoderma* spp. for agriculture applications. Annals of Agricultural Sciences, 65(2): 168-178.