The Effect of Seaweed Spirulina Platensis Extract and Micronutrients on Wheat Yield and Yield Components

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Abstract

Many literatures have reviewed and confirmed the importance of the seaweed extract in terms of improving crop yield. A field experiment was carried out during winter season at Izzah Heuristic Farm in Wasit Province, Iraq to examine the effect of combination of seaweed extract and micronutrient fertiliser on some wheat cultivars. Three cultivars were used in this experiment as well as four stimulator treatments: control (no added extract), seaweed extract, micronutrient, and a combination of both of them. A randomized completely blocked design (RCBD) with a factorial arrangement and three replicates was used in this experiment. The results showed that BHTH cultivar had significantly largest number of spikes, spike length, number of grains per spike, kernel weight and grain yield. The mixture treatment enhanced grain yield of all cultivars was better treatment compared with the others. In terms of the interactions, BHTH cultivars in the mixture treatment had the greatest grain yield and other components. It is clear that a combination of marine algae with micronutrient fertiliser can improve the crop grain yield and its component and can be recommended for farmers to enhance grain production. However, further study might be better step for further exploration about the impact of seaweed extract and micronutrient fertiliser with further rates and other crops or crop cultivars.

Keywords: Seaweed extract, Marine algae, Micronutrient, Wheat cultivars.

1. Introduction

Wheat (Triticum aestivum) is considered as the second most significant cereal crop globally [1], and nationally in Iraq. It is estimated that over two thirds of the world’s population feed on wheat due to its high protein and gluten rich content. Including Iraq, wheat crop provides about 20% of its protein content and about 21% of its calories for the majority of population in many parts of the world [2,3]. The importance of the seaweed or what is called marine algae as a crop stimulant has been well documented. It was reported that there are many advantages of the seaweed extract for crop growth such as IAA and IBA acids as well as amino acids and vitamins [4-11]. These benefits of the seaweed extract include human feeding, fodder fertiliser and many other benefits, and most importantly it is considered as a sustainable agricultural resource in the cropping systems [5]. Seaweed has many important regulators such as cytokinin that can enhance crop growth, and therefore, they are marketed as liquid biofertilizer [5]. It can also enhance seed germination and improve yield quality and quantity due to its content of influential nutrition (Zewail, 2014). Micronutrients such Ca, Cu, Zn, Fe, B and Mn are also important ingredients that the seaweed extract includes [4,5, 13], have reported that the seaweed can be applied in different ways. For example, it can be applied directly into the crop canopy as a forage spray or can be added as a soil drench or directly to crop roots. It can be used for various vegetations such as field crops including cereals, trees and vegetable crops [1]. Micronutrient (e.g. Zn, B, Cu, Mn, etc…) is essential for better yielding in cropping systems, particularly in cereal crops such as wheat [7]. Because of the importance of micronutrient and the seaweed extract in the cropping systems, this research aims to evaluate a combination of seaweed extract concentration and the micronutrient fertiliser on the yield component of some wheat cultivars under Iraqi Central Region environments.
2. Material and Methods

A field experiment was carried out during winter season 2020-2021 at the Izzah Heuristic Exemplary Farm in Wasit Province, southeast of Baghdad. The soil texture was loamy and mostly contained silt, and (Table 1) shows some soil chemical and physical properties. A randomized complete block design (RCBD) was used in the experiment with a factorial arrangement and three replicates. The treatments included three national wheat cultivars: IBA99, Buhooth22 and Jad and symbolized as IBA, BHHTH and JAD respectively, and four stimulator treatments: control (no added stimulant), seaweed extract (or marine algae) (2.5 ml/L water), micronutrient fertiliser (1.25 ml/L water) and mixture of both seaweed extract and micronutrients.

All crop management processes were applied included fertilisers application such as phosphorus fertiliser (P₂O₅=48% P) (200 kg super phosphate/ha) and nitrogen fertiliser as urea (46% N) as three applications at crop tillering, elongation and booting stages. The crop was irrigated as needed throughout the growing season. Cultivars were planted as 140 kg/ha in mid-November 2020, and the crop was harvested on May 10th, 2021. Plot size was 2 x 2 m, and the size of the harvested samples was 50 x 100 cm.

Grain yield and yield components were recorded at the conclusion of the experiments. The yield components included the crop number of spikes per square meter, spike length, the number of grains per spike and kernel weight.

The collected data were analysed in R i386 v 3.5.2 [13]. The data were analysed using analysis of variance (ANOVA) for significant difference at α= 0.05 (Table 2) and significantly different means separated using 95% confidence intervals [3]. The assumption of normal distribution and homogenous variances were checked and confirmed.

| Property      | Value | Unit   |
|---------------|-------|--------|
| pH            | 7.31  |        |
| Organic matter| 0.68  | g.kg⁻¹ |
| Available Nitrogen | 32.51 |        |
| Available Phosphorus | 6.80  | mg.kg⁻¹ |
| Available Potassium | 288.3 |        |
| Soil texture  | Silt  | 468.7  |
|               | Clay  | 287.2  | gm.kg⁻¹ |

| Variables                  | Factors                        |
|----------------------------|--------------------------------|
| Number of spikes           | Cultivars *** Stimulator Treatments *** Cultivars X Stimulator treatments * |
| Spike length               | *** NS                         |
| Number of grains per spike | *** ***                         |
| Kernel weight              | *** *** ***                    |
| Grain yield                | *** *** ***                    |
| P> 0.05 = NS               | P<0.05 = * P<0.01 = ** P< 0.001 = *** |

3. Results

3.1 Number of spikes

The results showed that the crop cultivars had highly significant differences in the number of spikes per square meter (Table 2 and Figure 1). The crop cultivar BHHTH produced the highest number of spikes in comparison with other cultivars about 407.3 spikes/m², whereas JAD produced the lowest number of spikes about 340.0 spikes/m². Similarly, there were highly significant differences in the number of crop spikes between the stimulator treatments as shown in Table 2 and Figure 2. The mixture treatment of seaweed extract and micronutrients had significantly highest number of spikes about 434.6 spikes/m² followed by the seaweed extract treatment about 377.4 spikes/m² in comparison with the other treatments.

The results also showed significant interaction between the seaweed treatment and micronutrients on the number of crop spikes (Table 2 and Figure 3). The highest number of crop spikes were recorded for the cultivar BHTH in the mixture treatment and was approximately 484.7 spikes/m², whereas JAD had the lowest number of crop spikes in the control and the micronutrients treatment about 311.7 and 318.3 spikes/m² respectively. The crop production of spikes was generally
increased when applying the seaweed extract and the mixture of both the seaweed and the micronutrient. The cultivar BHTH was the superior cultivar in all treatments compared with the other two cultivars. However, it was not significantly different from the cultivar IBA99 in all stimulant plots except for the mixture treatment, where it produced significantly higher number of spikes compared with IBA99 (Figure 3).

**Figure 1.** The effect of crop cultivar on the number of spikes per square meter (P < 0.001 and LSD =44.86). The vertical bars are 95% confidence, and the central bullets are the mean values of the replicates for the number of spikes.

**Figure 2.** The effect of the stimulator treatments on the number of spikes per square meter (P < 0.001 and LSD =43.45). The vertical bars are 95% confidence, and the central bullets are the mean values of the replicates for the number of spikes.
Figure 3. The effect of crop cultivar and the stimulator treatments on the number of spikes per square meter (P < 0.05 and LSD =29.8). The vertical bars are 95% confidence, and the central bullets are the mean values of the replicates for the number of spikes.

The results showed that the crop cultivars have significantly differed in the crop spike length (Table 2 and Figure 4). BHTH had the tallest spikes about 11.81 cm, whereas JAD had the shortest spikes about 11.02 cm. Likewise, the stimulator treatments were significantly different (Table 2) in the spike length. The mixture and seaweed extract treatments were not significantly different, but they had significantly the tallest spikes about 12.13 and 11.69 cm respectively compared with the other treatments Figure 5.

The analysis of variance showed that there no significant interaction effect between crop cultivars and stimulator treatments in the spike length (Table 2).

Figure 4. The effect of crop cultivar on the spike length (cm) (P<0.001 and LSD =0.65). The vertical bars are 95% confidence, and the central bullets are the mean values of the replicates for the spike length.
Figure 5. Figure 4. The effect of stimulator treatments on the spike length (cm) (P<0.001 and LSD =0.45). The vertical bars are 95% confidence, and the central bullets are the mean values of the replicates for the spike length.

3.2 Number of grains per spike

The crop cultivars had highly significant differences in the number of grains per spikes (Table 2 and Figure 6). The results showed that BHTH produced the largest number of grains per spikes about 60.3 grain/spike in comparison with the other two cultivars.(Figure 7) reveal that seaweed treatments have significantly differed in the number of grains per spike. As appeared with the number of crop spikes and spike length, the mixture and seaweed plots produced the largest number of grains per spike about 62.77 and 58.67 grain/spike respectively.

There was a significant interaction effect in the number of grains per spike between the crop cultivars and seaweed treatments (Table 2). While the mixture treatment generally had the largest number of grains for all cultivars compared with other treatments (Figure 8), and BHTH produced the largest number of grains, the greatest number of grains per spike was recorded for BHTH in the mixture treatment in comparison with the other plots. Overall, the number of grains increased in all plots. The increase was generally linear for all cultivars, where they can be arranged from the largest to the lowest as the mixture followed by the seaweed extract, micronutrient, and the control treatment respectively. The cultivar JAD always had the lowest number of grains per spike in comparison with the other cultivars across the stimulant plots (Figure 8).

Figure 6. The effect of crop cultivar on the number of grains per spike (P<0.001 and LSD=3.59). The vertical bars are 95% confidence, and the central bullets are the mean value of replicates for the number grains per spike.
Figure 7. The effect of stimulator treatments on the number of grains per spike (P<0.001 and LSD= 5.07). The vertical bars are 95% confidence, and the central bullets are the mean values of the replicates for the number of grains per spike.

Figure 8. The effect of crop cultivar and the stimulator treatments on the number of grains per spikes (P<0.01 and LSD= 1.66). The vertical bars are 95% confidence, and the central bullets are the mean values of the replicates for the number of grains per spike.

3.3 Kernel weight

The results reveal that a similar trend was observed for the crop cultivars in the kernel weight, where BHTH had significantly greatest kernel weight about 29.05 g (Figure 9 and Table 2). On the other hand, JAD had the lowest kernel weight about 26.67 g. Similarly, the analysis of variance showed that the stimulator treatments had a highly significant effect on the crop kernel weight (Table 2 and Figure 10). The mixture plot had the largest kernel weight followed by the seaweed extract treatment about 30.38 and 28.22 g respectively. As what appeared with the other yield components, there was a highly significant interaction between the crop cultivars and stimulator treatments in the kernel weight (Table 2). BHTH was the superior crop cultivar in this characteristic throughout all the treatments followed by IBA99 (Figure 11). Similarly, the mixture treatment had larger kernel weight than the other treatments followed by the seaweed extract treatment across all crop cultivars.
**Figure 9.** The effect of crop cultivar on the kernel weight (P<0.001 and LSD= 0.21). The vertical bars are 95% confidence, and the central bullets are the mean values of the replicates for the number of kernel weight.

**Figure 10.** The effect of stimulator treatments on the kernel weight (P<0.001 and LSD= 1.48). The vertical bars are 95% confidence, and the central bullets are the mean values of the replicates for the number of kernel weight.

**Figure 11.** The effect of crop cultivar and the stimulator treatments on the kernel weight (g) (P<0.001 and LSD= 0.99). The vertical bars are 95% confidence, and central bullets are the mean values of the replicates for the kernel weight.
3.4 Grain yield

Grain yield is the most important among the crop growth and yield characteristics and it represents the total accumulated products from the photosynthesis process throughout the growing season of the crop. The results showed that the crop cultivars had a similar significant trend that appeared with other yield components (Table 2). For example, BHTH produced the greatest grain yield about 5.4 t/ha, whereas JAD produced the lowest grain yield about 4.7 t/ha (Figure 12). The treatments of the seaweed, micronutrient and their mixture also had a highly significant effects with a similar trend as shown in Figure 13). The mixture had the greatest grain yield about 5.6 t/ha, whereas the control and the micro had the lowest grain yield about 4.4 and 4.8 t/ha respectively.

The interaction between the crop cultivars and the treatments was highly significant (Table 2) and was also similar to those interactions observed with the other yield components. BHTH had the greatest grain yield in the mixture treatment followed by the seaweed treatment about 6.1 and 5.5 t/ha respectively in comparison with the other treatments (Figure 14).

![Figure 12](image1.png)

**Figure 12.** The effect of crop cultivar on the grain yield (t/ha) (P<0.001 and LSD= 0.54). The vertical bars are 95% confidence, and central bullets are the mean values of the replicates for the grain yield.

![Figure 13](image2.png)

**Figure 13.** The effect of stimulator treatments on the grain yield (t/ha) (P<0.001 and LSD= 0.40). The vertical bars are 95% confidence, and central bullets are the mean values of the replicates for the grain yield.
4. Discussion

Crop yield parameters including grain yield have generally increased due to the use of micronutrient and seaweed extract as well as their combination. The mixture of seaweed extract and micronutrient fertiliser increased the crop grain yield and its components for all cultivars. However, the crop cultivars responded to the treatments differently most likely due to their genetical variations. The results of the present study agree with [1], who have found that applying the seaweed extract as an organic foliar fertiliser improved the crop grain yield, and thus it can be used as an effective stimulant for better crop growth and yield production. The importance of both micronutrient and the seaweed extract have been well documented. For example, 8 have reported that the seaweed extract is a significant source of some macronutrient such as P and some micronutrients such Zn, Cu and Fe and others that play an important role in plant growth. In addition, this study confirms our results where the seaweed extract contributes to the enhancement and improvement crop yield. Similarly, another previous study on maize have found that the use of seaweed extract has improved some growth characteristics such as plant height and the number of leaves by about 48.2 and 61.8% respectively [10]. This could, in return, improve crop yield and its components. Moreover, a study has been done on the effect of the seaweed extract on rice by [6], also found similar results attributing the increase of the yield to the improvement of the crop canopy growth traits through the use of seaweed extract.

Conclusion

It can be summarized that the seaweed extract increased all of wheat grain yield and other yield components. Although the micronutrient increased the crop yield compared with the control, the seaweed extract was more effective as a foliar organic fertiliser. However, when the micronutrient applied in combination with the seaweed extract, the mixture was the most effective treatment in comparison with the other treatments. The cultivar Buhooth (BHTH) was the superior crop cultivar under the Iraqi Central Region environments since it produced the largest number of spikes, tallest spikes, largest number spike grains and greatest kernel weight as well as the highest grain yield. It is clear the seaweed can be used as an effective organic fertiliser, but it can more influential if it is combined with micronutrient. Further studies are required for more finding explorations in terms of the effect other seaweed rates with further crop and cultivars under the Iraqi environments.

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