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Effect of Time of Seaweed Consumption and Composition of Seaweed and Urea Fertilizer on Nitrogen Use Efficiency and Wheat Yield

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ABSTRACT

BACKGROUND: Fertilizer management plays an important role for obtaining satisfactory yields and to increase crop productivity. Nutrient management may be achieved by the involvement of organic sources, bio fertilizers, and micro-nutrients. Studies have shown that long-term use of fertilizers reduces crop yields. This decrease is due to the acidification of the soil, the reduction of biological activity of the soil and the inappropriate physical properties of the soil.

OBJECTIVES: The present study was conducted to evaluate the effect of different level of growth stage of use seaweed extract and combination of seaweed extract and Urea fertilizer on plant height, leaf area index, biologic yield and nitrogen use efficiency under warm and climate condition in Khuzestan province (Southwest of Iran).

METHODS: Current research was arranged via factorial experiment based on the randomized complete block design with three replications. The treatments included growth stage of use seaweed extract (G_1: 100% at tillering stage, G_2: 50% at tillering stage+50% at booting stage, G_3: 50% at tillering+25% at booting +25% at beginning at Pollination) and different combination of seaweed extract and Urea fertilizer (S_0/N_{100}= Nonuse of seaweed extract + 100% Urea fertilizer, $S_{1.5}/N_{66}$= 1.5 $L.ha^{-1}$ seaweed extract + 66% Urea fertilizer, S_3/N_{33}= 3 $L.ha^{-1}$ seaweed extract + 33% Urea fertilizer, $S_{4.5}/N_0$= 4.5 $L.ha^{-1}$ seaweed extract + Nonuse of Urea fertilizer).

RESULT: According result of analysis of variance effect of growth stage of use seaweed extract and different combination of seaweed extract and Urea fertilizer on all measured traits was significant but interaction effect of treatments was not significant. Mean comparison result the maximum biologic yield was noted for apply seaweed extract at 50% at tillering stage+50% at booting stage and $S_{1.5}/N_{66}$ treatment. The highest amount of nitrogen use efficiency belonged to S_3/N_{33}.

CONCLUSION: Finally use 1.5 $L.ha^{-1}$ seaweed extract + 66% Urea fertilizer along 50% at tillering +50% at booting stage by improve biologic yield can advised for producers.

KEYWORDS: *Biologic yield, Biofertilizer, Leaf area, Nutrition, Plant height.*

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1. BACKGROUND

Chemical fertilizers have been widely used in the production of agricultural products since the mid- 20th century and have contributed a significant role in enhancing the performance of agricultural and garden products. As with other countries in the world, consumption of organic fertilizers has spread to more than 4 million tons in recent years (Rahimi, 2009). The use of excessive fertilizers in the world has caused degradation of agricultural soils, environmental pollution, including surface and groundwater pollution, and problems in human health and other organisms (Mukesh *et al*., 2013). Sustainable agriculture with the aim of reducing chemical fertilizers is a desirable solution to overcome these problems. Biofertilizers have abundant economic and environmental benefits in comparison with chemical fertilizers and cause sustainability in soil resources, maintaining long-term production potential, and preventing environmental pollution and in providing healthy and richer food needs. Nitrogen from chemical fertilizer with nitrogen resulted from organic manure has the same nature in crop yield but it is stated that the side effects of chemical fertilizers cause yield loss. For example, researchers have reported that application of chemical fertilizers in addition to increasing the amount of nitrate increases the concentration of free amino acids, polyphenols and other harmful compounds in agricultural products. Vitamins and vitamins are also common in organic food products. Thus, the edible biopolymers that are caused by organic farming not only satisfy consumers but also guarantee their physical health. In sustainable agricultural systems, application of biofertilizers is very important in increasing crop yield and maintaining stable soil fertility. Any improvement in the agricultural system should lead to an increase in production and reduction of ecological footprint that ultimately increases system stability. In recent years the use of marine algae has gained popularity with regard to its abilities to use in organic and sustainable agriculture (Russo and Beryln, 1990). Unlike fertilizers obtained from seaweed, it avoids environmental degradation, is non - toxic and does not produce dangerous pollution for humans, animals and birds (Dhargalkar and Pereira, 2005). The extract of seaweed containing macro and micro-nutrients, amino acids, vitamins, growth hormones like Cytokine, dioxin and Abscess acid (Mooni and Van Ostaden, 1986). The use of seaweed juice stimulates growth and increase in plant performance, increasing tolerance for environmental tensions, increasing nutrient uptake from the soil (Turan and kozy, 2004) and an increase in antioxidant properties (Verkleij, 1992). Badri and Salim (2016) report on the quantities of seaweed and Biochars juice, that the application of seaweed juice separately or combined with more morphological features and performance components have an incentive effect compared to plants. Altndal (2019) In order to evaluate the effect of sea juice on some of the growth parameters and seedling of wheat, growing said that by the use of a 25% con-

centration of seaweed, it increased biomass, length of branch and root. Since wheat is the first corn and the most important crop in the world and one of the most important crops is the food requirement of humans in different countries and also reducing the use of chemical fertilizers for sustainable agricultural purposes.

2. OBJECTIVES

The present study was conducted to evaluate the effect of different level of growth stage of use seaweed extract and combination of seaweed extract and Urea fertilizer on plant height, leaf area index, biologic yield and nitrogen use efficiency under warm and climate condition in Khuzestan province (Southwest of Iran).

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

Current research was arranged via factorial experiment based on the randomized complete block design with three replications along 2020-2021. Place of research was located in Hamidiyeh region at southwestern of Iran (latitude: 31 48' N, longitude: 48 43' E and 22 meters above sea level) with moderate winters and hot summers. The treatments included growth stage of use seaweed extract (G_1: 100% at tillering stage, G_2: 50% at tillering stage+50% at booting stage, G_3: 50% at tillering+25% at booting +25% at beginning at Pollination) and different combination of seaweed extract and Urea fertilizer (S_0/N_{100}= Nonuse of seaweed extract + 100% Urea fertilizer, $S_{1.5}/N_{66}$= 1.5 L.ha^{-1} seaweed extract + 66% Urea fertilizer, S_3/N_{33}= 3 L.ha^{-1} seaweed extract + 33% Urea fertilizer, $S_{4.5}/N_0$= 4.5 L.ha^{-1} seaweed extract + Nonuse of Urea fertilizer). Based on the importance of the soil condition, the depth of 0-30 cm was sampled, whose results are shown in table 1.

Table 1. Soil properties of the studied field

Depth of soil	Soil texture	Sand (%)	Silt (%)	Clay (%)
0-30	silt loam	18	48	34
EC (ds.m^{-1})	**OC (%)**	**N (%)**	**P (mg.kg^{-1})**	**K (mg.kg^{-1})**
3.6	0.52	0.039	13	159

3.2. Farm Management

The extract of seaweed used in this experiment was sprayed in liquid as well as a leaf by using a solo manual of 461. The average consumption of urea fertilizer was considered to be 300 kg.ha^{-1} (about 138 kg.ha^{-1}). In all treatments, 50% of urea fertilizer was based on the basis of cultivation and the rest of it in the late tillering) coinciding with the start of rapid growth stage) and Phosphorus from the super phosphate source at 90 kg.ha^{-1} and Potash fertilizers from the source of potassium sulfate (50 kg.ha^{-1}) as base and pre-seeding application. All seeds used by the Mehregan digit. The density was 400 seeds per square meter at 16NOV. The first irrigation was done immediately after the cultivation. The next Irrigation was performed on the basis of the appearance of the plant. No significant pest or disease was observed during the growth period, and the weeds were carried out in a manual manner without the consumption of herbicide.

3.3. Measured Traits

To determine the height of the stem, each of the treatments were separately and randomly 10 the stem and their average height were considered as the stem height.

The leaf area index (LAI) was determined through the following equation:

Equ. 1. $LAI = \frac{LA}{SA}$

LA= SA= leaf area index (m^2) Area

In order to measure the biologic yield, the area is equivalent to two square meters of each plot and after removal of margins is calculated. The following equation was used to calculate the nitrogen use efficiency (NUE) by Fageria *et al*. (2015):

Equ.2. NEU= Seed yield/Total Nitrogen×100

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done via SPSS (Ver.8) software and Duncan multiple range test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Plant height

According result of analysis of variance effect of growth stage of use seaweed extract and different combination of seaweed extract and Urea fertilizer on plant height was significant at 1% probability level but interaction effect of treatments was not significant (Table 2). According result of mean comparison maximum of plant height (13.4 cm) was obtained for G_1 treatment (76.48 cm) also it doesn't have significant difference with G_2 treatment and minimum of that (71.65 cm) was for G_3 treatment (Table 3). Evaluation mean comparison result indicated in combination of seaweed extract and Urea fertilizer the maximum plant height (80.69 cm) was noted for S_0/N_{100} treatment and minimum of that (67.12 cm) belonged to $S_{4.5}/N_0$ treatment (Table 4). These results were consistent with the findings of Golestani Zadeh (2018) who stated that the highest plant height in the atmosphere was observed in the one-stage treatment of foliar application of seaweed extract at the time of tillering. Sibi *et al*. (2016) reported that the highest height of the first safflower branch from the soil surface was obtained from the treatment of two liters per hectare of seaweed extract at the time of plant growth. Because nitrogen fertilizer increases vegetative growth in plants, plants that were well fed with nitrogen had higher plant height. Basically, the cause of height increase due to urea application can be attributed to the effect of nitrogen intensification on vegetative growth and cell divisions in plant organs, especially stems, and pointed out that as a result, leaf and stem weight increases (Kanaani Alvar *et al*., 2013).

Table 2. Result of analysis of variance effect of treatments on Plant height and Leaf area index

S.O.V	df	Plant height	Leaf area index
Replication	2	12.677^{*}	0.00776^{ns}
Growth stage (G)	2	84.492^{**}	0.14506^{*}
Concentration (C)	3	326.293^{**}	0.34532^{*}
G × C	6	1.929^{ns}	0.00420^{ns}
Error	22	3.031	0.00288
CV (%)	-	8.01	4.5

ns, * and **: no significant, significant at 5% and 1% of probability level, respectively.

4.2. Leaf area index (LAI)

Result of analysis of variance revealed effect of growth stage of use seaweed extract and different combination of seaweed extract and Urea fertilizer on leaf area index was significant at 5% probability level, but interaction effect of treatments was not significant (Table 2). Mean comparison result of effect of growth stage of use seaweed extract indicated that maximum leaf area index (4.61) was noted for G_2 treatment and minimum of that (4.39) belonged to G_1 treatment (Table 3). As for Duncan classification made with respect to different combination of seaweed extract and Urea fertilizer maximum and minimum amount of leaf area index belonged to S_0/N_{100} (4.68) and $S_{4.5}/N_0$ treatment (4.24) (Table 4).

Table 3. Mean comparison effect of different growth stage of apply seaweed extract on plant height and leaf area index

Growth stage	Plant height (cm)	Leaf area index
G_1	76.48a	4.39c
G_2	75.95a	4.61a
G_3	71.65b	4.47b

*Similar letters in each column show non-significant difference at 5% probability level in Duncan test.
G_1: 100% at Tillering stage, G_2: 50% at tillering stage+50% at booting stage, G_3: 50% at tillering+25% at booting +25% at beginning at Pollination.

Nitrogen increases leaf area index because of its positive effect on vegetative growth and leaves. Therefore, the plant produces more photosynthetic materials due to more use of sunlight. In other words, by increasing the leaf area which is the most important organ of photosynthesis, the amount of material made in plants grows. These results were consistent with the results of Williams *et al*. (2002) who announced that leaf area index increased with increasing nitrogen use. Leaves require a large amount of nitrogen as the main component of the enzymes involved in photosynthesis. About three-quarters of nitrogen is associated with photosynthesis (Sinclair and Horie, 1989). In fact, the majority of the protein on the ground is carboxylase (enzyme that absorbs carbon dioxide as the first step in photosynthesis). Nitrogen deficiency limits leaf area development, but leaf dry matter accumulation is less affected by nitrogen deficiency, thereby increasing leaf area nitrogen deficiency, and since most of the plant nitrogen is allocated to leaves, leaf area expansion is considered as an important factor in determining the need for nitrogen (Soltani and Sinclair, 1980).

Table 4. Mean comparison effect of different Concentration of seaweed extract and Urea fertilizer on plant height and leaf area index

Treatment	Plant height (cm)	Leaf area index
S_0/N_{100}	80.69a	4.68a
$S_{1.5}/N_{66}$	78.15b	4.61b
S_3/N_{33}	72.82c	4.43c
$S_{4.5}/N_0$	67.12d	4.24d

*Similar letters in each column show non-significant difference at 5% probability level in Duncan test.
S_0/N_{100}= Nonuse of seaweed extract (spraying with distilled water) + 100% Urea fertilizer, $S_{1.5}/N_{66}$= 1.5 $L.ha^{-1}$ seaweed extract + 66% Urea fertilizer, S_3/N_{33}= 3 $L.ha^{-1}$ seaweed extract + 33% Urea fertilizer, $S_{4.5}/N_0$= 4.5 $L.ha^{-1}$ seaweed extract + Nonuse of Urea fertilizer.

4.3. Biologic yield

According result of analysis of variance effect of growth stage of use seaweed extract and different combination of seaweed extract and Urea fertilizer on biologic yield was significant at 1% probability level but interaction effect of treatments was not significant (Table 5). Result of mean comparison showed maximum of biologic yield was obtained for G_2 treatment (10921 kg.ha^{-1}) and minimum of that was for G_3 (10021 kg.ha^{-1}) treatment also it doesn't have significant difference with G_1 (10302 kg.ha^{-1}) treatment (Table 6).

Table 5. Result of analysis of variance effect of treatments on biologic yield and Nitrogen use efficiency

S.O.V	df	Biologic yield	Nitrogen use efficiency
Replication	2	13^{ns}	2.5^{ns}
Growth stage (G)	2	25437**	150.1**
Concentration (C)	3	375133**	9453.3**
G × C	6	1648^{ns}	11.3^{ns}
Error	22	2442	7.6
CV (%)	-	8.07	11.41

$^{ns, *}$ and **: no significant, significant at 5% and 1% of probability level, respectively.

Evaluation mean comparison result indicated in combination of seaweed extract and Urea fertilizer the maximum biologic yield (12427 kg.ha^{-1}) was noted for $S_{1.5}/N_{66}$ treatment and minimum of that (8196 kg.ha^{-1}) belonged to $S_{4.5}/N_0$ treatment (Table 7). It has been stated that the application of nitrogen fertilizer can increase plant biomass yield by developing vegetative growth and longer leaf and stem area (Sadeghi *et al*., 2009). Use of seaweed extract ($S_{1.5}/N_{66}$) was effective in increasing biomass yield. In this regard, it has been stated that the use of seaweed extract due to increasing beneficial microbial population in the soil, increases the plant's access to nutrients, control of soil diseases, increase vitamins and other nutrients for the plant that these factors increase plant growth (Kurdfiroozjai *et al*., 2012). The results of this experiment were consistent with findings of Moradi *et al*. (2011) that increasing the ratio of chemical fertilizer to biofertilizer, biomass yield increased.

Table 6. Mean comparison effect of different growth stage of apply seaweed extract on Biologic yield and Nitrogen use efficiency

Treatment	Biologic yield (kg.ha^{-1})	Nitrogen use efficiency (Kg.kg^{-1})
G_1	10302b	41.54b
G_2	10921a	44.82a
G_3	10021b	41.07b

*Similar letters in each column show non-significant difference at 5% probability level in Duncan test.
G_1: 100% at Tillering stage, G_2: 50% at tillering stage+50% at booting stage, G_3: 50% at tillering+25% at booting +25% at beginning at Pollination.

Carvalhi *et al*. (2013) also stated in their research that the use of seaweed extract has increased the biomass yield in wheat. Another reason for the increase in wet and dry yield due to seaweed extract has been attributed to the increased mobility of the hormone cytokinin from root to shoot (Vijayand *et al*., 2014).

4.4. Nitrogen use efficiency

Result of analysis of variance revealed effect of growth stage of use seaweed extract and different combination of seaweed extract and Urea fertilizer on nitrogen use efficiency was significant at 1% probability level, but interaction effect of treatments was not significant (Table 5). Mean comparison result of effect of growth stage of use seaweed extract indicated that maximum leaf area index was noted for G_2 treatment (44.82 $kg.kg^{-1}$) and minimum of that (41.07 $kg.kg^{-1}$) belonged to G_3 treatment also it doesn't have significant difference with G_1 (41.54 $kg.kg^{-1}$) treatment (Table 6). As for Duncan classification made with respect to different combination of seaweed extract and Urea fertilizer maximum and minimum amount of leaf area index belonged to S_3/N_{33} (74.16 $kg.kg^{-1}$) and $S_{4.5}/N_0$ treatment (0.01 $kg.kg^{-1}$) (Table 7). Nitrogen utilization efficiency is from the amount of economic production organs to nitrogen consumed as fertilizer (Hamidi and Dabbagh Mohammadinasab, 2006). Other researchers also reported that with 75 $kg.ha^{-1}$ of pure nitrogen, the highest nitrogen use efficiency was obtained, but with its increase to 150 $kg.ha^{-1}$, nitrogen use efficiency decreased (Satari *et al*., 2017), which was consistent with the results of this experiment. With increasing nitrogen application, nitrogen use efficiency decreases with a significant difference between all fertilizer levels. It seems that the application of seaweed biofertilizer, in addition to providing the nitrogen required by the plant due to increased shoot growth, has increased nitrogen uptake and thus has achieved the maximum efficiency of this element in the plant. Since the efficiency of nitrogen consumption is obtained from the ratio of the amount of grain produced to the fertilizer consumption, with increasing the amount of grain produced, the efficiency of fertilizer consumption also increases (Rabiei, and Tousi Kahel, 2011). The researchers reported that the yield of safflower in terms of plant dry weight increased with decreasing nitrogen supply. Nitrogen yield ratio in safflower increased under the nitrogen deficiency conditions (Mohsennia and Jalilian, 2012).

Table 7. Mean comparison effect of different Concentration of seaweed extract and Urea fertilizer on biologic yield and nitrogen use efficiency

Treatment	Biologic yield ($kg.ha^{-1}$)	Nitrogen use efficiency ($kg.kg^{-1}$)
S_0/N_{100}	11843b	35.95c
$S_{1.5}/N_{66}$	12427a	59.80b
S_3/N_{33}	9192c	74.16a
$S_{4.5}/N_0$	8196d	0.01d

*Similar letters in each column show non-significant difference at 5% probability level in Duncan test.

S_0/N_{100}= Nonuse of seaweed extract (spraying with distilled water) + 100% Urea fertilizer, $S_{1.5}/N_{66}$= 1.5 $L.ha^{-1}$ seaweed extract + 66% Urea fertilizer, S_3/N_{33}= 3 $L.ha^{-1}$ seaweed extract + 33% Urea fertilizer, $S_{4.5}/N_0$= 4.5 $L.ha^{-1}$ seaweed extract + Nonuse of Urea fertilizer.

5. CONCLUSION

Although the application of nitrogen fertilizers is very important in the nutrition of cereals, but due to improper use and their destructive effects on arable soils, it is necessary to modify their use. The use of biofertilizers as a very suita-

ble solution can be effective in reducing the use of chemical fertilizers. The effect of different amounts of combination of seaweed and urea fertilizer showed that the application of 1.5 liters per hectare of seaweed extract with 66% urea fertilizer on biomass yield trait and nitrogen use efficiency and improved and increased these traits in wheat. The effect of time of application of seaweed fertilizer showed that its application in 50% in the tillering stage + 50% in the pregnancy stage improved and increased the leaf area index and plant height. Therefore, by using nitrogen fertilizer along with seaweed biofertilizer while producing maximum crop production, the consumption of chemical fertilizer can be reduced by 34%. Therefore, while reducing production costs, the effects of environmental pollution can be significantly reduced. Finally according result of current study use 1.5 $L.ha^{-1}$ seaweed extract + 66% Urea fertilizer along 50% at tillering stage+50% at booting stage by improve biologic yield can advised for producers.

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FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

CONFLICT OF INTEREST: Authors declared no conflict of interest.

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