



EFFECT OF SOAKING HOURS IN DIFFERENT CONCENTRATIONS OF SEAWEED EXTRACT ON GREEN FEED YIELD, DRY MATTER, AND QUALITY FOR FENUGREEK (*TRIGONELLA FOENUM–GRAECUM* L.)

Marwan Sami Said¹, Ali Hussein Abed AL- khafaji¹, Luay Dawood Farhan² and Adnan Hussein Al-Wagaa¹

¹Department of Field Crops Science, College of Agriculture, University of Diyala, Iraq

²Department of Soil Science and Water Resource, College of Agriculture, University of Diyala, Iraq

Corresponding author: adnan_alwakaa2003@yahoo.com

Abstract

Experimental was carried out at the field of agricultural college, University of Diyala for the season 2017 - 2018 in order to study the response of the of Fenugreek plant properties (green fodder, the dry matter and its quality) to seed soaking hours of seaweed extract. The experiment was conducted with the Randomized Complete Blocks Design (RCBD) in the factorial experiments arrangement with three replicates. The seeds of Fenugreek were soaked in two concentrations (1 ml and 2 ml) of seaweed extract in addition to water as a control for 12 (W_1), 24 (W_2) and 36 (W_3) hours. The results showed that there was a significantly positive effect on all studied attributes by the interaction between soaking hours and the concentration of seaweed extract. The W_2 treatment was significantly higher in the dry matter (4.35 t. h^{-1}), crude fibre percent (38.7 %) compared to the control. The two concentrations of seaweed extract had a significant effect on all studied attributes in which the 2 ml concentration was the highest compared to other treatments.

Keywords: Fenugreek, soaking hours, seaweed extract, green feed yield, forage quality.

Introduction

The Fenugreek plant (*Trigonella foenum – graecum*) is annual, wintry and herbal plant. It is cultivated worldwide and originally was brought from countries of south-west Europe and Mediterranean Sea (Shapiro, 2002). The fenugreek has been used as a fodder crop and in medicine as treatment for diabetes, blood cholesterol and back pain. In addition, it has been reported to have role in protection soil surface from erosion, and air nitrogen fixation by rhizobium (Acharya, 2008 and Kor *et al.*, 2013). Using of chemical fertilizers widely around the world have been found to have negative effects on environment and human health (kumara *et al.*, 2014). The seaweed extract has been selected as one of alternative solutions that can be used instead of chemical fertilizers since it is rich in nutrients, amino acids, vitamins and growth regulators (Oglu, 2018). Treating the plants with seaweed extract increases the ability of plants to withstand the environmental stress circumstances such as salt stresses, thermal stresses and other stresses that results from attacking of pathogens and insecticides (Wang *et al.*, 2005 and Sia *et al.*, 2014). Kavipriya *et al.*, 2011 noted that soaking the mung bean seeds with five concentrations (0.1%, 0.2%, 0.3%, 0.4% and 0.5%) of seaweed extract led to a significant increase in the seed germination rate, root length, total height of plant, number of transverse roots, fresh weight and dry weight, recording 90%, 7.6 cm, 2.18 cm, 18.6, 0.392 gm and 0.046 gm respectively at 0.4 % concentration. They continued to say that 0.5 % concentration caused a significant reduction in plant attributes that was mentioned above. El-Sheekh and El-Saied, 2000 reported that a significant increase in the protein content of total root and vegetative, and the concentration of saccharides occurred when the broad bean seeds were soaked with different concentrations of seaweed extract. The seeds of Legume family have the same attribute in term of the hardness in which the seed coat has low permeability to water and oxygen, leading to decrease seed germination. Therefore, soaking the seeds with water, growth regulator, seaweeds or any other solutions may decrease this

circumstance, leading to an increase in the seed germination. Furthermore, this process has been stated to reduce the germination period and reduce the issues at beginning of vegetative growth such as soil organism attacking and the reduction of water, light and oxygen (Egli & Tekrony, 1995 and Sabongari & Alierio, 2004). Bharati and Vaidehi, 1989 indicated that soaking the seeds with solutions increases the availability of nutrients. The objective of this study is to determine the benefit effect of soaking the Fenugreek seeds with different concentrations of seaweed extract and soaking hours on green feed, dry matter and quality.

Materials and Methods

This study was carried out at the Crops Science Department, Agricultural College, University of Diyala during season 2017 - 2018. The experiment was designed according to Randomized Complete Blocks Design RCBD in the factorial experiments arrangement with three replicates. Table 1 demonstrates the chemical and physical properties of soil, which were measured using standard methods (Page *et al.*, 1982). The main factor was soaking hours while the secondary factor was soaking concentration. Soaking hours included 12 hours (W_1), 24 hours (W_2) and 36 hours (W_3). Soaking concentrations included water (S_1) and seaweed extract (*Ascophyllum nodosum*) of 1 ml (S_2) and 2 ml (S_3). The properties of seaweed extract are demonstrated in Table 2. Soil was prepared for cultivation as normal practice then the experimental land was divided to three replications, and each one had nine beds, in which the area of each bed was 4 m². Each bed had 20 cultivation lines, and the distance between each other was 10 cm. The soil was cultivated on 18 of October 2017 directly after seed soaking as mentioned above. The seeds were cultivated on 1-2 cm depth, and then covered by soil. After that, the experimental soil was fertilized using NPK (200 kg. ha⁻¹). The crop service processes was conducted as required. The plant was cut after 120 days of cultivation using manual sickle.

Table 1 : Some physical and chemical properties of soil before cultivation

Values	Units	Property
8.4	Ds/m	pH 1:1
4.2	Mg/kg soil	Electrical conductivity
34.8	Mg/kg soil	Available nitrogen
13.7	Mg/kg soil	Available potassium
205	Mg/kg soil	Organic matter
2.5	%	
32.7	Clay %	Particle size
39.3	Silt %	
28	Sand %	
1.42	g/cm ³	Bulk density

Table 2 : The chemical and physical properties of seaweed extract

Value	Units	Properties
Brown		colour
18≤	g/L	Seaweed extract
14≥	g/L	alginic acid
60 ≤	g/L	K ₂ O
30≤	g/L	P ₂ O ₅
90 ≤	g/L	N
4 ≤	g/L	Mn
8 ≤	g/L	Zn
8 ≤	g/L	Cu
16≤	g/L	Fe
150≤	g/L	Organic matter

The studied attributes

1. The leaf/stem ratio: ten stems were randomly selected for each experimental unit, then the weight of leaves and stems were separately taken using sensitive scales, and the ratio was determined by dividing the weight of leaves on the weight of stems.
2. The weight of green feed: the weight of plant were taken for each experimental unit directly after cutting and converted to tan/ha.
3. The dry matter: it was calculated by weighing the green feed (fresh weight), which was air dried under lab condition, then it was weighed using sensitive scale after the weight constancy. The equations below were used to calculate the dry matter.

$$\text{Moisture\%} = \frac{(\text{fresh weight} - \text{dry weight})}{\text{fresh weight}} \times 100 \quad (1)$$

$$\text{Dry matter \%} = 100 - \text{moisture \%} \quad (2)$$

$$\text{Dry matter yield} = \text{dry matter \%} \times \text{yield of green feed} \quad (3)$$

4. Crude protein percent: Kjeldahal method was used to determine the nitrogen content, then the protein % was determined using equation 4 (Thachuk *et al.*, 1977).

$$\text{Protein \%} = \text{N\%} \times 8.625 \quad (4)$$

5. Crude protein yield was determined as t. ha⁻¹ using equation 5

$$\text{crude protein yield} = \text{dry matter} \times \text{crude protein\%} \quad (5)$$

6. Crude fibre yield (t. ha⁻¹) was determined using equation 6.

$$\text{crude fibre yield} = \text{dry matter yield} \times \text{crude fiber} \quad (6)$$

Statistical analysis. The experimental data was analysed using Gen stat program at significant of 0.05.

Results and discussion

Leaf/stem ratio

Results indicated that there were no significant differences in the leaf/stem ratio between treatments of soaking hours (Table 3). On the contrary, the treatments of seaweed extract significantly affected the leaf/stem ratio, in which the S₃ treatment had the highest mean value (1.230%) while S₁ treatment had the lowest mean value (0.881 %). This was attributed to that soaking the seeds in high seaweed extract increased availability of nutrient elements and bioactive compound of seeds. As a result, the growth and development of plant increased, which reflected positively on the leaf/stem ratio.

The interaction between two factors significantly increased leaf/stem ratio (table 3). For W₁ and W₂, the mean of leaf/stem ratio decreased at S₂ and then increased at S₃. While, for W₃ treatment, it was noted that there was a linear increase in the leaf/stem ratio as the seaweed concentration increased.

Table 3 : The effect of soaking hours, seaweed concentration and the interaction between them on leaf/stem ratio

Mean	Seaweed extract			Soaking hours
	S ₃	S ₂	S ₁	
0.996	1.285	0.803	0.902	W ₁
0.953	1.105	0.784	0.972	W ₂
1.051	1.300	1.085	0.769	W ₃
	1.230	0.891	0.881	Mean
n.s.	P < 0.05 for soaking hours			
0.228	P < 0.05 for seaweed extract concentration			
0.395	P < 0.05 for interaction between seaweed extract and soaking hours			

Green feed yield

For soaking hours, no significant difference was noted on yield of green feed (Table 4). On the other hand, yield of green feed significantly increased when the seeds treated with seaweed extract. The control treatment (S₁) recorded the lowest value of green feed (14.83 t. ha⁻¹) while the S₃ treatment recorded the highest value (20.40 t. ha⁻¹). Bai *et al.* 2011 reported that the seaweed extract delay plant senescence through strength and supporting plant cells in addition to increase resistance of plant to disease such as fungal disease and nematodes.

The interaction between two factors significantly influences this property (Table 4). For treatments of W₁ and W₂, the yield of green feed linearly increased as the concentration of seaweed extract increased. For W₂ treatment, the yield of green feed increased at S₂ treatment and decreased at S₃ treatment.

Table 4 : The effect of soaking hours in different concentration of seaweed extract on yield of green feed (t. ha⁻¹)

Mean	Seaweed extract			Soaking hours
	S ₃	S ₂	S ₁	
16.94	20.82	18.12	11.87	W ₁
20.58	20.04	22.83	18.85	W ₂
17.06	20.32	17.11	13.76	W ₃
	20.40	19.35	14.83	Mean
n.s.	P < 0.05 for soaking hours			
3.697	P < 0.05 for seaweed extract concentration			
6.403	P < 0.05 for interaction between seaweed extract and soaking hours			

Yield of dry matter

The results indicate that there were significant differences in the dry matter yield among treatments of soaking hours (Table 5). The highest mean value (4.35 t. ha⁻¹) was achieved by W₂ while the lowest mean value (3.47 t. ha⁻¹) was achieved by W₁. As the period of seed soaking in the seaweed extract increases, the benefit of seaweed extract for seeds increases, which was attributed to that the seaweed extract contains compound and nutrients such as nitrogen, phosphor and potassium that play important role in plant metabolism. These all reflected positively on the yield of dry matter.

There were significant differences among seaweed extract treatments in which the highest mean value (4.4 t. ha⁻¹) of dry matter was achieved by S₃ while the lowest mean value (3.0 t. ha⁻¹) was achieved by S₁ (Table 5). The seaweed extract was mentioned by Mohammed *et al.*, 2018 to have the ability of increasing the nutrients that reflected positively on dry matter. Spenilla *et al.*, 2009 also stated that treating the plant with seaweed extract lead to physiological changes such as growth simulation and acceleration for root and vegetable group, and therefore increasing the amount of made nutrient by metabolism as a result of increasing the vegetative area. The interaction between treatments of seaweed and soaking hours resulted in significant differences in dry matter yield (Table 5). For W₂ treatment, the dry matter percent increased at S₂ treatment while decreased at S₃ treatment. The W₃ and W₁ treatments behaved differently in which the dry matter increased linearly as the seaweed extract increased.

Table 5 : The effect of soaking hours in different concentration of seaweed extract on dry matter yield (t. ha⁻¹)

Mean	Seaweed extract			Soaking hours
	S ₃	S ₂	S ₁	
3.47	4.26	3.84	2.31	W ₁
4.35	4.40	4.75	3.91	W ₂
3.63	4.54	3.56	2.8	W ₃
	4.4	4.05	3.00	Mean
0.628	P < 0.05 for soaking hours			
0.628	P < 0.05 for seaweed extract concentration			
1.088	P < 0.05 for interaction between seaweed extract and soaking hours			

Crude protein percent

For hours of soaking treatments, there were significant differences in crude protein percent in which the highest and lowest mean value was observed at W₃ and W₂, recording 14.27 % and 11.12 respectively (Table 6). This was attributed to that the increase in crude protein percent was because of the increase in leaf/stem ratio (table 3), in which the crude protein increases in the leaves compared to stems. In similar to soaking treatments, the seaweed extract treatments differed in their content of crude protein (Table 6). The highest mean value (15.05 %) was achieved by S₃ while the lowest mean value (11.31 %) was achieved by S₁. This was attributed to the role of nutrients in the seaweed extract such as potassium that play an important role in delaying leaf senescence through delaying protein demolition and increasing growth regulation (Cytokinin), that is responsible for leaf senescence (Mohammad, 2014). Moreover, seaweed extract has been reported to be rich in zinc that protect plant tissues from oxidation and produce growth hormone. The plants contain more than 500 types of proteins that zinc enters into their composition (Taiz & Zeiger, 2010 and Amiri *et al.*, 2016). The interaction between two factors significantly influenced the crude protein percent (Table 6). For W₁ and W₃ treatments, the mean value of crude protein percent declined at S₂ treatment and increased at S₃ treatment. For W₃ treatment, crude protein percent increased as the concentration of seaweed extract increased.

Table 6 : The effect of soaking hours in different concentration of seaweed extract on crude protein percent.

Mean	Seaweed extract			Soaking hours
	S ₃	S ₂	S ₁	
12.97	13.33	12.63	12.96	W ₁
11.12	11.84	10.65	10.88	W ₂
14.27	19.99	12.73	10.10	W ₃
	15.05	12	11.31	Mean
1.129	P < 0.05 for soaking hours			
1.129	P < 0.05 for seaweed extract concentration			
1.956	P < 0.05 for interaction between seaweed extract and soaking hours			

The protein yield

The results indicate that soaking hours significantly influenced the values of protein yield (Table 7). The highest and lowest mean value of protein yield was achieved by W₃ and W₁, recording 0.550 ton/ha and 0.452 t. h⁻¹ respectively. This was attributed to the increase in the mean value of the leaf/stem ratio and crude protein percent (Table 3 and Table 6).

For seaweed extract, significant differences were observed in the protein yield between treatments (Table 7). The mean values of protein yield at S₃ and S₁ were 0.666 ton/ha and 0.341 t. h⁻¹ respectively. The highest mean value of protein yield at S₃ was because of the highest mean value leaf/stem ratio (1.230 %), dry matter yield (4.4 ton/ha) and crude protein percent (15.05 %).

The response of protein yield to soaking hours was influenced by seaweed extract treatments (Table 7). There was a linear increase in protein yield for all soaking hour treatments when the seaweed extract increased.

Table 7 : The effect of soaking hours in different concentration of seaweed extract on crude protein yield.

Mean	Seaweed extract			Soaking hours
	S ₃	S ₂	S ₁	
0.452	0.567	0.484	0.307	W ₁
0.485	0.520	0.506	0.431	W ₂
0.550	0.911	0.452	0.287	W ₃
	0.666	0.481	0.341	Mean
0.088	P < 0.05 for soaking hours			
0.088	P < 0.05 for seaweed extract concentration			
0.153	P < 0.05 for interaction between seaweed extract and soaking hours			

Crude fibre percent

Significant differences were observed in the mean values of crude fibre percent between seaweed treatments (Table 8). The highest mean value was achieved by S₁ while the lowest value was achieved by S₃, recording 40.1% and 31.0 % respectively. This was attributed to the negative relationship between crude fibre percent and crude protein percent. There was a significant interaction between two factors, in which the mean value of crude fibre for W₁ and W₃ treatments decreased at S₂ treatment and then increased at S₃ treatment. On contrary, W₂ treatment differed in its behaviour, in which crude fibre percent increased at S₂ and decreased at S₃.

Table 8 : The effect of soaking hours in different concentration of seaweed extract on crude fibre percent.

Mean	Seaweed extract			Soaking hours
	S ₃	S ₂	S ₁	
34.5	37.4	20.7	45.4	W ₁
38.7	31.8	43.8	40.5	W ₂
34.2	39.5	28.6	34.4	W ₃
34.5	31.0	36.3	40.1	Mean
n.s.	P < 0.05 for soaking hours			
7.24	P < 0.05 for seaweed extract concentration			
12.55	P < 0.05 for interaction between seaweed extract and soaking hours			

Fibre yield

Treatments of soaking hours significantly affected the fibre yield (Table 9). The highest value was achieved by W₂ and the lowest value was achieved by W₁, recording 1.694 t. ha⁻¹ and 1.160 t. ha⁻¹ respectively. The high mean value of this property at W₂ treatment was attributed to the high value of dry matter and crude fibre percent compared to W₁ (Table 5 and 8). The seaweed extract also significantly influenced the mean value of fibre yield. The S₂ and S₁ treatments had the highest and lowest mean value of fibre yield, recording 1.622 t. ha⁻¹ and 1.064 t. ha⁻¹ respectively. This was attributed to the high value of crude fibre percent in S₂ treatment (Table 8).

The interaction between two factors significantly influenced this property (Table 9). The treatments of seaweed extract increased the response of the plant to soaking hours, leading to an increase in fibre yield. For W₁ and W₂

treatments, fibre yield increased at S₂ and then decreased at S₃. For W₃ treatment, there was a linear increase in this property as the seaweed extract increased.

Table 9 : The effect of soaking hours in different concentration of seaweed extract on crude fibre yield (t. ha⁻¹).

Mean	Seaweed extract			Soaking hours
	S ₃	S ₂	S ₁	
1.160	0.886	1.735	0.861	W ₁
1.694	1.936	1.940	1.206	W ₂
1.205	1.298	1.191	1.126	W ₃
	1.373	1.622	1.064	Mean
0.383	P < 0.05 for soaking hours			
0.383	P < 0.05 for seaweed extract concentration			
0.663	P < 0.05 for interaction between seaweed extract and soaking hours			

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