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

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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 s 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 & Aliero, 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 m^2. 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 %	Clay loam	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_2O
30≤	g/L	P_2O_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.

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

Dry matter % = 100 – moisture% (2)

Dry matter yield = dry matter % x yield of green feed (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).

Protein % = N% * 6.25 (4)

5. Crude protein yield was determined as t. ha^{-1} using equation 5

Crude protein yield = dry matter x crude protein % (5)

6. Crude fibre yield (t. ha^{-1}) was determined using equation 6.

Crude fibre yield = dry matter yield x crude fiber (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 S_3 treatment had the highest mean value (1.230%) while S_1 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 W_1 and W_2, the mean of leaf/stem ratio decreased at S_2 and then increased at S_3. While, for W_3 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 (S_1) recorded the lowest value of green feed (14.83 t. ha^{-1}) while the S_3 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 W_1 and W_2, the yield of green feed linearly increased as the concentration of seaweed extract increased. For W_2 treatment, the yield of green feed increased at S_2 treatment and decreased at S_3 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 W_2 while the lowest mean value (3.47 t. ha^{-1}) was achieved by W_1. 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 S_3 while the lowest mean value (3.0 t. ha^{-1}) was achieved by S_1 (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 W_2 treatment, the dry matter percent increased at S_2 treatment while decreased at S_3 treatment. The W_3 and W_1 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 W_3 and W_2, 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 S_3 while the lowest mean value (11.31 %) was achieved by S_1. 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 W_1 and W_3 treatments, the mean value of crude protein percent declined at S_2 treatment and increased at S_3 treatment. For W_3 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
	S3	S2	S1	
12.97	13.33	12.63	12.96	W1
11.12	11.84	10.65	10.88	W2
14.27	19.99	12.73	10.10	W3
	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 W_3 and W_1, 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 S_3 and S_1 were 0.666 ton/ha and 0.341 t. h^{-1} respectively. The highest mean value of protein yield at S_3 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			

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 S_1 while the lowest value was achieved by S_3, 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 W_1 and W_3 treatments decreased at S_2 treatment and then increased at S_3 treatment. On contrary, W_2 treatment differed in its behaviour, in which crude fibre percent increased at S_2 and decreased at S_3.

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 W_2 and the lowest value was achieved by W_1, recording 1.694 t. ha^{-1} and 1.160 t. ha^{-1} respectively. The high mean value of this property at W_2 treatment was attributed to the high value of dry matter and crude fibre percent compared to W_1 (Table 5 and 8). The seaweed extract also significantly influenced the mean value of fibre yield. The S_2 and S_1 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 S_2 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 W_1 and W_2 treatments, fibre yield increased at S_2 and then decreased at S_3. For W_3 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	$\mathbf{W_1}$
1.694	1.936	1.940	1.206	$\mathbf{W_2}$
1.205	1.298	1.191	1.126	$\mathbf{W_3}$
	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			

References

Acharya, S.N.; Thomas, J.E.; Basu, S.K. Fenugreek (2008). An alternative crop for semiarid regions of North America. Crop Science, 48(3): 841-853.

Amiri, A.B.; Baninasab, C.; Ghobadi, A. and Khoshgoftarmanesh, H. (2016). Zinc soil application enhances photosynthetic capacity and antioxidant enzyme activities in almond seedlings affected by salinity stress. Photosynthetic, 54(2): 267- 274.

Bai, N.R.; Christi, R.M. and Kala, T.C. (2011). Effect of seaweed concentrate of *Padina pavonia* on growth and yield of a pulse crops. Plant Archives, 11: 117-120.

Bharati, P. and Vaidehi, M.P. (1989). Treatment of sorghum grains with calcium hydroxide Calcium enrichment. Food and Nutrition Bulletin, II (2).

Egli, D.B. and Tekrony, D.M. (1995). Soybean seed germination, vigor and field emergence. Seed Sci. Technol., 2(3): 595-607.

EL-Sheekh, M.M. and El-Saied, (2000). Effect of crude Seaweed extracts on seed germination, seedling growth and some metabolic processes of *Vicia faba* L. Cytobios.101: 23-35.

Kavipriya, R.; Dhanalakshmi, P.K.; Jayashree, S. and Thangaaju, N. (2011). Seaweed-extract as a bio stimulant for Legume crop, green gram. Journal of Ecobiotechnolog, 3(8): 16-19.

Kor, N.M.; Didarshetaban, M.B. and Pour, H.R.S. (2013). Fenugreek *(Trigonella Foenum-graecum* L.) As a valuable Medicinal Plant. Int. J. of Advanced Biological and Biomedical Research.1(8): 922-931.

Kumari, K.A.; Kumar, K.N. and Rao, Ch.N. (2014). Advers effects of chemical fertilizers and pesticides on human health and environment. Journal of Chemical and Pharmaceutical Science, 2115, Special Issue 3, ISSN: 0974- 2115.

Mohammad, H.A. (2014). The effect of supplemental irrigation and foliar application of potassium and boron on growth and yield for faba bean (*Vicia faba* L.) Diyala Journal of Agricultural sciences, 6(1): 187- 201.

Mohammed, H.A.; Bedwi, T.K. and Shamsullah, J.A. (2018). Reduction of the negative effect of moisture tension by the effect of spraying cucumber with boron and bracinolite. Biochemical and Cell. Arch. 18 (Supplement 1). 1145–1155.

Oglu, M.A.S. (2018). Effect of soaking with gibberellic acid, spraying humus acids and Seaweed extract on growth, flowering, corms and cormels production of gladiolus. M.Sc. Collage of Agriculture, University of Diyala.

Page, A.I.; Miller, R.H. and Keeney, D.R. (1982). Methods of soils analysis part 2. Chimerical and microbiological properties. Amer. Soc. Agron. Midison, Wisconsin, USA.

Sabongari, S. and Aliero, B.L. (2004). Effect of soaking duration on germination and seedling growth of tomato (*Cycopersicum esculentum* Mill.). African Journal of Biotechnology, 3(1): 47-51.

Shapiro, K. and William C.G. (2002). Natural products used for diabetes. Journal of the American Pharmaceutical Association 42.2: 217-226.

Siah, W.M.; Aminah, A. and Ishak, A. (2014). Optimization of soaking conditions for the production of seaweed (*Kappaphycus alverazii*) paste using response surface methodology. Inter. Food Research J. 21(1): 471-477.

Spinelli, F.; Fiori, G.; Noferini, M.; Sprocatti, M. and Costa, G. (2009). Perspectives on the use of a seaweed extract to moderate the negative effects of alternate bearing in apple trees. J. Hort. Sci. Biotechn. 84(6):131-137.

Taiz, L. and Zeiger, E. (2010). Plant physiology. 5th (ed.), Sianauer Associates Sunderland, UK: 629.

Thachuk, R.J.H.; Rachi, K.O. and Billingaleyed, W (1977). Calculation of the nitrogen to protein conversion factor in nusle nutritional standards and methods of evaluation for food legume breeders. Intern. Develop, Res. Center, Ottawa. 78–82.

Wang, Q.; Shi, W.Y.; Rong, F.J.; Ma, J.W.; Guan, C.H. and Jiang, L.N. (2005). The effect of the liquid seaweed extract on resisting salinity stress of cucumber. Acta-Agriculture –Zhejiangensis. 17: 268-272.