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Effect Of Seaweed Extracts On The Growth And Biochemical Constituents Of Wheat

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ABSTRACT: In the present study, the effect of seaweed liquid fertilizer (SLF) of Ulva fasciata, Nizimuddinia zunardini and Gracilaria corticata without chemical fertilizer on seed germination, growth parameter, pigment and carbohydrate content of Wheat var. (Chamran) was investigated. The seeds soaked with aqueous extract of seaweeds performed better when compared to the water soaked controls. The 10% concentration of aqueous extracts of N. zunardini and G. corticata and 20% concentration of U. fasciata promoted the seedling growth including the parameters of germination percentage (95.1%, 96.4%, 90.3%), shoot length (9.8, 9.15, 10.46 cm), root length (5.78, 6.30, 6.16 cm), fresh weight of shoot (3.09, 2.83, 2.69 g), fresh weight of root (2.14, 1.87, 2.56 g), dry weight of shoot (0.27, 0.25, 0.23 g) and dry weight of root (0.15, 0.14, 0.13 g), chlorophyll a (0.21, 0.19, 0.19 mgg^{-1} fr. Wt.), b (0.06, 0.04, 0.03 mgg^{-1} fr. Wt.) , total (0.27, 0.23, 0.22 mgg^{-1} fr. Wt.), carotenoids (0.09, 0.09, 0.09 mgg^{-1} fr. Wt.) and carbohydrate (21.57, 22.23, 24.63 mgg^{-1} fr. Wt.) content in wheat. Among the three seaweed liquid fertilizers N. zunardini exhibited better responses.
Keywords: seaweed liquid fertilizer(SLF), Triticum aestivum, Ulva fasciata, Nizimuddinia zunardini, Gracilaria corticata

INTRODUCTION

Fertilizer is one of the most important inputs in agricultural production. There is growing concern about hazardous effects of chemical fertilizers, in particular nitrogen, on the environment and human health directly or indirectly (Dubey, 2010). Consequently, farmers began to shift from chemical-based conventional farming methods towards organic, alternative, or low input sustainable agriculture. With increasing demand, availability of organic fertilizers from one or two sources was not adequate. To meet the increasing demand many viable options have to be explored and one such option is the use of seaweed extracts as fertilizer (Mukesh, 2013). Seaweeds have been used as manure, cattle feed, food for human consumption and as a source of phycocolloids such as agar, alginic acid and carrageenan. Besides their application as farmyard manure (FYM), liquid extracts obtained from seaweeds (LSF/ SLF) have recently gained importance as foliar sprays for several crops because the extract contains growth promoting hormones (IAA and IBA), cytokinins, trace elements (Fe,Cu,Zn,Co,Mo,Mn,Ni), vitamins and amino acids (Sivasankari, 2006). Seaweed extracts have been reported to stimulate the growth and yield of plants, develop tolerance to environment stress, increase nutrient uptake from soil and enhance antioxidant properties (Rathore, 2009). Thus, these extracts when applied to seeds or when added to the soil, stimulate growth of the plants (Blunden, 1971). Earlier studies have shown that application of three seaweed suspensions enhanced seed germination of Tomato, Pepper and Aubrtgine (Demir et al., 2006). Extract of Ascophyllum nodosum was found to be an effective stimulant for the germination of Orobanche ramose seeds (Economou et al., 2007). Aqueous extract of Sargassum wightii when applied as a foliar spray on Ziziphus mauritiana showed an increased yield and quality of fruit (Rao, 1991). Sridhar (2011) observed that the seeds of five treated plants with 1.0% SLF of Ulva lactuca and Sargassum wightii have an increased on germination and protein profile. Earlier study reveals that SLF of Ulva reticulata could be used as foliar spray at low concentration 2% to maximize the growth and yield of Vigna mungo and also increase the number of stomata in the leaf (Ganapathy, 2013). Seaweed extracts are now available commercially under the names, such as Maxicrop (Sea born), Algifert (marinure), Goemar GA14, Kelpak 66, Seaspray, Seasol, SM3, Cytex and Seacrop 16. Recently researchers proved that seaweed fertilizers are better than other fertilizers and are very economical (Sivasangari et al., 2011).

Importance of wheat worldwide as a main food can be understood by utilization of stylized wheat spike as a symbol of FAO. Wheat (Triticum aestivum L.) ranks first with respect to area and production among the other food grain crops on global basis. The nutritional value of wheat is extremely important as it takes an important place among the few crop species being extensively grown as staple food sources and main source of nutrients to most of the world's population (Mukesh, 2013).

The application of seaweed concentrates has been reported many beneficial effects on plant in general and on wheat in particular (Beckett and van Staden, 1990). The present study was undertaken to investigate the effect of seaweed liquid fertilizers (SLF) on the growth and biochemical characteristics of Wheat var. 'Chamran'.

MATERIALS AND METHODS

Collection of seaweeds

The seaweeds used in the present study were Ulva fasciata, Nizimuddinia zunardini and Gracilaria corticata belonging to the classes Chlorophyceae, Phaeophyceae and Rhodophyceae, respectively. They were collected from the coastal area of Chabahar, Iran (25° 17_ N and 60° 37_ E) during November, 2013. The seaweeds were handpicked and washed thoroughly with seawater to remove all the unwanted impurities.

Preparation of seaweed liquid fertilizer

Freshly collected seaweeds were shade dried for ten days. Dried material was finely powdered. Fifty gram of finely powdered material was extracted with 500 mL boiling water for 60 min and then filtered. The resulting extract was cooled and taken as 100% concentration of the SLF (Ramarajan, 2012). As the seaweed liquid fertilizers contained organic matter, the seaweed liquid fertilizers were refrigerated between 0 and 4 °C.

Physico-chemical analyses of SLF

The color, pH, nitrate, phosphorus, potassium, iron, zinc, copper and manganese content were analyzed and are described in table 1.

Experimental design and treatments

The seeds of Wheat were collected from Chamran University, Khozestan, Ahvaz, Iran. They were surface sterilized with 5% sodium hypochlorite. The seeds with uniform size, color and weight were chosen for the experimental purpose. Hundred seeds were soaked in the 5 petriplates for each treatment. The treatments were 2.5%, 5%, 7.5%, 10% and 20% aqueous extracts of seaweeds. Five petriplates of seeds were considered as the control and they were watered with 10ml of distilled water and the remainders of them were treated with 10 ml of 2.5%, 5%, 7.5%, 10% and 20% of aqueous seaweed extract at the first and three days later. All petriplates were 80 and they were taken on 7th day after sowing.

Growth and biochemical analysis

The growth parameters including germination percentage, fresh and dry weight, shoot length and root length were calculated. The biochemical constituents such as chlorophyll a, b, and total chlorophyll content, carotenoid and total sugar content were estimated in Wheat.

RESULTS

The physico-chemical properties of SLF of U. fasciata, N. zunardini and G. corticata were analyzed and are presented in Table 1. The colour of the SLF of U. fasciata was light green and N. zunardini was brown and G. corticata was pink. The pH of SLF of U. fasciata was 6.8 and SLF of N. zunardini was 7.2 and SLF of G. corticata was 6.2. Among the three seaweed liquid fertilizers, the SLF of N. zunardini contained higher levels of potassium, phosphorus, iron, Magnesium, copper and nitrate than the SLF of U. fasciata and G. corticata. The amount of Zinc was high in U. fasciata than in G. corticata and N. zunardini. The effect of extract of U. fasciata, N. zunardini and G. corticata on germination percentage, shoot length, root length, fresh and dry weight of shoot and fresh and dry weight of root of Wheat is presented in Tables 2, 3 and 4. The greatest seed germination was found at 20% concentration of U. fasciata, 10 concemtration of N. zunardini and G. corticata respectively. The germination percentage of N. zunardini and G. corticata increased with concentration levels up to 10% and there after it declined. The lowest germination percentage was found at 7/5% extract of U. fasciata and 2/5% extract of N. zunardini and 20% extract of G. corticata treated water soaked seeds respectively.

Table 1 . Physico-chemical properties of SLF of Ulva fasciata, Nizimuddinia zunardini and Gracilaria corticata

General parameters	Ulva fasciata	Nizimuddinia zunardini	Gracilaria corticata
Color	Light green	Brown	Pink
pH	6.8	7.2	6.2
Chemical parameters			
Nitrate	14	146	57
Phosphorus	ND	32	16
Potassium	136	234	84
Iron	0.32	0.89	0.44
Zinc	1.1	0.87	0.75
Copper	0.88	1.4	0.98
Magnesium	102.4	132.5	99.8

All the parameters are expressed in mg/l except colour and pH

Table 2. Effect of SLF of Nizimuddinia zunardini on germination and growth of wheat seedlings

concentration	Germination percent	Shoot length (cm)	Root length (cm)	Fresh weight of shoot(g)	Dry weight of shoot(g)	Fresh weight of root(g)	Dry weight of root(g)
0	80.23±0.410^{cde}	4.84±0.047^{b}	4.69±0.035^{cd}	0.403±0.002^{b}	.055±0.001^{ab}	0.260±.003^{b}	0.036±0.000^{de}
2.5	76.63±0.902^{bcd}	8.35±0.051^{e}	5.30±0.027^{ef}	0.731±0.008^{f}	0.283±0.213^{ab}	0.317±0.002^{c}	0.035±0.000^{d}
5	83.27±0.549^{ef}	8.54±0.045^{e}	5.52±0.043^{ef}	0.816±0.002^{h}	0.072±0.000^{ab}	0.373±0.006^{d}	0.036±0.001^{de}
7.5	88.67±4.372^{g}	8.91±0.041^{fg}	5.63±0.082^{fg}	0.845±0.007^{i}	0.299±0.225^{b}	0.632±0.004^{k}	0.040±0.001^{f}
10	95.10±0.493^{i}	9.84±0.064^{i}	5.76±0.055^{gh}	1.06±0.022^{l}	0.092±0.001^{ab}	0.723±0.005^{m}	0.048±0.001^{i}
20	90.10±0.493^{gh}	3.88±0.063^{a}	4.06±0.039^{a}	0.550±0.007^{c}	0.063±0.001^{ab}	0.134±0.005^{a}	0.021±0.001^{a}

Values are mean ±SD; Different letters in a single column show statistically significant differences according to Duncan's multiple range test ($p = 0.05$).

Table 3. Effect of SLF of Gracilaria corticata on germination and growth of wheat seedlings

concentration	Germination percent	Shoot length (cm)	Root length (cm)	Fresh weight of shoot (g)	Dry weight of shoot (g)	Fresh weight of root (g)	Dry weight of root (g)
0	80.53±0.578^{def}	4.60±0.578^{b}	4.80±0.080^{cd}	0.414±0.005^{b}	0.063±0.00005^{ab}	0.257±0.004^{b}	0.033±0.001^{c}
2.5	76.30±0.964^{bc}	8.38±0.073^{e}	4.95±0.038^{d}	0.754±0.004^{fg}	0.070±0.0005^{ab}	0.406±0.004^{e}	0.036±0.001^{de}
5	91.03±0.578^{gh}	8.66±0.076^{ef}	5.75±0.029^{gh}	0.763±0.005^{g}	0.073±0.0005^{ab}	0.423±0.003^{f}	0.041±0.001^{fg}
7.5	93.47±0.555^{hi}	8.84±0.084^{f}	5.90±0.029^{hi}	0.842±0.016^{hi}	0.077±0.0008^{ab}	0.578±0.007^{j}	0.042±0.001^{h}
10	96.37±0.561^{i}	9.15±0.063^{g}	6.30±0.032^{j}	0.940±0.015^{k}	0.085±0.0014^{ab}	0.620±0.002^{k}	0.047±0.001^{i}
20	69.73±0.592^{a}	5.40±0.156^{c}	4.31±0.093^{ab}	0.353±0.007^{a}	0.044±0.0023^{a}	0.261±0.001^{b}	0.027±0.001^{b}

Values are mean ±SD; Different letters in a single column show statistically significant differences according to Duncan's multiple range test ($p = 0.05$).

Table 4. Effect of SLF of Ulva fasciata on germination and growth of wheat seedlings

Concentration	Germination percent	Shoot length (cm)	Root length (cm)	Fresh weight of shoot(g)	Dry weight of shoot(g)	Fresh weight of root(g)	Dry weight of root(g)
0	81.90±0.723^{ef}	4.58±0.120^{b}	4.40±0.148^{b}	0.371±0.004^{a}	0.047±0.001^{ab}	0.265±0.004^{b}	0.041±0.000^{fg}
2.5	84.50±1.50^{f}	9.55±0.057^{h}	6.08±0.023^{ij}	0.876±0.006^{j}	0.070±0.001^{ab}	0.692±0.003^{l}	0.041±0.001^{fg}
5	80.00±0.577^{cde}	7.49±0.094^{d}	5.28±0.151^{e}	0.661±0.006^{e}	0.063±0.001^{ab}	0.537±0.013^{i}	0.038±0.001^{e}
7.5	73.13±0.899^{ab}	7.37±0.127^{d}	4.52±0.202^{bc}	0.623±0.007^{d}	0.060±0.001^{ab}	0.476±0.006^{g}	0.027±0.001^{b}
10	76.43±1.07^{bc}	8.42±0.210^{e}	5.58±0.125^{efg}	0.656±0.004^{e}	0.067±0.001^{ab}	0.509±0.002^{h}	0.036±0.001^{de}
20	90.33±0.882^{gh}	10.45±0.035^{j}	6.37±0.175^{j}	0.891±0.004^{j}	0.078±0.001^{ab}	0.856±0.008^{n}	0.044±0.001^{i}

Values are mean ±SD; Different letters in a single column show statistically significant differences according to Duncan's multiple range test ($p = 0.05$).

Table 5. Effect of SLF of Nizimuddinia zunardini on biochemical constituent of wheat seedlings

concentration	Chlorophyll a (mgg^{-1} fr. wt.)	Chlorophyll b (mgg^{-1} fr. wt.)	Chlorophyll total (mgg^{-1} fr. wt.)	Carotenoid (mgg^{-1} fr. wt.)	Carbohydrate (mgg^{-1} Dr. wt.)
0	0.160±0.003^{bc}	0.024±0.001^{ab}	0.184±0.002^{b}	0.088±0.001^{efg}	18.40±0.624^{ef}
2.5	0.177±0.001^{g}	0.031±0.001^{ef}	0.208±0.002^{f}	0.086±0.000^{de}	10.77±0.260^{a}
5	0.190±0.001^{hi}	0.034±0.001^{h}	0.224±0.001^{gh}	0.088±0.001^{efg}	15.23±0.233^{bc}
7.5	0.194±0.001^{i}	0.039±0.001^{i}	0.233±0.001^{i}	0.089±0.001^{fg}	16.13±0.425^{cd}
10	0.208±0.001^{k}	0.060±0.001^{k}	0.268±0.001^{k}	0.094±0.001^{hi}	21.57±0.433^{hi}
20	0.203±0.001^{j}	0.038±0.001^{i}	0.242±0.000^{j}	0.091±0.001^{gh}	18.50±0.737^{ef}

Values are mean ±SD; Different letters in a single column show statistically significant differences according to Duncan's multiple range test ($p = 0.05$).

Table 6. Effect of SLF of Gracilaria corticata on biochemical constituent of wheat seedlings

concentration	Chlorophyll a (mgg^{-1} fr. wt.)	Chlorophyll b (mgg^{-1} fr. wt.)	Chlorophyll total (mgg^{-1} fr. wt.)	Carotenoid (mgg^{-1} fr. wt.)	Carbohydrate (mgg^{-1} Dr. wt.)
0	0.155±0.001^{ab}	0.021±0.001^{a}	0.177±0.001^{a}	0.080±0.001^{ab}	17.90±0.568^{e}
2.5	0.160±0.001^{bc}	0.029±0.001^{de}	0.189±0.000^{bc}	0.084±0.001^{cd}	13.97±0.328^{b}
5	0.164±0.001^{cd}	0.033±0.001^{gh}	0.197±0.001^{de}	0.088±0.000^{ef}	18.33±0.371^{ef}
7.5	0.170±0.001^{ef}	0.038±0.001^{i}	0.208±0.001^{f}	0.089±0.000^{efg}	20.70±0.305^{gh}
10	0.186±0.002^{h}	0.042±0.001^{g}	0.228±0.002^{hi}	0.097±0.001^{j}	22.23±0.440^{i}
20	0.173±0.001^{fg}	0.039±0.001^{i}	0.211±0.002^{f}	0.095±0.001^{ij}	16.17±0.233^{cd}

Values are mean ±SD; Different letters in a single column show statistically significant differences according to Duncan's multiple range test (p = 0.05)

Table 7. Effect of SLF of Ulva fasciata on biochemical constituent of wheat seedlings

concentration	Chlorophyll a (mgg^{-1} fr. wt.)	Chlorophyll b (mgg^{-1} fr. wt.)	Chlorophyll total (mgg^{-1} fr. wt.)	Carotenoid (mgg^{-1} fr. wt.)	Carbohydrate (mgg^{-1} Dr. wt.)
0	0.166 ± 0.002^{de}	0.026 ± 0.001^{bc}	0.192 ± 0.002^{cd}	0.092 ± 0.002^{hi}	17.27 ± 0.409^{de}
2.5	0.171 ± 0.001^{ef}	0.030 ± 0.001^{de}	0.200 ± 0.001^{e}	0.087 ± 0.001^{def}	20.57 ± 0.497^{gh}
5	0.163 ± 0.002^{cd}	0.027 ± 0.001^{cd}	0.190 ± 0.003^{c}	0.083 ± 0.002^{bc}	19.57 ± 0.504^{fg}
7.5	0.154 ± 0.002^{a}	0.024 ± 0.001^{ab}	0.177 ± 0.002^{a}	0.079 ± 0.001^{a}	15.47 ± 0.296^{c}
10	0.164 ± 0.002^{cd}	0.028 ± 0.002^{cd}	0.192 ± 0.005^{cd}	0.084 ± 0.001^{c}	17.63 ± 0.674^{e}
20	0.189 ± 0.001^{hi}	0.032 ± 0.001^{fg}	0.221 ± 0.001^{g}	0.093 ± 0.001^{hi}	24.63 ± 0.783^{j}

Values are mean ±SD; Different letters in a single column show statistically significant differences according to Duncan's multiple range test (p = 0.05

In the U. fasciata the highest shoot length, root length, fresh and dry weight of shoot and fresh and dry weight of root was observed at 20% concentration and the lowest parameter was found at 7.5% concentration. In the N. zunardini the highest shoot length, root length, fresh and dry weight of shoot and fresh and dry weight of root were found at 10% concentration and the lowest parameter was observed at 20% concentration. In the G. corticata the highest shoot length, root length, fresh and dry weight of shoot and fresh and dry weight of root were found at 10% concentration and the lowest parameter was observed at 20% concentration. In general the highest shoot length and fresh weight of root was in the U. fasciata and the highest fresh and dry weight of shoot and dry weight of root was in the N. zunardini and the highest root length was in the G. corticata.

The data of various biochemical studies are presented in Tables 5, 6 and 7. There were significant differences in biochemical status of different concentration levels. In the U. fasciata the highest values of chlorophyll a, chlorophyll b, total chlorophyll, carotenoid and carbohydrate were observed at 20% concentration. In the N. zunardini the highest values of chlorophyll a, chlorophyll b, total chlorophyll, carotenoid and carbohydrate were recorded at 10% concentration. In the G. corticata the highest values of chlorophyll a, chlorophyll b, total chlorophyll, carotenoid and carbohydrate were recorded at 10% concentration. In general the highest content of chlorophyll a, b, and total chlorophyll was found in the N. zunardini and the highest content of carotenoid was observed in the G. corticata and the highest content of carbohydrate was found in the U. fasciata.

DISCUSSION

The present study shows that the percentage of seed germination of T. aestivum seeds soaked with SLF was increased with compared to control. Similar results were also observed in Cajanus cajan (Kalaivanan et al., 2012) and Lycopersicon spp. (Alalwani et al., 2012). This may be due to the presence of growth-promoting substances such as IAA and IBA, Gibberellins (A&B), cytokinins, in SLF (Gupta, 2012). Growth hormones can trigger the de novo synthesis of hydrolytic enzymes which would increase ameliorating effect (Ramarajan, 2012).

There was an increase in vegetative growth parameters by the application of seaweed extract. This is coincided with those of earlier studies made in Phaseolus vulgaris L. (Kocira et al., 2013). The increased seedling growth may be due to the presence of phenyl acetic acid (PAA) and other closely related compounds (P-CH-PAA). It was reported that the presence of plant growth regulators, trace elements, vitamins, micronutrients and amino acids in the low concentration of SLF enhance the growth of root and shoot(Nedumaran, 2012). Auxin plays a key role in growth of plants. By increasing and activating H-ATPase pumps, Auxin sends protons to apoplast space. Resulting from decreasing pH, some enzymes will be activated which loosen cell wall. Auxin also by increasing production of some soluble materials inside the cell, decrease the water potential and finally let water enter to the cells. These procedures lead to growth of cell and finally growth of plant (Taize & Zieger, 2006).

There was significant increase in chlorophyll content in leaves under different treatments and maximum (10% concentration of N. zunardini and G. corticata and 20% concentration of U. fasciata) was recorded. Our results confirm those previously reported by Thambiraj et al., (2012) who noted increased content of total chlorophylls in Cyamopsis tetragonoloba (L). with seaweed concentrate application. Blunden (1997) reported that when inorganic constituents of the SLF applied in quantities equal to those present in the SLF, did not produce a significant difference in leaf chlorophyll contents between control and test plants. This strongly indicated that the active components of the extract are organic. The higher chlorophyll concentrations in the leaves resulting from application of the seaweed extract could be achieved also by using the solution of betaines. These data strongly indicate that the effects on leaf chlorophyll contents produced by the use of seaweed extracts are due to the betaines contained in them. It appears probable that the activity of the seaweed extract and the betaines is the result of slowing down the degradation of leaf chlorophyll rather than increasing its content.

The total carbohydrate content increased in seaweed treated plants. This also has been seen in Trigonella foenum-greacum L. which treated with seaweeds (Pise, 2010). This may be due to increasing of chlorophyll which can improve photosynthesis so it would increase production of carbohydrate and alternative explanation is that organic molecules such as organic acids, methionine and even PAs in SLF can increase nutrient absorption in plants by chelating to the available nutrients, thereby increasing their absorbance and so can increase carbohydrates (Papenfus, 2013).

CONCLUSION

Of the three seaweeds tested, the extract prepared from N. zunardini, was found to be promising in possessing fertilizer activity. Hence, this simple practice of application of ecofriendly seaweed liquid fertilizers to pulses is recommended to the growers for attaining better germination, growth and yield.

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