J Appl Phycol (2011) 23:251–255
DOI 10.1007/s10811-011-9660-9

Effect of seaweed liquid extract on growth and yield of *Triticum aestivum* var. Pusa Gold

Gaurav Kumar · Dinabandhu Sahoo

Received: 6 February 2010 / Revised and accepted: 24 January 2011 / Published online: 19 February 2011

Abstract The effect of seaweed liquid extract (SLE) of *Sargassum wightii* on germination, growth and yield of *Triticum aestivum* var. Pusa Gold was studied. Application of a lower concentration (20%) of SLE enhanced the percentage of seed germination, growth and yield, as measured by kernel number and seed dry weight. All growth and yield parameters were found to be highest at the 20% concentration SLE treatment. Total (100%) seed germination was observed for the 20% concentration SLE treatment, an 11% increase over the control. The present study demonstrated that seaweed liquid extract could serve as an alternative biofertilizer as is eco-friendly, cheaper, deliver substantial economic and environmental benefits to farmers.

Keywords Biofertilizer · Germination · *Sargassum wightii* · Phaeophyta

Introduction

India is mainly an agricultural country with approximately 70% of the population located in rural areas and directly engaged in agriculture. The growing population is placing pressure on food production and to meet this increasing demand, farmers are using chemical fertilizers to enhance their crop production. Chemical fertilizers mixed with pesticides get accumulated in plants which lead to health problems in humans due to biomagnification (Hansra 1993). The adverse effect of inorganic fertilizers on soil and environment is leading science to examine alternative biofertilizers (Metting et al. 1990).

Seaweeds are important marine renewable resources. They are used as food, feed, fodder, fertilizer, agar, alginate, carrageenan and source of various fine chemicals (Sahoo 2000). In recent years, the use of natural seaweeds as fertilizer (Hong et al. 2007) has allowed for substitution in place of conventional synthetic fertilizer (Crouch and van Staden 1993). Seaweeds extracts are marketed as liquid fertilizers and biostimulants since they contain many growth regulators such as cytokinins (Durand et al. 2003; Stirk et al. 2003), auxins (Stirk et al. 2004), gibberellins (Wildgoose et al. 1978), betaines (Blunden et al. 1991; Wu et al. 1997), macronutrients such as Ca, K, P, and micronutrients like Fe, Cu, Zn, B, Mn, Co, and Mo (Khan et al. 2009), necessary for the development and growth of plants. Seaweeds and seaweed extracts also enhance soil health by improving moisture holding capacity (Moore 2004) and by promoting the growth of beneficial soil microbes (Khan et al. 2009).

Seaweed extracts are known to enhance the growth of vegetables, fruits, and other crops (Blunden 1991; Crouch and van Staden 1994; Washington et al. 1999). Seaweed extracts when applied to seeds, added to the soil or sprayed on crops at vegetative and flowering stages, can stimulate seed germination (Hong et al. 2007), growth (Moore 2004; Khan et al. 2009), and yield (Arthur et al. 2003; Norrie and Keathley 2006) of various crops (Masny et al. 2004; Ei-Zeiny 2007; Kumar 2008). Plants treated with seaweed extract have been reported to show increased nutrient uptake (Mancuso et al. 2006), better plant growth, deep root development by improving lateral root formation (Atzmon and van Staden 1994) and increased total volume of the root system (Slàvik 2005). Seaweed extract also

This paper was presented at the 7th Asia Pacific Congress on Algal Biotechnology, New Delhi, 2009

G. Kumar · D. Sahoo (✉)
Marine Biotechnology Laboratory, Department of Botany, University of Delhi,
Delhi 110007, India
e-mail: dbsahoo@hotmail.com

enhances plant defense against pest and diseases (Allen et al. 2001; Cluzet et al. 2004) increase salt tolerance (Mancuso et al. 2006), drought tolerance (Zhang and Ervin 2004), and heat tolerance (Zhang and Ervin 2008). There is not much information available about the application of seaweed liquid extract (SLE) on growth and yield of wheat plants. Thus, the present study is an attempt to examine the effect of SLE on wheat plants.

Materials and methods

For this study, the seaweed *Sargassum wightii* Greville (Phaeophyceae, Sargassaceae) was collected from Thirumullavaram, Kerala, India in January, March, June and September, 2007. Plants collected in the field were cleaned with seawater to remove sand and epiphytes, shade-dried, and transported to laboratory.

The crop plant, used in the present study was wheat, i.e., *Triticum aestivum* var. Pusa Gold (Poaceae). Seeds of *T. aestivum* were obtained from National Seeds Corporation (IARI) Pusa, New Delhi, India.

Preparation of seaweed liquid extract One kilogram of seaweed was finely chopped and boiled with 1 L of distilled water for 1 h in water bath and then extract was filtered through muslin cloth. The filtrate was allowed to cool at room temperature thereafter filtered through Whatman filter paper no. 41 (pore size 20–25 μm). The filtrate was a 100% seaweed extract (Bhosle et al. 1975). Different concentrations of SLE (5, 10, 20, 30, 40 and 50%) were prepared by diluting this extract with distilled water. The seaweed extract was stored at 4°C for further applications.

Experiment Seeds with uniform shape, size, color, and weight were selected for soaking in seaweed extract. One hundred seeds in ten replicates each were soaked for each concentration of seaweed liquid extract for 24 h. Control seeds were soaked in distilled water for 24 h. After an incubation period of 24 h at room temperature (24±2°C), seeds were placed on Petri plates containing filter paper. Seed containing Petri plates were placed at temperature 21°C, light intensity of approximately 100 μmol photons m^{-2} s^{-1} for 12 h in a germinator. The filter paper was kept moist by regular addition of distilled water for control seeds and SLE for treatment seeds. Parameters such as seed germination, root length, shoot length, and number of lateral roots was regularly monitored every fifth day, till 25 days of growth. The soaked seeds were also transferred to the field and were regularly monitored with an interval of 5 days, for number of branches, number of kernels, kernel length, number of seeds per kernel, and dry weight of seeds. The experiment was terminated after a period of 4 months.

Statistical analysis One-way analysis of variance was performed on each variable. Tukey's Post hoc multiple mean comparison test was used for analysis of significant differences between treatments (at 5% level). All statistical analyses were performed with Statistical Package for Social Sciences (SPSS, version 10).

Results

The effect of the 20% SLE concentration gave an 11% increase in seed germination over control (Fig. 1a). An increase in several growth parameters such as root length, number of lateral roots, shoot length and number of

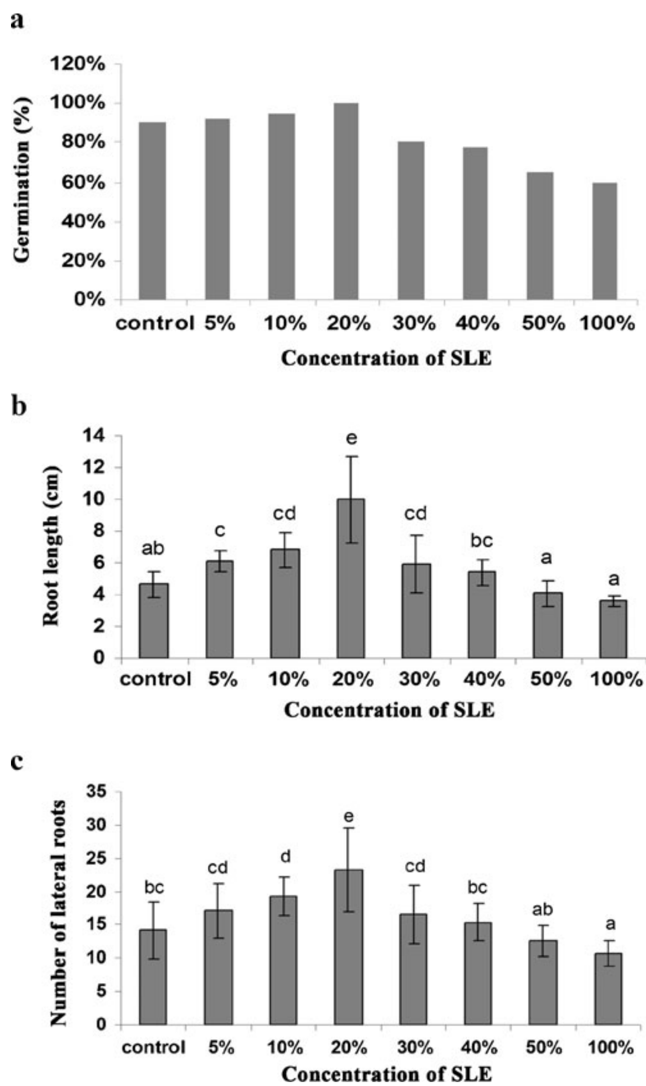

Fig. 1 **a** Seed germination percentage, **b** root length and **c** Number of lateral roots of wheat plants under control and different concentrations of seaweed liquid extract (values are mean±SD, *n*=10)

branches were also found to be highest for the 20% SLE treatment, and declining at higher concentrations. Root length was highest for the 20% treatment (Fig. 1b). Application of 20% SLE showed a 63.38% increase in the number of lateral root as compared to control (Fig. 1c). A 6.7% increase in shoot length over control was measured 25 days after germination (Fig. 2a) and a 46.15% increase in the number of branches plant^{-1} for the same 20% treatment (Fig. 2b). The number of kernels plant^{-1} and kernel length were observed to be highest that was 54.16% and 18.75%, respectively, increased over control at 20% and lowest at the 100% SLE treatment (Figs. 2c and 3a). Treatment of 20% also gave a 13.69% increase in number of seeds kernel^{-1} and 22.86% increase in dry weight of seeds over control (Fig. 3b and c). The effect of SLE on germination, growth and yield of *T. aestivum* is shown in Table 1.

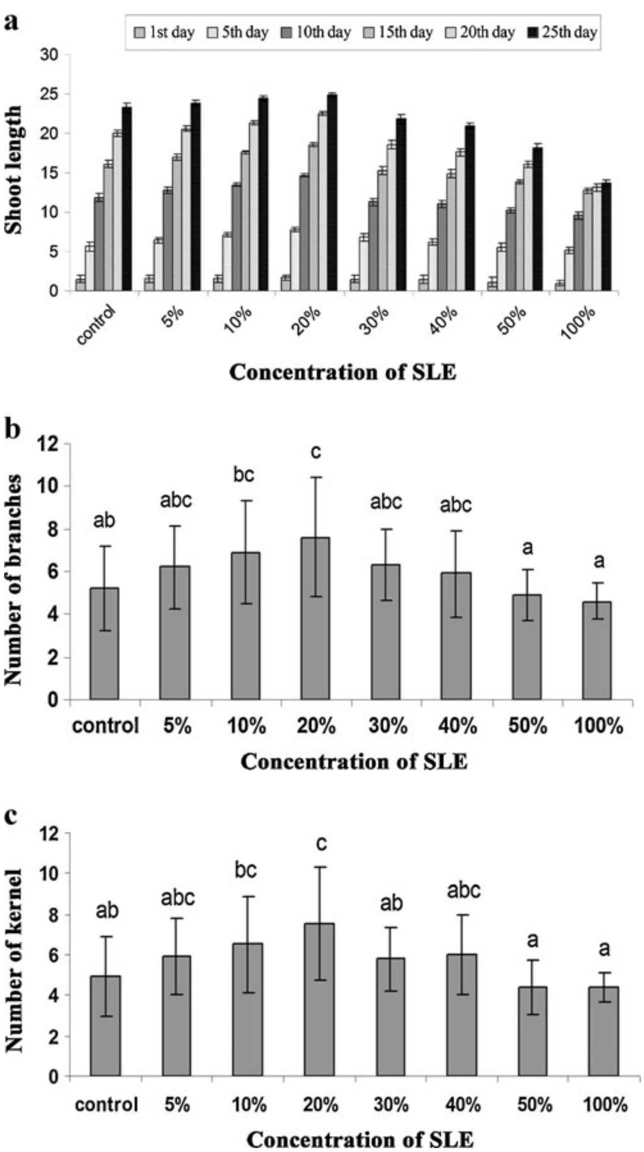

Fig. 2 **a** Shoot length, **b** number of branches plant^{-1} and **c** number of kernels plant^{-1} under control and different concentrations of seaweed liquid extract (values are mean±SD, $n=10$)

Discussion

Seaweed extracts are known to enhance the growth of vegetables, fruits, and other crops as they are reported to contain growth regulators such as auxins (IAA and IBA), gibberellins, cytokinins, betaines, and major macro- and micronutrients (Blunden et al. 1991). Thus, seaweeds are now being used as biofertilizers (Bokil et al. 1974). This study showed that the application of seaweed liquid extract enhances the germination, growth, and yield of wheat plants.

This study showed that the application of *S. wightii* seaweed liquid extract increases seed germination percentage. Seed treatment with 20% seaweed extract gave highest percentage of seed germination while 100% concentration gave least. Hong et al. (2007) reported that the percentage of germination in various crops such as vegetables and fruits were increased by using seaweeds as a biofertilizer. Xavier and Jesudass (2007) also reported that 100% seed germination was found in lower concentrations of *Caulerpa recemosa* extract. The increased germination percentage at low concentrations may be due to the presence of some growth regulators, micro- and macronutrients (Challen and Hemingway 1965).

The application of SLE-enhanced root length, number of lateral roots, shoot length and number of branches increased maximum for the 20% treatment. Beyond this concentration, these variables decreased substantially. The lowest root length, number of lateral roots, shoot length, and number of branches were observed for the 100% SLE concentration. Rayorath et al. (2008) reported an increase in root length (up to 32%) with the application of extract from *Ascophyllum nodosum*. Seaweed concentrate prepared from *Ecklonia maxima* was found to enhance root growth of tomato at 0.4% concentration (Crouch and van Staden 1992).

The number of lateral roots in *Vigna sinensis* was observed to be highest at a 20% concentration and the minimum number of lateral roots was recorded for a 100% concentration of *S. wightii* extract (Sivasankari et al. 2006). Tomato plants treated with lower concentration (0.4%) of *E. maxima* extract showed an increase in plant height (Crouch and van Staden 1992). Anantharaj and Venkatesalu (2002) observed that the number of branching increases after the application of seaweed extracts on *Dolichos biflorus*. Significant differences at 5% level of significance ($P \leq 0.05$) were observed for root length, number of lateral roots, and number of branches at 20% SLE treatment.

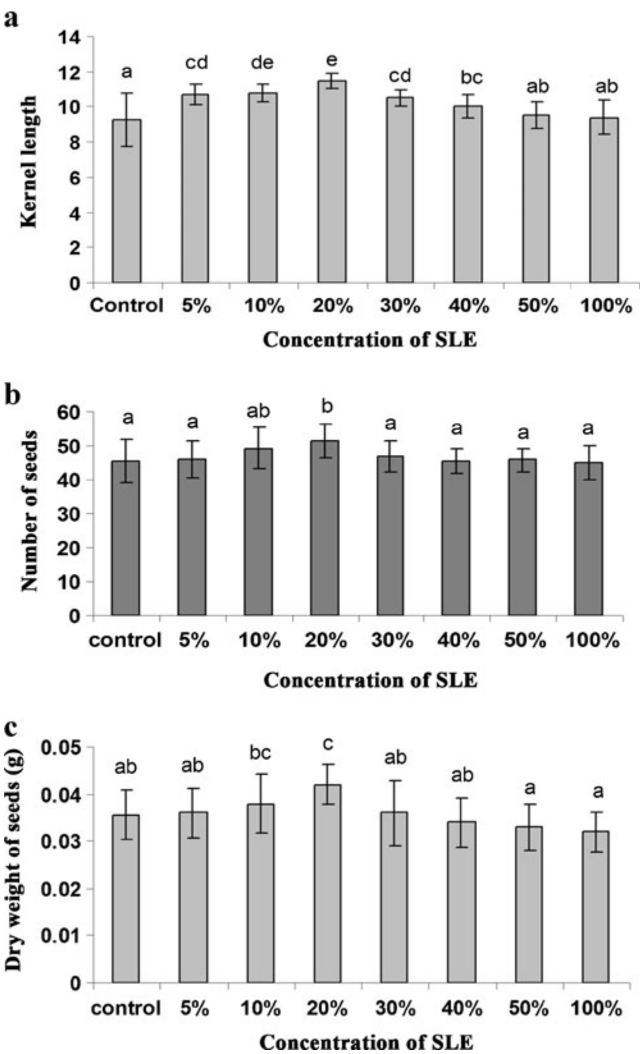

Fig. 3 **a** Kernel length, **b** number of seeds kernel^{-1} and **c** dry weight of seeds under control and different concentrations of seaweed liquid extract (values are mean±SD, n=10)

The present investigation clearly demonstrated that SLE enhanced the reproductive parameters. The number of kernels plant^{-1}, kernel length, number of seeds kernel^{-1} and dry weight of seeds increased to highest at 20% concentration and lowest in 100% concentration of SLE. Plants sprayed with 0.4% concentration of seaweed concentrate of *Ecklonia* showed 10% increase in fruit number (Crouch and van Staden 1992). The pod yield for beans increased after foliar spray with crude extracts of *Macrocystis integrifolia* and *E. maxima* (Temple and Bomke 1989). Similarly, a substantial increase in yield was achieved in Thompson seedless' grape *Vitis vinifera* and peppers (Norrie and Keathley 2006; Arthur et al. 2003), respectively. The effects of the application of seaweed fertilizers in improving total fruit production may be related to the effect of cytokinins (Featonby-Smith 1984). Kumar et al. (2007) also reported highest fruit length of *Abelmoscus esculantus* following treatment with a 5% SLE fertilizer.

Foliar applications of an aqueous extract of *Hypnea musciformis* increased the yield of tea by 14% over control (Thevanathan et al. 2005). Kelpak seaweed concentrate increased the number of grains in wheat (Beckett and van Staden 1989). The highest increase in dry weight was observed at 20% SLE and the lowest for the 100% treatment with *S. wightii* extract (Sivasankari et al. 2006). Kelpak at lower concentrations increased the grain weight of wheat (Beckett and van Staden 1989). Significant differences at 5% level of significance ($P \leq 0.05$) were observed for number of kernels plant^{-1}, kernel length, number of seeds kernel^{-1}, and dry weight of seed. Treatment of 20% SLE produced positive response over others. Liquid extract prepared from *S. wightii* was found to have promising fertilizer activity. Finally, the application of low SLE concentrations may increase plant growth and deliver substantial economic and environmental benefits to farmers. Thus, the present study demonstrated that seaweed liquid extract could serve as an alternative biofertilizer as

Table 1 Effect of SLE on germination, growth, and yield of *Triticum aestivum*

Parameters	Control	Maximum in 20% concentration of SLE	Minimum in 100% concentration of SLE
Germination (%)	90	100	60
Root length (cm seedling^{-1})	4.71±0.77	11.96±2.63	3.49±0.37
Number of lateral roots (lateral roots seedling^{-1})	14.2±4.29	23.2±6.29	10.6±1.90
Shoot length at 25th day (cm seedling^{-1})	23.28±0.51	24.84±0.27	13.7±0.35
Number of branches (branches plant^{-1})	5.2±1.99	7.6±2.80	4.6±0.84
Number of kernels plant^{-1}	4.8±1.87	7.4±2.87	4.1±0.99
Kernel length (cm plant^{-1})	9.31±1.41	11.48±0.39	9.37±0.93
Number of seeds kernel^{-1}	45.3±6.15	51.5±4.88	45.3±4.03
Dry weight of seeds (g)	0.035±0.005	0.043±0.005	0.031±0.003

Values are mean±SD, n=10

they are eco-friendly, cheaper and can overcome the ill-effect of chemical fertilizers along with pesticides.

Acknowledgments The authors would like to thank the University Grants Commission, New Delhi for granting fellowship for this study.

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