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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

OPEN ACCESS Pakistan Journal of Biological Sciences

ISSN 1028-8880
DOI: 10.3923/pjbs.2022.23.28

Research Article
Study the Effect of *P. minor* Seaweed Crude Extract as a Biostimulant on Soybean

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Abstract

Background and Objective: Seaweed biostimulants are often used in agriculture because of their benefits in increasing growth, production and quality of plants and are safe for the environment. *Padina minor* is one of the potential seaweeds that contains high macro and micronutrients and has also been shown to increase the vegetative growth of several plants. This study aims to determine the effect of *P. minor* seaweed extract in various concentrations and frequencies as a biostimulant on the growth and production of soybean plants. **Materials and Methods:** *Padina minor* extract was applied to soybean plants with several concentrations (0, 10, 20, 30 and 40%) at three different application times. Where 1 application (2 weeks after planting), 2 applications (2 and 4 weeks after planting) and 3 applications (2, 4 and 5 weeks after planting). **Results:** *Padina minor* extract with a concentration of 40% with 1 application was able to increase plant height and shorten soybean harvest life. While the *P. minor* extract with a concentration of 40% with two and three applications was able to increase the gross and dry weight of plants, the number of pods, gross and dry mass of whole seeds. **Conclusion:** *Padina minor* seaweed extract with a concentration of 40% was able to increase the growth and production of soybean plants.

Key words: *Padina minor*, seaweed extract, soybean, abiotic stresses, plant metabolism, planting, biostimulant

Citation: Noli, Z.A., P. Aliyyanti and Mansyurdin, 2022. Study the effect of *P. minor* seaweed crude extract as a biostimulant on soybean. Pak. J. Biol. Sci., 25: 23-28.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Biostimulants are natural or synthetic organic compounds that are not fertilizers, which can increase growth and plant response to stress. Its utilization can modify plant physiological processes such as photosynthesis and absorption of ions. Seaweed is one of the most important marine resources whose potential has not been fully explored. Therefore, seaweed extract has the opportunity to be used as a biostimulant and physioactivator that can stimulate plant growth and development. Seaweed extracts contain polysaccharides, proteins, unsaturated fatty acids, polyphenols and minerals. These components can positively influence plants, especially in germination, growth, productivity and plant resistance to biotic and abiotic stresses[1,2].

Seaweed extract biostimulants and physioactivators exert parallel effects on several processes, including activating mineral nutrients in plants by stimulating several enzymes that play vital roles in plant metabolism. These enzymes are nitrate reductase and phosphatase. In addition, seaweed can also activate photosynthesis by increasing the activity and amount of chlorophyll in the leaves and the activation of flowering and fruit formation through the mechanism of polyamine synthesis, a compound responsible for flower abundance and pollination efficiency. High polyamine stimulates the intensity of cell division which promotes an increase in the number of cells[3]. Biostimulants in seaweed extracts have been applied to several plants such as *Zea mays*, *Phaseolus vulgaris* and *Oryza sativa*[4-6].

Noli *et al.*[7] has researched by screening four types of seaweed distributed in the waters of Kasiak Gadang Island, Nirwana Beach, West Sumatra. The results obtained in this study were that *P. minor* was the seaweed with the highest nutrient content compared to other seaweeds. Furthermore, the results showed that *P. minor* was the best seaweed extract in increasing soybean germination and vegetative growth. Moreover, the type of biostimulant, the frequency of application and the concentration of the seaweed extract significantly increase plant growth and productivity[8,9].

Soybean is one of the important food commodities for the Indonesian people, especially as the main raw material for tempeh and tofu, which are popular foods for the Indonesian people. The level of consumption and demand for soybeans increases along with population growth. At the same time, national soybean production tends to decline, causing domestic soybean needs to be met through imports from abroad[10].

This research will study the effect of concentration and frequency of *P. minor* seaweed crude extract application as a biostimulant on soybean plants.

MATERIALS AND METHODS

Location: This research was conducted from March-June 2020 in the greenhouse of Andalas University, Padang, West Sumatra, Indonesia.

Research design: This study used an experimental method arranged in a factorial Completely Randomized Design (CRD) consisting of 2 factors and 3 replications. Factor A is the concentration of seaweed extract which consists of 0, 10, 20, 30 and 40%. Factor B is the frequency of seaweed extract application consisting of 1 application (2 MST), 2 applications (2 MST and 4 MST) and 3 times (2,4 and 5 MST).

Seaweed extract *P. minor* production: Seaweed was collected from Kasiak Gadang Island, Padang, West Sumatra, Indonesia. Then the seaweed was cleaned and dried for four days. Furthermore, the seaweed is mashed so that it is in powder form. Coarse powder of seaweed is mixed with water in a ratio of 1: 20 (w/v) and then macerated using an autoclave at 121°C, 15 lbs/sq for 20 min. Furthermore, the seaweed extract was filtered and the filter results were centrifuged at 5000 rpm for 15 min. The supernatant formed is a seaweed extract with a concentration of 100%[11].

Planting and plant care: The planting medium used was a mixture of Ultisol soil and manure with a ratio of 5:1. Planting is done by planting three seeds in one polybag with a depth of 3 cm. Plant care includes fertilizer application at the beginning of planting (0.23 g urea; 0.9 g TSP and 0.9 KCl per polybag) and 30 days after planting (0.23 g per polybag)[8,12].

Seaweed extract application: The application of seaweed extract with several concentration groups was carried out by spraying the extract as much as ±25 mL evenly on the leaves according to the time and concentration determined[13].

Observation parameters: Parameters observed in this study included vegetative and generative growth parameters of soybean plants which included plant height, number of branches, number of leaves, gross weight and dry weight of plants, chlorophyll content, harvest age, number of pods, the mass of whole seeds, dry mass of whole seeds and dry mass of 100 seeds.

Data analysis: Data analysis was performed using analysis of variance (ANOVA). Suppose the effect of treatment is significantly different. In that case, it will be continued with Duncan's New Multiple Range Test (DNMRT) at a 95% confidence level and continued with multivariate regression analysis to determine the relationship between growth parameters and soybean yield parameters.

RESULTS AND DISCUSSION

The effect of *P. minor* extract on the vegetative growth of soybean plants is presented in Table 1. Based on Table 1, *P. minor* extract with a concentration of 40% with one application increased plant height. In comparison, *P. minor* extract with a concentration of 40% with two and three times application was able to increase the plant's gross and dry weight. *P. minor* biostimulant contains macro and micronutrients that can stimulate plant growth. According to Rajasekar *et al.*[14], nitrogen and phosphorus in *P. minor* extract are essential elements in photosynthesis, respiration, enzymatic reactions and cell division and enlargement that can increase plant height and gross and net weight plants. Previous studies reported that seaweed extract increased plant height, gross and dry weight of some plants such as tomatoes[15], strawberries[16] dan beans[17].

The effect of *P. minor* extract on soybean harvesting age is shown in Fig. 1. The result of Fig. 1 shows that the application of *P. minor* extract with a concentration of 40% with one application could shorten the harvest life of soybean plants compared to controls. The high phosphorus content in *P. minor* extract is estimated to stimulate root growth so that plants can absorb nutrients in deeper soil layers, which has an impact on the faster pod formation process so that soybean harvest life is shorter[18]. This result is similar to Yao *et al.*[19] that reported that the application of seaweed extract could accelerate the ripening of tomatoes.

The effect of *P. minor* extract as a biostimulant on soybean crop production is presented in Table 2. Application

Table 1: Effects of foliar applications *P. minor* extract on soybean growth parameters

Treatments	Plant height	Number of branches	Leaf number	Fresh weight of the plant	Dry weight of the plant	Total of chlorophyll content
A_0B_1	33.05^{ab}	13.00^{a}	19.00^{a}	84.17^{abc}	40.02^{ab}	2.67^{ab}
A_0B_2	36.13^{ab}	13.00^{a}	20.66^{a}	148.75^{def}	65.12^{cd}	2.67^{ab}
A_0B_3	40.36^{ab}	14.66^{a}	20.66^{a}	157.21^{def}	76.36^{de}	2.53^{ab}
A_1B_1	33.30^{ab}	14.00^{a}	17.50^{a}	67.87^{a}	35.38^{a}	2.26^{a}
A_1B_2	34.16^{ab}	11.66^{a}	19.33^{a}	107.96^{abcd}	50.03^{abc}	2.34^{a}
A_1B_3	36.90^{ab}	14.33^{a}	19.33^{a}	129.71^{bcde}	64.97^{cd}	2.54^{ab}
A_2B_1	24.03^{a}	12.33^{a}	17.00^{a}	74.97^{ab}	36.39^{a}	2.37^{a}
A_2B_2	40.30^{ab}	11.00^{a}	19.66^{a}	105.02^{abcd}	48.07^{abc}	2.51^{ab}
A_2B_3	30.50^{a}	12.66^{a}	19.00^{a}	148.42^{def}	68.83^{cde}	2.31^{a}
A_3B_1	37.03^{ab}	12.33^{a}	16.00^{a}	119.06^{abcde}	60.55^{bcd}	2.33^{a}
A_3B_2	32.63^{ab}	13.00^{a}	18.00^{a}	162.01^{def}	71.21^{cde}	2.55^{ab}
A_3B_3	39.40^{ab}	11.33^{a}	23.00^{a}	132.01^{cde}	61.43^{bcd}	2.38^{a}
A_4B_1	48.30^{b}	12.50^{a}	23.00^{a}	89.25^{abc}	51.05^{abc}	2.89^{b}
A_4B_2	38.95^{ab}	14.00^{a}	23.50^{a}	168.38^{ef}	83.58^{de}	2.63^{ab}
A_4B_3	40.50^{ab}	14.55^{a}	23.50^{a}	193.84^{f}	90.90^{e}	2.32^{a}

A_0: 0%. A_1: 10%, A_2 :20%, A_3: 30%, A_4: 40%, B_1: 1x application, B_2: 2x application, B_3: 3x application, Means within a column with different superscripted letters are significantly different from each other according to DNMRT at $p \leq 0.05$

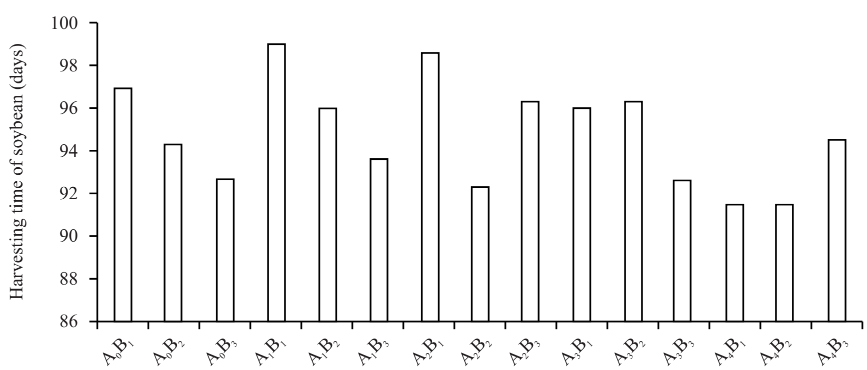

Fig. 1: Graphic harvesting time of soybean was applied by *P. minor* extract as a biostimulant
A_0: 0%. A_1: 10%, A_2 :20%, A_3: 30%, A_4: 40%, B_1: One time application, B_2: Two time application, B_3: Three time application

Table 2: Effects of foliar applications *P. minor* extract on yield of soybean

Treatments	Number of pods	Fresh weight of seed	Dry weight of seed	Dry weight of 100 seeds
A_0B_1	55.50^{a}	23.74^{ab}	18.05^{ab}	15.09^{a}
A_0B_2	81.66^{abc}	42.38^{bcd}	28.73^{cde}	15.57^{a}
A_0B_3	95.33^{cde}	51.46^{def}	29.37^{cde}	13.20^{a}
A_1B_1	60.50^{ab}	18.75^{a}	14.32^{a}	19.62^{a}
A_1B_2	77.66^{abc}	34.15^{abcd}	22.32^{abcd}	15.15^{a}
A_1B_3	88.33^{bcd}	45.06^{cde}	27.52^{cde}	15.53^{a}
A_2B_1	55.33^{a}	19.80^{a}	14.85^{a}	13.73^{a}
A_2B_2	62.33^{ab}	28.20^{abc}	18.30^{ab}	14.03^{a}
A_2B_3	102.00^{cde}	48.30^{cdef}	33.32^{efg}	15.30^{a}
A_3B_1	80.33^{abc}	40.47^{bcd}	27.09^{bcde}	16.41^{a}
A_3B_2	86.00^{bc}	51.33^{def}	30.59^{def}	15.58^{a}
A_3B_3	96.66^{cde}	47.51^{cdef}	31.53^{defg}	15.78^{a}
A_4B_1	84.50^{bc}	35.07^{abcd}	20.18^{abc}	12.71^{a}
A_4B_2	117.00^{e}	64.32^{ef}	40.39^{g}	15.67^{a}
A_4B_3	115.00^{de}	67.12^{f}	39.19^{fg}	15.79^{a}

A_0: 0%. A_1: 10%, A_2 :20%, A_3: 30%, A_4: 40%, B_1: 1x application, B_2: 2x application, B_3: 3x application, Means within a column with different superscripted letters are significantly different from each other according to DNMRT at $p \leq 0.05$

Table 3: Macro and microelements composition of ultisol soil and seaweed extract of *P. minor*

Elements	Ultisol soil (%)	Seaweed extract of *P. minor* (%)
Nitrogen (N)	2.94	1.459
Fosfor (P)	0.085	0.946
Kalium (K)	0.608	0.588
Natrium (Na)	0.298	0.661
Kalsium (Ca)	0.507	0.644
Magnesium (Mg)	0.325	0.489
Sulfur (S)	0.017	0.097
Mangan (Mn)	0.002	0.176

of *P. minor* extract increased the number of pods, gross weight and dry mass of whole seeds. Previous studies have reported that the application of seaweed extract can increase the production of some crops such as wheat[20], rice[21], chilli, pepper dan tomatoes[22]. The increase in soybean yield is closely related to the macronutrient activity in the seaweed extract *P. minor* (Table 3). According to Hellal and Abdelhamid[23], Phosphorus is needed for seeds formation because it plays an important role in the process of converting light into chemical energy to synthesize sugars, starches and proteins. The increase of soybean yield is also influenced by other macronutrients such as Nitrogen (N), Phosphor (P), Cadmium (Cad) and Magnesium (Mg). These nutrients are constituents of chlorophyll that play role in photosynthesis. Meanwhile, the Mn micronutrient also plays an important role in photosynthesis, especially activating the RNA polymerase enzyme in chloroplasts[24].

Based on multivariate regression analysis, the growth parameter that most affected soybean production was the dry weight of the whole plant. The dry weight of the plant contributed to the increase in the dry weight of all seeds by 91.52%. Plant dry weight is the accumulation of photosynthetic results in plant organs. This result indicates that the higher the accumulation of photosynthate in plant organs will increase soybean productions. Similar results were reported by Karyawati and Puspitaningrum[25], where the dry weight of the plant has a positive correlation to soybean yields. The equation for multivariate regression analysis of growth parameters on the dry mass of all seeds is as follows:

$$Y_1 = 5.773\text{-}0.036\ X_1 - 0.207\ X_2 - 0.207\ X_3 + 0.489\ X_4$$

where, Y_1 is the dry mass all seeds, X_1 is the plant height, X_2 is the number of leaves, X_3 is the plant gross weight, X_4 is the plant net weight.

CONCLUSION

The 40% concentration of *P. minor* seaweed extract increased vegetative growth (plant height, gross and net weight of plants) and yield of soybean (number of pods, gross and dry mass of whole seeds). *P. minor* extract also was able to shorten the harvest life of soybean plants. Therefore seaweed extract of *P. minor* can be considered as a potential source of biostimulant to increase the growth and yield of soybean in agriculture.

SIGNIFICANCE STATEMENT

This study discovers the potential benefits of concentration and frequency of *P. minor* extract application as a biostimulant in increasing soybean growth and yield. This study also showed that the potential seaweed extract of *P. minor* sources from the role of macro and micronutrients.

ACKNOWLEDGMENT

We thank the Indonesian Ministry of Research, Technology and Higher Education for funding this research with grant number (No). 034/SP2H/LT/DRPM/2020.

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