Efficiency of seaweed fertilizer as Biostimulant and Radioprotectant on growth of *Vigna unguiculata* (L.) Walp.

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Abstract

One of the important abiotic factors affecting the growth and productivity of plants is ultra violet radiation. The bioactive substances derived from seaweeds impart stress tolerance in plants. This experiment was designed to analyze the efficiency of the seaweed liquid fertilizer as radio-protectant which helps the plants as a damage controlling agent in addition to its nutrient value. Cowpea plant (*Vigna unguiculata* (L.) Walp.) was used as the experiment plant; the plants grown in pots were supplied with 1% liquid seaweed fertilizer through roots and as foliar spray and they were exposed to U-V light for one hour. Growth and Biochemical parameters were analyzed on 30th day after the treatment. Shoot length, root length and leaf area were very much reduced in UV treated plants. Similarly there was a reduction in chlorophyll and protein contents, a reduction in catalase and peroxidase activities. But this reduction was not observed in plants treated with UV light and supplemented with seaweed fertilizer. The above said parameters showed even better results than the control. On the other hand the aminoacid content was found to be increased under UV stress as well as the plants supplemented with seaweed fertilizer. This present study clearly manifests the potentiality of the seaweeds which can be used as prospective agents to mitigate the harmful effects of UV radiation.

Key words: Ultra violet radiation, seaweed liquid fertilizer, radio-protectant, *Vigna unguiculata*

INTRODUCTION

The study of plant stress Physiology deals with the effects of all abiotic factors which impose stress on plants [1]. These abiotic factors include extreme levels of light (high and low), radiation (UV-B and UV-A), temperature (high and low), water (drought and flooding), chemical stress (heavy metals, pH, fertilizers and herbicides), saline stress (excessive Na^+, deficient or in excess of essential nutrients), gaseous pollutants (ozone, sulfur dioxide), mechanical factors, and other less frequently occurring stressors [2].

An important factor affecting the growth and productivity of plants is ultra-violet radiation, which is a part of the non-ionizing region of the electromagnetic spectrum. It comprises approximately 8- 9% of the total solar radiation. UV radiation is of particular interest because this can induce a variety of damaging effects in plants. Due to the damage of the stratospheric ozone layer the level of ultraviolet radiation reaching the biosphere, especially in the range of UV-B (280–320 nm), is increasing day by day. Strong absorption of UV-B photons by biologically important macromolecules such as proteins and nucleic acids has a large effect on plant and animal metabolisms [3].The effects of UV-B radiation on plants include inhibited growth, morphological changes and an increase in the level of pigments [4]. The deleterious effect of UV-B radiation on the efficiency of photosynthesis can be attributed to specific reductions in expression of important photosynthetic genes, a reduction in Rubisco activity, changes in ion permeability of thylakoid membranes, and in the level of chlorophyll and carotenoids [5].

Simultaneously, there can be many anatomical and morphological changes, such as the reduction of plant height and leaf length/area, leaf glazing, chlorosis and necrosis [6]. Thus, the effect of increased UV-B radiation on growth and physiology of many plants, including crop and terrestrial plant species, under both greenhouse and field conditions, has become one of the most important subjects of investigation [7].

The use of marine macro algae or seaweed as fertilizer in crop production has a long tradition in coastal areas all over the world. Seaweed products elicit abiotic tolerance in plants and the bioactive substances derived from seaweeds impart stress tolerance and enhance plant performance. The beneficial anti-stress effects of seaweed extracts may be related to cytokinin activity. Cytokinins mitigate stress-induced free radicals by direct scavenging and by preventing reactive oxygen species (ROS) formation by inhibiting xanthine oxidation [8]. Balamurugan and Sasikumar studied the effect of Seaweed Liquid Fertilizer (SLF) of *Caulerpa scalpelliformis* at different concentrations on growth, biochemical, and enzymatic activity of *Abelmoschus esculentus*. The seaweed extract was found to be effective in increasing the biomass growth of shoot, root length, fresh and dry weight, pigmentation of chlorophyll - a,b and carotenoids. The biochemical tests like protein, amino acids, the enzymatic activity like α, β amylase, catalase, peroxidase, polyphenol oxidase were also found to be high [9].

Hence this experiment was carried to analyze the efficiency of the seaweed liquid fertilizers as radio-protectant which can help the plant as a damage controlling agent in addition to their nutrient values.

MATERIALS AND METHODS

In this experiment one set of 15 days old cowpea plants (*Vigna unguiculata* (L.) Walp.) were supplied with 1% liquid seaweed fertilizer through roots and as foliar spray. Another set of plants were exposed to U-V light for one hour and the impact of UV light was analysed. A third set of plants were supplied with 1% liquid seaweed fertilizer through roots and as foliar spray and exposed to U-V light. The plants neither exposed to U-V light nor supplied with seaweed fertilizer were considered as control. Growth and biochemical parameters were analyzed on 30th day after the treatment.

This work was carried out with the objective of i) assessing the damage caused by the U-V radiation on *Vigna unguiculata*, ii) studying the efficiency of seaweed liquid fertilizer as a growth stimulant on *Vigna unguiculata* and iii) testing the efficiency of seaweed liquid fertilizer as a potential radio-protectant on *Vigna unguiculata.*

The plants were grown in green house of the department garden in the college campus following soil culture method. About 20 seeds were sown in pots filled with garden soil. Six such pots were prepared and each treatment was maintained in triplicates. Treatment of seaweed supplementation was given on 15th day of sowing. In this experiment one set (two pots) of cowpea plants (*Vigna unguiculata*) were grown without seaweed supplementation (C, T1). Second set of plants in two pots were supplied with 1% solution of seaweed fertilizer through roots (T2, T3). Another set of 15 days old plants were foliar sprayed with 1% solution of seaweed fertilizer (T4, T5). On 25th day of sowing one pot from each set (T1, T3, T5) were exposed to U-V light for one hour and the impact of various treatments were analyzed. Various analysis were carried out on 10th day of treatment. Whole plant was used to measure shoot length and root length. Fully expanded leaves were used to calculate leaf area and for the estimation of biochemical parameters such as chlorophyll (10), protein (11), amino acid (12) content and to observe catalase and peroxidase activity (13) following the standard procedures. The experiment was conducted in triplicate and the results were expressed as their mean ± S.D values.

RESULTS AND DISCUSSION

The growth of the plants was very much affected by UV radiation. Shoot length, root length and leaf area were very much reduced in UV treated plants (T1). But this reduction was not observed in plants supplemented with seaweed fertilizer before exposure to UV light, instead the results showed much improvement than their respective control. The growth was enhanced in the seaweed supplemented plants (Figs. 1, 2 and 3). Root supplementation of seaweed fertilizer (SF) was found to be more efficient than foliar spray. Alexieva *et al.* have reported a reduced growth in parameters such as plant height, fresh weight, dry weight and leaf area due to UV radiation [14].

Enhanced growth of plants treated with seaweed extracts were reported by many previous workers. The enhanced growth of the plant may be due to the bioactive compounds present in seaweeds. Seaweed components such as macro and micro nutrients, amino acids, vitamins and growth substances like cytokinins, auxins and abscisic acid (ABA), affect cellular metabolism in treated plants leading to enhanced growth and crop yield [15].

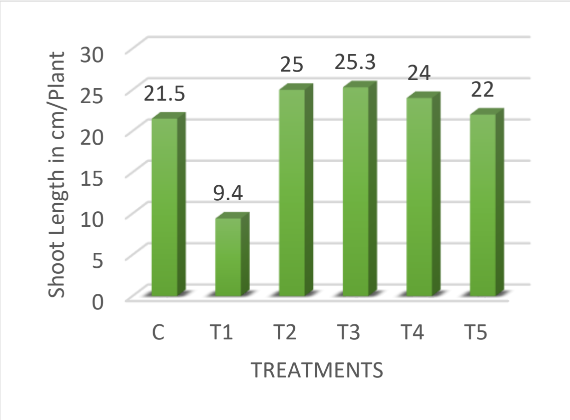

Fig 1 Shoot length of control and treated Plants of *Vigna unguiculata* (L.) Walp.

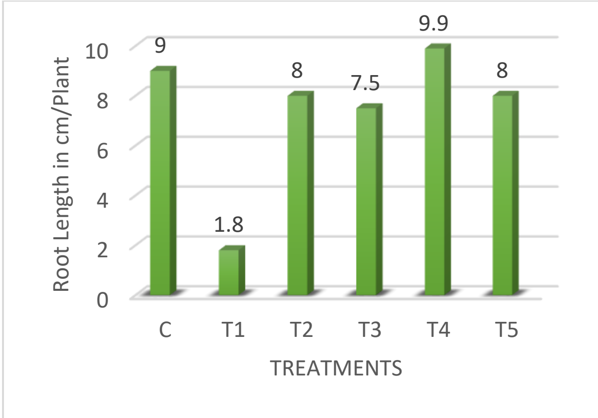

Fig 2 Root length of control and treated Plants of *Vigna unguiculata* (L.) Walp.

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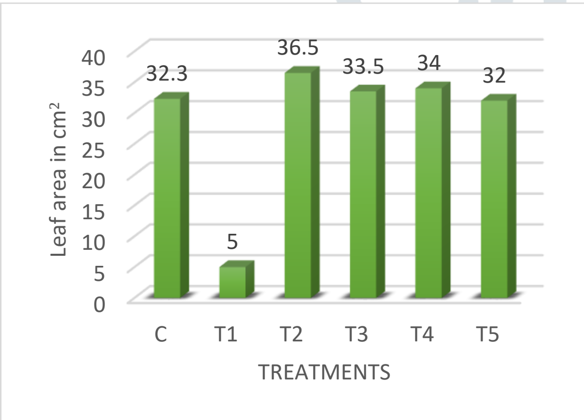

Fig 3 Leaf area of control and treated Plants of *Vigna unguiculata* (L.) Walp.

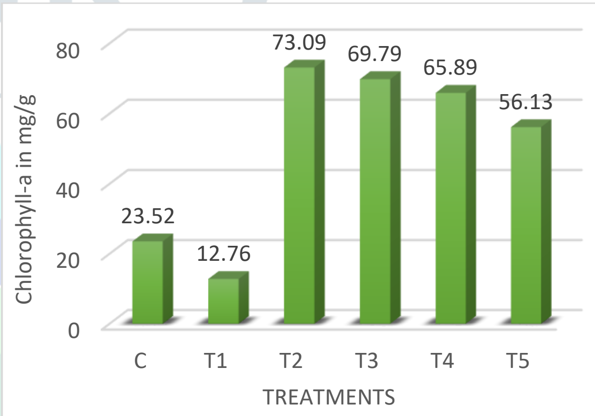

Fig 4 Chlorophyll-a of control and treated Plants of *Vigna unguiculata* (L.) Walp.

In this present experiment a decrease in chlorophyll a, b, and total chlorophyll was observed in the U-V irradiated plants. But this reduction was not observed in seaweed fertilizer (SF) supplemented plants (Figure 4, 5 and 6). This may be because of the positive impact of SF supplementation. Among the two methods of seaweed treatment, supplementation through roots was found to be more efficient than foliar spray.

A decrease in the chlorophyll content with the U-V irradiated plants have been supported by the findings of Khatami and Ghanati. The reduction in the amount of chlorophyll a, b and total chlorophyll may be due to the effect of U-V light on the structure and function of chloroplast or the biosynthesis of pigments [16].

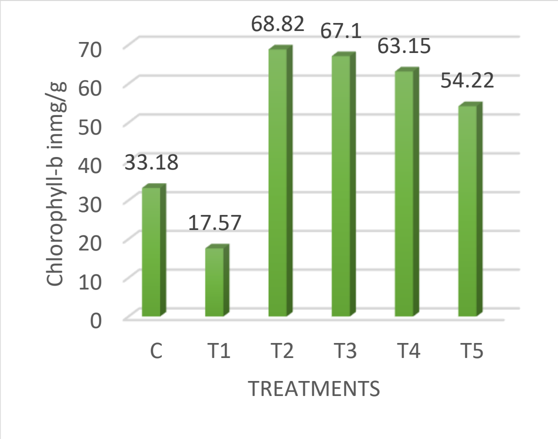

Fig 5 Chlorophyll-b of control and treated Plants of *Vigna unguiculata* (L.) Walp.

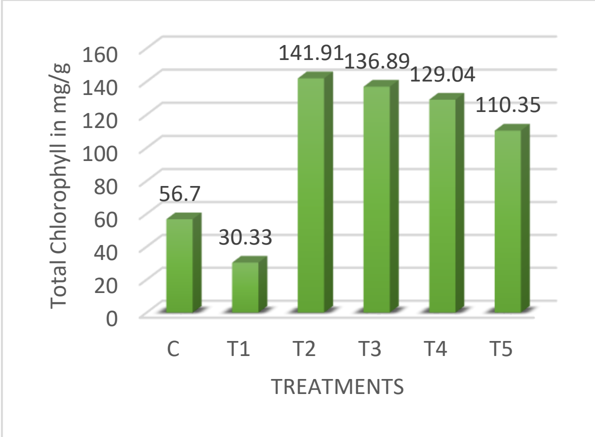

Fig 6 Total chlorophyll of control and treated Plants of *Vigna unguiculata* (L.) Walp.

Another harmful effect of U-V radiation on plant is a reduction in protein content. In the present investigation there was a decrease in the protein content under UV radiation (Figure 7). Rupali and Prabhat have reported a decrease in the protein content in the U-V stressed plants [17]. Application of SF had increased the total protein content. And the reduction observed in UV irradiated plants was not prominent in the plants supplemented with SF. Even it was more than that of the control. A decrease in protein content in U-V treated plants may be attributed to a decreased rate of incorporation of amino acids into proteins and hydrolysis of protein and due to increased protease activity leading to higher rate of protein hydrolysis.

In this present investigation there was an increase in total free amino acids in the U-V treated plants when compared to the control. In the plants supplemented with seaweed fertilizer, the values were more than even the control. (Fig. 8). This increase under SF may be due to the new synthesis of aminoacid, since the increase here was not accompanied by a decrease in protein content.

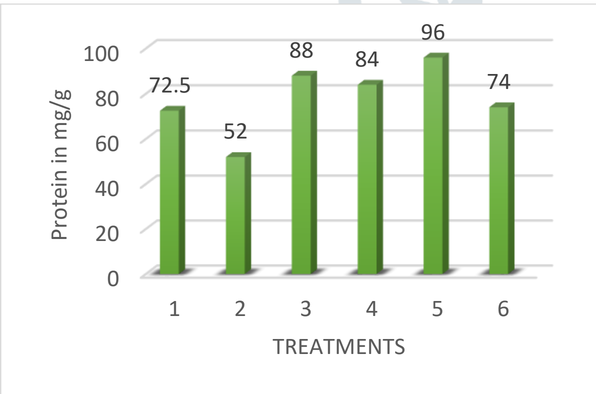

Fig 7 Protein content of control and treated Plants of *Vigna unguiculata* (L.) Walp.

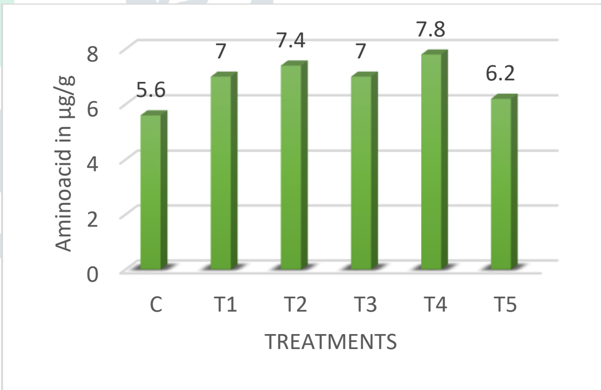

Fig 8 Amino acid of control and treated Plants of *Vigna unguiculata* (L.) Walp.

One of the major consequence of U-V radiation on nitrogen metabolism is its interferences with the free amino acid metabolism or due to protein degradation leading to an accumulation of total free amino acids. The increase in total free amino acid might be due to the effect of UV radiation on its new synthesis, not incorporating into protein and protein hydrolysis.

The effects of stress on plant nitrogen metabolism has been frequently studied, with an increase in protein degradation, inhibition of protein synthesis and the accumulation and/or depletion of protein and non-protein amino acids in a variety of monocots and dicots. Changes in amino acid composition of phloem sap has been demonstrated in Alfalfa in response to water deficit, including increased transport of proline, valine, isoleucine, leucine, glutamic acid, aspartic acid and threonine [18].

Exposure of plants to unfavourable environmental conditions can increase the production of reactive oxygen species such as singlet oxygen, superoxide radical, hydrogen peroxide (H_2O_2) and hydroxyl (OH^-) radicals [19]. The ROS is potentially harmful to cell membranes, resulting in oxidative degradation of membrane lipids (lipid peroxidation), which leads to leakage of cell contents into intercellular spaces by increasing membrane permeability. Plants possess both enzymatic and non-enzymatic mechanisms for scavenging of ROS. The enzymatic mechanisms are designated to minimize the concentration of O_2^- and H_2O_2. The enzymes overproduced include superoxide dismutase (SOD), ascorbate peroxidase (APX), catalase (CAT), glutathione reductase (GR), guaiacol peroxidase (GPX) and glutathione-synthesizing enzymes. The elevation of SOD/APX+GPX+GR+CAT ratio and H_2O_2 accumulation indicates the occurrence of oxidative stress in leaf cells under stress [20].

The activity of catalase was found to be reduced by the induced radiation stress. There was an increase in the activity of catalase in all the UV stressed and seaweed extract supplemented plants and were more than their respective control (Fig. 9). The activity of peroxidase was found to be lower than the control in UV stressed plants on the day of sampling (Fig. 10). In all the seaweed supplemented plants there was an enormous increase in the activity of peroxidase. Especially in the plants supplemented with SF through roots there was a many fold increase in peroxidase activity. Even under UV treatment the supplemented SF had increased the activity and it was more than that of the control.

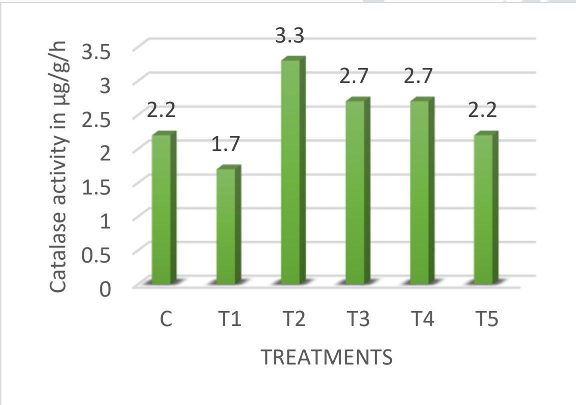

Fig 9 Catalase activity of control and treated Plants *of Vigna unguiculata* (L.) Walp

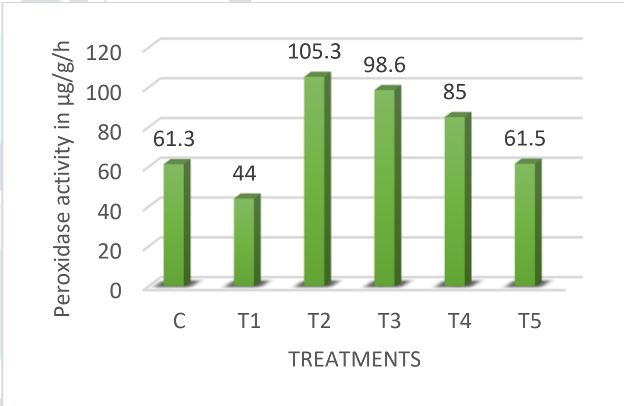

Fig 10 Peroxidase activity of control and treated Plants of *Vigna unguiculata* (L.) Walp.

This present study clearly manifests the potentiality of the seaweeds which can be used as prospective agents to mitigate the harmful effects of UV radiation on cowpea plants (*Vigna unguiculata* (L) Walp). It would indeed be a major breakthrough if seaweed extracts could be commonly used as modulators of gene expression to improve stress tolerance and crop productivity.

CONCLUSION

The intensity of U-V light is believed to be going high in the coming days because of the greenhouse effect. Agriculture sector is facing a major threat that the productivity may be going to touch a new abysmal line. Already scientists are advocating the farmers to go for biofertilizers rather than chemical fertilizers. Being a maritime country India has a rich resource of a variety of marine algae. The total standing crop of seaweeds from intertidal and shallow waters of all maritime states and Lakshadweep islands was estimated at 91,339 tons (wet weight). The quantity of seaweeds growing in deep waters of Tamil Nadu was estimated at 75,372 tons (wet weight) in an area of 1,863 Km^2 from Dhanushkodi to Kanyakumari. Recent research proved that seaweed fertilizers are better than other fertilizers since they are very economic and eco- friendly. Seaweed extracts are also now available commercially. India, a tropical South Asian country, has a stretch of about 7500 km coastline. This coastline has 271 genera and 1153 species of marine algae. So, they can very well be used to ameliorate the harmful effects of abiotic stress, which is a growing universal problem.

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