OPEN ACCESS Asian Journal of Crop Science

ISSN 1994-7879
DOI: 10.3923/ajcs.2018.

Short Communication
Effect of Seaweed Liquid Fertilizer and Humic Acid Formulation on the Growth and Nutritional Quality of *Abelmoschus esculentus*

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Abstract

Background and Objectives: The problem of agro based pollution due to the extensive use of chemical fertilizers is combated by searching for natural organic fertilizers that can be obtained from various sources. In this line, a study was conducted to evaluate the potential of seaweed liquid fertilizer (SLF) and humic acid (HA) as potential bio-fertilizer. The aim of the study was to determine the influence of seaweed liquid fertilizer, humic acid and seaweed liquid fertilizer:humic acids in various concentrations on the growth of *Abelmoschus esculentus*. **Materials and Methods:** The above plant growth promoters were applied as foliar spray at different intervals with the following concentrations namely SLF (1-10%), HA (0.1-1%) and SLF:HA (8.0:1.0% to 8.9:0.9%). Total carbohydrates measured by Anthrone method and total proteins contents measured by Lowry's method. **Results:** The study revealed that the maximum growth was obtained at the concentrations of 0.4% HA, 8% SLF and 8.5:0.5% of SLF:HA combination that reflected in the increased carbohydrate and protein content. **Conclusion:** This study clearly established the fact that seaweed fertilizer and humic acid preparation can be used to enhance the growth of the plants and hence can be incorporated in the production of crops on a large scale.

Key words: Humic acid, seaweed liquid fertilizer, *Abelmoschus esculentus*, growth parameters, biochemical analysis

Received: Accepted: Published:

Citation: P. Prakash, Amitesh Mitra, Ritanjan Nag and Swetha Sunkar, 2018. Effect of seaweed liquid fertilizer and humic acid formulation on the growth and nutritional quality of *Abelmoschus esculentus*. Asian J. Crop Sci., CC: CC-CC.

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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

The earth acts as dust bin because of all polluting materials being dumped on earth. Most of the materials were degraded by soil microorganisms and the remaining materials were retained i.e., those which cannot be degraded. Wastes from thermal power stations, nuclear power stations, dye industries, agro based practices are a major cause of pollution. Agro based pollution was due to the chemical fertilizers that pollute the agriculture environment and caused serious impact on soil by changing its parameters like increase in pH, soil texture, eutrophication and reducing the crop yield. The alternative fertilizers which did not cause serious impacts are organic fertilizers such as seaweed liquid fertilizers, vermicompost, fish compost, effective microorganism and humic acid. In recent years, seaweed liquid fertilizer is looked upon as an alternative source for chemical fertilizers because seaweed liquid fertilizers are shown to enhance seed germination, increase yield and resistant ability of many crops. Unlike chemical fertilizers, extracts from seaweeds are biodegradable, non toxic, non polluting and non hazardous to human, animals and birds[1].

Seaweeds are macro algae an economically important marine resource. Seaweeds had been marketed for several years as gelling agents, fertilizer additives, food and pharmaceutical purposes. Seaweeds constitute the most essential live organisms used on a wide scale commercially and extracts from seaweeds are commonly called seaweed liquid fertilizer (SLF)[2]. These advantages make SLF a good replacement for chemical fertilizer.

Humic acid (HA) was noted as another alternative for chemical fertilizer since it is economical and environment friendly bio-fertilizer. Humic acid is formed by the breakdown of organic matter and can be obtained from coal, soil, peat and dystrophies lakes. It was found to show a positive influence on plant growth in a number of ways. It was found to stimulate seed germination in several varieties of crops. Both plant root and top growth had been stimulated by humates but the effect was usually more prominent in the roots. A proliferation in root growth, resulting in an increased efficiency of the root system, is a likely cause of higher plant yields seen in response to humic acid treatment[3]. Humic matter has been shown to increase the uptake of nitrogen by plants and to increase soil nitrogen utilization efficiency. It can also enhance the uptake of potassium, calcium, magnesium and phosphorus. Colloid structure of humic acid and high degree of hydrophilicity of their functional groups gives them ability for gel formation. This explains their ability to increase water holding capacity of soils[4]. Humic acid also acts as a bio-stimulant, growth booster by inflicting positive effects on soil and plant characteristics.

In view of the advantages posed by sea weed liquid and humic acid as biofertilizer individually, this study focused on developing a formulation of fertilizer that comprises of HA and SLF in different concentrations and study its effect on the growth of *Abelmoschus esculentus*. *Abelmoschus esculentus* is an important summer vegetable. It is a popular home garden vegetable and a good source of energy for the body. It provides vitamin A, B, C, proteins, amino acids, minerals and iodine. The vegetable is quite palatable and liked equally by poor and rich people.

MATERIALS AND METHODS

Collection of seaweed liquid fertilizer: Seaweed liquid fertilizer collected from "Jeppiar Maritime Private Ltd.", Chennai, Tamil Nadu, India and the study was carried out at Sathyabama University, Chennai from December, 2016 to March, 2017.

Preparation of humic acid from lignite: Humic acid was extracted by following the procedures of International Humic Substances Society. Crude humic acid was used for all trials. About 10 g of coal (leonardite) was weighed and ground. It was then passed through a mesh sieve to get the fine particles and the coal sample was treated with 100 mL of 4% potassium hydroxide and mixed thoroughly. Water soluble salt of humic acid thus formed was filtered through a Whatman No. 42 filter paper to separate it from insoluble residues and 1 mL of concentrated hydrochloric acid was added to bring the pH<2. The humic acid will get precipitated at the bottom of the beaker and the precipitate thus obtained was humic acid.

Formulation of seaweed liquid fertilizer and humic acid: The HA in various concentrations was treated as group 1 and SLF in various concentrations as group 2. Group 3 had a combination of SLF and humic acid in different ratios. Water was used as control.

Effect of HA, SLF formulation on growth parameters: Seeds were purchased from local market and then healthy seeds were selected for this study. The seeds (10 Nos)

were soaked in sterile distilled water and treated with various concentration of humic acid, SLF, SLF:HA for 1 h. All the treated seeds were placed in sterile petri dishes containing a thin layer of wet cotton and covered with wet filter paper. Seed germinated in distilled water was served as a control. The percentage of seed germination, root length and shoot length were recorded after 7 days of sowing and tabulated.

Effect of HA, SLF formulation on protein and carbohydrate content of *Abelmoschus esculentus*: Garden soil was collected from the premises of university garden and mixed with 10% of cow dung and filled in 25×10 cm size black colour polythene bags. About 1.5 kg of soil was added in 40 bags. In each bag 3 *Abelmoschus esculentus* seeds were sown. After germination, first treatment was started as per the formulation. Bags were watered regularly and every 15 days monitoring plant height and biochemical analysis such as total carbohydrates (Anthrone method Trevelyan *et al.*[5]) and total proteins contents measured by Lowry's method[6] which were expressed in μg g^{-1}.

RESULTS AND DISCUSSION

Seaweed is naturally available resource in ocean which was mainly used in food industry, medical purpose, cosmetics and agro industry. This study focuses mainly on the suitability of SLF and HA as effective growth enhancers when used in combination.

Effect of HA, SLF formulation on seed germination and growth parameters: The present study evaluated the effect of humic acid, seaweed liquid fertilizer and a combination of both, *in vitro* on seed germination, shoot length and root length of *Abelmoschus esculentus* (Table 1).

The germination rate was observed after 7 days of growth. It was noticed that HA, SLF and SLF:HA effected the germination of seeds positively when compared to the control. Hundred percent germination rate was achieved with 0.4% HA, 8% SLF and 8.6:0.4 HA:SLF while the control (water) showed 80% germination rate pointing out the ability of these substances as effective fertilizers. Moreover, the shoot length and the root length also showed significant change in length with these sources than that of the control. Selvam and Sivakumar[7] stated the effectiveness of SLF on the growth, biochemical and pigment characteristics of *Arachis hypogea*. The effiiency of humic acid was well documented by the studies carried out by Ali and Elbordiny[8], who reported good seed germination of *Tritticum aestivum* L. seeds using potassium humate.

The efficacy of these substances can be attributed to the fact that seaweed extracts are known to promote plant growth as it is a source of certain compounds like auxins (IAA and IBA), gibberellins, cytokinins which were the known growth regulators and also houses many macro- and micro-nutrients[9]. Seaweed liquid fertilizer is mainly helpful in boosting plant health and helping plants deal with environmental stressors such as heat, cold, wind, drought and disease and also increase overall nutrition, including protein content. The biggest advantage is the ability to spray this directly onto the plant. These advantages posed by SLF makes it a suitable growth compliment. A formulation containing HA and SLF can therefore be all the more effective in promoting the plant growth owing to the enormous advantages posed by them. Likewise, humic acid was also known to enhance the growth of plants as they posses the ability to promote hormonal activity in plants, antioxidant production in plants also humic acid was known to add organic matter to organically-deficient soils, increase root vitality,

Table 1: Effect of HA, SLF formulation on seed germination

HA (%)	SGR (%)	SL (cm)	RL (cm)	SLF (%)	SGR (%)	S L (cm)	RL (cm)	SLF:HA	SGR (%)	SL (cm)	RL (cm)
Control	80	6.3	4.8	Control	80	6.3	4.8	Control	80	6.3	4.8
0.1	70	9.5	4.1	1	50	7.3	3.5	8.0:10	60	7.0	3.0
0.2	90	9.6	4.3	2	60	7.5	4.0	8.1:0.9	60	8.0	3.0
0.3	90	10.2	4.6	3	70	8.0	3.5	8.2:0.8	60	5.0	4.0
0.4	100	10.6	5.6	4	80	9.0	6.0	8.3:0.7	70	11.0	4.0
0.5	80	9.2	3.2	5	80	9.2	3.5	8.4:0.6	70	10.2	3.5
0.6	80	8.0	3.1	6	90	9.7	4.0	8.5:0.5	80	8.0	4.5
0.7	60	9.0	5.0	7	90	10.5	5.0	8.6:0.4	100	10.9	6.4
0.8	60	10.0	3.5	8	100	11.8	9.0	8.7:0.3	90	10.0	5.2
0.9	50	8.0	4.0	9	70	10.1	4.0	8.8:0.2	80	8.7	5.0
1	50	7.0	4.0	10	60	8.0	5.0	8.9:0.1	60	7.9	4.6

HA: Humic acid, SLF: Seaweed liquid fertilizer, SGR: Seed germination rate, SL: Shoot length, RL: Root length

Table 2: Evaluation of growth parameters and biochemical parameters of the treated plants

HA (%)	SL (cm)	TS (µg)	TP (µg)	SLF (%)	SL (cm)	TS (µg)	TP (µg)	SLF:HA (%)	SL (cm)	TS (µg)	TP (µg)
Control	16	80.3	81.0	Control	15	96.7	83.7	Control	15	96.1	85.5
1	20	100.7	83.3	1	20	100.2	90.0	8.9:0.1	15	131.7	100.0
0.2	23	105.0	81.7	2	22	103.3	85.0	8.8:0.2	25	138.3	120.0
0.3	20	110.0	88.3	3	25	115.0	91.7	8.7:0.3	30	145.0	128.3
0.4	19	150.0	130.0	4	28	130.0	98.3	8.6:0.4	32	155.0	146.7
0.5	28	136.7	126.7	5	25	146.7	106.7	8.5:0.5	33	195.0	153.3
0.6	20	136.7	120.0	6	25	161.7	108.3	8.4:0.6	30	195.0	135.0
0.7	22	120.0	125.0	7	27	167.7	117.1	8.3:0.7	28	166.7	126.7
0.8	20	111.7	115.0	8	30	186.0	127.2	8.2:0.8	25	153.3	125.0
0.9	18	120.0	98.3	9	28	140.0	98.3	8.1:0.9	22	138.3	115.0
1	20	111.7	93.3	10	25	123.3	90.0	8.0:10	26	126.7	106.7

SLF: Seaweed liquid fertilizer, HA: Humic acid, SL: Shoot length, TS: Total sugars, TP: Total proteins

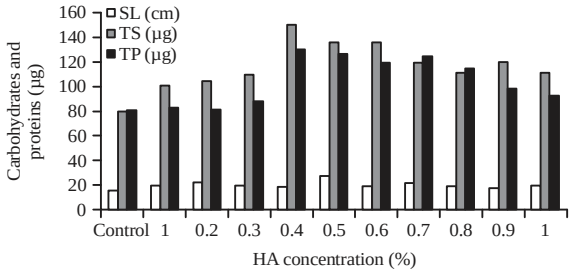

Fig. 1: Effect of HA on the shoot length, total sugars and total proteins

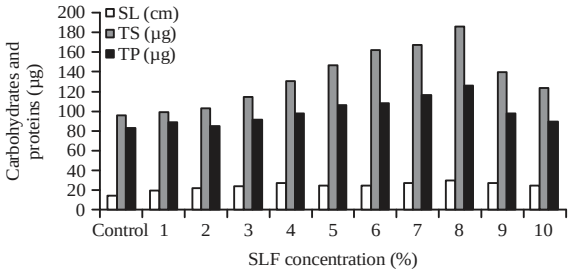

Fig. 2: Effect of SLF on the shoot length, total sugars and total proteins

improve nutrient uptake and increase fertilizer retention all of which contribute to the growth of the plant.

A formulation based on the combination of humic acid and seaweed liquid fertilizer would prove effective in promoting the growth of plants and the results obtained in the present study clearly demonstrated the positive effect of the duo at the concentration (8.6:0.4) thus making them suitable bio-stimulants.

Effect of HA, SLF formulation on protein and carbohydrate content of *Abelmoschus esculentus*: The plants when grown under good nutritious supplements were known to showed enhanced growth with enhanced nutritional quality. Therefore, when observed that HA and SLF were known to promote growth, a study was carried out to estimate the amount of total carbohydrates and total proteins in the plant reflecting their nutritional quality. A pot level study was conducted where the plants were treated with HA, SLF and a combination of both and the nutritional content was assessed. It was observed that there is an increase in the length of the shoot along with an increase in the carbohydrate and protein content (Table 2).

The effect of humic acid on the carbohydrate and protein content were showed in Fig. 1 and it was noticed that plants when supplemented with 0.4% HA showed maximum carbohydrate and protein content (150 and 130 µg, respectively).

Similarly, Fig. 2 showed the influence of SLF concentration on the carbohydrate and protein content. About 0.7% SLF showed maximum carbohydrate and protein content (186.7 and 120.1 µg, respectively).

The combined effect of HA and SLF were studied at the pot level where the concentrations of HA and SLF are decided based on the earlier optimization studies. The ratio of 8.5:0.5 SLF and HA, respectively showed the presence of maximum carbohydrate and protein content (Fig. 3). The authors successfully demonstrated the effectiveness of SLF and HA on the growth of *Arachis hypogaea* earlier[10].

Results showed that as the concentration of these supplements was increased there was also an increase in the growth of the plant as well as the nutritional content. The ability of the stomata and cuticle hydrophilic pores to absorb the nutrients may be the main reason for the increased growth as suggested by Arthur *et al.*[11]. They also reported an increase in the yield of pepper when supplemented with seaweed fertilizer. Another study by Dogra and Mandradia[12] also demonstrated similar kind of effect on the growth of onions. But after a certain concentration, there was a decrease

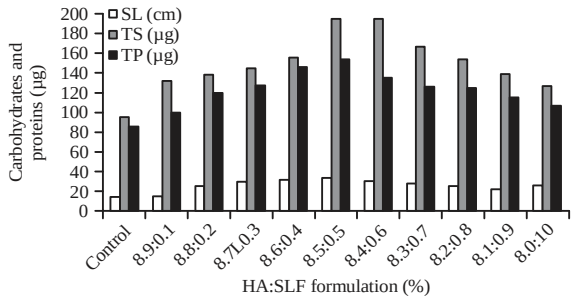

Fig. 3: Effect of HA:SLF on the shoot length, total sugars and total proteins

in the growth as well as the carbohydrate and protein content which may be due to the effect of salts that perhaps effect the absorption and growth of the plants[13].

CONCLUSION

Alternatives to chemical fertilizers were on the rise owing to the long term negative effects on the soil as well as the plant. The efficacy of Seaweed liquid fertilizer and humic acid as plant growth promoters individually provided the basis for the present investigation. This study is conducted to understand their effect in combination on the growth of *Abelmoschus esculentus*. Nutritional quality was also evaluated in terms of carbohydrate and protein content after the plants were grown in pots treated with HA and SLF and a combination of HA:SLF. This study revealed that HA and SLF effectively promoted the growth of the plants at concentrations 0.4 and 8%, respectively. A combined effect of (8.5:0.5) SLF and HA was effective in enhancing the growth of the plant in the pots that also reflected in the increased carbohydrate and protein content. This study therefore successfully demonstrates the ability of HA and SLF to promote plant growth and also increase the nutritional quality making them an effective alternative to chemical fertilizers.

SIGNIFICANCE STATEMENTS

The present study carried out demonstrates the ability of SLF and HA, as effective growth enhancers and also found to be a feasible alternative to the chemical fertilizers that during the course of time become a threat to the quality of the soil. Studies have been carried out using SLF and HA separately but focused on developing a concoction using both and thereby understanding its effect on the growth of the plant. These results can be a cue to use this combination of SLF and HA on a large scale in the field of agriculture.

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