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Research Article
Effects of Natural and Commercially Available Seaweed Liquid Extracts on Growth and Yield of *Vigna unguiculata* L.

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Abstract

Background and Objective: Recent studies have proved that application of 20% seaweed liquid extract provided better performances in tomato, anthurium and maize. Therefore a pot experiment was conducted at the Crop Farm of Eastern University, Sri Lanka to compare the effects of natural (*Sargassum crassifolium* L.) and commercially available (Maxicrop™) seaweed liquid extracts on the growth and yield performances of cowpea (*Vigna unguiculata* L.). **Materials and Methods:** The experiment was arranged in a Completely Randomized Design with 5 treatments (T1: 20% seaweed liquid extract+compost, T2: Maxicrop+compost, T3: 20% seaweed liquid extract+Department of Agriculture, Sri Lanka (DoA) recommended inorganic fertilizer, T4: Maxicrop+DoA recommended inorganic fertilizer and T5: Distilled water+no fertilizer (control)) and 8 replications. Seaweed liquid extract (20%) was applied five times at one week interval from 2 weeks after planting. Maxicrop™ was applied at the onset of flowering according to the product recommendation. **Results:** Foliar applications of the natural seaweed liquid extract and Maxicrop™ showed significant ($p<0.05$) effects on the growth and yield parameters of cowpea compared to the control. Highest growth and yield performances were observed in plants applied with both natural seaweed liquid extract (T3) and Maxicrop (T4) with the DoA recommended inorganic fertilizer treatments. **Conclusion:** Therefore, it could be concluded that application of 20% seaweed liquid extract of *Sargassum crassifolium* L. with the DoA recommended fertilizer could be recommended for cowpea cultivation as it enhances the growth and yield over the Maxicrop™ applied with DoA recommended fertilizer which is an environment friendly option for sustainable agriculture.

Key words: Seaweed, *Sargassum crassifolium* L., Maxicrop™, *Vigna unguiculta* L., Foliar application

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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 greatest challenge of today's agriculture is the fast growing population which is mounting tremendous pressure in food production in the world. Organic farming has emerged as an important area globally in view of the growing demand for safe and healthy food and long term sustainability and concerns on environmental pollution associated with indiscriminate use of agrochemicals.

In this context, use of seaweed liquid extract has become popular in the world. There has been a marked increase in the utilization of commercial seaweed products in agriculture. Seaweed extracts are now commercially available under several trade names, such as Maxicrop, Algifert and Goemar etc. These extracts are prepared from a number of different seaweeds but *Ascophyllum nodosum* L. is the species most commonly utilized due to its wide distribution around the world. Maxicrop™ is a concentrated seaweed extract containing 8% seaweed extract made from *Ascophyllum nodosum* L. Cowpea is an important leguminous crop in Sri Lanka. It is a hardy crop well adapted to relatively dry environments. Cowpea is cultivated in more than an extent of 6,807 ha producing nearly 8,576 Mt per year[1] in 2017. Seaweeds are available in plenty, easily accessible and not utilized properly in Sri Lanka[2]. About 320 species belonging to different families have been identified by several workers especially in northern, western, southern coastal areas[3]. It has been documented that species such as *Sargassum crassifolium*, *Sargassum vulgare* and *Turbinaria orriata* were available in plenty in Batticaloa coastal area of Sri Lanka[2]. Sutharsan *et al.*[4] has also reported that 20% seaweed liquid extract of *Sargassum crassifolium* significantly increased biomass, plant height and leaf area in *Zea mays* L. Another field experiment by Sutharsan *et al.*[2] has reported that when once a week the seaweed extract of *Sargassum crassifolium* L. at different concentrations was applied to tomato plants, seaweed extract with 20% of foliar application increased growth, yield along with the quality of tomato.

Therefore, this study was conducted to investigate the effects of the application of natural seaweeds extract (*Sargassum crausifolium* L.) and commercially available seaweeds extracts (Maxicrop™) on growth and yield of cowpea (*Vigna unguiculata* L.).

MATERIALS AND METHODS

Collection of seaweed: Seaweed of *Sargassum crassifolium* was collected from Pasikudah (7.9228°N, 81.5651°E), coastal area of Batticaloa, Sri Lanka.

Preparation of seaweed liquid extract: Seaweed liquid extract was prepared using the protocol as described by Sutharsan *et al.*[2].

Experimental design: A pot experiment was conducted at the Crop farm, Eastern University, Sri Lanka (7.7944°N, 81.5790°E) for a period of 3 months from June-August, 2018. The experiment was arranged in a Completely Randomized Design with 5 treatments (T1: 20% seaweed liquid extract+compost, T2: Maxicrop+compost, T3: 20% seaweed liquid extract+Department of Agriculture, Sri Lanka (DoA) recommended inorganic fertilizer, T4: Maxicrop+DoA recommended inorganic fertilizer, T5: Distilled water+no fertilizer (control) with 8 replications.

Seaweed liquid extract (20%) was applied five times at 1 week interval from 2 weeks after planting. Maxicrop™ was applied at onset of flowering according to the product recommendation thereafter continued up to 7th week after planting, at weekly interval.

Measurements

Leaf area: The total leaf area of each plant in each replication of all treatments was measured by using leaf area meter (LI-3100C, Li-Cor Inc., USA). Leaf area was measured at once during harvesting.

Number of effective nodules: Number of effective nodules in each plant of each replication in all treatments was counted after destructing the plant after the final harvest. All the nodules from each plant were separated based on their size; less than 2 mm diameter and greater than 2 mm diameter. More than 2 mm in diameters were cut into halves to examine the pink color to identify the effective nodules.

Biomass of root, shoot and leaves: Root, shoot and leaves of each plant in each replication in all treatments were cut into small pieces and placed in Aluminium trays separately and then they were dried at 80°C in the oven until constant weight was gained and their dry weight (g) was measured using an electronic balance (Hanon Instrument, China). This measurement was taken once after final harvest after destructing the plant.

Yield parameters: Total number of flowers in each plant of each replication of all treatments were counted in the 6th and 7th week after planting. Total number of pods in each plant of each treatment of all treatments were counted at 1st and 2nd harvest. Total weight of seeds per plant (g) in each plant of each treatment of all treatments were counted at 1st and

2nd harvest. Length of each pod was measured using scale and the average length of pods of each treatment was calculated.

Statistical analysis: The statistical analysis (ANOVA) was done using statistical software, SAS 9.1 and mean comparison within treatments was performed using Duncan Multiple Range test at 5% significant level.

RESULTS

Leaf area (cm^2): Application of 20% seaweed liquid extract and Maxicrop with DoA recommended inorganic fertilizer and compost showed significant increase ($p<0.05$) in leaf area when compared to control plants (T5) (Table1). The maximum leaf area (1071.6 cm^2) was recorded in T3 followed by T1, T4 and T2. The minimum leaf area (290.3 cm^2) was recorded in control plants (T5).

Number of effective nodules: The application of 20% seaweed liquid extract of *Sargassum crassifolium* and Maxicrop had significantly ($p<0.05$) increased number of effective nodules when compared with control (T5) (Table 1). The maximum number of effective nodules were recorded in T3 followed by T1, T4, T2 and the minimum in T5 (control).

Biomass of leaves, stem and root (g): Maximum biomass of leaves, shoot and root was recorded in T3 followed by T1, T4, T2 and minimum in T5 (control) (Table 1). Application of 20% seaweed liquid extract of *Sargassum crassifolium* and Maxicrop significantly increased the biomass of leaves, shoot and root in comparison to control (T5).

Mean number of flowers per plant: Foliar application of 20% seaweed liquid extract of *Sargassum crassifolium* and Maxicrop significantly ($p<0.05$) increased mean number of flowers per plant when compared to the plants in control (T5) (Table 2).

Average length of pod (cm), number of seeds per pod and weight of seeds per pod (g): Foliar application of seaweed liquid extract and Maxicrop had significantly increased yield parameters such as the average length of pod (cm), number of seeds per pod and weight of seeds per pod (g) when compared to the control plants (T5) (Table 2).

Total number of pods per plant and total weight of seeds per plant (g) at 1st and 2nd harvest: Total number of pods per plant and weight of seeds per plant at 1st and 2nd harvest were significantly ($p<0.05$) high in comparison to the control plants (T5) (Table 2). The maximum total number of pods per plant and weight of seeds per plant at 1st and 2nd harvest were recorded in T3 followed by T4, T1, T2 and the minimum in T5 (control).

DISCUSSION

El-Yazied *et al.*[5] reported that spraying plants with seaweed extract significantly increased average leaf area in snap bean when compared to control. Similar results were recorded by Gurusaravanan *et al.*[6] in chickpeas and Erulan *et al.*[7] in pigeon peas. However, the maximum leaf area was recorded in T3. The application of seaweed liquid extract of *Sargassum crassifolium* with DoA recommended inorganic fertilizer (T3) significantly increased the leaf area

Table 1: Effect of 20% seaweed liquid extract of *Sargassum crassifolium* and Maxicrop on the growth of *Vigna unguiculata* L.

Treatments	Leaf area (cm^2)	No. of effective nodules	Biomass of leaves (g)	Biomass of stem (g)	Biomass of root (g)
T1	905.962±75.558^{a}	208.0±18^{b}	6.277±0.365^{ab}	6.578±0.505^{ab}	8.601±0.535^{ab}
T2	679.889±69.995^{b}	137.0±9^{bc}	4.745±0.463^{b}	5.135±0.529^{b}	6.305±0.707^{bc}
T3	1071.538±107.232^{a}	334.0±33^{a}	7.099±0.585^{a}	7.963±0.536^{a}	10.336±0.386^{a}
T4	737.296±42.118^{b}	172.0±18^{b}	5.356±0.312^{b}	5.705±0.682^{b}	7.778±0.631^{b}
T5	290.309±32.008^{c}	71.0±8^{c}	3.033±0.304^{c}	4.125±0.732^{b}	4.510±0.751^{c}
F-test	*	*	*	*	*

Value represents mean±standard error of 8 replicates, *Significant at 5% level of probability, ns: Not significant, mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance by DMRT

Table 2: Effect of 20% seaweed liquid extract of *Sargassum crassifolium* and Maxicrop on the yield of *Vigna unguiculata* L.

Treatments	Mean No. of flowers per plant	Average length of pod (cm)	No. of seeds per pod	Weight of seeds per pod (g)	Total No. of pods per plant at 1st and 2nd harvest	Total weight of seeds per plant at 1st and 2nd harvest
T1	21.0±2^{ab}	13.3±0.4^{b}	12.0±0.089^{ab}	1.498±0.032^{ab}	4.7±0.1^{c}	5.062±0.186^{c}
T2	14.0±1^{bc}	9.4±0.5^{c}	9.0±0.384^{cd}	1.018±0.010^{cd}	3.1±0.2^{c}	3.817±0.089^{c}
T3	26.0±3^{a}	16.8±0.2^{a}	13.0±0.282^{a}	1.548±0.046^{a}	9.8±0.3^{a}	13.367±0.372^{a}
T4	17.0±3^{b}	13.2±0.6^{b}	10.0±0.357^{bc}	1.210±0.019^{bc}	6.5±0.1^{b}	8.932±0.255^{b}
T5	6.0±2^{c}	9.3±0.3^{c}	7.0±0.328^{d}	0.768±0.038^{d}	2.0±0.0.1^{d}	1.151±0.039^{d}
F-test		*	*	*	*	*

Value represents mean±standard error of 8 replicates, *Significant at 5% level of probability, ns: Not significant, mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance by DMRT

(27.27%) when compared to the plants applied with Maxicrop and DoA recommended inorganic fertilizer (T4). These results revealed that the application of 20% seaweed liquid extract with DoA recommended inorganic fertilizer enhanced the growth of *Vigna unguiculta* L. through increased leaf area than Maxicrop applied with DoA recommended inorganic fertilizer (T4). These results were in agreement with the findings of Sutharsan *et al.*[4], where they reported that seaweed extract of *Sargassum crassifolium* with 20% of foliar application increased leaf area in *Zea mays* L.

Khan *et al.*[8] had reported that application of *Ascophyllum nodosum* extracts on alfalfa plants increased the number of total nodules per plant as well as number of functional nodules. It was observed that application of 20% seaweed liquid extract of *Sargassum crassifolium* with DoA recommended inorganic fertilizer had significantly increased the number of effective nodules (94.19%) over the plants in T4 which was applied with Maxicrop with DoA recommended inorganic fertilizer which revealed that the maximum nodulation was induced by 20% seaweed liquid extract of *Sargassum crassifolium* when compared to Maxicrop applied with DoA recommended inorganic fertilizer.

It has been reported that cytokinins are found in brown algae extracts including trans zeatin, trans-zeatin-riboside and their dihydro derivatives[9]. Cytokinins play a major role in nodule organogenesis. They induce cortical cell division and activate many nodulation-related proteins which are involved in early nodulation process[10].

Further, it is clearly observed that the application of 20% seaweed liquid extract of *Sargassum crassifolium* with DoA recommended fertilizer has increased the biomass of leaves (32.54%), stem (39.58%), root (32.89%) over the plants applied with Maxicrop with the DoA recommended fertilizer. Similar result was observed in chilli by Jayasinghe *et al.*[11]. Plant biomass associated with dry matter production of plants and it depends on leaf area. The higher value of leaf area was recorded in T3 which was applied with 20% seaweed liquid extract with DoA recommended fertilizer. It might be due to the presence of P in the seaweed liquid extract which promotes the root development. In addition it is the luxurious source of secondary nutrients like Mg; hence, it helps in root growth[2].

The number of flowers produced are associated with the developmental stage of plants. The seaweed extracts encourage flowering by initiating robust plant growth. This may be due to the presence of hormonal substances in the seaweed liquid extracts, especially cytokinins[9]. The presence of higher amount of potassium than other macro-nutrients in *Sargassum* and other growth regulators probably stimulate flower initiation and hence enhance the number of flowers per plant. This was supported by Sutharsan *et al.*[4], who had reported that seaweed liquid extract of *Sargassum crassifolium* was rich in macronutrient of Potassium.

The maximum average length of pod (cm), number of seeds per pod and weight of seeds per pod (g) were recorded in T3 followed by T1, T4 and T2. The minimum average length of pod (cm), number of seeds per pod and weight of seeds per pod (g) were recorded in T5 (control). This may be due to the effect of cytokinins present in seaweed extracts[12]. Similar results were found by El-Yazied *et al.*[5] in Snap bean. Zodape *et al.*[13] has also reported that foliar application of seaweed extract on green gram increased the yield significantly when compared to the control. Jayasinghe *et al.*[11] reported increased number of pods and pod length over control in chilli. Similar results of maximum length of vegetables was recorded in okra and cluster beans that received 20% seaweed liquid fertilizer with recommended level of chemical fertilizer[14]. These results were in agreement with the findings of Sutharsan *et al.*[2], who reported significant increase on fruit number and fruit yield per hectare over the control with 20% seaweed liquid extract of *Sargassum crassifolium*.

The highest total number of pods per plant and weight of seeds per plant at 1st and 2nd harvest recorded in T3 which revealed that the foliar application of 20% seaweed liquid extract of *Sargassum crassifolium* with DoA recommended inorganic fertilizer increased the total number of pods per plant and weight of seeds per plant at 1st and 2nd harvest with the ultimate increase in the total yield in comparison to T4 which was applied with Maxicrop and DoA recommended inorganic fertilizer. These results were similar to the reports of Sutharsan *et al.*[2] who found significant effects on fruit number and fruit yield per hectare over the control with 20% seaweed liquid extract of *Sargassum crassifolium*. Similar results were reported by Thirumaran *et al.*[14] in cluster bean and okra in the plants that received 20% seaweed liquid extract of *Rosenvingea intricate* with recommended level of chemical fertilizer.

Application 20% seaweed liquid extract gives better results in growth and yield of *Vigna unguiculata*. This study will be extended for other economical impotents crops as well in future.

CONCLUSION

The results of this study revealed that application of 20% seaweed liquid extract of *Sargassum crassifolium* L.

with the DoA recommended fertilizer gave the best performances compared to Maxicrop™ applied with DoA recommended fertilizer. Therefore, application of 20% seaweed liquid extract of *Sargassum crassifolium* L. with the DoA recommended fertilizer could be recommended for the cultivation of cowpea (*Vigna unguiculata* L.) to enhance the growth and yield and it is an environment friendly option as well.

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