ISSN: 2347-4688, Vol. 7, No.(2) 2019, pg. 236-244

Current Agriculture Research Journal

www.agriculturejournal.org

Roses Growth and Flowering Responding to Concentration and Frequency of Seaweed (*Sargassum crassifolium* L.) Liquid Extract Application

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Abstract

Rose is a popular cut flower in Sri Lanka and mainly cultivated for the export market. An experiment was conducted at the Crop Farm, Eastern University, Sri Lanka to assess the effects of seaweed liquid extract on growth and flowering of roses (*Rosa* sp.) from June to September 2018. Seven treatments of seaweed liquid extract applications (10% once a week (T1), 10% twice a week (T2), 20% once a week (T3), 20% twice a week (T4), 30% once a week (T5), 30% twice a week (T6) and distilled water (T7- control)) were applied at completely randomized design with ten replications. Plant height, leaf area, plant biomass and number of flowers were significantly higher in T3. Once a week application of 20% seaweed liquid extract had the potential to increase the plant height, leaf area, plant biomass, number of flowers and dry weight of flowers in this experiment. It might be due to the presence of nutrients and the growth promoters in the *S. crassifolium* L. seaweed extract and optimum concentration of seaweed extract received by plants at T3. From this experiment, it could be concluded that once a week application of 20% seaweed liquid extract is suitable for promoting growth and flowering of roses.

Article History

Received: 23 April 2019
Accepted: 13 June 2019

Keywords:

Number of Flowers;
Plant Biomass;
Plant Height;
Rosa sp.;
Seaweed Liquid Extract.

Introduction

Rose is a woody perennial plant, which belongs to genus *Rosa* and family Rosaceae.[1] Rose is number one cut flower in world floriculture trade both in quantity and quality.[2] Rose is popular for its beauty, fragrance and long lasting blooming qualities.[3] They are used for variety of purposes namely pot plant, garden plant and cut flower production.[4]

Seaweed is a marine macro-algae. Brown seaweed are the second most abundant group comprising about 2,000 species which are most commonly

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Doi: http://dx.doi.org/10.12944/CARJ.7.2.11

used in agriculture.[5] *Ascophyllum* spp., *Fucus* spp., *Laminaria* spp., *Sargassum* spp., and *Turbinaria* spp. are the seaweeds which are used as biofertilizers to improve the plant growth.[6] Coastline area of Sri Lanka is consisted of many varieties of seaweeds.

There are many benefits of application of seaweed extract in agriculture. Several studies reported that, the seaweed extract (*Sargassum crassifolium* L.) has the potential to induce growth and flowering in crops. Srikrishna and Sutharsan[7] found that, foliar application of 20% of seaweed extract of *Sargassum crassifolium* L. increased growth and flowering in Anthurium. Sutharsan *et al.,*[8] reported that, foliar application of 20% seaweed extract (*Sargassum crassifolium*) increased number of flowers in tomato.

Performance of flowering in roses is very low due to unfavorable climatic and soil conditions. Therefore, it is necessary to induce flowering with the enhancement of vegetative growth in roses to maximize flower production. Hence seaweed liquid extract could be used as a bio stimulant to enhance flowering in roses. It is cost effective and eco-friendly technique. However, optimum concentration and frequency of application of liquid seaweed extract of *Sargassum crassifolium* L. to promote growth and flowering in roses need to be more investigated. Hence the present study was conducted to select the optimum concentration and frequency of application of seaweed extract (*Sargassum crassifolium* L.) to enhance the growth and flowering of roses.

Materials and Methods

Collection of Seaweeds (*Sargassum crassifolium*)

The seaweeds were collected from Pasikudah, coastal area, East of Sri Lanka about 35 km from Batticaloa. Seaweeds were collected by using hand and were immediately washed with sea water to remove the foreign particles, sand particles and epiphytes. It was kept in polythene bag with seawater and immediately transported to Crop Science Laboratory, Eastern University, Sri Lanka. The seaweeds were washed by tap water and then distilled water to remove the salt on the surface. Finally, they were spread on the blotting paper to remove excess water.

Preparation of Seaweed Liquid Extract (SLE)

Shade drying of seaweeds was done for 3-4 days. After shade drying seaweeds were hand crushed to make into small pieces. Then, they were ground to make as coarse powder by using the laboratory blender. Then the material was taken to prepare the seaweed liquid extract (SLE) in the laboratory as per the methodology described by Rama Rao.[9] Seaweed powder was added with distilled water in the ratio of 1:20 (W/V) and was autoclaved at 15 lbs/sq and 121^{o}C for a period of 20 minutes. The hot extract was filtered by double-layered cheese cloth and it was allowed to cool at 4 ^{o}C. Thereafter, the filtrate was centrifuged (5000 rpm) for 15 minutes. The supernatant was separately collected and it was considered as 100% of seaweed liquid extract. 10%, 20% and 30% concentration of seaweed liquid extract was prepared by adding distilled water at volume basis as per the treatment structure.

Experimental site

The pot experiment was conducted from June to September 2018 at the Crop Farm, Eastern University, Vantharumoolai, Sri Lanka. The experimental site belongs to low country dry zone (DL2) agro ecological zone. The site is in between the latitude of 7.73 ^{0}N and longitude of 81.67 ^{0}E.

Experimental Design

The experimental design was Completely Randomized Design (CRD) with seven treatments. Each treatment was replicated ten times. An experimental unit consisted of one plant. The treatments were defined as, once a week application of 10% seaweed liquid extract (T1), twice a week application of 10% seaweed liquid extract (T2), once a week application of 20% seaweed liquid extract (T3), twice a week application of 20% seaweed liquid extract (T4), once a week application of 30% seaweed liquid extract (T5), twice a week application of 30% seaweed liquid extract (T6) and application of distilled water (T7- control). Other management practices were followed uniformly as per the recommendations of Department of National Botanic Gardens, Sri Lanka.

Planting Materials and Application of Seaweed Liquid Extract

Budded rose plants (var. local) of one year old were obtained from a private nursery. All the plants were pruned to uniform height (35cm) before commencement of the experiment. Seaweed liquid extract was applied as foliar spray as per treatment structure.

Measurements

Plant height (distance from soil surface in the pot to top most leaf by meter scale), leaf area (leaf area meter, LI-310 ^{0}C), plant biomass (oven dry method) and number of flowers were measured at monthly interval. Destructive sampling method was practiced.

Statistical Analysis

Analysis of variance (ANOVA) test was used to determine the effects of treatments on measured parameters. Duncan's multiple range test at 5% probability was used to compare treatments means.

Results

Plant Height

It was found that there were significant ($p<0.05$) differences in the plant height of rose plants grown under different treatments at 2 and 3 months after transplanting (MAT). Highest plant height was obtained in T3 (20% seaweed extract application at once a week) compared to other treatments at 2 and 3 MAT (Fig.1).

Leaf Area

It was observed that there were significant ($p<0.05$) differences in the leaf area of rose plants grown under different treatments. Highest leaf area was recorded in T3 (20% seaweed extract application at once a week) compared to other treatments. Lowest leaf area was obtained in T7 (control) (Fig. 2).

Plant Biomass

It was recorded that there were significant ($p<0.05$) differences in the plant biomass of rose plants between different treatments. Highest plant biomass was observed in T3 compared to other treatment as well as lowest plant biomass was obtained in T7 (Fig. 3).

Number of Flowers

It was found that there were significant ($p<0.05$) differences in the number of flowers of Rose plants grown under different treatments at 1, 2 and 3 months after transplanting (MAT). Highest number of flowers was obtained in T3 compared to other treatments as well as lowest number of flowers was obtained in T7 at 1, 2 and 3 months after transplanting (Fig. 4).

Discussion

Plant Height

Highest plant height was observed in plants grown at T3 throughout the experiment. It could be due to increase in vegetative growth by the application of seaweed extract. Similar results were also reported in marigold,[10] *Cajanus cajan* (L.)[11] and *Vigna sinensis* L.[12] Growth promoting substances in the seaweed extract could be the reason for the increased vegetative growth of crops.[13] Further, the growth promoting potential is induced by the micro and macronutrients of seaweed extract.[14]

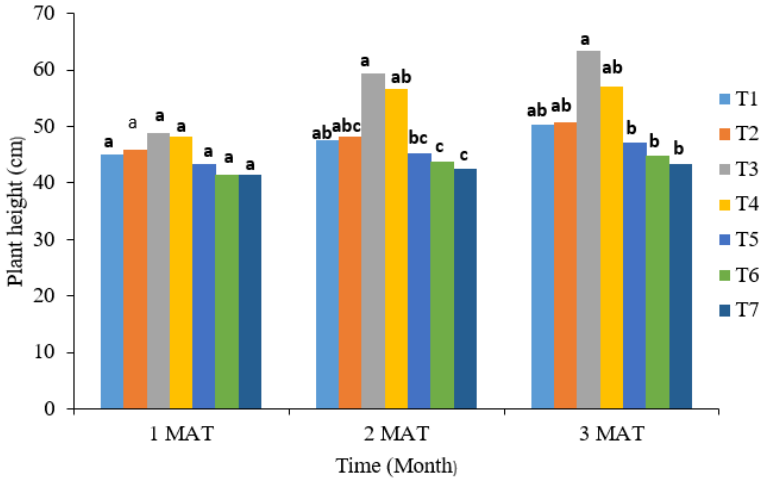

Fig. 1: Effect of concentration and frequency of application of seaweed liquid extract on plant height of roses (*Rosa* spp.) cv. 'Local' at 1, 2 and 3 months after transplanting. Bars with same letter are not significantly different according to the Duncan's multiple range test at 5% probability

Materials which are applied in small quantities to promote the plant growth are called biostimulant.[15] Sea weed extract is a biostimulant.[16] Seaweed extract contains growth regulators (auxins, cytokinine and gibberellins), amino acids and mineral nutrients, which positively affect plant growth and cell division.[17] Seaweed extracts improve nutrient uptake by roots.[18] These activities in turn help to promote plant height. However, Rayorath *et al.,*[19] opined that, application of seaweed extracts increased the plant growth at very low concentration. Therefore seaweed extract should be applied in optimum concentration to promote its stimulatory effects. This could be the reason for highest plant height observed in T3 throughout the experiment as the plants received optimum frequency and concentration of seaweed extract.

Plants grown at T1 and T2 would have received sub optimum amount of seaweed extract. Plants

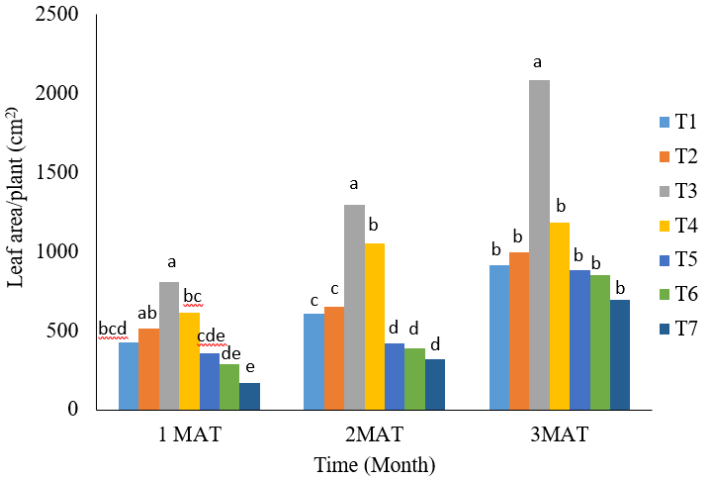

Fig. 2: Effect of concentration and frequency of application of seaweed liquid extract on leaf area of roses (*Rosa* spp.) cv. 'Local' at 1, 2 and 3 months after transplanting. Bars with same letter are not significantly different according to the Duncan's multiple range test at 5% probability

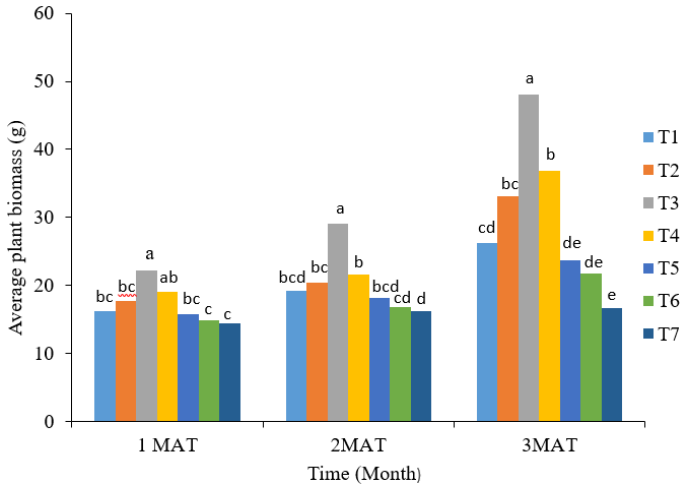

Fig. 3: Effect of concentration and frequency of application of seaweed liquid extract on plant biomass of roses (*Rosa* spp.) cv. 'Local' at 1, 2 and 3 months after transplanting. Bars with same letter are not significantly different according to the Duncan's multiple range test at 5% probability

belong to these treatments had shown lowest plant height and reduced growth rate. Sutharsan et al8 reported that plant height in tomato was increased by the application of 20% seaweed liquid extract of Sargassum crassifolium compared to 10% of seaweed liquid extract.

Plants grown at T4, T5 and T6 would have received excess amount of seaweed extract. Increase in the frequency and concentration of application reduced the plant hieght.Seaweed extract is a biostimulant and biostimulatory effects would be expressed in low concentrations. Hence increase in the frequency and concentration of application had a negative effect on plant growth.[20] Seaweeds have plant growth regulators. In lower concentrations they promote plant growth. However in higher concentration they may suppress the growth. These could be the reasons for the reduction of plant height in these treatments.

Leaf Area

Application of seaweed liquid extract (SLE) increased the leaf area of experimental plants over the control. Several studies reported that seaweed extract has potential to increase leaf area of different plants. Mahajan[21] reported that foliar application of seaweed extract increased leaf area of soybean (*Glycine max* L.) Shehata *et al.,*[22] found that, application of seaweed extract increase the leaf weight of celeriac (*Apium graveolens* L.) plant. Srikrishnah and Sutharsan[7] revealed that, foliar spray of seaweed extract increased the leaf number and leaf area of Anthurium (*Anthurium andreanum* L.).

Plants belong to T3 (20% seaweed extract application at once a week) would have received optimum amount of seaweed extract. It could be the reason for highest leaf area observed in this treatment. Sutharsan *et al.,*[23] reported that, application of 20% *sargassum crassifolium* L. seaweed extract increased the leaf area of maize. Srikrishnah and Sutharsan[7] reported that application of 20% *Sargassum crassifolium* L. extract increased the leaf number and leaf area of Anthurium plants. Sutharshan *et al.,*8 found that, maximum leaf number and leaf area produced by tomato *(Lycopersicon esculentum* L.) plants received 20% seaweed extract of *Sargassum crassifolium* L. Therefore it could be stated that, plants grown at T3 would have received optimum frequency and concentration of seaweed extract of *Sargassum crassifolium* L.

Plants grown at T3 had highest plant height. Plant height has a close relationship with leaf number and leaf area. Leaf area could be increased with plant height. It could also be the reason for highest leaf area observed in T3. Berntson and Weiner[24] observed positive correlation between plant height and its total leaf area of Impatiens pallida plants.

Plants grown at T1 and T2 would have received reduced amount of seaweed extract to promote their growth. Seaweed extract is a biostimulant. It might

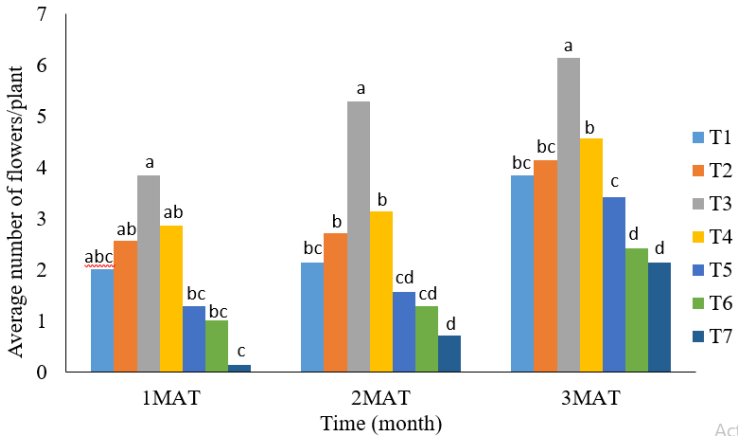

Fig. 4: Effect of concentration and frequency of application of seaweed liquid extract on number of flowers of roses (*Rosa* spp.) cv. 'Local' at 1, 2 and 3 months after transplanting. Bars with same letter are not significantly different according to the Duncan's multiple range test at 5% probability

promote growth at optimum concentration. Effect of five different concentrations of seaweed extracts (5%, 10%, 15%, 20%, 50% and 100%) of *Sargassum crassifolium* on maize (*Zea mays* L.) seedling performance was studied. In which, higher leaf area was observed at plants received 20% seaweed extract.[23] It showed that, seaweed extract promotes maximum growth at optimum concentration.

Plants grown at Treatment 4 to 6 would have received higher amount of seaweed extract than their requirement. At higher concentration seaweed extract might suppress the plant growth. Sutharshan *et al.,*[8] found that application of higher concentration of seaweed extract reduced leaf number and leaf area in tomato (*Lycopersicon esculentum* L.) Average leaf area of maize was increased by 37.87% while applying 20% Sargassum crassifolium extract.[23] This could be the possible reason for reduced LA observed in these treatments.

Plant Biomass

Plants grown at T3 would have received optimum frequency and concentration of seaweed extract. Plant biomass of Anthurium (*Anthurium andreanum* L.) was increased by foliar application of 20% of seaweed liquid extract.[7] Sutharsan *et al.,*[8] reported that shoot dry weight and root dry weight were increased by 80.92% and 81.57% respectively by the foliar application of 20% seaweed liquid extract of Sargassum crassifolium. Lingakumar *et al.,*[25] also reported that seaweed extract enhanced the growth parameters and biomass accumulation in legumes. Plant biomass of maize (*Zea mays* L.) was also increased by the application of 20% seaweed liquid extract of Sargassum crassifolium.[23] Further, Srikrishnah *et al.,*[26] observed that, biomass production were in accordance with the trend of variances for LA in Dracaena. Hence, highest LA was observed in T3 in the experiment. These could be the reasons for the highest plant biomass production of plants at T3.

Plants grown at T1 and T2 would have received sub optimum amount of seaweed extract. It could be due to application of lowest concentration of seaweed extract. Seaweed acts as a biostimulant in lowest concentration. It should be applied in small quantity to enhance the growth rate.[20] However, if the amount of application is less than the optimum, it could not promote growth. T4, T5 and T6 would have received excess amount of seaweed extract. Increase in the frequency and concentration of application reduced the plant biomass. Biostimulatory effects of seaweeds would be expressed in low concentrations. Hence increase in the frequency and concentration of application had a negative effect on plant growth.[20] This could be the reason for reduction in plant biomass in these treatments.

Number of Flowers

At 3 months after transplanting, highest number of flowers was obtained in T3 followed by T4 and lowest number of flowers was recorded in the T7. Potassium, Nitrogen, Magnesium and Phosphorous are the major macronutrients in seaweed. Further, there are some micronutrients in small quantity such as zinc, iron, manganese, and copper.[8] Several studies reported that, seaweed could trigger flowering in many crops such as tomato,[27] cluster beans[12] and greengram.[11] Poincelot[28] also found that application of seaweed liquid extract of Ascopyllum nodosum increased flowering in tomato and broccoli.

Seaweed liquid extract of *Sargassum crassifolium* L. contains higher amount of potassium. Therefore all the treatments except control showed increase in flowers. Plants at T3 would have received optimum amount of seaweed extract. It could be the reason for highest number of flowers observed in this treatment. Several studies reported that application of 20% of seaweed liquid extract of *Sargassum crassifolium* L. could increase flowering. Sutharsan *et al.,*[8] stated that, number of flowers on tomato was increased by 50.37% by the foliar application of 20% seaweed liquid extract of *Sargassum crassifolium* L. Srikrishnah and Sutharsan[7] found that foliar application of 20% seaweed liquid extract of *Sargassum crassifolium* L. could increase number of flowers in Anthurium. Sasikumar *et al.,*[29] reported that 25% seaweed liquid extract increased flower number in *Abelmoschus esculentus* L.

Plants grown at T1 and T2 would have received sub optimum amount of seaweed extract to induce flowering. Lowest number of flowers was observed in T1 and T2 compared to T3 and T4. Sutharsan *et al.,*[8] reported that 10% of seaweed liquid extract of *Sargassum crassifolium* L. reduced flowering compared to 20% concentration. Seaweed extract is

a biostimulant. It might induce flowering at optimum concentration.

Plants grown at treatment 4 to 6 would have received higher amount of seaweed extract than their requirement. At higher concentration seaweed extract might suppress flowering. Stephenson[30] found that lower concentrations of seaweed liquid extract accelerated growth than the higher concentrations of seaweed extract. Sutharshan *et al.,*[8] found that application of higher concentration of seaweed extract reduced flowering and number of flowers in tomato (*Lycopersicon esculentum* L.). In his experiment number of flowers was decreased by the application of 50% and 100% of seaweed liquid extract compared to 20% and 10% of seaweed extract. Sasikumar *et al.,*[28] stated that low levels of seaweed liquid extract (12.5%, 25%) increased growth and flower number in Dictyota dichotoma compared to high levels (75%, 100%) of seaweed liquid extract. Hence increase in the frequency and concentration of application had a negative effect on plant growth.[20] Seaweeds have plant growth regulators. In lower concentrations they promote plant growth. However in higher concentration they may suppress the growth. These could be the reasons for the reduction of number of flowers in these treatments.

Conclusions

From the findings, it can be concluded that the application of 20% seaweed liquid extract of *Sargassum crassifolium* L. at one week interval could be the optimum concentration and frequency to increase the growth and flowering in rose plants. Lower (10%) and higher (30%) levels of application of seaweed extract of *Sargassum crassifolium* L. reduced the growth and flowering of rose plants.

Acknowledgement

The authors acknowledge the funding provided by Eastern University, Vantharumoolai, Sri Lanka.

Conflict of Interest

Authors declare no conflict of interest.

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