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Research Article

Influence of Seaweed (*Padina antrillarum*) Extract Foliar Application on Growth and Flowering of Roses Variety 'Local'

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Abstract

The Seaweed (*Padina antrillarum*) abundantly found in the coastal region of Eastern Sri Lanka. Seaweed contains a wide range of nutrients and hormones for plant growth. An experiment was conducted at the Crop Farm, Eastern University, Sri Lanka to assess the effects of seaweed (*Padina antrillarum*) extract on the flowering of roses var. 'Local' from July to September 2020. Four treatments were used in this experiment viz. 10% (T1), 20% (T2), and 30% (T3) seaweed extracts with control treatment (T4). Treatments were applied at once-a-week interval. The experimental design was a completely randomized design with three replications. All other management practices were followed uniformly. Measurements were done at once a month. Collected data were analyzed. The higher performances in measured parameters (plant height, leaf area, plant biomass, number of flowers per plant) were observed in T2. It showed that once a week application of 20% seaweed liquid extract had the potential to increase growth and flower production in roses. It might be due to the presence of nutrients and the growth hormones in seaweed extract and optimum concentration of seaweed extract received by plants at T2. In T1 and T3, plants received sub-optimum and higher concentration respectively. It could be the reason for the lowest performances in these treatments. From this experiment, it could be concluded that once a week application of 20% seaweed liquid extract of *Padina antrillarum* is suitable to increase flowering in roses of treatment tested.

Keywords: Rose Plant; Plant height; Leaf area; Number of flowers; Plant biomass; Seaweed

Introduction

Floriculturist has main goals to increase yield and quality of roses due to roses are mostly used as a cut flower for export (Hashemabadi and Zarchini, 2010). Roses require great fertilizer input for proper growth (Leghari *et al.*, 2016). Optimum supply of macro and micronutrients which influence the balance of phytohormones and photosynthesis is essential to increase the yield and quality of roses (Manimaran *et al.*, 2017). Roses cultivate for several applications such as the medicine preparation industry, perfume manufacture plant, gardening flower, domestic cultivation, and various types of foodstuffs (Younis *et al.*, 2013). Sri Lankan export sector relies mainly on a series of rose species (Beneragama and Peiris, 2015).

Seaweeds consider as ocean lungs because of those plant-like life forms which generate 70 to 80 percent atmospheric oxygen through photosynthesis (Mahomoodally *et al.*, 2020). The extracts of seaweed are ideal sources of major elements such as N, P, K, Ca, and Mg as well as numerous micronutrients, vitamins, plant hormones essential for crop

growth and production (Muraleedharan *et al*., 2020). *Padina* sp. belongs to brown alga which can be utilized as food, fodder, plant growth promoter, and bio-fertilizer (Ansari *et al*., 2019).

Application of *Padina pavonica* seaweed liquid extract provides maximum plant growth performance on the *Solanum melongena* plant (Patel *et al.*, 2018). Uthirapandi *et al.*, (2019) reported that seaweed liquid extract (*Padina tetrastomatica*) improved the photosynthetic pigments, carotenoids due to the presence of Mg and Fe could have influenced the chlorophyll synthesis. Seaweed extract of *Padina gymnospora* was indeed largely constituted not only different betaines like bioactive substances that have been very effective for improving crop yield (Abbas *et al*., 2020). Applicaton of 20% seaweed (*Sargassumcrassifolium*) foliar spray could increase the anthurium (*Anthurium andreanum*) flower yield (Srikrishnah *et al*., 2018).

Flowering yield is very low in roses due to adverse weather and soil conditions. Hence it is crucial to encourage blooming to maximize floral production with the improvement of vegetative growth. Some studies reported the bio-stimulant effect of *Padina sp.* on crops (Setha *et al.*, 2013). Hence, the application of seaweed extract prepared from *Padina* sp. could enhance the growth and flowering of roses. However, there are no studies that have been carried out to assess the effect of *Padina antrillarum* extract on roses. Seaweed foliar application is an economical and environmentally friendly approach. However, organized research is vital to identify the optimum concentrations of the use of seaweed liquid extract (*Padina antrillarum*). Hence, the research was carried out with the objective of identifying the effects of seaweed extract (*Padina antrillarum*) application on the growth and flowering of Roses var. 'Local'.

Materials and Methods

This research was done from July to September in 2020 at the agricultural farmstead, Eastern university, Vantharamoolai, Sri Lanka. Those seaweeds were collected from Pasikudah which is located in the Eastern side of the country.

Preparation of Seaweed Liquid Extract (SLE) from Padina antrillarum

Seaweed drying had been achieved in shade for 3-4 days. Seaweeds were completely crushed by hand following shade dry to turn into tiny pieces. Then afterward, these were hardly grounded by using the laboratory blender (Waring Commercial, USA) to transform into the coarse powder. Seaweed's powder was added as a proportion of 1:20 (w/v) with distilled water and autoclaved (Gemmy, Taiwan) for 20 minutes at 121ºC, 15 Ibs /Sq. The warm concentration was further filtered down via double-layered cheesecloth as well as allowed for release heat to cool down at 4ºC. The filtrate was centrifuged at 5000×g for 15 minutes by centrifuge (Legend micro-17/17R, Thermo Electron Corporation, Germany). The supernatant which is separated from centrifugation has been regarded as a 100% liquid extract of seaweed. Therefore, distilled water was added to the 100 % seaweed liquid extract for the preparation of 10%,20% and 30 % liquid extract of seaweed according to the treatments on a volume basis (Sutharsan *et al*., 2014a).

Experimental Design

The experimental design was a complete randomized design with four treatments and three replicates. Those treatments have been defined as, once a week application of 10% (T1), 20% (T2) and 30% (T3), seaweed liquid extracts) and application of distilled water (T4- control). Budded roses (var. local) were obtained from a private nursery and transplanted in plastic pots. The composition of the potting mixture was red soil, compost, sand, coir dust in the ratio of 1:1:1:1. All the plants were pruned to uniform height before the commencement of the experiment. Those certain management activities have been consistently followed, as recommended by the National Botanical Garden, Peradeniya.

Table 1: Different concentrations of application of Seaweed liquid extract of *Padina* sp.

Treatments	Description
T1	Once a week application of 10% Seaweed liquid extract
T2	Once a week application of 20% Seaweed liquid extract
T3	Once a week application of 30% Seaweed liquid extract
T4	Control

Measurements

Plant height (The height of the rose plants had been quantified mostly from ground surface of the pot to the leaf tip by meter scale), Leaf area have been taken through nonportable leaf area machine (LI-3100C, LI-COR, USA), Plant Biomass (dry mass of the samples (24h at 80ºC) was recorded in an electric balance until the persistent weight was achieved in the electric oven, Number of Flowers (counted at a monthly interval by manually). The destructive sampling method was practiced. Data were collected once a month and analyzed statistically using SAS software. ANOVA was carried out to determine the treatment effects on measured parameters and means separation was done through ($p \leq 0.05$) Duncan Multiple Range Test (DMRT).

Results and Discussion

This research was performed to evaluate the significant influence of seaweed foliar spray on the growth progress measurements and flowering of rose plants at the Batticaloa in Sri Lanka.

Plant Height of Rose Plants

Significant differences ($p<0.05$) were ascertained among treatment methods at crop elevation at 1 and 2 months after transplantation (MAT). Significantly ($p<0,05$) the greatest crop height was measured at T2 (20% seaweed foliar spray) at 1 and 2 MAT. The smallest height of the plant was reported in the control treatment (Fig. 1).

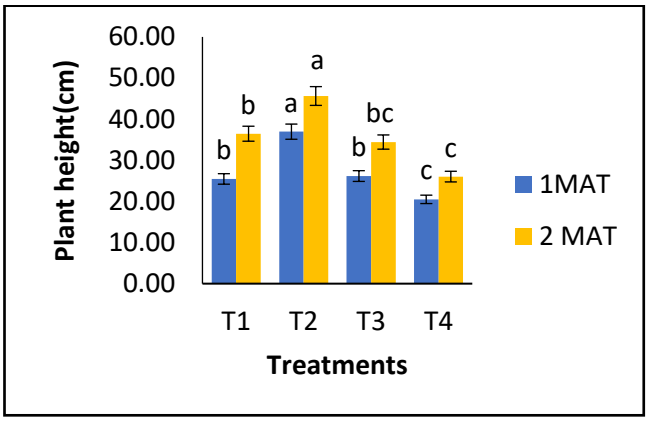

Fig. 1: Influence of different concentrations of seaweed liquid extract on plant height of roses. Means followed by same letter within a month were not significantly distinct in DMRT test by 5% probability.

Plant height seems to be an agronomical important phenotype as well as a significant morphological feature that performs as a potential indicator including its existence of nearby fertility resources (Zhang *et al*., 2000). The potential for growth of the plant may be influenced by the presence of plant growth hormones, polysaccharides, micro, and macronutrients, which significantly increased the lengthening of stems because of the supplementation of seaweed foliar application (Abou El-yazied *et al*, 2012).

In T2, plants received 20% seaweed extract foliar spray weekly. It could be the optimum concentration for rose plants. Therefore, the highest plant height was observed in plants grown at T2. A similar result was obtained with once a week application of 20% seaweed extract on rose plants which provide greater plant height compare to other 10% and 30% concentrations of seaweed (*Sargassum crassifolium*) extract (Sumangala *et al*., 2019). Sutharsan *et al*., (2014b) stated which seaweed extract significantly improved plant height of tomato (*Lycopersicon esculentus*) plants compare to 10% and 50% concentration of seaweed extract. Application of 20% concentration of seaweed foliar spray increased plant height by 25.07% of maize seedling owing to the existence of macro and micronutrients in seaweed liquid extract (Sutharsan *et al*., 2014a).

Bandara *et al*., (2017) informed that once a week spraying of seaweed foliar spray (*Sargassum crassifolium* and *Turbinaria turbinata*) increased plant height in two soybean varieties Pb-1 and MISB -01. The highest plant height was recorded in the *Cyamopsis tetragonaloba* that received 20% seaweed foliar spray (Thirumaran *et al.*, 2009). Not only the highest salt content but also the influence of hormones of seaweed is stimulated at a reduced dosage of seaweed extract (Sutharsan *et al*., 2014b). The lowest plant height was measured in *Cajanus cajan* L. plants which received 10% seaweed concentrate (Seenivasan *et al.*, 2010). Thirumaran *et al.*, (2009) stated that the lowest plant height with 40% seaweed extract on *Cyamopsis tetragonoloba*. Therefore 10% and 30% seaweed extract could be stated as suboptimum and higher concentration respectively.

From the findings, might be stated that usage of 20% foliar spray of *Padina antrillarum* macroalgae extracts increased the plant height of roses over the control and 10 and 30% concentrations of seaweed extracts. 20% seaweed extracts provide the best concentration of growth regulators such as cytokinin, auxins, gibberellins, betaines, and macronutrients such as Ca, K, P, as well as micronutrients such as Fe, Cu, Zn, B, Mn, Co, and Mo, which are required for plant development and growth.

Leaf Area (LA)

Significant differences ($p<0.05$) were ascertained among treatment methods at crop leaf area after transplantation (MAT). Significantly ($p<0,05$) the greatest crop leaf area was measured at T2 (20% seaweed foliar spray) at 1 and 2 MAT. (Fig. 2). The smallest leaf area of the plant was reported in the control treatment(T4).

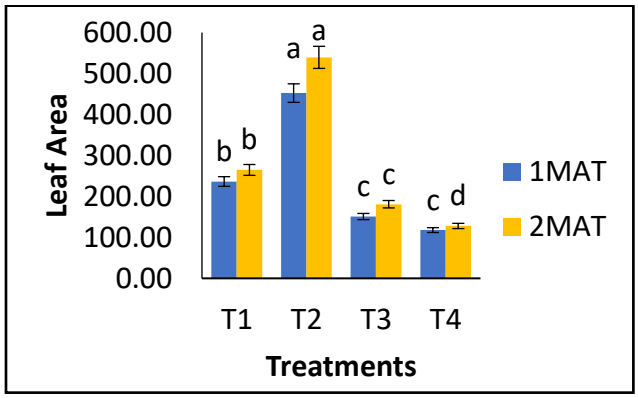

Fig. 2: Influence of different concentrations of seaweed liquid extract on plant leaf area of roses. Means followed by same letter within a month were not significantly distinct in DMRT test by 5% probability.

The leaf area of a crop is a major consideration in processes including the interception of radioactivity (Srikrishnah *et al.*, 2012). The leaf morphology heavily affects the photosynthetic capacity per unit leaf area (Teobaldelli *et al.*, 2019). Increasing the leaf area often through an advanced concentration of seaweed extract possibly owing to minerals which include potassium, improves the plant's metabolism like photosynthesis (Al-khuzaey and Al-asadi, 2019).

In T2, plants received 20% seaweed extract foliar spray weekly. It could be the optimum concentration for rose

plants. Therefore, the maximum leaf area was obtained by plants grown at T2. Srikrishnah *et al.*, (2018) discovered that the leaf area of anthurium (*Anthurium andereanum*) plant was enhanced by the application of 20% *Sargassum crassifolium* seaweed extract. Once a week application of 20% seaweed extract on roses which provide greater leaf area compared to 10% and 30% concentrations of seaweed extract (Sumangala *et al*., 2019). Application of 20% concentration of seaweed foliar spray significantly ($P<0.05$) increased leaf area by 37.87% of maize (*Zea mays* L.) seedling compare to owing to the abundance of crop growth regulators, promoters of *Sargassum crassifolium* (Sutharsan *et al*., 2014a). Kalaivany *et al*., (2019) stated that spraying of 20% macroalgae liquid extract enhanced the growth of *V. unguiculate* L. through enlarged leaf area. Sutharsan *et al*., (2014b) reported that 20% of seaweed liquid extract improved leaf area by 64.71% of tomato (*Lycopersicon esculentus*) plants compare to 10% and 50% concentration. Consequently, it might be detailed that the applying of 20% seaweed foliar spray (*Padina* sp.) foliar spray is optimum for roses and increased the leaf area of roses.

Plants received a weekly application of 30% (T3) and 10% (T1) seaweed extract showed significantly lowest leaf area compared to T2. Therefore 10% and 30% seaweed extract could be stated as suboptimum and higher concentration respectively. Seaweed extract significantly increased leaf area compared with the control treatment in strawberry (El-Miniawy *et al.,* 2014). The inhibitory impact of seaweed foliar spray on crop growth could be owing to the identical enormous salt content observed in macroalgae extracts which in turn affected the growth (Sutharsan *et al*., 2014a).

From the findings, it might be stated that usage of 20% foliar spray of macroalgae (*Padina antrillarum*) increased the leaf area of roses over the control, 10%, and 30% concentrations of seaweed extracts. 20% seaweed extract improve soil health by increasing moisture retention and encouraging the growth of beneficial soil microbes. Therefore, it suitable to increase the leaf area of the rose plants.

Plant Biomass

The measured biomass of rose plants was significantly ($p<0.05$) different between the treatments at 1 and 2 months after transplantation (MAT). Significantly ($p< 0.05$) greatest biomass was measured in T2 (20% seaweed foliar spray) at 1 and 2 MAT. Minimum plant biomass was recorded in the control treatment (T4) (Fig. 3).

Seaweed extract encompasses not only macro and microelements, amino acids but also cytokinin, auxins, and gibberellins corresponding growth hormones (Zodape *et al*., 2011). Seaweed extracts enhanced biomass gathering in tomato plantlets and wheat by enhancing root progress due to containing nutrients (Finnie *et al*., 1985). The influence of seaweed foliar spray on the development of the vegetation was suggestive of the action of plant hormone, which enhanced growth progress at small concentrations (Battacharyya *et al*., 2015). Seaweed extract of *Caulerpa racemose* on *Vigna catajung* was increased fresh weight as well as dry mass reduced concentrations of seaweed extract (Kumar *et al*., 2012).

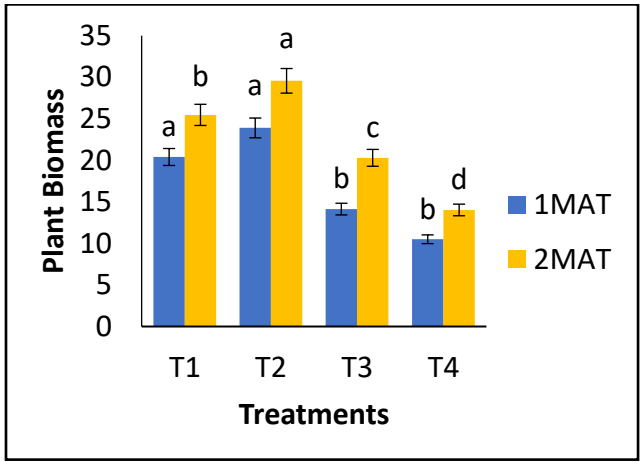

Fig. 3: Influence of different concentrations of usage of seaweed liquid extraction on plant biomass of roses on 1,2 months after that transplanting (MAT). Means followed by same letter within a month were not significantly distinct in DMRT test by 5% probability.

Plants received 20% seaweed extract (*Padina antrillarum*) foliar spray weekly in T2. It might be the optimum concentration for rose plants. Therefore, the highest plant biomass was obtained by plants grown at T2. Numerous researchers have reported that seaweed extract tends to increase plant biomass in various plants. El-Din *et al*., (2015) found that the consequence of 20% seaweed foliar spray was enhanced the harvest of *V. unguiculata* compared to lower (10%) and higher (30%,40%.50%) concentration of seaweed extract. The dry weight of *Cajanus cajan* was recorded in the plants that received 20% seaweed extract of *Chaetomorpha linum* compare to 10% and 50% concentration of seaweed foliar spray (Seenivasan *et al*., 2010).

Jothinayagi *et al*., (2009) stated that spraying of 20% *Sargassum wightii* was provided maximum fresh and dry weight (4.0, 1.2 g/seedling) of *Abelmoschus esculents* seedling and compare to 40% seaweed extract. The highest dry weight in *Vigna mungo* was observed at 25% seaweed (*Sargassum myriocystum*) extract and the lowest value of dry weight was observed at 50%,75%, and 100% seaweed extract (Kalaivanan *et al.*, 2012). Ramya *et al.*, (2011) found that the usage of 5% of seaweed foliar spray was reduced the total dry weight of cluster bean.

Through the results, it might be reported that the application of 20% foliar spray of macroalgae (*Padina antrillarum*) concentrate increased the plant biomass of roses over the control, 10, and 30% concentrations of seaweed extracts.

Number of Flowers

Significant differences ($p<0.05$) were ascertained among treatment methods for the number of flowers at 1 and 2 months after transplantation (MAT). Significantly ($p<0,05$) the maximum number of flowers was measured in T2 (20% seaweed foliar spray) at 1 and 2 MAT. The smallest number of flowers was reported in the control treatment (Fig. 4).

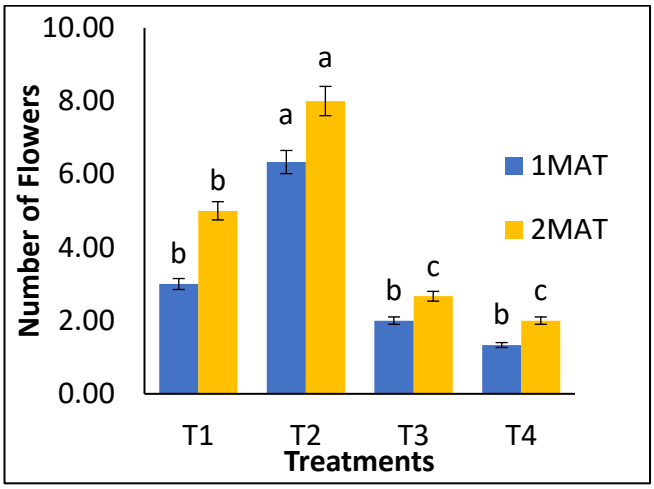

Fig. 4: Influence of different concentrations of usage of seaweed liquid foliar spray on number of rose flowers at 1,2 MAT. Means followed by same letter within a month were not significantly diverse with the DMRT test at 5% level of probability.

Roses need frequent providing of nutrients to make virtuous growing and gorgeous flowers (Manimaran *et al.*, 2017). These activities of the seaweed foliar spray as plant progress enhancers is not only due to plant hormones but is also attributed to polysaccharides (alginate, fucoidan) and polyphenols (Craigie *et al*, 2011). Harvest improvement influence owing to enhanced chlorophyll content that is attributed to the betaines which act as nitrogen sources present in the seaweed (Panda *et al*., 2012). Seaweed extracts possibly inspire flowering by acquiring vigorous plant development (Abetz *et al*., 1983).

Weekly spraying of 20% seaweed in roses considers as T2 treatment. The 20% concentration of seaweed extract might be the optimum concentration for rose plants. Therefore, the highest number of flowers was counted by plants grown at T2. Kalaivany *et al.*, (2019) stated that the usage of 20% seaweed liquid extract enhanced the growth of *V. unguiculate* through enlarged leaf area. Spraying of 15% (v/v) seaweed extracts made from *K. alvaezii* also lead to an increase of soybean yield, compared to the control and increased nutrient absorption by the plant (Rathore *et al.*, 2009).

The maximum number of flowers was recorded in cluster bean that received 20% seaweed extract and the lowest number of flowers observed at 10% and 40% seaweed liquid extract (Thirumaran *et al.*, 2009). A fewer number of flowers were recorded in Tuberose (*Polianthes tuberosa L.*) with foliar application of seaweed extract at 0.5 cm^3/l (Abd-El-Hady, 2000). Usage of *K. alvarezii* extract (5 %) gave a lower yield over control in green gram (*Phaseolus radiata* L) (Zodape *et al.*, 2010). Spraying of 100% Seaweed liquid extract (*Ascophyllum nodosum*) reduces the yield of ornamental sunflower (Santos *et al.*, 2019). Foliar application of *K. alvarezii* 100% seaweed extract gave a lower yield in green gram (Zodape *et al.*, 2010).

From the findings, it might be stated that the usage of 20% foliar spray of macroalgae (*Padina antrillarum*) extract amplified the number of flowers in roses over the control, 10%, and 30% concentrations of seaweed extracts.

Conclusions

The findings of the experiment revealed that plants are grown with 20% seaweed liquid extract application showed better performances in plant height, leaf area, plant biomass, and the number of flowers of roses. The lowest performance was observed in the control treatment. Plants that received lower (10%) and higher (30%) concentrations of seaweed extract expressed significantly lower performances than 20% seaweed extract. It showed that bio stimulatory effects of seaweed could be expressed in optimum concentration. It could be the reason for higher performance observed in roses grown with the usage of 20 % seaweed foliar spray.

Authors' Contribution

All authors equally contributed in all stages of this research work till the finalization of the manuscript. Final form of manuscript was approved by all authors.

Conflict of Interest

Authors declare that there are no conflicts of interest.

References

Abbas M, Anwar J, Zafar-ul-hye, M. and Khan RI (2020) Effect of Seaweed Extract on Productivity and Quality Attributes of Four Onion Cultivars. *Horticulture* **6**(2): 28. DOI:10.3390/horticulturae6020028

Abd-El-Hady WMF (2020) The response of tuberose (*Polianthes tuberosa L* .) Plants to chitosan and seaweed foliar application. *Scientific Journal of Flowers and Ornamental Plants* 2**(7)**: 153–161. DOI: 10.21608/sjfop.2020.100637

Abetz Pand Young CL (1983) The effect of seaweed extract sprays derived from Ascophyllum nodosum on lettuce and cauliflower crops. *Botanica Marina* **26(10)**:487-492. DOI: 10.1515/botm.1983.26.10.487

Abou El-Yazied A, El-Gizawy AM, Ragab MI, Hamed ES (2012) Effect of seaweed extract and compost treatments on growth, yield and quality of snap bean. *Journal of American Science* **8(6)**:1-20.

Al-Khuzaey AH, Al-Asadi FA (2019) Effect of Seaweed Extract Spray on Vegetative and Flowering Growth of Two Narcissus Species. *Basrah Journal of Agricultural Sci*ence **32**:134-139. DOI: 10.37077/25200860.2019.263

Ansari AA, Ghanem SM, Naeem M (2019) Brown Alga *Padina:*

A review. *International Journal of Botany Studies*1**(4)**, 01–03.

Bandara BWLW, Sutharsan S and Srikrishnah S (2018) Foliar application of seaweed liquid extracts on the growth performance of *Glycine max* (L.).*Proceeding of the second International Research Symposium, Uwa Wellassa University, Sri Lanka.*

BattacharyyaD, Babgohari MZ, Rathor P, and PrithivirajB (2015) Seaweed extracts as biostimulants in horticulture.**196**: 39–48. DOI: 10.1016/j.scienta.2015.09.012

Beneragama CK, Peiris SE (2015) Research and development and innovations in floriculture: lessons from the market giants for developing countries like Sri Lanka. *InIII International Conference on Quality Management in Supply Chains of Ornamentals* **1131:** 127-138. DOI: 10.17660/ActalHortic.2016.1131.17

Craigie JS (2011) Seaweed extract stimuli in plant science and agriculture. *Journal of Applied Phycology*, *July* 23(**3**) 371–393. DOI: 10.1007/s10811-010-9560-4

El-Din SM (2015) Utilization of Seaweed extracts as bio-fertilizers to stimulate the growth of Wheat seedlings. *The Egyptian Society of Experimental Biology* 11(**1**): 31–39.

El-Miniawy SM, Ragab ME, Youssef SM, and Metwally AA (2014) Influence of Foliar Spraying of Seaweed Extract on Growth, Yield, and Quality of Strawberry. *Journal of Applied Sciences Research* 10(**2**): 88–94.

Finnie JF, Van Staden J (1985) Effect of seaweed concentrate and applied hormones on in vitro cultured tomato roots. *Journal of Plant Physiology*Aug 1.120**(3)**:215-22. DOI: 10.1016/S0176-1617(85)80108-5

Hashemabadi D and Zarchini M (2010) Yield and quality management of rose (*Rosa hybrida cv . Poison*) with plant growth regulators. *Plant Omics Journal* 6**(3)**: 167–171.

Hewapathirana GI (2011) The role of social identity in the internationalization of women-owned small businesses in Sri Lanka. *Journal of Asia business studies* 2(5):172-193. DOI: 10.1108/15587891111152339

Jothinayagi, N., and Anbazhagan, C. (2009) Effect of seaweed liquid fertilizer of sargassum wightii on the growth and biochemical characteristics of *Abelmoschus esculentus(l.)Medikus*. *Recent Research in Science and Technology*, *1*(4), 155–158.

Kalaivanan C, Venkatesalu V (2012) Utilization of seaweed *Sargassum myriocystum* extracts as a stimulant of seedlings of *Vigna mungo (L .) Hepper*. *Spanish Journal of Agricultural Research10* **(2)**:466–470. DOI: 10.5424/sjar/2012102-507-10

Kalaivany, V., Sutharsan, S., and Srikrishnah, S. (2019) Effects of Natural and Commercially Available Seaweed Liquid Extracts on Growth and Yield of *Vigna unguiculata L.Asian Journal of Biological Sciences*.DOI: 10.3923/ajbs.2019

Kumar NA, Vanlalzarzova B, Sridhar S and Baluswami M (2012) Effect of liquid seaweed fertilizer of Sargassum wightii Grev. on the growth and biochemical content of green gram (Vigna radiata (L.) R. Wilczek). *Recent Research in Science and Technology* **4**(4): 40–45.

Leghari AJ, Laghari UA, Laghari AH, Bhutto TA (2016) Cultivation of rose (*Rosa indica L.*). *Journal of Floriculture and Landscaping***2**:1–4. DOI: 10.25081/jfcls.2016.v2.3044

Santos PL, Zabotto AR, Jordão HW, Boas RL, Broetto F, Tavares AR (2019) Use of seaweed-based biostimulant (*Ascophyllum nodosum*) on ornamental sunflower seed germination and seedling growth. *Ornamental Horticulture* **25**(3): 231–237. DOI: 10.1590/2447-536x.v25i3.2044

Mahomoodally MF, Bibi Sadeer N, Zengin G, Cziáky Z, Jekő J, Diuzheva A, Sinan KI, Palaniveloo K, Kim DH, Rengasamy KR (2020) In Vitro Enzyme Inhibitory Properties, Secondary Metabolite Profiles, and Multivariate Analysis of Five Seaweeds. *Marine drugs* **18**(4):198. DOI: 10.3390/md18040198

Manimaran P, Rajasekar P, Rameshkumar D, Jaison M (2017) Role of nutrients in plant growth and flower quality of rose : A review. *International Journal of Chemical Studies* **5**(6), 1734–1737.

Muraleedharan A, Sha K, Kumar S, Sujin GS, Joshi JL, Kumar CP (2020) Influence of seaweed extract along with growth regulators on the growth, flowering, and yield of anthurium plants. *Plant Archives* **20**(2), 1196–1199.

Panda D, Pramanik K, Nayak BR (2012) Use of Sea Weed Extracts as Plant Growth Regulators for Sustainable Agriculture. *International Journal of Bio-Resource and Stress Management* **3**(3):404–411.

Patel RV, Pandya KY, Jasrai RT, Brahmbhatt N (2018) Significance of green and brown seaweed liquid fertilizer on the seed. *International Journal of Recent Scientific Research* **9**(2): 24065–24072. DOI: 10.24327/ijrsr.2018.0902.1590

Rama Rao K (1990) Effect of seaweed extract on preparation, properties, and use of liquid seaweed fertilizers from Sargassum workshop on algal products. Seaweed Research and Utilization Association.1990; **14**: 7-8.

Ramya SS, Nagaraj S, Vijayan and N (2011) Influence of Seaweed Liquid Extracts on Growth, Biochemical and Yield Characteristics of *Cyamopsis tetragonolaba (L .) Taub*. *Journal of Phytology* **3**(9), 37–41.

Rathore SS, Chaudhary DR, Boricha GN, Ghosh A, Bhatt BP, Zodape ST, Patolia JS (2009) Effect of seaweed extract on the growth, yield and nutrient uptake of soybean (*Glycine max*) under rainfed conditions, *South African Journal of Botany* **75**(2): 351–355, DOI: 10.1016/j.sajb.2008.10.009

Seenivasan R, Geetha S and Sathya B (2010) Influence of seaweed liquid fertilizer on the growth and biochemical composition of legume crop, *Cajanus cajan (l.*) Mill sp. *Journal of phytology* **2**(5):50–63.

Setha B, Gaspersz FF, Idris AP, Rahman S, Mailoa MN (2013) Potential Of Seaweed *Padina* sp. As A Source Of Antioxidant. *International Journal of Scientific and*

Technology Research **2**(6): 221–224.

Srikrishnah S, Peiris SE, Sutharsan S (2012) Effect of Shade Levels on Leaf Area and Biomass Production of Three Varieties of *Dracaena sanderiana* L . in the Dry Zone of Sri Lanka. *Tropical Agricultural Research* **23**(2):142–151.

Sumangala K, Srikrishnah S, Sutharsan S (2019) Roses Growth and Flowering Responding to Concentration and Frequency of Seaweed *(Sargassum crassifolium L .)* Liquid Extract Application. Current *Agriculture Research Journal* **7**(2): 236-44. DOI**:** 10.12944/CARJ.7.2.11

Sutharsan S, Nishanthi S, Srikrishnah S (2014a) Preliminary studies on the effects of seaweed extract (Sargassum crassifolium) foliar application on seedling performance of *Zea mays*L.*Research Journal of Agriculture and Forestry Sciences* **5**(4), 1–5.

Sutharsan S, Nishanthi S, Srikrishnah S (2014b) Effects of foliar application of seaweed (Sargassum crassifolium) liquid extract on the performance of Lycopersicon esculentum Mill. in sandy Rego sol of Batticaloa District Sri Lanka. sandy Rego sol of Batticaloa district Sri Lanka. *American-Eurasian Journal of Agricultural Environmental Sciences* **14**(12):1386-96. DOI: 10.5829/idosi.aejaes.2014.14.12.1828

Teobaldelli M, Rouphael Y, Fascella G, Cristofori V, Rivera CM, Basile B (2019) Developing an Accurate and Fast Non-Destructive Single Leaf Area Model for Loquat (*Eriobotrya japonica Lindl)* Cultivars.*Plants* **8**(7):230. DOI: 10.3390/plants8070230

Thirumaran G, Arumugam M, Arumugam R, Anantharaman P (2009) Effect of Seaweed Liquid Fertilizer on Growth and Pigment Concentration of *Cyamopsis tetrogonolaba* (L) Taub. *American-Eurasian Journal of Agronomy* **2**(2) :50–56.

Uthirapandi V, Eswaran S, Boomibalagan P, Ramya SS, Vijayan and N, Rathinavel S (2019) Biofertilizing potential of seaweed liquid extracts of marine macroalgae on growth and biochemical parameters of *Andrographis paniculata.Plant Archives* **19**(2), 3201–3206.

Zhang X, Ervin EH (2000) Cytokinin-Containing Seaweed and Humic Acid Extract Associated with Creeping Bentgrass Leaf Cytokinins and Drought Resistance.*Crop science* **44** (5): 1737–1745.

Zodape ST, Mukhopadhyay S, Eswaran K, Reddy MP, Chikara J (2010) Enhanced yield and nutritional quality in green gram (*Phaseolus radiata* L) treated with seaweed (*Kappaphycus alvarezii*) extract. *Journal of Scientific and Industrial Research* **69**(6), 468–471. DOI: 10.3390/horticulturae6020028