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Short Communication

Effect of Seaweed Extract (*Kappaphycus alvarezii*) on the Growth, Yield and Nutrient uptake of Leafy Vegetable *Amaranthus polygamous*

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ABSTRACT: *A greenhouse study was conducted during the dry (March to April) season of 2018 at the District Agriculture Training Center (DATC), Thirunelvely, Jaffna, Sri Lanka to study the effect of seaweed (Kappaphycus alvarezii) extracts (SWE) as foliar spray at the rates of 5.0% and 10.0% (v/v) on growth and yield of common leafy vegetable crop Amaranthus polygamous. The study was conducted as a three factor factorial with two levels of fertilizers (100% and 50% recommended chemical fertilizer dose (CF)) and two sources of irrigation water with different salinity levels collected from Thirunelvely (high salinity water, EC = 1 500 µS/cm) and Moolai (very high salinity water, EC = 12200 µS/cm). At the harvesting stage, highest plant height was observed with 100% chemical fertilizer and Thirunelvely water. However comparable plant growth was found with 50% chemical fertilizers when supplemented with 10% (v/v) SWE. In addition, number of leaves per plant, fresh weight of leaves, stem and whole plant (28.6 g) as well were highest in T2 (100% CF + Thirunelvely water). Replacement of 50% of fertilizer with SWE and Thirunelvely water yielded significantly comparable fresh plant weight (22.8 g), while addition of Moolai water resulted in poor yield (20.1 g) even with addition of 10% SWE. Leaf N, P, K and Na content further confirmed the effect of SWE on plant at harvesting stage. There was no significant difference in the percentage of N in leaves between chemical fertilizer alone and foliar application of SWE combined with 50% CF. In all treatments, which has received Moolai water contained significantly the highest Na concentration in Amaranthus leaves. The study indicates that foliar application of 10% (v/v) seaweed extract combined with 50% of recommended chemical fertilizer dose and irrigation with Thirunelvely water (at 1 500µS/cm) could be an effective alternative for sustainable cultivation of Amaranthus polygamous.*

Keywords*: Amaranthus polygamous, salinity, seaweed extract, Kappaphycus alvarezii*

INTRODUCTION

The agricultural sector will continue to play a vital role in developing and implementing strategies targeted towards a planned socio-economic development in Sri Lanka. Salinity is the one of the major problems faced by agricultural areas, which decreases the crop production drastically. In Sri Lanka, 22 300 ha (about 3% of the Island) of salt affected lands are found in dry zone (Subasinghe, 2004). Due to rapidly growing population, there is a considerable

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pressure on limited good quality water resources. So it needs to consider the use of poor quality water in crop irrigation for more efficient and sustainable agricultural production systems to feed these growing populations. On the other hand, agriculture sector in the country is threatened due to excessive use of synthetic agro-chemicals. For example, WHO-UN report in December 2013 identified that Sri Lanka as the highest per hectare user of pesticides and the eighth highest user of chemical fertilizers in the world. Therefore, it is very important to focus on approaches for using naturally available renewable resources of plant nutrients as alternatives to chemical fertilizers. Research attempts have been largely made to increase soil fertility and crop productivity *via* organic farming (Roy chowdhury *et al.*, 2013). Seaweed extracts is known as a bio stimulant and organic fertilizer, which contain plant growth promoters/regulators, hormones, macronutrients and micronutrients which promote faster seed germination and a higher yield (Sasikala *et al*., 2016). *Kappaphycus alvarezii* is edible red seaweed which is one of the largest tropical algae with relatively higher growth rate.

On this background, a pot experiment was conducted to study the effect of *K. alvarezii* seaweed extract applied as a foliar spray at 5% and 10% concentration combined with 100% and 50% recommended chemical fertilizer dose (CF) on growth of *Amaranthus polygamous* which is a widely grown leafy vegetable crop.

METHODOLOGY

Preparation of Sea Weed Extract (SWE)

The seaweed extract used in this study was obtained from marine red alga *Kappaphycus alvarezii*. The marine *alga K. alvarezii* was collected from coastal area of Jaffna (9° 77' 60.41" N latitude, 79° 91' 22.35" E longitude), Sri Lanka during March 2018. The fresh *K. alvarezii* alga were brought to the laboratory and washed thoroughly in tap water for 3 or 4 times. Then the fresh *K. alvarezii* were homogenized by grinding using an electrical grinder, filtered (Eswaran *et al*., 2005) and stored at 4˚C for further use. The filtrate (100% concentration) was used as the stock solution for preparation of 5.0 % and 10.0% (*volume*/volume; *v*/v) SWE by mixing appropriate volumes of distilled water.

Greenhouse experiment

The greenhouse pot experiment was conducted at the *DATC, Thirunelvely, Jaffna, Sri Lanka* (9° 69' 61.76" N latitude, 80° 03' 20.54" E longitude). The soil of the site is characterized as Calcic red latosols and some important soil characteristics are given in Table 1. The pot experiment was designed with 10 treatments arranged in a completely randomized *design* (*CRD*). The treatments are given in Table 2 and details about inorganic fertilizer application are given in Table 3. Each treatment was replicated 3 times. Pots (cross sectional area of 452.16 cm^2 and heights of 20 cm) were filled with soil *w*ith 1.5 g/cm^3 bulk density and basal fertilizer was added according to the fertilizer treatments. Six seeds of *A. polygamous* were planted per pot at 3–5 cm distance. During the growing period, 10 ml of each SWE (5% and 10%) was applied as foliar sprays at three times, first at 7 days (seedling stage), second at 14 days and third at 24 days after sowing.

For irrigation, two types of water sources were selected from Thirunelvely and Moolai areas in Jaffna. Based on salinity hazard to crop (Wilcox, 1955), Moolai water (12 200 µS/cm) was belonged to the hazard class unsuitable water (> 2,250 µS/cm), while Thirunelvely water (1

500µS/cm) belonged to doubtful water (750-2,250 µS/cm). As control, distilled water was used and the irrigation was carried at 3 days intervals.

Table 1. Soil characteristics at the study site, Thirunelvely, *Jaffna, Sri Lanka*

Soil characteristic	Average value
pH (1:5/ soil: water)	7.24±0.06
EC (µS/cm)	98.50±6.76
Available N (mg/100g)	6.30±0.48
Available P (kg/ha)	74.40±7.01
Available K (kg/ha)	376.80±28.45
Organic matter (%)	0.48±0.0007

Table 2. Treatment panel used in the greenhouse study

Treatment	
T1	100%CF + D water
T2	100%CF + T water
T3	100%CF + M water
T4	50%CF + 5% SWE +D water
T5	50% CF + 10% SWE + D water
T6	50% CF + 5% SWE + T water
T7	50% CF + 10% SWE + T water
T8	50% CF + 5% SWE + M water
T9	50% CF + 10% SWE + M water
T10	Only soil + D water

(CF-Chemical Fertilizer as Department of Agriculture Recommendation, SWE-Sea Weed Extract, T – Thirunelvely, M - Moolai, D – Distilled)

A. polygamous from each pot were harvested once it reached marketable size at 30 days after sowing (DAS). Measurements and analysis namely, plant height, total number of leaves per plant, diameter of main stem, root length, fresh weight of leaves, stem and roots, dry weight of leaves, stem and roots, nitrogen percentage in leaves (total N was determined by semi-micro Kjeldahl method), Phosphorous percentage in leaves (by vanado-molybdate yellow spectro-photometric method at the wave length of 450 nm : Jackson, 1973), Potassium percentage in leaves (by flame photometer : Jackson, 1973) and Sodium percentage in leaves (by flame photometer : Jackson, 1973) were performed.

Table 3. Fertilizer recommendation for *Amaranthus* by Department of Agriculture

Fertilizer type	**Basal**	**1st top dressing** (14 DAE)
Urea [$CO(NH_2)_2$]	85 kg/ha	85 kg /ha
Triple superphosphate [$Ca(H_2PO_4)_2•H_2O$]	130 kg/ha	-
Muriate of Potash [KCl]	100 kg/ha	-

(DOA=Department of Agriculture, Sri Lanka, DAE=Days after emergence)

Statistical analysis

Data were analyzed by SAS (9.1) package and the mean separation were done by Duncan multiple range test at p=0.05.

RESULTS AND DISCUSSION

Effect of SWE and quality of irrigation water on plant growth

Plant height in each treatment increased from 18 DAP to harvesting at 30 DAP (Table 4). At the harvesting stage, plant height was the highest in T2 followed by T1, however it was not significantly different from T7 and T5. Therefore 10% SWE and 50% CF with Thirunelvely water have given comparable results with 100% CF with respect to plant height. It can be due to the presence of growth promoting hormones and nutrients in seaweed extract (Sasikala *et al*., 2016). However, irrigation with Moolai water has resulted significantly lower plant height with 100% CF or with addition of SWE. This can be due the high salinity (12200µS/cm*)* of Moolai water. Salinity decreases the cell division, elongation and meristemic activity (Ruf, *et al.*, 1963). In the case of unsuitable water application (Moolai at 12 200 µS/cm), spraying 10% of SWE enhanced the plant height as compared to 100% of CF. It's obvious that addition of foliar application (10%) of SWE reduced the salt stress on *Amaranthus* crop and increased the growth of the plant under very high saline water application.

Effect on yield parameters

Yield parameters at harvesting are given in the Table 5. Maximum values for fresh weight of leaves, fresh weight of stem and fresh weight of whole plant were recorded in T2 (100 %CF + Thirunelvely water). In addition, highest dry weights of leaves, roots and whole plant were observed in T2. Replacement of 50% fertilizer with SWE with Thirunelvely water (T7-50% CF + 10% SWE + Thirunelvely water) has yielded second highest fresh plant weight, while addition of Moolai water resulted poor yield irrespective of addition of SWE. El-Yazied *et al.* (2012) also reported that fresh and dry weights of leaf and Stem per plant of Snap bean were significantly increased by foliar application of seaweed extract at higher rate (750 ppm).

Nutrient uptake

Figures 1a to 1d illustrate the effects of *K. alvarezii* seaweed SWE with or without CF and irrigated using *Thirunelvely water* and Moolai water compared with control. Nitrogen is the key element required for crop growth in combination with Phosphorus and Potassium. *K. alvarezii* seaweed extract contain high in macro (N: 0.45-0.70%, P: 0.007-0.010%, K: 1.60-2.10%) and micro elements for plant growth (Zodape, *et al*., 2009). It was found that there was no significant difference in the percentage of N in leaves among 100% CF alone and foliar application of SWE combined with 50%CF treatment, due to the availability of nitrogen in *K. alvarezii* seaweed extract. In the case of P% and K% in leaves, foliar application of SWE (10%) combined with 50% CF treatments resulted higher values, compared to that in 100% CF alone under all both types of irrigation water and control with distilled water. The reason may be that *K. alvarezii* extract which was applied 3 times contains readily available forms of *P* and *K. Alam et al*. (2013) also confirmed that seaweed extract provides a readily available source of nutrients and organic compounds. Pramanick *et al*. (2013) reported that foliar sprays of 7.5% *Kappaphycus* SWE with 50% recommended dose of basal CF gave the higher P and

K in grains of green gram compared with that of 100% of recommended dose of CF alone. *K. alvarezii* extract is rich in potassium and found to affect on the regulation of stomata pore size and protein synthesis (Karthikeyan and Shanmugam, 2016).

Table 4. **Effect of *K. alvarezii SWE* on the plant heights of *A. polygamous* on 18th to 30th day after sowing (DAS)**

	18th DAS (cm)	21th DAS (cm)	24th DAS (cm)	27th DAS (cm)	30th DAS (cm)
T1	19.0±1.32 ^{ab}	29.0±5.07 ^{ab}	34.3±3.75 ^{a}	39.0 ±3.61^{ab}	44.3 ±2.08^{ab}
T2	21.0±1.00 ^{a}	30.0±2.59 ^{a}	35.0±2.64 ^{a}	41.3±4.72^{a}	46.3 ±3.40^{a}
T3	11.0±0.50^{e}	14.7±1.60 ^{cd}	18.7±0.76 ^{c}	22.7±0.57^{c}	27.7 ±0.76^{d}
T4	17.7±0.76 ^{bc}	24.5±2.50 ^{b}	28.2±3.01^{b}	33.7±1.52 ^{b}	37.3±2.51^{c}
T5	19.3±1.60 ^{ab}	26.2±1.89 ^{ab}	31.7±2.46 ^{ab}	36.2 ±3.25 ^{ab}	42.3 ±4.61^{abc}
T6	18.7±1.89 ^{ab}	26.5±2.59^{ab}	30.2±2.02^{ab}	35.0±4.58 ^{b}	38.7±6.33 ^{bc}
T7	19.7±2.02 ^{ab}	26.8±3.78 ^{ab}	33.7±5.13 ^{a}	38.2 ±4.31^{ab}	44.2±3.68 ^{ab}
T8	12.0±2.78 ^{e}	12.8±0.57 ^{d}	18.5±3.61 ^{c}	21.7±3.51 ^{c}	24.3±3.05 ^{d}
T9	12.7±1.25 ^{de}	17.8±0.76 ^{c}	21.2±2.08 ^{c}	24.8±1.61 ^{c}	29.0±1.73 ^{d}
T10	15.0±1.50 ^{cd}	18.3±1.44 ^{c}	21.0 ±1.73^{c}	23.3 ±2.52^{c}	24.7±2.08 ^{d}

Values are means of triplicates with ± SD. Different letters in a single column show statistically significant differences at P <0.05.

Table.5. Effect of *K. alvarezii* SWE on the yield contributing characters *of A.polygamous on* 30th day after sowing

	Fresh weight of leaves (g)/plant	Fresh weight of stem(g) / plant	Fresh weight of root(g) / plant	Fresh weight of plant (g)	Dry weight of plant(g)
T1	9.3±3.46^{ab}	12.1 ±1.69^{bcd}	1.94±0.30^{bc}	23.3±4.97^{abc}	3.25±0.66^{ab}
T2	10.7±1.89^{a}	15.4 ±0.88^{a}	2.59±0.19^{a}	28.6 ±1.23 ^{a}	4.07±0.28^{a}
T3	8.8±1.18^{abc}	7.5±1.34^{ef}	1.65±0.31^{c}	17.9 ±2.57 ^{cde}	2.14 ±0.47^{cd}
T4	6.4±0.91^{bc}	9.1±1.38^{ed}	1.72±0.41^{bc}	17.3 ±2.16 ^{de}	3.04 ±0.39^{abc}
T5	8.7±1.68^{abc}	11.9 ±2.35^{bcd}	2.27±0.18^{ab}	22.9 ±3.73 ^{abcd}	3.84±0.61^{a}
T6	8.3±1.87^{abc}	12.7 ±1.61^{abc}	1.78±0.39^{bc}	22.8±3.57^{abcd}	3.92±0.73^{a}
T7	9.1±0.47^{ab}	13.3 ±2.30^{ab}	2.03±0.29^{bc}	24.5 ±2.20 ^{ab}	3.90 ±0.69^{a}
T8	5.6 ±1.14^{dc}	5.5±1.04^{gf}	1.62±0.45^{c}	12.7±1.50^{ef}	1.98±0.49^{cd}
T9	8.6±2.42^{abc}	9.6 ±2.64^{cde}	1.84±0.23^{bc}	20.1 ±5.02 ^{bcd}	2.73 ±0.85^{bc}

Values are means of triplicates with ± SD. Different letters in a single column show statistically significant differences at P <0.05.

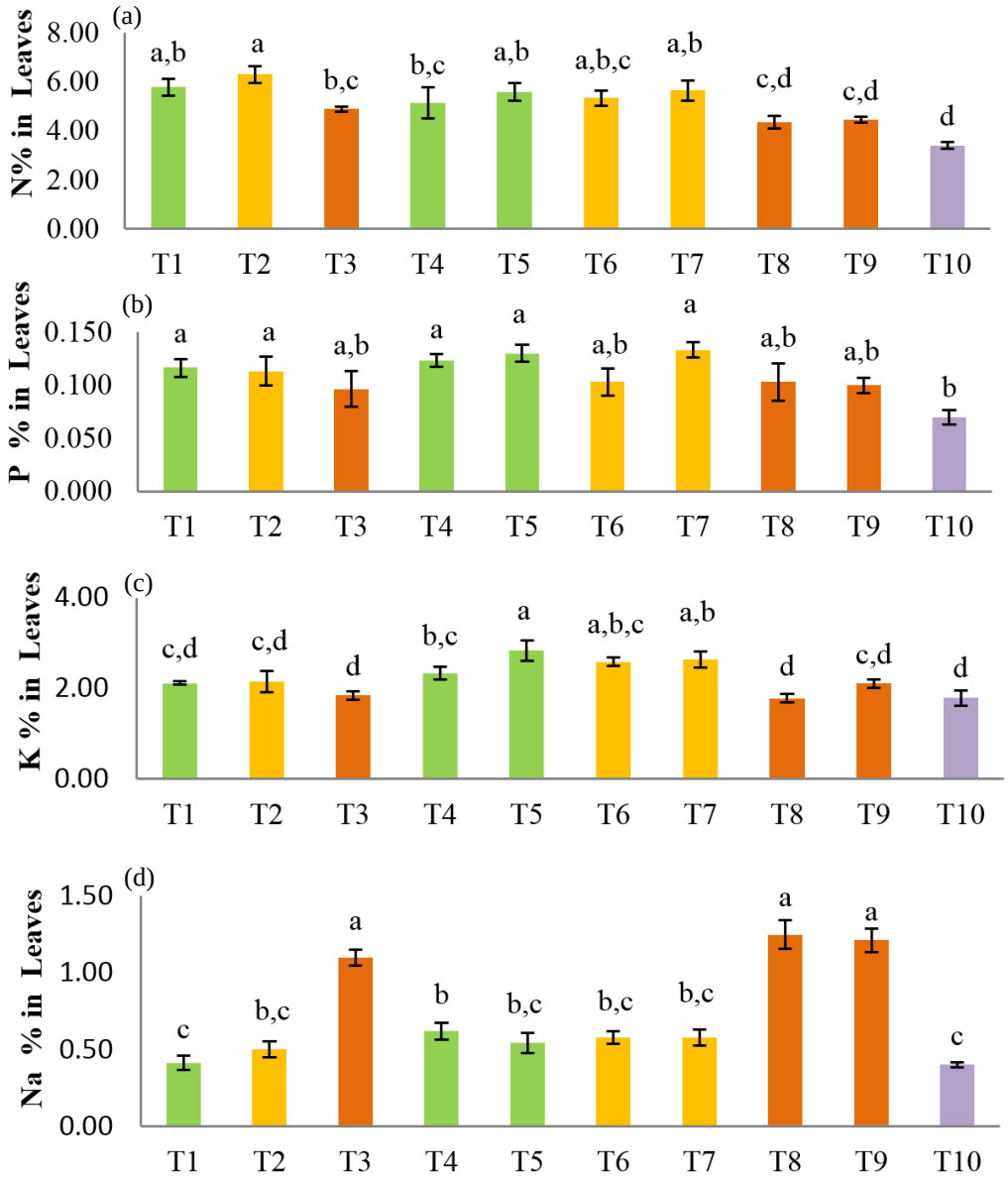

Figure1. Effects of *K. alvarezii* seaweed extracts (SWE) on (a) nitrogen (N), (b) phosphorous (P), (c) potassium (K) and (d) sodium (Na) percentage in leaves of *A. polygamous* plants growing under different treatments. The columns marked with same lowercase letters do not differ significantly (p>0. 05). Error bars represent standard error (*n*=3).

In all treatments which have received Moolai water (T3, T8 and T9), significantly highest sodium content in leaves was observed. Observed sodium content in leaves was mostly opposite to the percentage of potassium in leaves. Na^+ has adverse effects on K^+ nutrition results a competition between uptake of Na^+ and K^+ by plant roots. In agreement, De Lacerda *et al*. (2003) reported that salt stress leads to accumulation of Na^+ and reduction of K^+ content in leaves. SWE applied with 50% CF treatments showed higher Na percentage than that of

100% CF alone, which can be due to the higher sodium levels in marine algae. Marine alga of *K. alvarezii* extract reported to contain sodium at the rate of 0.45- 0.7 % (Eswaran *et al*, 2005).

CONCLUSIONS

At the harvesting stage, highest plant height was observed with 100% Chemical fertilizer and Thirunelvely water. However comparable plant growth was found with 50% CF when supplemented with 10% (*v*/v) sea weed extract. In addition, number of leaves per plant, fresh weight of leaves, stem and whole plant (28.6 g) as well were highest in T2 (100%CF + Thirunelvely water). Replacement of 50% of fertilizer with 10% SWE and Thirunelvely water yielded significantly comparable fresh plant weight (24.5 g) with T2 treatment (28.6). Leaf N, P, K and Na content in leaves further confirmed the effect of SWE on plant growth. There was no significant difference in the percentage of N in leaves between chemical fertilizer alone and foliar application of SWE combined with 50% CF. In the case of P and Kin leaves, foliar application of SWE (10%) combined with 50% CF treatments resulted higher values compared to that in chemical fertilizer alone. In contrast, all treatments which have received unsuitable MOOLAI water indicated significantly highest sodium content in *Amaranthus*. It is evident that foliar application of 10% (*v*/v) seaweed extract combined with reduced recommended chemical fertilizer doses (50%) with comparatively less saline water could be an effective alternative for sustainable cultivation of *Amaranthus polygamous*.

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