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EFFECT OF TWO SEAWEED PRODUCTS ON RADISH (*RAPHANUS SATIVUS*) GROWTH UNDER GREENHOUSE CONDITIONS

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ABSTRACT

Several studies have revealed a wide range of beneficial effects of seaweed products applications on plants growth and development. Seaweeds may cause different effect in plant responses because there are a range possible factors acting in concert. These factors may include to the amount of plant growth regulator (PGR) and nutrients present in the products. PGR activity in two seaweed products (Maxicrop® and Seasol®) was investigated using Radish (*Raphanus sativus*). Treatments included a control, standard concentrations of the seaweed Products (SS1 and MC1), 2 and 4 times the recommended rates (SS2, SS4, MC2 and MC4) ashed seaweed products (SS-ash and MC-ash), and equivalent amounts of N, P and K to that found in seaweed products (SS-NPK and MC-NPK). The results obtained show that both Maxicrop® and Seasol® can significantly increase crop performance. Maxicrop® increased chlorophyll content and root and shoot growth, while Seasol® only increased the chlorophyll content.

Key Words: Plant growth regulator, radish, seaweed.

INTRODUCTION

Excessive use of chemical fertilisers to address nutrient deficiencies of the soil has created several environmental problems, with increased pollution, acidification, and production of greenhouse gases (GHGs) (Maraseni *et al.*, 2010). A major strategy to counteract the decline in environmental quality is to promote sustainable agriculture. Productivity can only be achieved by use of ecologically sustainable inputs (Polat *et al.*, 2008).

In Australia and elsewhere (including Indonesia), there is interest in the use of seaweed concentrates in agriculture and there are a number of seaweed products on the markets (Kaliaperumal, 2003; Khan *et al.*, 2009). These products may cause differing effects on plant growth and development because there are a range of possible factors. These may include the amount and type of plant growth regulators (PGRs) and the level of nutrients present in the products (Temple *et al.*, 1989).

Inorganic amendments are likely to diminish as global energy demands and costs increase and finite nutrient resources are depleted. Unlike inorganic amendments, organic amendments such as seaweed products can improve the health of soil by increasing the organic carbon content, the availability of plant nutrients, microbial biomass and activity, and by enhancing soil structural stability (Quilty and Cattle, 2011).

Reports indicate that seaweed extracts can improve the growth rate and yields of crop plants (Robertson-Anderson *et al.*, 2006), including vegetables, trees, cut flower crops and grain crops. This may be due to the effect of PGRs in the extract or the effect on soil micro-organisms, soil structure and soil physics, and macro- and micro-nutrient availability. Owing to the wide range of elicited physiological responses, it is probable that more than one group of

PGRs is involved with cytokinins (Stirk *et al.*, 2004), auxins (Sanderson *et al.*, 1987) and gibberellins (Sivasankari *et al.*, 2006) reported to be present in seaweed extracts.

To evaluate the effects of PGRs and mineral nutrients in two seaweed products (Seasol® and Maxicrop®), a greenhouse experiment was conducted using radish (*Raphanus sativus*) as test plant. Results from bioassays (Yusuf *et al.*, 2012) indicate that Seasol® was effective in promoting initial seedling shoot and root elongation. However, it is uncertain whether the effects observed in the bioassay are also manifested at the whole plant level.

The aim of this research was to investigate the effect of application rate of Seasol® and Maxicrop® seaweed products, and a range of allied treatments that included or excluded the corresponding PGRs and mineral nutrients, on the growth and development of radish growing under glasshouse conditions.

MATERIAL AND METHODS

Experimental Conditions. A grey-brown granite-derived Chromosol with a sandy to sandy-loam texture was used for the experiments was collected from the Kirby Research Farm, UNE (30.4° S and 151.5° E, elevation of 1,050 m). Properties for the soil are given in Table 1.

Radish was germinated in Petri dishes and after the radicle had reached 5 mm in length, four seedlings were sown into each pot containing with 3 kg of soil. After one week, the seedlings were thinned to two per pot and watered daily. The experiment was conducted in a greenhouse under natural light with temperatures set at a 25/15°C day/night regime.

Table 1. Soil Properties for The Soil Used in The Pot Trial

Parameter	Units	Value
pH (1:5 water)		5.86
Organic carbon	%	0.65
Nitrogen	%	0.04
Sulphur	mg/kg	10
Phosphorus [c]	mg/kg	47
Potassium [a]	meq/100g	0.38
Calcium [a]	meq/100g	19
Magnesium [a]	meq/100g	19
Aluminium [b]	meq/100g	0.11
Sodium [a]	meq/100g	0.26
Chloride	mg/kg	15
CEC		38.7
EC	dS/m	0.06
EC (se)	dS/m	0.4

a ammonium acetate extraction, b KCl extraction, c cowell

Table 2. Treatments used to Assess Plant Growth

Treatment	Water (ml)	Seaweed Product (ml)	Amount of Mineral
1. Control	100	0	0
2. SS 1	99.84	0.16 seasol	0
3. SS 2	99.68	0.32 seasol	0
4. SS 4	99.36	0.64 seasol	0
5. SS-ash	100	0.16 seasol	0
6. SS-NPK	100	0	Urea = 0.17g KH_2PO_4 = 0.025g K_2SO_4 = 6.6g
7. MC 1	99.74	0.26 maxicrop	0
8. MC 2	99.48	0.52 maxicrop	0
9. MC 4	98.96	1.04 maxicrop	0
10. MC-ash	100	0.26 maxicrop	0
11. MC-NPK	100	0	Urea = 4g KH_2PO_4 = 0.87g K_2SO_4 = 5g

Experimental Design and Treatments. This experiment used Seasol® (SS) at the recommended dilution rate of 1:600 and Maxicrop® (MC) at the recommended dilution rate of 1:375 as well as 2 and 4 times the recommended rates. The concentrations of N, P and K in Maxicrop® and Seasol® were determined and mineral nutrient solutions were prepared to create two treatments with the equivalent amounts of N, P and K to that found in Maxicrop® (MC-NPK) and Seasol® (SS-NPK) respectively. Laboratory-grade urea ($[NH_2]_2CO$), tripotassium phosphate (K_3PO_4) and potassium sulphate (K_2SO_4) in distilled water were used to make these solutions. Finally, Seasol® and Maxicrop® were heated in crucibles for 48 hours at 450°C to create SS-ash and MC-ash treatments with presumably similar mineral contents as the unashed products, but no organic compounds such as PGRs. A control treatment consisted of 100 ml deionized water and all other treatments consisted of a total of 100 ml, with the additives included in that volume. The eleven treatments are listed in

. The solutions were applied as a soil drench. Each treatment was replicated four times in a completely randomised design. Treatments were applied one day after transplanting and were repeated every 14 days until the conclusion of experiment at harvest.

Harvesting and Measurement. On the harvest day, the following parameters were measured: plant height, shoot and root dry, and chlorophyll content. Chlorophyll content was recorded using a Minolta SPAD-502 chlorophyll meter. The measurements were taken from top, middle and bottom leaves and the average of these leaves was calculated.

Statistical analyses. Analysis of variance was carried on using the R program version 2.10.1 (R Development Core Team, 2012). Assumptions of heterogeneous variances and normal distributions were confirmed, and significantly different means were separated using 95% confidence intervals (CI = 1.96 × standard error) (Cumming, 2009). Treatment means and CI are presented in the graphs.

RESULTS

Plant Height. Increase the dosage of Maxicrop® were significantly increased radish plant height ($P_{slope} < 0.001$) (Figure 1). The slopes for Control and all SS treatment were similar, whereas the slopes for MC treatments were significantly greater than the control, in the order MC4 > MC2 > MC1 > MC-ash > MC-NPK.

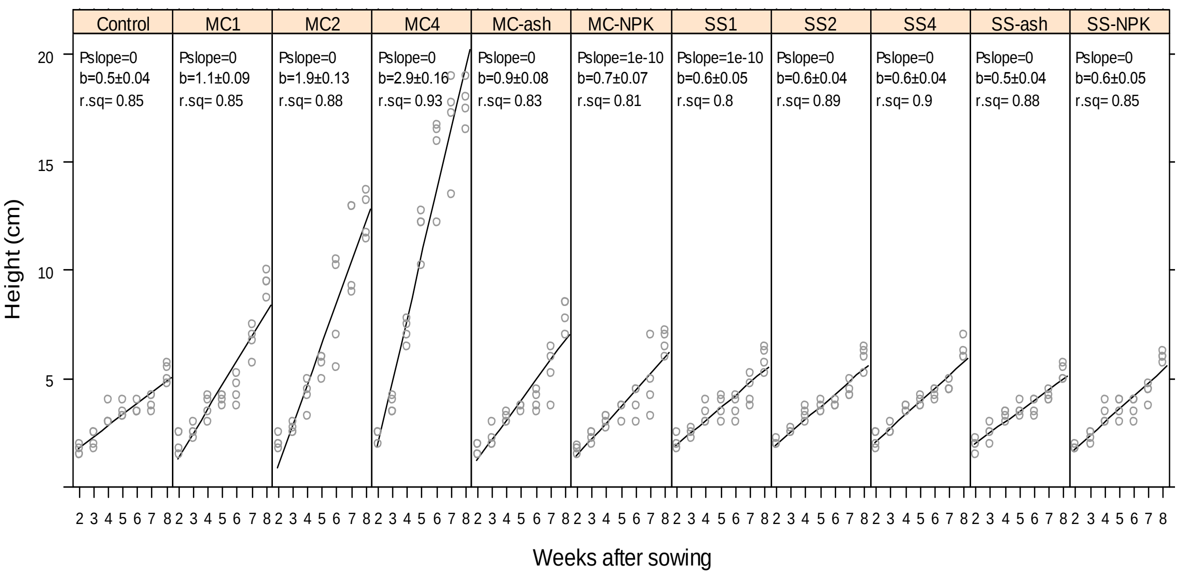

Figure 1.
Effect of Two Seaweed Products on Plant Height (cm)

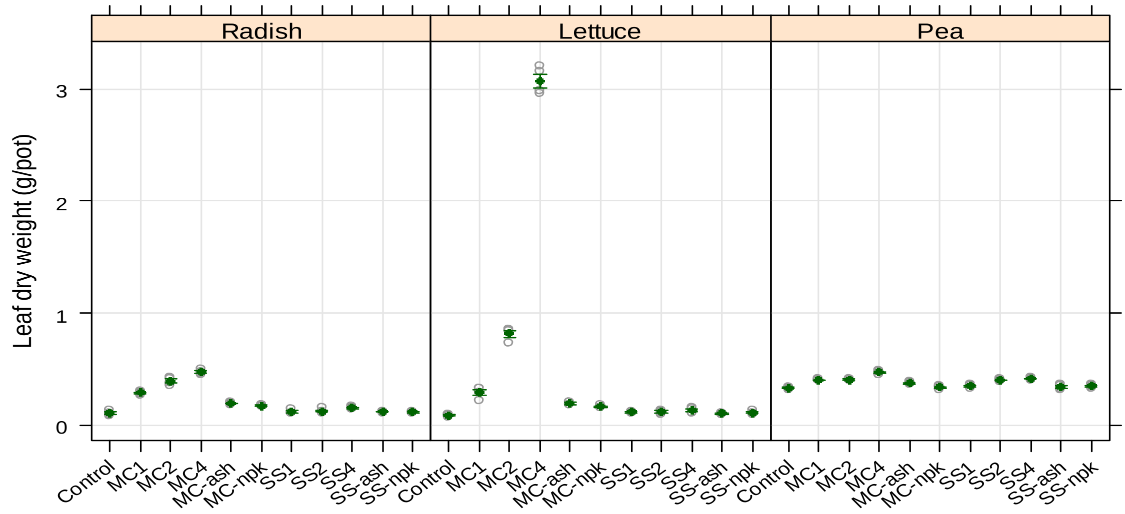

Figure 2.
Effect of Two Seaweed Products on Shoot Dry Weight (g/pot) of Radish. Values are Means ± s.e

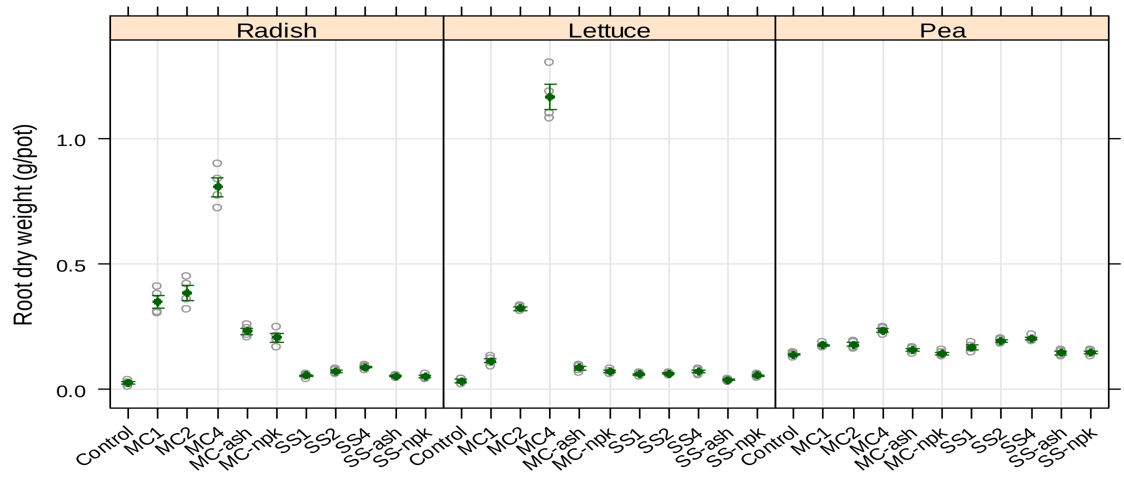

Figure 3.
Effect of Two Seaweed Products on Root Dry Weight (g/pot) of Radish. Values are Means ± s.e

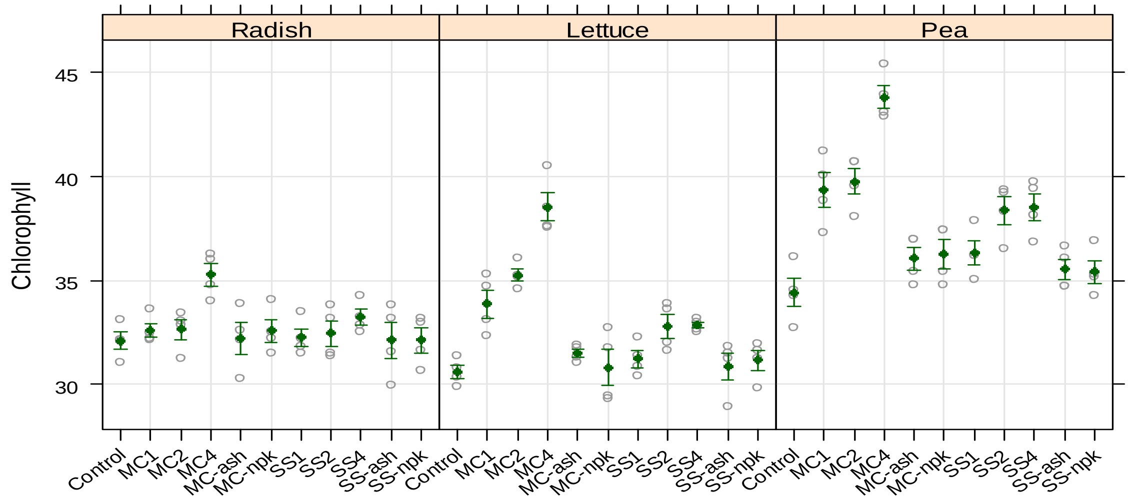

Figure 4.
Effect of Two Seaweed Products on Chlorophyll Content of Radish Leaves

Shoot Dry Weight. Application of Maxicrop® significantly showed a significant increase shoot dry weight with increased MC concentrations. However, for Seasol®, increasing dosage did not significantly increase shoot dry weight in radish (Figure 2).

A comparison between the ash treatments (MC-ash and SS-ash) and the seaweed products at recommended rates (MC1 and SS1) shows that MC-ash was significantly (P < 0.001) less effective (Figure 2). SS-ash showed no significant difference in radish plant, however, MC-ash was more effective than the control. The SS-ash treatment was not significantly different compared to the control.

Root Dry Weight. Maxicrop® showed a significant increase root dry weight for radish and this became more significant with increased concentrations (Figure 3). For Seasol®, increasing dosage did not significantly increase root dry weight in radish.

SS-ash treatment was not significantly different compared to the SS1 treatment. MC-ash was significantly more effective than the control in radish, but SS-ash was not different to the control.

MC-NPK compared to MC1 treatment was not significantly different. Similarly, SS-NPK was not significantly different compared to the SS1 treatment. The NPK treatments had significantly greater root dry weights than the control for both Maxicrop® and Seasol®. The ash treatment was not significantly different compared to the NPK treatment for either Maxicrop® or Seasol®.

Chlorophyll Content. In radish, only the MC4 and SS4 treatments were significantly higher compared to the control.

DISCUSSION

The highest concentration of Maxicrop® (MC4) had the greatest effect of the various treatments. In general. In contrast, Seasol® only had a significant effect on chlorophyll content. Most of the literature reporting the beneficial effects of seaweed products have indicated that plant dry weight and chlorophyll of treated plants was significantly increased (Erulan *et al.*, 2009; Sivasankari *et al.*, 2006; Norrie and Keathley, 2006). These increases were attributed to seaweed components such as macro- and micro-element nutrients, amino acids, vitamins, cytokinins, auxins, and gibberellins and others PGRs substances (Singh and Gupta, 2011; Finnie and Vanstaden, 1985; Khan *et al.*, 2009). All these compounds could affect cellular metabolism in treated plants leading to enhanced growth and development (Norrie, 2008; Crouch and Staden, 1992). However, some of these reports found that the concentration of mineral nutrient elements present in seaweed products cannot account for the growth responses (Blunden, 1991; Edmeades, 2002). The beneficial effect may therefore relate to the various plant growth regulators present in these seaweed extract (Khan *et al.*, 2009; Tay *et al.*, 1985).

The MC-ash treatment was generally less effective than MC1 treatment, but it was more effective than the control. This suggests that organic compounds such as PGRs present in Maxicrop® and Seasol® and are responsible for some of the increase in crop performance (Tay *et al.*, 1987; Khan *et al.*, 2009), as ashing of these two seaweed products resulted in a loss of their PGRs and the activity of other organic compounds (Finnie and Vanstaden, 1985; Beckett and van Staden, 1989). Crop cultivation using organic fertilisers contributes to improved physical and chemical properties of soil that are important for stimulation of microbial activity in soils (Haslam and Hopkins, 1996; Galbiatti *et al.*, 2007). Seaweed as organic fertiliser (Zodape, 2001) may have increased the biological activity in the soil treated with Maxicrop® and Seasol®.

The NPK treatments were generally less effective when compared to the equivalent Maxicrop® treatment, but were more effective than the control. This suggests that the minerals such N, P, and K in Maxicrop® and Seasol® are responsible for some of the increase in crop growth (Khan *et al.*, 2009), but the improvement is lower than plants treated with the un-ashed seaweed products..

Table 3. Fertiliser Requirement (kg/ha) for Radish (Napier, 2004) And Amount of N,P, and K (kg/ha**)** Consisting in Maxicrop® and Seasol®

Nutrient Requirement	Radish
N	200
P	100
K	150

The dry matter yield and chlorophyll for the ash treatment was similar to that for the NPK treatment in all instances. This provides evidence that the nutrient solutions used in this experiment closely matched the mineral composition of the seaweed products (Finnie and Vanstaden, 1985) and possibly indicates that other mineral nutrients beside NPK were not important enough to cause difference in plant growth.

CONCLUSIONS

The results demonstrate that Maxicrop® and can significantly increase crop growth and development, while Seasol® only increased chlorophyll content. The results indicated that, for Maxicrop®, PGRs compounds present in seaweed products can improve plant growth in glasshouse conditions beyond that which can be expected from equivalent mineral fertilisers.

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