

# Potential Effect of Plant Growth Regulators in Two Seaweed Products

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## Abstract

Seaweeds and seaweed products have been applied in vegetable production systems for many years. This is because seaweeds have beneficial effects in vegetable production systems. However, the mechanism by which seaweed can elicit the growth and development response is still not fully understood. Mineral nutrient concentrations are commonly too low to be effective, and plant growth regulators (PGR) have been suggested as a causal factor. PGR activity in two seaweed products (Maxicrop<sup>®</sup> and Seasol<sup>®</sup>) was investigated using field pea (*Pisum sativum* L.) bioassays. Treatments included a control, standard concentrations of the seaweed products, ashed seaweed products, auxin, cytokinin, gibberellin and mineral nutrients (matched to each seaweed product). The results obtained show that the seaweed products have potential plant growth regulator activity rather than a mineral nutrient effect alone. Ashing reduced the root growth effect of Seasol<sup>®</sup> but not Maxicrop<sup>®</sup>. Seasol<sup>®</sup> performed better than Maxicrop<sup>®</sup> based on the root and shoot length.

## INTRODUCTION

Many factors affect crop growth and development, one of which is the adequate supply of necessary plant nutrients. The addition of nutrients to soil in the form of chemical fertiliser is the dominant means of increasing food supply in modern agriculture. The use of chemical fertiliser can create some problems (Thirumaran et al., 2007). Natural sources such as compost, and farmyard, poultry manure and seaweeds can be used to enhance soil nutrients for better crop performance.

Seaweed and seaweed products have also been reported as a potential fertiliser (Blunden et al., 1996). Various seaweed products are now available for sale and these products may result in different plant responses. This is due to many factors including the amount and type of plant growth regulators (PGR) and mineral nutrients present in these products. Previous research has shown that the mineral nutrient concentrations in seaweed products do not consistently explain plant responses and it has been speculated that PGRs may play a role in increasing plant growth and development (Finnie and Vanstaden, 1985).

To evaluate the plant growth regulator activity of seaweed products, we used field peas (*Pisum sativum* L.) bioassay to study the effect on root and shoot elongation. Bioassays can be a relatively cheap and simple way to test the effect of known and putative biologically active substances. When dealing with biologically active substances such as PGRs, researchers must have a means of measuring their biological activity which is easy to perform and accurate (Devlin and Witham, 1983; Rayorath et al., 2008).

The aim of this research is to investigate the effect of Maxicrop<sup>®</sup> and Seasol<sup>®</sup> seaweed products and a range of allied treatments that included or excluded PGRs and mineral nutrients on pea seed growth in a bioassay test.

## MATERIALS AND METHODS

Seeds of field pea (*Pisum sativum* L.) were germinated using vermiculite (Arditti and Dunn, 1969) and grown in the dark at 20°C for 48 h in order to facilitate a uniform germination (Mackie-Dawson, 1989; Nitsch and Nitsch, 1956; Quesnelle and Emery, 2007; Rayorath et al., 2008; Whatley and Slife, 1983). Five uniform seeds with a root length of 2 mm were immersed in 30 ml of each treatment solution. All seeds were

distributed randomly in petri dishes containing the test solution. After 96 h of incubation in the dark at 25°C, the length of shoots and roots were measured. There were four replications for each treatment and the experiment was repeated twice.

This experiment used Seasol<sup>®</sup> (SS) with a recommended dilution rate of 1:600 dilution and Maxicrop<sup>®</sup> (MC) with a recommended rate of 1:375 dilution. Maxicrop<sup>®</sup> is a natural product. It is the whole non-fibrous content of seaweed made by an extraction process which gives a liquid seaweed plant food that is beneficial to plants (Multicrop, 2009). Seasol<sup>®</sup> is a refined seaweed plant conditioner containing naturally occurring growth regulators (plant hormones), trace elements, alginates, carbohydrates and vitamins derived from a blend of brown kelps including King Island Bull Kelp, *Durvillaea potatorum* from north west Tasmania (Tay et al., 1987) and Knotted Kelp *Ascophyllum nodosum* from the North Atlantic Ocean (Seasol, 2011). Both Seasol<sup>®</sup> and Maxicrop<sup>®</sup> products were diluted with distilled water. The concentration of PGRs, auxin (indole-3-butyric acid, IBA), cytokinin (6-benzylaminopurine), BAP, and gibberellin (gibberellic acid, GA<sub>3</sub>), used in this trial were based on optimal doses determined in earlier dose-response experiments using a logarithmic series from 5×10<sup>-6</sup> to 5×10<sup>-1</sup> μM. The two seaweed products were ashed by heating in a crucible for 48 h at 450°C and then re-hydrated to the original volume (Beckett and van Staden, 1989; Finnie and Vanstaden, 1985). The concentration of nitrogen, phosphorus and potassium (NPK) in the two seaweed products was determined in the University's analytical chemistry laboratory. These concentrations were used to make up mineral nutrient solutions of using laboratory-grade urea ([NH<sub>2</sub>]<sub>2</sub>CO) and tripotassium phosphate (K<sub>3</sub>PO<sub>4</sub>) in distilled water. The treatments were:

1. Control: test solution containing water only,
2. Standard rate of Maxicrop<sup>®</sup> (0.26%),
3. Standard rate of Seasol<sup>®</sup> (0.16%),
4. Ashed Maxicrop<sup>®</sup> (ashing of 0.26% solution, re-hydrated),
5. Ashed Seasol<sup>®</sup> (ashing of 0.16% solution, re-hydrated),
6. Auxin (IBA) at 0.005 ppm,
7. Cytokinin (BAP) at 0.5 ppm,
8. Gibberellin (GA<sub>3</sub>) at 5 ppm,
9. MC-NPK (equivalent NPK solution to match Maxicrop<sup>®</sup>), and
10. SS-NPK (equivalent NPK solution to match Seasol<sup>®</sup>).

Statistical analysis was carried out with analysis of variance using the R program version 2.10.1 (RTeam, 2011). Assumptions of heterogeneous variances and normal distributions were confirmed, and significantly different means were separated using standard errors (1.96 × SE assumed to be equivalent to P=0.05). Treatment means and SEs are presented in the graphs.

## RESULTS

Adding Maxicrop<sup>®</sup> and Seasol<sup>®</sup> solutions to the growth medium enhanced pea shoot (Fig. 1) and root (Fig. 2) growth compared to the control (P<0.001). At 96 h after incubation, both repetitions of the experiment showed that Seasol<sup>®</sup> performed better than Maxicrop<sup>®</sup>. Exogenous PGRs (IBA, BAP and GA<sub>3</sub>) resulted in increased root and shoot length over the control. GA<sub>3</sub> produced longer shoots than the NPK treatments in the first run, but no differences were observed in the second run, except that Seasol<sup>®</sup> produced slightly longer shoots. Root elongation was very significantly increased by improved by Seasol<sup>®</sup> compared with all other treatments (P<0.001), and BAP and GA<sub>3</sub> improved root growth compared with IBA and the NPK treatments. Maxicrop<sup>®</sup> generally performed similarly to its NPK equivalent treatment.

Ashing did not significantly affect either seaweed products' effect on shoot growth (Fig. 3) but ashing Seasol<sup>®</sup> resulted in a reduction of root growth (Fig. 4) by about 20% (P<0.001). The ashed treatments showed similar responses to the NPK treatments (P≥0.382).

## DISCUSSION

Seaweed products have been shown to improve the growth in several plants (Blunden et al., 1996). This may be because seaweeds consist of many organic and inorganic components (Crouch et al., 1990; Finnie and Vanstaden, 1985). Therefore, it is important to clarify which of those components are responsible for improving the plant growth. It has been shown in this investigation that these two seaweed products stimulated the root and shoot growth, in some cases, more than that observed for treatments with an equivalent amount of mineral fertilisers. This suggests that the seaweed products, especially Seasol<sup>®</sup>, had an effect beyond that attributable to mineral fertilisers alone.

Ashing of the seaweed products resulted in a loss of growth promoting activity in Seasol<sup>®</sup>, presumably due to the loss of organic material such as PGRs due to ashing. Inorganic compounds in these seaweed products such as N, P, and K are likely to have remained in the ashed material and thus stimulated root and shoot growth more than the control treatment.

The cytokinin and gibberellin treatments had a larger root response compared with the NPK, ashed and auxin treatments, but less than the complete Seasol<sup>®</sup> seaweed fertiliser treatment. This provides an indication that PGRs promoting cell elongation and division may be acting in seaweed products (Rayorath et al., 2008). It has been reported by several authors that seaweed consists of both organic and inorganic compounds which mean that PGRs found in seaweed are partly responsible for root and shoot growth (Finnie and Vanstaden, 1985; Quesnelle and Emery, 2007).

## CONCLUSIONS

Under the experimental conditions reported here, Seasol<sup>®</sup> performed better than Maxicrop<sup>®</sup> in the pea elongation bioassay. Overall, our results indicated that both products promoted root and shoot growth over the control plants. The addition of NPK or PGRs also promoted the root and shoot growth. However, the addition of NPK or exogenous PGRs resulted in less root and shoot growth compared to the seaweed products, especially Seasol<sup>®</sup>. Confirmation of these results in pot trials and under field conditions would provide evidence of the economic value of seaweed products.

## ACKNOWLEDGEMENTS

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## Literature Cited

- Arditti, J. and Dunn, A. 1969. *Experimental Plant Physiology, Experiments in Cellular and Plant Physiology*. Rinehart and Winston, New York.
- Beckett, R. and van Staden, J. 1989. The effect of seaweed concentrate on the growth and yield of potassium stressed wheat. *Plant and Soil* 116:29-36.
- Blunden, G., Jenkins, T. and Liu, Y.W. 1996. Enhanced leaf chlorophyll levels in plants treated with seaweed extract. *Journal of Applied Phycology* 8:535-543.
- Crouch, I.J., Beckett, R.P. and van Staden, J. 1990. Effect of seaweed concentrate on the growth and mineral nutrition of nutrient-stressed lettuce. *Journal of Applied Phycology* 2:269-272.
- Devlin, R.M. and Witham, F.H. 1983. *Plant Physiology*. Willard Grant Press, Boston.
- Finnie, J.F. and van Staden, J. 1985. Effect of seaweed concentrate and applied hormones on in vitro cultured tomato roots. *Journal of Plant Physiology* 120:215-222.
- Mackie-Dawson, L.A. 1989. The effect of surface soil consolidation on the early root development of pea (*Pisum sativum* L.). *Plant and Soil* 116:126-128.
- Multicrop. 2009. Fertilisers, Australia, <http://www.multicrop.com.au/fertilis.htm#Maxicrop%EF%BF%BD%20Seaweed%20Plant%20Food%20Concentrate>.
- Nitsch, J.P. and Nitsch, C. 1956. Studies on the growth of coleoptile and first internode section: a new, sensitive, straight-growth test for auxin. *Plant Physiology* 31:94-111.
- Quesnelle, P.E. and Emery, R.J.N. 2007. cis-Cytokinins that predominate in *Pisum*

- sativum* during early embryogenesis will accelerate embryo growth in vitro. Canadian Journal of Botany-Revue Canadienne De Botanique 85:91-103.
- Rayorath, P., Jithesh, M., Farid, A., Khan, W., Palanisamy, R., Hankins, S., Critchley, A. and Prithiviraj, B. 2008. Rapid bioassays to evaluate the plant growth promoting activity of *Ascophyllum nodosum* (L.) Le Jol. using a model plant, *Arabidopsis thaliana* (L.) Heynh. Journal of Applied Phycology 20:423-429.
- RTeam, D.C. 2011. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing. Vienna.
- Seasol. 2011. Commercial concentrates farms and orchards, Australia, <http://www.commercial.seasol.com.au>
- Tay, S.A.B., Palni, L.M.S. and MacLeod, J.K. 1987. Identification of cytokinin glucosides in a seaweed extract. Journal of Plant Growth Regulation 5:133-138.
- Thirumaran, G., Anantharaman, P. and Kannan, L. 2007. Effect of seaweed extracts used as a liquid fertilizer in the radish (*Raphanus sativus*). Journal Ecobiology 20:49-52.
- Whatley, L.L. and Slife, F.W. 1983. Bioassay of benazolin for auxin activity using the pea (*Pisum sativum*) straight growth test. Weed Science 31:801-802.

## Figures

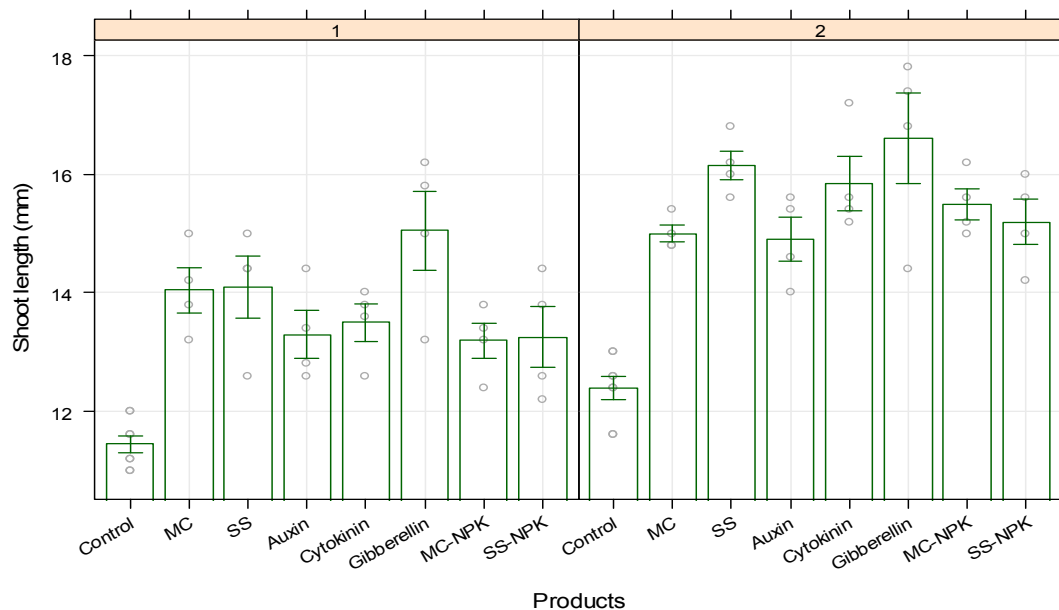


Fig. 1. Effect of seaweed products (Maxicrop<sup>®</sup> [MC] and Seasol<sup>®</sup> [SS]), plant growth regulators (auxin, cytokinins and gibberellin), and mineral nutrients (matched to Maxicrop<sup>®</sup> [MC-NPK] and Seasol<sup>®</sup> [SS-NPK]) on shoot length in two repeated trials (1 and 2).

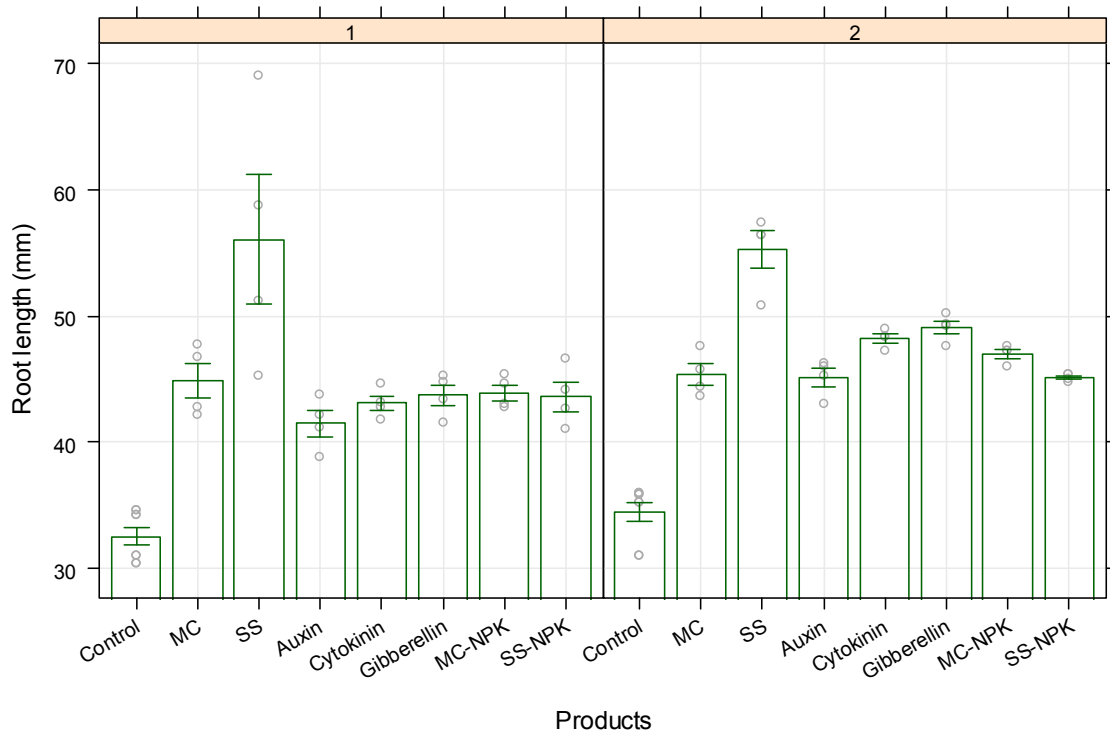


Fig. 2. Effect of seaweed products (Maxicrop<sup>®</sup> [MC] and Seasol<sup>®</sup> [SS]), plant growth regulators (auxin, cytokinins and gibberellin), and mineral nutrients (matched to Maxicrop [MC-NPK] and Seasol [SS-NPK]) on root length in two repeated trials (1 and 2).

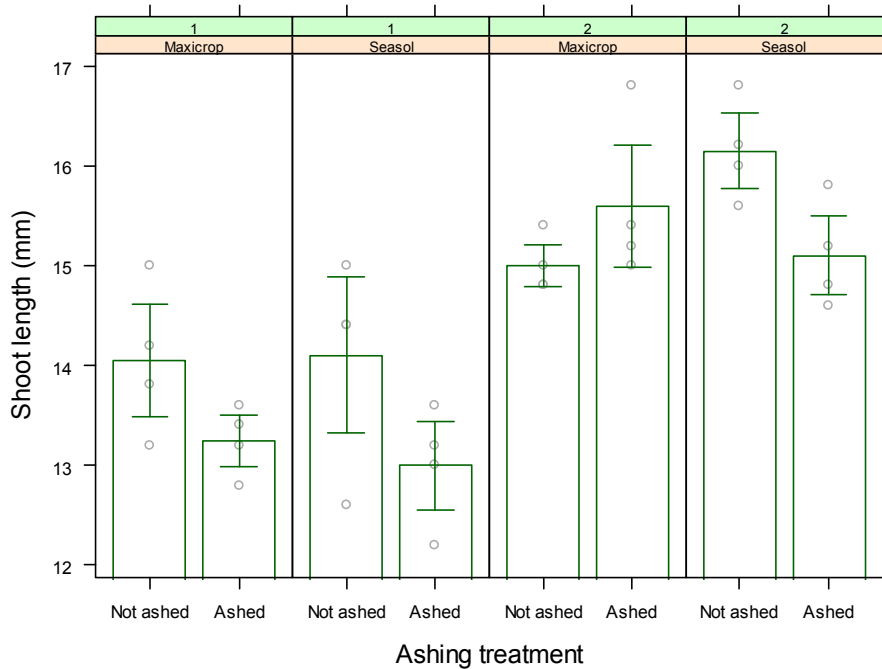


Fig. 3. Effect of ashing of two seaweed products (Maxicrop<sup>®</sup> and Seasol<sup>®</sup>) on shoot length in two repeated trials (1 and 2).

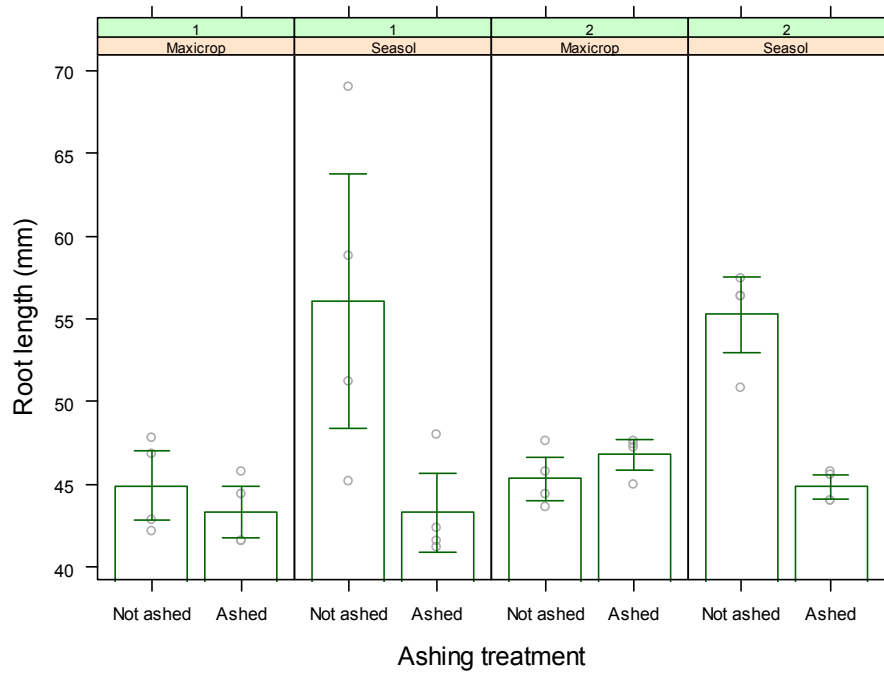


Fig. 4. Effect of ashing of two seaweed products (Maxicrop<sup>®</sup> and Seasol<sup>®</sup>) on root length in two repeated trials (1 and 2).