Plant Hormone Content in GrowGreen's Microbe Plus® Kelp versus Seasol Liquid Fertilizer.

Key words

Plant hormones, Plant growth stimulation, Bio-stimulants, Plant metabolites, Morphogenesis

Introduction

In recent years there has been renewed interest in the use of seaweed extracts as a fertilizer within Australian agriculture (Arioli, et al., 2015). As well as containing a range of macro-nutrients seaweed extracts also contain plant hormones and natural growth regulators which can potentially act as crop bio-stimulants (Panda, et al., 2012).

However, since seaweed is a natural product, plant hormone concentrations within it may vary considerably, and may only be short lived. Seaweed extracts can produce real benefits to growers, but it's important for a grower to understand the properties of any product they are using in order to get the best out of it.

Two leading seaweed based liquid fertilizers Microbe Plus® Kelp (M+Kelp) and Seasol are assessed in terms of their plant hormone content and bio-stimulant effect. The potential benefits of using each are discussed below. M+Kelp has been created via a unique process that blends and digests high grade seaweed species with plant beneficial microbes, fungi and bacteria and selected plant nutrients to create an excellent fertilizer.

Seasol is derived from different seaweed species. Both the botanical family[1] and the environmental factors affect the composition and concentration of the different hormones and other biostimulants in different seaweeds. That's why the efficacy of the different products when used as plant fertilizers may vary.

What are plant hormones and why are they important?

Plant hormones are nature's way of controlling plant growth and development, they are also essential in helping plants adapt to environmental stress. They act as chemical messengers, and help to regulate the plants physiological processes. Plant hormones fulfil essential roles in cell differentiation, and it is well established that plant hormones can initiate primary growth and morphogenesis or the development of the plants form. Plant hormones also play a crucial role in helping plants adapt to environmental stress, e.g. for drought by stimulating stomatal closure to reduce water loss (Peleg & Blumwald, 2011). Plant hormones are also involved in regulating the uptake of nutrients and the response to infection by pathogens (Argueso, et al., 2009).

[1]E.g. Brown Algae (Phaeophyta); Green Algae (Chloropha); Red Algae (Rhodophyta).

Several groups of plant hormones have been identified; being abscisic acid (ABA), auxins, gibberellins cytokinins and ethylene (ACC) the most relevant for plant health and growth.

ABA controls processes, including seed and bud dormancy, the control of organ size and stomatal closure. For example ABA synthesis is one of the fastest responses to water stress, initiating stomatal closure and a reduction in water loss (Peleg & Blumwald, 2011).

Auxins control cell enlargement or the growth of shoots and play a role in virtually every aspect of plant growth and development. One of the main functions of auxins is to balance the speed of growth. Auxins also control root development, and synthetic auxins are widely used in rooting powders and gels to assist with plant propagation. As with other plant hormones only low concentrations of auxins are necessary to stimulate a response, however at higher concentrations root growth can be inhibited, and can have a negative impact – in fact synthetic auxins are the basis for many herbicides. For example in maize plants it has been found that low IAA concentrations (0.1-10 nM) stimulated root elongation, but higher concentrations (0.1-1 M) had an inhibitory effect (Eliasson, et al., 1989).

Auxins in seaweed extracts have been shown to initiate root formation, inhibit its elongation, differentiation of phloem elements, apical dominance and tropisms; however auxin concentrations in seaweed extracts are different and strongly depend on the species (El Shoubaky & Salem, 2016).

Gibberellins play important roles in a wide range of processes including, bolting and flowering, light induced inhibition of cell growth, parthenocarpy or fruit set. Cytokinins promote cell division or cytokinesis in plant roots and shoots. They initiate and activate basic growth processes.

Plant hormone types, functions and benefits.

Hormone	Function	Benefits
Abscisic Acid (ABA)	Seed and bud dormancy, induces seeds to synthesize storage proteins, regulates seed germination, stimulates the close of stomata, a growth inhibitor.	Improved resilience to water stress.
Auxins	Shoot elongation, apical dominance.	Thinning of tree fruit, increase rooting and flower formation.
Cytokinins	Stimulate cell division, cell growth and differentiation also affects apical dominance, axillary bud growth, and leaf senescence.	Prolongs the storage life of flowers and vegetables and stimulates bud initiation and root growth.
Gibberellins	Stimulate cell division and elongation. Flowering and bolting.	Increased stalk length, increased flower and fruit size.
Ethylene (Precursors)	Ripening along with cell shape and growth.	Induces uniform ripening in fruit and vegetables and helps to strengthen cells.

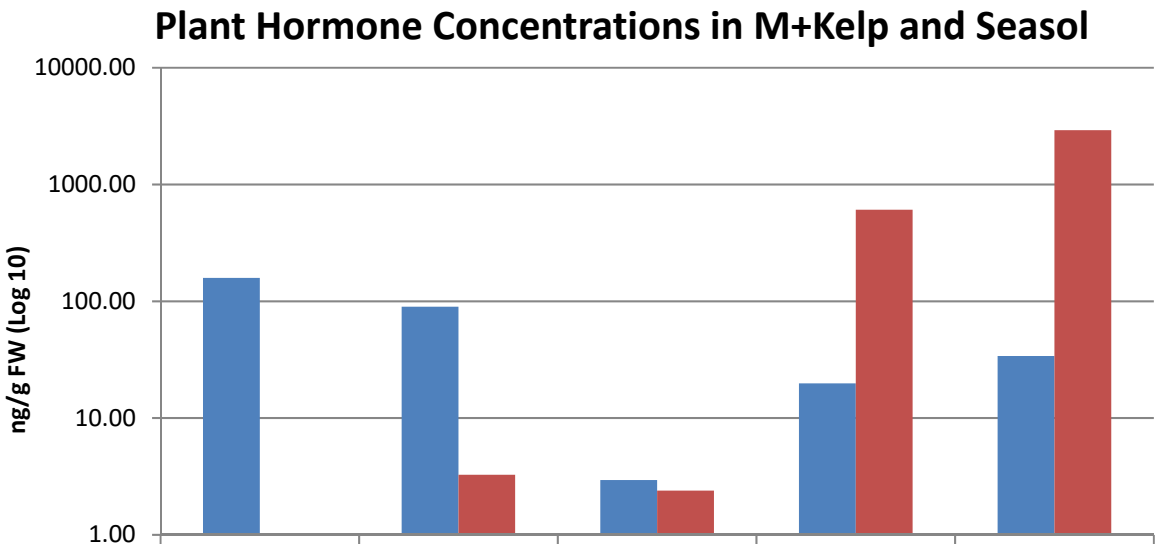
Ethylene is a gas produced within the plant and governs the development of leaves flowers and fruits, and depending on its level it may also promote, inhibit or induce senescence. Ethylene controls the process of ripening in fruit and flowering and plays a key role in plant development. However it also interacts with other plant hormones in controlling other processes.

Ethylene is often produced in response to plant stress, and can stimulate responses to damage, disease, and submergence. During ripening in fruits, ethylene regulates firmness and colour changes involving chlorophyll reduction, and an increase in carotenoids or anthocyanins, sugars, and the biosynthesis of volatile organic compounds (VOCs) (Iqbal, et al., 2017). Ethylene has also been reported to stimulate leaf growth.

Plant hormones often interact with each other, and can have both positive and negative effects, they are often involved in more than one stage of a crops development, and more than one can play role in key processes, for example auxins, gibberellins, and cytokinins are major regulators of fruit set (Kumar, et al., 2014). It is the balance of plant hormones present rather than the absolute concentrations that makes a difference to the crops development. Thus the range of plant hormones present in a bio-stimulant can make a big difference in its ability to support crop growth and development and the results a grower can achieve. Moderate levels of all plant hormones interacting together are likely to provide the optimum balance between plant stress tolerance, and any negative impacts of crop growth and development (Peleg & Blumwald, 2011).

The Results

The analysis found wide difference in the plant hormone present in the two fertilisers and their concentrations. GrowGreen's M+Kelp samples contained traces of 16 different plant hormones, whereas the Seasol samples contained only six.



	ABA and ABA metabolites	Cytokinins	Giberellins	Auxins	Ethylene
M+Kelp	158.29	89.63	2.94	19.79	33.95
Seasol		3.27	2.39	607.43	2917.86

M+Kelp contained traces of all the main plant hormone groups, whereas Seasol did not contain any Abscisic acid or Abscisic acid metabolites. Seasol however did contain substantially higher levels of auxins (over 600 ng/g) and ACC (2917.9 ng/g) compared with M+Kelp.

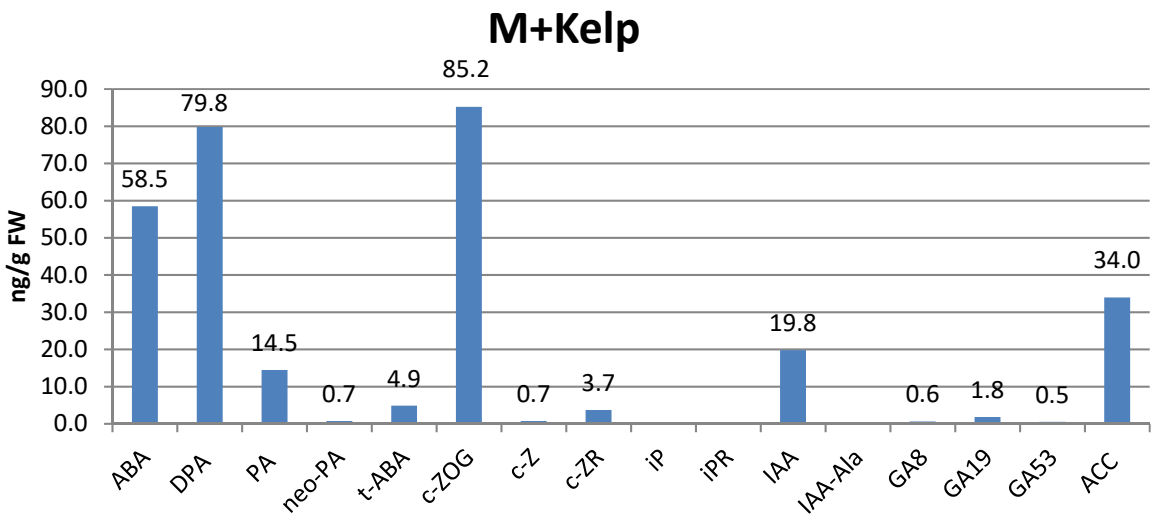
The Individual Plant hormones found in M+Kelp and Seasol

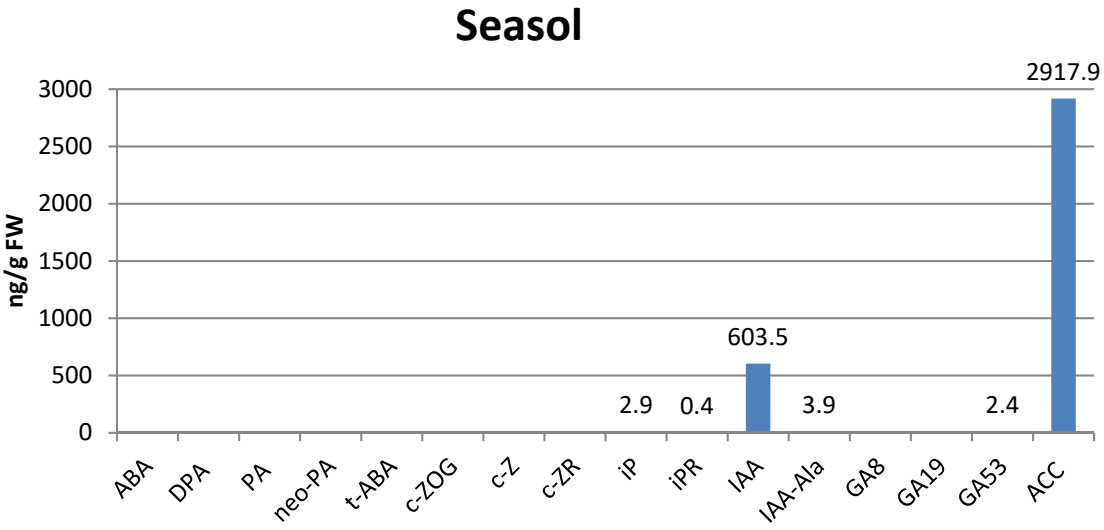
Hormone Type	Hormone	Abbreviation	M+Kelp	Seasol
			Concentration ng/g FW	
ABA & ABA metabolites	cis-Abscisic acid	ABA	58.5	
ABA & ABA metabolites	Dihydrophaseic acid	DPA	79.8	
ABA & ABA metabolites	Phaseic acid	PA	14.5	
ABA & ABA metabolites	neo-Phaseic acid	neo-PA	0.7	
ABA & ABA metabolites	trans-Abscisic acid	t-ABA	4.9	
Cytokinins	(cis) Zeatin-O-glucoside	c-ZOG	85.2	
Cytokinins	(cis) Zeatin	c-Z	0.7	
Cytokinins	(cis) Zeatin riboside	c-ZR	3.7	
Cytokinins	Isopentenyladenine	iP		2.9
Cytokinins	Isopentenyladenosine	iPR		0.4
Auxins	Indole-3-acetic acid	IAA	19.8	603.5
Auxins	N-(Indole-3-yl-acetyl)-alanine	IAA-Ala		3.9
Gibberellins	Gibberellin 8	GA8	0.6	
Gibberellins	Gibberellin 19	GA19	1.8	
Gibberellins	Gibberellin 53	GA53	0.5	2.4
Ethylene	1-aminocyclopropane-1-carboxylic acid	ACC	34.0	2917.9

Discussion

GrowGreen's M+Kelp contains a wider range of plant hormones and higher concentrations of cytokinins and gibberellins. Abscisic acid (ABA) and ABA metabolites are absent altogether from Seasol. As a metabolite, Abscisic acid is important in terms of a plants resilience to water stress.

Each of the main classes of plant hormone is represented in M+Kelp, and with the exception of auxins by more than one specific hormone, e.g. they are three gibberellins GA8, GA19 and GA 53 in M+Kelp compared with only GA53 in Seasol. Gibberellins and cytokinins are the key hormones to stimulate root and shoot development, and they are all present in M+Kelp, in adequate concentrations. According to research the bio-stimulant activity of extracts obtained from marine algae is connected with the presence of plant growth regulators, particularly the cytokinins which are mainly responsible for plant aging delay, mitosis induction, stimulation of chloroplast maturation, growth of shoot and lateral buds (Tuhy, et al., 2013).





The concentration of the ethylene precursor (ACC) in M+Kelp was very low compared with that in the Seasol samples. Ethylene is often thought of as an 'ageing hormone and plants overproducing ethylene are often dwarfed (Dubrois, et al., 2013). High ethylene concentration is also a potent inhibitor of nodule development in plants (Hoe Lee & La Rue, 1992).

Only small concentrations of plant hormones are needed to trigger a response, and exogenous hormones supplied via natural substances such as seaweed are likely to provide enough hormones in a more appropriate and natural form compared with many other commercial products. The typical response of roots to exogenous auxin is inhibited elongation and it has been reported that concentrations down to 1 nM or 175.19ng IAA[2] in the solution surrounding the roots of wheat and flax seedlings can inhibit root growth (Eliasson, et al., 1989). Thus M+Kelp with an auxin concentration of 20 ng/g FW is below the threshold where a negative response would be expected.

[2] Assuming IAA has a molecular weight of 175.19 g·mol−1.

M+Kelp contains a broad range of plant hormones in moderate quantities compared with Seasol which had higher levels of auxins and ethylene pre-cursers but lacked Abscisic acid and Abscisic acid metabolites altogether. This mix of hormones in combination with the beneficial bacteria within M+Kelp makes it an excellent natural liquid fertiliser.

Conclusions

Seaweed extracts do not just provide a crop with nutrients and beneficial bacteria but a range of plant hormones which can act as natural bio-stimulants and alternative plant growth regulators, and can help a plant react to and survive environmental pressures including drought and insect attack. There is growing evidence that the real benefits of using seaweed extract fertilisers come from the bio-stimulation which these hormones and other bioactive molecules induce within the crop as much as the micronutrients found within the product.

GrowGreen's M+Kelp has been shown to contain a better balance of all the key plant hormone groups compared with Seasol, and also being a source of plant beneficial fungi and bacteria will give crops on organic and sustainable farming systems a real boost.

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