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Improving the quality of horticultural produce through the addition of seaweed products

Key external stakeholders:
Growers, Agronomists, Crop Protection Specialists

Practical implications for stakeholders:
The application of seaweed extracts to field vegetable crops did not result in a consistent yield increase, however several favourable factors, such as a significant increase in secondary metabolites were observed. The use of seaweed extracts did, in some cases increase ornamental and vegetable seed germination and its incorporation into artificial growth media did increase the number of flowers produced by seaweed treated plants.

Main results:
- The application of seaweed extracts at recommended application rates and frequency did not result in a statistically significant increase in yield in brassica crops. Yields remained comparable to the untreated controls.
- The application of seaweed extracts resulted in significant increases in the concentration of secondary metabolites observed in both broccoli and cabbage crops, with observed 2 fold increases in total phenolics, total flavonoids and total isothiocyanates in broccoli crops with lower but statistically significant increases for the same parameters observed in pointed cabbage (Summer and Winter).
- Increased seed germination post exposure to seaweed extracts was inconsistent, but observable in some instances. The treatment of flowering plants (Cyclamen) with seaweed extracts did result in an increased number of flowers being produced after a 40 day period

Opportunity / Benefit:
This study demonstrates the importance of investigating secondary benefits when assessing the potential agronomic benefits of seaweed extracts, and plant stimulants in general, for use on horticultural crops. While no increase in yield was consistently observed in treated crops, the increase in secondary metabolites is an interesting observation given their roles in both the plants innate defense systems and also in their beneficial dietary role when consumed. The observation of increased flower number when applied to cyclamen crops indicates an ability to increase ornamental plant quality, however this observation would need to be replicated and tested on a wider range of flowering crops.

Overall the results indicate that pure seaweed extracts (without supplementation with fertilisers and plant based hormones) may potentially be useful components of an integrated crop protection strategy, but the costs and benefits would need to be assessed on a crop by crop basis.

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1. Project background:

The use of seaweed products in horticulture is primarily based on the application of seaweed extracts, mostly as foliar applications. Often they are supplemented with macro and micro nutrients as well as plant growth hormones and elicitors such as oligosaccharides. There is a diverse array of seaweed based products currently available; however there is a limited amount of field assessment of these products in order for growers to make informed decisions on their use and benefits. With increased legislation around the use of plant protection products (PPPs) and the requirement for growers to adopt Integrated Pest Management (IPM) approaches to crop protection decisions, the use of seaweed products, bio stimulants, plant elicitors and similar products is increasing. The objective of this project was to determine the impact of using seaweed products on Irish grown horticultural products, both edible and ornamental and assess their impact on the quality of the produce.

2. Questions addressed by the project:

- Does the application of seaweed products result in measurable changes within Brassica crops?
- Is yield affected by the application of such products?
- Do seaweed products increase seed germination?
- Does the application of seaweed products impact on cyclamen flowering?

3. The experimental studies:

Field experiments on brassica and onion crops described in this report were conducted at Kinsealy Research Centre in North Dublin (53° 25' N, 6° 10' W). The soil type at this site is characterized as loam to clay loam belonging to the grey brown podzolic soil group (Altitude: 28 meters O.D., Slope 1°, moderately well drained). Brassica plants for the 4 experiments were raised from seed (Cabbage: cv *Caraflex*; Green Broccoli: cv *Ironman*; Purple Broccoli: cv *Red Admiral*). Experiments were laid out in a complete randomized block design and replicated 5 times for the Cabbage experiments and 6 times for the broccoli experiments. Each replicate consisted of 26 individual plants at 45cm x 45cm spacing on a 1.2m width bed. A runoff area of 1m separated each replicate. Seaweed products were applied using a knapsack sprayer (Solo 475 Classic Sprayer) to the base of the plants. Application rates varied in the different experiments; Broccoli experiments were 3, 30 & 300L per Ha^{-1} applied every 4 weeks; Cabbage experiments 3.5 & 5 L Ha^{-1}, applied every 4 weeks. All crops received a standard level of fertilization, as per the Teagasc fertiliser manual. Apart from an insecticide drench to protect the brassica plants from cabbage root fly (*Delia radicum*) damage, no other plant protection products were applied to the crops. Crops were harvested when appropriate and yield and quality parameters were assessed. Secondary metabolites were assessed by standard methods, described more fully in Lola-Luz et al., 2013 and Lola-Luz et al., 2014. Experiments on seed germination and flowering ornamentals was conducted in a heated glasshouse, also at Kinsealy Research Centre. Peat based seedling mix was used for germination studies and standard peat based potting medium was used to pot cyclamen plants. Cyclamen plug plants were obtained from commercial supplier.

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4. Main results:

The application of seaweed extracts at the tested application rates and frequencies did not result in a statistically significant increase in yield in brassica crops (Table 1). Yields remained comparable to the untreated controls.

Table 1: Effect of seaweed liquid extract (*Ascophyllum nodosum*) on yield of two broccoli cultivars

	Green Broccoli (c.v. *Ironman*)			Purple-sprouting Broccoli (c.v. *Red Admiral*)		
Treatment	Total Yield (n=6)	Plot Mean (± SD)	% Change*	Total Yield (n=6)	Plot Mean (± SD)	% Change*
Untreated Control	54.74	9.1 ± 0.5	0	16.7	2.8 ± 0.5	0
3 L Ha^{-1}	54.86	9.2 ± 0.2	0.18	13.6	2.3 ± 0.3	-18.3
30 L Ha^{-1}	53.49	8.9 ± 0.7	-1.8	14.7	2.4 ± 0.3	-12.04
300 L Ha^{-1}	58.53	9.7 ± 0.3	7.2	21.9	3.6 ± 0.4	31.1

The application of seaweed extracts resulted in significant increases in the concentration of secondary metabolites observed in both broccoli (Fig 1) and cabbage crops, with observed two fold increases in total phenolic, total flavonoid and total isothiocyanate in broccoli crops with lower but statistically significant increases for the same parameters observed in pointed cabbage (Summer and Winter). This effect was consistent when using multiple different *Ascophllum nodosum* whole seaweed extracts. The greatest increase in secondary metabolites was observed when applying seaweed extracts at 300L/Ha, which would not be commercially viable, however significant increases were observed at lower (product recommended) application rates (Fig 1).

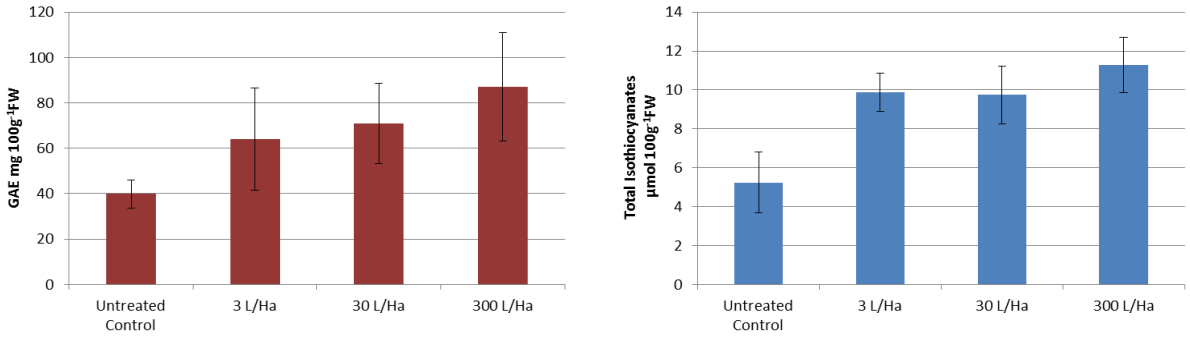

Figure 1: Effect of applying increasing concentrations of *Ascophllum nodosum* extracts on total phenolic and total isothiocyanate content of green broccoli (c.v. Ironman) (n=6; ± SD).Total phenolic content is expressed in gallic acid equivalents (GAE mg $100g^{-1}$ FW)Isothiocyanate results are expressed as sulforaphane equivalents (µmol g^{-1} FW)

In a similar experiment conducted on bulb onions (cv *Hybing* F1) levels of Total Flavonoids were significantly increased ($p < 0.005$) with the addition of seaweed extracts as compared to the untreated controls, demonstrating that the effect may not be unique to brassicas. With regards to plant protection, apart from cabbage root fly control (Chlorpyrifos), plant protection products were not applied to field experiments. This was to allow observation of disease development from natural infection. High levels of plant pathogens were not observed and as such an estimation of any contribution of increased secondary metabolites within the plant to decrease disease infection was not possible. Other quality parameters, such as protruding bracts in broccoli were not affected by the application of seaweed extracts.

Increased seed germination post exposure to seaweed extracts was inconsistent, but observable in some instances. The treatment of flowering plants (Cyclamen) with seaweed extracts did result in an increased number of flowers being produced after a 40 day period. This effect was observable in two differing peat based growth media. However a similar effect was not observed when tested on a *Viola* species, and as such it is necessary to test a wider range of flowering plants to ascertain if increased flowering is reproducible across a wider range of flowering species.

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5. Opportunity/Benefit:

This study demonstrates the importance of assessing secondary benefits, such as secondary metabolites when assessing the potential agronomic benefits of seaweed extracts and plant stimulants in general, for use on horticultural crops. While no increase in yield was consistently observed in treated crops, the increase in secondary metabolites is an interesting observation given their role in both the plants innate defense systems and also in their beneficial role when consumed. There is an increasing awareness and marketability for produce with additional quality benefits however there are strict guidelines as to what claims can be made on product packaging.

The observation of increased flower number when applied to cyclamen crops indicates an ability to increase ornamental plant quality, however this observation would need to be replicated and tested on a wider range of flowering crops.

6. Dissemination:

Lola-Luz, T., Hennequart, F, and Gaffney M.T (2012).Increase of health promoting phytochemicals of *Brassicae* crops following application of commercial seaweed extracts (*Ascophyllum nodosum*). 12th New Ag International conference, March 2013 Rio de Janeiro, Brazil.

Lola-Luz, T., Hennequart, F, and Gaffney M.T (2012). Enhancement of phenolic compounds, Flavonoids and isothiocyanate content of broccoli (*Brassica oleraceae var Italica*) in response to seaweed applications. 6th Brassica conference, Catania, Italy 12-16th of November 2012.

Lola-Luz, T., Hennequart, F, and Gaffney M.T (2012). Effect of a novel cold seaweed extract on the germination of vegetable seeds and flowering of an ornamental plant The 10th New Ag International conference, Bangkok March 28-30th 2012.

Main publications:

Lola-Luz, T., Hennequart, F. & Gaffney, M. (2013) Enhancement of phenolic and flavonoid compounds in cabbage (*Brassica oleraceae*) following application of commercial seaweed extracts of the brown seaweed (*Ascophyllum nodosum*). Agricultural and Food Science, 22:288-295

Lola-Luz, T., Hennequart, F. & Gaffney, M. (2014) Effect on health promoting phytochemicals following seaweed application, in potato and onion crops grown under a low input agricultural system. Scientia Horticulturae Vol. 170: 224-227

Lola-Luz, T., Hennequart, F. & Gaffney, M. (2014) Effect on yield, total phenolic, total flavonoid and total isothiocyanates content of two broccoli cultivars (*Brassica oleraceae var italic*) following the application of a commercial brown seaweed extract (*Ascophyllum nodosum*). Agricultural and Food Science, 23: 28-37

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