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Short communication

Effect on health promoting phytochemicals following seaweed application, in potato and onion crops grown under a low input agricultural system

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ABSTRACT

Regular consumption of fruits and vegetables is linked with a lowered risk of heart disease, cancer and stroke. Two different pilot studies were set up in Greece (potato), and Ireland (onion) to study the effect of a commercial cold process seaweed extract from *Ascophyllum nodosum* on the yield and phytochemical content of potato and onion. Results from this study indicated that there was an increase in phenolic and flavonoid content in onion while in potato significant differences were detected only in flavonoid content. There were no statistically significant differences in yield in either crop, although seaweed treated potato plants had higher yields. These results indicate the potential of seaweed extracts in increasing the phytochemical content of vegetables.

1. Introduction

Seaweed extracts are biostimulants that have been traditionally used as soil conditioners in improving plant growth in agricultural crops (Hurtado et al., 2009). Numerous studies have revealed the benefits of seaweed extracts on plants including early seed germination, improved crop performance and yield, enhanced shelf life and better resistance to biotic and abiotic stress (Eyras et al., 2008; Jayaraman et al., 2011). Seaweed extracts have also been shown to improve the phytochemical content in plants, this is due to an increase in the concentration of bioactive molecules including antioxidants in the treated plants (Fan et al., 2011). In recent years, more consideration is being given to bioactive compounds that play a vital role in growth and development of plants as well as the protective benefits they offer in chronic diseases such as cancer and cardiovascular diseases (Chu et al., 2002; Picchi et al., 2012). Phenolic compounds are a group of polyphenols, and can be found in many fruits and vegetables. They are predominant in potatoes, accounting for 80–90% of the total phenolic content (Brown, 2005). Flavonols are another group of polyphenols that can be found in many fruits and vegetables, with onions being a rich source of these compounds (Hollman and Arts, 2000).

There is very little information about the influence of seaweed extracts on health promoting compounds and nutrition value of onions and potato treated with seaweed. The objective of this study was to investigate the effect of seaweed extract (*Ascophyllum nodosum*) application on the phytochemical content in low input production systems on onion and potato. We report preliminary results of two different experiments on the effect of a cold process seaweed extract Algae Green™ on the phytochemical content and yield of onion and potato, evaluating different products, application rates and methods.

2. Materials and methods

2.1. Onion

In the first experiment, onion seeds (cv Hybing F1) were placed in cell trays (23 mm × 23 mm × 35 mm) containing potting mix (Shamrock compost) and sown at 1.5 cm deep. Cell trays were placed in a unheated greenhouse (approximately 20–22 °C) and were grown for 7–10 weeks prior to planting in the field. The experiment was conducted at a site in Kinsealy (53° 25 N Lat 6 10 W), located in north county Dublin, Ireland. Soil type was char-

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acterised as loam to clay loam belonging to the grey brown podzolic soil group (altitude: 28 m O.D., slope: 1°, drainage: moderately well drained). Onions were planted in late April 2011 and were harvested in September 2011. The experiment was a complete randomised block design with five treatments: control, 3, 5, 10 L/ha spray and 3 L/ha drench and spray. Each plot consisted of three rows (10 plants/ row); the distance between the plants on the row was 25 cm. Some of the plants were drenched in seaweed extract prior to planting (3 L /ha), these also received a seaweed extract spray of 3 L/ha once a month. Prior to planting, plots received the herbicides Stomp and CICP at the manufacturers recommended rates.

2.2. Potato

The second experiment (potato, cv Belladonna) was carried out in Volos, Greece at a farmers site (39° N, 22.9° E). The experimental area was 250 m^2, with four experimental rows (5 m × 50 m). Potatoes were planted in April 2011 and harvested in the first week of July 2011. The experiment was a split plot design. In two of the rows dry seaweed (OGT, Kilcar, Co. Donegal, Ireland) was incorporated in the soil at the rate of 50 kg/ha prior to planting the potatoes. The dry seaweed (by-product of the seaweed extract) was a newly developed product and it was used in this experiment to assess if there are any positive effects that would justify a bigger trial. In total there were four treatments control (water), dry seaweed soil application, seaweed spray only, dry seaweed soil and spray application. All treatments were replicated twice. The application rate for the liquid seaweed extract was 5 L/ha. The spray application was applied once a month with a knap sack sprayer, the other treatments received only water.

2.3. Total phenolics

The total phenolic content (TPC) was analysed using the Folin–Ciocalteu method (Singleton and Rossi, 1965). Methanolic extracts of potato and onion tissue were prepared as followed: plant tissue was ground into fine powder with liquid nitrogen, 0.5 g of ground tissue were placed in a 50 ml falcon tube where 5 ml of 80% methanol (Lennox) were added. Tubes were vortexed and left to stand for 20 min. The tubes were then mixed by inversion and 2 ml of the suspension was transferred into a clean 2 ml micro-centrifuge tube (Anachem). The tubes were centrifuged at 12,000 rpm at 4 °C for 5 min. The supernatant was placed in a clean Eppendorf tube and stored at −20 °C until use. For measurement of total phenolics samples were prepared as followed: in a 2 ml micro-centrifuge tube, 150 μl of extract, 150 μl of 80% MeOH, 150 μl of Folin–Ciocalteu reagent (Sigma–Aldrich) and 1050 μl of 20% Na_2CO_3 (Lennox) were placed. Tubes were vortexed immediately and placed in the dark for 20 min. They were then centrifuged at 13,000 rpm for 3 min absorbance readings were taken with a spectrophotometer at 735 nm (Jenway 6300). Gallic acid was used as a standard and the results are expressed as milligrams of gallic acid equivalent (GAE) per 100 g FW. A calibration curve was prepared.

2.4. Total flavonoids

Total flavonoid content was determined spectrophotometrically by the aluminium chloride method using catechin as standard (Zhuang, 1992). Briefly 150 μl of methanolic extract, prepared as above, were mixed with 600 μl of H_2O and 45 μl of 5% $NaNO_2$ (Sigma–Aldrich). The solution was incubated for 5 min at room temperature and then 45 μl of 10% $AlCl_3$ were added (Sigma–Aldrich) and incubated for 1 min. Finally 300 μl of 1M of NaOH (Sigma–Aldrich) and 300 μl of H_2O were added. Absorbance was measured with a spectrophotometer at 512 nm (Jenway 6300) and expressed as mg catechin equiv./L. A calibration curve was prepared.

2.5. Yield

After maturation onion and potato were harvested and total weights were recorded. Immediately after weighing, subsamples were set aside for phytochemical analyses. For phenolics and flavonoid content analyses, onion and potatoes were subsampled from each plot, immediately after weighing, by randomly choosing three healthy onions and potatoes from each plot. These were then sliced in half, and the same half from all samples was placed in Ziplock bags (Sparks) and stored at −20°C until further use. Onions and potatoes were harvested 15 days after the last seaweed application.

3. Statistical analysis

All data are expressed as mean ± standard deviation unless otherwise stated. Data were analysed using Friedman's non parametric test (R statistical package). A significant difference was considered at the level of $P < 0.05$ or $P < 0.01$.

4. Results

4.1. Total phenolics

In the onion crop statistically significant differences were recorded in total phenolic content (Friedman, $df = 4$, <0.01). Seaweed treated plants had a higher phenolic content relative to the control (Fig. 1). There were also significant differences between the 5 L/ha and the 3 L/ha rate. In the potato trial no statistically significant differences were recorded in total phenolic content (Friedman, $df = 3$, $P < 0.11$), although the seaweed treated plants had a higher concentration in phenolics (Fig. 2).

4.2. Total flavonoids

Significant differences were recorded in onion on the total flavonoid content between the treatments (Friedman, $df = 4$, <0.005). Statistically significant differences were also recorded between the seaweed treatments, with the highest accumulation recorded at the 10 L/ha application rate (Fig. 1). In the potato trial, there were also statistically significant differences in total flavonoid content compared to the control (Friedman, $df = 3$, $P < 0.03$). There we no statistically significant differences between the seaweed treatments (Fig. 2).

4.3. Yield

In the onion trial (Fig. 1), no significant differences in yield were found between the treatments (Friedman, $df = 4$, $P < 0.844$). Similarly, in the potato trial there were no statistically significant differences in yield between the treatments (Friedman, $df = 3$ $P < 0.112$), although seaweed treated plants had higher yields (Fig. 2).

5. Discussion

Phytochemical compounds have been linked with the inhibition of certain types of cancer (Simon, 2002). It has been proposed that seaweed extracts are promising compounds for providing both novel biologically active substances and essential compounds for human nutrition, with high potentially economical impact in food and pharmaceutical industry and public health (Jimenez-Escrig