



## OWC 2020 Paper Submission - Science Forum

Topic 4 - Innovation in Organic farming: "thinking out of the Box"

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### HARVESTING OUR FERTILISERS FROM THE SEA - AN APPROACH TO CLOSE THE NUTRIENT GAPS IN ORGANIC FARMING

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**Abstract:** Organic production in Europe is currently dependent on the input of fertilisers derived from conventional agriculture, such as farmyard manure, slurry and fertilisers derived from slaughter residues. A significant part of the nutrient flows in our food systems goes in one direction, from land to sea, via sewage and leaching. Harvesting marine organisms for fertilisation, or utilising residual materials e.g. from fish industry as fertilisers, may close such nutrient gaps and promote active cycling of nutrients. At NORSØK, we are studying the use of algae fibre (rich in potassium (K), magnesium and sulphur) and fishbones (rich in nitrogen (N), phosphorus (P) and calcium) as fertilisers. High yields were produced with fishbones, and the short-term N availability was much higher than for mineral N fertiliser or dried poultry manure. Plants with a long period of nutrient uptake benefited from algae fertiliser. However, seaweeds contain significant amounts of arsenic (As), and easily available K may impact a balanced mineral content in the food or feed products. Excess P in the fishbones may cause eutrophication of this fertiliser is applied to cover N demands of the crop. Research is needed to make a well balanced commercial fertiliser.

**Introduction:** Many commercial fertilisers are used in organic farming. E.g. in Norway, 118 products were permitted for use in certified organic growing in 2019. Organic gardeners often apply compost, e.g. from household waste, (conventional) animal manure and/or green waste to cover the plants' need for nutrients, especially nitrogen (N). Over time, this commonly leads to high levels of soil phosphorus (P), which is not environmentally sound. On the other side, organically managed soils are often depleted in P and other minerals, especially in arable farming systems, but also in milk production (Cooper et al. 2018). Organic farming is currently dependent on the input of animal manure and other animal-derived fertilisers, commonly derived from conventional production. This weakens the integrity of organic farming and is questioned due to animal welfare and environmental footprint. A significant part of the nutrient flows in our food systems go from land to sea, via sewage. Harvesting, or utilising available residues from seaweed, fish and other marine organisms for fertilisation may close such nutrient gaps, and promote active cycling of nutrients.

**Material and methods:** Fertilisers made from marine ingredients are rarely used in Norwegian agriculture, in spite of historical traditions and a significant marine industry. For our study, we searched for residual materials from marine industry which were locally available in the region around Tingvoll, Norway. We have worked with algae fibre, which are residues from extraction of liquid fertilisers from knotted wrack (*Ascophyllum nodosum*) which grows wild and is collected along the Norwegian coast. The extracts are produced at Algea AS, Kristiansund, and residual algae fibre is currently mixed into compost in a local waste treatment plant. Further, we have worked with fish residues, which are mainly bones from cod (*Gadus morhua*) and saithe (*Pollachius virens*), grinded and conserved with formic acid. This material was achieved from Fjordlaks AS in Ålesund, a company producing clipfish. The residues, here called fishbones, is a leftover sediment when grinded mass has been subject to hydrolysis during storage, and the layers of fish oil and soluble proteins have been removed to be utilised as feed in aquaculture. This sediment is currently disposed of as residual waste and usually incinerated.

**Pot experiment with ryegrass, 2018**

Fishbones and algae fibre were tested separately in an indoor pot experiment with annual ryegrass (*Lolium westerwoldicum*) in 2018. Fertilisers were mixed with a sandy soil with medium to low P concentration, and plants were harvested five times (4 replicate pots per treatment). At each harvest, the amount of aboveground dry material was recorded. We aimed at applying the same amount of N with each fertiliser, corresponding to 300 or 600 kg N per hectare. We tested the effect of applying dried (at 105 °C) or fresh materials. Calcium nitrate was used as a control, and we also had a zero treatment with only soil.

#### **Combined field and pot experiment with oats and leek, 2019**

In 2019, new batches of the same fertiliser materials were used, separately or mixed, in a combined outdoor pot and field experiment. Oats (*Avena sativa* L.) and leek (*Allium porrum* L.) were grown in 10 litre pots buried in experimental soil, and oats were additionally grown in nearby localised plots. We aimed at a fertilisation corresponding to 80 or 160 kg N/hectare in oats, and 160 or 320 kg N/hectare for leek (4 replicates for each treatment). These levels were tested in pots. In field plots, only the highest N level was tested. We had two control treatments, being a commercial fertiliser made from dried poultry manure with meat and bone meal and vinasse; and calcium nitrate. Fishbones and algae fibre were applied separately, and in a mixture where 30% of N was given as algae fibre, and 70% as fishbones. The plants were harvested at the aboveground maximum dry matter production stage, in late July for oats and late August for leek. Yields of aboveground fresh and dry matter (DM) were recorded. In all experiments, nutrient concentrations in soil and plants were analysed.

#### **Results: Pot experiment with ryegrass, 2018**

Application of fishbones increased the yields of ryegrass significantly. Converted to yields of dry matter (DM) per hectare, on average for the two N levels, fishbones gave 10.9 tons per hectare, whereas non-fertilised soil (control) gave 7.2. Calcium nitrate gave 8.6 and algae fibre 8.5 tons. We found no significant effect of drying the fertiliser materials. Algae fibre gave a high uptake of potassium (K), hence decreasing concentrations of magnesium (Mg) and calcium (Ca) in plant material. In spite of high concentrations of arsenic (As, 33 mg/kg DM) in AF, and a large application of material (up to 4 g of dry fibre per pot), the concentrations of As in plant material were below the detection.

#### **Combined field and pot experiment with oats and leek, 2019**

Similarly to the pot experiment with ryegrass in 2018, the yields of oats in the field experiment were significantly increased with application of fishbones. On average, 4.8 tons of DM per hectare were produced, as compared with 2.7 tons with no fertiliser application (control). For algae fibre applied alone, the yield level was equal to the control. With poultry manure, the yield level was 3.8 tons, and with a combination of AF and FB it was 4.4 tons per hectare. In leek, with a longer period of growth and nutrient uptake, a positive effect of mixing algae fibre and fishbones was achieved with high application of fertiliser. The yield level was generally low as compared with commercial growing of leek, where a leek for sale should have a fresh weight of about 200 g (roots removed). However, we achieved very clear differences in growth with different fertilisation. With no fertiliser (control), the fresh weight of leek was 4.4 g per plant. Calcium nitrate decreased the yield slightly to 3.4 g (both application levels), whereas poultry manure gave leeks weighing 8.3 g with low and 9.8 with high application. With algae fiber as the only fertiliser source, yields were 21.6 and 30.3 g per plant. Fishbones alone gave 29.4 and 34.5 g per plant. Mixing algae fibre and fishbones gave the highest yield, with 27.5 g per plant for low and 42.1 g per plant for high application of fertiliser. The amount of DM in the leeks was 17% in the experimental soil (control), and algae fibre had a clear negative effect on this characteristic. With algae fibre alone, DM was 11.5% with low and 11.2% with high application. Highest values of DM were obtained with application of fishbones; 19.4% with low and 17.9% with high application.

**Discussion:** Several experiments at NORSØK have shown that crop plants grow vigorously with application of fishbones to the experimental soil. This may be due to a high proportion of mineral N in this material, since analyses show that close to 100% of the total N in the fishbones is ammonium. Possibly, the N in the fishbones may occur in organic molecules which are converted to ammonium during the analytical procedure, and which are taken up by the plants very easily (Dion et al. 2018). The very rapid growth effect, much faster than for calcium nitrate which also is expected to give a rapid response, may point in this direction. However, it may also be due to easily available P, and further study should include more complex mineral fertiliser treatments for comparison to explain this effect in more detail.

The effect of algae fibre on plant growth is long-term (Ahuja & Løes 2019). Combining algae fibre, fishbones and possibly other materials into a balanced, complete fertiliser is an important field of study. Fertilisation with marine residues obtained from Norwegian industry partners have given positive results so far. Hence, harvesting nutrients from the sea seems to be a useful strategy for organic farming to close existing nutrient gaps.

**References:** Ahuja I, Løes AK (2019): Effect of fish bones and algae fibre as fertilisers for ryegrass. NORSØK Report 4 (7) 2019, 64 p.

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**Disclosure of Interest:** None Declared

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