Rock Dust as a Sustainable Amendment in Northwestern European Agriculture

remineralize.org/2022/05/rock-dust-as-a-sustainable-amendment-in-northwestern-european-agriculture/

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Glacial deposit in Greenland

Introduction

The EU is the world's leading exporter of agri-food, supplying 20% of world food and drink (Matthews, 2021; EEA, 2020). In 2020, more than 40% of Europe's acreage was used for agriculture. 61% of this agricultural area was operated by high to medium intensity farms in terms of fertilizer and pesticide cost. The considerable growth in crop and livestock has caused environmental impacts that call for sustainable solutions.

Northwestern Europe

There are several initiatives currently focused on sustainable agricultural practices in Northwestern Europe. The European Commission has announced several strategies under the guise of the European Green Deal geared towards general sustainability (von der Leyen, 2019), including the Farm to Fork and EU Biodiversity strategies, which aim to reduce use of chemical pesticides by half by 2030. The Integrated Nutrient Management Action Plan seeks to reduce nutrient loss by at least 50% and reduce use of fertilizers by at least 20% while securing soil fertility (Schilthuis, 2021).

This article investigates efforts in Northwestern Europe to achieve the European Commission's goals with special attention to the attention of rock dust in nutrient management and reduction of fertilizer, albeit in experimental stages or on a larger scale. The pursuit of alternate mineral and nutrient sources has gained particular importance as a result of the 2022 Russian invasion of Ukraine, which has affected global mineral supply chains (GlobalData, 2022).

The role of rock dust in sustainable nutrient and pest management

A key element in many chemical fertilizers is phosphorus (P), due to its integral part in a crop plant's primary functioning (Schaller *et al.*, 2019). Commercial and affordable phosphorus reserves are expected to be depleted in 50 to 100 years (Gronholt-Pedersen, 2021). Although natural phosphorus in soils is relatively abundant, it is often bound to iron minerals or stabilized organic matter, and therefore not readily available for plant uptake. Schaller *et al.* (2019) of the University of Bayreuth demonstrated the efficiency of silicon to mobilize phosphorus in unaffected Arctic soils. It implied that silicon may be valuable to sustainably manage the availability of phosphorus in soils in general, when applied as silica or amorphous silicon structures (Knoll, 2019). As a result, the use of phosphorus fertilizers and the mining of phosphorus for fertilizer production could be scaled back.

Silica is currently applied as a vegan pest manager in German organic farming, which prohibits using pesticides (Fecke, 2016), capitalizing on silica's proven effectiveness as a desiccant to combat undesirable insects and restore insect balance (US EPA, 1991).

In United Kingdom pig farming, a rock dust additive is applied to straw to absorb accumulated water and urine to form a solid, which in turn serves as nutrient-rich manure (Howell, 2021). Under the right conditions, this could also lead to a 20% decrease in ammonia (NH_3) runoff, as opposed to so-called indoor deep straw systems (Howell, 2021). Another advent of nitrogen in agriculture is in nitrous oxide, a potent greenhouse gas that is the product of soil microbial activity in conversion of nitrogen-based fertilizer. Treating crop fields with basalt rock dust has shown to reduce nitrous oxide emissions (Ferber, 2022).

The role of rock dust to minimize use of conventional fertilizers

Glacial rock flour is another potentially climate-friendly soil amendment. About one billion tonnes of rock dust are deposited annually by glacial retreat in Greenland. This easily mineable material is nutrient-rich and enhances agricultural output due to the ready uptake of nutrients from the product's predominantly micro-sized particles (Gronholt-Pedersen, 2021). This rock dust comes from glaciolacustrine deposits in Greenland, which consists of Archaean granite and gneiss. They are mainly composed of

Sorghum bicolor

quartz, plagioclase and hornblende, in addition to biotite and K-feldspar (Sukstorf *et al.*, 2020). Hamaker & Weaver (1982) highly recommended slow-weathering glacial gravel for remineralization and the agricultural importance of periglacial sediments has been widely demonstrated (i.e. Catt, 2011). Recently, scientists at multinational brewer Carlsberg demonstrated that an application of 25 tonnes of glacial rock dust per hectare on a barley field in Denmark increased crop yields by 30% (Gronholt-Pedersen, 2021). The glacial rock dust could replace phosphorus in fertilizer. However nitrogen (N) still needs to be added (Gronholt-Pedersen, 2021). In the next three years, large-scale field tests in Denmark, amongst others, will demonstrate the economic feasibility of distributing rock dust to farmers worldwide (Gronholt-Pedersen, 2021).

Researchers at the University of Sheffield have proven that adding relatively coarse-grained crushed basalt to UK clay-loam agricultural soils increased the yield of the cereal *Sorghum bicolor* – one of the most important crops for food and animal nutrition – by 20% without adverse effects (Armour, 2020; Kelland *et al.*, 2020). Basalt contains at least six nutrients essential to plant growth, and has the added benefit of mitigating soil acidification. The latter is normally accomplished using agricultural limestone, the production of which causes significant agricultural emissions of greenhouse gas (Armour, 2020).

Basalt rock dust in carbon sequestration

Apart from improving crop yield while limiting conventional fertilizer usage, basalt rock dust could be employed to serve another goal: to sequester carbon dioxide. Kelland *et al.* (2020) also showed that application of basalt rock dust to soil samples increased its potential to store carbon dioxide (CO_2) by four times.

Mike Kelland of the Leverhulme Centre for Climate Mitigation in a field of perennial grains

These results support the outcome of prior research by Beerling *et al.* (2018), who modeled the impact of applying enhanced weathering in order to slow climate change by using basalt rock dust on croplands (see also Ferber (2022) and Armour (2020)). They found that enhanced weathering could sequester 2 billion tonnes of CO_2 from the atmosphere per year by 2050; corresponding to the joint annual CO_2 emissions of Germany and Japan (Ferber, 2022).

The main principle of enhanced weathering rests on generating aqueous chemical reactions between weathering silicate rocks and soluble CO_2. These reactions yield base cations and primarily bicarbonate anions that – in turn – drain away from croplands. The process especially relies on the fast-weathering pyroxene in basalt to react with CO_2. Beerling *et al.* (2018) envisions byproducts from the mining industry, such as stockpiled silicate rock dust, as a source. Commercial interest is evident through the funding of small field tests and new trials by the likes of The Future Forest Company based in Scotland.

Similarly, the German Carbon Drawdown Initiative and several experts from various academic fields planned a field project to support global carbon sequestration and mitigate climate change (Paessler, 2021). They argue that enhanced weathering meets the three major criteria of scalability, speed and permanence that are required for effective CO_2 removal. The resulting "Project Carbdown" commenced in 2021 and bypasses the public funding process, increasing the frequency of experiments.

It must be noted that the Carbon Drawdown Initiative is focused on olivine, which Remineralize the Earth does not recommend for agriculture because the mineral profile of olivine may create a nutritional imbalance and nickel accumulation in soils and crops (Berge *et al.*, 2012).

A year into the study, the Project Carbdown team reported measurable weathering effects. However, it was difficult to give exact measurements of weathering products due to the limited amount of rock dust used (Paessler, 2022). To that end, the team aims to use more rock dust in 2022 to develop reliable results. Moreover, the team will apply controlled irrigation as much as possible in order to optimize water supplies.

Conclusions

The considerable increase in the production of crops and livestock has caused environmental impacts that call for sustainable solutions, especially as commercial phosphorus reserves employed for chemical fertilizers are expected to be depleted in 50 to 100 years.

There are manifold current applications of rock dust in Northwestern European agriculture. Silicon in rock dust may be valuable to sustainably manage the availability of phosphorus in soil and for a vegan method of pest control. Other uses include managing nutrients, improving crop yield, limiting conventional fertilizer usage and sequestering CO_2.

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