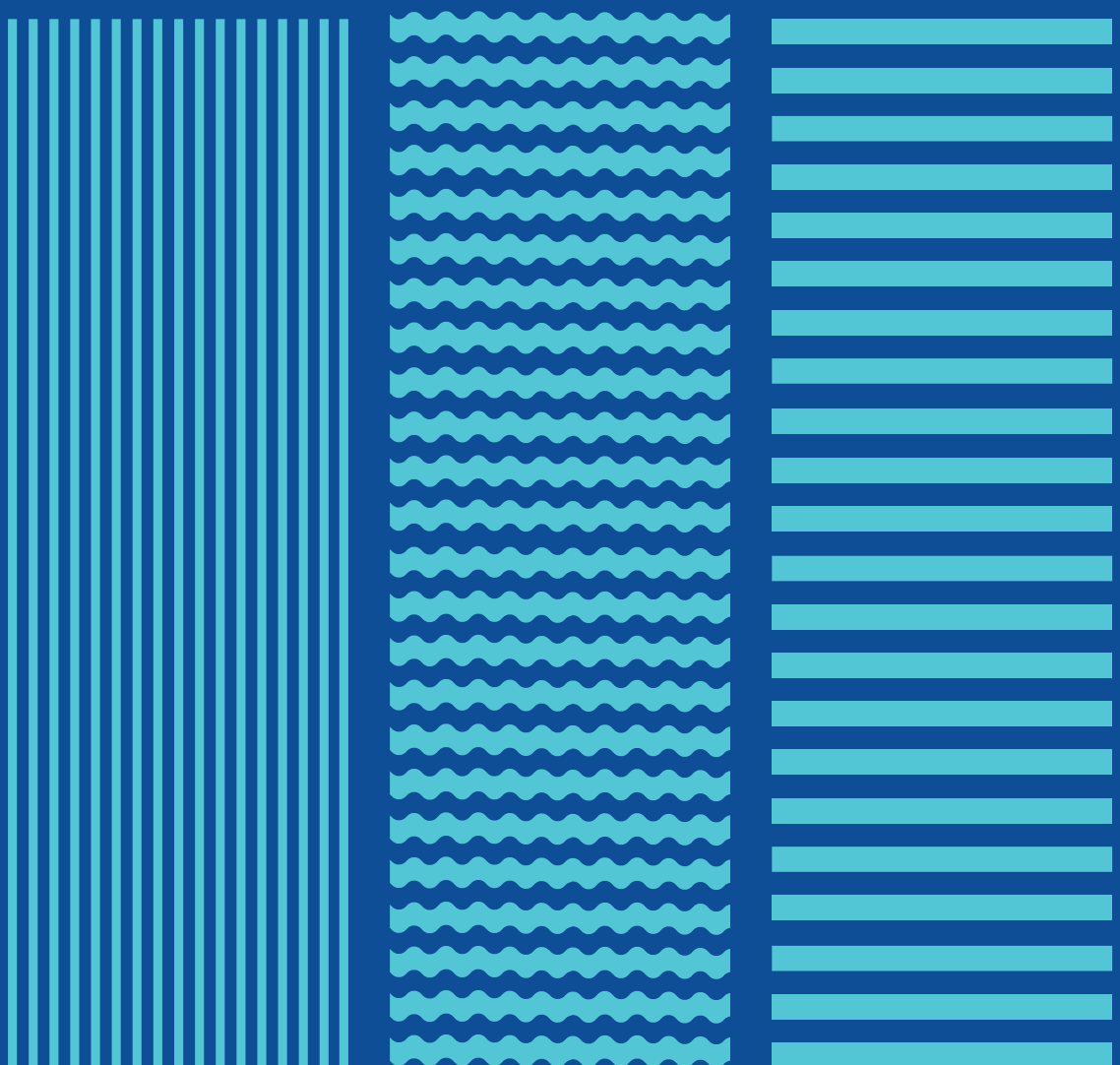
WATER PROTECTION PROGRAMME

Gypsum, fibre and structure lime

– *a quide for farmers*



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Gypsum, fibre, and structure lime – a guide for farmers is a compilation of information related to a single theme. The Ministry of the Environment funded three projects as part of the Water Protection Programme:
Fibre sludge as a water protection method in agriculture (FIBRE),
Structure lime as a water protection method in agriculture (STRUCTURE LIME),
and Spreading gypsum on fields in the Archipelago Sea's catchment area (GYPSUM).

PHOTO: Gabriel Jimenez, Unsplash

Dear Reader,

Finnish farmers are multi-talented. They produce clean high-quality raw materials and foodstuffs, while taking care of agricultural land and the environment. Based on experience, farmers know what practices are the most productive on their fields. Farmers deploy new cultivation methods suitable for their production, especially if research data about them is available. Farmers are eager to test new methods if old ones prove unproductive in changing conditions.

Many farmers have worked for more than 20 years to reduce nutrient loads in agriculture. Despite their hard work, amounts of phosphorus bound in farmland remain high, and taking care of the soil structure is a never-ending activity. Soil and nutrients are still lost into water bodies through rainwater and meltwater, potentially reducing the quality of local water bodies.

Soil amendments– gypsum, fibre, and structure lime – offer new solutions for water protection in agriculture. They improve the soil structure, reduce erosion and nutrient loads.

We compiled a guide for selecting the most suitable soil amendment for different kinds of fields. This guide presents results of the impact of different soil amendments. The results are based on projects funded by the Ministry of the Environment as part of the programme to enhance the effectiveness of water protection.

However, soil amendments alone cannot permanently reduce non-point source loading. Instead, sustainable farming is based on a good soil structure, fertility, and water management in arable land. Soil amendments support climate-smart farming.

I wish high yields and clear waters to all our readers!

JAANA UUSI-KÄMPPÄ
Senior Scientist
Natural Resources Institute Finland

Gypsum, fibre, and structure lime in brief

Gypsum, fibre, and structure lime maintain the fertility of soil. At the same time, they help protect water bodies.

Soil amendments support the management of the soil structure. They reduce erosion and losses of nutrients from fields.

Two types of phosphorus are exported from fields, causing eutrophication. When the rain falls or meltwater sweeps the ground, phosphorus bound in soil is carried by runoff. Such erosion is strong in fine-textured soils, especially if the soil structure is weak. Water also carries dissolved phosphorus away from fields – and the higher is the soil phosphorus level, the higher is the dissolved phosphorus concentration of runoff waters.

Soil amendments help adapt to extreme conditions caused by climate change, such as drought and heavy rainfall.

SOIL AMENDMENTS HAVE DIFFERENT PROPERTIES AND LIMITATIONS:

Soil improvement fibres are recommended for mineral soils

Fibres are suitable for clay soils and coarse mineral soils. Fibres produce the most benefits when used in soils with low organic matter content. Different types of soil improving fibers are available including composted or lime-stabilised, the latter also increases soil pH. Fibres must be spread between 1 April and 31 October. They must be prepared in the soil surface layer within one day of spreading.

PHOTO: Johanna Nikama

Structure lime is effective in clay soils

Structure lime improves the stability of soil aggregates and reduces slaking of clay soils. Dry soil is a requisite for structure lime spreading. Suitable conditions for spreading and incorporation of structure lime exist often immediately after harvesting. Incorporation of structure lime should take place immediately after spreading or no later than within 48 hours afterwards. When dissolved in soil, structure lime increases the pH level of the soil.

PHOTO: Tiina Roine

Gypsum is suitable for clay soils

Gypsum improves the soil structure more effectively the more clayey the soil is. Gypsum spreading is not recommended in catchments discharging into lakes or in groundwater areas. Gypsum cannot be spread in fields in so-called Natura 2000 sites, which are nature conservation areas according to Habitats Directive. The recommended time for spreading gypsum is after harvest and before soil preparation. Gypsum can also be used together with direct sowing if spread in the autumn, and sowing is carried out in the spring.

Selecting the correct soil amendment

The most suitable soil amendment should be selected according to the properties of each parcel. A soil fertility analysis leads to smart choices.

When you select a soil amendment, focus on the soil's pH value, soil test conductivity value (electrical conductivity), nutrient content, soil type and clay content. The pH value measured in a soil fertility analysis is a good indication of which soil amendment is the most ideal for each parcel. Do you want to increase your field's pH, or is it already at the targeted level?

As structure lime increases the soil's pH value, it is an alternative to ordinary agricultural lime. Nutrient-rich and lime-stabilised fibres also increase the soil's pH. Other soil improvement fibres have also been found to increase the pH to some extent. Gypsum is a neutral salt, which can temporarily reduce pH, but this has no practical significance.

SOIL FERTILITY ANALYSIS AIDS IN SELECTION OF THE SOIL AMENDMENT

Soil amendments contain crop nutrients. When conducting a soil fertility analysis, focus on calcium, magnesium, and sulphur, as well as the relationships between them. Gypsum and structure lime contain calcium, which has a positive impact on the soil's structure. However, if the concentration of magnesium is low, added calcium may reduce the crop's magnesium intake, because any additional calcium will increase magnesium leaching.

Gypsum also acts as a sulphur fertiliser. Gypsum obtained as a by-product of phosphoric acid production also adds some 2 kg of phosphorus per hectare per each tonne of spread gypsum. This should also be considered.

TABLE 1

When considering which soil amendment is the best choice for your field, pay attention to the following:

	Soil improvement fibres	Structure lime	Gypsum
SOIL TYPE	Mineral soils	Clay soils	Clay soils
SOIL pH	No impact, or a slight increase in the case of lime-stabilised fibres	Increase	May decrease temporarily, but this has no impact on cultivation
ELECTRICAL CONDUCTIVITY	No impact	Increase	Clear increase
FERTILISING IMPACT	• No impact when using zero-fibres • N, P, K, S, Ca, and Mn when using nutrient-rich fibres • For nutrient-rich fibres, P and soluble N to be considered in additional fertilisation	Ca and Mg (product-specific)	• Ca, S and P • Not to be spread on field where the Mg or K level is low or fairly low
RECOMMENDED SPREADING AMOUNT	20–40 tonnes per hectare	1 tonne of active lime per hectare, i.e., total of 2.5-7 tonnes per hectare	2-5 tonnes per hectare; 4 tonnes per hectare in water protection projects
ELIGIBILITY FOR ORGANIC FARMING	Yes	No	No; natural gypsum permitted

Nutrient-rich fibres contain a broad range of macro and micro nutrients. When using nutrient-rich fibres, their fertilising effect must be considered. Soil improvement fibres are suitable for all mineral soils, but the fibre grade should be selected based on a soil fertility analysis. Depending on the selected fibre grade and the volume used, nutrient-rich fibres increase the soil's total phosphorus content, ranging from a few kilograms to dozens of kilograms per hectare. Nutrient-rich fibres also contain soluble nitrogen, the volume of which is indicated in the product specification of each batch.

Nutrient-poor zero fibres are suitable for soils with a high phosphorus level. They are also suitable for use after terminating crops that contain plenty of nitrogen. In this case, microbes activated by fibres consume the nitrogen released from crops and preserve nitrogen for the coming crop and decrease nitrogen losses into water bodies.

Restrictions on soil amendment use

Even though soil amendments produce significant benefits, the following limitations must be considered:

- The use of gypsum is not recommended in catchment areas of lakes or in groundwater areas, or on fields in Natura 2000 areas.
- Structure lime and gypsum obtained as a by-product of the phosphorus industry are not accepted in organic farming.

  However, mined gypsum and fibre products can be used in organic farming.

- According to the current environmental subsidy system (2021), nutrient-rich fibres that contain phosphorus cannot be used in soils with excessive phosphorus concentration class.

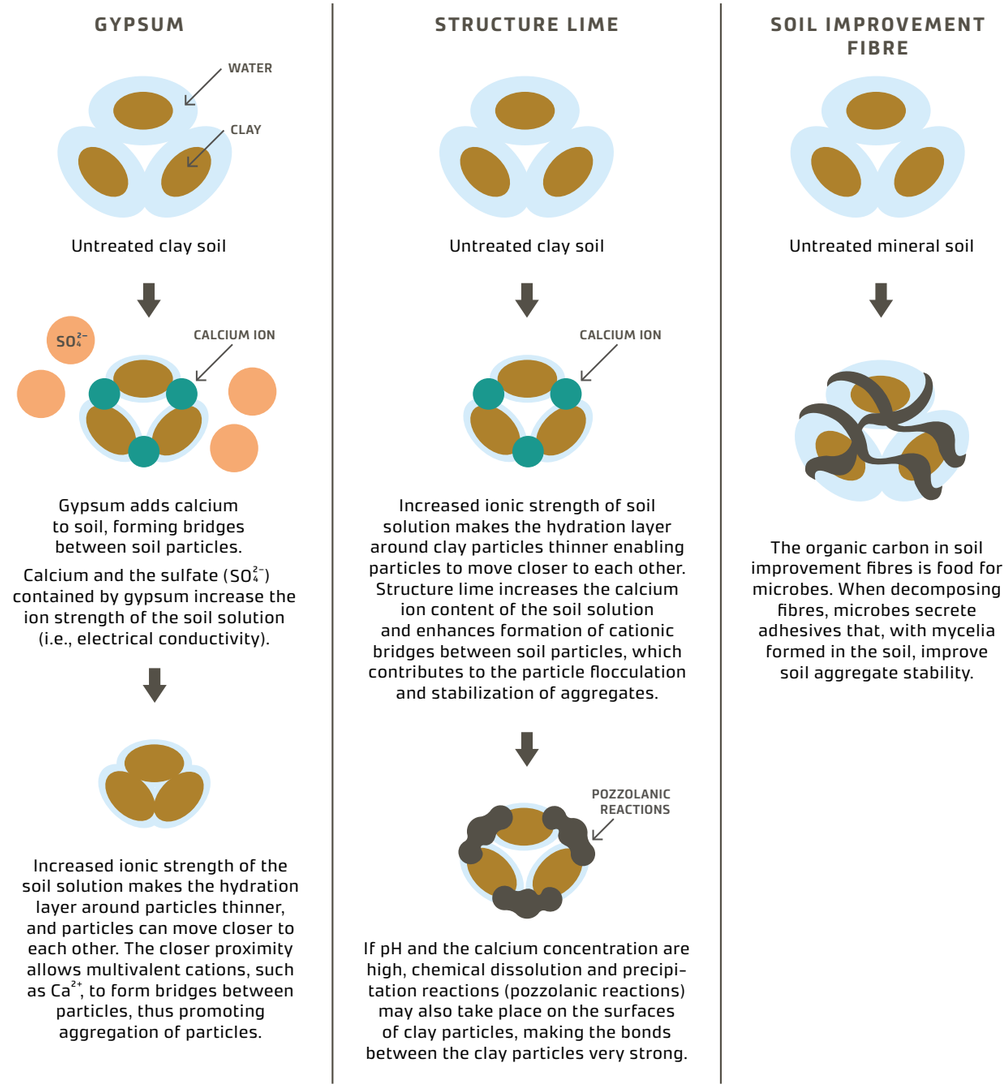
  Nutrient-poor zero fibres are suitable for all parcels (no limitation because of soil phosphorus)

- The legislation imposes some restrictions on the use of nutrient-rich fibres. Cadmium, phosphorus and soluble nitrogen content of fibres may limit the amount of fibres that can be spread on fields.

FIGURE 1

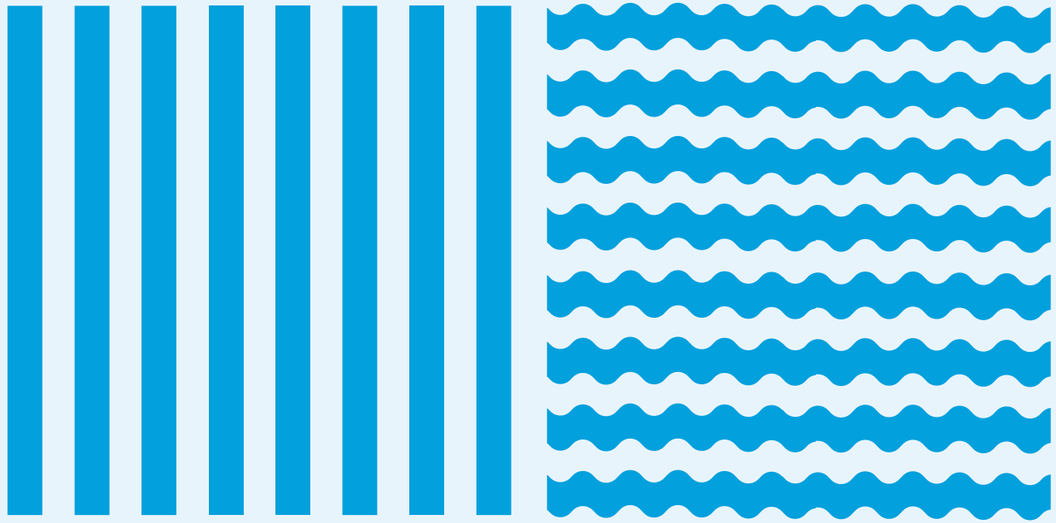
Impact of soil amendments on soil

Gypsum and structure lime increase soils' electrical conductivity. Fibers boost microbial activity in soil.



Impact of soil improvement fibres on soil

Soil improvement fibres are suitable for practically all fields. They increase organic matter in soils and improve their fertility. Fibres accelerate the activity of soil microbes, which has a positive impact on the soil aggregate stability.



The Finnish pulp and paper industry creates 420,000 dry-matter tonnes of organic by-products annually. Currently, this massive volume is mainly burned. A smarter solution would be to spread fibres on fields.

Zero-fibres can be used as a soil amendment as such. Suppliers process nutrient-rich fibres by means of composting or lime stabilisation, after which they can be spread directly onto fields. To ensure the quality of product batches, product specifications are provided for each fibre batch to indicate the organic carbon, nitrogen, phosphorus, potassium, sulphur, magnesium, and calcium content, as well as the pH level. The content of harmful metals, such as arsenic, mercury and cadmium in product batches is also monitored. Their concentration must fall below the threshold limit values set by the Ministry of Agriculture and Forestry.

FIBRES ARE ACCEPTED ON ORGANIC FIELDS - THE LOCATION DETERMINES THE PRICE

Currently (2021), fibres available on Finnish markets can be used in organic farming, and there are no regional restrictions on their application. However, the eligibility for organic production should always be verified. Fibres are suitable for all types of soils, but they probably produce the most benefits when used in fine-textured soils.

Currently, forest industry fibres are processed by a few suppliers in Finland. The price of the product is determined according to the processing method and transport costs. The closer a farmer's fields are to the fibre supplier's facilities, the lower the final price is.

EXCELLENT CONDITIONS FOR MICROBES

Fibres increase the volume of organic matter in field soils. An application volume of 40 tonnes per hectare equates to some 6–7 tonnes of carbon per hectare. Fibres are food for microbes, which means that the increased microbial activity results in the disintegration of fibers on the field. After the treatment, more than half the organic matter contained by soil improvement fibres decompose during the next 5–10 years, providing soil microbes with nutrition, energy and building material. This boosts the natural nutrient turnover in soil which is also beneficial for crops. Part of the added carbon is preserved as very slowly decomposable soil carbon.

Soil improvement fibres support soil functions.

Organic matter increases the number and activity of microbes. It also changes fungal and microbial communities. Soil improvement fibres increase the proportions of microbes favourable for many soil functions.

Microbes that decompose fibres secrete organic compounds that improve the strength of soil aggregates. This has a positive impact on the soil structure. In particular, nitrogen-containing compounds secreted by microbes adhere effectively to the mineral surfaces of soil and bind soil particles together. This mechanism generates waterproof soil aggregates and adds carbon in the slowly decomposing pool.

Based on research results, fibres help reduce erosion and losses of particulate phosphorus from fields. This benefits both farmers and water bodies: valuable soil and nutrients remain on the fields. Furthermore, all fibre grades slightly increase the soil's pH level, with lime-stabilised fibres increasing it most. The nutrients introduced by composted and lime-stabilised nutrient-rich fibres also replace mineral fertilisers.

Forest industry side streams benefit soils with low organic matter content

Soil improvement fibres are processed from fibre sludge generated in the production of paper, board, and pulp in the forest industries. Biosludge (i.e. the residue from a mill's effluent water treatment in a biological process) contains the nutrients, nitrogen and phosphorus, that are added in the purification process, as well as microbial biomass. Because the mill effluent is not mixed with municipal wastewater, no urine, faeces, microplastics or pharmaceuticals end up in the fibre material.

Fibre sludge is a technical concept which covers all fibre-containing side streams generated in the forest industries. Despite its name, fibre sludge is not sludge-like: 30-40 per cent of it is dry matter, and it appears more like moist peat.

All soil improvement fibres are rich in carbon. In addition, biosludge -based nutrient-rich fibres contain significant amounts of nutrients. Zero fibres have a very low nutrient content, and the nutrient state of a field does not limit their application volume. However, one should be aware that zero fibres immobilise nitrogen in soil the first year after application. Ideally zero fibre would be added to soil when terminating a legume crop that leaves a residue with high nitrogen content in the field.

Impact on the environment

Soil improvement fibres reduces soil erosion and water pollution. Microbial activity strengthens soil aggregates.

When fibres are added to soil, microbes get easily accessible food, and the microbial biomass increases. In the process, microbes secrete organic compounds that act as a glue between soil particles, strengthening soil aggregates. Durable aggregate structure in soil reduces erosion and the transport of attached nutrients into water bodies.

The benefits of soil improvement fibres for the environment are the clearest in lighter clay soils. Erosion is not usually significant in coarse mineral soils, and organic soils already contain a large amount of organic matter. In these, the application of fibres is expected to have a minor impact on erosion and the associated nutrient losses.

PHOTO: Paula Luodeslampi

Field experiment results:

FIVE-YEAR EFFECTS DOCUMENTED IN JOKIOINEN

When the Natural Resources Institute Finland (Luke) conducted field experiments in Jokioinen, it was discovered that the soil's aggregate structure remained durable for at least five years after a single application of fibres.

A rainfall simulation was conducted for 40-cm-deep soil monoliths taken from the field to study the concentrations of soil and nutrients in percolation water leached through them. In the spring following the spreading of fibres, the concentrations of soil and total phosphorus in runoff had at least halved (Figure 2). Even four years after the addition of fibres, the concentrations were a quarter lower than in untreated control groups. Soil improvement fibres help reduce especially the losses of particulate phosphorus.

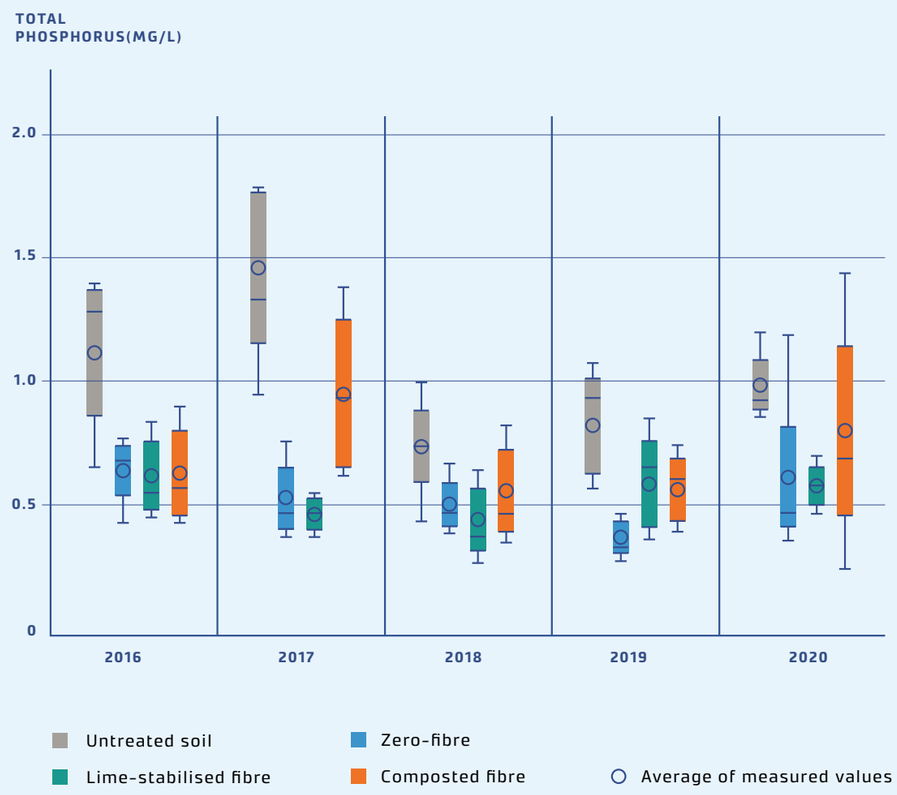
The addition of fibres did not have any impact on the leaching of soluble reactive phosphorus. For nitrogen, different fibre products had various impact. Zero fibres reduced the leaching of dissolved nitrogen during the first year after spreading, as microbes had consumed nitrogen for growth. During the growing season following the addition of zero fibres, the immobilization of nitrogen was so strong that it competed with crops for dissolved nitrogen and reduced the cereal yield by 10–15 per cent during the summer following the autumn application. No decreases in yields were identified when using other fibre products or during the following growing seasons. Zero fibres can be added when terminating nitrogen-rich crops, thereby using the ability of zero fibres to reduce the leaching of nitrate nitrogen. When nitrogen leaching decreases, it preserves this nutrient available for the following crop.

Lime-stabilised fibres increase the soil's pH level, which may improve the availability of previously accumulated phosphorus by crops in acidic soils. The leaching of dissolved carbon can be expected to increase slightly during the first year following the application of fibre products.

FIGURE 2

Total phosphorus content in water after the spreading of fibres in autumn 2015 in Jokioinen

The lower and upper edges of the boxes show the 25 and 75 per cent quarters of the data and the centre line represents the median. The ends of the lines indicate the smallest and highest measured values.



Field experiment results:

SUSPENDED SOLIDS IN SUBSURFACE DRAINAGE WATER DECREASED DECREASED IN ESPOO

In Röylä, Espoo, automatic in situ sensors were used for two years to measure the quality of water in subsurface drains during the spring and autumn in four parcels. Two of the parcels had been treated with lime-stabilised fibres, and the two others acted as untreated controls.

Fibres reduced the concentration of suspended solids (soil matter) in subsurface drain flow by 50 per cent and the concentration of total phosphorus by 45 per cent. During the monitoring period, total losses of suspended solids was 461 kg per hectare in the treated parcels and 705 kg per hectare in the untreated ones (Figure 3). The differences between the treated and untreated parcels were greatest during the highest flows. This means that fibres reduced the mobilization of soil particles most effectively during heavy rainfalls.

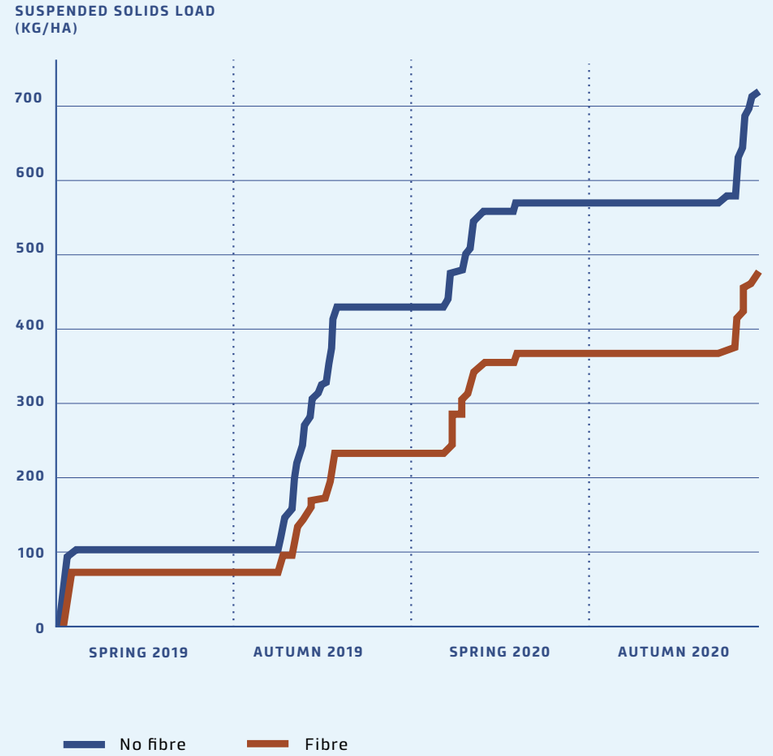
As a result of the addition of fibres, the nitrogen concentration in water of subsurface drains decreased during the first spring after spreading, but was after that twice as high compared with the control group. During the entire testing period, total nitrogen loss was 10.6 kg per hectare in the treated parcels and 5.3 kg per hectare in the untreated parcels. Overall, the losses were low. Any increase in nitrogen leaching can be prepared for by reducing nitrogen fertilisation or using catch crops, for example.

As a result of the promising results of the field tests, the application of fibres is also being tested on the scale of an entire catchment area. In the autumn of 2019, a test was set up in the Lake Tuusula catchment area to monitor ditch water quality in a field area treated with fibres in the autumn of 2021. A similar untreated area serves as a control for comparison. The first results of the catchment area test will be obtained during 2022.

FIGURE 3

Soil improvement fibers reduce soil losses from fields to the water bodies

Cumulative suspended solids loading through subsurface drains in parcels treated with fibre and in untreated control parcels. Lime-stabilised fibres were spread in autumn 2018, and each monitoring period lasted roughly two months.



Tips for spreading

How can I select the correct type of fibre?

There are three types of soil improvement fibres: nutrient-containing composted and lime-stabilised fibres, and nutrient-poor zero fibres. All increase organic matter in fields.

Nutrient-rich fibres are ideal if the aim is also to decrease mineral fertilise use at the same time. Zero fibres are particularly suitable for soils with a high soil test phosphorus, because nutrients do not restrict the application volume. If a parcel requires liming, you can choose lime-stabilised nutrient-rich fibres to decrease acidity.

What restricts the use of fibres?

Fibres cannot be spread on fields between 1 November and 31 March. Nutrient-rich fibres cannot be spread on fields within the scope of an environmental commitment and that have excessive soil test phosphorus class. However, nutrient-rich fibres can be spread on fields with a high soil test phosphorus class using phosphorus balancing if required. The nitrates directive restricts the application volume of nutrient-rich fibres regarding soluble nitrogen.

The amount of cadmium added through nutrient-rich fibres cannot exceed 7.5 g per hectare or 1.5 mg per kg. The amount of cadmium and the period after which the next treatment can be given are indicated in the product specification. Product-specific information should always be checked with the seller.

Freight charge is a large cost item and may constrain use of soil improving fibres. The distance between the fibre manufacturer and the field should therefore be reasonable so that the cost does not become too high.

What kinds of subsidies are available for the use of fibres?

Nutrient-rich fibres meet the national requirements set for environmental subsidies (2021) for recycling nutrients and organic matter in parcel-specific activities. The subsidy is EUR 40 per hectare.

Financial compensation can also be obtained for the use of fibres in agriculture through carbon emissions offsetting. This is a new mechanism. The current situation, the amount of compensation and the operating policy should be checked on relevant/suppliers websites.

How do I know how much fibres to spread on my fields?

Soil improvement fibres can be spread on a field by taking the threshold values set for nutrients and cadmium into account. The application volume ranges from 20 to 40 tonnes per hectare, depending on the soil type and organic matter content.

How are fibres spread in practice?

Soil improvement fibres are spread using dry manure spreading equipment or a similar system. According to the nitrates directive, fibres must be prepared in soil within one day of spreading.

SOIL IMPROVEMENT FIBRE

Where can I get help in planning the spreading of fibres?

For help in planning how to spread fibres, contact the product seller/supplier, agricultural advisors, contractors, or other farmers. As application volumes are high, you can also request an offer for spreading from the seller.

How can I choose when to spread fibres?

Fibres can be spread between 1 April and 31 October. For cereals, soil improvement fibres should be spread immediately after harvesting.

Fibres can only be transported to fields during seasons when the ground has a sufficient load-carrying capacity. In addition to fields, the roads leading to them must be able to withstand the loads. In many places, roads are unsuitable for lorries, especially during the autumn.

The application period in crop rotation and the fibre grade should be planned well beforehand. For example, the spreading of fibres can be planned to take place in conjunction with an early crop, autumn oil crops, or the termination of grass and caraway crops. Early harvesting gives more time for spreading before autumn rains.

For crops sown late, such as buckwheat and caraway, fibres can also be spread in the spring. There should be a two-week safe period between the spreading of fibres and sowing. Zero fibres can be spread when terminating crops that contain plenty of nitrogen.

How can fibres be stored?

Soil improvement fibres can wait for spreading by the side of the field for four weeks. The pile must be located at least five metres from a ditch and 100 metres from a main ditch or water body. Piling fibres in a groundwater area is not recommended. Contact the municipal environmental protection authority for their opinion on piling fibres in a groundwater area.

Fibres can also be stored in a windrow if they are not spread within four weeks of piling. According to the nitrates directive, the solid matter content in fibres stored in a windrow must be at least 30 per cent, and the windrow cannot be placed in a groundwater area or an area susceptible to flooding. A windrow storage notification must be submitted to the municipal environmental protection authority 14 days beforehand. Municipal authorities also provide further instructions for storage windrows.

What can go wrong in the spreading of fibres?

When planning the spreading of soil improvement fibres, pay attention to road connections and the field's load-carrying capacity. As fibres are transported to fields on lorries, the road connection and the soil's load-carrying capacity must be suitable for them.

The impact of soil improvement materials focuses on the surface layer. Even though organic matter improves the soil's water retention capacity, the field's water balance (incl. drainage) must be cared by also other means.

A FARMER'S EXPERIENCES

TAPIO ANTTILA FROM MYRSKYLÄ

Tapio Anttila, a farmer on the Tattari estate, has been spreading fibres on his fields regularly since 2015. Over time the organic matter content and water retention capacity of his fields have improved, which was favorable during last summer's drought.

PHOTO: Mediafarmi

I've used nutrient-rich fibres on my organic fields for nearly seven years now. The organic matter content of Finnish fields is low, and the main reason for using fibres is to improve the organic matter content of my fields. Earthworms thrive in a field with a high organic matter content, which is important for soil fertility. My fields mainly consist of clay soil, and I also wanted to use fibres to improve their water retention capacity. Although we have rainy summers here in Finland, water shortage was experienced this summer, for example. The higher the organic matter content, the better the soil retains water.

I transport fibres myself and order spreading from a service provider that was once recommended to me. After spreading, I cultivate the fibres in the surface layer at a depth of roughly 5-10 cm. Fibres are transported here during the winter because I don't want any lorries on my fields when the ground isn't frozen.

The location of my farm in the region of Uusimaa determines what fibres can be spread on my fields. As we don't have many cattle farms here in Myrskylä, it isn't easy to get fertilisers eligible for organic production at a reasonable price. While Southwest Finland benefits from its cattle farms, our advantage is the local wood production industry, and we have access to wood fibres at low costs. In addition, the use of wood fibres is subsidised similarly to the use of manure."

A LONG-TERM PROCESS TO IMPROVE THE SOIL FERTILITY

"Increasing the organic matter content of fields requires patience. Fibres should be spread in abundance if you want to see results. However, eventually the fibre addition leads to better soil condition. According to measurements, the organic matter content of my fields has increased significantly. There are no longer as many water or soil compaction problems, and the soil's water retention capacity has improved.

"I often say that you don't just throw fibres on the ground to magically improve yields - it's the sum of its parts."

In 2021, the autumn's wheat yield was higher than in previous years. However, it's hard to say what impact fibres specifically have had because they're one component having impact on the soil fertility and the crop growth. Cultivation methods and other solutions that increase the organic matter content also affect soil fertility. For example, I try to keep my fields covered with crops during the winter so that they bind the soil and keep nutrients in the field."

ATTITUDES TOWARDS FIBRES BECOME MORE FAVORABLE ALONG WITH THE NEXT GENERATION FARMERS

"I still hear many mixed opinions about fibres. Many are sceptical of their benefits, because the short-term advantages of soil amendments are so hard to prove. I often say that you don't just throw fibres on the ground to magically improve yield - it's the sum of its parts. However, fibres turn into soil over time, so this must produce some benefits.

Luckily, attitudes are changing among the younger generation of farmers. This year, 2021, I heard for the first time in these seven years that there hadn't been enough fibres for everyone. Fibres obtained from the forest industries are a prime example of the circular economy. It will be promoted strongly in Finnish agriculture in the future. The subsidy policy also has a significant impact on the use of soil amendments, but I believe there'll be high demand for fibres."

Impact of structure lime on soil

Structure lime improves the soil structure and water retention capacity. This reduces the erosion risk.

Structure lime is a mixture of agricultural lime and quicklime or slaked lime. As structure lime reacts with clay, it is effective in all clay soil types. Structure lime produces the most benefits on fields where the aggregate structure is poor, and electrical conductivity is low.

Structure liming improves the workability of soil. Soil treated with structure lime dries more quickly in the spring and maintains better aggregate structure than untreated soil. Furthermore, structure lime improves the seedbed because of the aggregation. The more even aggregate size distribution in the top soil reduces evaporation. This is beneficial especially during dry summers. Structure liming also increases the soil's pH level. All in all, structure liming may be the best option when maintenance liming is required on the field.

Structure liming has not been found to have any significant impact on microbial diversity in soil. However, reduced soil acidity because of structure liming may accelerate microbial activity, which improves the stability of the soil aggregate structure. Earthworms thrive when acidity decreases.

STRUCTURE LIME INCREASES THE SALT CONCENTRATION IN SOIL WATER

The erosion-reducing effect of structure lime is based on an increase in salt concentration in soil water (electrical conductivity), cation exchange reactions and possibly on solubility–precipitation reactions (pozzolanic reactions).

The concentration of water-soluble salts in soil is represented by electrical conductivity value measured also in soil fertility analyses. As a result of increase in electrical conductivity, or an increase in dissolved salts, the water layer surrounding clay particles becomes thinner which allows them to come closer to each other, and clay particles flocculate, i.e., become loosely joined. Cation exchange reactions help the calcium ions to form bonds between separate clay particles, creating micro-aggregates. In ideal conditions, a high pH, combined with a high calcium content, may also change mineral surfaces so that the bonds between clay particles become very durable and long-lasting.

Sugar beet is known to be a demanding crop in terms of soil pH. Adding calcium to the soil reduced the incidence of root rot in sugar beet.

Field experiment results:

VARYING RESULTS OF THE IMPACT OF STRUCTURE LIME ON YIELDS

In 2019–2021, the Sugar Beet Research Centre in Paimio studied the impact of structure liming on crop yields (Figure 4). Two fields with a high clay content (57 and 58 per cent) and a pH level of 5.2 and 6.5 were selected as the test group. Both fields had three different treatment areas, in which the active lime application rates were 0, 1.6 and 2.3 tonnes per hectare, and the corresponding total structure lime rates were 0, 8 and 12 tonnes per hectare.

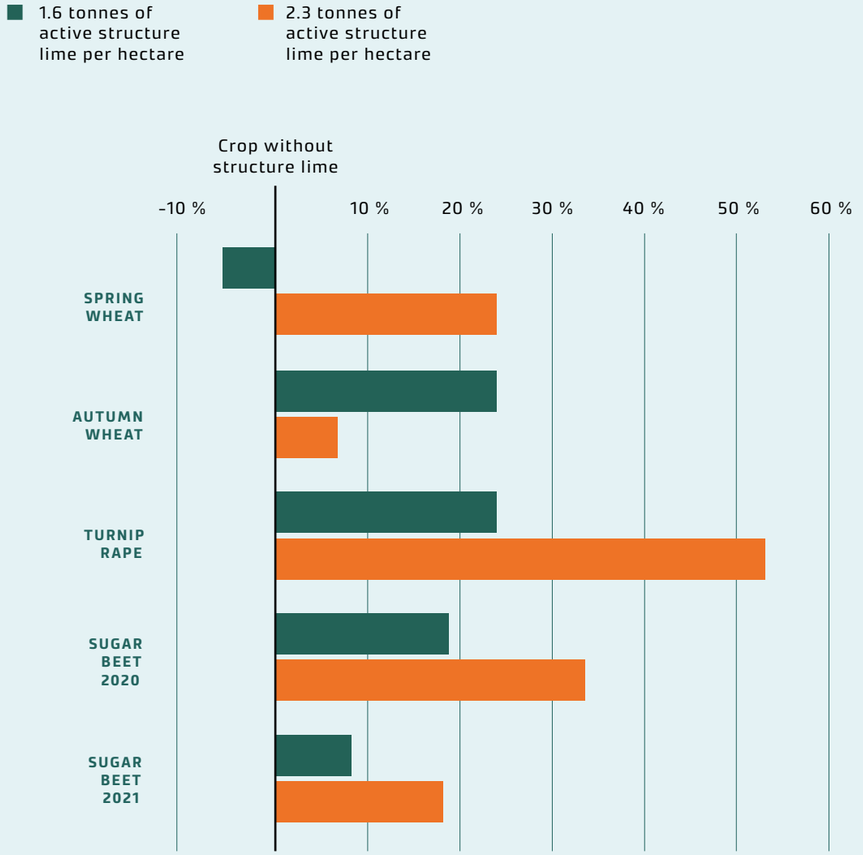
Sugar beet is known to be a demanding crop when soil pH is considered. Adding calcium to the soil reduced root rot in sugar beet. This partly explains the increase in sugar beet yield. Turnip rape yields increased the better, the more structure lime had been added to the soil. Furthermore, no subsequent blooming was discovered in the areas treated with lime. For autumn and spring cereals, yields showed more variation and, due to weaker roots, they were more susceptible to weather than other studied crops. Similar results have been obtained in Sweden regarding cereals, with structure lime having varying impact on yields.

There were also differences in the nutrient intake of crops. The more structure lime was added, the lower the concentration of manganese was in crops. This can be explained by the increased pH level, as the availability of manganese decreases when the pH level increases. This is not alarming, but farmers should be aware of the impact of liming on nutrients.

FIGURE 4

Impact of structure liming on crop yield

Crop yield in structure lime treated field compared with untreated field. Active structure lime accounted for 19.5 per cent of the total lime volume.



An effective mixture of agricultural lime and active lime

Structure lime is a mixture of agricultural lime and active lime. Agricultural lime is ground limestone i.e. calcium carbonate ($CaCO_3$). The active lime contained by structure lime is quicklime (CaO) or slaked lime ($Ca(OH)_2$). Less than half of structure lime (15-40 per cent) consists of highly soluble reactive lime. Thus, a major part of the lime is ground limestone.

Structure liming differs from regular liming, intended to increase the soil's pH level, in that it aims to have a quick and long-term impact on the aggregate structure of clay soils.

PHOTO: Juha Kääriä

Impact on the environment

Good results have been obtained regarding the impact of structure liming on nutrient losses. Structure lime decreases the losses of phosphorus into water. In this way, it helps to control eutrophication.

The positive impact of structure lime on the environment has been proven at several structure limed sites in Finland and Sweden. In Sweden, structure liming is widely used and subsidised water protection measure in agriculture.

Field experiment results:

PHOSPHORUS LOSSES REDUCED IN EURAJOKI AND TURKU

The impact of structure lime on water bodies was studied in Eurajoki and Turku in 2019–2021. Water samples were collected from ditches, subsurface drains, and from the surface runoff of fields. Various water quality variables were analysed from the samples. One of the most important variables affected by structure lime is the particulate phosphorus carried by water.

Structure liming reduced the particulate phosphorus (PP) concentration in ditches, in subsurface-drainage water and surface runoff (Figures 5 and 6). Water samples were collected before and after structure liming. In Eurajoki water quality was also monitored using in situ high frequency monitoring equipment, thus it was possible to calculate flow-weighted phosphorus concentrations.

In ditches, the phosphorus concentration decreased, even though runoff increased after liming compared with the situation before structure liming. The results were verified by also collecting water samples from control areas without structure lime treatment. In the waters of control areas, the concentration of PP was significantly higher than in the waters of structure lime treated areas.

FIGURE 5

The structure liming decreased flow-weighted particulate phosphorus concentration of runoff in Eurajoki

Runoff was monitored in Eurajoki in spring 2020 before structure liming. The periods following structure liming are from autumn 2020 to spring 2021.

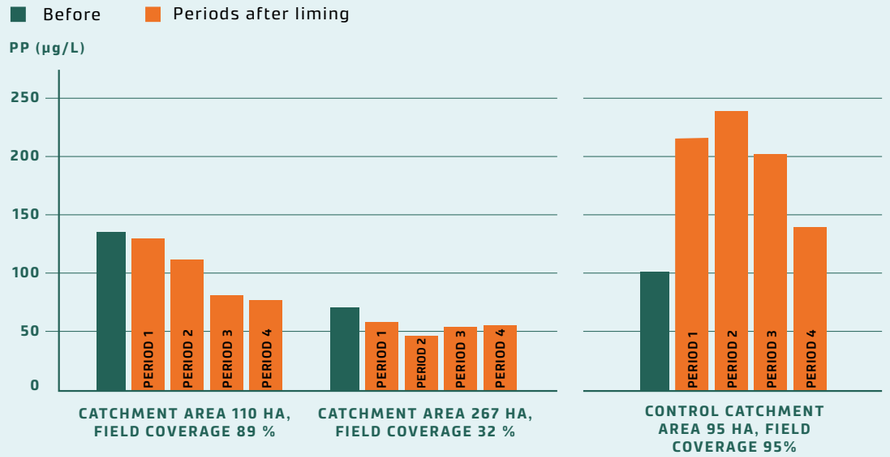
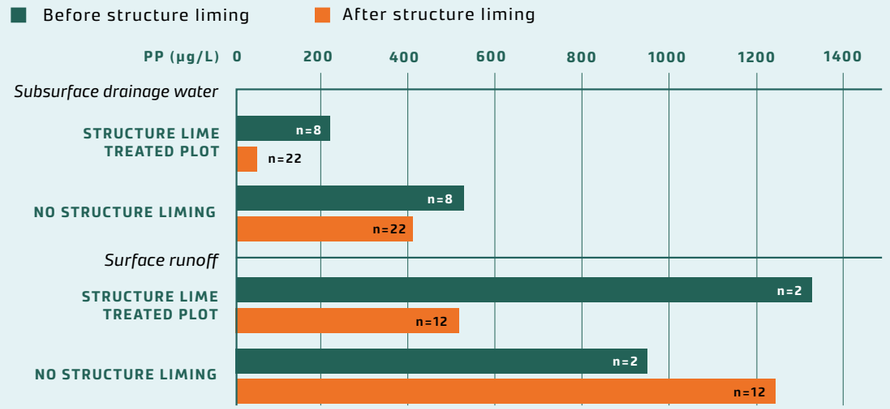


FIGURE 6

The particulate phosphorus concentration of runoff water decreased in Turku

Water samples were collected from the test field's runoff between 17 October 2019 and 27 October 2021.



Laboratory test results:

TURBIDITY OF THE WATER DECREASED

Structure liming is an effective water protection measure if water in field ditches is turbid due to clay. The low electrical conductivity and the high clay content in arable soil increase the risk of the erosion especially when the soil is wet.

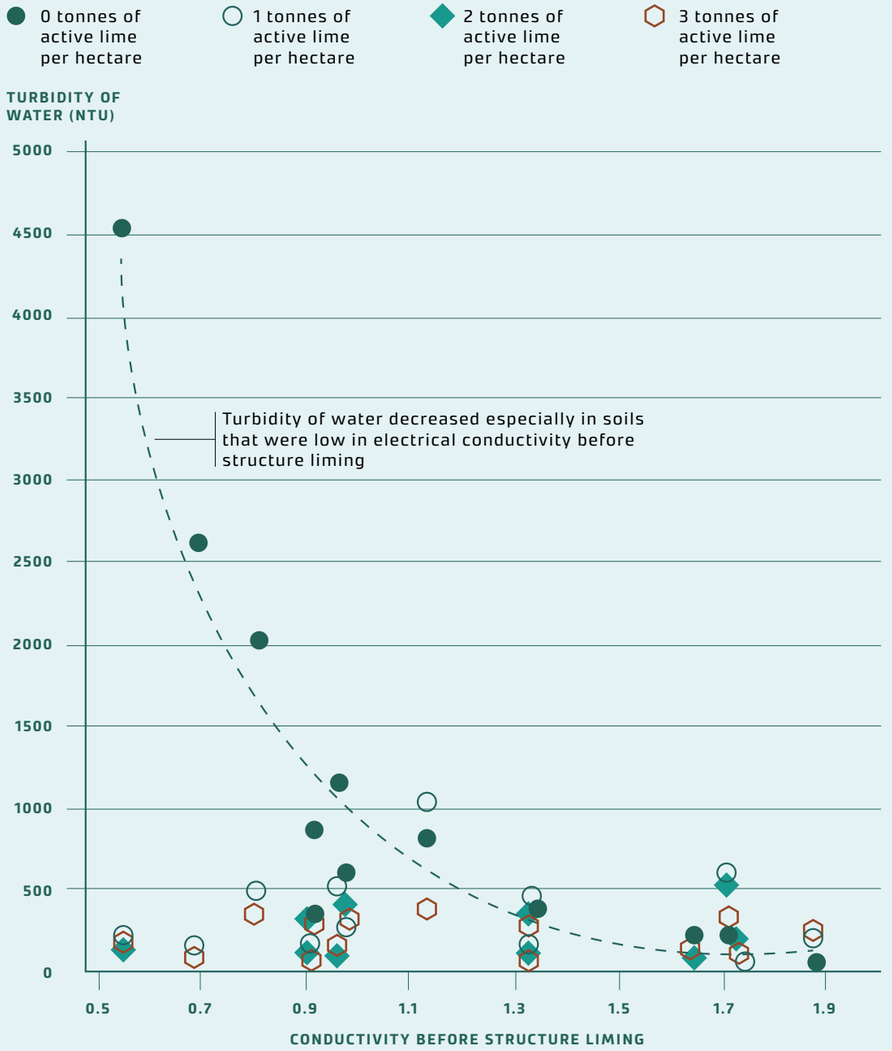
In rainfall simulations conducted in Luke's laboratory, structure liming reduced the detachment of clay particles from soil samples, especially in soils with low electrical conductivity. Even a dose of one tonne of active structure lime per hectare significantly reduced turbidity in drainage water. In the rainfall simulations, an increase in structure lime dosing did not have any significant impact.

Soil samples were collected from fields before and after structure liming. Based on soil fertility analyses, structure liming increased the electrical conductivity in soil. A higher conductivity improves the flocculation of clay particles, with particles joining loosely together, forming larger aggregates. The bonds formed between clay particles contribute to the formation of a stable aggregate structure. This reduces the erosion risk.

FIGURE 7

Active structure lime reduced turbidity in water compared with water percolated through untreated soil

Added structure lime contained 27 per cent of active lime, while the rest consisted of regular agricultural lime.



Tips for spreading

How can I select the correct type of structure lime?

Pay attention to soil pH. The neutralising ability of active structure lime (CaO or Ca(OH)2) corresponds to that of ground limestone but, being more soluble, it quickly increases the soil's pH level. A dose of 1,000 kg of active lime per hectare is sufficient to reduce turbidity in drainage water from clay soil fields with a poor structure.

The concentration of the active element in structure lime ranges between 15 and 40 per cent in different products. In other words, the choice of product can affect the volume of active lime applied to soil and the rapid impact of structure liming on the pH level.

What restricts the use of structure lime?

The use of structure lime is not permitted in organic farming. If soil pH is at the targeted level or higher, structure liming should be postponed to the future.

Pay attention to the soil's Ca/Mg ratio when selecting the lime type to be applied. The relative share of magnesium can be increased by using dolomitic lime, and the volume of calcium can be increased by using calcitic lime. The lime contained by structure lime products is calcitic lime, which helps to adjust the soil's Ca/Mg ratio in a more favourable direction considering the soil structure. If the magnesium state is low, structure liming will further reduce the availability of magnesium for crops.

What kinds of subsidies are available for the use of structure lime?

Currently, no subsidies are available. Because the situation may change, contact agricultural advisors, agricultural secretaries in municipalities, or the ELY Centre for up-to-date information.

How do I know what the suitable amount is?

Contact the product manufacturer to identify the percentage of active lime. Then, calculate how much structure lime you need to purchase to spread at least 1,000 kg of active lime per hectare. Example: A structure lime product contains 25 per cent of active lime and 75 per cent of agricultural lime. As a result, the recommended minimum amount of the product is 4,000 kg per hectare.

If soil pH needs to be increased significantly, more structure lime should be spread. In field plots where the soil structure is the weakest, you should also consider a higher amount. If you want to apply structure lime to part of your fields, you should focus on sloping fields that are the most susceptible to surface runoff.

How is structure lime spread?

To obtain the best results, structure lime should be incorporated thoroughly in the surface layer at a depth of roughly 10 cm immediately or as soon as possible after spreading. Preparation needs to be carried out twice to completely mix structure lime in the surface layer and to have it in contact with clay.

Regular spreading equipment for moist or dry lime is suitable for spreading. Contact a local contractor to identify options for liming. You can also spread lime yourself. Washing the spreading equipment will take a little more time than usual. Active lime adheres firmly to equipment and causes oxidation if it is not washed properly.

For example, a disc harrow or cultivator can be used for incorporation of structure lime. Tillage/ploughing is not recommended, as the incorporation method must mix the surface layer.

How can I choose when to spread structure lime?

The best conditions for structure liming exist when the soil is dry and withstands preparation. The weather must be warm, with low winds and without any rain. As a result, the temperature will accelerate reactions between structure lime and the soil.

The summer is the most ideal season for spreading, in case the crop rotation permits lime application then. By changing crop rotation and by using grasslands in conjunction with spreading, you will obtain many benefits. Usually, the best time is immediately after harvesting. However, with the current farm sizes, there is not always enough time or a suitable weather for spreading after harvesting. Structure lime can also be spread in conjunction with fallowing, the harvesting of early crops, or the termination of perennial crops. If the weather is not suitably dry and calm for structure liming during autumn and the field is wet, you should postpone structure liming by a year.

Note that the field drainage, i.e., usually subsurface drainage, should be in proper condition. Structure lime does not help in case the drainage is not sufficient. You should postpone structure liming a year if the weather conditions are not optimal. Note that in optimal conditions the weather is dry and calm and the ground should not be wet.

How can structure lime be stored?

Structure lime storage is not recommended. Instead, it should be spread and incorporated immediately after its delivery. Long-term storage at the field side is not recommended because the slaked lime ($Ca(OH)_2$) reacts with carbon dioxide in the air and becomes calcium carbonate ($CaCO_3$), which is regular agricultural lime. As a result of storage, structure lime loses its ability to improve the soil structure. However, this problem only concerns the surface of the lime pile. If the lime needs to be stored, the pile should be covered.

Is there any work safety considerations?

Remember to read the product's material safety data sheet. Follow the manufacturer's safety instructions. Wear a protective eyewear and a respirator.

Where can I get help in planning the spreading of structure lime?

Contact agricultural advisory organisations for help. More information about structure lime is also available (in Finnish) on the website of the "Structure lime as a water protection method in agriculture" project at **proagria.fi/rakennekalkki**.

What can go wrong in the spreading of structure lime?

If the wind is strong when spreading structure lime, it may spread outside the intended parcel. Structure lime adheres to surfaces and spreads easily like dust. Make sure that there are no people, animals, vehicles, machines, or buildings downwind that could potentially be exposed to wind-born spreading of structure lime.

There will be problems if structure lime is not immediately mixed with the clay minerals in the soil, as the desired reactions will not take place. The results may be unoptimal if the soil is too wet or cold. Spreading and incorporation should be carried out during a dry season to avoid soil compaction resulting from the use of machinery. Also consider that the low load-carrying capacity of roads and fields may cause problems during delivery, spreading and preparation.

A FARMER'S EXPERIENCES

OSKARI VIRTANEN FROM VIHTI

Oskari Virtanen, a farmer from Vihti, wanted to improve the water retention capacity of one of his parcels and fix its pH balance using structure lime. Oskari says that soil amendments offer useful tools for improving soil fertility and water protection, but he would also like to point out other means.

Soil fertility is a prerequisite for good yield. To foster fertility, crop rotation must be effective, and the soil structure needs to be improved.

I wanted to test structure lime in one of my parcels which had a low pH level and was too wet during spring. The clayey parcel was also difficult to prepare in the spring. I thought that structure lime would fix both problems: increase the pH level and improve the clay soil's aggregate structure.

Structure lime was spread in a field in which grass crops had been grown for a few years. Structure lime was spread and incorporated in summer. The conditions were then the most ideal for spreading because the field was as dry as possible. Immediately after structure liming, autumn crops were sown.

The spreading process was easy. I also ordered spreading from the lime supplier. Timing of spreading is important. Structure lime needs to be incorporated immediately after spreading to get the most out of it."

"Structure lime was spread in a parcel in which grass crops had been grown for a few years. Structure lime was spread and incorporated in summer. The conditions were then the most ideal for spreading because the field was as dry as possible. Immediately after structure liming, autumn crops were sown."

A CONTEST BETWEEN TWO PARCELS

"I have two parcels with a similar cultivation history side by side. One of them was treated with structure lime and the other was not. It has been easy to compare the two parcels and observe the concrete benefits of structure liming.

The parcel treated with structure lime is much easier to prepare in the spring. The other parcel continues to have the same problems with water in the spring: it barely dries for sowing. In the spring, I had to sow part of the untreated parcel separately.

I believe that structure liming has produced benefits on my fields. Others should also consider structure liming if they have faced similar problems."

TAKING CARE OF SOIL FERTILITY IMPROVES YIELD IN EXTREME CONDITIONS

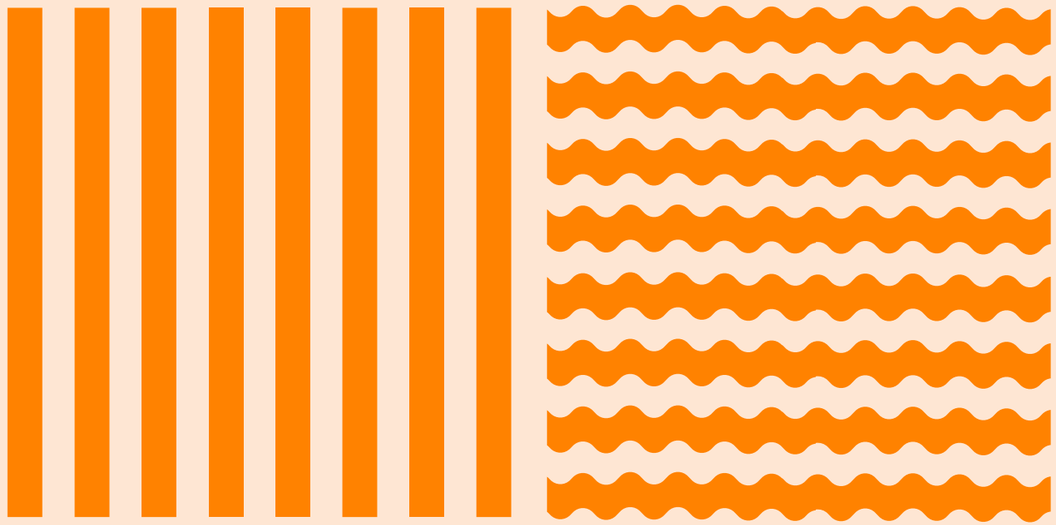
"Us farmers have many tricks up our sleeves to improve soil fertility. We also have access to volumes of research data. Considering water protection, it would be important that farmers retained nutrients in the field available for crops to prevent them from being discharged into water bodies. Soil amendments are a good addition to the broad range of water protection measures.

For example, the improved soil structure resulting from structure liming prevents the leaching of nutrients. Alongside soil amendments, there are a number of other ways to reduce nutrient leaching, such as buffer zones, minimised soil preparation, and vegetal cover during winter.

Climate change is clearly starting to have an impact on our Nordic conditions here in Finland. Extreme weather conditions also test our fields. High soil fertility also supports crop growth in extreme conditions. The impact of soil fertility can also be seen in the farmer's wallet, as better soil produces higher yields."

Impact of gypsum on soil

By treating fields with gypsum, erosion and the losses of phosphorus and carbon into water bodies can be reduced significantly. Small-scale reactions with major results will take place in soil.



Gypsum reduces the losses of soil-bound and dissolved phosphorus. In addition to its impact on water protection, some farmers who have used gypsum have also found improvements in the soil structure.

GYPSUM GENERATES MICROSCOPIC REACTIONS IN CLAY SOILS

Gypsum is the most effective in terms of water protection in clay soils, where it causes soil particles to form into larger micro-aggregates. When microscopic soil particles form aggregates, they are not as easily carried by rainwater or meltwater.

Gypsum also strengthens the binding of phosphorus to the surface of soil particles, while keeping phosphorus available to crops. In addition, gypsum acts as a fertiliser: one tonne of gypsum per hectare adds 200 kg of calcium and 160 kg of sulfur, plus 2 kg of phosphorus. If four tonnes of gypsum per hectare are spread, a total of 800 kg of calcium, 640 kg of sulfur and 8 kg of phosphorus will be added to the soil. This should be taken into account in fertilization. Gypsum is especially suitable for potato and sulfur produces benefits for oil crops, for example. In clay soils rich with magnesium, the calcium contained by gypsum can improve the cation balance and soil structure.

The effectiveness of gypsum is direct and visible to the naked eye: puddles and runoff are clearer.

Gypsum has no liming impact. Furthermore, gypsum does not increase soil acidity, even though the pH value measured from soil may temporarily be a little lower after the spreading of gypsum.

... VISIBLE EFFECTS TO THE NAKED EYE

The effectiveness of gypsum is direct and visible to the naked eye: puddles and runoff waters are not turbid but clear. The rapid effect is the result of the easy solubility of gypsum in the soil. At its best, gypsum remains effective for more than five years.

Gypsum is safe to use. Siilinjärvi gypsum, which is used generally in Finland, does not contain any hazardous substances, and it has no harmful impact on the yield or crop quality. If the soil has a shortage of sulfur, yields may improve. The selenium content of yields will first decrease after gypsum treatment, which needs to be considered.

In spring gypsum spreading tests, no negative impact on oat or sugar beet growth was discovered. Instead, clearly fewer sugar beets damaged by root rot were found in the test plot treated with gypsum than in the untreated plot. However, the spreading of gypsum in the spring may delay the sowing of crops, as gypsum should only be spread when the soil is sufficiently dry to prevent soil compaction.

Information on gypsum

Gypsum ($CaSO_4 \cdot 2H_2O$) is calcium sulfate in terms of its chemical composition, and sulfate is a form of sulfur available to crops. Gypsum also contains water of crystallisation and moisture bound to the surface of particles. Gypsum dissolves in soil water, increasing its salinity, or its ionic strength when speaking in the language of chemistry. As a result, conductivity increases in a soil fertility analysis.

Gypsum is a by-product of phosphoric acid manufacturing, and smaller volumes are generated in flue gas scrubbing at coal-fired power stations. Most of the gypsum spread on Finnish fields comes from Yara's Siilinjärvi plant. Gypsum is also excavated at mines in other countries.

Gypsum grades produced industrially or in energy generation cannot be used in organic farming. Some natural gypsum grades are also eligible for organic fields, but these were more expensive than by-product gypsum at the time of writing this guide (in 2021).

PHOTO: Ministry of Environment's image bank / Tero Pajukallio

Impact on the environment

Above all, treating fields with gypsum is a water protection measure. In fact, gypsum treatment reduces the leaching of phosphorus and organic carbon from fields into water bodies.

For the prevention of eutrophication, it is important that gypsum reduces the losses of phosphorus bound to soil and dissolved phosphorus. Gypsum treatment roughly halves the particulate phosphorus discharged from fields.

In addition, gypsum reduces the losses of dissolved and particulate organic carbon into water bodies. Considering the soil structure, it is important that carbon is retained in fields. In water, carbon produces a harmful impact.

TABLE 2

Gypsum-induced decrease in phosphorus and carbon loading in percentage in accordance with different studies

	Field experiment in Jokioinen and laboratory rainfall simulations	Catchment area experiment in Nurmijärvi	Catchment area experiment in the Vantaa river	Catchment area experiment in Lieto and Paimio
DURATION OF STUDY IN YEARS	3	4	2	5
PARTICULATE PHOSPHORUS	70	50	53	31*
DISSOLVED PHOSPHORUS	50	25	Decreased	-11*
DISSOLVED ORGANIC CARBON	35	Decreased	Decreased	33*

*Preliminary results. There was a major difference between two research areas: gypsum was highly effective in one, and less effective in the other. The figures are averages calculated based on all research areas.

Gypsum obtained from Siilinjärvi would be sufficient to treat all fields in Finland many times over!

BE CAREFUL WITH SULFATE

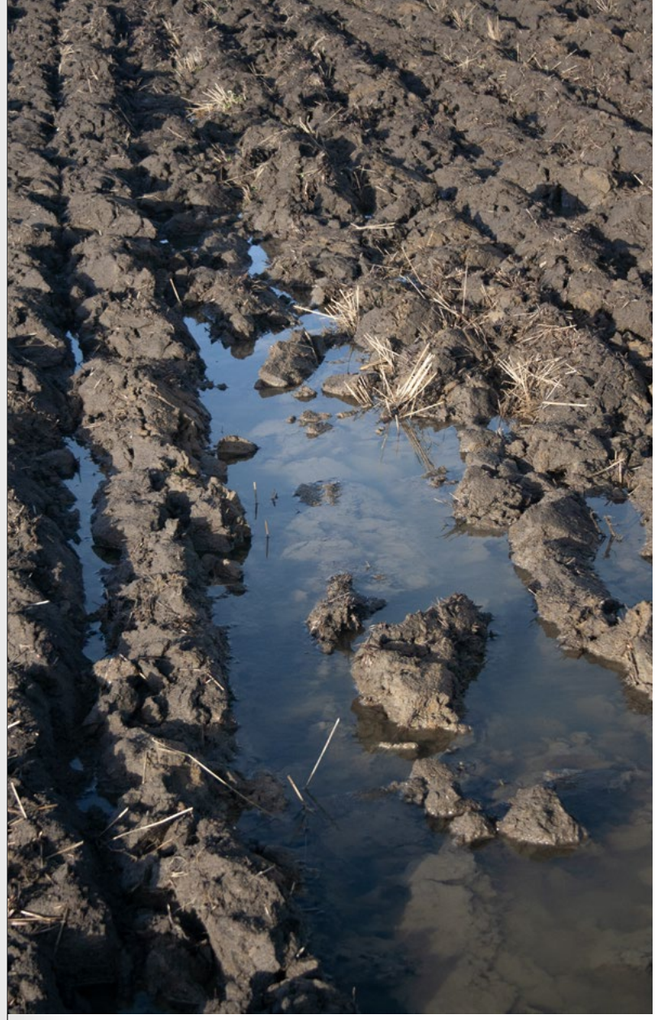
As a result of gypsum treatment, sulfate concentrations in rivers do not rise to problematic levels. The impact of the sulfate contained by gypsum has been studied in detail on the threatened thick shelled river mussel and trout roe, and no adverse impact was discovered. Furthermore, gypsum has not been found to have any negative impact on the activity of soil microbes.

However, gypsum should not be used extensively in catchment areas of lakes because, in lakes, sulfate may increase the amount of phosphorus released from the bottom sediment, which increases eutrophication. The Baltic Sea naturally contains such high volumes of sulfate that its concentration cannot even be changed by more extensive gypsum treatment. Due to sulfate, gypsum cannot be used in groundwater areas.

TREATING FIELDS WITH GYPSUM IS A CONTRIBUTION TO THE CIRCULAR ECONOMY

The gypsum mainly used in Finland is a by-product of the fertilisation industry, and its use supports the circular economy. Gypsum obtained from Siilinjärvi (Eastern Finland) would be sufficient to treat all fields in Finland many times over!

The use of gypsum mainly causes environmental burden through its transport and spreading. The transport distance is inevitably long because gypsum is mainly used in coastal clay soils, and it cannot be used in the Finnish lake district. Overall, the greenhouse gas emissions during the manufacturing, transport and spreading of gypsum are however low.



Gypsum cleared a field pond in Nummenpää (TraP project)

The photo on the right shows a nearby parcel not treated with gypsum.

PHOTO: Pasi Valkama

Tips for spreading

How can I select the correct type of gypsum?

Siilinjärvi gypsum is primarily used in Finland. It is approved by the Finnish Food Authority as a by-product used as such as a soil amendment. Organic farms can only use excavated natural gypsum. When using products other than the even-quality Siilinjärvi gypsum, it must be ensured that the product does not contain any harmful substances. Some foreign gypsum grades contain radioactive substances, cadmium, or too high concentrations of phosphorus.

What restricts the use of gypsum?

Due to the sulfate it contains, gypsum cannot be used in catchment areas of lakes, groundwater areas or Natura areas. If a water supply well is located on a field or in its immediate vicinity, a buffer zone of 30-100 m not treated with gypsum must be left around it.

Furthermore, gypsum should not be used if the soil contains low amounts of potassium and magnesium, as the calcium contained by gypsum may boost their deficiency. Gypsum can be applied to soils other than clay soils, but its effectiveness in other soil types is not known.

What kinds of subsidies are available for the use of gypsum?

Currently, no agricultural subsidies are available for the use of gypsum. Because the situation may change, contact agricultural advisors for up-to-date information. In the GYPSUM project, for example, the use of gypsum received funding from the programme to enhance the effectiveness of water protection: gypsum and its spreading have been free and tax-exempt for farmers in the catchment area of the Archipelago Sea.

How do I know how much gypsum I need to spread on my fields?

The established amount for the use of gypsum in water protection is four tonnes per hectare. At present, it is not known whether the amount can be adjusted according to local conditions. When using natural gypsum, the amount depends on how much it contains other compounds.

How is gypsum spread in practice?

Gypsum can be spread using spreading equipment for moist lime or manure. The spreading of gypsum should take place during crop rotation so that the field can be lightly prepared after spreading.

Where can I get help in planning the spreading of gypsum?

Plenty of information about the application of gypsum is available on the website of the SAVE project at **https://blogs.helsinki.fi/save-kipsihanke/?lang=en**. Further information is also available from agricultural advisors and the GYPSUM project (**www.ely-keskus.fi/kipsinlevitys**).

How can gypsum be stored?

When gypsum is delivered, it should be ensured that parcels and roads have a sufficient load-carrying capacity for lorries. Once gypsum has been delivered, it should be spread as quickly as possible. If this is not possible, cover the pile with a tarpaulin, as it may form clumps when wet.

How can I choose when to spread gypsum?

The best time is in the autumn after harvesting. Parcels sown during autumn should be prepared after the spreading of gypsum and before sowing. Perennial crops can only be treated with gypsum in conjunction with regeneration. If the field is prepared after the spreading of gypsum, sowing can be carried out normally during the same autumn. No-till cultivation is not recommended during the same autumn after the spreading of gypsum.

Similarly to machinery work on fields, clay compaction is a risk when spreading gypsum. Spreading should be carried out during a dry season to avoid soil compaction. If crop rotation includes crops sown later during spring or fallows are used to improve the condition of the field, the spreading of gypsum should be timed correctly in the spring. Gypsum should not be spread on frozen ground or snow, as it cannot then be in contact with the soil.

What can go wrong in the spreading of gypsum?

If the amount is four tonnes per hectare, no problems have been discovered in the spreading of gypsum. New information and experiences are collected continuously regarding gypsum. If any problems are identified, they will be communicated through the GYPSUM project (https://www.ely-keskus/web/kipsinlevitys/), for example.

A temporary increase in salinity in the surface layer may reduce germination after the spreading of gypsum. If gypsum is spread in the autumn, no-till cultivation should only be carried out in the spring following the gypsum treatment. If the field is at least lightly prepared after the spreading of gypsum, sowing can be carried out normally. If both gypsum and manure are spread during the same autumn, gypsum should be prepared before manure for hygiene reasons.

A FARMER'S EXPERIENCES

AKI LAAKSONEN FROM MYNÄMÄKI

Aki Laaksonen, a farmer on the Kivilä estate, spread gypsum to prevent any imbalance between nutrients and improve the sugar beet yield. Aki believes that it is important to prevent the leaching of nutrients from the perspectives of water protection and finances: when nutrients are retained in the field available for crops, return on investments in fertilisation will be high.

Farming and the maintenance of soil fertility start from keeping nutrients in balance. Some of my fields have had an imbalance of calcium and magnesium. I decided to try gypsum to improve this situation. My goal was to keep nutrient values in balance and add calcium without raising the soil's pH level. It is important to retain phosphorus in the field available for crops, and this is where gypsum helps as well.

I will sow sugar beets in one of my parcels next year. According to the Sugar Beet Research Centre's studies, gypsum reduces the incidence of sugar beet root rot. I hope that gypsum also benefits my sugar beet yields.

As a soil amendment, gypsum is one way to retain nutrients in the field - a piece of the puzzle. It's part of crop rotation and the maintenance of the nutrient balance. I want to take good care of soil fertility on my fields."

"When nutrients are retained in the field available for crops, return on investments in fertilisation will be high."

DRY WEATHER CONDITIONS MADE THE SPREADING OF GYPSUM EFFORTLESS

"It was easy to order and spread gypsum. Placing an order online took just a few minutes, the gypsum pile was delivered directly next to the field, and a contractor took care of spreading. This year, the weather was favourable, as the ground had a good load-carrying capacity and gypsum was spread in dry weather.

My background research took up the most time. I had to determine carefully how fertile the soil was, at what stage of crop rotation should gypsum be spread and what parcels were the most ideal for it. Even though planning took quite a long time, the order and delivery only required a few minutes on the Internet and few calls.

When you consider the use of soil amendments, you need to start by analysing your own soil. What does it contain, what does it smell like, are there any earthworms, and how can it be prepared? When walking on their own field, I believe that every farmer does all these things without even knowing it. By making observations every day, you can learn a lot about soil fertility. Your observations and experiences, combined with fertility information, help to choose the right soil amendment for each parcel."

HIGH-QUALITY ARABLE LAND IS A FARM'S KEY ASSET

"Agriculture runs on nature's conditions. The Mynäjoki river, which discharges into the Archipelago Sea, flows right next to my fields so I'm naturally concerned about it's water quality. In agriculture, water protection starts from farmers retaining nutrients in their fields. I also want to prevent the leaching of nutrients for financial reasons. When nutrients are retained in the field available for crops, return on investments in fertilisation will be high.

Maintaining soil fertility is a farm's key asset. High fertility means that fields can also better withstand challenging weather conditions. Of course, not even a good field necessarily has a chance against extreme conditions, but the possibilities of producing high yields are better. Maintaining fertility is a comprehensive process. Therefore, it is still too early to tell what impact gypsum has on my fields. However, it turned the nutrient balance in a better direction, and I expect high sugar beet yields next year."

Aki Laaksonen obtained gypsum on the Kivilä estate's fields through the GYPSUM project.

SOURCES AND FURTHER READING

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