Organic fertilisers and biostimulants in organic plant production

In the framework of the project "Innovation in organic farming", Maheklaster NGO (Organic Cluster) conducted research on the use of different mineral fertilisers and biostimulants in organic production in 2017-2022. The project was implemented in cooperation with scientific research institution Estonian Crop Research Institute (ECRI) and organic farms from different regions of Estonia. The field trials were implemented on the test plots at ECRI and on the fields of the organic farms of Juppi in Tartu County, EHE Pojad in Viljandi County, Riido Ökotalu in Saare County, Põlgaste talu in Võru County and Väljaotsa in Ida-Viru County.

The trials investigated ways to improve yield and crop quality in organic production using a complex of fertilisers and soil conditioners (e.g., several types of stone meals, micronutrients) and biostimulants authorised for organic farming. In total, around fifty products were used in testing.
The main experimental factors investigated were: different fertilisers applied to the soil, different fertiliser mixtures, different fertiliser rates, different biostimulant mixtures as seed treatments and combinations of fertilisers and biostimulants.
Experiments were carried out with the most common crops grown by organic farmers – oats, spring and winter wheat, winter rye, field peas, winter turnip rape, but also barley and winter rape. Crop yield and quality, plant disease incidence and soil microbial community status were assessed.
The experimental design was based on the ECRI and organic farms' commonly used technologies, which differed somewhat between companies and years, and included the main experimental factors to be investigated.

Fertilisers were chosen on the basis that they would primarily improve soil fertility and only then improve the nutritional conditions of the plants, i.e., fertilising the soil, not the plant. Such a choice based on the assumption that the effect would not be immediate but would occur over time. Nitrogen was not added to the soil with fertilisers, but other macro and micronutrients were applied. Soil samples were taken in the experimental plots to determine the need for fertilisation, and leaf analyses were also partly used. An economic calculation was also made, considering the additional costs associated with fertilisation and the use of biostimulants (fertilisers and preparations, soil application, seed treatment, spraying), and the additional cash income or cost per hectare associated with this activity, taking into account the sales revenue from the yield harvest.

In general, fertilisers applied to the soil which are based on ground natural rock are difficult for plants to take up and need the help of soil microbes to reach the plant. To support this, soil microbes - bacteria and mycorrhizal fungi - were used. The microbial preparations were applied to the soil with seed treatment of the main crop, undersowed crop or catch crop.

Several combinations of mineral fertilisers and biostimulants were identified in the trials, which resulted in significant yield gains and, in smaller number of cases, improved crop quality. At the same time, there were also many combinations that did not give any yield gain or even yields were lower than the unfertilised control.

Crop yields were relatively low or average in several trials, due to the weather conditions in the years of the trials, or due to the specific soil conditions and basic technologies used at the farms. However, in some experiments, the experimental factors were able to achieve significant yield gains even at low yield levels, and in some experiments high yields were achieved, e.g., in the context of organic production of winter rape and turnip rape and wheat.

The trials gave the indication that it is possible to increase yields and quality in organic farming through the combined use of fertilisers and biostimulants, but it is overly complex, and it is easy to fail. Often the question is the economic return of the cost, which can be low or even negative, even if yields increased.

Measurements of soil microbiological parameters, microbial respiration and biomass showed that the use of fertilisers and biostimulants can both support and suppress soil microbial communities. However, when looking at the experimental plots over several consecutive years, it appears that the high buffering capacity of the soil can overcome the negative effects relatively quickly. The study of microbial communities indicated that both bacteria and soil fungi are still relatively resistant to different fertilisers.

A total of seventeen different tests were conducted in eleven test plots at the ECRI and at the producers' fields, some of which are presented in this article, while the full report can be found on the Maheklaster website https://maheklaster.ee/wp-content/uploads/2022/11/Lopparuanne_maheklaster_P1_lyhem.pdf.

Fertilisation trial with winter turnip rape at ECRI

In the ECRI winter turnip rape trial 2017/2018, fertilisers and some fertiliser mixtures applied to the soil (Table 1, Figure 1) gave the best yields, 2264 kg/ha, with Patentkali (fertiliser high in magnesium, sulphur, potassium, 30% K_2O, 10% MgO, 42.5% SO_3) at 150 kg/ha (variant 8), which is 2 times lower than the lowest recommended amount by the manufacturer. This variant also had the highest crude oil content, 44.6%. It also yielded the highest economic gain compared to the control, over €700/ha. In general, the higher yielding variants also had higher crude oil contents.

Table 1. Fertilisers in ECRI winter turnip rape trial 2017/18

1. Patentkali 30 kg; Magnesia Kainit 30 kg; Niles (K-Mg) 50 kg; SEA-90 15 kg; fish meal 50 kg; Nordkalk 1:3 100 kg; Vulkamin 50 kg.
2. Patentkali 50 kg; Magnesia Kainit 50 kg; SEA-90 8 kg
3. Fish meal 100 kg
4. Niles (K-Mg) 200 kg
5. Black Pearl 50 kg
6. Eco Plant 300 kg
7. Magnesia Kainit 100 kg
8. Patentkali 50 kg
9. SEA-90 15 kg
10. Vulkamine 100 kg
11. Magnesium Niles 200 kg
12. Rock phosphate 400 kg
13. Biochar 200 kg; wood ash 200 kg
14. Biochar 400 kg; wood ash 200 kg
15. Control

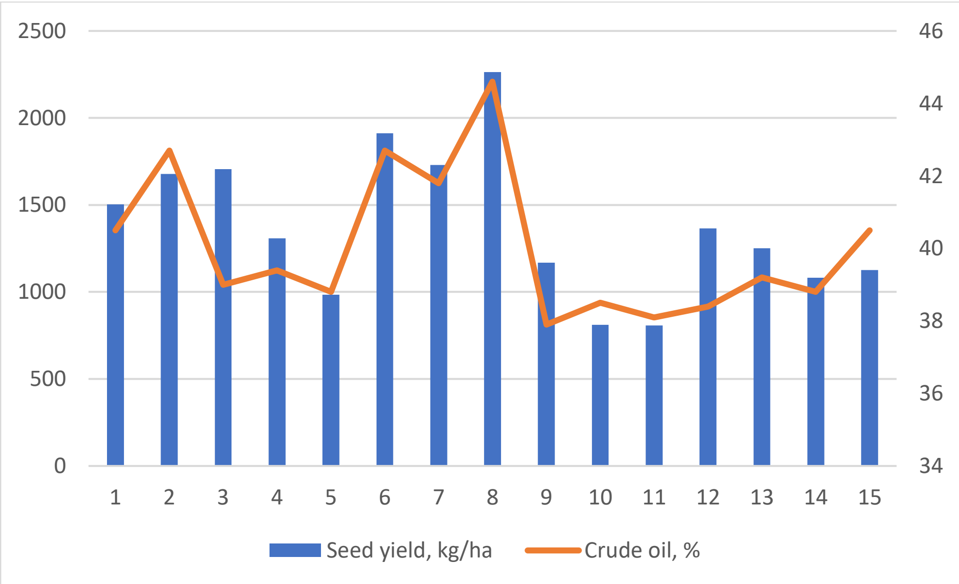

Figure 1: Winter turnip rape seed yield and crude oil content in the ECRI trial in 2018.

Fertilisation and seed treatment with winter wheat in Juppi farm

In a trial with winter wheat at Juppi farm fields, the effect of five fertilisers (Table 2) and seed treatments with bacteria and mycorrhizal fungi (Table 3) applied at two different rates (200 and 300 kg/ha) in 2019/2020 on wheat yield and quality was evaluated (Figure 2).

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Table 2. Fertilisers in Juppi farm's winter wheat trial 2019. a

Fertiliser	Quantity 200 kg/ha	Quantity 300 kg/ha
Sulgran S-90	16	24
ESTA Kieserite	42	63
Labinor P-30	46	69
Patentkali	83	124
Magnesia Kainit	13	20

Table 3. Fertilisation and seed treatment options in the 2019 Juppi farm winter wheat trial in 2019

Variant	Seed treatment and fertilisation
Variant 1	Bacteria seed treatment + fertilisers 200 kg/ha
Variant 2	Bacteria seed treatment + fertilisers 300 kg/ha
Variant 3	Bacteria seed treatment (no fertiliser)
Variant 4	Mycorrhizal seed treatment + fertilisers 200 kg/ha
Variant 5	Mycorrhizal seed treatment + fertilisers 300 kg/ha
Variant 6	Mycorrhizal seed treatment (no fertiliser)
Variant 7	No seed treatment + fertilisers 200 kg/ha
Variant 8	No seed treatment + fertilisers 300 kg/ha
Control	No seed treatment or fertiliser

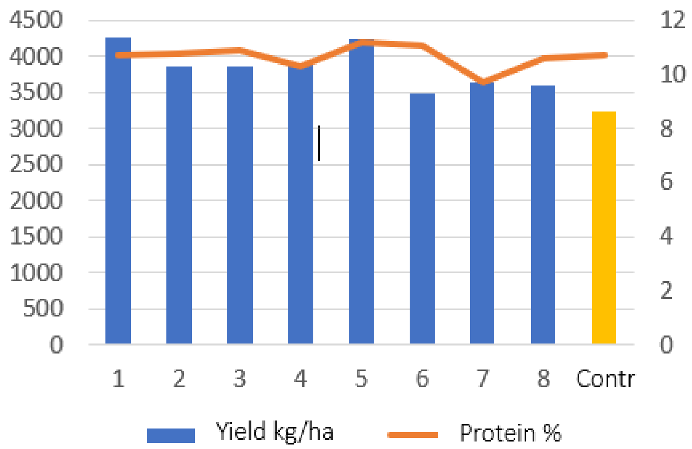

Figure 2: Winter wheat yield and quality in the Juppi farm fertilisation and seed treatment trial in 2020.

The grain yield of winter wheat 'Edvins' was 3,252-4,267 kg/ha (Figure 2). All the fertiliser + seed treatment variants gave higher grain yields than the control, with significally higher yields in experimental variants 1-5. The highest yield (4,267 kg/ha) was obtained with variant 1, which used bacteria seed treatment and fertiliser at 200 kg/ha. Wheat yields of more than 4 t/ha were also obtained in variant 5 (4,238 kg/ha), where mycorrhizal seed treatment + fertiliser at 300 kg/ha was used. Protein contents of wheat grains ranged from 9.7% to 11.2%, with none of the variants having a significantly higher protein content than the control. Other quality parameters differed little between the variants.

Fertilisation and biostimulant trial with oats in Riido Ökotalu

An oat trial at Riido Ökotalu examined the after-effects of fertilisation and biostimulants on oat yield and quality over the previous three years. The trial consisted of 3 variants, which were fertilised in 2017 and 2018 with the same fertiliser and in 2019 two variants were fertilised with different biopreparations, one of the

variants was not treated. The control did not receive any fertiliser or seed treatment. In the oat growing year, no fertiliser or bio-preparation was applied in either variant.
The field was fertilised both in 2017 (Ecoplant 22 kg/ha, Patentkali 73 kg/ha, Magnesia Kainit 37 kg/ha and SEA 90 9 kg/ha) and in 2018. a (Sulgran S-90 20 kg/ha, ESTA Kieser 10 kg/ha, Patentkali 10 kg/ha, Labinor P 10 kg/ha, Algeafert Solid 5 kg/ha, Humic acid 5 kg/ha). In 2019, two different seed treatments were applied (Table 4). In 2020, the post-emergence effects of previous years on oats were studied. All three experimental variants gave a significally higher grain yield compared to the control (Figure 3). The highest oat yield was found in the variant 1 (1132 kg/ha) where only mineral fertilisers were used, i.e., the biostimulants did not increase the yield in the experiment. Differences in oat grain quality were within the experimental error.

Table 4: Seed-treated soil biostimulants in the Riido Ökotalu experiment in 2019.

Preparation, amount per ha	**Variant 1**	**Variant 2**	**Variant 3**
EM Multi Grower	No treatment	6000 ml	
Algeafert Base		1000 ml	1000 ml
BIOORG EMO-N		30 ml	
VH VermiHumus		120 ml	
Molasses		100 g	105 g
Baikal EM-1			110 ml
Seaweed powder			20 g
Mycorrhiza Soluble			60 g

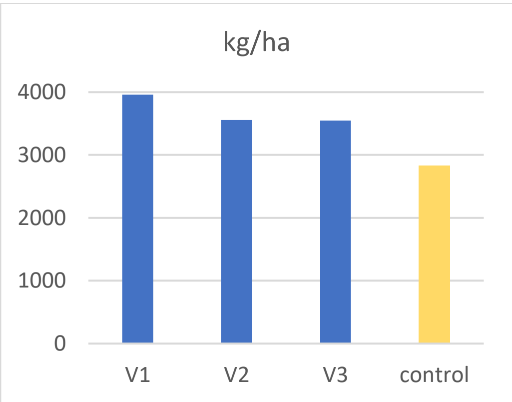

Figure 3: Results of the minerals and biostimulants trial in the Riido Ökotalu in 2020.

Summary

In general fertilisation should be complex and consider as many nutrients as possible for the plants. In many cases, it was also possible to increase yields in this way. Seed treatment with biostimulants in some cases improved fertiliser efficiency and increased yields. However, it must be acknowledged that there were also poorer results compared to controls. It was found that it is worth applying less fertiliser rather than more, as increased amounts of fertiliser did not result in significant yield gains. Differences in yields between lower and higher rates of fertiliser were often within the limits of the experimental error and, from an economic point of view, lower rates tended to be more profitable economically.
The introduction of mineral fertilisers and biostimulants should be very carefully analysed on the organic farm and the costs associated with their application should certainly be calculated, and the necessary yield increase to cover the costs should be estimated. The cost-effectiveness may be questionable, especially for higher priced inputs. As the trials have shown, the use of fertilisers and biostimulants can provide an economic

return but can also only generate additional costs. A positive outcome cannot be taken granted in the context of current knowledge. It would therefore be advisable for producers not to take excessive risks, but rather to start with smaller areas and with crops where the yield increase is more profitable.

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