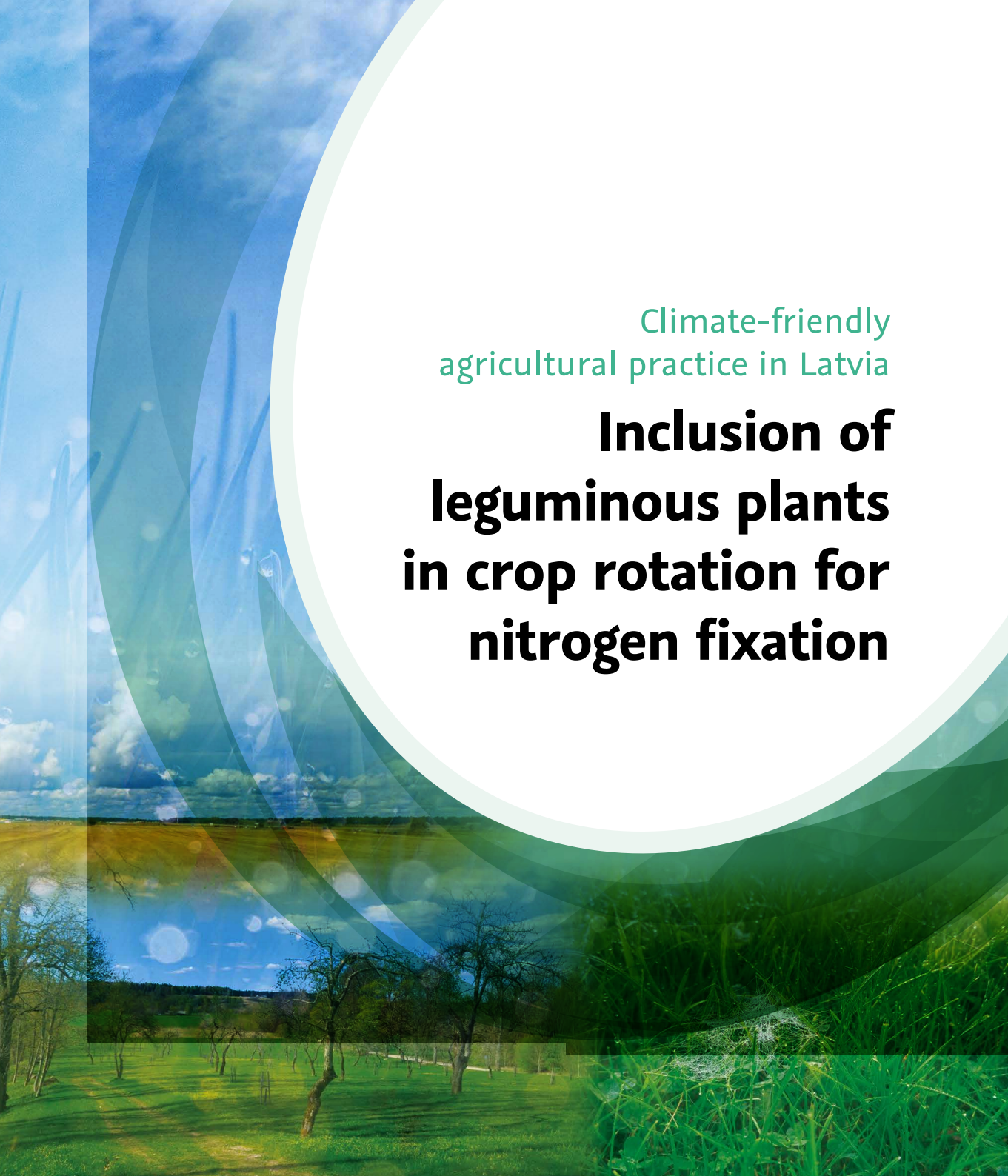

Climate-friendly agricultural practice in Latvia

Inclusion of leguminous plants in crop rotation for nitrogen fixation

Agronomic significance

In Latvia, protein crops can be successfully cultivated for fodder, green manure and bee pasture providing additionally 50-370 kg of nitrogen per hectare to the soil. This amount is equivalent to the amount applied with nitrogen fertilisers. It promotes both the increase of organic matter content in the soil and the improvement of other soil properties.

Leguminous plants create symbiotic relationships with soil-based bacteria, as a result of which the accumulation of fixed atmospheric nitrogen in the soil increases significantly. In addition, it provides accumulation of nitrogen in the soil also for the post-plant; thus, reducing the need for nitrogen fertiliser in the coming season. Leguminous plants as a cross-cultural crop during the autumn and winter period ensure the accumulation of mineral nitrogen compounds in biomass; thereby, reducing the risk of leaching. The incorporation of this biomass into the soil in the spring, before sowing of the next crop, improves the supply of plant nutrients to the crop and reduces the need for fertiliser. During the vegetation period, the amount of mineral nitrogen can reach 60 kg per hectare.

Leguminous plants is the main possibility of ensuring nitrogen in the structure of organic crops.

According to the research done in the European Union countries, field beans fix 62.4 kg of nitrogen, peas - 40.2 kg and soybeans - 50.2 kg per tonne of crops, while in Latvia the variegated lucerne (Medicago varia Hartynf.) grasses are the most productive nitrogen fixators reaching even 433 kg of nitrogen per hectare, lucerne grasses - above 300 kg of nitrogen per hectare, slightly less nitrogen is fixed by fodder galega (*Galega orientalis Lam.*) - 156-238 kg of nitrogen per hectare. These figures show the high efficiency of legume cultivation in the crop rotation, ensuring the nitrogen needed for the production of crop itself and partly for the post-plant.

Leguminous plants have a strong, deep-rooted taproot, which effectively irrigates and aerates the soil. After the cultivation of leguminous plants, vertical passages remain in the soil allowing the movement of moisture and nutrient elements. The large amount of root and plant residues left in the soil after the leguminous plants provides an increase in humus and improves the soil structure.

Environmental impact

The cultivation of galega and legumes (protein crops) significantly increases the accumulation of symbiotically fixed atmospheric nitrogen in the soil; hence, the measures related with the cultivation of leguminous plants are one of the cheapest methods of fixing atmospheric nitrogen, reducing the application of chemically synthesised nitrogen and N2O emissions.

In grasslands, nitrogen, which is biologically fixed by means of the leguminous plants, provides also nitrogen for the production of grasses, so the leaching of nitrates from the soil is generally much less – only 30-50% compared with nitrogen losses from intensively fertilised grass fields. After the use of perennial grasses, root mass and harvest residues generally containing a significant amount of nitrogen remain in the soil. Mineralisation of these organic substances results in the accumulation of mineral nitrogen in the soil.

The leguminous plants are also good nectar plants, they promote the proliferation of pollinators and the increase in biodiversity.

The provision of ecologically important areas of at least 5% of the declared arable land on farms with more than 15 ha of the UAA is also an important factor, unless an exception is applicable to

the farm, for example, it is an organic farm. This mandatory agro-environment measure provides an increase in soil fertility, reduces the need for nitrogen fertilisers and ensures the production of self-produced protein on livestock farms. Reduction of the application of nitrogen fertilisers, even only for 5% of the arable land, could lead to significant reductions in N2O emissions to the atmosphere.

The amount of nitrogen oxides released into the atmosphere due to the cultivation of leguminous plants is relatively small. Furthermore, the soil itself also annually emits an average of 1.2 kg nitrogen per hectare; however, nitrogen emissions may vary from 0.03 kg to 4.8 kg per hectare depending on the soil characteristics and conditions. Elevated emissions are due to mineral nitrogen occurring or being accumulated in the soil in higher concentrations than plants can consume. For example, a higher proportion of legumes in grazing grassland, animal dung and urine as well as denitrification, promoted by anaerobic conditions on wet soils compacted by animals, significantly increases emissions of nitrogen oxides, reaching up to 10 kg per hectare. The emission may equal 30 kg of nitrogen per hectare if grazing grasslands are additionally fertilised.

Positive experience in legume cultivation on farms

- It is easy for livestock farms to integrate legumes in rotation.
- Protein source in feed.
- Increases the diversity of crops.
- Ability to reduce the use of nitrogen fertilizers in after-crop and in crop rotation as a whole.
- The use of pesticides in crop rotation is declining.
- Positive effect on bees.
- Harvest time is extended.
- The rural landscape is improving.
- Lucerne can be grown with good success under appropriate conditions.
- In dry years, crops are very profitable because of the deep root system.

→ The carbon content of the soil increases, which also contributes to nitrogen durability.

Hindering factors for the implementation of the measure on a larger scale

→ Lucerne takes up the woody structure faster if mowing time is delayed, poorer digestibility.

→ Ca-containing bedrock is important for growing lucerne, therefore conventional soil analyses are not suitable because they do not show what is in the deeper soil layers.

Aspects	Limitations	Solutions
Technological	Crop rotation planning.	• Introduction of new, efficient crop species and varieties in livestock and crop farms. • Inclusion of annual Fabaceae and legumes in crop change or crop rotation on crop farms. • Sowing of crop mixtures: cereals with legumes. • Increasing the proportion of legumes in pasture grass with additional sowing and regular renewal of grasslands.
Environmental	• Impact of weather conditions. • Acidic soil reaction limits legume growth and nitrogen uptake.	• Improving of soil fertility, nitrogen sequestration, increasing of carbon content. • Strong taproot promotes vertical drainage in the soil, aerates the soil. • The biodiversity of flora and fauna inside and above the soil is improving.
Economic	Foregone harvest due to abandoning the traditional cultivation of crops.	The need for purchased protein feed decreases.
Social aspects (knowledge, experience, cooperation)	There is a lack of knowledge about the possibilities of growing legumes, variations of the combination, the need for nitrogen.	Promotion of legumes through culture (songs, folk songs).

Impact on the farm economy

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Cultivation of clover, lucerne, galega and other grasses is economically beneficial, since the productive life of these plants is between 2 and 20 years and more, and only a small start-up amount of nitrogen fertiliser is required in spring (~ 30 hg per hectare) for good yields. The cultivation of leguminous plants on farms is facilitated by the fact that the cultivation of field beans, peas, vetches, lupines, lucerne, Eastern galega, red clover, alsike clover, white clover, soybean and hemp grown in clean sowing as well as the cultivation of peas or vetches in mixtures with cereals where the percentage of protein crops is at least 50% is eligible for support. Latvian scientists have researched that field beans, little lupine, yellow lupine, spring vetches and sowing peas can be cultivated equally well on conventional and organic production conditions. Organic farming allows harvesting field beans of 3-4 t per hectare and little lupine of 2-4 t per hectare, yields of peas are also good.

The cultivation of leguminous plants is financially beneficial due to reduced purchasing costs of nitrogen fertilisers in the year of legume cultivation and the following year. It is relatively more difficult for economically smaller farms to compete on the market; thus, the opportunity to save money on production of cheaper agricultural produce is particularly important for them. However, saving money and product quality are important factors for all farms as biologically fixed nitrogen contributes to protein synthesis in grasslands and legume seeds. It is estimated that replacing 1/10 of the EU area of grasses intended for the production of fodder with a mixture of legume-straw grasses would ensure more than EUR 1300 million for the European livestock sector with a simultaneous saving of fossil energy resources consumed for the production of nitrogen fertilisers.

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The impact of growing protein crops on the yield of post-crops is relatively less effective than the application of nitrogen fertilisers. Therefore, this model is not recognised in the intensive farming systems, as nitrogen included in the biomass of leguminous plants cannot ensure the potentially possible yield level for the next crop compared with nitrogen fertilisers. However, the extra yield benefit from the application of intensive mineral fertilisers as compared with green manure is only about 3%. In contrast, the applied leguminous green manure provides higher yields of post cultures at a moderate fertiliser rate.

The inclusion of leguminous plants in crop rotation will result in unearned revenue from the yield that would be generated if a conventional crop such as wheat was grown, since the yield of leguminous crops is lower, and also the price of beans or peas per tonne is lower than the price of wheat per tonne. In addition, the cultivation of biennial or perennial legumes on farms is limited because there is no demand for fodder on most intensive crop farms. A farmer may incur losses from unrealised profit at around EUR 350 per hectare. It is partially offset by the aid for protein crop production or the so-called greening payment, which was EUR 46 per hectare in 2018.

Little lupine

Practical aspects for cultivating leguminous plants

Legumes form a large nitrogen removal with harvest. After harvesting the unused nitrogen leaches without providing a sufficient nitrogen stock for the next crop; thus, it is recommended to sow an intercrop or green manure plant after harvesting the legumes. For example, after harvesting peas or a mixture of peas with oil rut, they accumulate 56-108 kg of nitrogen per hectare in the biomass depending on the soil and the duration of cultivation, while biologically fixed nitrogen forms another 30-70 kg per hectare.

Leguminous plants shall be sown as early as possible in well-cultivated soil. Seeds have a relatively thick seed cover, so the soil moisture supply is important for swelling and sprouting of seeds. The addition of nitragine to seeds prior to sowing may promote nitrogen uptake, which results in improved crop quality as well as the provision of nitrogen for the subsequent crop yields. The inoculation can help increase the population of rhizobia bacteria in the fields where legume cultivation has been absent for several years or ever, especially in areas with adverse environmental conditions, such as pH below 6.0. In Latvia, the experience in the use of special rhizobia bacteria in the sowings of leguminous plants is smaller. Nitragine contains rhizobia bacteria that provide preconditions for nitrogen accumulation. The treatment of six kilograms of clover seeds requires 20 g of this preparation, which corresponds to the sowing of a half hectare. In total, the cultivation of one hectare costs almost EUR 5 or EUR 0.02 per kilogram of seeds, excluding VAT. The incorporation of azotobacterin into the soil has a positive effect on the nitrogen fixation in leguminous plants. The addition of manure and $CaCO_3$ increases the viability of azotobacterin in the soil, and this activity can take place for several years without plant participation. The rate of azotobacterin (azotobacter) is 1 g per

kilogram of seed material or 5 kg per hectare.

When growing peas or vetch in a mixture with spring crops, the ratio in the seed material is 50 + 50%, correspondingly reducing the seed rate of each component by half.

The cultivation of leguminous plants as an undersow for grain or other crops also contributes to the supply of nitrogen to the surface plant, provides weed suppression and good soil moisture.

Peas in the mixture of spring wheat and oats

Mixture of oats and vetch

Barley undersown with clover

Leguminous plants mainly grown in Latvia

Annual leguminous plants to be included in crop rotation.

Field beans
Seed rate 250–300 kg ha^{-1}, (100–120 seeds per m2)

Peas
Seed rate 240–290 kg ha^{-1} (100–120 seeds per m2)

Little lupine
Seed rate 150–230 kg ha^{-1}

Soya
Seed rate 45–55 kg ha^{-1} (60–90 kg ha^{-1})

Perennial leguminous plants used for grass fodder and bee pastures.

Red clover. *Seed rate 12–16 kg ha^{-1}*

Alsike clover. *Seed rate 10–12 kg ha^{-1}*

White clover. *Seed rate 10–12 kg ha^{-1}*

Hybrid Lucerne or alfalfa. *Seed rate 12–18 kg ha^{-1}*

Eastern galega. *Seed rate 20–25 kg ha^{-1}*

Common Bird's-foot trefoil. *Seed rate 10–12 kg ha^{-1}*

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