2.2. Crop rotation

Summary: Optimized crop rotation is an element for efficient nutrient cycles and maintains good soil fertility to ensure high yields. Nitrogen-fixing plants will decrease the need for fertilizers and enhance economic and environmental sustainability of whole farm. Catch crops prevent soil erosion and reduce runoffs and also add organic matter content of soil. Increased biodiversity will give plants a better resistance and reduces demand for pesticides.

Operation and Applicability: Biological N-fixation is natural way to increase soil N-level during growing season. It is applicable to all farms except on peaty soils with very low pH value.

Efficiency: Legumes can biologically fix around 50 kg N / 1 t legume dry matter. Legumes can produce even 4 t dry biomass/ha per growing season, thus total N fixing can be as high as 200 kg/ha.

Efficiency and functionality Costs of the Practice Ease of Operation Potential for nutrient recovery

Basics of the good practice:

- Careful planning and design of crop rotation ensure high yields, healthy and fertile soils and help to control weeds, pests and diseases.
- Crop rotation should be planned according to farm structure, labour and equipment, site conditions and land use (climate and soil type), market options and feed requirements.
- Forage legumes supply N to soil for following crop, improve physical soil characteristics, increases soil humus and fertility.
- Root and leaf crops used as preceding-crops reduce weeds, improve soil physical characteristics, but are vulnerable to diseases and decompose humus.

Crop rotation planning:

- N-fixing plants can be used as legumes to produce harvestable beans (broad bean), be cover plants, catch crops or undercrops (clovers) and crop mixtures for forages (clovers with hays or broad bean with wheat)
- E.g. 1-2 years of legumes in 5 year crop cycle
- Apply cultivation breaks in crop monocultures and prevent pests and diseases when host plant is absent.
- After legumes, N-rich soil is ready for N-consuming plant, e.g. autumn wheat
- Check soil pH, P and K levels, humus proportions and plan manure distribution for the best nutrient utilization to prevent runoffs.

Ability for climate chance mitigation: Optimal crop rotation and especially use of legumes reduce the need for manufactured fertilizers and thus reduce also N_2O emissions. Moreover, increased biodiversity improves yield security under varying conditions.

Potential for nutrient recovery: Legumes contain nitrogen-fixing symbiotic bacteria in their root nodules and can be used as green manure.

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Evidence of Success: Incorporating of legumes into crop rotation

50-60 % portion of clover in grass growth, upload enough N into soil to improve crop rotation

Achieved environmental benefits:

- Biological atmospheric N-fixing of legumes reduce need for artificial N fertilizers and N_2O emissions.
- Deep rooting legumes e.g. red lover, improve soil structure, soil fertility and mitigates soil condensation, which in turn prevent nutrient leaching and runoffs.
- Provide high-protein fodder and increase protein self-sufficiency of farm.
- Improve overall plant health and reduce pesticide use.

Appropriate performance indicators:

- Number of break crops in a rotation
- Length of rotation in years
- Field nitrogen balance (kg N/ha/year)
- Avoided fertilizer application (kg/ha)
- Humus balances (soil fertility)
- Home-grown forage and fodder utilized (%)
- Legume and clover share in permanent grassland (%)
- Soil organic C and humus content

Table: Interpretations of field N-budget and possible management options (Stein-Bachinger et al., 2013).

N-budget (kg N/ha)	Interpretation
-10 and lower	N-output exceeds the input. N is used from soil reserves and no N is contributed to the system. Not sustainable, lead to depletion of soil N and lower yields in the future.
-10 to +10	Additional N-output equals the input. N fixed by the legumes is removed through the harvest and hardly any N remains in the system.
+10 and higher	Additional N-input exceeds the output and lead to a net gain of N to the system which can be used by subsequent crops.

MORE INFORMATION:
http://www.zalf.de/de/forschung_lehre/publikationen/Documents/oekolandbau/handbuecher/BERAS_Farming_guidelines.pdf
https://www.ilmase.fi/site/hanke/climate-wise_solutions_for_the_countryside/
https://www.luke.fi/en/natural-resources/agriculture/profitability-of-agriculture/

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