Optimizing nitrogen utilization by Ecological Recycling Agriculture (ERA)

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Implications

The main purpose of agriculture is food production. There are always limited resources available for food production, thus the resource efficiency is always the key issue. The modern agriculture is using resources like external nutrients (fertilizers) and non renewable energy in large scale. The high production intensity results in high production per hectare, on the other hand it results also in serious environmental harms.

Organic farming is based on more internal and renewable resources than conventional farming. Very often it results also in lower production intensity and lower production per hectare. There is a common criticism against organic agriculture as inefficient use of land and also inefficient use of nutrients and energy per output unit.

Closer scrutiny indicates far too often, that the system boundaries and definition of production system explain the results rather than the fundamentals of different production systems. Some examples of these types of misleading factors are purchased fodder (e.g. production area and input resources for that are partly or fully ignored) and partial nutrient system, e.g. comparison between artificial nitrogen fertilizers and farm yard manure (FYM), i.e. primary nutrients and secondary nutrients (=FYM) are compared, despite of fact that no secondary nutrients exist without primary nutrients.

In this survey the whole production system is introduced and all the main nutrient flows are presented. Integration between the animal husbandry and crop production is supported by diverse crop rotation and nutrient recycling in form of FYM. High recourse efficiency is reached and environmental harms can be highly reduced by ERA-farming.

Background and objectives

There is a 3-year EU-financed Baltic Sea Region project, BERAS Implementation, where the main focus is to develop ecological recycling agriculture (ERA) aiming at to decrease the eutrophication to fresh waters and to the Baltic Sea. As a part of the project some 30 ERA-farms all around the 9 Partner countries on the Baltic Sea watershed were observed and recorded. Based on the data from Finnish ERA-farms a farm model was built up to illustrate the characteristics and fundamentals of ERA agriculture.

The main two ideas of ERA-concept are

1) the balanced ratio between the number of animals and the area of arable land, i.e. minimum 85 % fodder self-sufficiency;
2) running the production system with the intensity based on the local renewable resources and the system itself, i.e. biological N-fixation (BNF), crop rotation and nutrient recycling

Key results and discussion

In the farm model the main production line is milk production, but some beef and calves for beef production are produced as an essential part of milk production. In addition about 20 % of total crop yield is sold out. It reflects the average share of direct human consumption of crop yield in Finland and commonly around the Baltic Sea region. (Table 1.)

Table 1. Crop rotation, yields (dry matter and nitrogen) and biological nitrogen fixation (BNF) in the farm model.

		legume (d.m. kg/ha)	non-legume (d.m. kg/ha)	N-legume (%)	N-nonleg (%)	N-harvested (N kg/ha)	BNF (N kg/ha)
1. ley	red clover+timothy	2000	2000	3,5	1,5	100	100
2. ley	red clover+timothy	1600	2000	3,5	1,5	86	80
3. cash crop	barley/wheat		2200		2	44	20
4. mixture	pea+oats	1000	1100	4	2	62	50
5.undersown	barley+grass seed		2300		2	46	20

The only primary source of nitrogen into the system is based on biological N-fixation of legumes and the amount of N-fixation determines the maximum yield potential of non-legumes. BNF has been calculated with rough equation BNF = A*B*C, where A is average total content of N in legume biomass (A = 3,5 %), B is proportion of fixed nitrogen in legume biomass (B =70 %) and C is the proportion of harvested biomass to total biomass of legumes (C = 50%). Equation results in 4,9 kg BNF/1 t harvested legume biomass; finally, the rounded value 5,0 kg BNF/1 t harvested legume biomass has been used in the model calculations. However, some BNF is not related to harvested yield, i.e. the undersown ley and post-harvest ley. Both of them has been estimated to be 20 kg/ha BNF. Within the 5-year crop rotation the average total BNF equals 54 kg/ha. Beside BNF 5 kg/ha N as an atmospheric deposition has been added to total external input, i.e. primary nitrogen is totaling 59 kg/ha.

All the other harvested crops are used as a fodder inside the farm except cash crop yield. The amount of nitrogen in manure has been estimated to be 50 % from total content of nitrogen in fodder (25 % into animal products, 25 % mainly gaseous N-losses from manure before spreading to the fields). Thus, from total harvested N-yield (68 kg/ha) about 9 kg/ha is sold in the form of cash crop and about 30 kg/ha is left in the farm as farm yard manure (FYM). This amount of manure can be spread for one crop in a 5-year crop rotation, i.e. undersown cereal receives FYM (147 kg/ha total N).

How work was carried out

The work follows the method developed by Seuri (Seuri 2002, 2008; Seuri and Kahiluoto 2005). The model is built up based on data from farms. In this case there are 9 finnish organic farms all around southern Finland. The farms have been followed for two years (2011-2012).

References Seuri, P. 2002 Nutrient utilization with and without recycling within farming systems. In: Urban areas – rural areas and recycling – the organic way forward? / eds. Jakob Magid et al. DARCOF Report 3: 175-181.

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