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The impact of conversion to ecological recycling agriculture (ERA) on farm nitrogen budgets and production levels

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Implications

The data used in this study is collected under BERAS Implementation project from ERA-farms in Finland in 2010 to 2012 (three years averages) and from three different production lines on ERA farms: beef, egg and milk. The data indicates the production level, the products sold and feed and other supplements purchased on the farm each year. Accordingly it has been calculated A) how much area B) how much other inputs (e.g. nitrogen and phosphorus) is needed to maintain the production level. Based on these calculations it is possible to estimate how much of these nutrients are recycled on the farm, how much of the used nitrogen is based on biological nitrogen fixation and how much non-renewable resources have been needed. Thus it is possible to calculate the output-input ratio of nitrogen.

Materials and methods

The Results are based on the farm data from three years and were confirmed by the farmers in the summer 2013.

Three case examples (table 1):

1) Beef & lamb production

84,5 hectares of cultivated area. Crop rotation: 2 years timothy, wheat, oats, 2 years clover, rye, wheat. Total N production in the form of beef and cash crops is 1260 kg, equaling 14,9 kg N ha^{-1}. The only inflow of N is in the form of straw, which contains 2,8 kg N ha^{-1} on average. Thus nitrogen input/output ratio is -12,1. This calculation does not take into account natural pastures, where suckling cows graze in summertime (28 ha, semi-natural forest).

2) Milk production

61 hectares of cultivated area with 70 milking cows and young cattle, altogether 100 AU. The milking farm works in co-operation with three organic plant production farms, which have 150 ha of fields. The total area is thus 211 ha. Two different crop rotations are utilized: 1) 4 years grass, barley 2) 2 years grass, oats/wheat, broad bean, oats/wheat. N outflow from the farm is in the form of milk (636 tons a^{-1}, containing 3500 kg N), meat (22,5 tons a^{-1}, 700 kg N), fodder cereals and pea (49 tons and 14 tons a^{-1}, respectively, 1320 kg N). The output consist all together of 5500 kg N a^{-1}. The incoming nitrogen flows from the purchased fodder are 2300 kg N, organic fertilizers 8900 kg N and bedding materials 240 kg N annually. The N input/output ratio is 5940 kg N a^{-1}, which is 28 kg N ha^{-1} a^{-1}.

3) Egg production

55 ha of own cultivated area with 10 000 laying hens. Calculated production area requirement is 200 ha, including green manure area 40 ha. Crop rotation: wheat, barley, pea-oats, oats, green manure. The production level is 140 000 kg eggs annually, which contains 2800 kg N. Hens require 250 tons of cereal-pea mixture, of which 80 tons is produced on the farm. Feed concentrate (60 tons), peeled oats (24 tons) and lime (32 tons) are purchased outside the farm. Thus total fodder requirement is 370 tons. The N input in the form of fodder is 8076 kg N a-1 (4596 kg N from own cultivated area). The N input/output ratio for the total area is 5276 kg a-1 and 26,4 kg ha-1 a-1. The calculations do not take account of the fodder from the grazing area (4 ha).

Table 1. Crops, cultivated area and average DM yields in 2010-2012 in 1) beef & lamb production, 2) milk production and 3) egg production

		Cultivated area, ha a^{-1}	DM yield, kg $ha^{-1}a^{-1}$
1)	Oats	10	1800
	Wheat	19,5	1800
	Clover-grass silage	17,5	5600
	Timothy hay	25	2700
	Permanent pasture	12,5	
	Total	84,5	
2)	Fodder mix (pea-oats)	37,5	2150
	Silage (Viljo)	75	3450
	Silage (manure)	34	4730
	Pasture	12	2700
	Fodder cereal	52,5	2580
	Total	211	
3)	Oats	44	2000
	Wheat	37	2000
	Barley	37	1400
	Pea-oats	41	1500
	Green manure (clover-grass)	41	
	Total	200	

Background and objectives

There is increasing concern about the dependence of agricultural food production on mineral fertilizers (especially N and P) and other agrochemicals, because these inputs are associated with significant negative environmental impacts, reduce the sustainability of crop production systems and negatively affect future food security (Bartlett 1998, Cordell 2009, Tilman 2002). Ecological Recycling Agriculture (ERA) is organic agriculture based on local and renewable resources with an integration of animal and crop production (Granstedt et al 2008). This way a large part of the nutrient uptake in the fodder production is effectively recycled. This in effect means that each farm (or farms in close proximity) strives to be self-sufficient in fodder production (min 80 % own fodder) which in turn limits animal density and ensures a more even distribution of animals to most farms.

As in organic production generally no artificial fertilizers and pesticides are used in ERA model. However, it provides a system in which the recycling of nutrients is more effective, either within one/a farm or as a result of co-operation of a few farms located nearby. Consequently the input-output ratio is better in balance compared to conventional farms (Granstedt et al 2008.

Key results and discussions

The study of the three ERA-farms demonstrates, that the ERA-model enables a better input-output balance in N compared with conventional farming methods. It has however to be considered that implementing the ERA-model the field areas have to be larger than in conventional production, if the meat production and consumption stays at the present level. Another important factor is NUE (nitrogen use efficiency), which demonstrates the synchrony between N supply and crop demand (Cassmann 2002). The farm cases indicate that ERA-farms could have quite high NUE values because the yields are quite high in relation to the low inputs.

ERA-farms are using only recycling organic fertilizers, which are made from manure and crop residues in the farm. They increase the inherent fertility of soils, when used repeatedly over many years. Future food security is likely to depend on reducing the reliance on mineral fertilizer inputs yet maintaining and/or increasing current levels of productivity in crop production, because the production of mineral fertilizers relies on non-renewable resources. The main strategy available to replace mineral fertilizer use is to recycle a larger proportion of nutrients which are removed from soils as crops and livestock products back into agricultural soils. This will have to be based on the efficient recycling of agricultural, food processing and domestic organic waste.

Table 2. Results of N input/output ratios in beef & lamb, milk and egg production.

	Beef & lamb, 84,5 ha	Milk, 61+150 ha	Egg, 55+145 ha
Input	N kg ha^{-1} a^{-1}	N kg ha^{-1} a^{-1}	N kg ha^{-1} a^{-1}
Purcased fodder	0	11	17,4
Viljo fertilizer	0	42	0
Peat, cutter, straw	2,8	0	0
Total	2,8	53	17,4
Output			
Meat	3,3	3	
Milk	0	16	
Egg	0		14,1
Crop	11,6	6	
Total	14,9	25	14,1
N input/output ratio	-12,1	28	3,3

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