Evaluation of nutrient (nitrogen) efficiency – the concept of primary nutrients

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**Implications**

A method to evaluate nutrient utilization initially described by Seuri (2002, 2013) was improved. The system boundary was set covering the total target system including also the “invisible” processes outside the target system. The substitutive method is presented in the case of missing data of processes outside the target system. This study underlines the importance of understanding the total system instead of trying to improve single sub system.

**Background and objectives**

The concept of primary nutrients and primary nutrient efficiency, P(eff) = Y/P = C x U;

Y = nutrients in yield harvested in the system; P = primary nutrients ; C = circulation factor, (P+M)/P; M= secondary nutrients ; U = utilization rate, Y/(P+M); was presented by Seuri (2002, 2013). The system boundaries were set around the target system (farm) in such a way that some of the processes and nutrient flows were not included directly in the target system. Main processes not included were a) crop production of purchased fodder and seeds, b) production of purchased manure (crop and animal production), c) crop production of sold manure. The main reason to exclude those processes previously was the lack of data about those processes. However, ignoring those processes distorts the actual nutrient efficiency of the target system. The aim of this study was to improve the initial concept of primary nutrients and present a new method to evaluate nutrient efficiency of the whole target system including the processes outside the target system as well. The substitutive method is presented in the case of missing data of processes outside the target system.

**Key results and discussion**

The method of “shadow farms” was developed. In the reality many of the processes and nutrient flows in modern agriculture are run outside the target farm, F(target). However, the functioning of the evaluated target system is fully dependent on those processes, i.e. these processes are an essential part of the evaluated system. Since these processes are not “visible” at the evaluated system, they can be named as “shadow” processes, and the external sub systems of the target system can be called “shadow farms”. Missing data of nutrient utilization can be replaced with constant ratios (nitrogen only). Constant ratios indicate average figures in Finnish agriculture.

Following “shadow farms” were identified and defined (analogous with processes above):

1. F(pf/s), the “shadow farm” where purchased fodder/seed is produced to the target farm; constant ratio: 1 kg primary nitrogen equals 2/3 kg nitrogen in yield (67% utilization rate of primary nitrogen on the field,)
2. F(pm), the “shadow farm” where purchased farm yard manure (FYM) is produced to the target farm; constant ratios: 1 kg primary nitrogen equals 2/3 kg nitrogen in yield, furthermore equals 1/3 kg nitrogen in sold FYM (50% of nitrogen in fodder ends up in FYM)
3. F(sm), the “shadow farm” where manure sold out from target farm is used in crop production; constant ratio: 1 kg nitrogen in sold manure equals 1/5 kg nitrogen in yield (20% utilization rate of secondary nitrogen on field).

In order to evaluate the primary nitrogen efficiency, P(eff-N), in the total system (S), nutrient flows and yields must be aggregated from all of the sub systems: S = F(target) + F(pf/s) + F(pm) + F(sm). Primary nitrogen flows (P), secondary nitrogen flows (M) and yields (Y) are identified and defined in table 1. Minor flows (e.g. bedding materials, own milk for calves, atmospheric deposition) are ignored for this purpose.

Table 1. Specification of primary and secondary nitrogen flows and yields at all of the sub systems (Farm). Purchased/sold/own from F(target) point of view. Note, that nutrient flows and processes are not necessarily happening at same sub system, e.g. when purchased manure is used on F(target), manure itself has been produced on F(pm).

Farm Primary nitrogen (P) Secondary nitrogen (M) Yield (Y)

F(target) p(fertilizers) m(own manure, own fields) y(fodder, own animals) p(biol. N-fix) m(sold manure) y(cash crop) m(own seed) y(own seed)

F(fp/s) p(fertilizers for seed) m(purchased seed) y(purchased seed) p(fertilizers for fodder) y(purchased fodder)

F(pm) p(fertilizers for fodder) m(purchased manure) y(purchased manure)

F(sm) y(sold manure)

As it can be seen from table 1. it really doesn’t make any sense to evaluate any of the classic nutrient balances (farm gate balance or surface balance) or efficiency (nutrient utilization efficiency, NUE) for the target farm, F(target), if “shadow farms” are not included; at least the result doesn’t indicate the efficiency of the total system.

The principle of this new method is useful in any system approach. If there are several successive processes (e.g. crop production, animal production, new crop production process in different system, new animal production process in different system), there is a huge risk for wrong conclusion if the system boundary has been set between any of these successive processes. Evaluation must not be begun excluding previous processes or later processes if the target process is dependent on those others. The lack of data cannot be the excuse.

**How work was carried out?**

There is a serious lack of tools to evaluate nutrient utilization in agricultural systems. Seuri (2002, 2013) has pointed out the weakness of farm gate balance, surface balance or NUE methods for evaluation; they can’t identify the difference between primary and secondary nutrients (Fixen et.al 2015). The concept of primary nutrients and primary nutrient efficiency has been developed to evaluate specially the systems where nutrients are recycling (integrated crop and animal production systems). Original method was used for about 100 animal farms in South-Savo region in Finland through the years 2012– 2014. It was noted, that especially for the farms with low self-sufficiency of fodder and selling out the manure for neighbouring farms, get results with higher primary nutrient efficiency than others. Closer analysis indicated, that those farms avoided the losses in evaluation which originated from production of purchased fodder and usage of sold manure. Therefore, the evaluation method had to be improved.

**References**

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