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A new method to understand nutrient balances

Simple tools to understand information about nutrient balance calculations are introduced. The primary production balance shows how much crop production is produced per kilogram purchased nutrients – it doesn't matter if your farm is a crop farm or a cattle farm, results are comparable between any farms.

Farmgate balances, cattle balances, surface balances – how come we still need one more?

Contemporary nutrient balances are very sensitive for production type (crop vs. animal). That is why it is very difficult to compare different types of farms (Myrbeck 1999). A new balance, called primary production balance (N), is independent of production type. Primary production balance is formed of two components: surface balance (S) is multiplied by a circulation factor (e). Thus, we can write: N = S * e

What is surface balance?

Surface balance is widely used in litterature and most often it is defined: nutrients in harvested crop/total nutrient input. On the crop farm the only nutrient inputs are purchased fertilizers and possible biological nitrogen fixation. These inputs are called primary nutrients (P), i.e. they come into the farm from outside of the farm. On the cattle farm, besides primary nutrients, there are secondary nutrients, (M) manure, which means that nutrients are recycled on the farm. With help of these two components of nutrients we can define surface balance: S = Y/(P + M), where Y is harvested yield.

...but never heard about circulation factor before!

Right, circulation factor is something new, which is part of this new method! Circulation factor indicates how much recycled nutrients (=secondary nutrients) are utilized in primary production (= crop production) in proportion to primary nutrients, thus: e = (P + M)/P. We can note that the circulation factor is 1 if there is no manure on the farm (M = 0). This means that on the crop farm circulation factor is always 1. On the other hand circulation factor is always higher than 1 if any manure is produced and used on the farm. Note: if manure is produced outside the farm it is a primary nutrient like any other purchased nutrient.

Finally, what do we have?

- We have primary production balance: N = S * e
- On the other hand we have surface balance : S = Y/(P+M)
- ...and circulation factor: e = (P+M)/P
- If we put them all together we got: N = Y/(P+M) * (P+M)/P => N = Y/P

If we are only interested in nutrient utilization, we can calculate how much nutrients in yield we can harvest per kilogram purchased nutrient (N = Y/P). But if we are interested to know the components, like surface balance and circulation factor, we use the equation N = S * e. Theoretically a surface balance can't be higher than 1 (without changes in soil N). In practice the crop farm can reach values as high as 0,7 – 0,80 (Myrbeck 1999), but cattle farms get most typically values below 0,5. However, since there is no circulation at all on the crop farm, total utilization rate is 0,7 - 0,8 (i.e. to harvest a yield of 0,7 kg nitrogen 1,0 kg nitrogen is needed from outside the system). Potentially, cattle farms can reach higher primary production balances than crop farms. I would be pleased to hear about farms (systems) with high primary nutrient balances (N > 1,0). Please report if found!

Numeric example to count new balances:

crop farm

P = 100, Y = 80, M = 0

=> S = 80/(100+0) = 0,8 (S = Y/(P+M)

N = 80/100 = 0,8 (N = Y/P)

N = 0,8 * 1,0 = 0,8 (N = S * e,

e = (P+M)/P)

cattle farm

P = 100, Y = 140, M = 120

=> S = 140/(100+120) = 0,63

(S=Y (P+M)

N = 140/100 = 1,4 (N = Y/P)

N = 0,63 * 2,2 = 1,4 (N = S * e,

e = (P+M)/P => e = (100+120)/100 = 2,2)

It is obvious that surface balance (0,63 vs 0,8) and farm gate balance (approx. 0,2 vs 0,8) is worse on cattle farm than on crop farm, despite of higher crop production with same amount of external nutrients on cattle farm. New methods indicates the higher production (N = 1,4 vs 0,8) due to high circulation rate (e = 2,2). Without circulation the potential maximum yield is 100, on the cattle farm 140 is not the upper limit, yet. ■

Pentti Seuri
E-mail: pentti.seuri@mtt.fi
Tel: +358 15 321 2362

M.Sc.Agr Pentti Seuri is researcher at MTT Agrifood Research Finland, Ecological Production, Partala.

Litteratur

Myrbeck, Å. 1999. Växtnäringsflöden och -balanser på gårdar med olika driftsinriktningar – En studie av 1300 svenska gårdar. Meddelanden från jordbearbetningsavdelningen, nr 30. SLU.