Nutrient flows calculated

On the black cotton soils of South Gujarat, sugar cane has been a major cash crop for the last 15 years. It has developed because of a good cooperative establishment and a good demand for sugar. The sugar cane farming system is, however, also an example of the imbalance of the modern agricultural system.

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Fertilisers and pesticides are indiscriminately used. Pest and disease problems have increased over the years, the water table has gone up, causing salt coming up. Nitrogen is used at a rate of 450 kg/ha/yr, phosphorus 125 kg/ha/yr and potash 125 kg/ha/yr, without the supplement of organic manure. It is estimated that 10 to 15 tonnes of dry weight tops are burnt every year, an equivalent of 75-100 kg N/ha/yr. It is not surprising that micronutrient application has become necessary during the past years and some farmers are trying to adopt ecological techniques.

A thesis research was done to study the question: what changes can be made in the conventional sugar cane farming system, based on the experience of ecological farmers? Part of the study was to calculate nutrient balances. Nutrient balances can identify nutrient deficits from farm operations and clarify the differences between conventional and ecological farming practices. They can also be used to assess flows of nutrients entering and leaving the farm. They give an overall indication of nutrient cycles and show the result of farm management decisions. Nutrients enter the farm with bringing in organic material (manure, fodder, concentrates, wastes), N-deposition from the air, symbiotic N-fixation and through mineral fertilisers. Manure produced on the farm is assumed to be returned to the land. Nutrients are exported with farm products sold. Other nutrients are lost through unused farm wastes and residues, which are either burnt, sold, disposed of or "disappear" into soil, water or air. Fodder, straw or residues produced on the farm can be fed to cattle or mulched in which case nutrients are recycled.

Comparing farms

Two farms in Bharuch district of South Gujarat have been observed. Mr. Praful Pandya has a 9.1 ha sugarcane-sugarcane-rice based conventional farm system, using 10 to 25% less chemicals than recommended by the university and sugar factory. Besides paddy, cotton and sugarcane, he grows wheat, gram (*Cicer arietinum*), safflower (*Carthamus tintorius*), rajko (*Medicago sativa*, a fodder crop) for a cattle herd of 11, Sesbania and pigeon pea. Paddy straw is sold and wheat straw is fed to the cattle, as well as purchased concentrates. The farm is under permanent irrigation, manure is stored in the open and not always applied to the land.

Mr. Satish Patel has a 35 ha ecological farm in the same village. The crop rotation strategy is guided by soil management and before the Kharif (monsoon season) crop, he takes a green manure crop like Sesbania and he fertilises the plot. On the total farm, 1.5 tonnes of chicken manure (purchased externally) and 1.5 tonnes of oil cake are applied for fertilisation. Mr. Patel brings back the oil cake from the oil mill where he gets his oil seeds crushed for oil. After the Kharif crop, he takes a crop with minimum water requirement, which builds up organic matter, adding to the nutrient pool of the soil and breaking the pest and disease cycle: safflower. Safflower is a deep rooted crop bringing up the nutrients deep down, which otherwise would not be available to the crops. Other crops grown are paddy, mulberry for silkworm rearing, soybean, peanuts, pigeon pea, bajri (*Pennisetum typhoides*) and rajko. Without chemical fertiliser, he harvests a very good paddy crop (4000 kg/ha). Labourers come to his fields first as they get rice instead of money. They say the rice from his field tastes better, even as it gets old. Seed buyers come to him first as they are sure of 100% germination. There are 37 cattle and all manure is used on the farm. The slurry from the biogas digester is led into a closed pit. All harvest wastes are composted. The yields of the ecological farm are about 20% to 25% lower when compared to the conventional farm. However, Mr. Patel uses farm resources only and, moreover, he finds quality more important than just high yields. If labour, economics and even energy were to be calculated, a comparison would give quite a different outcome.

NPK balance

The nutrient balance is calculated for major nutrients in kg per ha in table 1. The NPK-balance has been calculated per three cropping seasons (one year). The nutrient content of crops and inputs are

Table 1:
Nutrient balances in kg/ha/yr

	Mr. Pandya's farm			Mr. Satish Patel's farm		
input	**N**	**P**	**K**	**N**	**P**	**K**
fodder & straw	26.3	3.6	26.2	0.8	0.1	0.3
fertiliser/ manure	131.9	49.0	52.7	20.0	0.9	5.7
deposition	10.0	1.0	3.0	10.0	1.0	3.0
N-fixation	34.4			99.6		
total input	202.6	53.6	81.9	130.4	2.0	9.0
output						
milk	6.9	1.3	1.5	8.4	1.4	2.3
food, fodder	107.9	40.4	108.1	81.2	9.6	32.9
total output	114.8	41.7	109.6	89.6	11.0	35.2
input/output (losses/accumulation/gain)	87.8	11.9	-27.7	40.8	-9.0	-26.2
efficiency %	56.7	77.8	133.8	68.7	550.0	391.1

Photo: Chris Pennarts

Nutrients in the Netherlands

Nutrient balances are not new in Dutch agriculture. As of 1 January 1995, the Ministry of Agriculture is making nutrient balance calculation obligatory for dairy farmers. A standard will be given, indicating what surplus of kg N, P or K is acceptable per ha grazing land. For nitrogen, this might be 350 kg/ha. If the balance shows a figure beyond that standard surplus, the farmer has to pay a levy. For example, a farmer has 25 ha and the surplus per ha is 470 kg N, or 120 kg over the accepted surplus. With a levy of Dfl. 2/kg N, he has to pay Dfl. 240 per ha or Dfl. 6000 in total (USD 3.500).

Farmers are joining study groups to learn how to calculate nutrient balances. Fokke Benedictus, a dairy farmer states: "It is important to know the figures to find room for improvement. Ten years ago, I applied 400 kg N per ha. Now only 255 kg, because the organic manure is better used. Our cows also have less feeding problems." One way to make better use of nutrients is through a so-called manure injector. In the barn, the liquid manure is pumped into the tank and in the fields it is directly injected into the soil (see photo). Today, 983 million kg pure N are imported into the Netherlands, of which only 274 million kg is used. Consequently, 709 million kg disappears into soil, water and air. There is still room for improvement!

standard data, taken from literature. The percentage of utilisation is calculated as total output of the system / total input of the system. Total N output = N in food, fodder & straw + milk & meat. Total N input = N in purchased feed and fodder + N-fixation + N-deposition + N in additional fertiliser or manure.

Human and animal excreta are added to the manure. Part of its N is returned to the land and part of its N is lost through volatisation. Some straw and fodder is also added to the manure. For example, the N-utilisation for Mr. Pandya's farm is calculated to be 57%. This means that 57% of the total N-input in the farm is used for production or, in other words, 43% (87 kg/ha) is lost or accumulated in the soil. This rate is not obtained by on-farm resources alone. For Mr. Patel's farm, N-utilisation is calculated to be 69%. This is obtained by proper nutrient and soil management and crop rotation. The only input is purchased chicken manure. But as the farm has a deficit of both P and K, in the long run an extra input of P and K will be needed.

Discussion

What is the use of these types of calculations? The nutrient balances of the farms were calculated with a computer model developed at the Department of Ecological Agriculture in Wageningen. However, Indian farmers, researchers and policy makers are not using it, as the tool is not available and the concept not present. Only a few farmers analyse their soil on the basis of nutrient deficiencies and pest problems. Then they use the recommended dose of fertiliser. But crop rotation and soil fertility management is not taken into account.

Mr. Patel sees the nutrient balance calculation as a powerful tool to analyse a farm. To solve the deficiency in P, he started an experiment with phosphate solubilizing bacteria for better phosphorus uptake as the soils in South Gujarat contain high amounts of available P. P deficiency can be further reduced by purchasing leguminous concentrates for cattle and reinforcing bio-gas slurry with bone meal or superphoshate. K-deficit can be reduced by proper handling of liquid manure. Mr. Pandya sees it as an additional promising method of analysing the nutrient requirements of the farm. In addition to this, he would also get the soils tested to confirm the soil reserves.

The future

The farming system in South Gujarat is specialises more and more towards monocropping of sugar cane, thereby undermining the long-term sustainability of farms. Nutrient balance analysis is an alternative for the conventional crop-oriented fertilisation approach. It will give farmers more insight in the nutrient flows on their farms and therefore it enables them to reduce both costs of fertilisation and environmental pollution. Livestock integration provides better waste recycling thereby achieving a better nutrient balance. Milk cooperatives could stimulate integration of livestock.

The nutrient balance calculation as a tool for better farm management should be developed by the sugar co-operatives. Also, NGOs can be involved in developing this tool further. They can calculate the nutrient balance of farms. The farmer's involvement is necessary and will not be left out as his farm management decisions are important for a proper nutrient balance of the farm. ■

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Reference

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