The next step in nitrogen budgeting: the dynamic approach

G.J.H.M. van der Burgt

Louis Bolk Instituut, Hoofdstraat 24, NL-3972 LA Driebergen, The Netherlands

g.vanderburgt@louisbolk.nl

Abstact

In organic plant production yield is often limited by nitrogen, water, pests and diseases or weeds. If nitrogen is scarce, budgeting per crop is helpful for optimising total production. Further improvement of nitrogen use efficiency can be obtained by a dynamic approach, synchronizing the availability of nitrogen and the plant uptake pattern. This synchronization can be improved by using the NDICEA nitrogen model as evaluation instrument and as predictive tool.

Results are shown from datasets out of the Netherlands, one showing the process of N-budgeting at crop level, one at rotation level. In case of more arid conditions, the process is principally the same but more complex : both nitrogen and water use must be optimized, and due to the interaction between these two, a dynamic approach is preferred.

Introduction

Besides water, pests and diseases and weed competition, nitrogen often is a limiting factor in (organic) plant production. Compared to conventional plant production, nitrogen budgeting in organic agriculture is more complex. This is due to the time-depending slow release of nitrogen during the decay of organic matter: soil organic matter, crop residues and manures. Contrary to artificial nitrogen fertilizer, the amount of nitrogen applied as organic manure is not 100% available for the next-growing crop. This creates two challenges. The first is to make an estimate of plant available nitrogen for the next crop. The second is to ensure a crop sequence in which the nitrogen, which will become available in the month or years after this first crop, will be used efficiently, since nitrogen is scarce in organic farming. The release of nitrogen out of different organic materials can be addressed on its own. It can also be assessed as part of a more comprehensive model approach, as is done in the NDICEA model (Burgt et al., 2006; www.ndicea.nl). This offers the advantage of a dynamic calculation in which several soil and climate variables are integrated. In this paper the NDICEA model is introduced and used to demonstrate the process of synchronizing and optimizing crop nitrogen need and soil nitrogen availability, thus optimizing nitrogen efficiency at crop level. Then, the model is used to demonstrate the optimization of nitrogen use efficiency at rotation level. The examples discussed are all from the Netherlands with a certain rainfall surplus during winter. To finish with, an example from a more arid climate is introduced and discussed.

The NDICEA model

The NDICEA nitrogen and organic matter model (Nitrogen Dynamics In Crop rotation in Ecological Agriculture) is originally build by Wageningen University and further developed by Louis Bolk Instituut (Burgt et al., 2006). Since 2005, a user-friendly version is freely available (www.ndicea.nl). The input for the model is simple and consists of data that most farmers know by heart (Table 1). No additional measurements are requested, although measurements of soil mineral nitrogen and plant nitrogen content can help to improve the model results. Besides these data, rainfall, temperature and evapotranspiration is requested. The model is aiming at the understanding of long-term nitrogen dynamics, and a minimum of three consecutive years with all its crops and manure applications is required as input.

Table 1. Input for the NDICEA model

Theme	Item	Theme	Item	Theme	Item
Soil	Texture	Crops	Crop type	Manures	Type of manure
	Groundwater level		Sowing date		Application date
	pH		Harvest date		Amount
	Organic matter %		Yield		N-content

Nitrogen release: optimization at crop level.

On a shallow sandy soil in the Netherlands the “Klein Boeschoten” farm (52.13.07 N ; 05.40.06 E) has a crop rotation of mainly cereals such as silage maize, winter rye, barley and spring wheat. In 2007 the farmer applied 65 tons of cattle slurry with 3 kg N per ton, total 195 kg of N, short before sowing silage maize. He aimed at a yield of 50 tons, 28% dry matter, 1.2% N in the dry matter, resulting in an expected N-uptake of 190 kg. He could have chosen for an Deep Stable Manure application (DSM), 30 tons per hectare with 6.5 kg N per ton, resulting in the same total N application of 195 kg. The availability of nitrogen in case of DSM is different from the availability out of slurry, and in case of DSM nitrogen would have limited the yield (Figure 1, week 70-93).

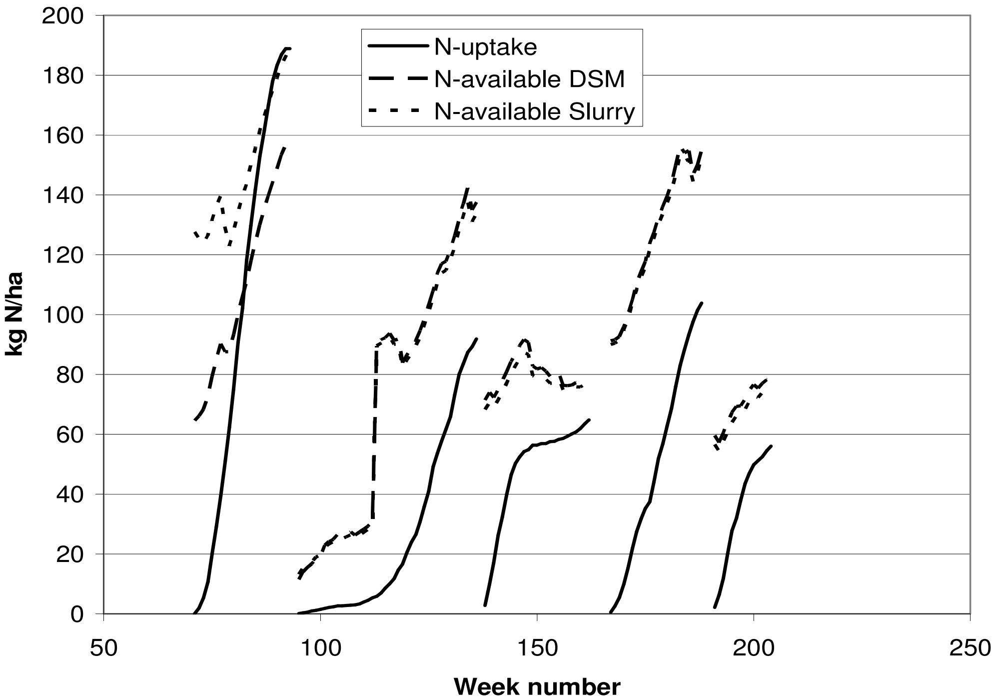
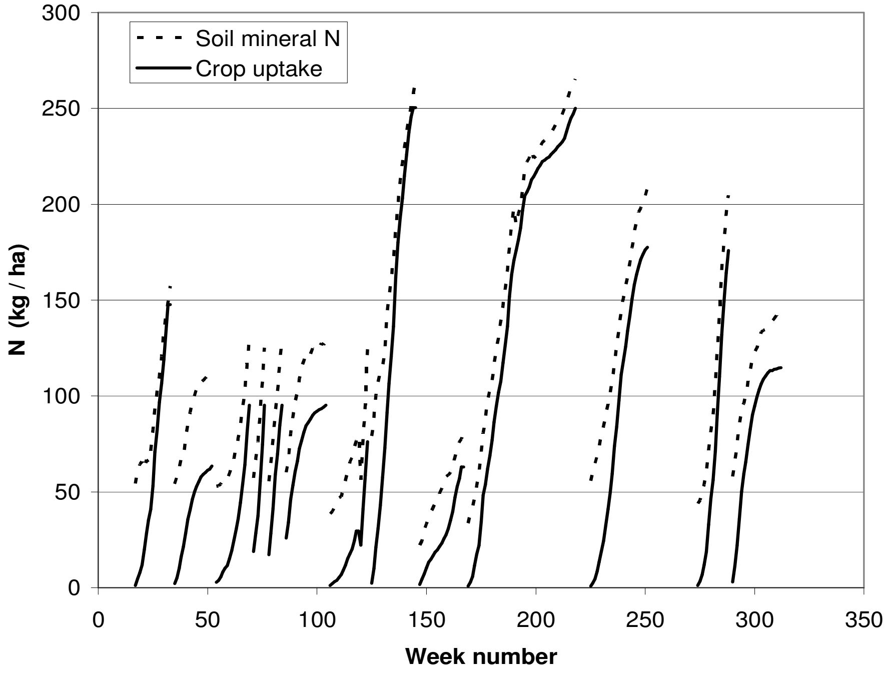


Figure 1. N-uptake and available N for two different manure applications with the same total-N amount.

Nitrogen release: optimization at rotation level.

The application of slurry or DSM results in differences in plant-available N not only in the first crop, but also during the next two (and more) years (Figure 1, week 100 – 200). In this example the differences are not big, but if year after year DSM is applied, the residual effect will build up and becomes relevant for decisions about manure application (Köpke et al, 2008). This long-term building of soil fertility can only be considered by using a dynamic model such as NDICEA. For an experimental farm in the Netherlands (OBS, 52.37.57N, 5.43.04 E) , this process of Nitrogen use optimization using the NDICEA model was done (Figure 2). Crop sequence and manure applications were in such a way arranged that soil mineral N levels were as good as possible adapted to crop and catch crop uptake, thus minimizing N-losses due to leaching.

Figure 2. Nitrogen use optimization for a six-year organic rotation: potato – grassclover – cabbage (+ catch crop) – spring wheat (+ catch crop) – carrots – peas (+ catch crop)



Arid conditions

Under more arid conditions, the potential losses of nitrogen due to leaching will be smaller than in the West-European climate. In this case, but also in case of irrigated crop production, there is a double task for the producer: optimizing the water use and optimizing the nitrogen efficiency. There is a strong interaction between these two processes. On the experimental farm Kompas (52.52.27 N, 6.56.30 E) NDICEA and an irrigation planning tool were evaluated in irrigated potato cultivation. The NDICEA model showed a good predictive performance (Burgt, 2007), and the use of the irrigation planning tool saved nitrogen due to reduced leaching losses (data not published). Again, the dynamic approach helps in better understanding the system and in improving it.

References

Burgt, G.J.H.M. van der, G.J.M Oomen, A.S.J. Habets and W.A.H. Rossing (2006). The NDICEA model, a tool to improve nitrogen use efficiency in cropping systems. Nutrient Cycling in Agroecosystems 74: 275-294

Köpke, U., J. Cooper, H. Lindhard Petersen, G.J.H.M. van der Burgt and L. Tamm (2008). Performance of organic and low input crop production systems. In: Proceedings 16th IFOAM Organic World Congress.

Burgt, G.J. van der (2007). Stikstofdynamiek Proefbedrijf 't Kompas. Louis Bolk Institut, Driebergen, The Netherlands, 27 pp.

www.ndicea.nl