N-Expert – A Decision Support System for Vegetable Fertilization in the Field[1]

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Keywords

Nitrogen, Nmin-method, models

Abstract

The computer program N-Expert calculates field specific fertilizer recommendations for vegetable crops. Since the calculation is based on simple plant growth- and soil-models, which need only few input data, the program can be used by both growers and advisers.

Introduction

Field studies in Germany showed that vegetable growers often make nitrogen fertilizer decisions by rules of thumb, which means that they regularly use too much nitrogen. Fertilization which meets the requirements of environment protection and prevents leaching of nitrogen is only possible if it is made after a detailed analysis. This is the aim of the computer program N-Expert, which calculates field specific fertilizer recommendations for vegetable crops.

The algorithm

The recommendation is calculated from six components. Each component is dependent on different parameters (Fig. 1). In order to make the system easy to use for growers and advisers, all input data fields in the program are filled in with standard values, which can be accepted by the user, or changed, if he has field specific information. In the data bank of N-Expert standard values are available for all important vegetable crops. The standard values are derived from experimental data, acquired in universities, horticultural experimental stations and in practice (sources see references).

+	**N in plant material**	
	dependent on:	plant species, stage of development, cropping system
+	**necessary Nmin-residue**	
	dependent on:	plant species
+	**N losses**	
	dependent on:	N supply, length of cultivation period
-	**Nmin at begin of cultivation**	

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- **N from mineralization of humus**
  dependent on: amount of humus, time of year, length of cultivation period
- **N from mineralization of crop residues**
  dependent on: amount and type of crop residues

N fertilizer recommendation

Figure 1: Calculation of N fertilizer recommendations

The components of the calculation and the experimental data, on which the standard values are based, are described below. The quantity and time course of N-uptake depends on plant species, stage of development and "cropping system". Figure 2 gives an example of the N-uptake of lettuce as a function of growing time and time of the year. In spring the growing time is longer than in summer, the yield is lower and the N-uptake starts slowly, due to low temperature early in the year.

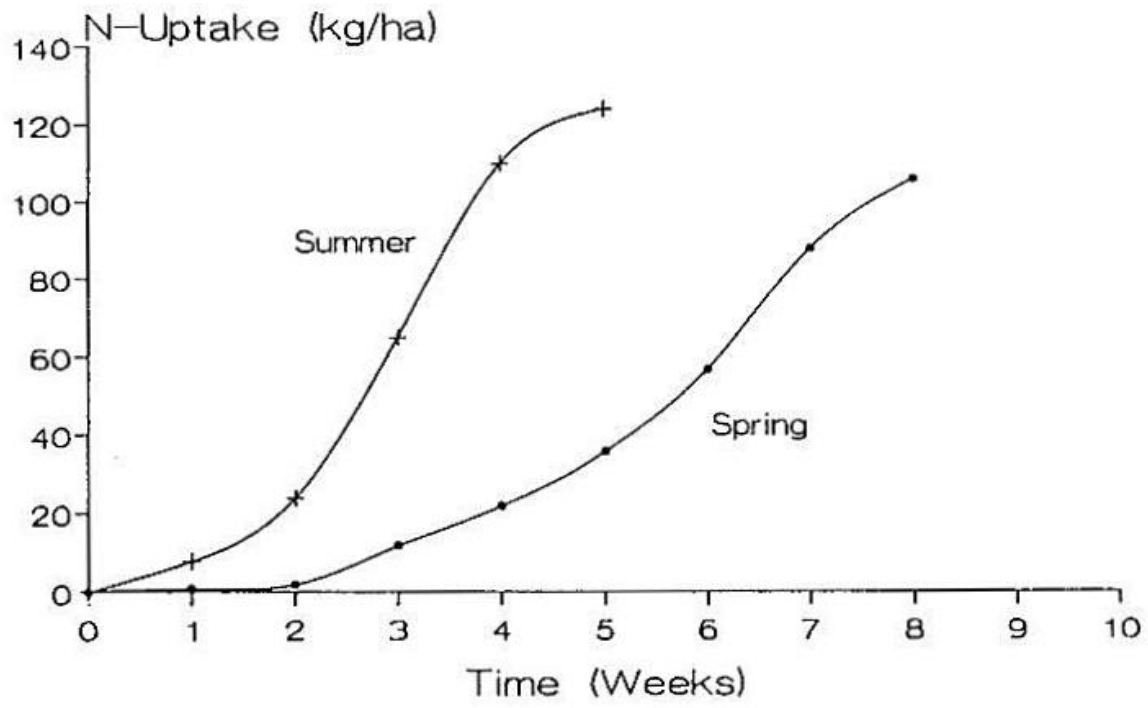

Figure 2: N uptake of lettuce (source: Lorenz et al. 1989)

The program user has only to select the name of the particular cropping system from a list (e.g. "Lettuce Summer") and all standard values (quantity and time course of N-uptake, growing period of the crop) are used for the calculation of the recommendation. In some cases the distinction between cropping systems is not made according to time of the year (spring / summer / fall), but by the production target. "Cabbage for Processing", for example, needs more nitrogen then "Cabbage for Fresh-Market", since the target for "Cabbage for Processing" is to produce larger heads, which means much more plant-material per area. The time-course of N-uptake is used for the calculation of head dressings to determine how much N will be taken up from the date of head dressing to the expected harvest date. The necessary Nmin-residue at harvest date is dependent on the plant species. Especially crops which are harvested at a time of high growth rate, such as spinach, leave high Nmin residues in the soil. In contrast, other crops, like Brussels sprouts, are able to use up all the nitrogen in the soil without yield or quality losses. The data for the necessary Nmin-residues are therefore derived

from fertilizer experiments for all the main commercially grown vegetables.

The term "N losses" combines all processes which lead to permanent or temporary losses. Analyses of fertilizer experiments showed that only 60 to 80 % of the N-supply can be used by the fertilized crop. Since no comprehensive model was found which calculates the components of these N losses (immobilization, denitrification) on the basis of few input data, a simple regression model is used. This model was fitted on measured losses in fertilizer experiments, dependent on the quantity of N in the soil and the length of the cultivation period (Scharpf and Weier 1992).

For the N from mineralization of humus a model based on data of the increase of mineral nitrogen in the soil of fallow plots is used. As shown in Figure 3, on several fields which were normally used to grow vegetables the increase of Nmin is almost linear from April to August, with a more or less constant rate of 5 kg N/ha/week. Only early and late in the year a lower rate of mineralization, caused by low soil temperatures, is taken into consideration.

If the user requires a recommendation for a second crop in the same field, it is necessary to calculate the N-supply from the residues of the previous crop, since depending on the amount and kind of crop residues, considerable amounts of nitrogen can be mineralized. Figure 4 shows an example for crop residues of leek, which are mineralized in about ten weeks supplying a following crop with up to 70 kg N/ha. Depending on the sort of plant material it is assumed that the mineralization takes from four weeks, for example for lettuce leaves, to twelve weeks, for example for cabbage stalks.

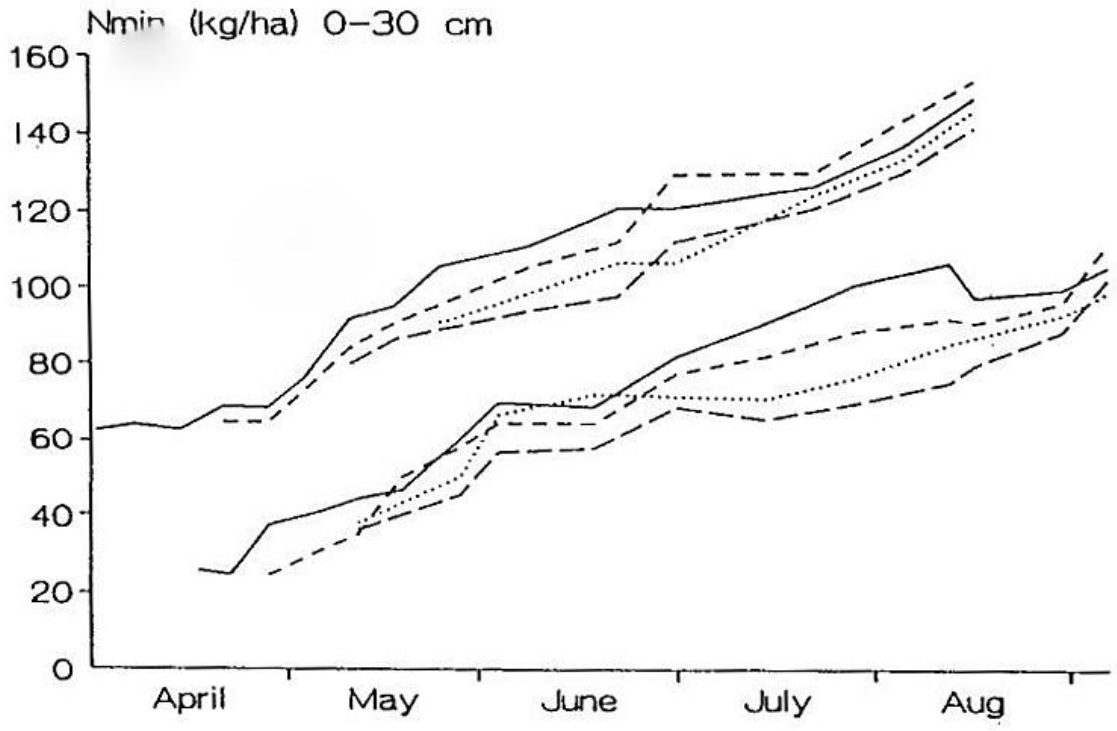

Figure 3: Mineralization of humus. The two groups of lines representing results from two experimental stations with different Nmin start values in spring. Lines representing different plots. (Source: Schrage 1990)

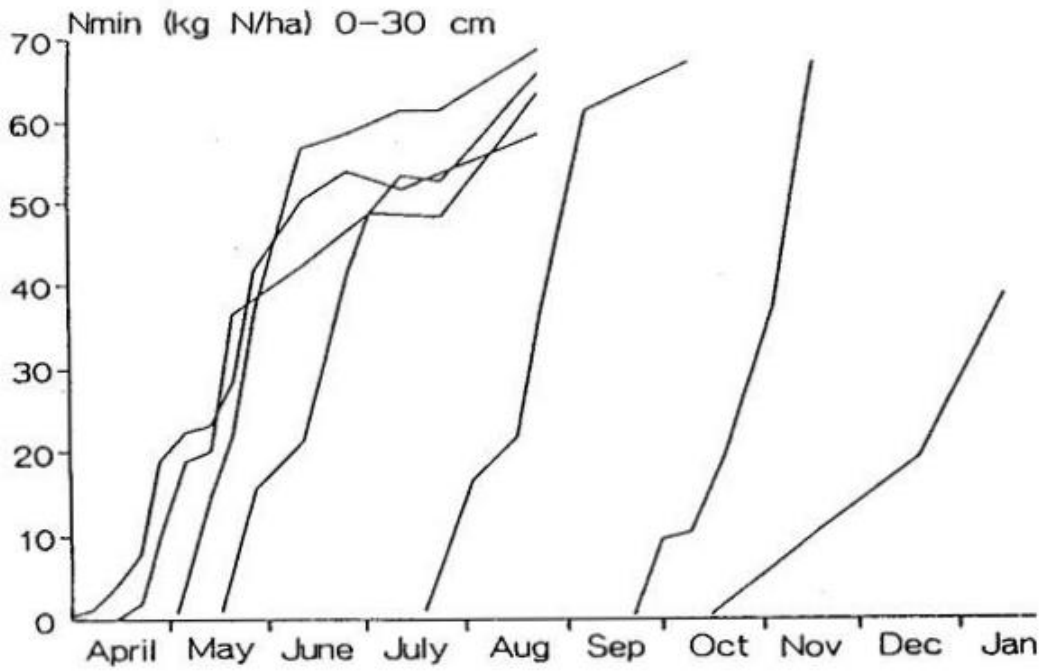

Figure 4: Mineralization of crop residues. Lines representing mineralization of leek residues (30 t/ha, brought into the soil at different dates. (Source: Schrage 1990)

Fertilizer recommendation based on measured or estimated Nmin-values

It is advisable to calculate fertilizer recommendations on the basis of measured mineral nitrogen values according to the "Nmin-Method" (Wehrmann and Scharpf 1986). However, growers are often reluctant to invest time and money in soil analyses, especially if they are producing for the fresh market many sets of different crops, on small plots in each case. Here, the amount of mineral nitrogen in the soil can be estimated by N-Expert. In order to do that it is necessary to enter, in addition to the crop data, the type of soil and the quantity of rainfall and irrigation. With this input-data a model - again a very simple model - is introduced to calculate possible N-losses caused by leaching. It is obvious that fertilizer recommendations based on estimated Nmin-values are more uncertain than recommendations based on measured Nmin-values. Evaluations of fertilizer experiments showed that about 75 % of the predicted values have errors in the range of +/- 40 kg N/ha (Figure 5). In individual cases prediction errors up to 160 kg N/ha were found. In these individual cases the recommendation based upon the estimated Nmin-value would be too high. But for growers who do not carry out soil analyses, these estimated Nmin values are on the whole much better than rules of thumb. This is concluded from a field study in North Germany: Schrage (1990) found that in practice after vegetable crops, mineral nitrogen residues were in the range 50 to 850 kg Nmin/ha, with the highest frequency at 250 to 350 kg Nmin/ha (Figure 6). Compared to these errors of several hundred kilograms the prediction error of N-Expert is small. Nevertheless it is necessary to work at improving the precision of predicted Nmin-values, by including additional experimental data and more sophisticated nitrogen turnover models.

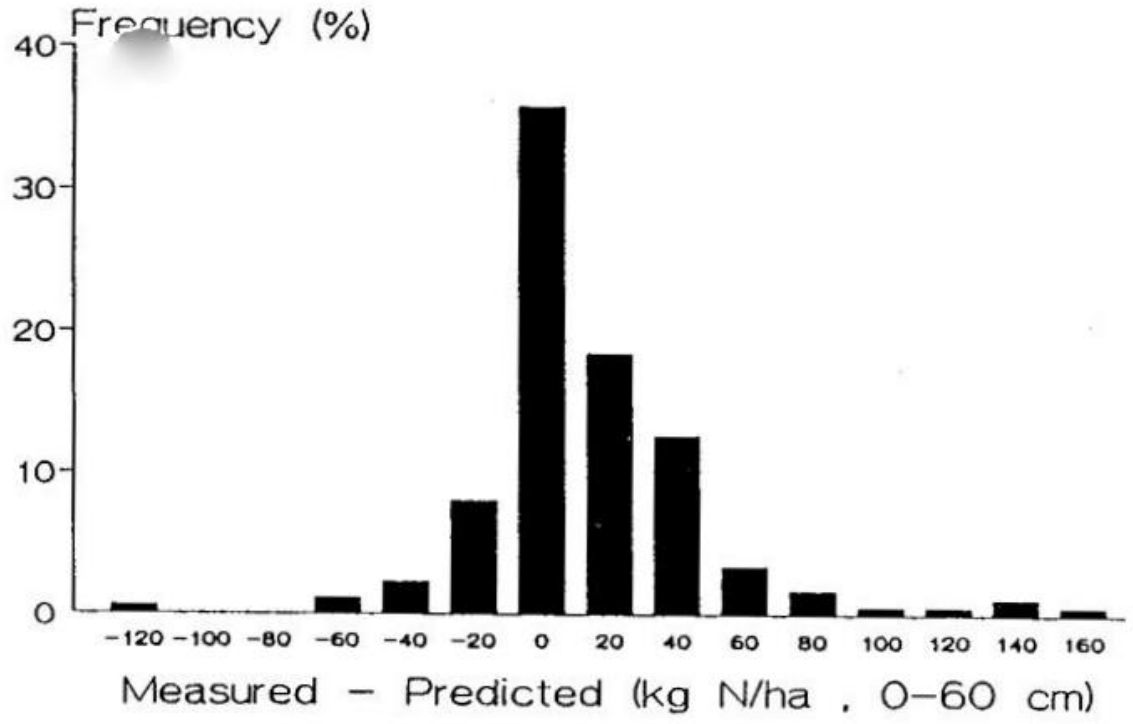

Figure 5: Differences of measured and predicted Nmin values. Measured values from fertilizer experiments (n=173)

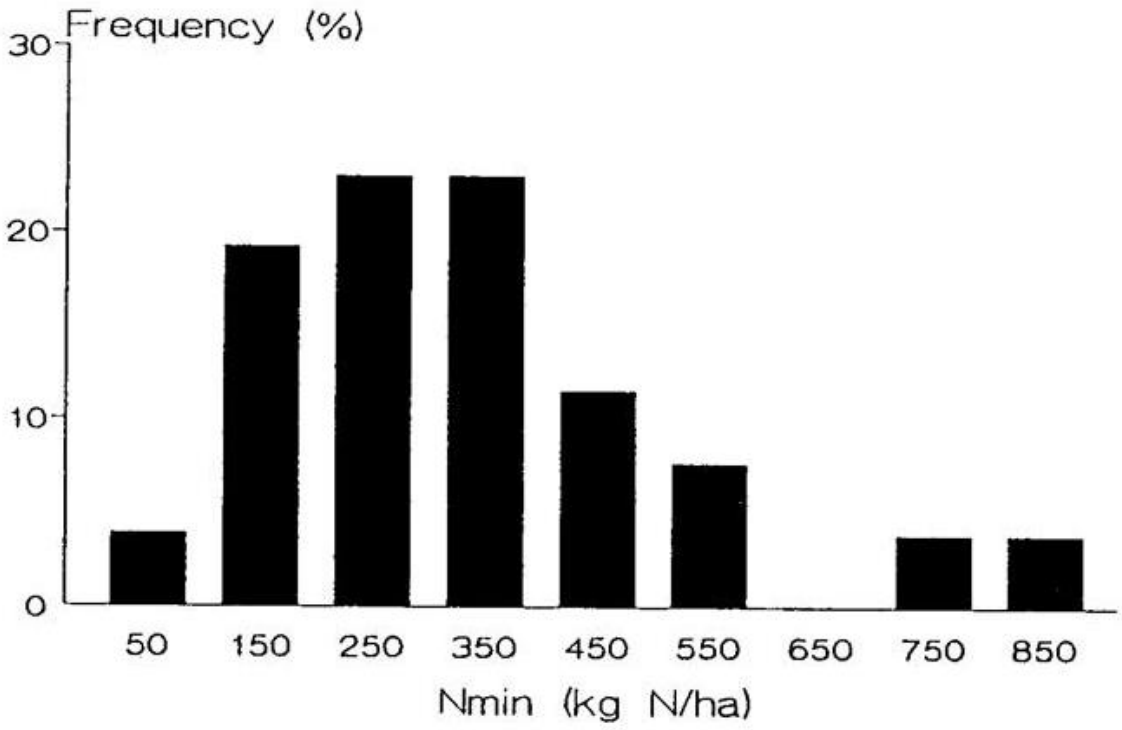

Figure 6: Nmin residues found in practice after vegetable crops (November 1989, n = 26, source: Schrage 1990)

Fertilizer recommendations in N-Expert are given not only for nitrogen, but also for phosphorus, potassium and magnesium. Details of these will be published elsewhere. N-Expert is easy to use, providing explanations and assistance. Until now over 80 copies have been distributed. The users are growers, advisers and teachers in horticultural schools, who are giving the authors valuable feedback for improvements in future updates.

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