

EVALUATION OF THE N-FERTILIZATION OF WINTER WHEAT BASED ON THE N_{MIN} -METHOD IN FARM PRACTICE

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Introduction

Among the major nutrients (NPK) nitrogen is most often the limiting element of crop production. On the other hand, in the case of overdosage, nitrogen can be harmful to the environment (especially for the quality of surface- and groundwater). Most arable crops depend on nitrate-N as a main nitrogen source. In the mid-1970's the principles of an uniform fertilizer recommendation system were worked out with the necessary institutional and laboratory background. This procedure included soil sampling on the farm fields every third year, respectively (all fields which were bigger than 6 hectares were involved in the program), and giving fertilizer advice for each field (Baranyai et al., 1987). The system worked up to the end of the 1980's when political and economical changes occurred in the country. From the agricultural point of view several changes had happened: reprivatization of land, elimination of the former state subsidies, lack of capital and loan, etc. For the determination of the nitrogen to be applied for the targeted (expected) yield in Hungary the widely used N-fertilization recommendations were based on the organic matter (humus) content of the ploughed layer. During the intensive period of arable cropping the applied nutrient quantities had exceeded the crops' nutrient demands. As a consequence of this, the nutrient (NPK) balances of many fields became positive and their nutrient supplying capacity had improved. This was favourable for soils which originally contained less nutrients (weak supply), under these conditions fertilization played a significant role in the sustainability of yields. In contrast, there were many fields on which only the plant nutrient demand was compensated. In the case of overfertilization, the surplus of nutrients could be detected easily in the ploughed layer for P and K using the standard AL-method (Sarkadi et al., 1986). The positive nutrient balance may also result in a similar change in the soil nitrogen content, but this process can not be followed by the analysis of soil' organic matter. The measurement of the organic-C content of the ploughed soil layer is not the best tool for detecting changes in the easily available soil N fraction. It is well known that the effect of N-fertilization on the N content of soil can be characterized better by measuring the mineral-N content (exchangeable ammonium-N and nitrate-N) of the soil (Wehrmann and Scharpf, 1983). Based on the measurement of the mineral-N content of the soil, a nitrogen fertilization advisory system was also developed in Hungary (Németh, 1996).

Materials and methods

On the basis of several long-term experiments and farm practice a nitrogen fertilization advisory system, based on the measurement of the nitrate-N content of the soil in late winter - early spring was developed more than a decade ago for Hungarian soil and environmental conditions. During the soil sampling composite (average) samples (20 subsamples make 1 composite sample) by hand with Eijkelpamp drills at two depths, 0-30 cm and 30-60 cm, separately. The soil samples are immediately forwarded to the laboratory and the mineral-N content of the samples is determined from wet soils. Growers receive the computer-aided field-level recommendations within 4-5 days.

In the commonly used mineral-N advisory system the experts calculate with both, the exchangeable ammonium-N and the nitrate-N content of a certain soil layer (Wehrmann and Scharpf, 1983). During the calibration of the mineral-N method under the conditions of the targeted area (more than 10 000 hectares yearly) it was proven, that it is more adequate to account only with the nitrate-N content than with the sum of the two (i.e. exc. ammonium and nitrate) forms. Nevertheless, both forms are always determined, but only nitrate-N is involved in the calculation.

Results and discussion

During these long-term studies it was found that in the case of winter wheat the nitrate-N content presents in the 0-60 cm soil layer reliably indicates the N-content available for plants. Under given conditions, at the end of winter, just before the start of the growing period, the nitrate-N content is characteristic of the soil type, of the previous (autumn N-fertilization), of the previous crop, etc. Due to the climatic conditions during the sampling period the mineral-N content is often determined from frozen soil samples. The nutrient uptake of winter wheat is rapid in spring just after the start of the growing season and even a slight nitrogen deficiency of the crop can result in lower harvested yields, it is very important to apply topdressing nitrogen at the start of the spring vegetation cycle (Horváth, 1993, Németh, 1996). According to the long-term, average meteorological data, no surplus rain has to be considered in Hungary in early spring, no leaching occurs. There is sufficient water in the profile during this period (but later, in most years, the water supply can be a limiting factor). In Hungary, long debates have been going on about splitting the spring N-rates. The evaluation of our results showed that the spring N-fertilizer can be applied once (except on sandy soils) if the required nitrogen does not exceed 100 kg/ha. Split application may have a negative result on yield if the second (or third) application is delayed by some days due to unfavourable weather conditions. In this case, yield loss cannot be avoided. On sandy soils, split application is definitely recommended because of the eventual N losses due to leaching and resulting hazard of groundwater contamination. Based on the data of the last eleven-year period, the relation between the nitrate-N content of the 0-60 cm soil layer and the residual effects of the forecrop's nitrogen (i.e. amount of nitrate-N remaining in the soil after different forecrops) has also been studied (Figure 1). The territorial distribution of winter wheat forecrops during the investigated period was the following: 10% legumes, 25% maize, 40% sunflower and 25% autumn sown plants. From Figure 1, the effect of the previous year and the cultivated forecrops - on the average of the total sampling area grouped into forecrop categories - on the "overwintering" of nitrate-N can be clearly observed. The evaluation of this effect shows that the best forecrops from residual-N point of view are the legumes, while the other three groups have more or less the same effect, with yearly fluctuation.

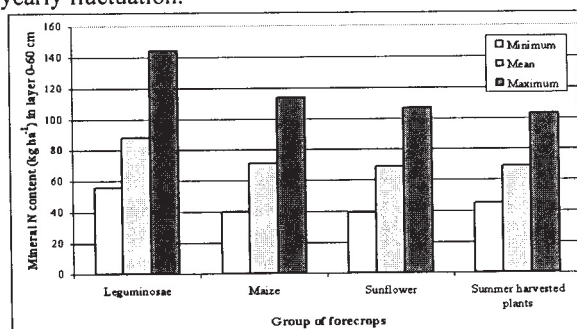


Figure 1. Residual mineral N content after different of forecrops (in mean of 1995–2005)

In Figure 2 the yearly nitrate-N content of soil layers at the two sampling depths (0-30 cm and 30-60 cm, respectively) and the sum of nitrate-N in the sampled layer can be seen at the end of winter, on the average of different forecrops. In six years out of eleven the nitrate-N content of the soil were higher than 60 kg/ha (in 2002 almost 120 kg/ha), while in five years this value was less than 60 kg/ha. It is also shown that at the end of winter the nitrate-N content of soil was slightly higher at the 30-60 cm depth than in the upper soil layer.

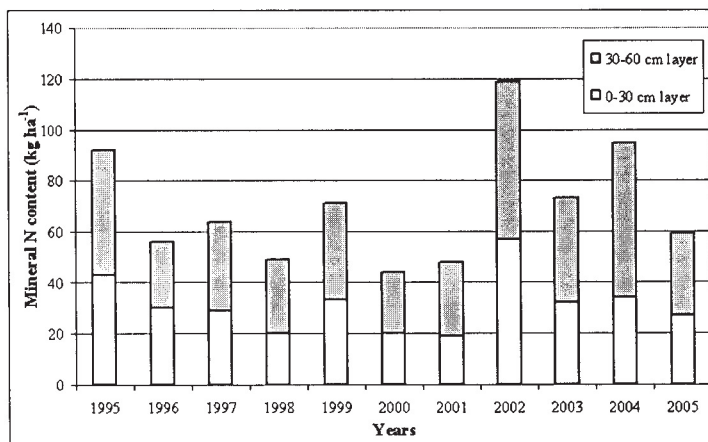


Figure 2. Yearly mineral N content in the soil layers (1995–2005)

Calculation of the amounts of the recommended nitrogen fertilizer on the basis of nitrogen demands of the predicted yields versus nitrate-N content in the sampled soil layers are summarized in Figure 3. It can be seen that the 11-year average is 91 kg/ha, which amount varies between 75 – 105 kg/ha according to the residual amounts of the previous year and the predicted yield level.

In spite of the changes in Hungarian agriculture (change in land ownership, rapid increase in the number of farms, earlier large fields turned into small plots, drastic decrease of fertilizer consumption, etc.), this nitrogen fertilizer recommendation method has been used on more than ten thousand hectares yearly in the last decades. It is obvious that farmers' profit does not come only from saving (reducing the nitrogen applied) but the productivity and yield safety have also improved. An environmentally friendly but economically reliable nitrogen fertilization system needs to be objective and can be based on the following: finding a characteristic nitrogen form, which can be calibrated under field conditions.

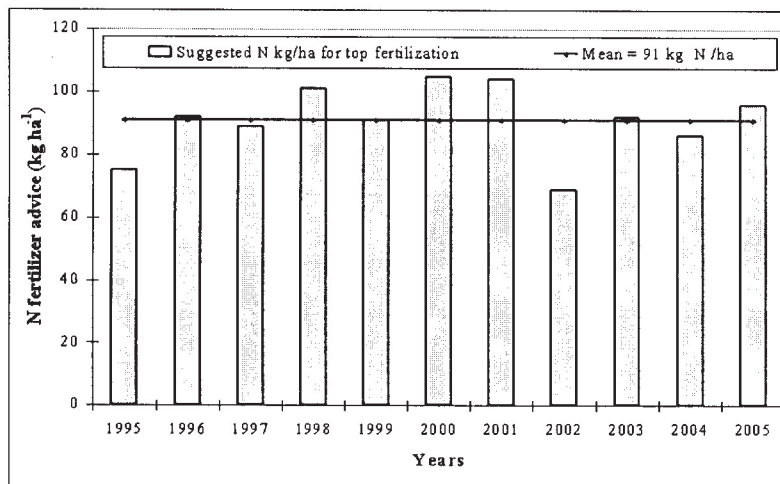


Figure 3. Top fertilization advice for winter wheat (1995–2005)

References

- Baranyai, F., Fekete, A. and Kovács, I. (1987): Results of the Hungarian plant nutrient survey. (in Hungarian) Mezőgazdasági Kiadó, Budapest.
- Horváth, J. (1993): Results of N fertilization based on soil and plant analyses in Somogy Country. (in Hungarian) Proc. National Environmental Protection Conference, Volume I., 201-203.
- Németh, T. (1995): Nitrogen in Hungarian soils - nitrogen management relation to groundwater protection. *J. of Contaminant Hidrology*, **20**, 185-208.
- Németh, T. (1996): Organic matter and nitrogen content of soils. (In Hungarian - English summary) MTA TAKI, Budapest, Hungary.
- Sarkadi, J., Németh, T. and Kádár, I. (1986): Heterogeneity of the readily soluble nutrient content of the soil. (in Hungarian - English summary) *Agrokémia és Talajtan*, **35**, 295-306.
- Várallyay, Gy., Buzás, I., Kádár, I. and Németh, T. (1992): New plant nutrition advisory system in Hungary. *Commun. Soil Sci. Plant Anal.*, **23**, 2053-2073.
- Wehrmann, J. und Scharpf, H.C. (1983): Sachgerechte Stickstoffdüngung-schatzen, kalkulieren, messen. AID-Heft. 17/1982.
- Kádár, I. (2004): Szennyvíziszap-adagok hatása a növény (*Triticum vulgare* L.)-talaj rendszer néhány mikrobiológiai és biokémiai tulajdonságára (Impact of sludge treatments on some microbiological and biochemical properties of plant (*Triticum vulgare* L.)-soil system. – in Hungarian). *Agrokémia és Talajtan*. 53. 3-4. 331-342 pp
- Svetková, K.; Henselová, M.; Morvová, M. (2005): Effects of a carbonization product as additive on the germination, growth and yield parameters of agricultural crops. *Acta Agron. Hun.* 53. (3). 241-250 pp
- Tanács, L., Matuz, J., Gerő, L., Petróczi, I.M. (2005): Effect of NPK Fertilizers and Fungicides on the Quality of Bread Wheat in Different Years. *Cereal Res. Commun.* 33 (2-3): 627-634 pp