Effect of N Fertilization on the Nitrate-N Content of Soil Profiles in Long-term Experiments

T. NÉMETH

Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences, Budapest

Recently, public opinion in Hungary has been much concerned about the harmful influence the chemicals used in agriculture exert on the environment. One of the most important problems is the increasing nitrate content of waters. Nitrate in different depths of the soil profile or in the groundwater may come from various pollution sources, such as industrial and communal establishments, animal husbandry or fertilizer storage, but it may also take its origin from the mineralization of organic N forms, geochemical processes, or leaching and transport by precipitation and surface waters. Fertilization with organic and mineral fertilizers could also take part in this process (NÉMETH & BUZÁS, 1990).

Nitrate leaching into the deeper soil layers or the groundwater occurs only when nitrogen is present in the form of nitrate in a certain soil layer, and the water can move in a vertical direction through the profile. What happens to the nitrate that gets into the deeper layers depends on the properties of the given soil and on the environmental conditions (NÉMETH et al., 1987-1988). When the groundwater table lies at great depth, or the amount of precipitation is not sufficient to soak the soil layers above the groundwater table, nitrate may accumulate in the profile in large amounts (hundreds or thousands of kg nitrate/ha soil). Nitrate accumulation may also occur if the soil profile includes clay or clayey-loam layers. When the soil is light-textured and the groundwater table can be found at no great depth, there is a considerable probability that nitrate will get into the groundwater. However, the leaching of nitrate need not occur in the latter case either, if nitrogen fertilization is carried out according to the N uptake of the plants, by applying the yearly N requirement split into two fertilizer doses, and if a catchcrop covers the soil during the winter season when leaching is most probable.

The results of previous investigations (NÉMETH et al., 1987-1988) in an 11-year-old long-term experiment showed that on the loamy chernozem soil examined the peak of nitrate-N accumulation was found at around 2 m (the depth of

the groundwater table was 13-15 m). The effect of soil texture and diverse environmental conditions can only be studied using a fertilizer network.

Material and Methods

The experimental series chosen for the measurements was initiated in 1968 at 9 experimental stations in different parts of the country, on different soil types, under diverse environmental conditions (supervised by the Pannon Agricultural University, Keszthely).

In the first four cycles (1968/69 - 1983/84) winter wheat, maize, maize and winter wheat were grown, while in the following period winter wheat, maize, sunflower and winter wheat represented the plant order. The basic soil analysis data of this network were published by DEBRECZENI (1992).

Deep-drilling was carried out at 8 experimental stations following the harvest of winter wheat in July 1988. Soil samples were taken from unfertilized plots and from plots receiving 50, 150 and 250 kg N/ha/year each. Deep drilling was continued to a depth of 3 metres and samples were taken every 20 cm.

In this paper results are presented from three (Iregszemcse, Karcag and Bicsérd) of the above mentioned 8 experimental stations.

The soil in *Iregszemcse* is a calcareous chernozem. In the soil profile of the experimental field the loess layer (C horizon) begins at 90 cm, above which a humous loam is found. The calcareous layer could be found at a depth of 60-90 cm in July 1988. All horizons found down to 3 metres belong to the loam group as regards their physical properties. The average depth of the groundwater table was 4-5 m.

Karcag has a solonetz-like meadow chernozem soil. The soil profile consists of the following horizons: down to 60 cm heavy black clay rich in humus, from 60 to 95 cm heavy, light brown clay, from 95 to 200 cm yellow clay with iron and manganese concretions. Below 200 cm the soil continues to be clayey, with a moisture content which increases considerably below 250 cm. The average depth of the groundwater table was 3-4 m.

At *Bicsérd* the soil is a forest soil deposition. Down to 3 metres the soils in the profile belong to the loam group as regards their physical properties. From 90 cm to the bottom of the profile lies a loess layer, in the deeper parts of which lime clods can be found as well as iron and manganese concretions. The average depth of the groundwater table was 3-4 m.

Results and Discussion

Iregszemcse Experimental Station

Fig. 1 shows the soil texture (v = loamy) and the distribution of the nitrate N contents of the soil determined for the treatments studied.

An annual 50 kg N/ha fertilizer dose caused no increase in the nitrate-N content of the soil when compared to the control treatment. The 150 kg N/ha/year dose resulted, when averaged over years, in the nitrate-N content of the soil exceeding the N demand of the plants. This fact was evidenced by a nitrate accumulation in the deeper layers of the soil. In plots fertilized with 250 kg N/ha/year, a total accumulation of 750-780 kg nitrate-N could be detected in the upper 300 cm. The peak of accumulation was found at a depth of 180 cm. In Fig. 1 it can also be seen that the nitrate-N contents of plots fertilized with 150 and 250 kg N/ha/year exceeded those of the control plots throughout the soil profile studied. In the same way, the nitrate-N data of plots fertilized with 250 kg N/ha/year exceeded those of plots fertilized with 150 kg N/ha/year throughout the soil profile.

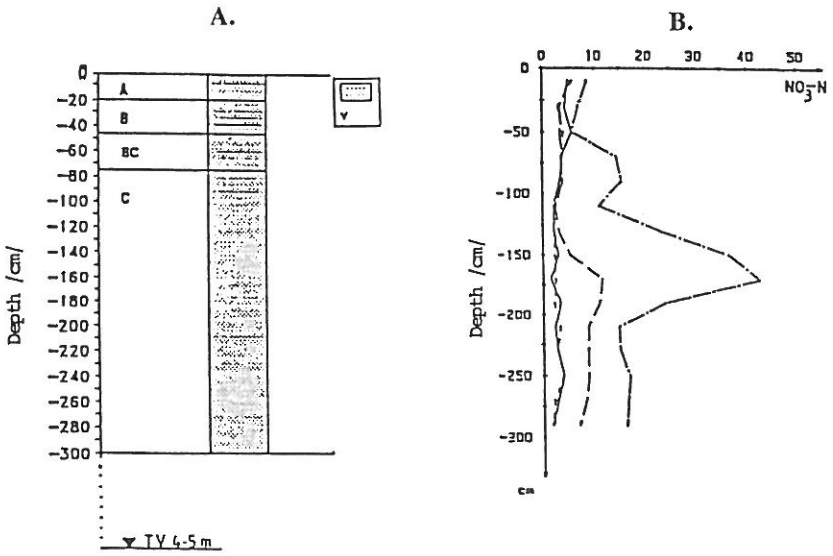

Fig. 1

The soil texture (v = loamy) and the distribution of the nitrate N contents of the calcareous chernozem soil (Iregszemcse) treated as follows: a) control; b) 50 kg N/ha; c) 150 kg N/ha; d) 250 kg N/ha.
Tv = depth of groundwater table

Karcag Experimental Station

The soil texture (a = clay, av = loamy clay, h = sand) and the distribution of the nitrate-N contents in the soils of the treatments are given in Fig. 2.

A real increase in the nitrate-N content of the soil could be determined in the profiles after the two higher (150 and 250 kg/ha/yer) N treatments. In the heavier soil of Karcag, the accumulation zone is more pronounced than in the lighter soil of Iregszemcse. The accumulation peak appears nearer to the soil surface, at a depth of 120 cm. The differences existing between the individual N treatments are smaller in the upper 50 cm of the profile than in the case of the Iregszemcse soil.

Bicsérd Experimental Station

The soil texture (v = loamy) and the distribution of the nitrate-N contents in the soils of the treatments are given in Fig. 3.

This forest soil is a loamy one through its 0-300 cm profile. An annual 50 kg N/ha fertilizer dose caused no increase in the nitrate-N content of the soil

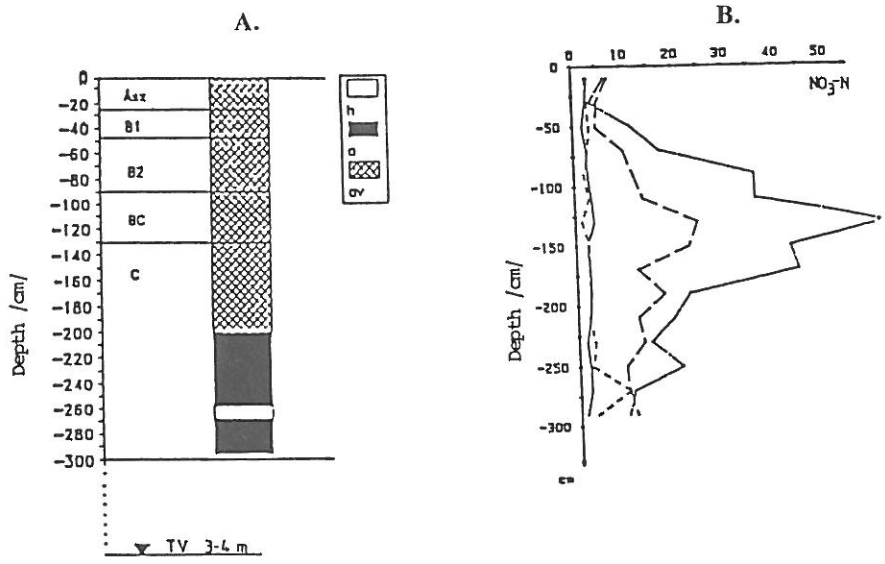

Fig. 2

The soil texture (a = clay, av = loamy clay, h = sand) and the distribution of the nitrate N contents of the solonetz-like meadow chernozem soil (Karcag) treated as follows: a) control; b) 50 kg N/ha; c) 150 kg N/ha; d) 250 kg N/ha.
Tv = depth of groundwater table

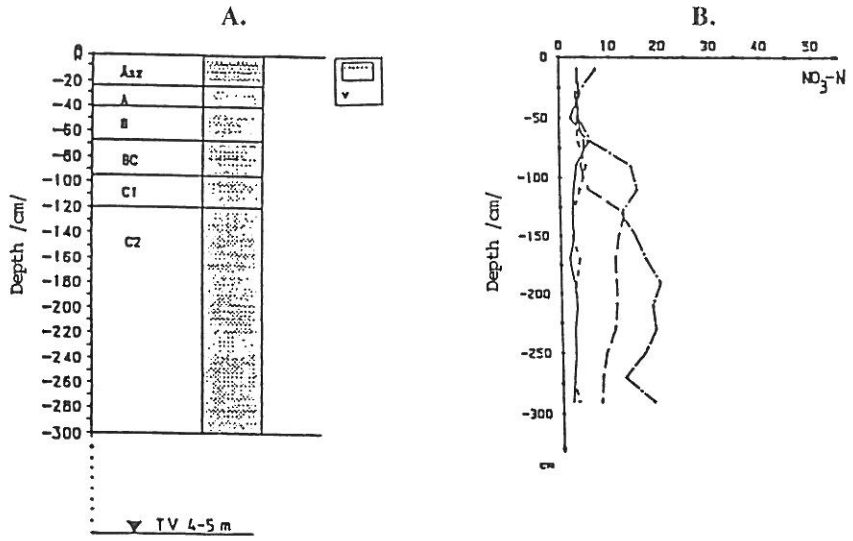

Fig. 3
The soil texture (v = loamy) and the distribution of the nitrate N contents of the forest soil (Bicsérd) treated as follows:
a) control; b) 50 kg N/ha; c) 150 kg N/ha; d) 250 kg N/ha.
Tv = depth of groundwater table

when compared to the control treatment. In this soil no distinct nitrate-N accumulation zone could be found. As a result of fertilization with the two higher (150 and 250 kg N/ha/year) N rates, the higher nitrate-N content caused by fertilization remains almost unchanged in the individual treatments, from a depth of about 50-75 cm down to 300 cm in the profile.

Summary

The influence of fertilization with different N doses on the nitrate-N content of the deeper soil layers are investigated in soils of long-term experiments.

The distribution of nitrate-N with depth was also studied in plots fertilized with different N doses at the experimental stations of the National Fertilizer Experiment Network. Though these experiments were set up according to the same experimental plan, after 20 years of experimentation differences could be detected between the nitrate-N content and nitrate distribution in various plots of the same treatment because of the different soil properties and environmental conditions existing at the individual experimental stations.

The conclusions which can be drawn from the nitrate-N contents and their distribution in plots fertilized with different amounts of nitrogen are very important when evaluating the role of N fertilizer in the nitrate contamination of soils, surface water and groundwater and for the more precise determination of the necessary N doses.

References

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