The Effect of Twenty-six Years of Permanent Fertilization on the Crop and Some Soil Properties

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Introduction

In the last decades environmental pollution (in water, soils and the atmosphere) has multiplied, thus investigations on the impact of fertilization on the environment (soil acidification, nutrient leaching etc.) have come to be of primary importance.

Experimental results obtained in long-term fertilization trials provide essential information on these processes and a reliable database for the interpretation of the possible causes of these changes. These results may also serve as concepts for the broader understanding of the nutrient supplying characteristics of different soil types and crop-nutrient interrelations.

The National Long-term Fertilization Trials in Hungary - established in 1967-1969 - actually have been continued at 9 experimental sites, representing different agro-ecological regions of the country.

The entire program is coordinated by the Pannon University of Agricultural Sciences in Keszthely, which is the founder of the trials and is responsible of the supervision and maintenance of the sites, the analysis of soil and plant samples and interpretation of results (DEBRECZENI & DEBRECZENI, 1994).

There are several other long-term fertilization trials in the country, e. g. experiments with organic manure and mineral fertilizers as well as with crop rotations and liming.

The results introduced in the present paper are from the network of the National Long-term Fertilization Trials (NLFT).

Soils in Hungary show considerable differences in humus and clay content, texture and other properties related to soil fertility. Therefore, the aim of conducting these multilocation trials was to study the long-term effects of increasing fertilizer rates on nutrient efficiency and yield stability. Much attention is given to these factors for the better evaluation of soil fertility (FRAGERIA, 1992).

Long-term trends obtained in the fertilization trials represent inestimable values both in science and practice, as they help the improvement of our knowledge on soil-crop nutrient dynamics needed for the development of nutrient management.

Apart from site characteristics, which show themselves in yield levels, long-term (25-27 years) effects of fertilizer treatments direct our attention to differences in crop responses depending on agro-ecological conditions.

Methods

Two experimental sites, Mosonmagyaróvár (MO) (located in the North-west of the Transdanubian part of the country) and Karcag (KA) (in the Eastern part of Hungary, in the Great Plain), were selected for this presentation.

The main characteristics of the calcareous Danube alluvial soil (FAO category: Calcaric fluvisol) at the Mosonmagyaróvár site are as follows: $CaCO_3$ 21%, sandy loam, humus content: 1.7%, AL-P_2O_5: 141mg.kg^{-1}, AL-K_2O: 107 mg.kg^{-1}, clay: 12%).

Some characteristics of the meadow chernozem soil (FAO category: Luvic chernozem) located at the second site, at Karcag, are: pH_{KCl} : 4.7, clayey loam, humus content: 2.7%, AL-P_2O_5: 34 mg.kg^{-1}, AL-K_2O: 270 mg.kg^{-1}, clay: 37%).

Meteorological data for the experimental sites are listed in Table 1. For characterizing the climate conditions, the mean values of 50 years (1901-1950) are given in the first part of the Table, including the experimental sites of the

Table 1
Meteorological data of the experimental sites

Parameters	Mean of 50 years (1901-1950)*		Mean of experimental years (1968-1987)**	
	Mosonmagyaróvár	Karcag	Mosonmagyaróvár	Karcag
Precipitation, mm				
Annual sum	594	527	554	476
In vegetation period:				
Winter wheat (Oct-June)	421	377	394	350
Maize (April-Sept)	338	315	319	300
Air temperature, °C				
Annual mean	9.6	10.0	9.7	10.4
Winter mean	-0.4	-1.3	0.1	0.1
In vegetation period:				
Winter wheat (Oct-June)	6.8	6.8	6.9	7.5
Maize (April-Sept)	16.2	17.4	16.2	17.7

* data from the Ministry, ** data observed at the sites

NLFT. Further details related to other parameters are available in DEBRECZENI (1991) and DEBRECZENI & DEBRECZENI (1994).

Marked differences in precipitation can be found between the Transdanubian district and the Great Plain. At the sites located in the Great Plain, the amounts of precipitation are smaller. Similar differences can be seen between the ratio of evapotranspiration (ET) and potential evapotranspiration (PET) values. Among the experimental sites of the NLFT, both similarities and differences can be observed. Mean values in the amounts of annual precipitation, even when calculated for the vegetation period of the two main crops (winter wheat and maize), are very similar to each other at sites located in rather different agro-ecological regions.

Climatic differences between the NLFT sites can also be observed in the data calculated for the hydrological year (1 Oct-30 Sept) or for the vegetation period of winter wheat (1 Oct-30 June) and maize (1 May-30 Sept.): the total amount of precipitation for winter wheat fluctuates between 350-470 mm, while it is between 300 and 378 mm for maize.

Long-term effects of 10 fertilizer treatments on grain yields of winter wheat and maize were studied (plot size was 50-70 m^2) in four-year rotations of wheat-maize biculture.

Crop rotations were initiated over a successive four-year period after 1967. Code numbers indicating the fertilizer rates are given in the order of NPK. Nitrogen fertilizer rates gradually increased by 50 kg, from 50 to 150 kg N per ha (code numbers: 0-1-2-3), phosphorus rates from 0 to 100 kg P_2O_5 per ha (code numbers: 0-1-2) and potassium rates were 0 and 100 kg K_2O per ha (code numbers: 0-1). Treatment codes selected for this study were as follows: 000, 101, 201, 301, 111, 211, 311, 121, 221 and 321.

The evaluation of long-term effects was carried out by calculating the cumulated grain yield results of winter wheat and maize obtained in the experimental years.

Main averages of yields obtained in each treatment of the crop rotations (plotted as zero points) and average differences (as cumulated values) are given in Figures 1 and 2, indicating either positive or negative values. These values represent responses of winter wheat and maize to increasing fertilizer rates after 4-8-12-16-20-24 years. Main averages of grain yields are given below the Figures as 0 values of the x axis.

Results and Discussion

Cumulated grain yield results (in tons per hectare) of winter wheat and maize are summarized in Figures 1 and 2, respectively.

From these results it can be suggested that adequate soil P level is a determining factor in winter wheat yield. The unfavourable effect of P deficiency could be reduced by N application, however, differences were still remarkable.

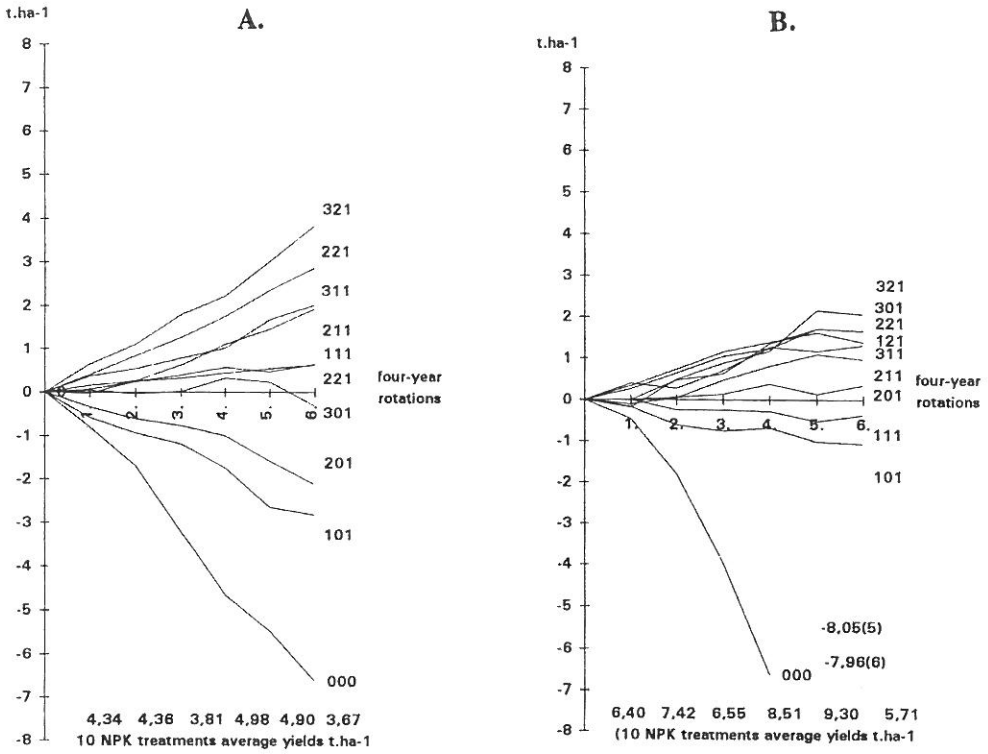

Figure 1
Cumulated grain yield differences (in tons per hectare) of winter wheat (A) and maize (B) at Mosonmagyaróvár

A considerably higher phosphorus adsorption could be observed for maize in the fine-textured (clay %) meadow chernozem soil (KA) than in the coarse-textured MO sandy loam in which diffusion movement of phosphorus is apparently better. Curves demonstrating effects of P deficiency in this soil are similar to those obtained in the MO soil. Although there were less curves in the negative interval for P deficient treatments.

Conclusions

Cumulated yield differences are effectively representing crop responses to long-term fertilizer effects.

Winter wheat responses to balanced macronutrient fertilization were more expressed than that of maize. This was especially remarkable in the case of

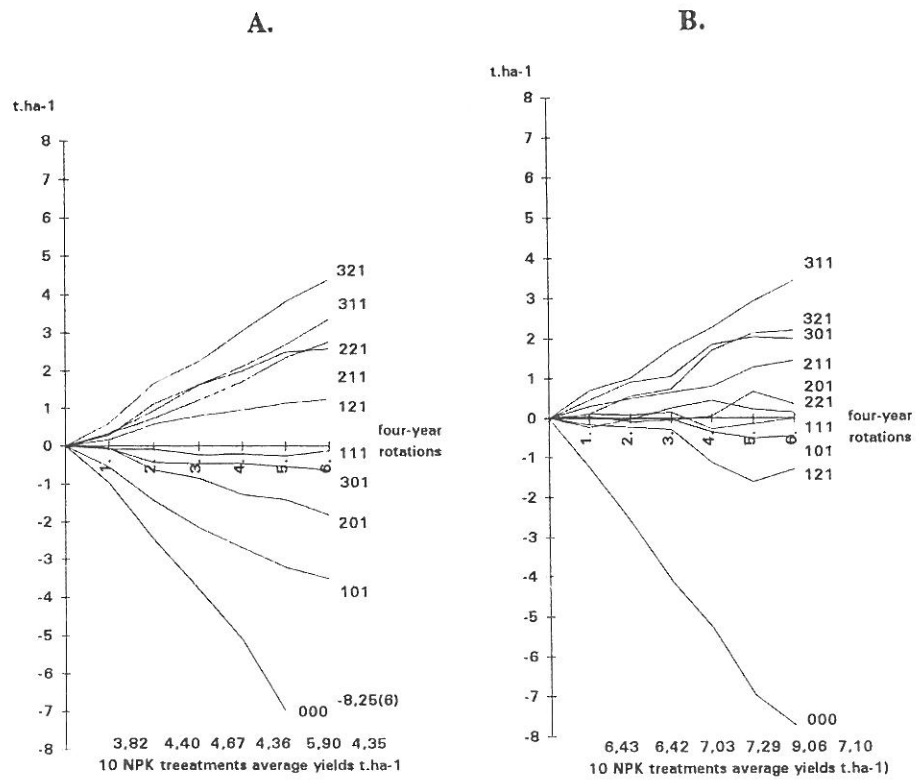

Figure 2
Cumulated grain yield differences (in tons per hectare) of winter wheat (A) and maize (B) at Karcag

phosphorus responses, which are related to the formation of grain proteins. Increasing N fertilizer rates - without P application - markedly reduced winter wheat grain yields, but only moderate responses to P nutrient imbalances were observed for maize yields.

Crops have specific responses to adequate phosphorus supply. The ability of maize in utilizing soil phosphorus resources may be a question to be studied.

Differences in yield responses were even marked in subsequent years, therefore it can be concluded that long-term effects may serve as more reliable information on crop responses for soil fertility evaluation.

Long-term yield curves obtained from the main averages of rotations can effectively demonstrate yield differences related to agro-ecological and climatic conditions.

References

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