

Soil Fertility Factors for the Growth of Hungarian Cereal Production

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For hundreds of years, up to the fifties of this century, an improvement in soil fertility in Hungary was considered to be possible only by increasing the in-farm circulation of nutrients.

West European countries started utilizing factory-made mineral fertilizers from the middle of the past century on. The beneficial effect provided by artificial manures made farms utilize more and more of them.

In Central Europe, specialists in Hungary and in other countries with a semi-arid climate refused to utilize mineral fertilizers, since in their opinions the water shortage was so great as to prevent the uptake of mineral nutrients. They thought that of all the fertilizers distributed on the soils, it was only manure that had the exceptional quality of being utilizable even in more arid years. That is why the main theory for improving soil fertility in Hungary was:

more animals - more manure - higher yields.

This theory had no great reserves, since the animal maintaining capacity of any country is limited. The number of animals cannot be increased beyond a certain point, and accordingly, the volume of nutrients cannot be increased either. Consequently, crop levels, including the yields of cereals, which occupy most of the fields in Hungary, hardly improved over the previous century. The slight progress attained during the decades immediately preceding the 1960's was mostly due to new species, and in the case of maize, first to the spread of species /e.g. *Zea mays convarietas dentiformis*/ having a longer breeding season and then of hybrids in general.

A new change in Hungary's soil conservation

In 1962 a government decision was made, aiming to double the volume of Hungarian plant production by 1980. Our Institute was charged with finding an efficient means of carrying out this large-scale improvement. Through the use of several methods it was proved that in most years the water supply is capable of producing 12 t/ha phytomass, instead of the 3 or 4 t/ha yielded in previous years. Of the two most important factors for crop yield improvement, in Hungary as elsewhere, it was not the water supply, but the amount of nutrients that was deficient.

Several methods were elaborated to define water supplies that, depending on soils and species, make different levels of mineral fertilizer utilizable.

In accordance with the available water supply, a yearly average utilization of 250 kg/ha NPK fertilizers was projected for the years between 1960-1980, against the 16 kg/ha N- P_2O_5 - K_2O fertilizers used on average between 1950-1960. In actual fact, 266 kg/ha of fertilizers were utilized. It was cereals, particularly wheat and maize, that gave the best response to mineral fertilizers. It is due to the results mentioned above that in the course of twenty years /1960-1980/ Hungarian yields caught up with those achieved in Western Europe /Fig. 1/.

Over the past twenty years, on a national average, cereal yields have increased from 1.6 t/ha to above 4 t/ha and maize yields from 1.8-2.0 t/ha to over 6 t/ha. The amount of N, which has a decisive effect on yields, plays a special role in the case of every species. To obtain wheat yields of around 4 t/ha and maize grain yields of above 6 t/ha on a national average it is necessary to utilize about 140 kg/ha of N fertilizers for wheat and 180 to 240 kg/ha for maize. These data are much in accordance with international findings.

A water supply improved to an optimum level through irrigation will modify the demand for N in proportion to the needs of each crop. In the case of wheat the level of N has to be decreased by about 60 kg/ha.

In the case of maize, however, an increase in the water supply to the optimum will bring about a need for about 60 kg/ha extra N fertilization. The extra yield expected as a result of irrigation will only materialize if higher N doses are applied.

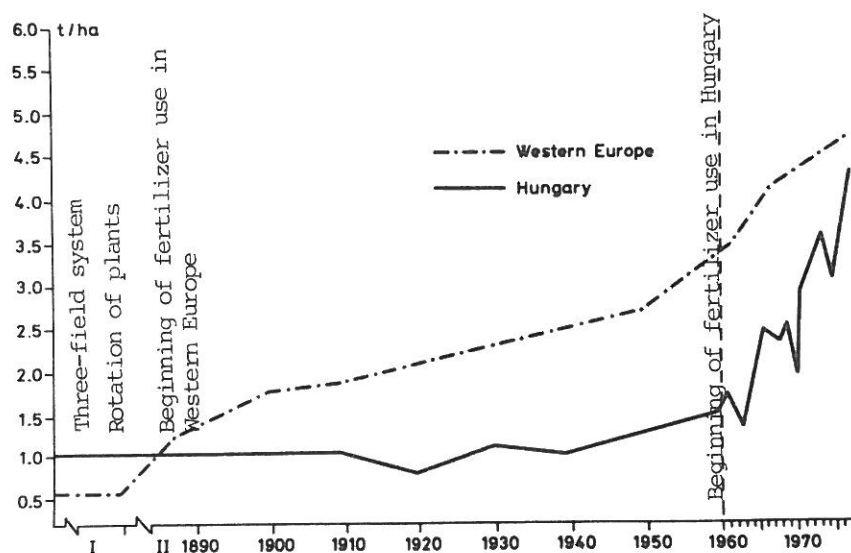


Fig. 1

Yield of wheat from the Middle Ages to our time

Different wheat and maize varieties were tested using 0-60-120-180-240-300 kg N+PK/ha doses with and without irrigation. More recent varieties capable of giving higher yields need relatively high doses of N. It is characteristic of newer, more productive varieties, mainly of maize and to some extent of wheat, that the yields in control plots were higher compared to those for previous varieties, thus the yield increases per N+PK doses diminished.

For twenty years, since higher doses of fertilizers have been utilized, yields have gradually increased while nutrient levels have remained the same. It is evident that the increase is partly due to the better productivity of the varieties, but increased soil fertility and microbiological activity have also played a role.

Under Hungarian conditions top yields are usually around 8 t/ha in the case of wheat and 12-14 t/ha for maize. 10 t/ha of wheat and 14-16 t/ha of maize can only be harvested in very good years or when the groundwater level and green crops are favourable.

In future it will only be possible to achieve further greatly increased yields and to ensure yield stability through regular water supply compensations.

A system of irrigation new even on an international scale has been elaborated and put into practice. Characteristics of the new irrigation system are as follows:

- the extension of summer irrigation /June-July-August/ to the whole period of vegetation, i.e. from March to November, which means from spring frosts till autumn frosts;
- even with a yearly precipitation of 400 to 500 mm the greatest concern is to create the possibility of irrigation in 7 years out of 10;
- both for reasons of economy and to ensure safe irrigation, it is advisable to concentrate irrigation on the most productive plots which also have a vast layer of groundwater and where it is possible to give reliable forecasts as to irrigation norms, indicating the water supply and levels of irrigation from March to November;
- within the framework of the system regular irrigation has been introduced for wheat, rye, barley, oats, pea, poppy, autumn coleseed, etc.;
- it is possible to greatly minimize the summer irrigation peak by watering the above crops before the summer irrigation season, in early spring, and in the autumn of the previous year;
- using the extended irrigation period it is possible to decrease the amount of irrigation equipment per unit of land and to reduce their size. It is also possible to irrigate in a highly concentrated way, to cut down expenses and to make use of the water which flows out of the country abundantly in spring.

The results of tests of many years on plant species and varieties give a basis for ranking plant species according to their response to irrigation. Within the species, there are great deviations in the response of different varieties and only relatively few of them respond efficiently enough to irrigation.

About 86% of the production of field crops is made up from the carbon, oxygen and hydrogen in the atmosphere. The current findings show that the efficiency of photosynthesis can be best influenced by increasing the amount of nitrogen. Over the past 20 years the 10 kg/ha of N utilized for centuries has been increased to more than 100 kg/ha, which in turn, on a national average, has made it possible to increase the amount of carbohydrate in phytomass production from 5.4 t/ha to 8.6 t/ha. Optimum effi-

ciency can only be achieved if the necessary harmony of plant nutrients is ensured. Greater and greater attention should be paid in future to securing the right proportions of mezzo- and microelements, the use of which is important in the case of cereals, parallel to weed control and plant protection in the form of fertilizer sprays.

Summary

For a long time, specialists in Central and East European countries with a semi-arid climate believed that only manure could be efficient because of the drought. They calculated that only 50 kg/ha of $N-P_2O_5-K_2O$ mineral fertilizers could reasonably be utilized.

In Hungary, within the long-range plans executed between 1960 and 1980, it has been proved that by utilizing the water supply at our disposal it is possible to make use of 10 to 20 times more mineral fertilizers than the amount of $N-P_2O_5-K_2O$ active agent contained in the manure in in-farm nutrient circulations. The idea to increase the amount from 16 to 250 kg/ha over the span of four five-year plans was put into effect with a consequence doubling in yields on a national average. Thus over a period of twenty years Hungarian yields caught up with the levels achieved in Western Europe.

In the case of wheat about 140 kg/ha N fertilizer was utilized and about 180 kg/ha in the case of maize. The varieties are tested using 0-60-120-180-240-300 kg/ha N doses with and without irrigation.

A new irrigation system has also been worked out for soils with a groundwater layer of more than 2.5 metres. Cereals, peas and other leguminous plants, poppy and autumn coleseed are irrigated not only during the traditional seasons, but also during periods outside these seasons.