Research in Agricultural Chemistry in Hungary

B. DEBRECZENI

Keszthely Agricultural University, Keszthely /Hungary/

The Soil Science Committee of the Hungarian Academy of Sciences set up the "Research on Agricultural Chemistry" project in 1980, and the Agricultural University of Keszthely was entrusted by the Ministry of Food and Agriculture with the professional and financial coordination. About twenty institutes and university departments were involved in the research, with the participation of several hundreds of teachers and research workers.

The projected research programme

The basic programmes and the most important topics were as follows:

I. Study of the relationship between mineral nutrition and the metabolic processes of plants.
   1. Studies on ion uptake through the roots.
   2. Examination of ion uptake through the leaves, and the effect of urea sprays.
   3. Effect of mineral fertilizers on yield quality.

II. Development of new methods of soil and plant analyses to help the advisory system service on mineral fertilization.
   1. Modernization of the methods used in soil and plant tests.
   2. Rating of valid limit values based on research for use in advisory services.

III. Examination and evaluation of ecological and agrochemical fertilization.
   1. Increasing the yields of the most important crops and their cultivars.
   2. Agrometeorological factors and their relation to the efficiency of mineral fertilization.
   3. Development of economic planning information, and biometric and mathematical modelling.

IV. The nutrient cycle, a study on the calculation method of nutritive balance.
   1. Determination of the mobility of nutrients and their losses under different field and growth conditions.
   2. The organic matter management of the soil /biological decomposition of humus and organic wastes/ from the point of view of nutritive matter cycle.

V. Testing the efficiency of new solid and liquid mineral fertilizers.
   1. Testing some new mineral fertilizers, their efficiency.
   2. Discovery of inexpensive preparations containing microelements; elaboration of ways of application.

VI. Utilization of organic wastes and manure.
   1. Study of the utilization of "thin" and "rich" manure.

VII. Prevention of environmental pollution caused by fertilization.

VIII. Interdisciplinary research to elucidate the biochemical role of microelements.

Important research results /1981-1983/

Theoretical and basic findings:

- The environmental stress effects /herbicides, pH/ have less influence on the ion uptake system of wheat roots, than on maize plants or rice. This is due to the fact that low pH /H^+ stress/ values resulted in a membrane /plasmalemma/ injury and consequently a considerable loss of K^+.
- As the result of a decrease in pH, the uptake of auxine-type /2,4 MCDPA/ herbicides increases with a proportionate rise in their phytotoxic effect /inhibiting ion uptake and growth/. Atrazine, for example, had a favourable effect on the mineral substance content of plants.
- The N-uptake of wheat and maize through the leaves from ammonium nitrate and urea containing ^{15}N showed that maize can fully utilize N from smaller doses of N and 70-90% of the mineral fertilizer N is incorporated into the grains. Wheat, however, did not show more than 40-50% utilization of N.
- Higher NPK doses increased the protein content and baking quality of maize, spring barley and winter wheat grains. It was also found that higher doses of NPK increased the Mn content of wheat, owing to the acidification of the soil. The Zn content in maize grain, cobs and horse beans decreased proportionately with the level of P doses; this is possibly due to P/Zn ion antagonism.
- After preliminary work carried out in 1981, the methodology of the molecular weight separation of proteins was elaborated. This made it possible to study the effects of mineral fertilization on wheat and maize in greater depth.
- It became evident from amino acid tests that the amount of non-essential amino acids, especially that of glutamic acid, shows an increase parallel with the increase in N doses. A similar increase in lysine and cystin was also observed. Methionine, however, did not show any change.
- The total weight gain of chickens fed with wheat grown using large doses of NPK was better than that of chickens fed wheat given no mineral fertilizers. The erathro-count was 17.5% higher in the latter case. Haemoglobin production was less intensive. The physiological rate of resorption in the liver function showed only minor differences.
- Elaboration of soil test methods.
- The results obtained using the Chaminade vegetation pot method proved that the correlations between measured levels of P-uptake and Chaminade indices were very close. The method is good for evaluating soil test methods.
- Using the Rinkiss-Nollendorf method, satisfactory data were obtained for macro- /N, P, K, Mg/ and microelements /Mn, Zn, Cu/ in field experiments. Consequently, the method can be applied for determining the macro- and microelement fertilizer doses required for Hungarian soils.

- A full N cycle was studied in certain grassland communities, taking the associations /mineral fertilizer - soil - vegetation - Articulata on the ground surface/ into account, using isotope analysis data and the total N content values.
- As a result of large amounts of sulphate and chloride ions, the application of extreme doses of PK fertilizers has a depressive effect on cellulose decomposition. It also brings about a change in the equilibrium of the microflora composition of the soil.
- The number of Azotobacter Chrooc. was not affected by increasing NPK doses, though the rate of denitrification considerably increased. The rate of cellulose decomposition doubled compared with the control. Liming and the use of mineral fertilizers increased the cellulose decomposition process.
- Using the complex humus state evaluation method it was found that an intensive, prolonged application of mineral fertilizer can only slightly increase the humus content of the soil, though the application of organic fertilizers, especially on soils with a low humus content, may increase it to a considerable extent.

Conclusions promoting development and practical work

- The Mv8, TALENT, Sava and NS Rana 2 cultivars tested all proved that the later the N fertilizer /^{15}N/ was applied, the greater amounts of fertilizer N were incorporated into the grains, though there were very great differences for the various cultivars. NS Rana 2, for example, took up half as much N from the fertilizer as TALENT, in spite of the fact that the N content of the grain showed considerably lower values.
- While maize plants given no basic N treatment /$\emptyset$ and PK/ used the N taken up from foliar urea spray labelled with ^{15}N mostly to develop the shoots, those grown on soils given various N levels, utilized the N in the reserve protein of the grain.
- No correlation was found between the infection of winter wheat with Septoria, the number of pests on the leaves of potatoes, and the rates of mineral fertilizers in 1981-1982.
- The fusariosis of corn cobs increased proportionately with the one-sided application of N fertilizers in continuous cultivation /the rate of increase was 16-21%/. As the result of increasing NPK doses the prolification of Lema Spp. was greater in winter wheat.
- The application of urea spray in winter wheat in the late afternoon hours during ear formation increased yields by 0.2-0.3 tons/ha over the average of two years, though this is statistically unverifiable.
- The after-effect of foliar sprays in maize grown for silage on brown forest soil did not increase yields. The protein content showed a linear correlation with the N content of the soil and the N fertilizer doses.
- A uniform principle for the application of mineral fertilizers was elaborated on a national scale. This forms the basis for the present application and doses of NPK fertilizers.

The starting point for this concept is the amount of required nutrients. The specific agent for the particular mineral fertilizer is given in tables showing yields in kg/tons for every crop grown, taking the quality grade of the fields /including soil types/ and the limit values of the nutrient supply into account.

The calculated mineral fertilizer rates are corrected for various effects resulting from different forecrops, the application of manures, irrigation and amelioration, or detrimental soil chemical properties.

- This uniform concept presents suggestions for efficient liming, and for the use of magnesium and certain microelements.

By using the samples taken for the Hungarian mineralogical map, a correlation was sought between the fixation of calcium and ammonium ions and the availability and quality of soil colloids based on X-ray diffraction changes. All these findings may lead to improvements in the advice given on fertilization.

- Results obtained in N fertilization experiments on winter wheat show that a favourable increase in yields was obtained in a rotation of cereals on Ramann-type forest soil, with a dose of 170 kg/ha, whereas on brown forest soil on sandy parent rocks a dose of 160-200 kg/ha was required. N fertilizers reliably increased the mineral N content of the soil measured at different times of the day. Based on experiments continued for ten years on spring barley it was found /on Ramann-type brown forest soil/ that the best dose of N was 60-80 kg/ha; higher amounts of N resulted in a slight yield decrease.

- When testing pseudogleyic soils it was found that liming had less effect in increasing yield than fertilization, but was more economical. In the western part of Hungary liming is very important, since it creates good conditions for other factors to take effect, at the same time providing an opportunity to keep the soil in good condition and for amelioration. It would be preferable to apply more lime than necessary to avoid unexpected, undesirable changes in the soil, though sustenance liming must be given greater priority. The results in this field of research are being continuously put into practice.

- By analysing the data collected between 1970 and 1981 from several agrometeorological stations belonging to the Central Institute for Aerology /meteorological, phenological, phenometric observations supplemented with soil moisture and water consumption measurements/ the following conclusions were drawn for maize: the various doses of fertilizers had no effect on the length of the phenological phases, but had a marked effect on foliar development, and consequently on evapotranspiration. The increased assimilative surface affected the yields. With a better nutrient supply the influence of the weather is reduced, and the stability of the yields is thus improved. The results of this work have been published in a scientific review.

Using uniform test methods /efficiency coefficient/ elaborated within a COMECON scientific cooperation involving experiments on the application of mineral fertilizers, calculations show that the level of surplus yields proportionate to the amount of fertilizer applied can be forecast much more reliably than with the previous calculation method. Knowing the amount of surplus yield, the various efficiency indices can be more easily calculated. Results cannot be expected until the second half of the present five-year plan period.

- It became evident that increasing NPK fertilization on acidic brown forest soils caused a considerable decrease in the pH value of the soil, at the same time increasing the P-K content of the soil. These processes - one positive the other negative - from the point of view of cultivation, can be well detected with soil tests and can be used very efficiently in giving expert advice on fertilization.

- On forest soils in Western Hungary N losses amounted to 7-31 kg, while this figure was 8-38 kg N/ha on acidic soils. The nutrient content of the water flowing away through drain-pipes showed the highest levels during the winter-spring period, when 80% of the total loss was entailed. The nutrient content of drain waters showed the following order during the winter period, in kg/ha: N /18/ - Ca /9/ - K /1.2/ - P /0.1/. During the summer period the order was as follows:Ca /1.2/ - N /0.9/ - K /0.2/ - P /0.02/.

- The total NPK balance of Hungary has been estimated together with a prediction of the long-term fertilizer demand.
- The capacity of the soil for various organic wastes is determined by their nutrient contents, and not merely by their amounts. This fact makes it possible for large amounts of organic wastes to re-enter the biological cycle through the soil. This holds true for the placement of sewage-sludge, too.
- In experiments on the best possible technical conditions for the application of liquid fertilizers, a "family" of corrosion-proof containers for storage and transport and a liquid fertilizer manipulator unit were designed.
- An examination of the labour organization aspects of using solid and liquid chemical fertilizers and a study of the on-farm labour processes showed the use of liquid fertilizers to be favourable not only from the viewpoint of agronomy, but also with regard to labour organization: the worktime demand for the whole application is considerably reduced.

The initial results of using stimulants and retardants show a favourable picture, but the studies direct attention to the fact that their practical application is only possible after far-reaching basic research.

Nutrition without manure can be carried out with no reduction in yield for a considerable length of time, but the application of manure leads to a substantial saving in mineral fertilizers.

- The application of green manure had a considerably lower effect on yield. The feeding of green mass /the so-called "Kecskemét method"/ had a much better effect. The reducting effect of stable green manure on yields has again been confirmed.

The results of long-term experiments conducted in Kompolt on chernozem forest soils can be summed up as follows: both the direct and indirect effects of green manure with papilionaceae on yields and on the efficiency of fertilizers were small. With the application of manures, however, the pronounced P-Zn ion-antagonism can be eliminated together with the P-doses.

Within the framework of the research, some prototypes of household compost-making devices were produced.

The examination of pulverizing drying methods for liquid cattle manure started with an analysis of some of the feasible methods. An evaluation of the possibilities for converting liquid manures and sewage sludges into marketable manures was also initiated. Compost-making experiments were conducted with dried manure and with communal sewage sludges.

The results obtained will be utilized in further research. Results suitable for practical use can only be expected towards the end of the current five-year plan period.

- The examination of the environmental pollution possibly arising from fertilization and of ways of avoiding it /7th basic programme/ is the subject matter of several agrochemical, ecological and other research projects focusing attention on the protection of Lake Balaton.