SOIL ANALYSIS (FOR PLANT NUTRITION) IN HUNGARY: PRACTICE AND RESULTS

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INTRODUCTION

Hungary is situated in the Carpathian basin of Middle-East Europe. The 66.9 % of its 9.3 million hectares territory is agricultural land (Table 1.). This ratio is higher than the average in the EU or OECD countries, or even in the whole World. This fact provided a special situation for Hungary in the last one hundred years, as agricultural production had a great importance.

On the other hand, it is also a fact, that because of the basin-character, Hungarian soils are very diverse by soil classification. Brown forest soils (34.6 %), chernozem soils (22.4 %) and meadow soils (13.1 %) are dominant (http://www.uni-miskolc.hu). Chernozem soils with the best production capacity can be found on Trans-Tiszanien, Trans-Danubia regions and between the Danube and Tisza rivers in Bácska. A special land rotation had been formed during the past two hundred years in these areas, which is still exists with some changing.

Table 1. Development of the ratios of cultivation types from the total land area (%) (Statistical Yearbook of Agriculture 2005, 2006; Statistical Yearbook of Hungary 2006, 2007)

Land use	Hungary	EU-15	OECD	World
Arable land, vegetable garden and fruit plantation	54.5	27.9	13.3	11.1
Grass	12.4	18.6	25.3	26
Agricultural area	66.9	46.5	38.6	37.1
Forestry	19.1	36.3	33.5	31.7
Area (1000 ha)	9 303	313 025	3 352 529	13 045 423

To understand the present situation, we should survey the historical processes joined to the plant production of the past 50 years. Figure 1. shows the

increasing use of mineral fertilizers and the yield data of the three most important products (winter wheat, maize and sunflower) from 1960 to 2005. The diagrams demonstrate very well, that from 1960 to 1975 the total amount of used NPK fertilizers increased and remained more than 200 kg/ha reached the 248 kg maximum amount in 1983 and then there was a slow decreasing period till 1989, when there was a political change in Hungary, moreover there were other changes also. reaching almost the 250 kg in 1983. During two years (from 1989 to 1991) the amount dramatically decreased to tenth part, and from that time there is a slow increase again. Regarding the yield data of the three plants, there is a decrease in the yield of winter wheat from 1990, and harvest fluctuation was increased. There is a more evident harvest fluctuation in the production of maize, because of the interaction of ground water and nutrient supply in soils.

To understand this process we can see the followings, how we can describe the Hungarian practice in the soil analysis in the period from 1960 to present days:

- 1960-1980 increasing yields
  - Soil test compulsory every 3 years
  - Organizing a large number of well-equipped laboratories
- 1980-1990 terminating compulsory tests
- 1990 political-economic change, fragmentation of producers, decrease in the number of large-scale enterprises
- 1990-2000 sharp decrease in the use of mineral fertilizers
- 2004 Hungary joins the EU

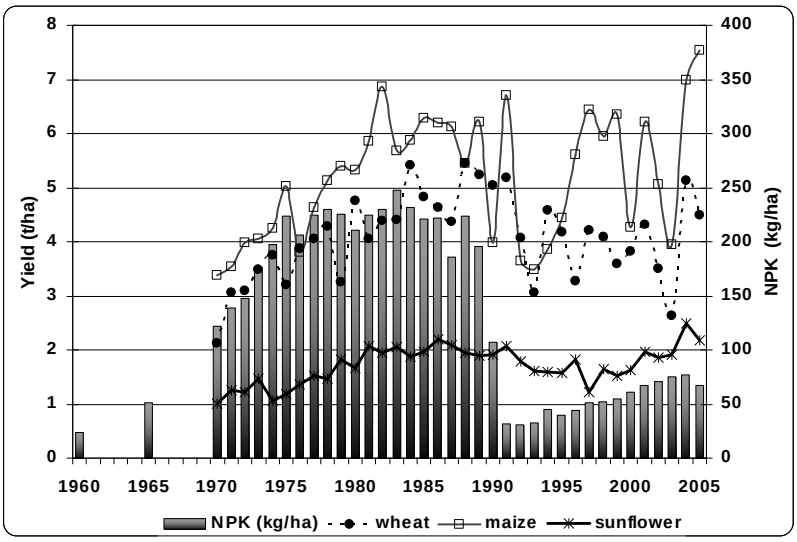

Figure 1. The application of mineral fertilizers in Hungary and wheat, maize and sunflower yields (Csathó et al., 2005; Németh, 2006)
NPK active ingredients per agricultural area

The main tendencies are shown in the above. During the 50 years period plant production and soil nutrition management in Hungary followed the political and economic decisions that were enforced through different regulators. Joining of Hungary to the EU in 2004 seems to be the most important event for Hungary, which is to improve the quality of different products, to reduce the cost, to prevent our environment, to battle against the overproduction.

NUTRIENT MANAGEMENT IN HUNGARY AND IN THE EU 15

In the followings the main characteristics of nutrient management in the EU 15 are detailed, which should be put into Hungarian practice also:

- Opportunities for subsidies offered for agricultural-environmental and organic/ecological farming are applied on environmentally sensitive areas
- Due to the high numbers of animals the regulations on the nitrate directive are not applied in the majority of the EU countries and further claims for derogation are submitted
- On environmentally not sensitive areas there has been a clear concentration of landed properties recently and so the intensity of agricultural production increased on these farms.
- Considering the principles of sustainable agricultural development – in a manner adapted to the particular area – the maintenance of the productivity of arable land areas is guaranteed in almost every EU member state (compulsory soil testing – linked to subsidies – operational extension services, compulsory preparation or giving accounts of the nutrient balance etc.)
- Limitations on nutrient management have so far worked as declared, expectable requirements. It seems that the principle has not brought about the expected effects and results in a number of member states.

A monitoring by authorities is to become necessary although in some EU countries organizations to carry out the task do not even exist.
We can make some comparison between in the practice of the 15 countries of EU and Hungary. Table 2. shows a brief summary, the characteristics of nutrient management in the EU 15. We can pay attention to the differences among the nutrient managements of the EU 15. For instance the high quantity application of mineral fertilizers in the Benelux States or Spain and Portugal apply similar quantity fertilizers (Table 2.) to ours (Figure 1. Hungary: the amount of total mineral fertilizers is approx. 50-80 kg/ha).
There is a desirable forecast for mineral fertilizer application in the EU for the period 1999-2009, when the EU would like to decrease the N utilization by 7%, the P utilization by 10% and the K utilization by 4%. During the same period, however the wheat yields are intended to be increased from 5.8 t/ha to 6.2 t/ha (http://ec.europa.eu/).

Table 2. Use of mineral fertilizers in the EU member states in 1998
Agricultural land area (kg/ha active ingredients)

	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)	Total
Austria	33	16	19	68
Belgium/Luxemburg	117	35	61	213
Denmark	107	19	37	163
Finland	81	26	36	143
France	83	37	47	167
Greece	59	26	13	98
Holland	188	34	33	255
Ireland	87	28	34	149
Great-Britain	79	25	28	132
Germany	103	24	38	165
Italy	55	31	24	110
Portugal	29	13	12	54
Spain	35	18	16	69
Sweden	66	16	17	99
EU 15	**70**	**26**	**30**	**126**

Besides various mineral fertilizers, manure and sewage are applied in soils as the source of different elements, furthermore various organic matters. In EU countries the ratio of the used mineral and organic fertilizers is equal. With increasing yield, these countries intend to decrease the amount of mineral fertilizers. However the ratio of the used mineral and organic fertilizers in Hungary is not far equal. The quantity of manure is only 2 %. In Hungary we should increase the quantity of manure, however the number of animals was decreased dramatically in the last years, so we do not have enough manure to apply.

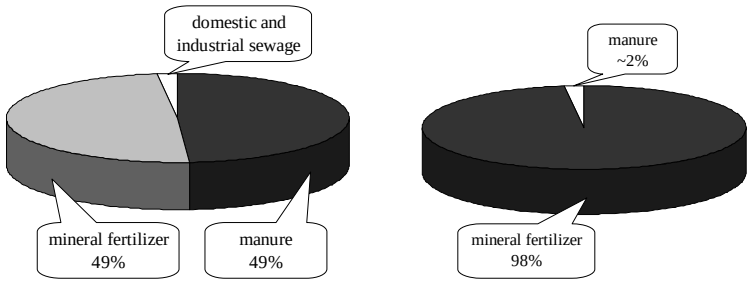

Figure 2. The application of fertilizers in the EU countries (left) and in Hungary (right)
(Source: European Fertilizer Manufacturers Association (EFMA))

The application and ratios of mineral and organic fertilizers are demonstrated in Table 3. There is the same tendency in NPK usage than before, while the ratio

of the areas where organic fertilizer was applied decreased from 25 % to 2 %. The total amount of the applied organic fertilizer also decreased from 30 millions t/year to 3 millions t/year. Nowadays the application of organic fertilizer is approximately less than tenth part then approximately 70 years ago.

Table 3. The application of mineral and organic fertilizers in Hungary (1931-2005) (Csathó et al., 2005; Németh, 2006; Kádár 1987, 1997, 2007)

Period	Arable land +gardens +orchards +vineyards	Use of mineral fertilizer active ingredients		Use of organic fertilizer		Land area where organic fertilizer is applied
		1000 t/year	kg/ha/year	million t/year	t/ha/year	ratio %
	million ha	NPK	NPK			
1931-40	5.95	13	2.2	30	5.04	25
1941-50	5.9	35	5.9	26.5	4.49	21
1951-55	5.85	35	6	25.7	4.39	20.1
1956-60	5.75	140	24.3	21.5	3.74	18.1
1961-65	5.63	299	53.1	20.5	3.64	13.7
1966-70	5.62	615	109.4	22	3.91	13.7
1971-75	5.54	1205	217.5	14.6	2.62	7.6
1976-80	5.39	1467	272.2	14.3	2.65	7.4
1981-85	5.3	1493	281.7	15.3	2.92	7.6
1986-90	5.25	1081	207.1	13	2.48	6.2
1991-95	5.02	224	44.6	6.3	1.25	3.1
1996	5.04	272	54	4	0.79	2.1
1997	5.05	288	57	4.9	0.97	2.4
1998	5.04	328	53	3.3	0.65	1.9
1999	5.04	346	56	3.9	0.77	2.1
2000	4.8	355	61	3.9	0.81	2.3
2001	4.8	395	67	2.9	0.60	1.8
2002	4.8	423	72	3.9	0.81	2.0
2003	4.8	439	75	3.6	0.75	1.8
2004	4.8	453	77	3.7	0.77	1.8
2005	4.8	392	67	3.0	0.63	1.7

RESULTS AND DISCUSSION

Evaluation of the findings of domestic soil tests 1978–2005

Figure 3. shows the average phosphorus and potassium contents in soil (on the basis of the data for West Hungary, 308 269 ha). Figure 3. represents the results of phosphorus and potassium analyses during the last 30 years (Horváth et al., 1999; Németh et al., 2006; Pálmai et al., 2003). The concentration of potassium in soil reached the maximum value (245 ppm=245 mg/kg) in 1989 and the content of phosphorus in soil reached the maximum value (208 ppm) in the same year, when Hungary had the political and economical changes. These concentration data confirm that from 1990 until today, we tried to utilize the advantages of the so called nutrient loading. At the same time, the potassium supply of our soils dropped below the 1978-1980 level, while as regards phosphorus the effect of the loading is still exist.

This trend is clearly visible on Figure 4. It shows the results of soil sample analyses taken on 308 269 ha land area in the West-Hungary, representing that the ratio of very good-supplied areas with phosphorus has decreased to its third from 1990 until 2006, at the same time, the ratio of medium-supplied areas has increased from 10 % to 27 %, while the good-supplied areas with phosphorus remained in the range of 44-55 %.

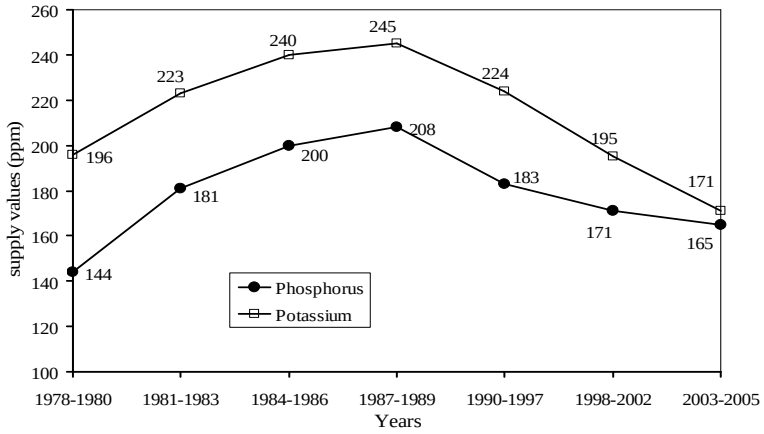

Figure 3. Phosphorus and potassium contents in soil (West-Hungary, 308 269 ha)

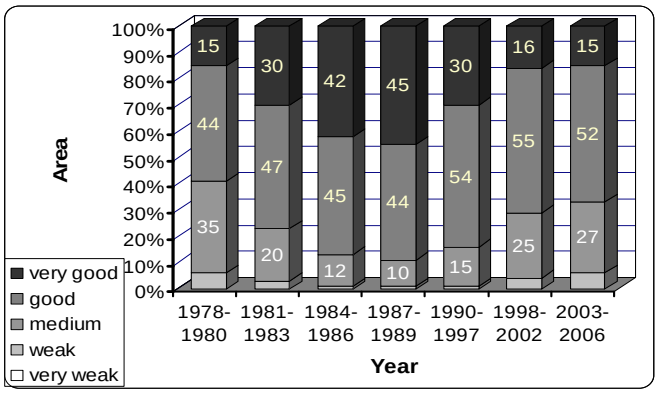

Figure 4. Changes in the phosphorus supply in soil (West-Hungary, 308 269 ha) (Horváth et al., 1999; Németh et al., 2006; Pálmai et al., 2003)

The similar trend is shown as regards potassium (Figure 5.), the ratios of very good-supplied areas has increased to its almost three folds, while the ratio of good-supplied areas remained almost constant, and after the political and economical changes the ratios of very good-supplied areas has dropped to its tenth and the ratios of good-supplied areas has decreased a little bit, while the ratio of medium and low supplied areas has grown.

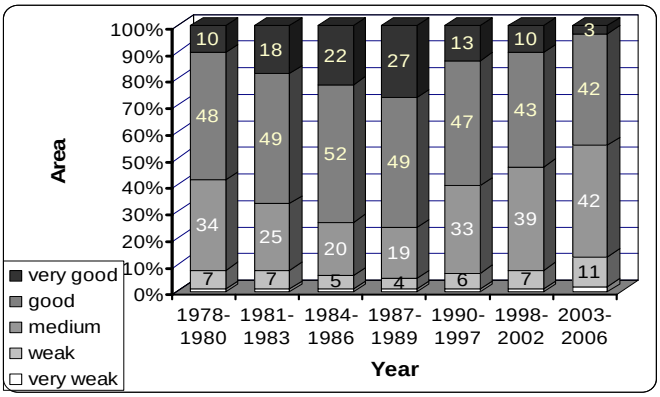

Figure 5. Changes in the potassium supply in soil (West-Hungary, 308 269 ha) (Horváth et al., 1999; Németh et al., 2006; Pálmai et al., 2003)

Unfortunately, the nitrogen-phosphorus-potassium balance of Hungary's agricultural land area has been negative since 1991, which is demonstrated on the Table 4.

Figure 6. presents data from the Eastern part of Hungary from 2006, where the ratio of low-supplied soils with nitrogen is high, this is smaller as regards phosphorus and potassium, moreover even over-supplementation can be existed. To determine the contents of different elements (eg. P, K, Mg and Zn) in soil, samples were analyzed by inductively coupled plasma optical emission spectrometry (Kovács et al., 1998) applying acid extractable (so-called total) wet digestion (nitric acid - hydrogen peroxide) as sample preparation (Kovács et al., 2000).

Table 4. NPK balances of cultivated land areas in Hungary (kg/ha) (Németh et al., 2006; Pálmai et al., 2003)

	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)
1900-1950	-33	-7	-22
1961-1965	-24	1	-23
1971	7	27	21
1975	16	47	52
1984	27	46	41
1986-1990	32	24	14
1991-1995	-30	-13	-28

As regards magnesium on Figure 7., 7 % of East-Hungarian soils is low-supplied and more than 90 % of our soils is well- or medium-supplied with magnesium, while as regards zinc, more than 80 % of our Eastern soils is well- or medium-supplied, however, nearly 20 % is low-supplied of zinc.

Consequently, these call ours attention to supplementation with trace elements also.

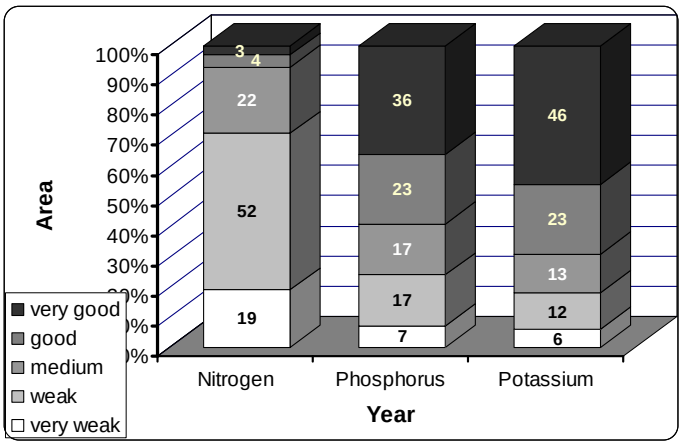

Figure 6. Nitrogen, phosphorus and potassium supplies of the studied areas (East-Hungary, 50 000 ha, Number of samples: 7900)

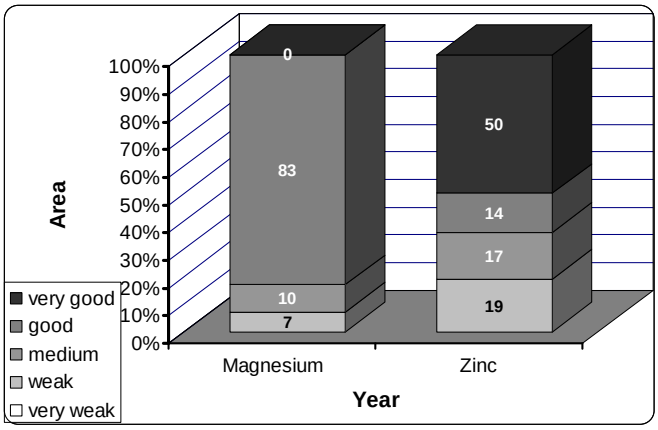

Figure 7. Magnesium and zinc supplies of the studied areas (East-Hungary, 50 000 ha, Number of samples: 7900)

Summarizing, we can state that substantial intellectual and financial capital has been mobilized to perform regular soil analyses which, together with a well-operating system of agricultural offices can be the basis of the production of safe and outstanding food products in Hungary:

- The intensification of agriculture in Hungary started about 10-15 years later than in western Europe but since 1990 it has become much more extensive than it is desirable.
- This is true for:

– the use of chemicals,
– due to difficulties there has little demand emerged as regards crop and soil testing and
– the trends in the numbers of animal heads.

- Agriculture as a potential polluter can be realistically considered in the case of storing liquid manure and even then as a local polluter.
- In addition, there is considerable demand for soil tests aiming at environmental purposes, linked to EU subsidies. The extension networks are increasing and the laboratories, which are owned by different owners, are well-equipped.
- As a result of the above Hungarian soils can be expressly regarded to be clean and thus there are no obstacles to producing high quality foodstuff (food safety).
- This clearly advantageous situation should be utilized of. This, however, is not a technical issue but one concerning agricultural policy.

SUMMARY

Agricultural goods obtained and produced in Hungary played an important role in the markets of Western Europe. By utilizing the ecological potentials of the Carpathian Basin, local inhabitants are in the position to produce considerable food surpluses in addition to meeting their own demands. With agricultural production becoming more and more intensive in Hungary, the application of mineral fertilizers also started slowly to increase from the 1960's. From the middle of the 1970's a uniform sampling, soil testing and fertilization extension system was created together with its own institutional and laboratory testing network. The intensive use of mineral fertilizers in Hungary lasted from the middle of the 1970's to the last quarter of the 1980's, during which period an average amount of 230 kg/ha NPK fertilizer was applied. During this period the so-called “replenishing” fertilization was applied in conformity with the improvement of all other elements involved in production technology, which was also clearly expressed in agro-political objectives of those days to obtain higher yields.

Then the nutrient supply and nutrient base of soils in Hungary increased clearly so production technology could not longer limit higher yields. In 1990 agriculture changed in Hungary fundamentally and radically and the same happened with nutrient supplies as well. At the beginning of the 1990's the level of mineral fertilizer application decreased suddenly to below 40 kg/ha of NPK active ingredients and after a slow increase it has reached the level of almost 70 kg/ha nowadays. In the meantime the animal stock in Hungary decreased and consequently the amount of manure decreased.

All in all, the nutrient balance of Hungarian soils has always been negative. Due to the changes in its structure and ownership over the past thirty years or so, it has become very difficult to obtain reliable information about Hungarian

agriculture. Soil Resources Management General Partnership (in Hungarian: Talajerőgazdálkodás Kkt.) conducts extension work based on soil sampling and has a continuous flow of data on over thirty thousand hectares beginning at the end of the 1970's.

Based on the analyses of these data it can clearly be claimed that the extra amount of nutrients applied during the period of replenishment until the change of regimes has been "removed" from the soil over the past fifteen years, consequently the Hungarian nutrient balance has become negative again. This kind of fertilization practice can not be sustained in Hungary, as the maintenance of the production potential of Hungarian soils is far from being resolved at the moment; it poses risks to and questions sustainability as well as it may cause a very serious competitive disadvantage for us.

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