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Slovene guidelines for expert based fertilization in a light of cross compliance rules

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ABSTRACT

Slovenian rules and regulation concerning fertilization are briefly presented. Current use of fertilizers, manures and compost, as well as nitrogen and humus balances in Slovene agriculture, and soil supply level with phosphorus and potassium dependent on various soils uses is given and critically stressed. Target values and fertilization norms for major plant nutrients as well as basic set of parameters and methods for national soil fertility- and fertilization control are proposed.

Key words: fertilizers, cross compliance, soil fertility, fertilization control.

IZVLEČEK

SLOVENSKE SMERNICE ZA STROKOVNO GNOJENJE V LUČI DOLOČIL NAVZKRIŽNE SKLADNOSTI

Na kratko so predstavljeni pravila in zakonodaja, ki posredno, v skrbi za varovanje okolja, urejajo ravnanje z gnojili v Sloveniji. Podan je pregled in kritična ocena porabe mineralnih ter organskih gnojil, dušikova in humusna bilanca v slovenskem kmetijstvu ter preskrbljenost tal s fosforjem in kalijem glede na rabo tal. Predlagane so ciljne vrednosti in gnojilne norme za glavna hranila kot tudi osnovni nabor parametrov in metode za nacionalni sistem kontrole rodovitnosti tal.

Ključne besede: gnojila, navzkrižna skladnost, rodovitnost tal, kontrola gnojenja.

ZUSAMMENFASSUNG

SLOWENISCHE RICHTLINIEN FÜR SACHGERECHTE DÜNGUNG IM RAHMEN DER CROSS COMPLIANCE REGELUNGEN

Die Gesetzgebung die in Slowenien für Umwelt sorgt und indirekt auch die Fachbereich Düngung regelt ist präsentiert. Die Übersicht sowie die kritische Bewertung von

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mineralischen- und organischen Düngerverbrauch, Stickstoffs- und Humusbilanzierung so wie die Bodenversorgung mit Hauptnährstoffen in Abhängigkeit von der Bodennutzung ist gegeben. Sollwerten und Düngungsnormen sowie die Grundlage und Methoden für das Nationalsystem von Bodenfruchtbarkeitskontrolle ist vorgelegt.

Schlüsselworte: Düngemittel, Cross compliance, Bodenfruchtbarkeit, Kontrolle der Düngung.

INTRODUCTION

Cross Compliance (CC) consists of rules for sustaining agricultural land in good agricultural (production) and ecological status, including 19 already valid EU-regulations. CC is already in action from Jan. 1, 2005 (EU Directive Nr. 1782/2003) in the fields of groundwater protection, sewage sludge and fertilizer use. EU regulations such as Nitrate directive and Water frame directive are the most important for the field of fertilization and soil fertility maintaining.

Soil fertility- and fertilization control should consist of the most important parameters to give clear fertilization advice to the farmers. Efficient use of nutrients is a key component of sustainable agricultural systems. In the production intensive systems, the inefficiency could lead to the environmental pollution, while in the extensive systems (including organic agriculture) to soil degradation through soil mining (Gregory and George, 2005).

In this article we describe the development, present guidelines and future outlooks for expert based fertilization in Slovenia in the light of Cross Compliance Rules.

SLOVENIAN RULES FOR IMPLEMENTATION OF GOOD AGRICULTURAL PRACTICE AT FERTILIZATION

In Nov. 2004 Slovenia has officially announced the Rule for implementation of good agricultural practice at fertilization (OJ RS 130, 2004). It is based upon the EU Nitrate directive (91/676/EGS). The main demand in the rule is that fertilizers should be applied in such a manner that plants can use the nutrients as efficiently as possible and that the losses of nutrients are minimised. The rule is in a concordance with the Decree on inputs of dangerous substances and plant nutrients into soil (OJ RS 68/96, 35/01, and 29/04, further cited as: decree).

The application of fertilizers should be based upon expected yield level and its quality, soil nutrients quantity and supply, taking into the account the regional conditions such as soil type, climate, weather conditions, crop rotation, tillage, eventual irrigation, and the results of regional field experiments. Soil nutrients and humus content of soils should be analysed according to the prescribed analytical procedures.

Arable soils should preferably be covered with plants also during the winter in order to minimise nutrient losses, especially nitrogen (nitrate) leaching.

Fertilization near water bodies are regulated by the Law of Waters (OJ RS 67/02, 110/02) which in the article 65 prohibit the use of fertilizers (organic or mineral) in the band 15 m from the shore of 1st order water bodies, and 5 m from the shore of 2nd order water bodies. Also land topography and soil texture must be taken into the account to prevent nutrients run-off into the streams. Flood areas must be fertilized by elevated caution – only after the period of probable flood accruing.

Machines and other devices for fertilizers' application must conform technical requirements in order to apply prescribed quantities, and assure even fertilizer spreading.

Use of organic fertilizers, especially livestock manures, sewage sludge, and composts, is quite extensively regulated by the decree. The maximum yearly-allowed amount to be put into one hectare of soil is based upon the major nutrients – nor more than 170 kg N/ha or 120 kg P₂O₅/ha or 300 kg K₂O/ha. That corresponds to the 2.5 LU (livestock unit = 500 kg of live animal weight) of cattle (ruminants) or 2.0 LU of pigs or poultry. Nitrogen is commonly the limiting nutrient in manures except for poultry manure where high phosphate content often limits the applicable amount. If a farm produces manure surpluses in respect to its agricultural land available for manure application the surpluses must be transposed elsewhere upon receipt (to neighbour farmers, sell through the market or as the last solution give it to the approved waste disposal service).

The **application of liquid organic fertilizers is prohibited during wintertime**, from Nov. 15 to Feb. 15 if the arable soils are bare (without vegetative cover) during this period. It is prohibited to use organic fertilizers on soils that are flooded, deeply covered by snow (> 10 cm), frozen, inclined so that surface runoff is possible, in swamps, marshes or in natural forests.

Manures must be **stored** in watertight storage places, with no leakages or overflows allowed. The volume of manure storage places must suffice for period of 6 months in central Slovenia or 4 months in seaside areas. The surfaces or volumes are prescribed according to the manure type: 3.5 m² of slab for solid (farmyard) manure if the heap is at least 2 m high or 7 m³ otherwise; 2 m³ for urine; 8 m³ for slurry. The losses of nitrogen should be minimised already during manure storage. They should not exceed 10% by liquid- and 25% by solid manures of total excreted N. Aeration of manures during storage is advised in order to speed up the maturation of manures and to lower the odour evolution and N-losses during spreading. Spreading of liquid manures should be as close to the soil surface as possible. In arable land manure should be covered by soil (ploughed under or deep injected) as soon as possible to avoid NH₃ volatilisation. The N-losses by spreading should not exceed 25%.

Composts and sewage sludge use are further restricted not only to their nutrient content but also heavy metal and potentially harmful organics (AOX, PAH, PCB). These materials must also be free of pathogenic organisms (indicative organism – Salmonella). Organic (biogenic) waste material must undergo the controlled process (bio-oxidative, thermophile) during which the determined parameters by the decree are met. According to the quality composts are classified as 1st or 2nd class compost. First class compost could be used on every soil. Second class compost on the other

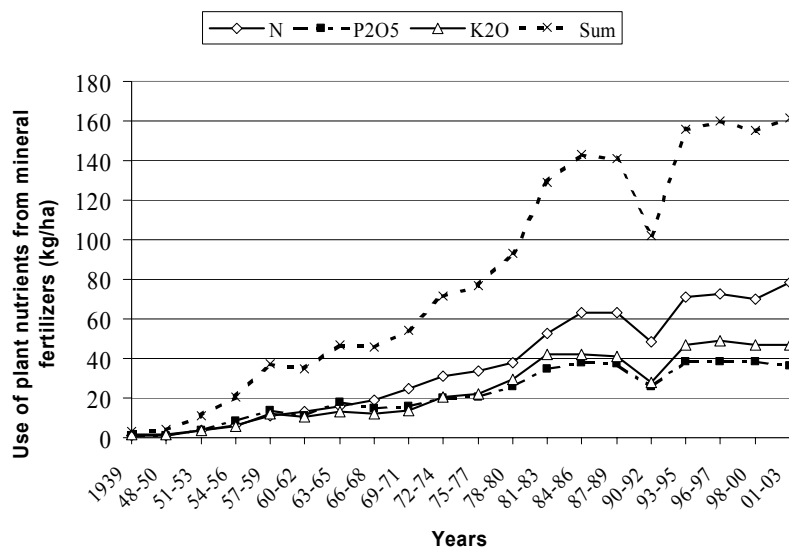


Figure 1: Use of plant nutrients from mineral fertilizers per ha of fertilized agricultural land in use in Slovenia (period from 1939 to 2003) (SORS, 2004)

hand could not be used in water protection zones, in the fields where crops for direct (fresh) human consumption are grown, and on pastures, meadow or fields with fodder crops except after the last use in the autumn.

USE OF FERTILIZERS AND SOIL FERTILITY PROGRAMME IN SLOVENIA

For the purposes of agricultural soil productivity and quality of the yields, soil fertility control is promoted in Slovenia already for four decades. The use of mineral fertilizers has practically started only after the 2nd world war. The growth in fertilizers use continued quite steadily until the beginning of the nineties (1990 to 92), a period of great political changes in former Yugoslavia, and of Slovene declaration of independence and sovereignty. Lately we reached the ceiling of fertilizers use of around 160 kg/ha of plant nutrients from 1996 on (Figure 1).

Nitrogen predominates and accounts for 45 % of all inputs. Present consumption of mineral fertilizers ranks Slovenia around the median level of the EU-countries, nearly at the same level as Denmark, Ireland, and France. Due to lower historical use of fertilizers compared to the developed countries, and as a consequence still poor or medium supply of majority of agricultural soils with nutrients (Fig. 2), we anticipate this consumption as not very high. However, the distribution of mineral fertilizers is not even across the country. A lot of work still needs to be done to promote expert based fertilization among farmers in order to some of them lower- and the others increase the use of fertilizers.

A comparison of two surveys of soil fertility level (soil supplied with available phosphorus and potassium) was made. The first one was performed in 1956, and the second one in 1998. Although the methodology of soil analyses and the number of soils sampled were not identical in the both surveys, a relative comparison of ranking the corresponding values into soil nutrient supply classes (= poor, medium, good) was possible (adapted after Leskošek, 2004).

From Fig. 2 it is clear that in 30 years of fertilizers use in Slovenia the levels of available P_2O_5 and K_2O in soils markedly improved. However, still in 1998, only around 50% of soils in investigation expressed good level of plant nutrients. Since only the most advanced farmers have given the soils analysed, we reasonably suspect that the actual level of nutrients in the agricultural soils are even lower, i.e. below the class "good".

The survey of available Slovene laboratory data (ca. 10.000 data) on soil fertility analyses in the year 2000 also showed that Slovenian soils were by nature poorly supplied with phosphorus, and somewhat better with potassium. Meadows were least fertilized: 65 - 75% of soil samples were poorly to intermediately supplied by P and K, in spite of the fact that it is easier to enrich 6 cm deep soil layer (depth of soil sampling of meadows) compared to 20 or even 30 cm of arable fields. This is understandable when we know that fields receive most of the animal manures produced. Fields (arable land), though better supplied with nutrients compared to meadows, especially with K_2O (only 10% in level A - poor), still showed great variability in nutrient content of soil. Fields used for cash crops (vegetable, hops, intensive vineyards and orchards) were on contrary often oversupplied with nutrients (Leskošek *et al.*, 1998).

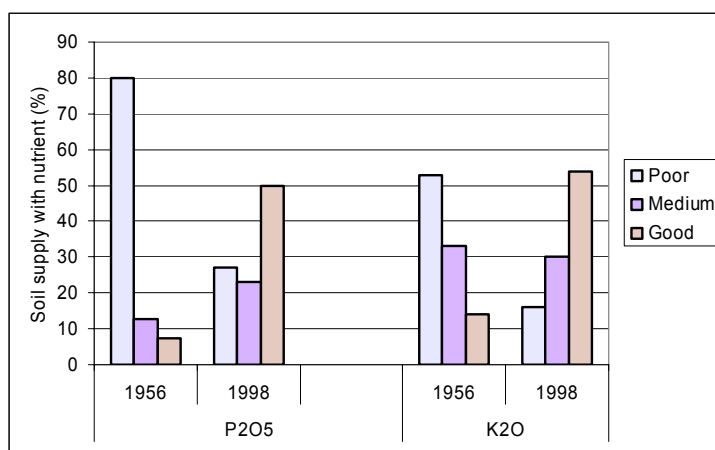


Figure 2: Improving of soil supply level with phosphate and potassium after 30 years (adapted after Leskošek, 2004)

Livestock manure and other biogenic wastes used as fertilizers

Animal husbandry remains the most important branch of Slovene agriculture. Cattle-followed by pig- and poultry rearing hold the largest share. The average livestock breeding intensity is relatively low (1 livestock unit - LU ha^{-1} = 500 kg of animal live weight). This would roughly correspond to 70 - 80 kg N, 30 - 40 kg P_2O_5 , and 80 -

100 kg K₂O (assumption made upon the data in Leskošek and Mihelič, 1998). Together with mineral fertilizers this gives the average use of 140 – 150 kg N, 65 – 75 kg P₂O₅, and 130 – 150 kg K₂O per ha and year. Such application of plant nutrients balances the average uptakes with yields. The input of phosphorus is probably a bit high, but as we can see from Fig. 2, the phosphorus in the soil is still predominantly below the desired level.

Animal rearing intensity is much more developed in the parts of the country, which are also most suited for arable crops production (in the plains), and not in the hilly areas of permanent (semi natural) grassland. The livestock burden of big farms in the valleys often exceeds 2 or even 3 LU ha⁻¹. This high burden is mostly due to the big confined pig, cattle or poultry raising. Such farms are lately adapting to the acts of IPPC directive (Integrated Pollution Prevention and Control). Adapting will not be easy since until recently only smaller part (30%) of pig slurry, which was produced at large farms, was used for fertilization, the rest (around 900 t N and 500 tonnes P₂O₅ per year) burdened the environment, mainly surrounding streams and groundwater (Mihelič *et al.*, 2001).

Also sewage sludge from communities waste water-treatment plants is used only marginally for fertilization, partly because of too high level of potential pollutants (heavy metals), and partly due to the fear of public against possible side effects of potentially dangerous substances it may contain. Compost is being produced more in the last years, due to the policy of source-separated collection of municipal wastes. Around 35% mass of waste produced by house holdings comprises of biogenic waste, which can be safely composted and used as soil amendment (Mihelič *et al.*, 2001).

Nitrogen balance

Nitrogen balance for the whole Slovenian agricultural land calculated according to the methodology of OECD N soil surface balance is positive – yearly the N inputs exceed the N outputs by 30 to 40 kg N/ha (Leskošek and Mihelič, 1999). Comparing to other European countries this N surplus is rather low. In the period 1995 to 1998 N balance surpluses were 60 kg/ha for EU-15, 262 kg/ha for Netherlands, 87 kg/ha for Great Briton, 61 kg/ha for Germany, 54 kg/ha for France, 27 kg/ha for Austria, etc. (OECD secretariat, 2001; www.oecd.org/agr/env/indicators.htm).

Another study based on a survey of fertilizing and farm production practices in only typical, and regionally relatively important agricultural areas of Slovenia in 1999 gave another N balance (Mihelič *et al.*, 2000). This result showed that in 45 % of the surveyed farms used N-fertilizers in accord with guidelines of good agricultural practice (yearly N balance up to + 45 kg N/ha). With such relatively low N- surplus we assumed that fertilization (organic and mineral) did not present a threat to the environment. In other cases (55%), the balance was in excess, mostly by field crops (average + 100 kg N/ha). The survey showed that farmers were not taken properly into the account the nutrients from organic manures. In the areas where fields are in close contact with shallow-lying groundwater, production in terms of plant nutrient use seems to be frequently over-intensive.

Humus balance

Farmers apply manure preferentially to the arable land. Permanent grassland from which fodder- and consequently manure is obtained, and forests from which litter for the stables is gathered, indirectly serve as a source of manures and hence soil organic matter in the arable fields. In spite of high ratio of intensively tilled crops, such as maize, potatoes, sugar beet, vegetables etc., which comprise aver 60% of arable crops in Slovenia (maize alone covers 40% of fields), by which the humus balance is negative, the constant additions of manures turns the humus balance of Slovene arable land positive. Analyses of arable field soils showed that majority of arable fields were well provided with humus. Only intensively tilled vineyards soils show diminishing of soil OM, because many wine-producing farmers specialized and stopped with animal rearing, so they did not apply any livestock manure for decades (Leskošek *et al.*, 1998).

Soil analyses and existing methods of soil fertility control

For practical application, only minimum data set of soil-quality indicators were proposed. This set must give as much information as possible, but it must be in the same time cheap for the users (farmers), and relatively easy, routinely to perform in the laboratories. The minimum dataset consists of four measured soil parameters:

- **pH** (in 0,1 M KCl or 0,01 M CaCl₂) as a measure of soil acidity or alkalinity. Upon this measurement we can give advice liming (method according VDLUFA, 2000, or according to the simplified advice by Leskošek and Mihelič, 1998). Some laboratories however still use the second determination of pH in the acetate-buffer according to Schachtschabel to advice liming;
- **“Plant available” fractions of phosphorus and potassium** in the soil are determined by the AL-method. This method is routinely used in all former republics of Yugoslavia, in Norway, Hungary... The method gives from 30 – 50% and from 0 – 25% higher values for P₂O₅ and K₂O, respectively, compared to the DL- or CAL-methods which are used as standard in Austria, Czech republic, Germany...
- **Soil organic matter** (“humus”) is determined either by wet combustion using concentrated inorganic acids and strong oxidants or by dry combustion after removal of carbonates from the soil sample. Furthermore, soil organic matter (organic carbon - C) is normally in a close correlation to the soil nitrogen (C/N ≈ 10), hence the soil organic matter is also indirectly a measure of soil total nitrogen.

Basic set of parameters, pH, P, K, is measured in an average soil sample of a plot (field) every 4 to 6 years, depends on a field crop rotation (soil sampling always in the same crop sequence of the rotation). More frequent determinations are neither necessary nor reasonable while only moderate change of soil supply with nutrients is obtained yearly with normal fertilization doses. Humus content could be measured even less frequently (once every second crop rotation, i.e. once in ten years) since it's content is normally changing slowly, and the relatively high bias of analysis blur the small differences in humus content caused in short-term.

Other plant nutrients are not included in a routine soil fertility monitoring, but only when a clear lack of the nutrient is detected either visually or by the soil or plant analyses. **Magnesium** is fortunately ample in the majority of Slovenian soils (parent

material rich in Mg). There are several spots, however, which need regular fertilization with Mg, as e.g. some vineyard areas over slate and marl in the costal region or soils formed on Mg-poor, silicate marl parent material in the NE part of Slovenia. Soil analysis on Mg is therefore advised primarily for vineyards.

Sulphur was until recently amply supplied as immision from polluted air (majority of Slovenia used to obtain more than 30 kg ha⁻¹ S per year with precipitation). It was supposed this amount together with the amount supplied by manures sufficed the demand of crops. Therefore, S was not a part of regular soil fertility control. In the recent years the air was markedly purified, so that major part of Slovenia now receive only about 10 kg ha⁻¹ S per year with precipitation, which could be less than the requirements of demanding crops, as oil rape, sugar beet, sunflower... The inclusion of S into the soil fertility control scheme in Slovenia is probably going to be necessary in the near future (Leskošek and Mihelič, 2002).

Micronutrients, such as B, Cu, Mn, Zn, Fe, and Mo, are not included in the normal scheme of soil fertility analysis. It is supposed that our fields and meadows/pastures have enough of micronutrients also for demanding crops and cultivars. Exclusion from this rule is soil supply of boron to sugar beet. There is also a lack of Cu in the fodder obtained from Ljubljana marsh (neutral organic soils). In general, there is a lack of systematic research on the micronutrients status in the Slovenian arable soils (Leskošek and Mihelič, 1998).

Target values and fertilization norms for phosphate (P₂O₅) and potassium (K₂O)

In the Table 1 and 2 limit values for P₂O₅ and K₂O and the corresponding fertilization norms used in Slovenia valid for normal soils and relatively high yields are presented. It is advisable to apply P and K according to the average needs of crops in the rotation instead of covering the uptake each year. If the soils are poorly supplied by a nutrient, extra addition of fertilizer is advised in order to step-by-step (in a period of 5 to 15 years) achieve the desired, target level of soil supply (rank - C).

Table 1: Target values and fertilization norms for phosphorus according to AL-method (Leskošek and Mihelič, 1998)

Rank of supply	Symbol	mg P ₂ O ₅ /100 g soil*	Fertilizer norms in kg/ha P ₂ O ₅				
			Fields; example for an average uptake of 70 kg P ₂ O ₅	grasslands, pastures			vineyards, orchards
				2 cuts	3 cuts	grazing**	
Poor	A	< 6	70 + 30 to 50	70 - 80	80 - 90	50	100
Medium	B	6 - 12	70 + 20 to 30	60 - 70	70 - 80	40	60
Good	C	13 - 25	70 + 0	50 - 60	60 - 70	30	15 - 20
Excessive	D	26 - 40	half of uptake	30	40	15	10
Extreme	E	> 40	zero until next analysis	0	0	0	0

***Depth of soil sampling**: in grasslands soil layer sampled is 0 - 6 cm; in fields within arable layer (0 - 20 cm); in orchards and vineyards: 0 - 30 cm when the ground of plantation is permanently covered by green cover (majority of plantations) or alternatively: 0 - 20 cm and 25 - 45 cm when the soil in the plantation is tilled.

****Rotational grazing** intensity of livestock rearing: 2.5 LU ha⁻¹ per year; fertilizer norm in mineral fertilizers besides all animal excrements.

Table 2: Target values and fertilization norms for potassium according to AL-method (Leskošek and Mihelič, 1998)

Rank of supply	Symbol	mg K ₂ O/100 g soil		Fertilizer norms in kg/ha K ₂ O			
		Light to middle -	Heavy textured soil	Fields; example for an average uptake of 200 kg K ₂ O	grasslands, pastures		
					2 cuts *	3 cuts ***	grazing **
Poor	A	< 10	< 12	200 + 40 to 60	120 – 160	160 – 200	70
Medium	B	10 – 19	12 - 22	200 + 20 to 30	100 – 140	140 – 180	55
Good	C	20 – 30	23 – 33	200 + 0	80 – 120	100 - 140	40
Excessive	D	31 - 40	34 – 45	half of uptake	50	60	20
Extreme	E	> 40	> 45	zero until next analysis	0	0	0

* Fertilization norm comprises nutrients from both, mineral fertilizers and/or organic manures

****Rotational grazing** intensity of livestock rearing: 2.5 LU ha⁻¹ per year; fertilizer norm in mineral fertilizers besides all animal excrements.

***At 4 or more cuts of grass per year the rations are higher for 15 kg P₂O₅ and 30 kg K₂O if the yields are higher for at least 10 dt ha⁻¹ of dry matter compared to the 3 cuts.

SOLUBLE (AVAILABLE) NITROGEN

Since nitrogen (it's soluble forms) is very dynamic in the soil, it cannot be measured only every 4 – 6 years to give us the basis for fertilization advice such as with P and K. Measurements of mineral nitrogen (N_{min}) in various phases of specific crop growth can help us to fertilize more rationally. However, the fields (plots) in Slovenia are normally small (well below 1 ha) and hence the N_{min} analysis being too expensive (laboratory cost ca. 50 Euro per soil sample), and besides also too laborious and time consuming by sampling (originally the samples should be taken from 90 cm of soil profile). Farmers do hence not use N_{min} analysis nor it is advised. Several quick tests are promoted as cheaper, easier, but still reliable alternatives to N_{min}-method. These are quick soil nitrate test for winter cereals early in spring, and for side dressing of maize in June (0 – 30 cm; Mihelič, 2004); quick plant sap nitrate test (for 2nd and 3rd side dressing of winter wheat; Leskošek *et al.*, 1993). Chlorophyll meter (N-tester or SPAD) was preliminary tested in wheat and maize, but the results need further verification.

In 2004, the Rule of Integrative Crop Production, which is a part of Slovene Agri-Environmental Program, demanded for performing of quick tests on N of at least 10% of fields. Majority of farmers still apply nitrogen according to self-experiences or according to professional advice based upon the data of field experiments.

FERTILIZATION PLAN

Fertilization plan for a 4 to 6 year crop rotation was practically without changes taught to the students of Biotechnical Faculty at Ljubljana University in the last 40 years by Prof. dr. Mirko Leskošek. The nutrient uptake is calculated from tables given in the Guidelines for expert-based fertilization (Leskošek and Mihelič, 1998). P and K are applied according to the soil nutrient level and the average needs of the crops in rotation. Nitrogen is applied in portions in concordance with specific crop needs at various growth stages based upon the expert advice or according to the tests. The

long-term availability of manure N is accounted for as 70% for farmyard manure (solid) in the fields and 50% in the grassland, 75% for slurry, and 85% for urine.

Also soil organic matter (humus) budgeting was included in the fertilization plan recently. The method used for this purpose is the Bavarian (Leskošek and Mihelič, 1998). It is just now discussed by the experts to switch to the newest method prescribed by VDLUFA (German union of agricultural and forestry institutes), which as a novelty, defines the target annual humus budgeted and ranks it into 5 classes (analogy to P and K) (Körschens *et al.*, 2004).

PRESENT SITUATION IN PRACTICE AND FUTURE PERSPECTIVES

Currently, in a reality of more and more stringent environmental demands and new regulation (including cross-compliance), soil fertility control is becoming an obligation for farmers, which apply for (many types of) governmentally mediated financial support. Program for rural development 2004 – 2006 together with Slovene Agri-environmental Program demand a fertilization plan for one year made upon soil analyses. As a consequence, the number of soil analyses made by Slovene laboratories became 4- to 5 times bigger - 40,000 to 50,000 soil samples analysed compared to around 10,000 samples in the preceding years (Fig. 3).

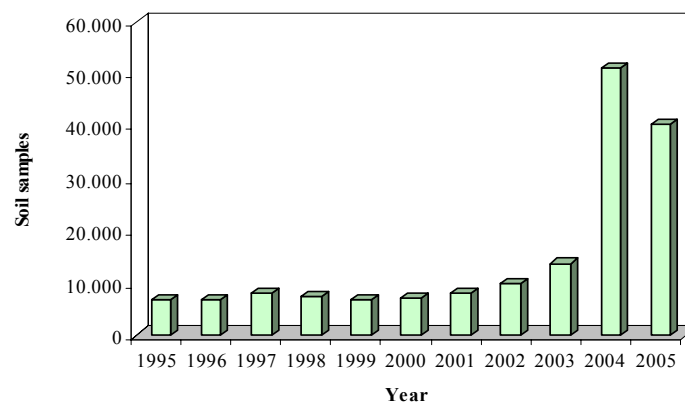


Figure 3: Number of soil samples analysed in Slovenia in years 1995 - 2005

However, the system for soil fertility control including fertilization plan, which is briefly presented in this paper, is still not officially declared as a standard and hence, in the practice, different soil sampling- or even analytical procedures are in use, which leads to difficulties in comparison the results. There is also a lack of integral data gathering and processing. Amending these shortcomings would create a rich database, suitable not only for adequate fertilization advisory and fertile soil and quality crops as a direct consequence, but coupling with GIS, also for creating various models important for environmental protection and expert-based landscape development policies. An **expert group for fertilizers and fertilization** established in Dec. 2004 by the Slovene Agricultural Chamber is aiming to provide advice to the extension service and farmers, and to help the governmental bodies in developing efficient and ecologically sound system of soil fertility and fertilizers use.

REFERENCES

- Gregory, P., J., George, T., S. 2005. Soil Management for Nutrient Use Efficiency: An Overview. The International Fertilizer Society - Proceeding 564 (2005), 32 p.
- Körschens, M., Rogasik, J., Schultz, E. 2004. Bilanzierung und Richtwerte organischer Bodensubstanz. Zbornik simpozija (proceedings of symposium) Novi izzivi v Poljedelstvu 2004., Četež ob Savi, 13. in 14. dec. 2004. Tanjšek, A. (ed.), Slovensko agronomsko društvo, Ljubljana. s. 50 – 62.
- Lekošek, M. 2004. Umetna gnojila zastrupljajo živila in okolje? Predavanje na Slovenskem svetovnem kongresu; Ljubljana, 1. April 2004. 17 str.
- Leskošek, M., Briški, L., Flisar-Novak, Z., Benec, J., Hrustel, D. 1993. Preverjanje hitrega rastlinskega nitratnega testa za dognojevanje ozimne pšenice. *Sodob. kmet.*, april 1993, 26, št. 4, str. 168-171.
- Leskošek, M., Mihelič, R. 1998. Smernice za strokovno utemeljeno gnojenje. Del 1, Poljedelstvo in travništvo. Ljubljana: Ministrstvo za kmetijstvo, gozdarstvo in prehrano, 1998. 51 str., tabele. ISBN 961-90479-3-1.
- Leskošek, M., Mihelič, R. 2002. Žveplo kot gnojilo = Sulphur as fertilizer. *Sodob. kmet.*, 2002, let. 35, št. 11-12, str. 488-492.
- Leskošek, M., Mihelič, R., Grčman, H., Pavlič, E. 1998. Oskrbljenost kmetijskih tal s fosforjem in kalijem v Sloveniji. V: Tajnšek, A. (ur.), Šantavec, I. (ur.). *Novi izzivi v poljedelstvu '98 : zbornik simpozija*, [Dobrna, 3. in 4. december 1998]: proceedings of symposium. Ljubljana: Slovensko agronomsko društvo, 1998, str. 37-41.
- Leskošek, M., Mihelič, R.. 1999. OECD national soil surface nutrient balances. 1993 – 1997. Country: Republic of Slovenia. Nitrogen. National report, 30 p.
- Mihelič, R. 2004. Dognojevanje koruze z dušikom na podlagi koncentracije nitratnega dušika v tleh = Maize side dressing with nitrogen according to the soil nitrate-nitrogen concentration. V: Tajnšek, A. (ur.). *Novi izzivi v poljedelstvu 2004 : zbornik simpozija: proceedings of symposium*, Četež ob Savi, [13. in 14. december] 2004. Ljubljana: Slovensko agronomsko društvo, 2004, str. 291-298.
- Mihelič, R., Andoljšek, L., Leskošek, M., Lobnik, F. 2001. Uporaba biogenih odpadkov v kmetijstvu: stanje v Sloveniji in perspektive. *Gospod. odpad.*, maj 2001, letn. 10, št. 38, str. 8-14.
- Mihelič, R., Hodnik, A., Hudnik, V., Lobnik, F., Ruprecht, J., Šporar, M., Vrščaj, B., Zupan, M., Knapič, M., Lapajne, S., Urek, G., Tič, I. Vzpostavitev monitoring mreže onesnaženja v kmetijstvu. 2000. Ljubljana: Biotehniška fakulteta, Oddelek za agronomijo, Center za pedologijo in varstvo okolja, 1 zv. (loč. pag.) + 8 zv. pril. (loč. pag.), ilustr.
- Statistical Office of the Republic of Slovenia (SORS). 2005. Statistične informacije, št. 204/2005 (Rapid Reports No 204/2005).
- Toplak, A., Osterc, J., Leskošek, M. 2005. Vpliv intenzivnosti govedoreje na vsebnost in dinamiko humusa in hranil = The influence of cattle rearing intensity on humus and mineral content and dynamic. *Acta agric. Slov.* 2005, letn. 86, št. 2, str. 103-115.