ENVIRONMENTAL ACCOUNTING IN AGRICULTURE: NUTRIENT ACCOUNTING AND OTHER ASPECTS
KÖRNYEZETI SZÁMVITEL A MEZŐGAZDASÁGBAN: TÁPANYAGKÖNYVELÉS ÉS EGYÉB LEHETŐSÉGEK

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ÖSSZEFOGLALÁS

A hagyományos számvitel a piacon értékelt vagyontárgyak, költségek, hozamok számbavételével foglalkozik, a környezeti számvitel ugyanezt a piacon meg nem jelenő vagyonelemekkel, költségekkel, hozamokkal kívánja megtenni. A vállalati tápanyagkörforgás számbavételének során vállalati szintű input-output szemléletet érvényesítenek, szembeállítva a vállalatba inputként bekerülő, ill. onnan termékekkel kikerülő tápanyagmennyiségeket. A módszer a gazdaságba bevitt tápanyagnak azt a részét, amely az értékesített termékekkel nem kerül ki a gazdaságból, veszteségnek, szennyeződésnek tekinti. A koncepció gyenge ponja a készletváltozás kezelése. Egy-egy időszakban még eladatlan termények tápanyagtartalma miatt a vállalkozásba bevitt és az értékesítéssel kivitt tápanyagok különbsége jelentős lehet, de ennek jó része nem veszteség, nem is a talajban van, hanem az eladatlan raktárkészletben. E probléma kezelésére vezetjük be a külső tápanyagmérleg, illetve a belső tápanyagmérleg fogalmát, melyeket két esettanulmány példáján keresztül elemzünk.

KULCSSZAVAK: környezeti számvitel, tápanyagmérleg, készletek, mezőgazdaság

ABSTRACT

While traditional accounting focuses on accounting for capital assets, costs, yields valued and sold in the market, environmental accounting intends to do the same with non-marketed capital assets, costs and yields, that is, externalities. The farm level nutrient balances are based on an input-output comparison, in which the nutrients entering the farm within inputs are compared to nutrients leaving the farm within the sold products. The method considers the amounts of nutrients entering the farm but not leaving it with the products to be wastes polluting the environment. The weakness of this approach is the handling of stock changes. In a farming year high amounts of nutrients contained in unsold products are not wastes, nor are they stored in the soil, but are stored in the stocks. To handle this problem the concepts of external nutrient balance and internal nutrient balance are introduced, and are tested in case studies of two Hungarian mixed farms.

KEY WORDS: environmental accounting, nutrient balance, stocks, agriculture

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DETAILED ABSTRACT

While traditional accounting focuses on accounting for capital assets, costs, yields valued and sold in the market, environmental accounting intends to do the same with non-marketed capital assets, costs and yields not entering market processes, focusing on externalities.

The establishment of an environmental accounting system requires the total overview of the flows of materials and energy within the business ([15], [16]). Full surveys about the flows of materials and energy within a farm system have not been generally used yet, although attempts have been made in this direction ([20]). At the same time, relatively well developed methodologies and research results are available for a number of nutrients – nitrogen, in particular, - under the name of nutrient accounting, and farm nutrient balances.

The most widely used form of farm-level nutrient balances is the so-called „farm gate balance". This is set up comparing the nutrient contents coming into the farm with the inputs (fertilisers, manures, fodders, animals, seeds), and those leaving the farm with the outputs, such as crops, animal products, or live animals. Farm-level nutrient balances are based on the same theoretical principles, their primary aim is to calculate the nutrient surpluses as the difference between the amounts of nutrients entering and those leaving the farm.

The concept of farm-gate balance, however, suffers from an inherent weakness, namely the way it handles the change of stocks. Due to the unsold products at the end of the farming year the differences in the nutrient contents of purchased and sold materials may be much higher than in the former year. However, the major part of this difference is not a loss, nor is it stored in the soil, but is contained in the unsold stocks of the farm. This is particularly important when farm gate balance is used as the foundation of environmental taxes.

To solve the problem two methods were used to assess nutrient balances and nutrient surpluses for the three macro-nutrients:

Nutrient surplus is calculated as the difference between the annual purchases and the annual sales of the farms ([18]), and this is called external nutrient balance ([29]). This is basically the same as the generally used farm-gate balance.

Nutrient surplus is computed as the difference between the annual yields and the annual amounts utilised in the farm, which is called internal nutrient balance ([29]).

A case study was carried out in a cooperative farm located in Somogy county, dealing with mixed farming of arable crop production and pig fattening. Data collection covered the purchased stocks and those produced by the cooperative (fertilisers, seeds, animals, manures, fodders) containing nitrogen, phosphorus and potassium. Results are presented in Table 1.

Table 2 gives the nutrient balances for another Transdanubian mixed farm of approximately 1.5 thousand hectares, dealing with dairy, fodder and cash crop production.

The analyses above show that the external nutrient balance in itself cannot be used to describe the nutrient surpluses present within the farm, because this concept does not take into account the nutrient amounts present in the outputs, that have not been sold yet, and thus staying within the farm in the form of stocks. The internal nutrient balances give a more precise description about the nutrient surpluses existing within the farm, taking into account the changes in the amounts of stocks as well.

The recording of the nutrient contents of the various materials could be incorporated into the presently used traditional accounting system as an integrated sub-system.

INTRODUCTION

In order to outline briefly the essential difference between traditional accounting and environmental accounting the following points may be emphasised. While traditional accounting focuses on accounting for capital assets, costs, yields valued and sold in the market, environmental accounting intends to do the same with non-marketed capital assets, costs and yields, focusing on externalities. Environmental accounting attempts to create an integrated accounting system which brings together the items handled by traditional accounting and items related to environmental assets, costs and performance ([6], [24]).

The concept of environmental accounting has several different meanings in the relevant literature. Many researchers deny the justification for the concept saying, that natural values and assets cannot be handled as the object of annual reports, or as factors of production to be transformed into profits ([26], [14]). Furthermore, the meaning of environmental accounting considerably differs among the supporters of the concept ([5]). A number of authors use the concept in a narrow sense, focusing only on the valuation and recording of external economic impacts. According to the views of other researchers the term alsoi includes elements of traditional accounting which are aimed at making the activities related to the environment more transparent. On top of this another layer of interpretation may be the level of the business unit (farm, industry, regional, or national level) for which the concept is applied ([1]).

Several researchers (e.g. [25], [17], [19]) distinguish three levels of environmentally conscious farm accounting. The first level is based on the records and reports arising from traditional accounting, in which the items related to environmental protection are distinguished and handled separately. Some of the researchers of the field consider only the second level to be the „true” environmental accounting, also called „environmental cost accounting”, which handles external impacts related to business activities and not accounted for in the traditional accounting framework. The third level is the integration of the traditional and the environmental accounting system, focusing on the allocation of external environmental costs to activities and cost bearers. This approach is often referred to as „full cost accounting”. For each level the distinction between „financial environmental accounting” and „managerial environmental accounting” can be used in the same way as in traditional accounting. The authors of the present paper consider it reasonable to distinguish also between a set of „passive” methods and of „active” ones, the latter including accounting tools and methords suitable not only for reporting the information related to environmental protection, but for guiding the farmers, without the aid of other policy tools, towards more environmentally conscious farming practices. As an example, annual reports on the costs of waste management belong to the set of passive tools, while the allocation of these costs for the various products is an active tool.

MATERIALS AND METHODS

The establishment of an environmental accounting system requires the total overview on the flows of materials and energy within the business ([15], [16]). Full surveys about the flows of materials and energy within a farm system have not been generally used yet, although attempts have been made in this direction ([20]). At the same time, a relatively well developed methodology and experimental results are available on several nutrients, mostly on nitrogen, - all included in nutrient accounting and farm nutrient balances.

The farm level nutrient balance includes not only the usual „inputs” to and „outputs” from the soil, that is, the amounts applied by fertilisation or in any other way, and the amounts taken up by crop yields, but account for the total nutrient cycle in the farm. A few good examples can be found in several papers ([18], [9], [7], or [21] and [22] for results obtained in farms in Hungary).

The primary data sources for farm level nutrient balances are usually the records available within the traditional accounting system, namely the quantities given in the analytic records of inverntories. The respective nutrient contents of the various plant and animal materials and products (e.g. crop yields, fodders, fertilisers, manures, livestock, animal products, etc.) are attached to the quantities of these materials given by the analytic records. In a few cases the nutrient balances were set up relying on the nutrient accounts meintained continuously throughout the year.

The most widely used form of farm-level nutrient balances is the so-called „farm-gate balance”. This is set up comparing the nutrient contents coming into the farm with the inputs (fertilisers, manures, fodders, animals, seeds), and those leaving the farms with the outputs, such as crops, animal products, or live animals.

Farm level nutrient balances are based on the same theoretical principles, their primary aim being the computation of nutrient surpluses as the difference between the amounts of nutrients entering and those leaving the farm. Differences in the approaches may be found, some of the researchers (see e.g. [17], [18], [19]) do not count with all possible components (e.g. the nitrogen fixation by legumes, ammonia volatilization), while others (as e.g [27]) include these components in their calculations.

The computation of the farm level nutrient balances often goes hand in hand with the establishment of a nutrient accounting system. This can serve to help tracing nutrient surpluses, the decrease of which is an important aim both from the environmental and the economic aspects.

The concept of nutrient accounting is becoming increasingly widespread in scientific papers, but the exact definition of the concept is rarely described. Sullivan et al. ([28]) defines nutrient accounting as a system of recording the nutrient amounts entering or leaving the farm, and tracing the nutrient cycles within the various units of the farm. The nutrient accounting system provides important information for the management and thus it contributes to the decrease of the environmental load and to the improvement of the efficiency of farning ([2]).

Applying the nutrient cycle models to the Hungarian conditions, a nutrient accounting system may be established, which traces the nutrient movements according to the mechanisms of the traditional accounting system ([29]). This means that the process of nutrient accounting does not require a separate information system, but may be incorporated into the presently used one. Thus the levels of nutrient surpluses being higher than an allowed maximum level can be identified, and proper taxation methods may be derived to decrease these high values ([2], [22]).

The concept of farm-gate balance, however, suffers from an inherent weakness, namely the way it handles the change of stocks. Farm-gate balance is set up comparing the nutrient contents coming into the farm with the inputs (fertilisers, manures, fodders, animals, seeds), and those leaving the farm with the outputs, such as crops, animal products, or live animals. Farm-level nutrient balances are based on the same theoretical principles, their primary aim being the computation of nutrient surpluses as the difference between the amounts of nutrients entering and those leaving the farm.

Due to the unsold products at the end of the farming year the difference in the nutrient contents of purchased and sold materials may be much higher than in the former year. However, the major part of this difference is not a loss, nor is it stored in the soil, but is contained in the unsold stocks of the farm. This is particularly important when farm gate balance is used as the foundation of environmental taxes.

To solve the problem two methods were used to assess nutrient balances and nutrient surpluses for the three nutrients:

1. Nutrient surplus is computed as the difference between the annual purchases and the annual sales of the farms ([18]), and this is called external nutrient balance ([29]). This is basically the same as the generally used farm-gate balance.
2. Nutrient surplus is computed as the difference between the annual yields and the annual amounts utilised in the farm, which is called internal nutrient balance ([29]).

RESULTS AND DISCUSSION

To analyse the difference between the external and the internal nutrient balances two case studies are given below.

The first case study was carried out in a cooperative farm located in county Somogy and dealing with mixed farming. The main activities of the cooperative farm are arable crop production and pig fattening, providing a good opportunity to assess the nutrient flows between crop production and animal husbandry. The first step in the analysis was to survey the existing accountancy system in the cooperative, to identify the possibilities and requirements for establishing a nutrient accounting sub-system within the present structure of data recording. Data collection covered all the purchased stocks and those produced by the cooperative (fertilisers, seeds, animals, manures, fodders) containing nitrogen, phosphorus and potassium.

The analytic records of the cooperative provided data (stocks either produced within the farm or purchased) needed for assessing the nutrient flows within the farm. Earlier research findings were used to identify the nutrient contents of the various stock items ([12], [4], [8], [10], [11], [23], and the analyses carried out by Katalin Sárdi) and relying on these data the annual flows and changes of nutrient amount in the farm were computed (Table 1). The external nutrient balance, the internal nutrient balance and the levels of stock were computed for the three important nutrients.

The data presented in the table show that the external nutrient balance gives the difference of the 293421 kg nitrogen entering the farm and the 264510 kg leaving it with the sales, which indicates the presence of a considerable nutrient surplus of 28911 kg nitrogen. The main reason for this is the fact, that the nitrogen content of purchased fertilisers and fodders is much higher than the low nitrogen content of the materials sold from the farms (crop products, fodders, fertilisers). The column of stock changes indicates a considerable surplus, as the difference of the closing stock and the opening stock, which indicates a large nitrogen surplus remaining in the farm. The major part of this surplus is due to the increased stock of unused fertilisers (16610 kg of nitrogen). The internal nutrient balance is the difference between the external nutrient balance and the nutrient contents remaining in the unused fertilisers. This is equal to 11857 kg of nitrogen used in the production processes, although a certain proportion of this might be lost in wastes. The positive internal nutrient balances for phosphorus and potassium (15737 kg of phosphorus, 18668 kg of potassium) show that the production processes had utilised nutrient contents accumulated in the soil earlier.

The following notations and relations are used in the tables below:

- The external nutrient balance (EB) is the difference of nutrients entering the farm with purchased material (P) and leaving it with sold stocks (S) (EB= P – S).
- The internal nutrient balance (IB) is the difference of nutrients leaving the farm with the yields of production (Y), and nutrients utilised by or inputted into the productions processes (U) (IB = Y –U).
- The stock change (SC) is the difference of nutrients of closing stock and opening stock, and is the same as the sum of external and internal nutrient balances (SC = EB + IB).

The weakest point of the external nutrient balance values, as it was said earlier, is the change of stocks. Due to the unsold products at the end of the farming year the difference in the nutrient contents of purchased and sold materials may be much higher than in the former year, although the major part of this difference is not a loss, nor is it stored in the soil, but is contained in the unsold stocks of the farm. This is particularly important when farm-gate balance is used as the foundation of environmental taxes ([2]), and after the introduction of the Environmental and Management Audit Scheme to agricultural production it may be used as the main element of the environmental audit system of the European Union ([3]).

It is worth pointing out, that positive values of the external nutrient balance (EB) mean that the nutrient contents of purchased material are higher than those of the sold stocks, accordingly, a positive amount of nutrients is added to the nutrient stocks being already present in the farm,. This difference may be in stocks of unused input materials, incorporated into the soil, or stored in unsold yield, or is lost in wastes. On the opposite, negative external nutrient balances suggest that larger nutrient amounts leave the farm than the amounts newly purchased during the year. This means that the nutrient stocks - either in inputs in stores, or in the soil, or in the form of stored yields – are depleted.

Similarly, the positive values of the internal nutrient balance (IB) means that produced yields contain more nutrients than the amounts used up in inputs, that is, the production process depleted the amounts stored in the soil or in the stocks. The negative values of IB suggest that yields absorbed less nutrients than the amount used in the production process, so a part of the inputted material is stored in the soil, or in unfinished production, or is lost as waste.

Table 1: Farm-level nutrient balances (kg), Farm 1

NITROGEN (N)	Opening stocks	Purchases (P)	Yield (Y)	Utilisation (U)	Sales (S)
Livestock	1476,6	12	3972	130	3837,9
Manure	870	0	238,6	24	0
Fodder	4765,34	69424	5933	27852,2	51538
Seeds	82	1953	0	1980,9	23
Fertilisers	24752	222032	0	146192	59230
Crop products	11410,1	0	167015	12836,6	149881
Total	43356	293421	177159	189016	264510

	Closing stock	Change of stocks (SC)	External nutrient balance (EB)	Internal nutrient balance (IB)
Livestock	1492,4	15,8	-3825,9	3841,7
Manure	1084,6	214,6	0	214,6
Fodder	732,06	-4033,28	17885,87	-21919,15
Seeds	31,1	-50,9	1930	-1980,9
Fertilisers	41362	16610	162802	-146192
Crop products	15708,2	4298,1	-149881	154178,7
Total	60410,36	17054,32	28911,37	-11857,05

PHOSPHORUS (P)	Opening stocks	Purchases (P)	Yield (Y)	Utilisation (U)	Sales (S)
Livestock	178,2	0,8	264,7	8,6	255,81
Manure	279	0	77,2	8	0
Fodder	932,77	13206	1181	5800,1	9353,2
Seeds	12	341,5	0	339,8	4,3
Fertilisers	3854,9	3954	0	5081	493
Crop products	2288,7	0	27866	2413,8	24332
Total	7545,6	17502	29389	13651	34438

	Closing stock	Change of stocks (SC)	External nutrient balance (EB)	Internal nutrient balance (IB)
Livestock	179,29	1,09	-255,01	256,1
Manure	348,2	69,2	0	69,2
Fodder	166,52	-766,25	3852,85	-4619,1
Seeds	9,4	-2,6	337,2	-339,8
Fertilisers	2234,9	-1620	3461	-5081
Crop products	3409,3	1120,6	-24331,6	25452,2
Total	6347,61	-1197,96	-16935,6	15737,6

POTASSIUM (K)	Opening stocks	Purchases (P)	Yield (Y)	Utilisation (U)	Sales (S)
Livestock	172,3	1,4	463,3	15,24	447,82
Manure	724	0	202,3	24	0
Fodder	912,104	15256	4718	12871,1	7721,3
Seeds	14,9	385	0	386,1	2,5
Fertilisers	16562	11209	0	16759	2581
Crop products	3174,5	0	46114	2773,7	41763
Total	21560	26851	51498	32829	52515

	Closing stock	Change of stocks (SC)	External nutrient balance (EB)	Internal nutrient balance (IB)
Livestock	173,94	1,64	-446,42	448,06
Manure	902,3	178,3	0	178,3
Fodder	293,704	-618,4	7534,7	-8153,1
Seeds	11,3	-3,6	382,5	-386,1
Fertilisers	8431	-8131	8628	-16759
Crop products	4752	1577,5	-41762,7	43340,2
Total	14564,24	-6995,6	-25663,9	18668,4

Notation: External nutrient balance-EB; Nutrients incoming with purchases –P; Nutrients outgoing with sales –S; Internal nutrient balance –IB; Nutrients contained in yields - Y; Nutrients utilised by production –U; Stock change – SC.

The stock change (SC), being the difference of nutrients of closing stock and opening stock, and is increased with positive EB values, and with positive IB values, adding up the increased nutrient contents of stocks in the form of unsold yields or unused inputs.

Table 2 and Table 3 give the nutrient balances of another mixed farm of approximately 1.5 thousand hectares, dealing with dairy, fodder and cash crop production, located in Western Hungary.

Table 2: Farm level nutrient balance (kg N), Farm2.

Item	External nutrient balance (farm gate balance)			Internal nutrient balance			SC
	P	S	EB	Y	U	IB	
Livestock	0	2841	-2841	2936	2079	857	-1984
Animal products	0	15219	-15219	15886	667	15219	0
Manure	0	1286	-1286	6291	7914	-1623	-2909
Fodder	88431	6	88425	51945	109981	-58036	30389
Seeds	1235	117	1118	0	1112	-1112	6
Fertilisers	252798	40320	212478	0	212478	212478	0
Crop products	0	84310	-84310	226435	143448	82987	-1323
Total	342464	144099	198365	303493	477679	-174186	24179

Notation: External nutrient balance-EB; Nutrients incoming with purchases –P; Nutrients outgoing with sales –S; Internal nutrient balance –IB; Nutrients contained in yields - Y; Nutrients utilised by production –U; Stock change – SC.

Table 3: Nutrient balances and stock changes for phosphorus and potassium, Farm 2.

Item	P (kg)			K (kg)		
	EB	IB	SC	EB	IB	SC
Livestock	-142	43	-99	-35	11	-24
Animal products	-2582	2582	0	-3940	3940	0
Manure	-230	-290	-520	-1148	-1449	-2597
Fodder	17266	-12979	4287	58600	-27213	31387
Seeds	209	-209	0	230	-228	2
Fertilisers	2403	-2403	0	7472	-7472	0
Crop products	-13118	13499	381	-13631	12398	-1233
Total	3806	243	4049	47548	-20013	27535

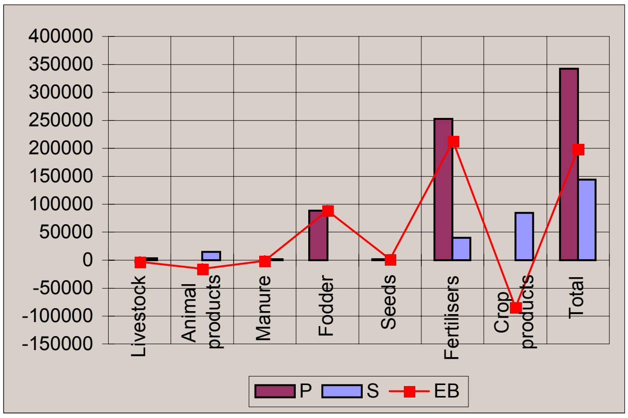
(for notation see Table 2)

Figure 1 shows the components of external nutrient balances of nitrogen for various stock items of the farm. Figure 2 gives the same information for internal nutrient balances. Figure 3 compares external and internal nutrient balances to the stock changes of the various materials and products. It is worth noting that the largest nutrient balances for nitrogen are related to fodder, fertilisers and crop products, the other components of farm inputs and outputs have much less significance.

CONCLUSIONS

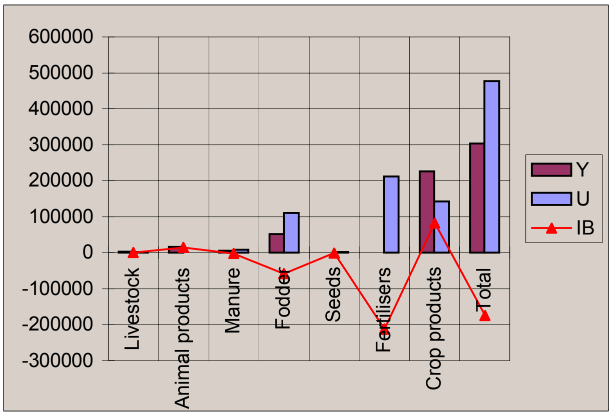
The analyses above show that the external nutrient balance in itself cannot be used to describe the nutrient surpluses accumulated within the farm, because this concept does not take into account the nutrient amounts present in the unsold outputs staying within the farm in the form of stocks. The internal nutrient balances give a more precise description about the nutrient surpluses present within the farm, because it means an improvement over the weaknesses of the external nutrient balances, taking into account the changes in the amounts of stocks within the farm.

Figure 1: External nitrogen balances in a mixed farm (kg) (Farm 2)



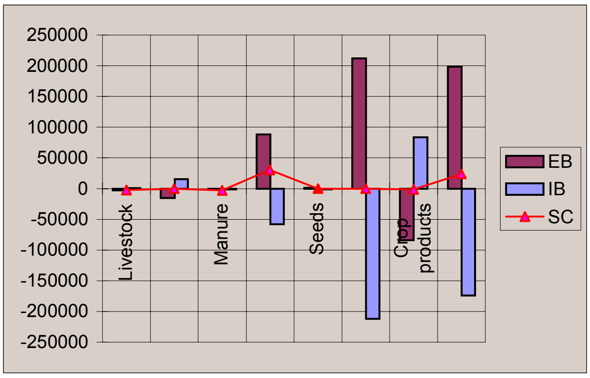
(Notation: P: purchases, S: sales, EB: external nutrient balances - see text)

Figure 2: Internal nitrogen balances in a mixed farm (kg) (Farm2)



(Notation: Y: yields, U: utilised nutrient amounts, IB: internal nutrient balances - see text)

Figure 3: Nitrogen stock changes and balances in a mixed farm (kg) (Farm 2)



(Notation: EB: external nutrient balances, IB: internal nutrient balances, SC: stock changes - see text)

The example of the analysed cooperatives leads us to the conclusion that the introduction of a nutrient accounting sub-system can be arranged within farm businesses relying on the present data recording system, after a minor modification of the presently used data record forms. A number of additional data (such as the amounts of nitrogen, phosphorus, potassium involved in a particular transaction or activity of the business) will have to be recorded together with the usual details of the event, and this ensures that the nutrient flows of the farm are traceable for the management of the business. The recording of the nutrient contents of the various materials could be incorporated into the presently used traditional accounting system as an integrated sub-system.

As a summary it was suggested that the definition of the concept of farm level nutrient balances, and their application is not unified among the researchers of the field. The different approaches of interpretation often cause difficulties in comparing research results, indicating the need for the development of methodology and the unification of terminology.

The results presented here are to be considered as preliminary approximations, and the next step of the research is to collect more detailed data and carry out more precise computations. Another important area of the future research is the clarification and the precise definition of the terms and concepts used in the field. However, even at the present stage of the research it must be stated, that the external and the internal nutrient balances differ considerably (this difference is reflected in the value of the stock change) for all the three nutrients analysed. The external nutrient balance, that is, the farm gate balance, cannot be sufficient then to assess the nutrient management practice of the farm business, and its impact on the environment.

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