The dry matter yields, nitrogen uptake, and the efficacy of nitrogen fertilisation in long-term field experiments in Prague

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ABSTRACT

Long-term field experiments conducted under different soil and climate conditions and their databases provide invaluable information and are indispensable means in the study of the productivity and sustainability of the soil management systems. We evaluated the results of the dry matter yields of the main products obtained with four variants of organic and mineral fertilisation in three long-term field experiments established in 1955. The experiments differed in the cultivated crops. The period of evaluation was 12 and 16 years (1985–2000), respectively. The productivity of nine-year crop rotation was lower with the fertilised variants than that with the alternative growing of spring wheat and sugar beets. The dry matter yields on the Nil variants, however, were higher in the crop rotation than in the alternate sugar beet and spring wheat growing, apparently due to the symbiotic nitrogen fixation. The dry matter yields of sugar beet and mainly of spring wheat declined in almost all variants of fertilisation in the alternate sugar beet and spring wheat growing, over the evaluated time period. In spite of the relatively high dry matter production, the declining yields indicated a lower sustainability of the alternate cropping system. Both organic and mineral fertilisation increased the production of the cultivated crops. The differences in the average dry matter yields were statistically significant. Both organic and mineral fertilisation enhanced significantly the N-uptake by the cultivated crops. The effectivity of nitrogen input was the highest with the alternate cropping of sugar beet and spring wheat indicating that it was more demanding for the external N-input and thus less sustainable than nine-year crop rotation.

Keywords: long-term field experiments; crop yields; nitrogen uptake; crop rotation; organic and mineral fertilisation

High productivity of agriculture has always been a priority of the agricultural soil management systems. The technical development within the last decades has remarkably increased the productivity, but on the other hand, it has also shown serious adverse effects on the soil properties and the environments. The increasing environmental impact of the new technologies has given rise to the requirement to adapt the soil management systems in such a way as to meet the requirements for sustainability.

The sustainability of the soil management systems can be defined as a development “that meets the present demand without spoiling the possibilities for covering those of the next generations” (Körschens 1997). Sustainable soil management, however, is hard to determine and guarantee in the long run because many factors that influence it remain yet unknown or are hardly predictable. Apart from that, numerous key processes in soil take place at a slow rate lasting for several decades and cannot be easily identified in a short-term monitoring.

For all these reasons, long-term field experiments conducted under different soil and climate conditions and their databases provide invaluable information and are indispensable means in the study of the productivity and sustainability of the soil management systems.

In this paper, we have evaluated the results of the dry matter yields and nitrogen uptake by the main products over 12-, resp. 16-year periods in four selected variants of three field experiments in Prague-Ruzyně.

MATERIAL AND METHODS

Experimental design

The long-term field experiments in Prague-Ruzyně belong to the oldest ones in the Czech Republic. Novák, Škopík and Škarda founded them in 1955 with the aim to investigate the effects of various fertilisation systems on the yields, nutrient uptake, and the soil quality.

The experiments were founded with six independent fields, five of which exist up to now (fields I, II, III, IV, and field B). Each field was split into four blocks differing in organic manuring and each block was further split into six variants of mineral fertilisation – altogether, twenty-four variants in four replicates (96 plots) in a semi-randomised design. The plots are squares, 12 m times 12 m, with 1.5 m protective stripes on all sides and 9 m times 9 m harvest plots in the middle. Three fields were cropped according to the original nine-year rotation (45% cereals, 33% root crops and 22% fodder crops) during the whole period of the experiment, till the present time. This original rotation was changed after the first rotation on

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Table 1. Selected fields and variants

	Crop rotation	Variants	Average N doses (kg N/ha/year)
Field III	9 years: lucerne, lucerne, winter wheat, sugar beet,	114 Nil	0
	spring barley, potatoes, winter wheat, sugar beet, spring barley	154 NPK	64.6
		214 FYM	38.6
		254 FYM + NPK	103.2
Field IV	9 years: lucerne, lucerne, winter wheat, sugar beet,	114 Nil	0
	spring barley, potatoes, winter wheat, sugar beet, spring barley	154 NPK	64.6
		214 FYM	38.6
		254 FYM + NPK	103.2
Field B	alternately sugar beet and spring wheat since 1965	114 Nil	0
		184 NPK	100
		214 FYM	57
		284 FYM + NPK	157

two fields in 1965. More cereals (67% cereals, 11% rot crops and 22% fodder crops) were introduced in field I, and sugar beet and spring wheat had been grown alternately on the field B since that time. This change extended the original objectives of the experiments, in which the long-term effect of crop rotation may be investigated since. The effects of the cultivated crops, and mainly legumes, on the yields, soil properties and nitrogen budget can be evaluated.

All experiments were rain fed, crop residues were removed with the exception of the plots that were fertilised with straw. Conventional tillage and agrochemicals were applied according to the local schemes.

Site characteristics

The altitude of the site is about 352 m above the sea level, the average annual temperature is 8.1°C and the average annual precipitation 450 mm. Soil type is Orthic Luvisol, clay-loam, developed on dilluvial sediments mixed with loess. The depth of the arable A horizon range between 26 and 33 cm, followed by a less apparent illuvial horizon which passes in the non-carbonaceous substrate. Clay content (particles < 0.002 mm) in the arable layer is 31.3%. Organic carbon content in the arable layer ranges between 1.1% and 1.4%. Its content in the upper layer of the illuvial horizon remains still relatively high (0.6–0.9%). Cation exchange capacity in the arable layer is about 20–22 meqv/100 g and it increases with the depth to 30–33 meqv/100 g. Soil reaction is neutral (pH_{KCl} is 6.8–7.1) in the whole profile. The results of the soil survey indicate processes of the downward clay migration in the profile and also of the processes of saturation of the sorption complex and the deepening of the humus horizon).

Basic measurements and selected variants

Yields of crops (main and second product), its dry matter and nutrient contents were determined over the whole

Table 2. Cultivated crops and the dry matter yields of the main products in field III over the period 1989 to 2000 (t/ha)

Year	Crop	Nil	NPK	FYM	FYM + NPK
1989	winter wheat	4.63	4.78	4.41	4.53
1990	sugar beet	8.27	8.26	8.68	9.71
1991	spring barley	3.43	5.40	4.16	5.13
1992	potatoes	3.63	6.04	4.90	5.74
1993	winter wheat	2.32	2.49	2.85	2.81
1994	sugar beet	8.97	12.17	11.92	11.79
1995	spring barley	2.17	4.73	2.85	4.35
1996	lucerne	3.11	2.49	3.07	3.01
1997	lucerne	6.96	7.08	6.80	7.90
1998	winter wheat	4.23	4.62	4.73	4.62
1999	sugar beet	15.14	20.80	18.47	18.92
2000	spring barley	1.85	2.52	2.30	2.62
Average		5.39	6.78	6.26	6.76

Table 3. Cultivated crops and the dry matter yields of the main products in field IV over the period 1988 to 1999 (t/ha)

Year	Crop	Nil	NPK	FYM	FYM + NPK
1988	winter wheat	5.09	6.08	5.82	6.39
1989	sugar beet	6.39	11.78	10.56	12.52
1990	spring barley	3.09	4.61	3.59	4.37
1991	potatoes	3.88	5.60	5.01	5.83
1992	winter wheat	2.88	3.78	3.52	3.59
1993	sugar beet	4.90	5.90	6.73	6.72
1994	spring barley	2.93	2.92	3.24	3.37
1995	lucerne	10.68	6.61	11.17	10.77
1996	lucerne	6.52	8.73	8.03	8.94
1997	winter wheat	5.43	5.42	5.27	5.45
1998	sugar beet	6.18	4.32	6.58	4.76
1999	spring barley	1.78	3.71	3.28	4.04
Average		4.98	5.79	6.07	6.39

duration of the experiments. The tillage, fertilisation and pest control measures were registered. Soil samples were taken from the arable layer of all the plots in the autumn each year and analysed for their organic C, total N, available P and K contents, and pH.

Four variants (Nil, NPK, FYM and FYM + NPK) from three fields (III, IV, and B) were selected for more detailed investigations during the last decade. The evaluation time periods for the individual fields differed. They were selected in view of the evaluation of the complete data and including the same crops i field III and field IV as shown in Tables 2–4.

The data were evaluated by means of t-test for the dependant samples that is available in the MS Excel.

The main characteristics of the selected fields and variants are presented in Table 1.

RESULTS AND DISCUSSION

The productivity of the farming systems has been determined mainly on the basis of the dry matter yields of the main products or both the main and the second products (Körschens 1997, Kubát et al. 2001, Lipavský et al. 2002)

Variability of the dry matter yields of the main products

The average dry matter yields of the main products in the selected fields and variants are presented in Tables 2–4. With on fields III and IV, the original design and nine-year crop rotation was maintained. The only differ-

Table 4. Cultivated crops and the dry matter yields of the main products in field B over the period 1985 to 2000 (t/ha)

Year	Crop	Nil	NPK	FYM	FYM + NPK
1985	spring wheat	2.54	4.65	3.12	4.75
1986	sugar beet	6.68	11.17	11.75	15.39
1987	spring wheat	2.94	5.53	4.31	6.06
1988	sugar beet	5.41	8.65	9.81	13.12
1989	spring wheat	2.04	3.88	3.32	3.73
1990	sugar beet	4.59	5.93	7.01	9.25
1991	spring wheat	3.19	5.57	4.36	5.26
1992	sugar beet	6.95	8.37	10.77	12.76
1993	spring wheat	2.22	3.64	3.16	3.45
1994	sugar beet	6.77	7.71	8.25	9.59
1995	spring wheat	2.43	5.25	4.17	5.43
1996	sugar beet	4.90	14.22	8.98	14.08
1997	spring wheat	2.10	3.69	2.82	3.98
1998	sugar beet	4.50	12.43	8.62	13.13
1999	spring wheat	1.88	3.19	1.90	2.97
2000	sugar beet	6.81	10.57	9.11	10.24
Average		4.12	7.15	6.34	8.32

Table 5. Statistical evaluation of the differences in the average dry matter yields; values of the *t*-stat in the *t*-tests for the dependant samples and the appropriate *t*-crit values

		Nil	NPK	FYM
Field III	FYM + NPK	4.298	0.096	3.327
	FYM	2.874	2.102	
	NPK	2.878		
		t-crit 0.05 = 2.179	*t*-crit 0.01 = 3.055	
Field IV	FYM + NPK	2.880	1.966	1.359
	FYM	3.617	0.644	
	NPK	1.325		
		t-crit 0.05 = 2.179	*t*-crit 0.01 = 3.055	
Field B	FYM + NPK	6.234	2.711	5.924
	FYM	5.976	1.856	
	NPK	5.370		
		t-crit 0.05 = 2.120	*t*-crit 0.01 = 2.921	

ence between these two fields was a one-year shift in the crop rotation. For this reason, the evaluated period in field IV was one year earlier than that in field III. The selected 12-year period included the same crops in both fields and also the same tillage and variants of organic and mineral fertilisation. This offered the possibility to evaluate the variability in the field experiments and the effect of different climate conditions in different years.

Although there were differences between the dry matter yields of the cultivated crops in the selected variants and also between the average values of dry matter yields over the whole period, these were not significant in the *t*-tests for the dependant samples. The *t*-values for the individual variants of fertilisation on both fields ranged between 0.156 and 0.673 while the critical value at 0.05 level was 1.782. Variability of the dry matter yields originating in the soil heterogeneity, the differences in climatic conditions in different years and also in the quality of the operations did not exceed the effect of the cultivated crops and fertilisation. These results support the credibility of the long-term field experiments in Prague-Ruzyně.

Effect of crop rotation

The highest average annual dry matter yields of the main products were reached in the fertilised variants of field B (alternate growing of spring wheat and sugar beets). The productivity of nine-year crop rotation was lower in both field III and field IV. On an average, 0.87 t/ha with NPK variants, 0.18 t/ha with FYM variants and 1.75 t/ha with FYM + NPK variants.

With the dry matter yields in Nil variants, on the contrary, the average dry matter yields in fields with nine-year crop rotation were higher than that in field B. The average difference between the dry matter yields of the main product in the fields with nine-year crop rotation (fields III and IV) and field B was 1.06 t/ha annually.

Lower dry matter yields of the main products in field III and field IV (nine-year crop rotation) were certainly caused by the differences in fertilisation. As shown in Table 1, the average annual nitrogen fertilisation in field B was higher by 34.5, 18.4, and 53.8 kg N/ha in variants NPK, FYM and FYM + NPK, respectively, that that in field III and field IV.

Besides that, however, the dry matter production depends as well on the cultivated crops. As shown in Table 3, the dry matter yield of spring barley in the Nil variant was 1.78 t/ha (in 1999) and the dry matter yield of lucerne reached 10.68 t/ha in the same variant in 1995. Obviously over a period of several years, the crop rotation composed of the crops that supply quantitatively higher yields may be more productive than the crop rotation composed of less productive crops. For this reason, a simple comparison of the yields in farm fields or field experiments differing in crop rotation would not be correct.

Effect of organic and mineral nitrogen fertilisation

Both organic and mineral fertilisation increased the dry matter yields of the cultivated crops. The differences of the results presented in Tables 2–4 were also statistically tested by means of *t*-tests for dependant samples. Results are shown in Table 5.

The differences in the dry matter yields of the main products between the non fertilised (Nil) and the combined organic- and mineral-fertilised variants (FYM + NPK) were significant on 0.01 level in all fields. The differences between the yields in the Nil variants and FYM and/or NPK variants were also significant in all fields with the only exception for NPK variant in field IV (Table 5). The differences in the dry matter yields in the fertilised variants were significant for FYM and FYM + NPK variants in field III, and for both FYM and NPK variants and combined FYM + NPK variant in field B. Other differenc-

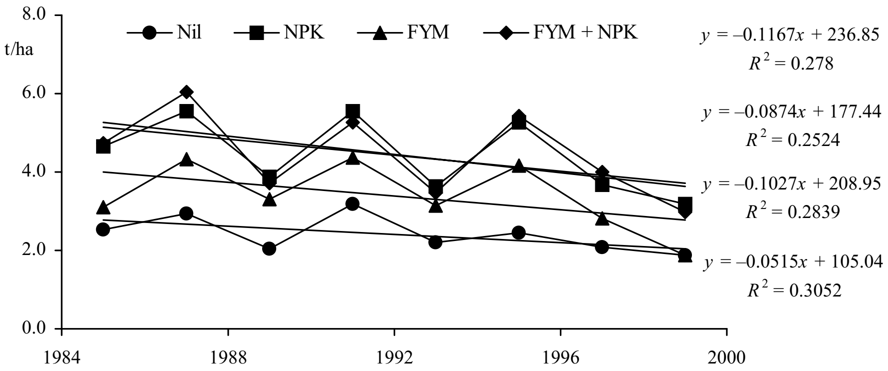

Figure 1. Dry matter yields (t/ha) of spring wheat grains in the selected variants of organic and mineral fertilisation in field B (t/ha)

es in the average dry matter yields between the fertilised variants were not significant.

Although the average annual N input was by about 67% higher in the NPK variants than in the FYM variants in fields III and IV, and by about 75% higher in field B, the differences in the dry matter yields between these variants were not statistically significant. Apparently, organic fertilisation with farmyard manure contributes to the nutrient supply to the cultivated crops and, simultaneously, it supports the crops indirectly, by means of the effect on the soil quality. Körschens (1983, 1990, 1997) evaluated a number of long-term field experiments in Germany and other countries in order to estimate the additional yield due to the organic fertilisation (differences in the yields on organic- and mineral-fertilised plots, and the yields on mineral-only fertilised plots in close to optimum doses). The value of the relative additional yield ranged between 6 and 11%.

These results may represent another indirect evidence of the favourable effect of organic fertilisation on the productivity and sustainability of farming systems.

Yield stability

Yield stability is an important indicator of the productivity and sustainability of agricultural systems. It is, however, difficult to determine in the field experiments, except for the oldest long-term experiments with the complete databases or those cropped with one single crop. Cropping field B with just two crops since 1965 and the complete database since 1985 enable to evaluate the trends in the dry matter yields of sugar beet and spring wheat, respectively, in this experiment. The dry mater yields of both crops were split and the regression lines for each crop were calculated. Results are shown in Figures 1 and 2.

Regression lines have clearly shown the decline in the average yields of both sugar beet and spring wheat in all the variants of fertilisation with the only exception for NPK variant and sugar beet. The decrease in the dry matter yields of sugar beet over the evaluated time period (1985–2000) was estimated from the regression lines to 3.6, 14.9 and 13.4% in the Nil, FYM and FYM + NPK variants, respectively. Mineral-fertilised variant (NPK)

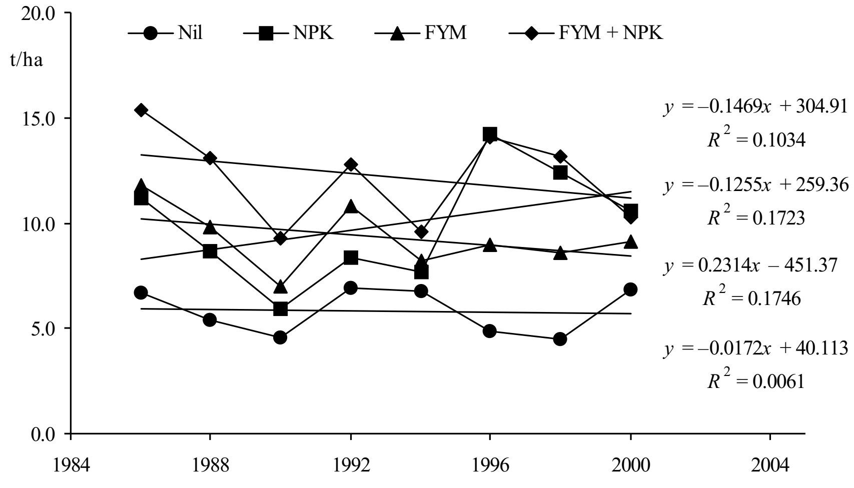

Figure 2. Dry matter yields (t/ha) of sugar beet roots in the selected variants of organic and mineral fertilisation in field B (t/ha)

Table 6. Nitrogen uptake by the main products of the cultivated crops in field III over the period 1989 to 2000 (kg N/ha)

Year	Crop	Nil	NPK	FYM	FYM + NPK
1989	winter wheat	82.9	88.0	81.9	100.6
1990	sugar beet	21.4	25.8	25.6	29.7
1991	spring barley	50.7	104.0	61.8	98.3
1992	potatoes	87.1	144.9	117.6	137.8
1993	winter wheat	44.0	56.6	51.1	65.6
1994	sugar beet	60.1	112.0	79.8	121.5
1995	spring barley	38.2	117.0	56.5	99.6
1996	lucerne	87.2	74.4	82.2	87.7
1997	lucerne	208.3	185.9	202.9	230.3
1998	winter wheat	89.0	104.7	101.8	111.8
1999	sugar beet	135.2	157.0	121.0	173.3
2000	spring barley	36.5	59.2	44.2	67.7
Average		78.4	102.5	85.5	110.3

showed an opposite trend. The average dry matter yield increase over the same time period was estimated to 29.0%.

Surprisingly, the decline in the dry matter yields of the spring wheat was much more pronounced than that of the sugar beet roots (Figure 1). Over the same time period (1985 to 1999), the estimated decrease in the grain dry matter yield was 28.4, 30.9, 39.3, and 34.4% in the Nil, NPK, FYM and FYM + NPK variants, respectively.

These results show that in spite of relatively high yield levels in field B, its declining trends indicate insufficient sustainability of the alternate growing of sugar beet and spring wheat.

Nitrogen uptake

The average annual nitrogen uptakes by the main products of the cultivated crops in the selected fields and variants are presented in Tables 6–8.

The data were evaluated by the same procedure as the dry matter yields, i.e. by means of *t*-tests for the dependant samples. The differences in the average N uptake in the same variants of fertilisation in field III and field IV were, again, statistically in significant. The *t*-stat ranged between 0.240 and 0.920 while the *t*-crit was 2.179 at 0.05 level. The residual variability of the N-uptake by the main products originating in the soil heterogeneity, climate conditions, and the quality of operations did not exceed the effect of the cultivated crops and fertilisation. The results of the *t*-tests for the dependant samples regarding N-uptake by the main products in the selected fields and variants are presented in Table 9.

Both organic and mineral fertilisation enhanced the N-uptake by the cultivated crops in all selected fields and variants. The differences in the average N-uptake by the main products were highly significant between all variants in field B and between the FYM + NPK variants and Nil variants in fields III and IV. The average N-up-

Table 7. Nitrogen uptake by the main products of the cultivated crops in field IV over the period 1988 to 1999 (kg N/ha)

Year	Crop	Nil	NPK	FYM	FYM + NPK
1988	winter wheat	83.0	111.8	97.7	119.4
1989	sugar beet	45.8	113.5	60.3	139.8
1990	spring barley	43.3	68.5	49.0	73.3
1991	potatoes	89.5	142.7	107.7	158.5
1992	winter wheat	42.7	81.4	57.3	89.3
1993	sugar beet	59.3	48.4	86.1	69.2
1994	spring barley	51.9	43.8	50.6	53.2
1995	lucerne	307.0	206.7	363.8	335.0
1996	lucerne	218.9	263.9	260.0	303.7
1997	winter wheat	94.1	116.9	91.2	129.9
1998	sugar beet	10.2	28.9	14.4	26.5
1999	spring barley	29.8	59.1	53.5	75.2
Average		89.6	107.1	107.6	131.1

Table 8. Nitrogen uptake by the main products of the cultivated crops in field B over the period 1985 o 2000 (kg N/ha)

Year	Crop	Nil	NPK	FYM	FYM + NPK
1985	spring wheat	44.0	75.8	50.8	81.3
1986	sugar beet	24.7	72.6	57.6	103.1
1987	spring wheat	45.0	91.3	61.6	106.7
1988	sugar beet	26.5	64.0	54.0	139.0
1989	spring wheat	30.7	69.1	52.2	72.3
1990	sugar beet	27.6	45.1	49.8	80.5
1991	spring wheat	47.5	124.4	75.3	124.3
1992	sugar beet	58.4	79.5	86.1	141.7
1993	spring wheat	37.8	89.5	59.7	84.9
1994	sugar beet	47.4	77.8	49.5	119.9
1995	spring wheat	41.5	98.7	72.6	112.3
1996	sugar beet	28.1	82.6	45.1	92.2
1997	spring wheat	31.9	58.2	45.1	84.0
1998	sugar beet	17.9	56.7	35.0	84.0
1999	spring wheat	35.6	62.9	36.7	58.0
2000	sugar beet	33.4	71.1	56.1	85.2
Average		36.1	76.2	55.4	98.1

take in the mineral-fertilised variant was significantly higher than that in the Nil variant in the field III, while the difference between these two values was not significant in field IV. As to the organic manuring, the difference in the average annual N-uptake between FYM manured variants was significant in field IV and insignificant in field III, the *t*-test value being, however, just below the *t*-crit on 0.05 level limit.

Estimation of the atmospheric nitrogen deposition

The Nil variant in field B had not received any organic or mineral N fertilisers since 1956. In this experiment, there had been no legumes grown since 1965 and the non symbiotic N_2 fixation might account for just a 5 kg N annually (3 to 5 kg N/ha/year); the total N content in soil did not practically change during the last eight years (Kubát et al. 2002). The average N-uptake may be used for the estimation of the atmospheric N deposition. The average N deposition should be at least at the level of the average N-uptake by the main products (36.1 kg N/ha/year) plus about 20 kg N/ha/year uptake by the second products.

Symbiotic nitrogen contribution to the nitrogen budget

The average annual nitrogen uptake was considerably higher in fields III and IV than in field B, in spite of a higher average N fertilisation in field B (Table 1). This was

Table 9. Statistical evaluation of the differences in the average nitrogen uptake by the main products; values of the *t*-stat in the *t*-tests for the dependant samples and the appropriate *t*-crit values

		Nil	NPK	FYM
Field III	FYM + NPK	6.009	1.957	5.954
	FYM	2.160	2.795	
	NPK	2.974		
		t-crit 0.05 = 2.179	*t*-crit 0.01 = 3.055	
Field IV	FYM + NPK	5.449	2.603	3.000
	FYM	3.897	–0.034	
	NPK	1.522		
		t-crit 0.05 = 2.179	*t*-crit 0.01 = 3.055	
Field B	FYM + NPK	12.379	4.036	10.343
	FYM	8.506	6.216	
	NPK	11.198		
		t-crit 0.05 = 2.120	*t*-crit 0.01 = 2.921	

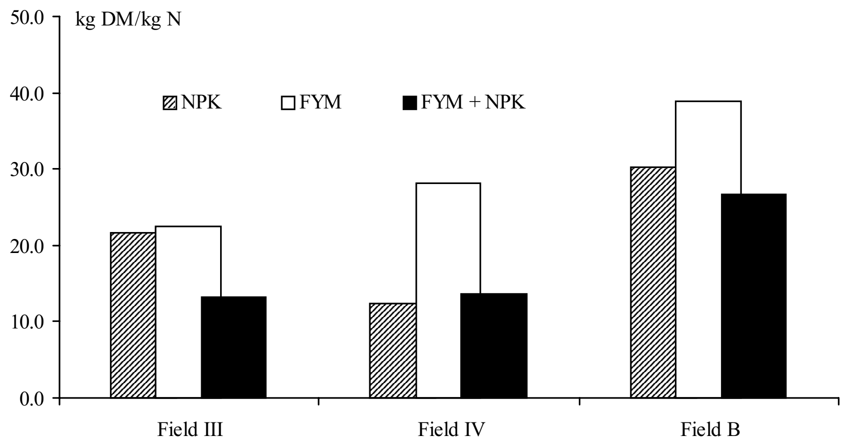

Figure 3. Efficacy of the N fertilisation in the selected fields and variants (kg dry matter/kg N)

apparently due to the lucerne and symbiotic nitrogen contribution to the nitrogen budget in fields III and IV. This contribution may be estimated from the average annual N uptake in the Nil variants in field III and IV (crop rotation with 22% lucerne) and in the Nil variant in field B (alternative growing of spring wheat and sugar beet). The difference between the mean N uptake in the Nil variants in fields III and IV and the Nil variant in field B was 47.9 kg N/ha/year. The proportion of lucerne in the crop rotation was 22%, which means that the average annual symbiotic N fixation by rhizobia exceeded 200 kg N/ha. This estimation is based on the N-uptake by the main products. It does not include N-uptake by the second products, e.g. straw or sugar beet leaves that had been removed over the whole duration of the experiments.

Efficacy of the nitrogen fertilisation

The efficacy of nitrogen fertilisation was estimated as a difference between the average annual N-uptake by the main products in the selected fields and fertilised variants, and that in the Nil variants, calculated on 1 kg N applied in FYM or mineral NPK fertilisers. The results are presented in Figure 3.

The efficacy of nitrogen fertilisation may be a useful indicator of the productivity and sustainability of the soil management systems. A strong response on N inputs indicates a lack of nitrogen in the system, while a weak response may indicate a higher degree of nitrogen saturation in the system. Actually, the yield increase calculated in relation to a unit of nitrogen added decreases with the increasing input.

In spite of the fact that the average N fertilisation in field B (alternate growing of spring wheat and sugar beet) was higher than in fields III and IV (nine-year crop rotation), the efficacy of both organic and mineral-N fertilisation was higher in field B than in fields III and IV. This is certainly due to the contribution of the crop rotation including 22% lucerne to the nitrogen budget with more than 47.9 kg N/ha/year. The average annual nitrogen input in fields III and IV thus exceeded that in field B except for FYM + NPK variant.

Crops cultivated in field B were much more external N-demanding than the nine year-crop rotation and, consequently, less sustainable.

CONCLUSIONS

The variability of the dry matter yields originating in the soil heterogeneity, differences in climatic conditions in different years, and also in the quality of operations did not exceed the effects of the cultivated crops and fertilisation.

The productivity (dry matter yields) of nine-year crop rotation (fields III and IV) was lower in fertilised variants than in field B (alternative growing of spring wheat and sugar beet). The dry matter yields in the Nil variants, however, were higher in fields III and IV, apparently due to the symbiotic nitrogen fixation.

The dry matter yields of sugar beet and, mainly, spring wheat (field B) declined in almost all variants of fertilisation over the evaluated time period. In spite of a relatively high dry matter production, the declining yields indicated a lower sustainability of alternate cropping with sugar beet and spring wheat.

Both organic and mineral fertilisation increased the production of the cultivated crops. The differences in the average dry matter yields were statistically significant. Organic fertilisation with farmyard manure contributed to the nutrient supply and, simultaneously, supported the crops indirectly by means of its effect on the soil quality.

Both organic and mineral fertilisation enhanced the N-uptake by the cultivated crops in all the selected fields and variants. The efficacy of nitrogen input was the highest in field B, indicating that alternate cropping with sugar beet and spring wheat was more external N-input demanding and thus less sustainable than nine year crop rotation.

Nitrogen balance in the long-term field experiments enables the estimation of atmospheric N deposition and the estimation of the contribution of the symbiotic N fixation to the nitrogen budget.

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ABSTRAKT

Výnosy, čerpání dusíku a účinnost dusíkatého hnojení v dlouhodobých polních pokusech v Praze-Ruzyni

Dlouhodobé polní pokusy prováděné v různých půdních a klimatických podmínkách a jejich databáze jsou nezbytné pro hodnocení produktivity a setrvalosti systémů hospodaření na orné půdě. Vyhodnotili jsme výnosy sušiny hlavního produktu ve čtyřech variantách organického a minerálního hnojení ve třech dlouhodobých polních pokusech založených v roce 1955. Pokusy se liší zejména v osevním sledu. Byla hodnocena časová řada 12, resp. 16 let v období 1985 až 2000. Produktivita (průměrný výnos sušiny hlavního produktu) devítihonného osevního postupu byla na hnojených variantách nižší než při alternativním pěstování cukrovky a jarní pšenice. Na nehnojených variantách byla naopak produktivita osevního postupu vyšší, a to zřejmě v důsledku přínosu symbiotické fixace dusíku. Výnosy sušiny cukrovky a zejména jarní pšenice při jejich alternativním pěstování ve sledovaném období klesaly téměř ve všech variantách hnojení. Přes relativně vysokou úroveň výnosů (produktivitu) lze jejich výrazně klesající tendenci považovat za indikátor nižší setrvalosti alternativního pěstování cukrovky a jarní pšenice. Organické i minerální hnojení zvyšovalo výnosy pěstovaných plodin. Rozdíly v průměrných výnosech byly statisticky významné. Organické i minerální hnojení zvyšovalo příjem dusíku pěstovanými plodinami. Účinnost hnojení dusíkem byla vyšší při alternativním pěstování cukrovky a jarní pšenice než v devítihonném osevním postupu. Rovněž vyšší účinnost hnojení dusíkem lze považovat za indikátor vyššího požadavku na externí N hnojení, a tedy nižší setrvalosti. Z bilance dusíku v dlouhodobých polních pokusech lze odvodit hladinu atmosférické depozice N a přínos symbiotické fixace N do systému.

Klíčová slova: dlouhodobé polní pokusy; výnosy plodin; příjem dusíku rostlinami; osevní postup; organické a minerální hnojení

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