Influence of different cultivation factors on the yield structure and on changes of soil properties

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ABSTRACT

The monitoring was carried on in the years 1996–2000 in the polyfactorial P-A field trial in Lukavec, Pelhřimov district. The given locality is characterized by low fertility sandy-loamy cambisoils, by long-term average annual rainfall of 653 mm, by average annual temperature of 7°C and its altitude is 620 m. The field trial included different organic fertilizations; graduate N-doses, different soil tillage as well as different forecrops. It manifested in this group of field trials that the forecrop value of red clover and dung manured potatoes before winter wheat was practically the same in the given locality. The optimal N dose for potato yields was about 80 kg $N.ha^{-1}$. In oats the yields after red clover with using the Horsch system in spring were significantly lower than after embedding of red clover in autumn. In cereals, graduated N doses increased the numbers of ears (panicles) per m^2, but the mass of 1000 grains often decreased. In addition, N content in grain and straw increased with N doses, while pH annually decreased by 0.1 to 0.4.

Keywords: winter wheat; winter barley; oats; potatoes; different organic fertilization; graduated N doses; structure and quality of yields; crop and soil analyses

N fertilization is decisive in less fertile brown cambisoils (Vaněk et al. 1997a, b). Very important in these conditions are organic fertilization and the fertilizing impact of soil fertility reproducing plants (Vach and Vrkoč 1995).

Many of ours and other papers proved irrefutably that using of yield potential of low fertility brown cambisoils which prevail in the Czech Republic depends mainly on the intensity of organic fertilization and on N doses in mineral fertilizers. The obtained crop yields are also significantly influenced by a suitable forecrop and variety as we had proved already earlier and quantified on the results of our different polyfactorial long-term field trials going on at several sites (Vrkoč 1992).

MATERIAL AND METHODS

Polyfactorial field trial (P-A) went on in the years 1996–2000 at the experimental station in Lukavec, Pelhřimov district, where less fertile sandy loamy combined soils containing 2–3% of humus of lower quality prevail, with average annual rainfall about 600 mm, average annual temperature of 7°C and altitude of 620 m.

The field trial included different crop rotations (forecrops), different soil tillage and several degrees of N fertilization (0–120 kg $N.ha^{-1}$).

Variants of crop rotation

A

1. Red clover (two cuts), ploughing to 18 cm at the end of August, harrowing, in the third decade of September pre-sowing preparation and sowing
2. Winter wheat, shallow ploughing after harvest, harrowing, at the end of October stall dung 30 $t.ha^{-1}$ and embedding to 22 cm, in spring tradition soil preparation and potato planting
3. Potatoes, at the end of October ploughing to 18 cm, in spring traditional pre-sowing preparation and sowing
4. Oats, shallow ploughing after harvest, harrowing, at the end of October ploughing to 18 cm, in spring traditional soil preparation and sowing
5. Green mixed crop with red clover undersowing

B

1. Red clover (two cuts), in the third decade of September sowing by the Horsch system
2. Winter wheat, shallow ploughing after harvest and sowing of mustard for green manure, at the end of October stall dung 30 $t.ha^{-1}$ and its embedding to 22 cm, in spring traditional soil preparation, planting
3. Potatoes, at the end of October ploughing to 18 cm, in spring traditional soil preparation and sowing
4. Oats, shallow ploughing after harvest and sowing of mustard for green manure, at the end of October ploughing to 18 cm, in spring traditional soil preparation and sowing
5. Green mixed crop with red clover undersowing

C

1. Red clover (three cuts), at the end of October ploughing to 18 cm, in spring traditional soil preparation and sowing
2. Oats with perennial ryegrass undersowing, at the end of October manuring by stall dung and ploughing to 22 cm, in spring traditional soil preparation and sowing
3. Potatoes, after harvest shallow loosening and sowing
4. Winter wheat, after harvest only surface loosening and sowing mustard for green manure, at the end of October

ploughing to 18 cm, in spring traditional soil preparation and sowing
5. Green mixed crop with red clover undersowing

D
1. Red clover (three cuts), in spring sowing by the Horsch system
2. Oats with perennial ryegrass undersowing, ryegrass mulching over winter, in spring manuring by stall dung 30 t.ha^{-1}, rotation soil tillage to 15 cm and planting
3. Potatoes, after harvest shallow loosening and sowing
4. Winter wheat, after harvest no soil tillage, in spring sowing by the Horsch system
5. Green mixed crop with undersowing

Evaluation of yields, of their structure and quality, agrochemical analyses of crops and soil were done annually by standard methods.

RESULTS AND DISCUSSION

In the polyfactorial field trials (P-A), grain yields of **winter wheat** (Siria variety) were significantly influenced by all factors (forecrop, N fertilization, year – Tables 1and 2). The five-year results allow to estimate that the fore-crop value of red clover as well as of stall dung manured potatoes for the following winter wheat is practically the same in the given locality. To obtain the same yields as after stall-dung manured potatoes, it was necessary on the plots without organic fertilization to increase the N dose by 20–40 kg.ha^{-1}. To obtain the same yield after shallow loosing of soil after potato harvest as after red clover embedded at the end of August, it was necessary, as already stated by Procházková and Dovrtěl (2000), to increase for the following winter wheat the N-dose by 40–60 kg.ha^{-1}. Similar results for winter wheat grain yields were obtained also in individual years and in straw yields.

As to **potato** tubers yields (Table 1) differences due to different forecrops with different soil tillage were not statistically significant. The effect of N_2 and N_3 as well as N_3 and N_4 doses did not significantly differ. Optimal from the viewpoint of yields and starch content of potatoes with middle dose of stall dung was the N dose of about 80 kg N.ha^{-1}.

The complex analyses of **oats** grain yields for the period 1996–2000 makes it clear that all the monitored factors (forecrop, N fertilization, years) as well as their mutual interactions had a significant impact on the variability of yields in the average of years (Tables 1 and 2). The highest yields were obtained after red clover embedded in October, the lowest ones when using the Horsch system after red clover in spring. The situation was similar in individual years also in oats straw yields.

Increased N doses and organic fertilization increased, similarly as in our former field trials (Vach and Vrkoč 1995), the number of ears (panicles)/m^2 in winter wheat and in oats. However, in some years, the highest N doses reduced the mass of 1000 grains (Table 3).

The highest percentage of N content in grain and straw of cereals as well as in potato tubers (Harris 1978) was always found in plots with the highest N doses, for other nutrients the values somehow oscillated.

Graduated N doses led, in accordance with Vaněk et al. (1997a, b) to a soil acidification of 0.1 to 0.4 pH value, which were naturally manifested also by a decrease of Ca and Mg content in soil (Table 4). A similar tendency was observed also in P and K content in soil. On the contrary, increased N doses increased after five years the content of total nitrogen, C_{ox} and humus.

Table 1. Yields of field crops (t.ha^{-1}) from the polyfactorial P-A trial according to forecrops, mineral fertilization, individual years and their incorporation into homogenous groups a–d* (Tukey P = 95%)

		Winter wheat		Potatoes		Oats	
Average yield		5.5775	*	44.6674	*	4.7575	*
Forecrop – crop rotation	A	6.1066	c	45.5034	a	4.8278	b
	B	5.6978	bc	43.8151	a	4.8875	b
	C	5.3421	ab	44.0108	a	5.3383	c
	D	5.1634	a	45.3404	a	3.9764	a
Mineral fertilization	N_1	4.4421	a	40.1729	a	3.9899	a
	N_2	5.3836	b	43.6396	b	4.7855	b
	N_3	6.1063	c	46.7533	bc	5.1155	b
	N_4	6.3779	c	48.1039	c	5.1390	b
Year	1996	5.2981	ab	40.8695	b	5.4902	d
	1997	5.6025	b	35.5278	a	3.9788	a
	1998	6.6509	c	55.3969	d	4.8927	bc
	1999	4.9542	a	41.0406	b	4.9891	c
	2000	5.3816	ab	50.5022	c	4.4367	ab

* if there is the same letter attached to the yields, the mutual values are not statistically significant, different letters indicate a statistically significant difference at the level of significance 95%

Table 2. Yields of field crops ($t.ha^{-1}$) from the polyfactorial P-A trial in the interaction of forecrop and mineral fertilization and reliability interval (Tukey P = 95%)

Interaction	Winter wheat			Potatoes			Oats		
	average	reliability interval		average	reliability interval		average	reliability interval	
		< 95%	> 95%		< 95%	> 95%		< 95%	> 95%
A × N_1	5.0240	4.7343	5.3137	40.5520	36.5588	44.5452	3.6605	3.3600	3.9610
A × N_2	5.8935	5.5427	6.2443	44.2320	39.7223	48.7417	4.7740	4.4059	5.1421
A × N_3	6.5625	6.2154	6.9096	46.7335	42.2642	51.2028	5.3140	4.8991	5.7289
A × N_4	6.9465	6.6568	7.2362	50.496	46.4743	54.5177	5.5625	5.1863	5.9387
B × N_1	4.6520	4.2994	5.0046	39.1875	34.9847	43.3903	3.9290	3.4922	4.3658
B × N_2	5.5305	5.1999	5.8611	43.2895	38.9950	47.5840	4.9970	4.4812	5.5128
B × N_3	6.2660	6.0329	6.4991	46.5840	42.8560	50.3120	5.2765	4.8509	5.7021
B × N_4	6.3425	6.1459	6.5391	46.1995	42.2677	50.1313	5.3475	4.8864	5.8086
C × N_1	4.0525	3.6007	4.5043	39.2835	33.8409	44.7261	5.0645	4.7695	5.3595
C × N_2	5.2120	4.8189	5.6051	43.2560	39.9957	46.5163	5.4815	5.2551	5.7079
C × N_3	5.8630	5.5675	6.1585	45.9485	42.4526	49.4444	5.4505	5.2352	5.6658
C × N_4	6.2410	5.8572	6.6248	47.555	44.6595	50.4505	5.3565	5.1807	5.5323
D × N_1	4.0400	3.5948	4.4852	41.6685	37.2220	46.1150	3.3055	2.6848	3.9262
D × N_2	4.8985	4.5132	5.2838	43.7810	40.1505	47.4115	3.8895	3.3096	4.4694
D × N_3	5.7335	5.2659	6.2011	47.7470	45.0521	50.4419	4.4210	3.9448	4.8972
D × N_4	5.9815	5.6117	6.3513	48.1650	45.0148	51.3152	4.2895	3.8620	4.7170

In general, a narrow connection was found between the level of obtained yields and the N content in soil (Skala and Vrkoč 1995, Vaněk et al. 1997a, b). It was also proven that an early embedding of red clover at the end of August – at the beginning of September lead to a considerable and quick mineralization of root residues and to subsequent N losses into underground water. When using the Horsch system after red clover, this was found only to a minimal extent, the winter wheat yields were nevertheless reduced.

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Table 3. Effect of forecrops on the number of ears (panicles) and the mass of 1000 grains in winter wheat and oats in Lukavec – P-A (average of monitored years)

Variant	Number of ears (pan) per 1 m^2		Mass of 1000 grains (g)	
	winter wheat	oats	winter wheat	oats
A N_1	436	338	43.19	35.13
A N_2	453	372	42.38	35.98
A N_3	447	399	42.91	35.04
A N_4	469	430	42.66	34.99
B N_1	416	351	44.00	35.04
B N_2	453	374	44.02	35.19
B N_3	463	376	43.70	34.90
B N_4	457	396	43.57	35.04
C N_1	389	349	42.08	35.45
C N_2	439	369	43.13	35.44
C N_3	451	380	43.02	34.77
C N_4	452	381	43.55	34.46
D N_1	424	338	43.57	34.95
D N_2	432	347	44.10	35.68
D N_3	461	372	44.22	35.69
D N_4	461	372	43.56	34.89

Table 4. Results of agrochemical analyses of soil from the polyfactorial P-A field trial – Lukavec year 2000

	Variant	pH/KCl	Basic nutrients content in mg.kg^{-1} soil				C_{ox} (%)	N_t (%)
			P	K	Ca	Mg		
Winter wheat	A N_1	5.53	146.6	149	966	88.5	1.871	0.176
	A N_3	5.25	126.7	119	879	86.4	2.053	0.166
	B N_1	5.55	128.9	131	922	112.7	1.871	0.169
	B N_3	5.20	150.3	137	966	116.2	2.252	0.180
	C N_1	4.67	140.8	113	794	109.2	2.008	0.173
	C N_3	4.95	118.9	79	836	113.9	1.773	0.182
	D N_1	4.97	123.7	149	753	118.1	1.982	0.205
	D N_3	4.50	122.1	119	712	111.6	2.038	0.220

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ABSTRAKT

Vliv různých pěstitelských faktorů na strukturu výnosu a změny půdních vlastností

Polyfaktoriální polní pokus (P-A) proběhl v letech 1996 až 2000 v Lukavci, okres Pelhřimov. Na dané lokalitě jsou málo úrodné písčitohlinité kambizemě, dlouhodobý roční úhrn srážek činí 653 mm, průměrná roční teplota 7°C, nadmořská výška 620 m. V polním pokusu byly zařazeny: různé organické hnojení, stupňované dávky N, různé zpracování půdy i různé předplodiny. U této skupiny polních pokusů se ukázalo, že předplodinová hodnota jetele lučního a hnojem hnojených brambor pro následnou ozimou pšenici se v dané lokalitě prakticky vyrovnává. Pro výnosy brambor se jako optimální ukázala dávka 80 kg N.ha^{-1}. U ovsa byly výnosy po jeteli lučním a za použití systému Horsch na jaře průkazně nižší než při zaorávce jetele lučního na podzim. Stupňované dávky N zvyšovaly u obilnin počet klasů (lat) na m^2, avšak hmotnost 1000 zrn se často snižovala. Rovněž obsah N v zrně i ve slámě se s dávkami N zvyšoval, zatímco pH půdy se ročně snižovalo o 0,1 až 0,4.

Klíčová slova: ozimá pšenice; ozimý ječmen; oves; brambory; různé organické hnojení; stupňované dávky N; struktura a kvalita výnosů; analýzy rostlin a půdy

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