CROP PRODUCTION AND GRASSLAND MANAGEMENT

THE EFFECT OF CATCH CROP NITROGEN ON SOIL PROPERTIES AND SPRING BARLEY YIELD

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Abstract

During the period 2001-2004 field experiments were carried out at the Lithuanian Institute of Agriculture's Joniskelis Experimental Station on clay loam soil. The experiments were designed to elucidate the mobilization of soil nitrogen by the catch crops oil radish (*Raphanus sativus* L.), white mustard (*Sinapis alba* L.), red clover (*Trifolium pratense* L.), cocksfoot (*Dactylis glomerata* L.), Italian ryegrass (*Lolium multiflorum* Lamk.) and their subsequent effect on soil organic carbon and the spring barley grain yield. The ranking among the different catch crops according to nitrogen content in biomass was: red clover > white mustard > oil radish = cocksfoot > Italian ryegrass. The N_2 fixation rate of red clover was 128 kg ha^{-1}. The averaged data of the experiments indicate that with increasing root and overground plant mass the C to N ratio widened (r=0.66, r=0.68; P≤0.05 respectively) and the fibre content increased (r= 0.59, r= 0.69; P≤0.05). Experimental evidence suggests that having incorporated the biomass of various crops (with C:N ratio = 17.0-25.7) - oil radish, white mustard and red clover at flowering the stage and that of cocksfoot and Italian ryegrass at the heading stage, the content of soil organic carbon in the soil increased (4.0-5.6 %). The legume catch crops biomass ploughed in as green manure significantly increased the spring barley yield.

Key words

Catch crops, nitrogen, carbon, yield

Introduction

Numerous studies have been done and recommendations have been provided on the most suitable fertiliser forms and rates, application timing and methods. However, research on the effects of the technologies used on nutrients, especially nitrogen, immobilisation in the soil after the harvesting of main crops, when the soil during the post-harvest period stays without any plant cover for a long time, is rather scanty. It was found that intensive crop fertilisation results in increased N_{min} content in the autumn, since the content of nitrogen unutilised by crops amounts to 25 to 155 kg ha^{-1}, which poses a real threat of pollution to ground water (Macdonald *et al*., 2005). Seeking to reduce environmental pollution, very important is an adequate selection of preventive measures when including the nutrients not utilised by plants into the biological turnover cycle (Stadler *et al*., 2005; Tripolskaja, 2005). With this end in view, technologies with catch crops that accumulate and localize in the soil the nutrients left in the biomass at the end of summer –during the autumn (winter) period, and during the most intensive leaching complex and prevent the nutrients from being leached, are widely used in Western Europe (Farthofer *et al*., 2004; Rinnofner *et al*., 2005).

The objective of the present study was to ascertain the effects of the catch crop overground biomass as green manure on the fertility of soil and the spring barley yield.

Materials and Methods

Experiments were conducted at the Joniskelis Experimental Station of the Lithuanian Institute of Agriculture located in the northern part of Central Lithuania Lowland during the period 2001-2004. The soil of the experimental site is characterised as Endocalcari-Endohypogleyic Cambisol (CMg-n-w-can), according to the texture – clay loam on silty clay, whose parental rock is lacustrine clay. The soil agrochemical properties in the 0–25 cm layer are presented in 1 table.

Experiments involved the following design: 1. Without catch crop; 2. Oil radish (*Raphanus sativus* L.); 3. White mustard (*Sinapis alba* L.); 4. Red clover (*Trifolium pratense* L.); 5. Cocksfoot (*Dactylis glomerata* L.); 6. Italian ryegrass (*Lolium multiflorum* Lamk.). Two analogous experiments were set up in 2001 (Experiment 1) and 2003 (Experiment 2) and lasted for two years (2001-2002 and 2003-2004) each. Red clover, cocksfoot and Italian ryegrass were undersown in spring barley – shortly after sowing. Catch crops as post-crops: white mustard and oil radish was direct drilled by a stubble drill after cereal harvesting (on the same day). N_{30} was applied after cereal harvesting for optimal growth and the development of oil radish, white mustard, cocksfoot and Italian ryegrass. The next year spring barley was grown after the incorporation of the catch crops biomass as green manure. Nitrogen, organic carbon and crude fibre in the green material of catch crops was determined by the following methods: by Kjeldahl and by the analyser „Heraeus" respectively. The total soil nitrogen was determined by the Kjeldahl method, organic carbon content- after picking out visible rootlets from the soil samples - by the Tyurin method. The experimental data was processed by methods of dispersion and correlation analysis, applying the programmes ANOVA and STATENG for statistical data treatment (Tarakanovas and Raudonius, 2003).

Results and Discussion

The highest overground biomass was produced by the undersown crops – red clover, cocksfoot and by postcrops –white mustard. Of all catch crops red clover was noted for the highest total dry matter content, which was 1.6 -2.4 times higher compared with the other catch crops.

Table 1. Soil chemical characteristics of the experiments (Joniškėlis, 2001, 2003)

Experiments	pH_{KCl}	Total Nitrogen, g kg^{-1}	Organic carbon, g kg^{-1}	Mobile, mg kg^{-1}	
				P	K
Experiment 1	6.0	1.50	12.8	63.8	211.7
Experiment 2	6.4	1.69	14.2	60.3	195.8

The nitrogen content in the biomass has a decisive effect on the mineralization of biomass incorporated into the soil (Velička *et al*., 2006). Higher nitrogen concentrations and greater variations were identified in the overground plant mass compared to the underground plant mass (Table 2).

Table 2. Nitrogen content in the biomass of catch crops, kg ha^{-1} (Joniškėlis, 2001, 2003)

Catch crop	Underground mass			Overground mass		
	experiment					
	I, 2001	II, 2003	average	I, 2001	II, 2003	average
Oil radish	14.9	15.8	15.4	59.0	64.2	61.6
White mustard	6.6	9.6	8.1	78.5	82.9	80.7
Red clover	61.7	42.0	51.9	161.0	119.1	140.1
Cocksfoot	22.1	21.2	21.7	65.2	65.1	65.2
Italian ryegrass	17.2	14.7	16.0	44.2	60.3	52.3
Average	24.5	20.7	22.6	81.6	78.3	78.0
LSD_{05}	6.64	3.53	5.98	21.63	18.72	17.48

The measurements of the nitrogen contents accumulated in the biomass of individual crops suggest that in 2001 the highest nitrogen content was in the red clover underground and overground biomass, which was 4.1 and 2.7 time higher compared with oil radish. The N_2 fixation rate of red clover was 128 kg ha^{-1}. Of the non-legume crops, the highest nitrogen content was found in cocksfoot roots and residues. The highest nitrogen content in the overground mass were found in the non-legume crop white mustard, 33.1 % higher compared with oil radish. The ability of catch crops to absorb nitrogen from the soil profile is affected by the rate and depth of the colonization of the soil by roots (Kavdir and Smucker, 2005).

The data from the second experiment (2003) indicates that the nitrogen content in plant underground mass was 28.9 % higher compared with those of the first experiment. However, the content of the nitrogen in the catch crops overground mass was 36.4 % higher (compared with that of the first experiment) and the higher contents of nitrogen were accumulated by red clover The lowest nitrogen content in the plant overground mass was identified in the overground mass of Italian ryegrasses. According to the averaged data, the ranking among the different catch crops according to nitrogen content in the biomass was: red clover > white mustard > oil radish = cocksfoot > Italian ryegrass.

The processes of soil-incorporated organic matter transformation are determined by the carbon to nitrogen ratio, which is narrower in the plant overground mass compared with the underground mass (Maiksteniene and Arlauskiene, 2004) In the first experiment (2001) having incorporated the plant biomass at a more advanced growth stage: of oil radish, white mustard and red clover at the flowering stage, of cocksfoot and Italian ryegrass at the heading stage, the carbon to nitrogen ratio in their biomass was close to the formation of soil humic compounds (Table 3).

Table 3. Characteristics of the overground biomass of catch crops (Joniškėlis, 2001, 2003)

Catch crop	C:N			Crude fibre, g kg^{-1}		
	Experiment					
	I, 2001	II, 2003	average	I, 2001	II, 2003	average
Oil radish	18.2	7.9	13.1	215	225	220
White mustard	21.6	8.5	15.1	354	203	279
Red clover	17.0	11.8	14.4	236	222	229
Cocksfoot	24.8	17.7	21.3	306	233	270
Italian ryegrass	25.7	19.3	22.5	323	265	294
Average	21.5	13.0	17.3	287	229	258
LSD_{05}			3.04			50.5

High nitrogen concentration determined that this ratio was the narrowest for oil radish and red clover, whereas in the second experiment (2003) the high concentration of nitrogen in the young biomass of *Brassicaceae* and *Leguminosae* caused a narrow C to N ratio, in to soil-incorporated organic matter mineralization. Averaged data suggest that a significantly higher carbon to nitrogen ratio was in the overground mass of undersown grasses compared with that of a postcrop of oil radish.

The degree and intensity of soil-incorporated organic matter decomposition is related to its chemical composition: the content of readily decomposable components and lignin in the biomass (Magid *et al.*, 2004). When the biomass of more mature plants was incorporated into the soil, (2001), the content of fibre in it was 25.3 % higher compared with younger plants (2003). Significantly more fibre was accumulated by undersown grasses in the overground part. The averaged data of the experiments indicate that with increasing root and overground plant mass the C to N ratio widened ($r=0.66$, $r=0.68$; $P\leq0.05$, respectively) and the fibre content increased ($r= 0.59$, $r= 0.69$; $P\leq0.05$).

When barley was grown under the effect of catch crops and their biomass incorporation, the soil nitrogen status varied insignificantly. In the first experiment having incorporated the biomass of catch crops, the soil total nitrogen did not increase, whereas in the soil with a higher

total nitrogen status (the second experiment) having incorporated plant biomass with a narrow C:N, an inappreciable nitrogen reduction trend was determined (Table 4).

Table 4. The effect of catch crops on the contents of total nitrogen and organic carbon and their ratio in the soil (Joniškėlis, 2002, 2004)

Catch crop	Total N, g kg^{-1}			Organic C, g kg^{-1}			C:N		
	Experiment								
	I, 2002	II, 2004	average	I, 2002	II, 2004	average	I, 2002	II, 2004	average
Without catch crop	1.49	1.64	1.56	12.6	14.3	13.4	8.5	8.7	8.6
Oil radish	1.49	1.61	1.55	13.2	14.4	13.8	8.9	8.9	9.0
White mustard	1.50	1.61	1.55	13.3	14.3	13.8	8.9	8.9	8.9
Red clover	1.50	1.62	1.56	13.1	14.5	13.8	8.7	9.0	8.9
Cocksfoot	1.48	1.62	1.55	13.1	14.5	13.7	8.9	9.0	8.9
Italian ryegrass	1.53	1.61	1.57	1.33	1.43	1.38	8.7	8.9	8.8
Average	1.50	1.62	1.56	1.31	1.44	1.37	8.7	8.9	8.8
LSD_{05}			0.84	0.69	0.54	0.27			0.36

This is also corroborated by the statistical analysis of this experiment, which suggests that with increasing nitrogen status in the incorporated plant biomass, the total soil nitrogen tended to decline ($r= -0.826$; $P \leq 0.01$). Organic carbon content has a marked effect on heavy textured soil physical properties, especially its structure and water stability. A more pronounced positive effect of catch crops on the variation of organic C was identified in the first experiment, where a plant biomass with a more favourable C: N ratio was incorporated. The amount of organic C in the soil increased after all catch crops, and after white mustard and Italian ryegrass the increase in C content in the soil was significant (5.6 %), compared with the soil without catch crops. The data from the second experiment suggest that soil organic carbon varied inappreciably. Averaged data over the two experiments indicate that catch crops significantly increased soil organic carbon content (2.2-3.0%), however, the ratio of C to N increased only minutely.

Spring barley grain yield depended on the amount of nutrients applied with catch crop residues and organic manure in the soil (Fig. 1).

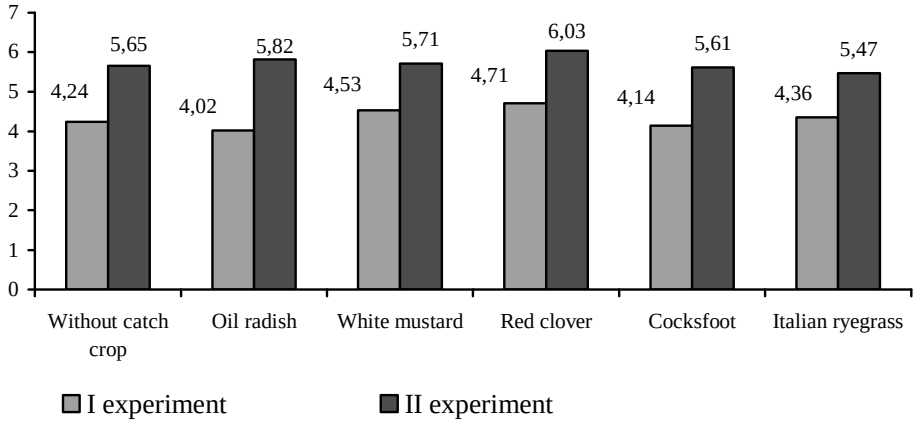

Figure 1. Effect of catch crop biomass as green manure on spring barley grain yield (Joniškėlis, 2002, 2004, t ha^{-1})

Cereals produced the highest grain yield (5.37 t ha^{-1}) in all experiment after red clover; a significant grain yield increase made up 0.42 t ha^{-1}, or 8.5 % more than after treatment without catch crop. Overground mass of oil radish and white mustard ploughed in as green manure tended to increase the spring barley yield 1.6 % and 3.4 % respectively.

Conclusions

The ranking among the different catch crops according to the nitrogen content in the biomass was: red clover > white mustard > oil radish = cocksfoot > Italian ryegrass. The N_2 fixation rate of red clover was 128 kg ha^{-1}. The biomass of catch crops (C:N ratio = 17.0-25.7) - oil radish, white mustard and red clover incorporated into the soil at the flowering stage and that of cocksfoot and Italian ryegrass incorporated at the heading stage increased the organic carbon content (4.0 – 5.6 %). Legume catch crops biomass ploughed in as green manure significantly increased the spring barley yield.

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BIO-MORPHOLOGICAL PECULIARITIES OF NEW CULTIVARS OF FODDER GALEGA (*GALEGA ORIENTALIS* LAM.)

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Abstract

The first Lithuanian fodder galega (*Galega orientalis* Lam.) high-yielding cultivars: ‘Vidmantai’, ‘Laukiai‘ and ‘Melsviai‘ were bred in 1986-2000 at the Research Station of the Lithuanian University of Agriculture by applying group and individual selection of progeny from the wild populations. A good adaptability to Lithuanian agro-climatic conditions wee established for the new fodder galega cultivar ‘Vidmantai’, ‘Laukiai‘ and ‘Melsviai‘. ‘Vidmantai’, ‘Laukiai‘ and ‘Melsviai‘ creating early, heavy, protein-rich yields and high resistance to phytopathogens and pests. The cultivars ‘Vidmantai’, ‘Laukiai‘ and ‘Melsviai‘ were tested in competitive variety trials during the period of 1996-2001. The aim of this research was to investigate and compare the characteristics of new bred Lithuanian cultivars with improved, economically–valuable cultivar characteristics.