THE IMPACT OF LEGUME/GRASS SWARDS ON THE FORMATION OF SPRING WHEAT YIELD UNDER ORGANIC FARMING CONDITIONS

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The goal of this paper – to explore organic N of legumes as a potential N source for subsequently grown spring wheat.

The effect of red clover/ryegrass and lucerne/ryegrass swards of two years of age on the yield of spring wheat that grew after them and on nitrogen accumulation in grain significantly differed due to the sward composition and practically did not differ due to different swards mixtures and combinations of cover crops.

Key words*: red clover, lucerne, spring wheat, yield, protein.*

Organic farming is practiced in approximately 100 countries of the world and its share on agricultural land and farms is growing. Nowadays, there is an increased interest in sustainable grassland systems. One of the steps towards sustainability is expansion of legumes because of their potential to fix nitrogen and their benefits for the environment [4]. Different authors give notice that amount of plant organic matter and biological nitrogen left different quantity in the soil. The statement of majority researchers is that lucerne and clover left most quantity and best quality residuals [5, 16]. Amount of them belongs to growing term, type of management and others factors [3, 6, 9].

Development of a more sustainable agricultural production system is an important aim nowadays. There is a pressing need to develop cereal growing methods that require much lower inputs of N fertilizer and other agrochemicals than conventional farming [2, 10, 13, 17]. Introduction of ley/arable rotations could be an effective tool for a significant further reduction of the use of external mineral N-input and an increase of the N use efficiency [14]. Therefore legumes are of great importance in the rotations as soil improvers and as valuable preceding crops. The complex of factors and their interactions influence the potential of legumes, which is greatly dependent on legume species and successful management [8, 11].

The aims of the studies were to explore organic N of legumes as a potential N source for subsequently grown spring wheat.

MATERIAL AND METHOD

Field trial conditions. Field studies were conducted on a loamy *Endocalcari-Epihypogleyic Cambisol* in Dotnuva (55° 24' N). Soil pH varied between 6.5 - 7.0, humus content was 2.5-4.0 per cent, available P 50-80 mg kg^{-1} and K 100-150 mg kg^{-1}.

Experimental design. The trials were set up in four replications, trial plots were arranged randomly. The total plot size of trial was 32.5 m^2, and record plot size 16.25 m^2. In the third year of experiment conduct the area of spring wheat record plot in trial was 31.2 m^2. Legume (bean family)-*Leguminosae* Juss. (*Fabaceae* Lindl.) and grass (grass family)-*Gramineae* Juss. (*Poaceae* Barnhart) mixtures were sown either without a cover crop or with semi-leafless peas (*Pisum sativum* L.) and spring barley (*Hordeum vulgare* L.) crops for forage and barley cover crop for grain (*tab.1*).

Table 1

Field trial design

Treatment		Type of yield in experimental years		
Sward	Cover crop	In the 1st year	In the 2nd year	In the 3rd year
Rcl+Pr	Without cover crop	Herbage	Herbage	Spring wheat for grain
Rcl+Pr+Bgr	Barley	Barley for grain, herbage	Herbage	Spring wheat for grain
Rcl+Pr+Bwc	Barley	Barley for whole crop, herbage	Herbage	Spring wheat for grain
Rcl+Pr+Pwc	Peas	Peas for whole crop, herbage	Herbage	Spring wheat for grain
Lc+Pr	Without cover crop	Herbage	Herbage	Spring wheat for grain
Lc+Pr+Bwc	Barley	Barely for whole crop	Herbage	Spring wheat for grain
Lc+Pr+Pwc	Peas	Peas for whole crop, herbage	Herbage	Spring wheat for grain
Pr	Without cover crop	Herbage	Herbage	Spring wheat for grain

N o t e. *Rcl-red clover, Lc-lucerne, Pr-perennial ryegrass, Bgr-barley for grain, Bwc-barley for whole crop, Pwc-peas for whole crop.*

Sowing. Red clover (*Trifolium pratense* L.) and lucerne (*Medicago sativa* L.) were sown in mixtures with perennial ryegrass (*Lolium perenne* L.), and ryegrass was also sown as a monoculture. The swards were set up for short-term use (two years) for cutting. The yields of swards were taken-off at flowering stage of the legumes. The swards were cut twice a year in the first year. Barley and peas as whole crops were harvested at the wax and grain 'greasy' stage, respectively, and for one treatment - barley for grain - at complete ripeness stage. In the autumn of the second experimental year the swards were ploughed in. In the spring of the third year spring wheat (*Triticum aestivum* L.) was sown for grain. Succeeding crop spring wheat was harvested at complete ripeness stage.

Methods of analysis. Nitrogen in the dry matter (DM) was determined by the Kjeldahl method, crude protein – according to the amount of nitrogen, multiplying it by 6.25 for herbage or 5.7 for grain. The yield data were statistically processed using analysis of variance.

RESULTS AND DISCUSSIONS

The swards were of higher quality, were noted for higher concentrations of biologically fixed nitrogen in subsequent yields (*tab. 2*).

Table 2

The effects of legumes on symbiotic nitrogen accumulation in the yield of swards intended for forage with and without cover crops, N kg ha^{-1}

Treatment	Total nitrogen kg ha^{-1}			Biologically fixed nitrogen of legumes kg ha^{-1}		
	In the 1st year	In the 2nd year	Total per 2 years	In the 1st year	In the 2nd year	Total per 2 years
Rcl+Pr	168	224	392	63	89	151
Rcl+Pr+Bgr	123	212	335	18	78	95
Rcl+Pr+Bwc	176	266	442	70	132	202
Rcl+Pr+Pwc	164	239	403	59	105	163
Lc+Pr	178	253	431	73	119	191
Lc+Pr+Bwc	117	151	268	12	16	28
Lc+Pr+Pwc	138	158	296	33	24	56
Pr	105	134	239	-	-	-
LSD_{05}	14.2	17.5	27.3	14.3	19.1	29.5

N o t e. *Rcl-red clover, Lc-lucerne, Pr-perennial ryegrass, Bgr-barley for grain, Bwc-barley for whole crop, Pwc-peas for whole crop.*

In the experiment was noted a strongly expressed sensitivity of lucerne to cover crops, which was observed earlier by other researchers [15]. In the first and second years of the trial conduct, in the yield of lucerne and ryegrass with a barley cover crop for whole crop forage there was identified 12 and 16 kg ha^{-1}, with peas 33 and 24 kg ha^{-1} fixed biological nitrogen, respectively, whereas the sward without a cover crop fixed 73 and 119 kg ha^{-1} of biological nitrogen, respectively. Red clover and ryegrass sward together with barley cover crop for grain accumulated in the yield 45 kg N ha^{-1} less than the sward without a cover crop. In the second year the sward differed in biological nitrogen content only by 11 kg ha^{-1} from the sward without a cover crop. However, the most significant effect on clover and ryegrass sward was exerted by barley cover crop for grain, this sward fixed the least amount of nitrogen compared with the other clover swards.

Summarising the data of the trial of two years we can confirm that clover and lucerne and ryegrass swards accumulated different amounts of biological nitrogen. Clover/ryegrass swards slightly surpassed or were equal with lucerne based swards.

In order to estimate the mode of action of swards for spring wheat, in the swards was identified biological nitrogen content in the roots of swards and in stubble (aboveground part remaining after the second year's last cut) (*tab. 3*).

Table 3

Impact of nitrogen amount (kg ha^{-1}) in dry matter of roots (soil depth 0-25 cm) and above ground biomass

Treatment	Roots			Above ground biomass			Total N amount
	Legumes	Grasses	Total	Legumes	Grasses	Total	
Rcl+Pr	66	6.3	72	28	5.3	33	105
Rcl+Pr+Bgr	75	12	87	31	9.6	41	128
Rcl+Pr+Bwc	68	7.4	75	31	8.3	39	114
Rcl+Pr+Pwc	61	15	76	29	14	43	119
Lc+Pr	76	19	95	23	16	39	134
Lc+Pr+Bwc	65	12	77	16	12	28	105
Lc+Pr+Pwc	62	17	79	20	22	42	121
Pr	0	28	28	0	14	14	42
LSD_{05}	34.4	13.3	36.3	12.6	6.5	14.4	48.1

N o t e. *Rcl-red clover, Lc-lucerne, Pr-perennial ryegrass, Bgr-barley for grain, Bwc-barley for whole crop, Pwc-peas for whole crop.*

The data presented in the table indicate that nitrogen content left in the aboveground and underground parts of legumes was 2.5-3 times higher than that left in grasses. There were no significant differences between the nitrogen contents left in lucerne swards and clover-ryegrass swards.

The focal point in analysing data of the third year of the experiment was to determine the effect of legumes on spring wheat yield and its quality. Spring wheat crops produced on average 1776-2274 kg ha^{-1} (*tab. 4*).

Table 4

Spring wheat yield and 1000 grain weight after different pre-crops

Treatment	Grain yield kg ha^{-1}	Straw $^{(x}$ yield kg ha^{-1}	1000 grain weight g
Rcl+Pr	2274	5214	25.4
Rcl+Pr+Bgr	2342	4524	25.4
Rcl+Pr+Bwc	2121	4089	25.1
Rcl+Pr+Pwc	2128	4495	25.4
Lc+Pr	2183	4010	25.5
Lc+Pr+Bwc	1866	4792	25.2
Lc+Pr+Pwc	2022	4682	26.4
Pr	1776	4072	27.1
LSD_{05}	185.4	944.6	

N o t e. *Rcl-red clover, Lc-lucerne, Pr-perennial ryegrass, Bgr-barley for grain, Bwc-barley for whole crop, Pwc-peas for whole crop;* $^{(x}$ biological grain yield.

The experimental findings of LIA researchers showed that without nitrogen fertilization and applying phosphorus and potassium at 60 kg ha^{-1} spring wheat yield was on average 2600 kg ha^{-1} [7]. Our research findings suggest that spring wheat yields were relatively high. Wheat grain yield was over 2300 kg ha^{-1}, when clover and ryegrass swards had been preceding crops. The preceding crop of red clover swards, according to the grain yield produced by wheat, was equal to 60 kg

ha^{-1} nitrogen rate before sowing. Spring wheat grain yield was higher after red clover swards than after lucerne swards. Wheat grain yield was after lucerne and ryegrass sward without a cover crop differ significantly from that after lucerne and ryegrass sward with barley cover crop.

The relationship between spring wheat grain yield and biological nitrogen content in the roots and stubble of swards was quite strong. Grain yield of wheat was especially dependence on nitrogen content that left after pre-crops (*fig.1*).

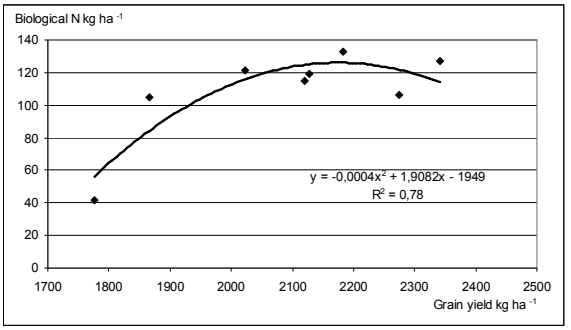

Figure 1 **The correlation between nitrogen content that left in the residuals of swards (y) and spring wheat grain yield (x)**

Red clover/ryegrass preceding crop with barley cover crop exerted the greatest effect on wheat grain yield increase compared with pure ryegrass preceding crop (*tab. 5*).

Table 5

The effect of biological nitrogen transformation on nitrogen accumulation in the spring wheat produces

Treatment	Amount of N input kg ha^{-1}	Amount of N in wheat kg ha^{-1}	Balance ± kg ha^{-1}	Coefficient of biological N utilization
Rcl+Pr	105	63	43	2.46
Rcl+Pr+Bgr	128	84	43	2.95
Rcl+Pr+Bwc	114	69	46	2.50
Rcl+Pr+Pwc	119	74	45	2.64
Lc+Pr	134	78	55	2.42
Lc+Pr+Bwc	105	73	32	3.28
Lc+Pr+Pwc	121	74	48	2.52
Pr	42	65	-23	-1.83
LSD_{05}	48.1	7.46	50.6	

N o t e. *Rcl-red clover, Lc-lucerne, Pr-perennial ryegrass, Bgr-barley for grain, Bwc-barley for whole crop, Pwc-peas for whole crop*

Legumes as preceding crop in all cases significantly increased nitrogen content in the spring wheat yield. Earlier we have already discussed higher yield of red clover and ryegrass with barley cover crop for whole crop forage compared with the other red clover swards. Thus, in this treatment nitrogen was applied together with sward's residues 21 and 12 kg ha^{-1} more than in the sward without a cover crop and with a cover crop of peas for whole crop forage. Lucerne and

ryegrass swards with cover crops did not increase nitrogen content in the soil, although the content of nitrogen in spring wheat yield was similar after all lucerne swards. Wheat utilized biological nitrogen most intensively after the swards with barley cover crop. Peas are rich of mineral elements [1, 18]. Therefore, in the experiment after swards with peas cover crop biological nitrogen utilization coefficient by wheat was higher than that after the swards without a cover crop.

CONCLUSIONS

The amounts of nitrogen accumulated in herbage and those biologically fixed over the two years of swards age depended on legume species and competitive plant (cover crop) species. The highest amounts were obtained in red clover/ryegrass swards with spring barley cover crop and lucerne/ryegrass swards that grew without a cover crop. Nitrogen accumulation and fixation rate, especially during the first year of age, were positively affected by a cover crop of peas of low competitive power.

Nitrogen content left in the aboveground and underground parts of legumes was 2.5-3 times higher than that left in grasses. The highest total amount of nitrogen was left of lucerne/ryegrass that grew without a cover crop.

The effect of red clover/ryegrass and lucerne/ryegrass swards of two years of age on the yield of spring wheat that grew after them and on nitrogen accumulation in grain significantly differed due to the sward composition and practically did not differ due to different swards mixtures and combinations of cover crops.

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