Nitrogen transfers from *Vicia sativa* L. and *Trifolium resupinatum* L. to the companion grass and the following crop

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ABSTRACT

The course of N-NO_3^- concentrations in soil, N transfer from the catch crops *Vicia sativa* L. and *Trifolium resupinatum* L. to the companion grass *Lolium multiflorum* ssp. *gaudinii* (Parl.) Schinz et Keller, and the preceding crop effect on *Lolium multiflorum* ssp. *italicum* (A. Br.) Volkart were studied in a field experiment. Catch crops were sown in pure stands and grass/legume swards (= two species in alternating rows) at two sowing dates and harvested at different dates from August to November. *Vicia sativa* was more effective concerning N_2 fixation than *Trifolium resupinatum*, this was also evident from above ground N yield and N-NO_3^- amount of the soil. The factor sowing date had the greatest influence on N yield. N transfer to the companion grass was generally low. Early sown legumes in pure stands and in mixture temporarily caused slightly increased N-NO_3^- amounts in soil compared with unfertilized grass in winter and following spring, whereas late sown legumes apparently had no effect on N-NO_3^- amounts. Both legumes had a considerable preceding crop effect in the mixture and in the pure stand for both sowing dates.

Keywords: legume catch crops; N_2 fixation; N transfer; preceding crop effect; soil N-NO_3^-

In general, catch crops may have a positive effect on soil structure and formation of humus (Kremer-Schillings 1981) and may reduce nitrate leaching by scavenging residual N-NO_3^- in the soil after main crop harvest (Gladwin and Beckwith 1992, Sainju et al. 1998). Legumes cultivated as catch crops also use nitrogen derived from the atmosphere by symbiotic N_2 fixation which is connected with the positive effects on the yield of the following crop (Heyland and Braun 1980, Opitz v. Boberfeld and Jasper 1994). However, legume cover crops are less effective in reducing residual N-NO_3^- and potential leaching from the soil than non-legume cover crops (Sainju et al. 1998). In general, the N supply by legume catch crops for the following crop is welcome, especially in organic farming systems, but depending on weather conditions in winter it is also possible, that nitrogen of catch crops is released too early and it might be exposed to leaching, which would be in contradiction to a sustainable agronomy. According to Berger and Kretschmer (1991) up to 80% of N incorporated by catch crops before winter may be plant available again before the growth period starts. The extent and rate of N release from legumes mainly depends on yield, N concentration and on the extent of decomposition of plant tissue, determined by physiological age of the plant (= senescence), weather conditions and physical properties of the crops. Possible agronomic measures to control N uptake of cover crops and subsequent N release amongst other things are: intensity of fertilization (= of preceding crop and catch crop), choice of crop species, sowing date and date of defoliation. The objective of this study is to determine the effects of legume species, sowing date, harvest date and mixture on the N-NO_3^- amounts in soil during autumn and winter to assess the probability of too early N release from legume catch crops with regard to possible leaching and to determine the N-NO_3^- amounts at the beginning of the growth period and N concentration of the following crop to assess their potential preceding crop effect. N yield of grass and legume in mixtures and pure stands were determined to estimate N_2-fixation and N transfers.

MATERIAL AND METHODS

The study was conducted near Giessen/Central Germany in an altitude of 160 m above sea level. A field experiment arranged in a split-plot design with four replicates was established in two subsequent years including the species *Lolium*

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multiflorum ssp. *gaudinii*, *Vicia sativa,* and *Trifolium resupinatum* in monoculture or in alternating grass and legume drills (= mixed grass/legume swards). The treatments are shown in Table 1. A detailed description of the experimental conditions and results on forage characteristics can be taken from Opitz v. Boberfeld et al. (2005). The previous crop was *Avena sativa* harvested as green matter in both research years. The crop following the catch crops was *Lolium multiflorum* ssp. *italicum* sown in the spring of the subsequent year. The soil is a Pseudogley with a pH-value of 6.0. The summer and autumn seasons of year 1 were warm and dry in contrast to spring and summer of year 2 that were relatively moist and cool. The early sowing date was early July; late sowing was in early August. The plots remained unfertilized with the exception of a variant with *Lolium multiflorum* (= N_1, 50 kg N/ha applied one or respectively two days after drilling). All catch crops were harvested by manual cuts. The harvest dates are indicated in Table 3. Stubble height was 1 cm, which was necessary for the assessment of N_2 fixation. The soil remained unploughed during winter. The following crop *Lolium multiflorum* ssp. *italicum* was sown in early April of the following year after soil preparation by harrow. 50% of the plot area remained unfertilized the other half was fertilized with 50 kg N after the establishment of seedlings and after each harvest, to ensure a proper development of the N demanding species *Lolium multiflorum* ssp. *italicum*.

For the N-NO_3^- determination by means of the UV absorption method according to Navone (1964), soil samples were extracted immediately in 0.025 N $CaCl_2$ solution to avoid mineralization processes. Extracts were stored at –18°C until the day of analysis. Soil samples were taken after each harvest of the catch crops and before sowing and after the last harvest of the following crop.

N yield of herbage was calculated by the multiplication of dry matter yield and N concentration in dry matter, analysed according to Kjeldahl (Anonymous 1997). Grass and legume from mixed swards were analysed separately. For the comparison of N yield (= kg/ha) of the separate components of grass/legume swards and the N yield of the species concerned in monoculture. The value of the grass or legume in mixture was multiplied by factor 2 to obtain equal reference space, because each single species in grass/legume swards took up 50% of the available space of the plots (= alternating rows) compared to 100% in pure stands. The proportion of ground space (= 50:50, two-dimensional proportion) was not identical with the actual yield proportion of grass and legume (= proportion depending on three-dimensional space and dry matter). The actual yield proportion was determined gravimetrically. N_2 fixation was estimated by the extended difference method (Stülpnagel 1982):

$$\text{N fixed} = (\text{N-shoot}_A + \text{N-NO}_3^-\text{-soil}_A) - (\text{N-shoot}_B + \text{N-NO}_3^-\text{-soil}_B) \quad (1)$$

with A = legume in pure stand or in companion with grass, B = reference crop *Lolium multiflorum* ssp. *gaudinii* N_0.

N transfer from legume to the companion grass was estimated by comparing N yield of rows of *Lolium multiflorum* ssp. *italicum* grown next to a row of legumes and rows of the grass grown in monoculture. Estimation methods based on the measurements of ^{15}N isotopes (Ruschel et al. 1979) were not used because of the high correlation between the extended difference method and the ^{15}N dilution method (Loges 1998). Furthermore, specific problems of isotope methods in calculating the N transfer from legume to grass are avoided, because it is likely to underestimate the transfer for the amount of released legume N that does not derive from the atmosphere (Brophy et al. 1987). Transferred N from legumes to the following crop was estimated by the difference of the N yield of the following crop (= fertilized and unfertilized *Lolium multiflorum* ssp. *italicum*) following the catch crop

Table 1. Experimental design, split plot design with four replicates

Factors	Levels
1. Sowing date	early = beginning of July
	late = beginning of August
2. Catch crop	*Vicia sativa* pure stand
	Trifolium resupinatum pure stand
	Vicia sativa/*Lolium multiflorum* mixture 50/50
	Trifolium resupinatum/*Lolium multiflorum* mixture 50/50
	Lolium multiflorum ssp. *gaudini* pure stand N_1 (50 kg N/ha)
	Lolium multiflorum ssp. *gaudini* pure stand N_0 (no fertiliser)

Table 2. Yield proportions (%) in mixed grass/legume swards

Year	Harvest date	Sowing	Mixture		Mixture	
			Vicia sativa	*Lolium multiflorum*	*Trifolium resupinatum*	*Lolium multiflorum*
1	July 31	July	70	30	58	42
	September 4	July	78	22	65	35
		August	70	30	34	66
	October 2	July	78	22	65	35
		August	66	34	46	54
	October 27	July	77	23	65	35
		August	50	50	43	57
2	August 13	July	49	51	23	77
	September 9	July	62	38	38	62
	September 27	August	91	9	72	28
	October 8	July	73	27	50	50
		August	93	7	81	19
	November 11	July	69	31	44	56
		August	90	10	76	24

concerned and the N yield of the following crop after the unfertilized catch crop *Lolium multiflorum* ssp. *gaudinii* N_0.

Competition effects were quantified by the relative yield total (RYT) according to de Wit (1960):

$$RYT = (\text{mixture 1/pure stand 1}) + (\text{mixture 2/pure stand 2}) \qquad (2)$$

Values of RYT > 1 indicate a synergistic relationship between components, in the case of RYT = 1 the competition effect is additional and for RYT < 1 the components are considered to compete antagonistically. The RYT quotation was applied to assess possible mixture effects on N yield.

The data was processed in SPSS for windows by analysis of variance; where responses were significant at $P < 0.05$, least-significant differences (*LSD*) were calculated separately for all sowing dates.

RESULTS

Table 2 shows the actual yield proportions of grass and legume in mixture. Table 3 indicates the above ground N yield of the pure stands and the components of mixtures. Early sown *Vicia sativa* frequently has an increased N yield in companion with *Lolium multiflorum* ssp. *gaudinii* compared to the N yield of the legume in monoculture. This effect is also evident for late sown *Vicia sativa* at late harvest date in the second research year, whereas N yield of *Trifolium resupinatum* is identical in mixed and pure stands. Early sown *Lolium multiflorum* ssp. *gaudinii* shows increased N yield in companion with *Trifolium resupinatum* in late summer and autumn, whereas there is no effect of the companion of *Vicia sativa* on the grass N yield. The calculated N transfer from the legumes to the companion grass *Lolium multiflorum* ssp. *gaudini* is illustrated in Figure 1. Table 4 shows the $N\text{-}NO_3^-$ amounts in the soil in layer 0–30 cm and 0–60 cm at different dates in autumn, winter and following spring. Four weeks after each sowing date, no distinction is possible between unfertilized swards of *Lolium multiflorum* ssp. *gaudinii* and mixed or pure stands with legumes. Only the control plots fertilized with 50 kg N/ha show significant higher amounts of $N\text{-}NO_3^-$ in the soil. In contrast to the grass in monoculture, the mixed swards and pure stands with *Vicia sativa* and *Trifolium resupinatum* show increasing $N\text{-}NO_3^-$ amounts in year 1, predominantly at early sowing. This effect mainly occurs in level 0–30 cm. *Vicia sativa* causes also slightly increased $N\text{-}NO_3^-$ amounts with a late sowing date, but only at the end of winter and beginning of spring. In year 2, the $N\text{-}NO_3^-$ levels are generally lower.

The N_2 fixation estimated by the N yield and $N\text{-}NO_3^-$ amounts in soils (= extended difference method) is shown in Table 5. The sowing date is the most important source of variance, followed by the

Table 3. Above ground N yield (kg N/ha) of legumes and grass in pure stand and as a mixture component depending on sowing date and harvest date

Harvest date		Year 1							Year 2						
		31.7.	4.9.		2.10.		27.10.		13.8.	9.9.	23.9.	8.10.		4.11.	
Sowing		July	July	August	July	August	July	August	July	July	August	July	August	July	August
V. sativa	pure	40.4	164.8	22.4	166.7	71.0	124.4	99.8	40.5	98.0	48.7	137.5	77.7	153.1	110.2
	mixture	39.7	230.4	21.9	241.9	77.9	150.4	76.0	37.9	114.4	42.6	187.0	78.7	196.6	180.0
T. resupinatum	pure	19.1	124.2	6.0	136.2	48.7	149.2	62.4	12.8	66.4	10.1	94.8	23.0	131.7	44.6
	mixture	28.8	136.6	6.5	163.1	38.8	111.6	52.3	14.5	50.9	11.1	89.5	26.7	87.7	61.7
	$LSD_{0.05}$	17.27	19.60	19.60	40.71	40.71	31.33	31.33	10.29	30.13	9.24	34.54	34.54	48.37	48.37
L. multiflorum	N_0	22.5	49.9	10.2	50.4	21.1	63.2	31.3	22.6	32.5	3.2	35.8	6.7	44.2	11.3
	N_1	26.3	67.0	20.0	78.8	51.1	76.7	64.8	48.6	47.1	6.1	51.8	15.6	65.2	28.0
	with *T. r.*	20.2	47.6	12.9	69.4	27.1	64.8	50.5	31.4	43.7	3.6	53.3	5.1	66.7	14.7
	with *V. s.*	16.6	40.6	8.8	41.0	23.4	40.5	52.8	24.7	34.8	3.1	36.2	4.5	52.2	15.2
	$LSD_{0.05}$	6.15	6.57	6.57	17.30	17.30	20.64	20.64	17.14	6.71	1.15	5.63	5.63	10.76	10.76

factor legume species. *Vicia sativa* is usually more effective in symbiotic fixation of N_2 than *Trifolium resupinatum*. The interaction sowing date/legume species is negligible. The differences between early and late sowing date decrease by delaying the harvest date. Both legumes – in mixture with *Lolium multiflorum* ssp. *gaudinii* and in pure stands – have a positive effect on the N yield of the following crop *Lolium multiflorum* ssp. *italicum* compared with the yield of the grass after the preceding crop *Lolium multiflorum* ssp. *gaudinii* in pure stands. Differences caused by the species and the sowing date of the preceding crop are mainly limited to the first cut of the following crop. No differences between the N yields of *Lolium multiflorum* ssp. *italicum* caused by the fertilization of the preceding nonlegume crop (= N_0 vs. N_1) are evident, whereas the fertilization of *Lolium multiflorum* ssp. *italicum* itself is the most important source of variance for N yield. No interaction N fertilization of the following crop/catch crop is evident. The positive effect of the legumes is evident for the N yield of the fertilized and the unfertilized following crop, see Figure 2. The relationship between legume and grass concerning

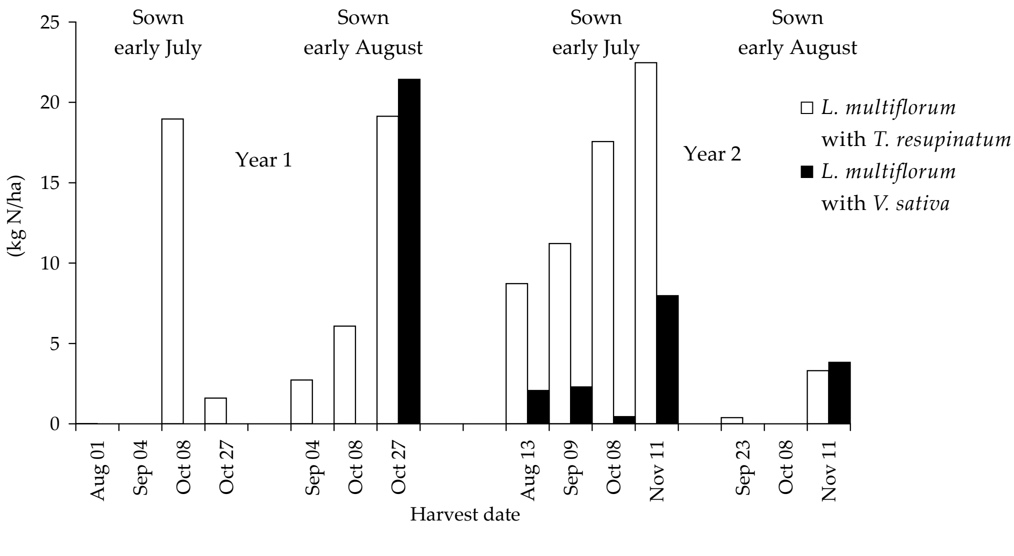

Figure 1. Estimated N transfer from *Vicia sativa* and *Trifolium resupinatum* to the companion grass *Lolium multiflorum* ssp. *gaudinii* depending on sowing date and harvest date

Table 4. N-NO_3^- amounts (kg/ha) in soil layer 0–30 cm and 0–60 cm depending on catch crop, sowing date, and sampling date

	Sowing	June	June	August	June	August	June	August	June	August	June	August
	Sampling date	31.7.	9.9.		10.10.		27.10.		12.12.		23.3.	
Year 1	**Layer 0–30 cm**											
	V. sativa	13.4	11.5	12.5	32.9	9.2	43.2	13.3	40.0	34.5	36.7	32.4
	T. resupinatum	20.4	8.0	20.7	12.2	8.3	39.8	8.3	64.1	11.3	26.5	22.0
	L. multiflorum. N_1	25.0	6.0	39.1	5.6	5.4	4.7	3.9	11.8	6.1	15.1	14.8
	L. multiflorum. N_0	13.6	4.7	13.4	5.2	4.5	4.3	4.2	–	–	15.3	11.6
	L. mult./V. sat. mix.	11.3	7.0	15.9	16.6	4.7	38.5	5.9	47.6	9.3	43.4	13.7
	L. mult./T. resup. mix.	17.2	6.4	15.3	7.0	5.2	14.7	4.1	50.0	6.1	26.4	14.6
	$LSD_{0.05}$	10.42	8.07	8.07	5.05	5.05	11.10	11.10	17.20	17.20	10.26	10.26
	Layer 0–60 cm											
	V. sativa	25.9	17.8	15.2	44.7	13.4	60.1	18.5	55.8	41.9	72.6	50.5
	T. resupinatum	34.5	15.6	25.9	20.7	15.1	48.1	12.4	80.6	15.8	50.3	34.5
	L. multiflorum. N_1	43.5	10.6	47.6	8.7	8.2	7.8	6.3	14.2	8.0	24.4	21.1
	L. multiflorum. N_0	28.3	9.1	16.5	7.4	7.0	6.1	5.7	–	–	20.7	15.4
	L. mult./V. sat. mix.	26.9	12.6	18.3	24.7	7.8	53.1	8.3	55.9	11.7	80.2	20.4
	L. mult./T. resup. mix.	30.8	10.5	23.4	10.6	7.6	21.7	6.1	56.8	7.1	47.0	21.0
	$LSD_{0.05}$	18.20	8.56	8.56	6.92	6.92	14.24	14.24	17.13	17.13	22.86	22.86
	Sampling date	14.8.	10.9.		8.10.		6.11.		19.2.		20.3.	
Year 2	**Layer 0–30 cm**											
	V. sativa	15.1	6.6	6.6	16.1	5.6	24.3	11.9	9.6	9.8	14.0	13.1
	T. resupinatum	19.5	7.5	5.4	7.7	6.2	12.5	6.0	10.2	8.4	16.5	15.0
	L. multiflorum. N_1	16.9	4.7	16.2	4.1	14.1	3.2	2.4	6.0	5.2	5.5	4.4
	L. multiflorum. N_0	7.7	4.3	5.5	3.9	4.6	2.2	1.9	–	–	5.6	3.0
	L. mult./V. sat. mix.	9.4	6.3	4.2	6.3	3.6	8.8	6.8	9.1	10.3	13.0	10.4
	L. mult./T. resup. mix.	9.5	4.1	5.8	3.4	5.8	8.9	3.0	7.5	8.0	12.5	10.5
	$LSD_{0.05}$	7.43	3.87	3.66	5.26	5.26	7.89	7.89	3.23	3.23	6.30	6.30
	Layer 0–60 cm											
	V. sativa	24.5	14.0	7.0	22.5	6.9	32.8	13.6	33.7	21.1	43.7	32.4
	T. resupinatum	30.1	14.4	6.4	11.1	8.8	17.7	8.3	19.7	16.7	29.6	24.3
	L. multiflorum. N_1	26.3	12.5	18.3	6.8	20.0	4.0	4.6	10.4	7.1	14.9	8.3
	L. multiflorum. N_0	17.5	10.8	7.0	5.4	6.0	2.8	3.4	–	–	9.6	5.5
	L. mult./V. sat. mix.	16.9	12.9	5.3	9.8	4.8	12.2	9.3	21.1	19.1	25.7	18.7
	L. mult./T. resup. mix.	15.7	9.3	7.1	8.0	8.0	11.3	5.3	13.2	10.3	22.4	15.3
	$LSD_{0.05}$	9.51	7.19	4.20	9.75	9.75	9.02	9.02	7.62	7.62	20.37	20.37

their N yield in mixtures is indicated by the RYT value according to de Wit (1960) in Table 6.

DISCUSSION

Trifolium resupinatum and *Vicia sativa* cultivated as catch crops under Central European conditions are able to fix more than 100 kg N/ha by plant/microbe symbiosis. Especially *Vicia sativa* is also very effective in grass/legume swards in providing of additional N. This study demonstrates that the following crop uses considerable amounts of surplus N. In comparison, the mineral fertilization of the nonlegume catch crop *Lolium multiflorum* ssp. *gaudinii* by 50 kg N/ha had no lasting effect

Table 5. Estimated N_2 fixation (kg N/ha) of legumes in pure stands and in mixtures

Harvest date	Year 1							Year 2						
	31.7.	4.9.		2.10.		27.10.		13.8.	9.9.	23.9.	8.10.		4.11.	
Sowing	July	July	August	July	August	July	August	July	July	August	July	August	July	August
V. sativa pure	15.5	123.6	11.0	153.6	56.3	115.3	81.1	25.0	68.8	45.5	118.9	71.9	138.9	109.1
V. sativa mixture	4.2	89.3	7.0	107.7	30.4	79.3	35.6	10.4	44.1	18.1	78.2	33.7	88.3	91.6
T. resupinatum pure	2.8	80.8	5.3	99.2	35.7	128.1	37.7	8.8	37.5	6.3	64.8	19.0	102.4	38.2
T. resupinatum mixture	4.5	43.6	6.4	69.1	17.0	40.5	20.4	3.0	13.4	4.3	38.1	11.2	41.4	28.6
$LSD_{0.05}$	n.s.	16.15	n.s.	33.12	33.12	33.11	33.11	n.s.	14.45	6.17	19.48	19.48	30.24	30.24

on the following crop compared to the unfertilized standard. But it is also evident that portions of the N derived from legumes and grass/legume swards might be released too early in autumn and winter. An early sowing date in combination with a late utilization causes N-NO_3^- amounts up to 80 kg/ha (= soil layer 0–60 cm) depending on weather conditions in autumn and winter. Concerning the annual legume catch crops *Vicia sativa* and *Trifolium resupinatum* and the grass species *Lolium multiflorum* ssp. *gaudinii* the factor sowing date is the main factor for yield (Opitz v. Boberfeld et al. 2005). However, increased yield of all species by an early sowing date (= early July) is coupled with a more rapid senescence, followed by stagnant growth rates or – depending on weather conditions – decreasing yield from September to November. Regarding the development of the N yield of the early sown legumes a substantial decrease is evident during 25 days in October of year 1. The above ground N amounts in plant tissue of *Vicia sativa* grown in companion with grass, for example, decreases by more than 90 kg N/ha, apparently caused by the drop off of leaves and decomposition of plant tissue. This effect is more distinct for *Vicia sativa* than for *Trifolium resupinatum*, whereas both legume species show no decrease in N yield when they are sown in August. The N yield of late sown *Vicia sativa* is even still increasing in October, especially in year 2, where the N yield of the legume grown in mixture rises from 78.7 at the beginning of October to 180.0 kg N/ha at the beginning of November. In

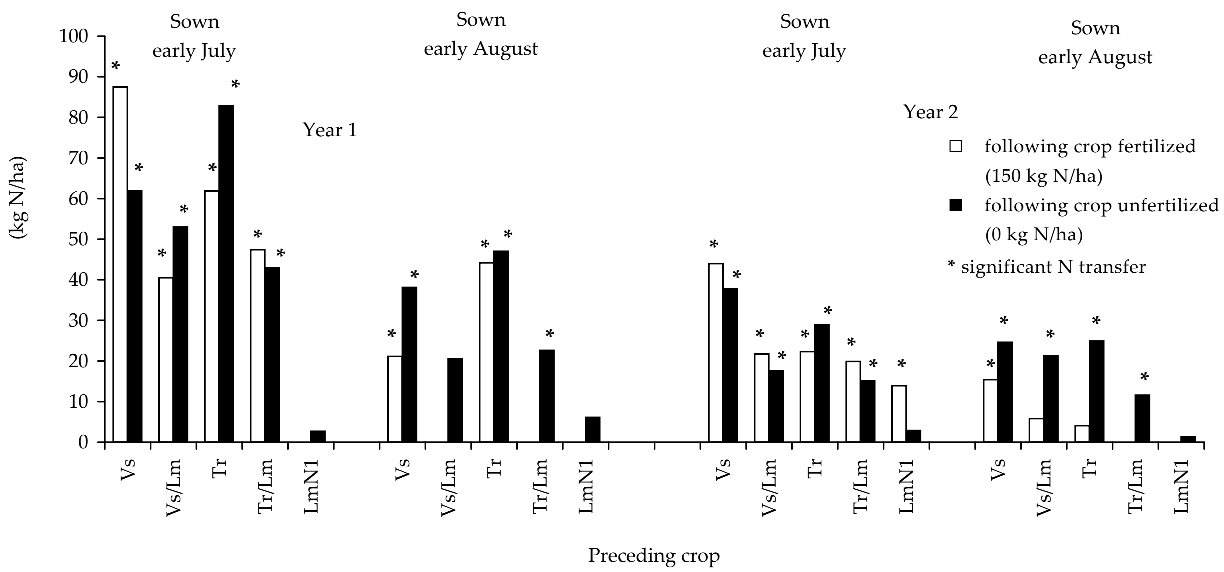

Figure 2. Estimated N transfer from *Vicia sativa* (= Vs) and *Trifolium resupinatum* (= Tr) in pure stands and in mixture with grass *Lolium multiflorum* ssp. *gaudinii* (= Lm) to the following crop *Lolium multiflorum* ssp. *italicum* compared with the N transfer from the fertilized nonlegume catch crop (= LmN1)

Table 6. Relative yield total (= RYT) according to de Wit (1960) applied for N yield

Sowing	June	June	August	June	August	June	August
Harvest date	31.7.	4.9.		2.10.		27.10.	
Lolium multiflorum/Vicia sativa mixture	1.8	2.2	1.8	2.4	2.2	1.9	2.4
Lolium multiflorum/Trifolium resupinatum mixture	2.5	2.1	2.4	2.6	2.2	1.9	2.5
Harvest date	13.8.	9.9.	23.9.	8.10.		4.11.	
Lolium multiflorum/Vicia sativa mixture	2.0	2.3	1.9	2.3	1.7	2.5	2.8
Lolium multiflorum/Trifolium resupinatum mixture	1.9	2.1	2.4	2.4	1.9	2.2	2.7

periods with increasing above ground N yield no increase of N-NO_3^- amounts in soil is evident and therefore, the risk of nitrate leaching is limited. Concluding from the development of N yield, apparently decomposition of plant tissue and too early N release is more likely with an early sowing date. Probably this effect might be influenced by the cutting date. Although the N yield of legumes sown in August is considerably less than that of legumes sown in early July, the previous crop effect of both legumes is also relevant with a late sowing date. The maximum N transfer from the legume to the following crop *Lolium multiflorum* ssp. *italicum* in this experiment – calculated by the difference of annual N yield of the crop following unfertilized *Lolium multiflorum* ssp. *gaudinii* and N yield following a legume catch crop – amounts to 61 kg N/ha in case of late sown catch crops and 90 kg N/ha in case of early sown catch crops.

Concerning the very early release of nitrogen from legumes, it could be expected that portions of N released from legumes are taken up by the companion grass immediately in mixed swards. N transfer from legumes to grass in catch crop systems can be a result of direct N excretion or decomposition of plant tissue, especially from above ground matter (Brophy and Heichel 1989). Another possible positive effect on N yield and N concentration of the companion grass may also be caused by the reduced competition for available soil N compared with grass monocultures (Mallarino et al. 1990a, b). In consequence, it could also be expected, that N-NO_3^- concentration in the soil of mixtures during autumn and winter is lower than the N-NO_3^- concentration of soils of legume monocultures, but this can not be found in the present study. Although there might be a slight transfer from the legume to the grass in mixed sward – as the increased N yield of *Lolium multiflorum* ssp. *gaudinii* in mixed swards with *Trifolium resupinatum* compared with the N yield of the grass in monoculture suggests – the relatively high nitrate amounts in soils of mixed swards in winter of year 1 are usually comparable to those of the legumes in monoculture. Apparently, the grass is not able to take up the released nitrogen in this case, because the grass is not able to grow under conditions that support the decomposition of legume tissue and release of nitrogen. Instead, the grass itself is exposed to decomposition and mineralization. The N-NO_3^- amounts in the soil of the grass/legume swards are only slightly reduced compared to legumes in monoculture when the catch crops are sown late or during the second research year, when growth conditions are sufficient until late autumn. Under conditions that enable growth of grass and legume, the N-NO_3^- uptake of the grass causes a temporary decrease of N-NO_3^- amounts in soil, which causes an increase of N_2 fixation (= g N/ plant) of the legume (Miller et al. 1982, Mallarino et al. 1990a) because nitrate affects the number and size of nodules and the fixation in active nodules (Giller 2001). This is the reason for estimated high amounts of fixed N_2 even by mixed swards. The RYT values for N yield (Table 6) are clearly > 1 for both legumes at any harvest date which gives evidence for the synergistic relationship between grass and legume. However, the positive mixture effect is more decisive for the legume component and the estimated N transfer from the legume to the companion grass is generally on a low level. The benefit to grass plants by the neighbourhood of legumes is more distinct in perennial swards (Mallarino et al. 1990a, Opitz v. Boberfeld and Biskupek 1995, Laser 1999). Apparently, the growth period is too short to enable an interspecific transfer of higher N amounts in catch crop swards, where it is more likely that surplus N from N_2 fixation is used by the following crop. In contrast to the N transfer in grazed swards, the legume-animal-non legume-pathway is missing in catch crop systems, which is another reason for the limited interspecific N transfer. Therefore, companion grasses of legumes are not effective in reducing the risk of a too early release of nitrogen derived from legume catch crops. However, the non-legume component uses residual N-NO_3^- in soil after the harvest of the preceding crop, e.g. intensively fertilized grain, more effectively than the legume does (Sainju et al. 1998), which is an advantage of mixed swards in relation to legumes in monoculture.

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ABSTRAKT

Transfer dusíku z *Vicia sativa* L. a *Trifolium resupinatum* L. do doprovodných trav a následujících plodin

V polních podmínkách byla studována koncentrace N-NO_3^-, možnost přenosu dusíku z meziplodiny *Vicia sativa* L. a *Trifolium resupinatum* L. do doprovodných trav *Lolium multiflorum* ssp. *gaudinii* (Parl.) Schinz at Keller a vliv předplodiny na *Lolium multiflorum* ssp. *italicum* (A.Br.) Volkart. Meziplodina byla zaseta ve dvou termínech jednak v čisté kultuře, jednak jako krycí plodina s leguminózami (= dva druhy ve střídajících se řádcích) a sklízena byla v různých termínech od září do října. *Vicia sativa* efektivněji fixovala N_2 než *Trifolium resupinatum*, což se projevilo v obsahu dusíku v nadzemní hmotě a obsahu N-NO_3^- v půdě. Termín setí měl největší vliv na obsah N. Transfer dusíku do doprovodných trav byl obecně nízký. Časně zaseté monokultury leguminóz i ve směsích způsobily dočasný mírný nárůst množství N-NO_3^- v půdě v porovnání s nehnojenými travami v zimním a následujícím jarním období, zatímco pozdě seté leguminózy neměly podle všeho žádný vliv na obsah N-NO_3^-. Obě leguminózy měly značný efekt jako předplodiny jak ve směsi, tak v monokultuře v obou termínech výsevu.

Klíčová slova: leguminózy; fixace N_2; transfer N; vliv předplodiny; půdní N-NO_3^-

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