Forage characteristics of *Vicia sativa* L. and *Trifolium resupinatum* L. in catch crop systems under Central European conditions

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ABSTRACT

In a field experiment the development of dry matter yield and forage quality of the catch crop *Vicia sativa* L. compared with *Trifolium resupinatum* L. was investigated and the suitability for cultivation in a mixture with *Lolium multiflorum* ssp. *gaudinii* (Parl.) Schinz et Keller was tested. The legumes and mixtures sowed in early July or August, respectively, were harvested at different dates from early September until late October/early November. The sowing date had the greatest impact on dry matter yield, crude protein content and net energy for lactation (= NEL). *Vicia sativa* yielded more dry matter than *Trifolium resupinatum*, especially at low temperatures and under short-day conditions. At late sowing *Vicia sativa* should be preferred to *Trifolium resupinatum* due to a better stability of yield. *Vicia sativa* had a higher crude protein content but a lower NEL than *Trifolium resupinatum*. In a mixture with *Lolium multiflorum* the differences in energy concentration between late sowed legumes were less distinct. In view of NEL, *Trifolium resupinatum* is superior at early sowing, whereas late sowed mixtures of *Vicia sativa* and *Lolium multiflorum* might enable it to feed fresh forage of acceptable quality until early November and in that way to save it for winter feeding and eliminate expensive sources of crude protein.

Keywords: sowing date; harvest date; forage quality; yield; cold autumn

Vicia sativa and *Trifolium resupinatum* are indigenous in the Mediterranean area and Asia (Mansfeld 1986). Both legumes are annual under Central European conditions (Uehling 1973) and are cultivated in a pure stand or in a mixture (Mansfeld 1986). Little information about the forage quality of *V. sativa* grown under European conditions (e.g. Wivstad et al. 1990) is available in contrast to the well-documented forage value of *T. resupinatum* (Puffe et al. 1984, Nonn 1988/1989). The voluntary intake of both, *T. resupinatum* (Ziegenbein 1965) and *V. sativa*, is high. Thomson et al. (1990) found a higher voluntary intake of *V. sativa* compared with other legumes such as *Lathyrus sativus* and *Pisum sativum* with a comparable digestibility. Compared with *T. resupinatum* the seed costs of *V. sativa* are nearly twice as high, but growing *V. sativa* in a mixture with grass or another supporting crop reduces the costs considerably. *L. multiflorum gaudinii* is apparently a suitable companion to the legumes. Its growth and quality aspects in pure stands are well documented (Herrmann 1999). The aim of this experiment was to analyse the performance of *V. sativa* in relation to dry matter yield and forage quality when compared with *T. resupinatum* and *L. multiflorum gaudinii* grown under Central European conditions as catch crops either in pure stand or in mixture at early and late sowing and harvest dates.

MATERIAL AND METHODS

In order to determine the development of important quality aspects of *V. sativa* and *T. resupinatum* grown as catch crops in pure stand and in mixture with *L. multiflorum gaudinii*, a two year field experiment designed as a split plot with four replications (Table 1) was carried out near Giessen, Central Germany, 160 m above see level. The soil is a Pseudogley with a pH-value of 6.0. The meteorological data of July to March in both years of the study are shown in Figure 1. The weather station at Giessen gives mean annual rainfall and temperature values of 609 mm and 9.0°C. The summer and autumn of year 1 were warm and dry in contrast to spring and summer

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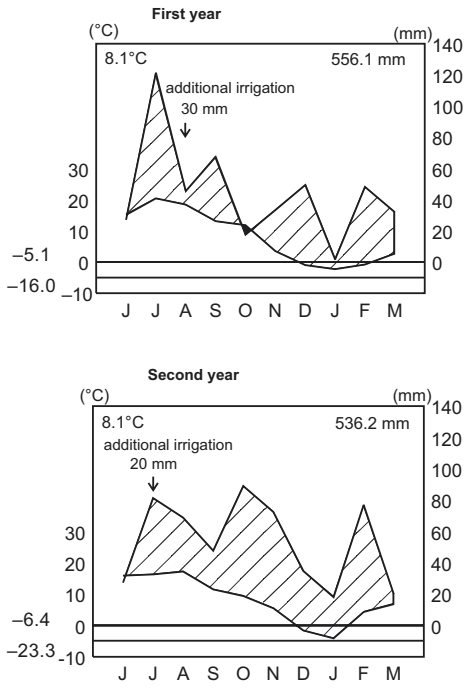

Figure 1. Meteorological data of the experiment site; designed according to Walter (1957)

of year 2 that were relatively moist and cool. The catch crops were sowed in drills, in mixtures with alternating rows of grass and legume. Therefore, the available space for both mixture components in the initial phase was 50% of the total plot area. So it was easier to assess potential inter-specific competitive or synergistic effects. The fertiliser applied to *L. multiflorum* in pure stand with 50 kg N/ha was applied one to two days after drilling. The plots were harvested by hand in a time series at a cutting height of 4 cm; the mixture components were cut separately to determine the yield proportions. The harvest dates and growth stages of the plants are shown in Table 2.

To assess forage quality, the plants were dried at 60°C for 48 hours and ground afterwards. Crude protein content by Kjeldahl and acid detergent fibre (ADF) was determined (Anonymous 1997). Net energy for lactation was estimated using the Hohenheim Gas Test (Steingass and Menke 1986), which is an *in vitro* fermentation method with rumen liquor. It takes the gaseous formation, crude protein, and crude fat content into account (Menke and Steingass 1987).

Every harvest was separately analysed by analysis of variance, otherwise mean values and variances would interact. The *F*-test ($P \leq 0.05$ and $P \leq 0.01$) was utilised. For comparison of the mean value the *LSD*-test was used ($P \leq 0.05$).

RESULTS

The yield proportions of the mixture components are shown in Figure 2. Table 3 shows the dry matter yield of the catch crops in both years. In the first year *T. resupinatum* when compared with *V. sativa* had a higher dry matter yield at early sowing and a lower dry matter yield at late sowing which caused a significant interaction between catch crop and sowing date ($P \leq 0.01$). In the second year there was no difference between the legumes at early sowing in contrast to late sowing resulting in a significant interaction catch crop × sowing date ($P \leq 0.05$). The sowing date was the main source of variation.

The dynamics of the NEL is shown in Table 4. The significant interaction between catch crops and sowing date ($P \leq 0.01$) in the first year was caused by a higher NEL of *L. multiflorum* N_0 compared with *L. multiflorum* N_1 at early sowing and lower at late sowing. The greater differences between the legumes at early sowing compared with the late sowing caused a significant interaction between catch crop and sowing date ($P \leq 0.01$) in the second year. The sowing date factor was significant ($P \leq 0.01$) and had the greatest share of variance. In both years *T. resupinatum* had mostly a higher NEL than *V. sativa*.

Table 1. Experimental design; split plot with four replications

Factor	Level
1. Sowing date	1.1 early = beginning of July
	1.2 late = beginning of August
2. Catch crop	2.1 *Vicia sativa* pure stand (380 germinable seeds/m^2 = 160 kg/ha)
	2.2 *Trifolium resupinatum* pure stand (1000 germinable seeds/m^2 = 14 kg/ha)
	2.3 *Vicia sativa/Lolium multiflorum* mixture 50/50 (190/500 germinable seeds/m^2 = 80/15 kg/ha)
	2.4 *Trifolium resupinatum/Lolium multiflorum* mixture 50/50 (500/500 germinable seeds/m^2 = 7/15 kg/ha)
	2.5 *Lolium multiflorum* ssp. *gaudinii* pure stand (1000 germinable seeds/m^2 = 30 kg/ha); N_0 (0 kg N/ha)
	2.6 *Lolium multiflorum* ssp. *gaudinii* pure stand (1000 germinable seeds/m^2 = 30 kg/ha); N_1 (50 kg N/ha)

Table 2. Harvesting dates and growth stages of the plants

Harvest date	First year						Second year					
	4 September		2 October		27 October		9 September	23	8 October		4 November	
Sowing date	early	late	early	late	early	late	early	late	early	late	early	late
V. sativa	F	S	R	S	R	S	F	S	L	S	R	S
T. resupinatum	F	L	R	S	R	S	F	L	R	S	R	S
L. multiflorum	F	L	R	S	R	S	F	L	R	L	R	L

L = lateral shoot formation or tillering, S = stem growth or shooting, F = flowering, R = ripening

Table 3. Dry matter yield (t dry matter/ha)

Harvest date	First year						Second year					
	4 September		2 October		27 October		9 September	23	8 October		4 November	
Sowing date	early	late	early	late	early	late	early	late	early	late	early	late
V. sativa	4.55	0.47	4.49	1.49	3.73	2.56	2.74	1.02	3.96	1.66	3.92	2.41
T. resupinatum	4.04	0.13	5.12	1.19	5.61	1.68	2.03	0.25	3.03	0.58	4.22	1.08
L. multiflorum N_1	3.53	0.36	5.09	1.96	4.16	2.34	2.37	0.13	2.90	0.37	3.68	0.99
L. multiflorum N_0	3.09	0.23	3.66	1.03	3.99	1.54	2.26	0.09	2.38	0.22	2.95	0.42
L. multiflorum/V. sativa	3.93	0.33	4.26	1.26	2.88	1.83	2.64	0.53	3.72	0.92	4.11	2.18
L. multiflorum/T. resupinatum	3.35	0.22	4.97	1.05	3.58	1.86	2.07	0.20	2.84	0.45	3.28	0.9
$LSD_{0.05}$	0.386	0.386	0.761	0.761	0.799	0.799	0.448	0.096	0.571	0.571	0.815	0.815

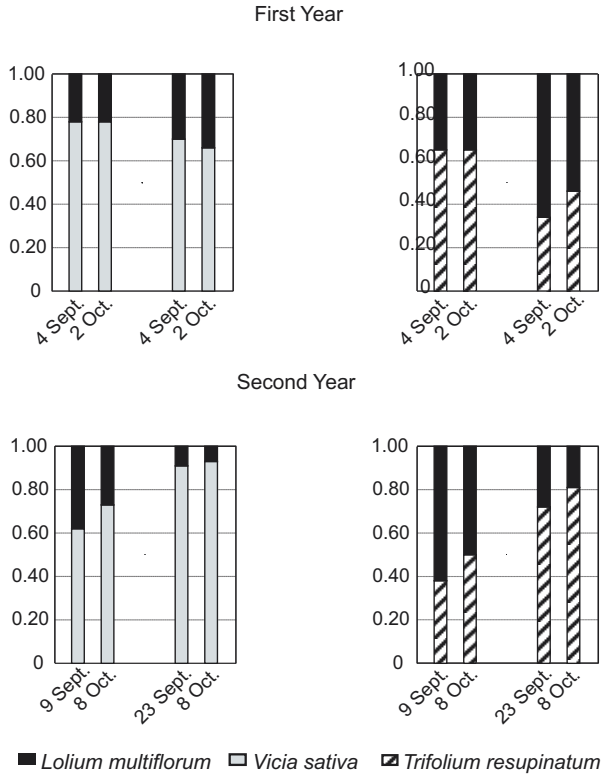

Figure 2. Yield proportion of the mixture components

Table 5 shows the development of the crude protein content of the pure stands and mixtures. Greater differences between the legumes at early sowing compared with late sowing resulted in a significant interaction between catch crop and sowing date ($P \leq 0.01$) in both years. The crude protein content of *V. sativa* was mostly significant higher than these of *T. resupinatum*. The factor of the sowing date was significant ($P \leq 0.01$) and had the greatest contribution to the variance. The crude protein content of the legumes remained relatively constant in contrast to the declining crude protein content of the grass.

DISCUSSION

As expected the dry matter yield of the catch crops was influenced by the sowing date. The growth promoting effect of long-day conditions in July and August for early sowed swards was evident, but the dry matter yield of early sowed *V. sativa* and *T. resupinatum* decreased from the beginning of October in year 1. This was due to the beginning decomposition in ground level, caused by the missing or insufficient pillar func-

Table 4. Net energy for lactation (MJ NEL/kg dry matter) of the catch crops in pure stands and mixtures

Harvest date	First year						Second year					
	4 September		2 October		27 October		9 September	23 October	8 October		4 November	
Sowing date	early	late	early	late	early	late	early	late	early	late	early	late
V. sativa	5.0	5.7	5.0	5.6	4.8	5.0	5.7	5.7	5.3	5.8	5.1	5.6
T. resupinatum	6.3	5.6	6.3	6.3	5.8	5.9	6.4	5.2	6.4	5.8	6.5	6.3
L. multiflorum N_1	5.4	5.3	4.8	6.4	4.1	6.0	5.4	5.4	5.4	5.8	5.1	6.3
L. multiflorum N_0	5.5	5.8	4.8	6.3	4.5	5.6	5.5	5.0	5.3	5.5	5.0	6.0
L. multiflorum/V. sativa	5.3	5.7	4.7	5.8	4.6	5.7	5.4	5.2	5.3	6.0	4.9	5.9
L. multiflorum/T. resupinatum	5.9	5.9	5.7	6.4	4.9	5.8	5.8	5.0	5.8	5.7	5.5	6.4
$LSD_{0.05}$	0.27	0.27	0.42	0.42	0.52	0.52	0.23	0.58	0.55	0.55	0.37	0.37

Table 5. Crude protein content (g/kg dry matter) of the crops in pure stands and mixtures

Harvest date	First year						Second year					
	4 September		2 October		27 October		9 September	23 October	8 October		4 November	
Sowing date	early	late	early	late	early	late	early	late	early	late	early	late
V. sativa	226	303	232	298	211	244	224	297	217	292	244	286
T. resupinatum	192	298	165	256	167	234	204	257	195	246	195	258
L. multiflorum N_1	120	352	97	162	116	170	124	302	112	265	111	177
L. multiflorum N_0	102	282	86	129	99	127	90	213	94	188	94	168
L. multiflorum/V. sativa	216	296	206	249	206	220	177	272	184	282	187	278
L. multiflorum/T. resupinatum	172	285	146	192	153	172	143	232	157	223	147	245
$LSD_{0.05}$	20.9	20.9	19.0	19.0	25.2	25.2	17.7	35.2	18.0	18.0	19.2	19.2

tion of *L. multiflorum*. However, the yield of late sowed legumes and the mixtures increased steadily until end of October/early November. *V. sativa* had a better yield potential and stability at cool temperatures than *T. resupinatum* that could be seen in the higher dry matter yield of *V. sativa* at late sowing in both years and at early sowing in the second year (Table 3). Wivstad et al. (1990) also reported a higher dry matter yield of *V. sativa* compared with *T. resupinatum*. *V. sativa* yielded more at low, than at high temperatures and low rainfall; however, it is not adapted to temperatures below 3–4°C in the long-term (Thomson et al. 1990). The yields of mixtures and pure stands of *V. sativa* are mostly even similar or superior when compared with *L. multiflorum*, even when the grass was fertilised with 50 kg N/ha. And caused by different weather conditions in year 1 and year 2, the growth of *L. multiflorum* and *T. resupinatum* under short day conditions (= late sowing date) was varied considerably, whereas the yield of *V. sativa* was similar in both years. This was of practical importance in year 2, when low growth rates of the late sowed grass, which was evident in pure stands and in the mixture, were compensated by growth of *V. sativa*, which had constantly quite high growth rates even in October.

The NEL of herbage of early sowed *V. sativa* and *L. multiflorum* decreases with increasing maturity, especially in year 1. *T. resupinatum* had mostly significantly higher and more steady energy concentrations. Pure stands of this legume enable to feed on fresh forage with > 6 MJ NEL until end of September/early October. Because of the high proportion of grass in the yield and its much lower NEL compared with the clover, *T. resupinatum* in the clover mixture had mostly a lower NEL. Early sowed *V. sativa* is clearly inferior to *T. resupinatum* because of a significantly higher ADF content (data not shown), but the relevance of this advantage

decreases with a delayed sowing date, due to an early growth stage and the low fibre contents of both legumes. In mixtures with *L. multiflorum* the energy concentration of both legumes is nearly identical, when sowed in August. During October, late sowed mixtures with *V. sativa* always have energy concentrations between 5.7 and 6.0 MJ NEL. At late sowing the energy value of *T. resupinatum* and *L. multiflorum* rarely differ significantly.

In the course of the development the catch crops had a lower crude protein content in the first than in the second year (Table 5). Apparently because polymerisation of higher carbohydrates was reduced by the cool and moist autumn of the second year, thus the crude protein concentration increased. The crude protein content of *L. multiflorum* decreased during growth as the stem has a lower crude protein content than the leaf and the structural carbohydrates are stored firstly in the stem base and not in the leaf (Puffe et al. 1984). The stem to leaf ratio decreased during growth. However, the crude protein content of the legumes decreased little during growth. Similarly in investigations by Wivstad et al. (1990) *V. sativa* was mostly superior to *T. resupinatum*.

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ABSTRAKT

Pícninářské charakteristiky *Vicia sativa* L. a *Trifolium resupinatum* L. v systému meziplodin v podmínkách střední Evropy

V polním pokusu byl sledován výnos sušiny a kvalita píce *Vicia sativa* L. ve srovnání s *Trifolium resupinatum* L., pěstovaných jako meziplodiny, a posouzena jejich vhodnost k pěstování ve směsi s *Lolium multiflorum* ssp. *gaudinii* (Parl.) Schinz et Keller. Leguminózy a jejich směsi byly vysety začátkem července, resp. v srpnu a sklízeny v různých termínech od začátku září do konce října, resp. do začátku listopadu. Termín výsevu měl největší vliv na výnos sušiny, obsah dusíkatých látek a netto energii laktace (NEL). *Vicia sativa* poskytovala vyšší výnos sušiny než *Trifolium resupinatum*, zvláště při nižších teplotách a v podmínkách krátkého dne. Později vyseté *Vicia sativa* by se mělo dát přednost před *Trifolium resupinatum* vzhledem k lepší stabilitě výnosů. *Vicia sativa* měla vyšší obsah dusíkatých látek, ale nižší koncentraci NEL než *Trifolium resupinatum*. Ve směsi s *Lolium multiflorum* byly rozdíly v koncentraci energie mezi později vysetými leguminózami méně zřetelné. S ohledem na NEL je *Trifolium resupinatum* lepší při

raném výsevu, zatímco pozdně seté směsi *Vicia sativa* s *Lolium multiflorum* by mohly prodloužit zkrmování čerstvé píce přijatelné kvality až do začátku listopadu, čímž by se mohla ušetřit konzervovaná píce pro zimní období a neplýtvalo by se drahými zdroji dusíkatých látek.

Klíčová slova: doba výsevu; doba sklizně; kvalita píce; výnos; chladný podzim

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