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Red clover cultivars of Mattenklee type show higher yield and persistence than Ackerklee type

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Abstract

Specialised dairy farmers have increased interest in multi-year red clover (*Trifolium pratense* L.)-ryegrass (*Lolium spp.*) ley pastures because of their high productivity and protein concentration. However, the adoption of such mixtures is restricted because of the poor persistency of many red clover cultivars (cv.) currently used. Extending the duration of the clover ley would reduce costs for seeding and have positive effects on yield, carbon sequestration and soil biodiversity. We aimed to assess dry matter yield (DMY), persistence and nutritive value of four Mattenklee and four Ackerklee cv., and to investigate the underlying plant morphological traits. We conducted a four-year field experiment with red clover-ryegrass mixtures, in combination with a short-term pot experiment. In the field, Mattenklees showed on average 42% higher production compared to Ackerklees in the third and fourth year. In the fourth year, Mattenklees had slightly lower digestibility and protein concentration compared to Ackerklees; however, the digestible dry matter and the protein yield were higher for Mattenklees. Both persistence and nutritive value of the different red clover cv. were closely correlated to stem length. For stem length there was close correlation between the pot and the field experiment, suggesting that this may be an important trait for plant breeding.

Keywords: nutritive value, morphology, breeding, plant traits, *Trifolium pratense* L.

Introduction

In the Netherlands, there is increasing interest in red clover for ley pastures with dairy farmers, who see its value and potential in terms of symbiotic nitrogen fixation, protein concentration and production capacity (Iepema *et al*., 2006). One of the main constraints that restricts the adoption of such mixtures is the poor persistency of the red clover cultivars (cv.) currently used by farmers (Iepema *et al*., 2006). Extending the duration of the clover ley beyond the two to three years currently achieved, would reduce costs for seeding and have positive effects on carbon sequestration and soil biodiversity (van Eekeren *et al*., 2008). In Switzerland, highly persistent and locally adapted red clover landraces, the so-called 'Mattenklees', show a high level of survival after three growing seasons in swards mixed with grass (as opposed to the traditional 'Ackerklees'). We aimed to assess dry matter yield (DMY), persistence and nutritive value of four Mattenklee and four Ackerklee cv., and to investigate the underlying plant morphological traits.

Materials and methods

A four-year field experiment was conducted at Esbeek, the Netherlands. Eight red clover cv. including four Ackerklee landraces (cv. Avanti, Lemmon, Maro and Taifun) and four Mattenklee landraces (cv. Fregata, Larus, Milvus and Pavo) were sown (270 viable seeds m^{-2}, ca. 7.1 kg ha^{-1}) in a mixture with diploid perennial ryegrass (cv. Mathilde, 30 kg ha^{-1}) in August 2011. The trial was arranged in a randomised block design with four replicates and plots were 4 × 8 m. The trial was managed with a four-cut regime and measurements were undertaken during 2012, 2014 and 2015. No measurements took place during 2013, as this year was deemed less relevant in terms of persistence. Total dry matter yield at each harvest was determined by cutting a strip of 0.84 × 4 m within each plot with a front bar mower, leaving a sward stubble height of ca. 6 cm. The samples were weighed and a sub-sample was dried in a forced-

draught oven at 70 °C for 24 h for dry matter (DM) analysis. At each harvest, the red clover content was determined on a fresh sub-sample of at least 200 g. The separated red clover sub-samples from the 1st cut in 2015 were dried and analysed for crude protein (CP) and digestible organic matter in the dry matter (DOMD). Before the first harvest in 2015, plant morphological measurements including plant density, shoot weight, leaf: stem-ratio, specific leaf area and stem length were determined. In addition to the field experiment, a pot experiment was established in a greenhouse, at Wageningen University, in which the eight red clover cv. were sown in four replicates in August 2014. After eight weeks the plants were harvested, morphological traits were determined and plants were oven dried at 70 °C for 72 h for DM determination. For more details we refer to Hoekstra *et al*. (2017). Data were subjected to analysis of variance in Genstat to test for a cv. effect (n = 4) or a clover type effect (Mattenklee vs Ackerklee, n = 16). Spearman correlation coefficients were conducted to determine the association between different morphological traits, nutritive value and persistence indicators.

Results and discussion

In the field, the red clover DMY and to a lesser extent the herbage DMY was significantly ($P < 0.01$) higher for Mattenklees compared to Ackerklees during the third (2014, increase of 33 and 5% respectively) and fourth (2015, increase of 54 and 8%) production year. The two types showed no significant difference during 2012 (Table 1). This was in line with our expectations and indicates that the breeding effort into more persistent red clover cv. is effective (Lehmann and Briner, 1998) under the local conditions in the Netherlands.

Dry matter yield and persistence of the different red clover cv. were closely correlated to plant morphological traits, in particular, stem length (Table 2). Higher stem length may give the red clover a competitive advantage for light competition, resulting in higher yield and persistence, which was also found by Herrmann *et al*. (2008). The stem length was negatively correlated to red clover CP and DOMD concentration (Table 2), which tended to be lower for Mattenklee compared to Ackerklee cv. However, in the first cut in 2015, CP yield was 38% higher and DOMD yield was 10% higher for Mattenklees compared to Ackerklees. Interestingly, for stem length, there was close correlation between

Table 1. Mean red clover and herbage dry matter yield (DMY) of the four Ackerklee (AK) and four Mattenklee (MK) ryegrass mixtures in 2012, 2014 and 2015.

Cultivar		Red clover DMY (t ha^{-1})				Total herbage DMY (t ha^{-1})			
		2012	2014	2015	Yield index[1]	2012	2014	2015	Yield index
Avanti (AK, 4n)		6.2^{cde}	7.4^{c}	4.8^{def}	80^{ab}	11.0^{bc}	12.4^{d}	10.6^{bcd}	98^{bc}
Lemmon (AK, 2n)		5.9^{de}	7.9^{c}	3.7^{f}	68^{a}	10.9^{bc}	12.7^{cd}	10^{cd}	92^{ab}
Maro (AK, 4n)		7.7^{a}	9.1^{bc}	4^{ef}	53^{a}	12.6^{a}	14.3^{a}	9.8^{d}	79^{a}
Taifun (AK, 4n)		7.5^{ab}	7.9^{c}	5de	68^{a}	11.7^{ab}	12.9^{bcd}	10.8^{abc}	94^{ab}
Fregata (MK, 4n)		6.7^{abcd}	10.7^{ab}	6.8^{b}	105^{bc}	11.4^{bc}	13.7^{abc}	11.6^{a}	104^{bc}
Larus (MK, 4n)		7.4^{abc}	11.1^{a}	8.4^{a}	116^{c}	12.0^{ab}	13.8^{abc}	11.2^{ab}	94^{ab}
Milvus (MK, 2n)		5.4^{e}	9.9^{ab}	6.3^{bc}	125^{c}	10.2^{c}	13.8^{abc}	11.2^{ab}	112^{c}
Pavo (MK, 2n)		6.4^{bcde}	11^{a}	5.2^{cd}	82^{ab}	11.6^{ab}	14.1^{ab}	10.5^{bcd}	92^{ab}
SED		0.58	0.86	0.53	14.9	0.59	0.61	0.45	7.3
P-value		**	***	***	***	*	*	**	*
Mean Type	AK	6.8	8.1	4.4	67	11.6	13.1	10.3	91
	MK	6.5	10.7	6.7	107	11.3	13.8	11.1	100
P-value		ns	***	***	***	ns	*	**	**

[1] Yield index = DMY 2015 / DMY 2012 × 100%.

Table 2. Mean plant morphological traits in the field experiment during the first harvest in 2015 for Ackerklee (AK) and Mattenklee (MK) cv. and coefficients of correlation of these traits with red clover yield and crude protein (CP) and digestible organic matter (DOMD) concentration in 2015 and morphological traits in the pot experiment.

Morphological traits 2015	Mean				Correlation (r)			
	AK	MK	SED	P^1	Clover DMY	CP	DOMD	Morphology pot exp
Plant density (# m^{-2})	21.1	32.5	2.17	***	0.93 ***	-0.60	-0.58	na
Shoot weight (g $plant^{-1}$)	9.5	12.7	1.26	*	0.72 *	-0.65	-0.57	0.68
Leaf: stem ratio (g g^{-1})	0.56	0.51	0.023		-0.28	0.63	0.49	0.68
Specific leaf area (cm^2 g DM^{-1})	235	228	7.9		-0.68 ·	0.12	0.29	0.41
Stem length (cm)	38.6	47.6	1.52	***	0.85 **	-0.75 *	-0.75 *	0.77 *

[1] *P*-value: · = $P < 0.1$; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$.

the measurements from the pot and the field experiment (Table 2). The apparent robustness of this measurement strengthens the potential of this trait use in plant selection and breeding.

Conclusion

In line with our hypothesis, the Mattenklees showed a higher DMY in the third and fourth year of production compared to the Ackerklees, indicating that these cv. are suitable for inclusion in a multiple year grass-clover ley. Both persistence and nutritive value of the different red clover cv. were closely correlated to stem length. Stem length showed close correlation between the pot experiment and the field experiment, indicating that this may be an important parameter for breeding.

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