VARIATION IN YIELD AND PERSISTENCE OF WHITE CLOVER UNDER N FERTILIZING AND GRAZING

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Abstract: Research objective was to examine the effect of nitrogen (N) application (0-N_0 and 150 kg ha^{-1} year^{-1}-N_{150}) and rotational grazing by cattle (C) and sheep (S) on the dry matter (DM) yield and persistence of white clover in mixtures with grasses. N_{150} significantly reduced the growing points, stolon length and stolon dry weight by more than 70% compared to N_0. Grazing treatment affected stolon population density only in interaction with N. The highest stolon population densities were achieved with SN_0. S had higher clover DM yield than C. N_0 had higher clover DM yield than N_{150}. However, the interaction grazing management x N rate was significant, so the highest yield of white clover was recorded for SN_0.

Keywords: white clover, stolon, nitrogen, sheep grazing, cattle grazing

Introduction

In recent years, environmental and economic factors have stimulated interest in the use of grass/clover swards with low or zero inputs of mineral N, as an alternative to grass swards receiving high inputs of N, for grazing beef cattle and sheep. Obtained yields of different crops can be too small if adequate amounts of N in soil are not available during the vegetation period while, at the same time, excessive fertilization can be very expensive and inefficient in economical and ecological sense (Mesić et. al., 2007). The use of 1 kg active N ingredient can result in 100 kg ha^{-1} of extra yield on the grassland (Tarnawa et. al., 2006, Husti, 2006). White clover plays an important role in the pasture ecosystem by contributing N fixed by symbiotic *Rhizobium* bacteria and improving pasture quality. Low sward content and its variability among years, with time of year and with management practices are the main problems encountered. Application of N fertilizer to mixed perennial ryegrass/white clover swards generally results in a decrease of the white clover population density (Frame and Newbould, 1986), although moderate spring applications do not necessarily have this effect (Laidlaw, 1984). Decline in the white clover growth associated with higher N fertilizer rates is even more expressed in grazed swards due to the influence of animals. The reduction in yields and, hence, in persistence of white clover under grazing is mainly due to stolon removal (Evans et al., 1992) and deposition of dung and urine. The objective of the current field study was to examine the effect of N application (N_0; N_{150}) and rotational grazing by cattle and sheep on DM yield and persistence of white clover (*Trifolium repens L.*) in a mixture with cocksfoot (*Dactylis glomerata* L.) and smooth-stalked meadow grass (*Poa pratensis* L.).

Materials and methods

The three-year experiment (2000-2002) was conducted in north-western Croatia, at the Faculty of Agriculture experimental station, on brown acid soil (650 m altitude). A mixture of 12 kg ha^{-1} cocksfoot (*Dactylis glomerata* cv. Amba), 6.4 kg ha^{-1} smooth-stalked meadow grass (*Poa pratensis* cv. Balin) and 6.4 kg ha^{-1} white clover (*Trifolium repens* cv. Rivendel) was sown in August 1998, with a seedbed dressing of 40 kg N, 130 kg P_2O_5 and 130 kg K_2O ha^{-1}. Potash and phosphate dressings were repeated at the same rates in the autumn of 1999, 2000 and 2001. During 1999, the sward was topped regularly to control annual weeds. In 2000, the total experimental area (0.6 ha) was divided into 12 equal paddocks (0.05 ha). The experiment consisted of all combinations of (i) two grazing managements (rotational grazing by cattle and sheep) and (ii) two annual N application rates: 0 kg N ha^{-1} and 150 kg N ha^{-1} in six applications from spring to autumn. The layout was a randomized-block design with three replications. The grazing regime was imposed when the mean sward height was 17-20 cm for cattle and 13-15 cm for sheep and continued until a post-grazing height of 5 cm was attained. Grazing was applied for a maximum of 24 hours with 10-12 Charolais heifers and 35-40 Charolais ewes plus lambs, depending on the herbage available. White clover herbage production was measured before each of the grazing cycles (rotations), from April to October, by cutting at random fifteen quadrats (1x0.3 m) per paddock to ground level. A 200 g sub-sample of the cut material was hand separated in the laboratory, oven-dried for 24 h at 105 ^{0}C and weighed to ascertain the clover content. Sward cores were taken for measurements of white clover components: growing point density (axillary + terminal buds), stolon length and stolon dry weight per unit area, twice a year, at the start of grazing in late April and at the end of grazing at the end of October. Fifteen representative turf cores per paddock were taken at random to a depth of ca 50 mm using a golf-course type corer (100 mm diameter). After hand separation in the laboratory, the clover growing points actively growing on the stolon were identified and counted. Clover stolon length per unit area of the ground was monitored at the same time. Roots were clipped off with scissors and discarded, the remaining stolon was then oven-dried for 24 h at 105 ^{0}C and weighed. There were 5-7 rotations per year, depending on the year and grazing treatment. All data were subjected to the analysis of variance using the GLM procedure of SAS (SAS Institute, 1997). All variables were transformed by square root transformation. Upon the analysis of variance, a multiple comparison test of average values, along with the Bonferroni correction method, was conducted for the significant effects and interactions.

Results and discussion

The total precipitation during 2000 (995.6 mm) was 19% less than the long-term average (1230.9 mm) and the mean annual temperature (8.4 ^{0}C) was 27% higher than average (6.6 ^{0}C). August, with only 0.5 mm precipitation and 2.8 ^{0}C higher temperature than average, was especially dry and warm. The following two experimental years were more humid (+104.6 and +20 mm, respectively) and warmer than the long-term average. No significant differences were recorded in the number of growing points, stolon length, stolon dry weight, clover DM yield and contribution to total grassland DM yield between grazing managements and N applications either within or between particular investigation years at the start and at the end of grazing seasons. However, a 60% reduction in the number of growing points, stolon length and stolon dry weight was recorded in April 2001 compared to the beginning of the experiment and a further decrease by more than 75% in April 2002 compared to April 2001 in all treatments and combinations (data not shown). Averaged over all years, the grazing management did not significantly affect the number of white clover growing points, stolon length and stolon dry weight (Table 1), whereas omission of N application (N_0) resulted in higher values of all white clover properties compared to N_{150} ($P<0.01$). A higher clover yield was obtained under sheep grazing ($P<0.05$) than under cattle grazing. However, a grazing management x N rate interaction ($P<0.05$) was recorded for all investigated properties except stolon dry weight in April. The highest values of the investigated clover properties were recorded in SN_0. Rhodes (1991) suggests that a minimum of 20 m m^{-2} of stolons is necessary in early spring to ensure satisfactory clover development later. This criterion was fulfilled only at the beginning of the experiment when the average stolon length of all treatments amounted to 46.87 mm^{-2}. At the same time of 2001, stolon length dropped to 16.44 mm^{-2}, and to only 3.89 m m^{-2} in 2002. Reduction in the number of growing points, stolon length and stolon dry weight during the investigation period resulted from N application and the interaction of N application and grazing. The adverse effect of N application on white clover growing points, stolon branching and stolon weight are consistent with the results of field experiments elsewhere (Davies and Evans, 1990; Höglind and Frankow-Lindberg, 1998; Sibbald et al., 2002, Laidlaw and Steen, 1989, Schils, 1997). One of the factors responsible for sudden reductions in clover stolon lengths is a combination of drought and rotational grazing (Brock and Caradus, 1995). During the grazing season of 2000, large deviations from normal monthly precipitation and temperatures were recorded, which probably contributed to the effects of the grazing method and N application on white clover growth. The potential benefits of white clover, namely its ability to fix nitrogen and its superior nutritional characteristics and intake can only be realized if white clover is present in a sufficient amount in the sward. An average content of 30-50% throughout the year has been suggested as a desirable amount (Stewart, 1984). In this experiment, this desirable amount was not achieved in any of the investigation years. Both grazing treatments had a destructive effect on the white clover yield and clover contribution to total sward production. Sheep grazing depressed the clover content less than cattle grazing, contrary to the results of Briseno de la Hoz and Wilman (1981), Evans et al. (1992) and Murphy et al. (1995), who reported that cattle grazing depressed clover content less than sheep grazing in ryegrass/white clover swards. This might be partly explained by the positive effect of more frequent defoliation and a lower sward under sheep grazing which, along with omission of N application, probably caused lower competition of grasses and better light conditions in the sward. It also lessened the white clover overshadowing by the aggressive companion grass cocksfoot and provided somewhat better conditions for its growth. Cocksfoot has been found to suppress white clover growth in established mixtures to a greater degree than some other cool-season grasses (Gooding and Frame**,** 1997).

Table 1. Effects of grazing treatments and N fertilizing on white clover growing points, stolon lenght, stolon dry weight, clover DM yield and clover contribution to total grassland DM yield at the start of grazing (April) and at the end of grazing (October) 2000-2002.

Treatment	Growing points m^{-2}		Stolon lenght m m^{-2}		Stolon dry weight g m^{-2}		DM yield	
	April	October	April	October	April	October	t ha^{-1}	%
Cattle (C)	414.2	309.6	8.20	5.58	7.29	6.39	0.13	1.40
Sheep (S)	663.1	808.6	12.14	13.14	9.78	13.88	0.21*	1.96
N_0	873.0**	890.6**	16.03**	14.91**	13.18**	16.25**	0.25**	2.50**
N_{150}	204.3	227.6	4.31	3.80	3.90	4.02	0.09	0.86

CN_0	589.5^{ab}	415.6^{ab}	11.26^{ab}	7.41^{ab}	9.90	8.61^{ab}	0.14^{b}	1.67^{b}
CN_{150}	238.9^{b}	203.6^{b}	5.14^{ab}	3.73^{b}	4.68	4.17^{b}	0.11^{bc}	1.13^{bc}
SN_0	1156.4^{a}	1365.6^{a}	20.79^{a}	22.40^{a}	16.45	23.89^{a}	0.35^{a}	3.32^{a}
SN_{150}	169.7^{b}	251.6^{b}	3.48^{b}	3.87^{b}	3.11	3.87^{b}	0.07^{c}	0.59^{c}
	Significance							
Grazing (G)	NS	NS	NS	NS	NS	NS	*	NS
Nitrogen (N)	**	**	**	**	**	**	**	**
G x N	*	*	*	*	NS	*	*	*

* Significant at the 0.05 level ** Significant at the 0.01 level NS Non significant
The differences between the values with the same letters are statistically insignificant at P=0.05.

Conclusions

Sheep grazing with absence of fertilizer N had the lowest depression effect on white clover growth which might be partly explained by the positive effect of more frequent defoliation and a lower sward under sheep grazing which, along with omission of N application, probably caused lower competition of grasses and better light conditions in the sward for her growth.

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