Strengthening the resilience of grasslands against the unpalatable C4 grass *Setaria pumila*

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Abstract

With increasing frequency of dry and hot events, ryegrass-dominated grasslands become more vulnerable to infestation by the drought and heat resistant, but unpalatable C4 grass *Setaria pumila*. Grassland management must therefore be readjusted to strengthen resilience against weather hazards and resulting weed infestation. We investigated strategies to strengthen high quality forage grasses, as well as overseeding grass species more resistant to drought than ryegrass. The study involved a factorial experiment testing mowing height, time interval between harvests and overseeding, and an on-farm survey on the effects of farmers' management practices on *S. pumila* abundance in 31 grasslands. Increasing mowing height from 3 to 8 cm or skipping one or two harvests during the summer months reduced *S. pumila* abundance during the years of strong infestation. These management options were also clearly beneficial for the abundance of forage grasses in the sward. A negative relationship between *S. pumila* abundance and mowing height was also observed in the on-farm survey. Overseeding cocksfoot significantly increased its abundance only by the fourth experimental year. We conclude that careful management focusing on the competitive ability of forage grasses is an important driver of grassland resilience against infestation by *S. pumila*.

Keywords: yellow foxtail, cutting height, defoliation frequency, oversowing

Introduction

Setaria pumila (Poir.) Roem. & Schult. is an annual C4 grass native to Europe. In Switzerland it mainly occurs in the lowland, under full sun on moderately dry, nutrient-rich soils (Landolt *et al.*, 2010). It is a common arable weed (Dekker, 2003) and is on the rise in grassland areas and spreading into higher altitudes. It germinates on patches of bare soil starting mid-spring and develops its biomass during the hot summer months. Its biomass is unpalatable to livestock. In grasslands, *S. pumila* has been shown to benefit from dry and warm conditions (Orlandi *et al.*, 2015), and thus from climate change. This grass is currently a serious challenge for forage production in some Swiss regions. After cutting, it is able to replace the lost flower stems and produce mature seeds within a very short time. Seed propagation can therefore not be prevented by intensive mowing. The aim of this study was to test three management options to reduce the abundance of *S. pumila* in intensively used meadows, and to evaluate the potential importance of management practices encountered on-farm.

Materials and methods

A factorial field experiment was run from 2017 to 2021 in Buochs (lat/lon 46.97, 8.39; 450 m a.s.l.) to test: (1) mowing height, either low (3 cm) or high (8 cm); (2) intervals between harvests; and (3) overseeding, yes or no. The intervals between harvests were: (1) repeated harvesting at early heading stage of the ryegrass with six harvests per year, thereafter abbreviated 0Sk; (2) third growth cycle left standing until the date of the fourth harvest of 0Sk, i.e. skipping one harvest in July (1Sk); and (3) four harvests per year on the dates of the first, third, fifth and sixth harvests of 0Sk, i.e. two harvests skipped, one in June and one in August (2Sk). The four replicates of the treatments were randomized in complete blocks,

with overseeding being nested in the other treatments. High mowing height, 1Sk and 2Sk were chosen to try increasing the competitive ability of forage grasses against *S. pumila*, especially during the summer months. The occurring forage grasses were *Lolium multiflorum, Lolium perenne, Dactylis glomerata* and *Poa pratensis* (respectively about 35, 10, 10 and 10% of the biomass in the initial sward). *Poa trivialis* – not a forage grass – was also abundant (35%) in the initial sward. Overseeding was performed yearly with a mixture of *D. glomerata*, *L. perenne*, *P. pratensis* and *Festuca rubra*. The evolution of the botanical composition was appraised by six visual assessments from spring to autumn. We here use the annual mean for the relative abundance of forage grasses and the mean of the August-September assessments for *S. pumila* as a proxy for its yearly peak of biomass. In addition, the abundance of *S. pumila* and the management of 31 grasslands was surveyed during 2017 to 2019. All grasslands were located in the same valley and visited during August-September, but not all during the same week. Because the relative biomass of *S. pumila* evolves quickly during the summer months, its abundance was assessed using a point method (presence/absence at each point) for the survey. We here use the means over years from the survey data. The factorial experiment was analysed by repeated measures ANOVA, the survey by GLMM using Statistica™ 13.5.0.

Results and discussion

In the experiment, the relative abundance of *S. pumila* was similarly high during the first three years (grand mean 20-25% *S. pumila* at the end of summer). Increasing mowing height from 3 to 8 cm decreased *S. pumila* abundance in all harvest interval treatments ($P<0.001$, Figure 1A). Harvest interval also influenced *S. pumila* abundance ($P<0.001$), and the interaction height × interval was significant. The reduction in *S. pumila* abundance achieved with High-1Sk could not be significantly outperformed by skipping a second harvest (Low-2Sk and High-2Sk). In 2020 and 2021, *S. pumila* abundance dropped to only 7 and 3%, respectively, on average over the whole experiment. This was most probably due to the moist weather conditions of these two years. At these low abundances, differences among treatments were not significant.

Mowing height and interval also influenced the competitive ability of the forage grasses as indicated by the significant differences in the trajectory of their abundance over the years (Figure 1B, interaction treatment × year: $P<0.001$). The Low-0Sk treatment was clearly detrimental to the forage grasses. On the contrary, these species considerably increased their relative abundance in all treatments with higher mowing height. Increasing mowing height might be preferred over skipping harvests because this first option does not reduce forage digestibility, while the second does (data not shown). Overseeding significantly increased the relative abundance of *D. glomerata*, but only starting 2020 (data not shown). Thus, it might contribute to an increased resilience against *S. pumila* infestation but only after several years.

Figure 1. (A) Effect of the interval between harvests (0Sk, 1Sk, 2Sk) and of the mowing height (Low/High) on the relative abundance of *Setaria pumila* for the years 2017 to 2019. The box plots show the median, the quartiles and the non-outlier range (n=8). Letters above the x-axis indicate significant differences (Tukey HSD test, $P<0.05$). (B) Evolution of the relative abundance of forage grasses from 2017 to 2021 in the different harvest mowing height × interval treatments. The plots show the means of 4 replicates × 2 overseeding treatments (n=8) and the whiskers the 0.95 confidence intervals.

Among the management parameters recorded during the survey (Table 1), only the mowing height appeared to have a significant effect on *S. pumila* abundance (P=0.017). For the survey, this parameter was categorized in the four classes <5, 5-6, 6-7 and >7 cm. Higher *S. pumila* abundance was not associated with higher numbers of fertilizer applications (range = 1 to 7 applications). No effect of overseeding or self-reseeding (one growth cycle harvested after seed maturity of the targeted forage grass species to allow it to shed seeds), summarized as 'Seed input' in Table 1, could be observed with this dataset. The results show that *S. pumila* infestation can affect both permanent and temporary grasslands. From an agricultural extension perspective, the survey was also very useful for discussing careful grassland management with farmers.

Table 1. Generalized linear mixed model summary with *Setaria pumila* abundance in 31 grasslands surveyed on-farm as dependent variable of grassland management factors. Seed input: overseeding and/or self-reseeding. Temporary/permanent grasslands as categorical variable.

Parameters	Estimate	Std. error	Significance
Intercept	0.619	0.202	**
Mowing height	-0.213	0.083	*
Number of fertilizer applications	0.038	0.033	ns
Seed input	0.129	0.137	ns
Temporary/permanent	-0.009	0.070	ns

Conclusions

Caring for the forage grasses with an adapted mowing height and time interval between harvests increases the competitive ability of the good quality grasses and decreases *S. pumila* abundance during years of high *S. pumila* occurrence. Such management options are a mid-term investment and are becoming increasingly important with increasing frequency of adverse weather events.

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