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IMPACT OF SHADING AND DEFOLIATION ON *Vulpia* spp.

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ABSTRACT

Vulpia species (Vulpia bromoides, Vulpia myuros) are annual grass weeds prevalent in southern Australian, dryland pastures. Vulpia provides poor quality forage and its seeds damage hides, carcasses and skins. Knowledge on how shading affects vulpia growth and survival can be used to develop grazing strategies aimed at vulpia suppression. A pot experiment was established to assess the impact of shading on vulpia growth by adjusting sward height. The swards (phalaris (Phalaris aquatica) and vulpia) were maintained at 3, 6, 12 or 24 cm to simulate continuous grazing at different grazing pressures, or defoliated to 2 cm once the sward reached 30 cm, to simulate rotational grazing. All treatments were compared to the control (vulpia without any shading / surrounding sward). Solar radiation and temperature at the soil surface, plus vulpia tiller numbers, panicle numbers and biomass were measured. There was a decline in solar radiation as sward height increased. Mean radiation levels in the simulated rotation were intermediate to the 12 and 24 cm treatments. However, the increase in shading in these treatments did not reduce vulpia panicle production. In contrast, vulpia panicles per plant were lower in 3 cm and 6 cm swards than in the control (16, 19 and 77 panicles per plant respectively). The most effective treatment was the rotation, or simulated grazing, which reduced tiller and biomass per plant when compared to the shorter swards (3 and 6 cm) and panicles per plant when compared to the control. A rotationally grazed system, with a combination of severe shading and defoliation, could suppress vulpia to a greater extent than in continuously grazed pastures, where solar radiation levels are higher and defoliation is less severe.

Keywords: Defoliation, grazing management, grass weed, shading, vulpia, weed suppression.

INTRODUCTION

Vulpia bromoides and *Vulpia myuros* are annual grasses which are prevalent in temperate pastures of Australia. These species have similar geographical distributions, co-occur in pastures and are collectively known as ‘vulpia’ (Dowling, 1996). Vulpia provides poor quality feed and its seeds damage hides, carcasses and skins (Code, 1996). Additionally, its allelopathic residues can impede germination

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and establishment of cereal crops and legumes (An *et al.,* 2007; An *et al.,* 1996).

Knowledge of vulpia ecology can be used to develop management strategies which favour sown perennial species and suppress vulpia. While research has been undertaken on vulpia germination, seedling establishment and interactions with moisture and nutrients, (e.g., Dillon and Forcella, 1984; Dowling, 1996; Ozanne *et al.,* 1969; Scott and Blair, 1987) less is known regarding the impact of shading on vulpia. Shading alone or in combination with severe defoliation can lead to plant mortality and reduce dry matter yield (Goldberg and Werner, 1983; Wong and Stur, 1996). Shading (low light intensity and low red/far red ratio) reduced ryegrass (*Lolium perenne*) vegetative and reproductive tiller production (Bahmani *et al*., 2000). When compared to undefoliated plants, defoliation of phalaris (*Phalaris aquatica*) to 6 cm doubled the percentage of light reaching emerging subterranean clover (*Trifolium subterraneum*) seedlings and increased their seedling weight (Dear *et al*., 1998). Pasture species such as phalaris have a large stature and leaf area and are easily able to overtop and shade vulpia when sward biomass is allowed to accumulate.

Shading can be manipulated in pastures by altering pasture biomass and height, which in turn is dependent on the grazing frequency and intensity. In continuously and intensively grazed pastures, there is less opportunity for sward biomass to accumulate, while in rotationally grazed pastures, sward biomass accumulates before the sward is defoliated to low levels. Under rotational grazing there is the potential for greater shading of vulpia.

To assess the impact of shading on vulpia growth and survival, a controlled microsward experiment was established. Microswards comprising potted phalaris plants surrounding a central potted vulpia plant were subjected to different defoliation regimes to simulate a range of defoliation intensities under continuous and rotational grazing. The hypothesis tested was that the regime with the greatest shading would be the most effective in suppressing vulpia growth and survival.

MATERIALS AND METHODS

Microsward Preparation

Vulpia seed (*V. bromoides*) was collected from a property near Vasey, Western Victoria in January, 2002. Vulpia seeds were sown on 10 July 2002 in potting mix in trays and kept in a glasshouse at ambient conditions. Six weeks later, individual seedlings were transplanted into 1.5 L (9 x 9 cm x 18 cm deep) pots containing potting mix. Phalaris (cv. Australian) seeds were sown (2 per pot) on

15 February 2002. Ten weeks after sowing, plants were transplanted into 1.5 L pots. To ensure that moisture and nutrients were not limiting, plants were grown on a capillary bed which provided sub-irrigation and slow release fertiliser was added as required according to label recommendations.

On 21 August 2002, a microsward was created by placing a pot of vulpia in the central cell of a 3 x 3 lattice and placing phalaris pots in the eight surrounding cells. Microswards were placed on the capillary bed. By this stage vulpia plants had between three and four leaves and phalaris plants were up to 30 cm in height. Keeping vulpia and phalaris in separate pots assured that root competition was not a confounding factor and that results could be more readily attributed to the different defoliation and solar radiation levels.

Experimental design and treatments

The study was a randomised, complete block design with ten replicates of each treatment. There were four treatments in which the microswards were 'continuously' defoliated to 3 cm, 6 cm, 12 cm and 24 cm on day one and every seven days thereafter, until the final harvest on 11 December 2002. The increase in plant height during regrowth ranged from 5 to 10 cm per week. A fifth 'rotation' treatment was applied in which the microsward grew to approximately 30 cm in height and was then defoliated to 2 cm. Two defoliation events were possible under this regime, on 4 September and 20 November. There was a sixth control treatment in which vulpia was grown as a single potted plant, without any surrounding phalaris pots (i.e., no shading or defoliation).

Measurements

At the final harvest, the numbers of tillers and panicles for each vulpia plant were counted. Additionally, vulpia plants were defoliated to ground level and the foliage oven dried for 72 hrs, at 70°C, to obtain dry matter estimates. Air temperature (°C) and solar radiation (W/m^2), both at the soil surface, were logged continuously, once an hour, for one replicate of all treatments. To obtain measurements, probes were placed on the soil surface of a central pot which had been filled with the potting mix but did not contain a vulpia plant. These data were used to obtain the average daily temperature and solar radiation over the experimental period. To convert W/m^2 to MJ/m^2/day, a daylength of 13 hours was assumed, which was the average day length over the experimental period, based on sunrise and sunset times.

Vulpia tiller and panicle number per plant and plant biomass were analysed with residual maximum likelihood function (REML). Data did not require transformation to normalise the variance. Temperature and solar radiation data were averaged over the experimental period

(21 August to 11 December 2002). All analyses were performed using the statistical package GenStat 5.42 (GenStat 2000).

RESULTS

All vulpia plants survived in all treatments, including the control.

Table-1. Effect of continuous defoliation to 3 cm, 6 cm, 12 cm, 24 cm, and a simulated rotation treatment, on vulpia tiller number, panicle number, and plant biomass at the final harvest in December 2002.

Variable	3 cm	6 cm	12 cm	24 cm	Rotation	Control	P value
Tillers/ plant	524 $_{a}$	485 $_{abc}$	491$_{ab}$	300 $_{cd}$	17$_{d}$	420 $_{bc}$	<0.001
Panicles/ plant	15.6 $_{b}$	18.6 $_{b}$	37.1 $_{ab}$	43.1 $_{ab}$	17.1 $_{b}$	76.6 $_{a}$	<0.001
Plant biomass (g)	6.6 $_{b}$	8.9 $_{b}$	9.7 $_{ab}$	7.2 $_{b}$	2.4 $_{c}$	13.6 $_{a}$	<0.001

Means within the same row with the same letter are not significantly different (P<0.05).

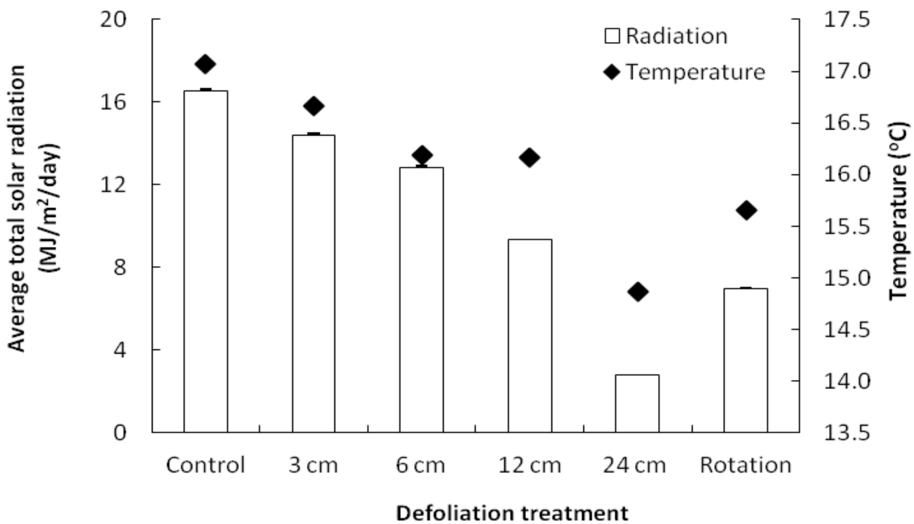

Figure 1. Average daily solar radiation (MJ/m^2/day) and average temperature (°C) at the soil surface, averaged over the duration of the experiment for the control, 3 cm, 6 cm, 12 cm, 24 cm and rotation treatments.

Increasing defoliation height resulted in less solar radiation reaching the soil surface (Figures 1 and 2). When compared to the control, only 17% of average total solar radiation reached the soil surface in the 24 cm treatment. Solar radiation fluctuated in the rotation treatment according to stage of regrowth and dropped to radiation levels similar to in the 24 cm treatment well before the defoliation event on 20 November (Figure 2). Soil surface temperature also declined with increasing defoliation height and average temperature was lowest in the 24 cm treatment (Fig. 1).

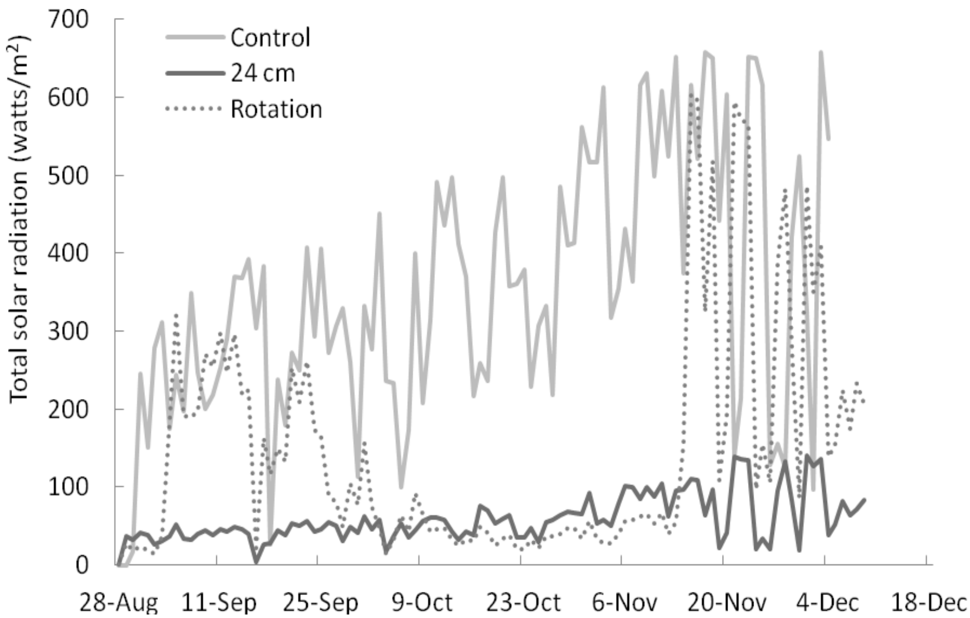

Figure 2. Average daily solar radiation ($MJ/m^2/day$) at the soil surface, for the control, 24 cm and rotation treatments.

DISCUSSION

Vulpia growth and panicle production declined with increasing levels of shading. However, at the higher levels of shading (12 cm, 24 cm) such as would occur in some continuously grazed pastures with low grazing intensity, tiller and panicle production were no different to that of the control. Average temperatures declined with increased shading, and were also lower in the 24 cm treatment (≈ 15 ^oC) than in the control (≈ 17^oC). This equated to a 12% reduction in temperature, which was much less than the 83% reduction in solar radiation. Solar radiation would appear to be more important than temperature in determining vulpia growth in this study.

In contrast, minimal shading with severe defoliation (3 cm treatment) resulted in the lowest plant biomass and fewer panicles, but more tillers. This is consistent with field studies. For example, in New South Wales temperate pastures, intense grazing of vulpia increased tiller production (Dowling and Kemp, 1997).

A combination of severe defoliation and severe shading (rotation treatment) led to reductions in all three parameters: smaller plants with fewer panicles and fewer tillers. While reducing vulpia growth will eventually limit its ability to produce seed, preventing or severely suppressing panicle production is essential to eliminate vulpia from pastures in subsequent years.

Results from this microsward study are consistent with Grant and Rumball (1971), who found that barley grass abundance was less in rotationally than continuously grazed pastures. They are also in agreement with a Western Victorian field study in which vulpia was less prevalent, etiolated in appearance and subject to greater mortality in rotationally stocked than continuously stocked pastures (Tozer *et al.* 2008; Tozer *et al.* 2009). Pasture biomass accumulation was much greater in the rotationally stocked treatment (mean 3680 kg DM/ha/yr) than continuously stocked treatment (2120 kg DM/ha/year) in that field experiment (Chapman *et al*. 2003), which would have led to significantly greater shading of weeds occurring at the ground surface in the rotationally grazed pastures.

Interestingly, the combination of severe shading and severe defoliation was insufficient to kill vulpia plants in this study. There are at least two possible reasons for this. Firstly, water and nutrients were not limiting factors in this study. This is in contrast to the situation encountered in pastures, where plants are often subject to multiple stresses, including nutrient deficiencies, water deficits and shading or extreme heat. They are also subjected to defoliation and damage through trampling, dung deposition and insect damage. It is most likely that the combination of a number of these stresses, rather than shading and defoliation alone, causes vulpia mortality in temperate Australian pastures. Secondly, vulpia plants were six weeks old when treatments were imposed, and they may have been more susceptible to shading at an earlier stage. For example, mortality of *Vulpia ciliata* was particularly high during seedling emergence before the radicle had extended 2 mm (Carey & Watkinson 1993).

CONCLUSION

While shading or severe defoliation suppresses vulpia growth and/or panicle production, the greatest suppression occurs with a combination of shading and severe defoliation. However, these two combined stresses are insufficient to kill vulpia when moisture and nutrients are not limiting plant growth. Grazing strategies that allow the accumulation of pasture biomass to increase shading of vulpia followed by severe defoliation have potential to suppress vulpia in perennial pastures.

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