Cultural weed management of vulpia

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Introduction

Silvergrasses (*Vulpia bromoides* (L.) Gray and *V. myuros* (L.) C.C. Gmel.) are common weed components of crops and grasslands throughout temperate Australia. In pastures, these species provide some early season forage for livestock, but are more widely known to decrease forage production, damage livestock carcasses, and contaminate clipped wool leading to a 30% reduction in sheep production. Vulpia is extremely persistent in both fertile and infertile pastures, and is difficult to control in pastures due to its high seed production, seed dormancy and resistance of its reproductive structures to removal by grazing. Prior to the 1980s, silvergrass was not considered a problem weed in cereal crops, but reports over the last decade indicate that silvergrass infestations may reduce wheat yields by as much as 1 t ha^{-1} (Forcella 1984). The adoption of direct drilled cropping systems has enhanced vulpia as a weed of crops in southern Australia.

The use of non-selective herbicides is an effective means of reducing vulpia infestations (Bowran and Wallace 1996), but the problem is not eliminated as re-infestation from viable seed leads to a rapid increase in subsequent years. Dowling *et al.* (1995) showed vulpia populations returned to pre-treatment levels within two years of herbicide treatment. Further, since chemical control over the whole property is not feasible and untreated adjacent paddocks provide additional seed source for invasion into treated areas, alternative control methods need to be employed. This suggests that the longer term management of vulpia may only be possible where a number of strategies are integrated to substantially reduce the seed production potential of vulpia. The two periods of the year during which vulpia populations are most vulnerable to manipulation are spring when adult plants produce seed and replenish the soil seed bank, and autumn when seeds germinate and deplete the seed bank (Jones 1992). The wide adaptation of vulpia within temperate Australia means that we must live with it and manage it rather than try to eradicate it.

A number of different cultural practices have been suggested which may achieve this:

i. removal of vulpia seed heads using hay cuts and ensilage technologies,
ii. grazing management strategies,
iii. selection of competitive crop and pasture species,
iv. prescribed burning,
v. cultivation, and
vi. strategic fertilizer application.

The aim of this paper is to review the effectiveness of these cultural techniques (i.e. non-herbicide methods) to control vulpia in pastures and crops, and to identify areas where future research is required.

Table 1. Effect of cutting and grazing on vulpia density (number m^{-2}) twelve months after treatment (Beattie *et al.* 1992).

Treatment	Before 19/10/89	After 30/10/90
Lax grazing (12.5 ewes ha^{-1})	35 100	8081
Heavy grazing (20 ewes ha^{-1})	35 100	7281
Early cut (November) – Silage	42 900	420
Late cut (December) – Hay	39 000	10 171

Table 2. Effect of grazing regimes on vulpia populations (Jones and Whalley 1993).

Treatment	Populations (number m^{-2})	
	July 1991	Sept 1992
Leave spring, leave autumn	843	233
Leave spring, graze autumn	929	1716
Graze spring, leave autumn	902	80
Graze spring, graze autumn	889	46

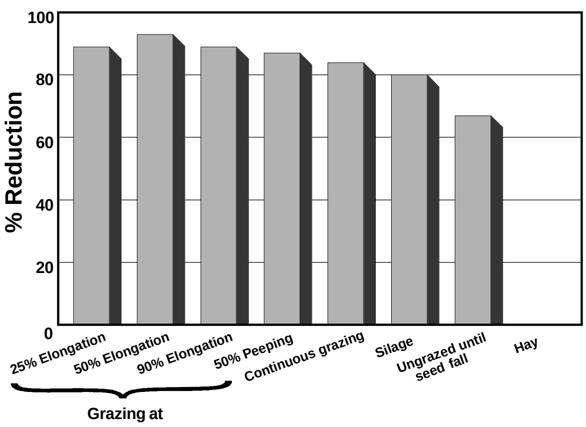

Figure 1. Effect of grazing and cutting on vulpia (Dowling *et al.* 1996).

Cutting and removal of seed heads

Hay and silage production provide an effective means of reducing seed reserves by mechanically removing developing and mature seed heads from vulpia infested pastures. Timing of harvest in relation to physiological development of vulpia is critical for successful mechanical intervention. Cutting early (November) and ensiling to remove seed heads before drying reduced the *Vulpia* spp. component in degraded Tasmanian pastures whereas late cutting (December) to produce hay allowed seed to mature and fall leading to ineffectual control of vulpia populations in the following year (Table 1). Peeping is the ideal development phase for ensiling vulpia-dominated pasture to maximize silage quality and minimize the opportunity for vulpia to re-tiller and produce seed after cutting.

Careful strategies are needed to minimize opportunities for re-infestation when vulpia infested conserved forage are fed to livestock. Dowling *et al.* (1996) showed that ensilage was effective in reducing viability of vulpia seed whereas conserved hay stored over summer and returned to the same plots in autumn retained high seed viability and resulted in the highest regeneration of vulpia compared to strategic grazing, silage, spray-topping, winter-cleaning and ungrazed treatments (Figure 1). From a practical viewpoint this suggests that 'sacrifice paddocks' should be selected in which livestock are fed vulpia-infested hay, thereby confining re-infestation to paddocks targeted for other cultural or herbicide treatments in an integrated farm program.

Strategic grazing

Strategic grazing provides a cheap and effective means to control vulpia (and other grassy annual weeds) in pastures and represents the only viable option on non-arable lands. Jones and Whalley (1993) examined effects of combinations of deferment and high grazing pressure in autumn and spring on soil seed banks and vulpia populations in phalaris-white clover pastures in the northern tablelands environment. Their results showed that the most effective strategy was to combine heavy grazing (100 DSE ha^{-1}) for short periods in both spring and autumn, i.e. heavy grazing pressure coincident with vulpia flowering in spring to reduce seed bank replenishment and heavy, light or nil grazing in autumn to open up the pasture to encourage vulpia recruitment to deplete the residual seed bank (Table 2).

However, autumn grazing can have the opposite effect and increase, rather than decrease, the proportion of vulpia in pastures. This appears to be due to a combination of two factors:

i. early grazing encourages greater tillering of vulpia, and

ii. selective grazing by sheep may transfer pressure to other more palatable companion pasture species (Dowling and Kemp in press).

Further, heavy grazing in spring may cause excessive soil compaction, reduce infiltration and render soil more vulnerable to erosion. Dowling (unpublished data) observed changes in soil bulk density when heavy grazing was used as a method to control vulpia at Orange, but not in alternative treatments (e.g. spray-topping).

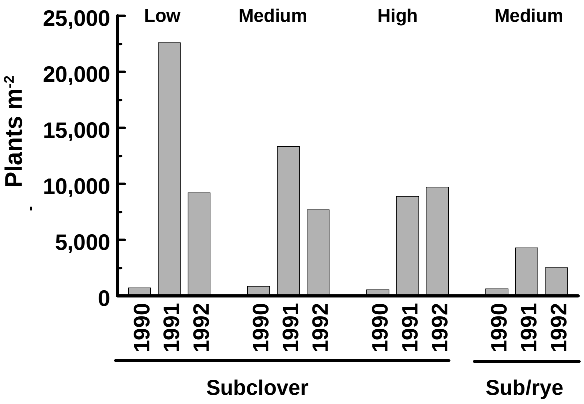

Figure 2. Effect of pasture density and composition on vulpia invasion (Leys *et al.* 1993).

Table 3. Effect of perennial grass (*Anthoxanthum odoratum*) competition on vulpia (*V. bromoides*) survival (number m^{-2}) and seed production (number m^{-2}) (Peart 1989).

Patch type	Input	Survivors	Seeds produced	
			1-year	2-year
Typical (1.2 kg m^{-2})	21 668	32	338	0
Low (1.0 kg m^{-2})	21 668	32	508	0

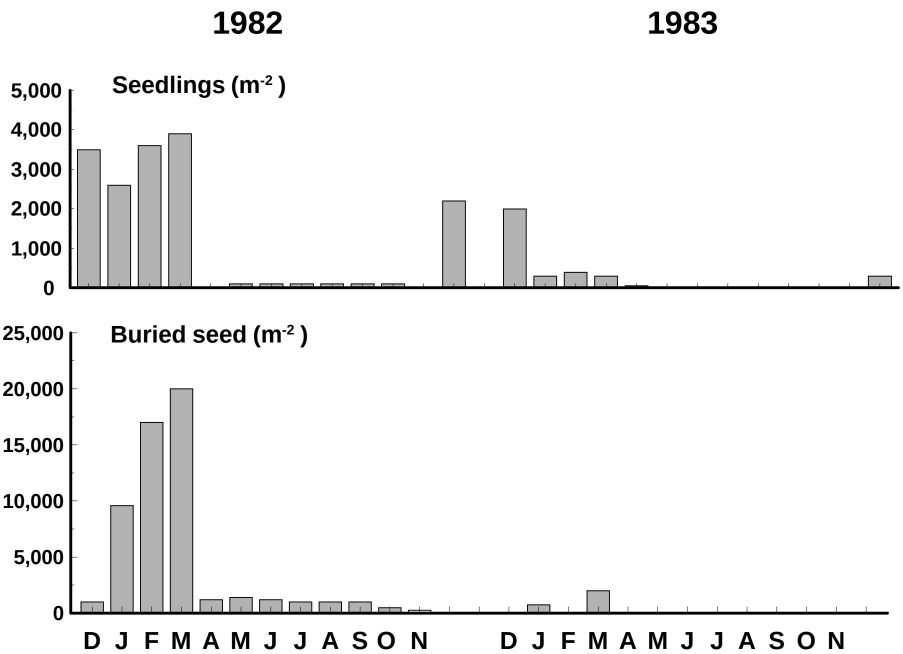

Figure 3. Effect of time of ploughing on numbers of buried seeds and emergent vulpia seedlings (Forcella and Gill 1986).

As a consequence, Dowling and Pickering (1995) have studied the phenology of vulpia in spring to identify the best compromise between elevation of the tiller apex and feed value so as to maximize tiller removal and effectively reduce further seed production following strategic grazing. These studies suggest that the elongation and peeping stages of tillers provide a suitable measurement of developmental progress towards the latter stages of vulpia's growth cycle which landholders can use to implement effective grazing programs in spring. The effectiveness of such monitoring is currently being investigated in an International Wool Secretariat-funded project at Gumble, New South Wales.

While strategic grazing may effectively control vulpia in pastures, the large numbers of livestock required coupled with the small window of opportunity when vulpia is vulnerable to damage by grazing, means that only a proportion of the property can be treated in any one year. It is important therefore, for producers to target paddocks such as those required for autumn cereal production, pasture renovation or simply highest vulpia populations, for treatment with strategic grazing (Jones and Whalley 1993).

Selection of competitive pasture and crop species

The selection of competitive crop and pasture species is an important weed control method. A vigorous pasture competes more effectively with weeds than a weak pasture. Mowing and grazing are of limited value as cultural control methods if a highly competitive pasture cover is not maintained. Where pasture cover is weak, vulpia rapidly invades the gaps created by poor grazing management. Pasture cover plays an important role in preventing germination of some vulpia species. For example, Jones *et al.* (1992) showed that monthly and cumulative emergence of *V. myuros* seedlings were negatively correlated with pasture cover, i.e. recruitment levels decreased as standing pasture dry matter increased over the range 13 to 4133 kg DM ha^{-1}. In contrast, pasture cover had less impact on the cumulative emergence of *V. bromoides.*

The lack of effective competition enables vulpia to produce high seed populations from a low density base. Leys *et al.* (1993) showed that medium to high subterranean clover densities reduced vulpia production in October by 50–77% and seed production by similar levels (Figure 2). The effect continued into the following spring. A mixed subterranean clover/annual ryegrass pasture was even more effective in reducing production and seed set of vulpia. Since grasses have an important role in maintaining grazing animals in early winter when pasture availability and growth rates are low, Leys *et al.* (1993) concluded that inclusion of a companion grass was necessary to reduce the growth, seed production and subsequent regeneration of vulpia.

Maintenance of a strong perennial grass component will ensure a minimal level of bare ground thereby reducing the potential for vulpia to invade. Peart (1989) showed from studies in California that while *V. bromoides* was able to establish from seed introduced into a vigorous perennial grass (*Anthoxanthum odoratum*), seed production after one year was only 2% of the original number sown (22 000 m^{-2}) and these failed to recruit in year 2 (Table 3). In Australia, reliance on annual legumes to provide nitrogen to sustain pasture systems means that full ground cover by perennials is rarely possible or desirable. It is these 'gaps' between perennial grasses that provide niches for invasion by vulpia in autumn, especially if the 'autumn break' is late. Inappropriate grazing strategies are also implicated in the creation of invasion sites for vulpia in perennial grass-based pastures.

Selection of more appropriate crops following pasture phases or in the crop cycle should also be considered in relation to control of annual grasses. For example, barley is becoming more popular in northern New South Wales because of superior competition with weeds, better frost tolerance (and therefore earlier sowing), better performance where fertility is declining, and earlier harvest (Wicks *et al.* 1995).

Prescribed burning

Fire is the oldest known practice used by man to manipulate vegetation on grazing lands. Nowadays, prescribed burning is used mainly in rangelands to suppress woody weed encroachment in grassland. Little is known about the effects of burning on seed viability and subsequent regeneration of vulpia following prescribed or stubble burning. However, Matthews *et al.* (1996) reported a 58% reduction in annual ryegrass seed numbers following burning of cereal stubble. The effect of burning on viability and subsequent regeneration of vulpia should be assessed.

Table 4. Abundance of vulpia in plots of wheat established with conventional tillage and direct drill (Forcella 1984).

Cultivation method	Vulpia yield (gm m^{-2})	Vulpia density (number m^{-2})
Conventional tillage	0	1
Direct drill	18.6	30

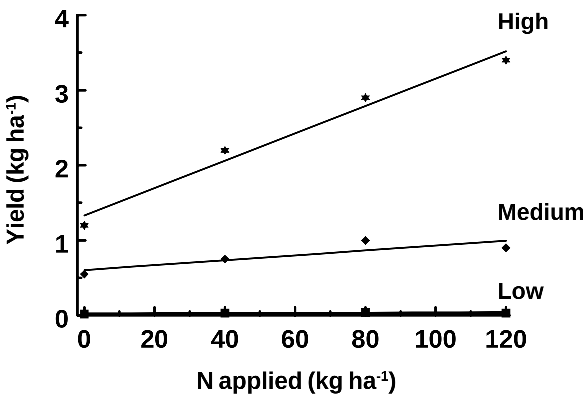

Figure 4. Effect of applied nitrogen on vulpia yield at low, medium and high density (Cocks 1974).

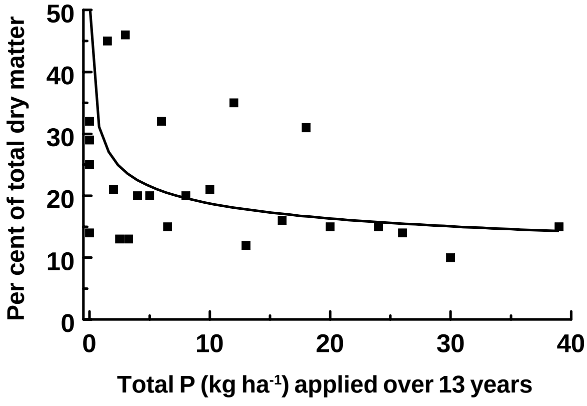

Figure 5. Effect of phosphorus application on the proportion of vulpia in pastures (redrawn from Rossiter 1964).

Cultivation

Vulpia is not present in conventionally tilled cereal fields (Forcella 1984) perhaps because of its germination-emergence intolerance to darkness and burial (Dillon and Forcella 1984). Timing of initial ploughing is important. Forcella and Gill (1986) reported that vulpia will be abundant in soils tilled before the autumn rains, but is only a minor species when soils are tilled at a later date because seedlings would be destroyed by subsequent cultivation and few viable seeds would remain in the soil (Figure 3). Delaying sowing of a crop or pasture by three weeks was an effective treatment in reducing the seed bank of annual ryegrass and improving crop yield. Adjusting seeding rate of the crop may also be useful in managing vulpia when undertaken in combination with tillage.

In contrast to conventional seed bed preparation, high vulpia populations are commonly observed where direct drilling is practised (Forcella 1984), especially where wide row spacings were used (Table 4). This means that herbicide application must be combined with direct drilling for effective control of vulpia in the establishment phases of pastures and crops.

Fertilizer application

Fertilizer application is particularly effective in reducing weed populations in pastures over time through manipulation of the competitive interactions between pasture components. Nitrogen and phosphorus supply affects the competitive ability of annual grasses. Plant density is often implicated in the response in herbage yield following fertilizer application. For example, Cocks (1974) reported that vulpia responded poorly to nitrogen fertilizer at low (10 m^{-2}) and medium (500 m^{-2}) density, but responded strongly at high (25 000 m^{-2}) density (Figure 4). This suggests that application of nitrogen fertilizer to pastures with sparse populations of vulpia, but with a high proportion of nitrogen-responsive grasses such as cocksfoot or perennial ryegrass (Widdowson *et al.* 1963) should improve perennial grass production at the expense of vulpia.

Some reports suggest that vulpia is restricted to soils low in phosphorus and that the invasion of sown pastures by vulpia is a consequence of failure to topdress with phosphate fertilizer. However, while the proportion of vulpia generally declines with increasing phosphate input, vulpia attains maximum yield at about 100 kg ha^{-1} $year^{-1}$ of superphosphate (Rossiter 1964). This is similar to the response expected for subterranean clover on many soils. This suggests that application of superphosphate may not be a useful strategy for direct control of vulpia in pastures where it is dominant, although it may have merit in changing the competitiveness of associated legumes and grasses when present in sufficient proportions. Rossiter's (1964) data suggest that once vulpia has invaded a subterranean clover based pasture, it will account for at least 10% of the feed on offer irrespective of the level of input of phosphate fertilizer (Figure 5).

Conclusion

In permanent pastures there is no simple cultural practice that will be effective in maintaining low vulpia density. Integration of strategies involving one-off (e.g. herbicide, cultivation) and on-going management (e.g. strategic grazing) is necessary to maintain vulpia below threshold levels. Where conventional cultivation is feasible and acceptable, spring cultivation at the end of a pasture phase seems to be a useful and cheap option in vulpia control. Extending this period by incorporating a cropping phase (2–3 years) and utilizing crops with associated herbicides that provide control of vulpia (e.g. lupins) is another option. The strategic use of these practices may enable producers to avoid the costly exercise of re-sowing degraded legume pastures. Trends towards vulpia dominance should be recognised as early as possible and steps taken to reverse the build up of residual seed reserves of vulpia.

Questions for future research

- How to best integrate cultural control options for long-term vulpia control?
- Determination of threshold densities when specific cultural methods may be effective in vulpia control. This requires an understanding of pasture ecology, i.e. demography of pasture components and interactions.

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