BOTANICAL AND MANAGEMENT FACTORS ASSOCIATED WITH *SETARIA PUMILA* ABUNDANCE: IMPLICATIONS FOR PASTURE MANAGEMENT

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ABSTRACT

Yellow bristle grass (YBG) causes significant production loss on dairy farms as it is unpalatable to stock and can reduce forage intake and milk production. This weed is rapidly spreading in North Island dairy pastures and effective control strategies are needed. Botanical surveying was undertaken in February 2008 on 12 dairy farms in Waikato to ascertain its presence in pastures in relation to key management factors. YBG cover was negatively associated with Olsen P, pH, paspalum cover and post-grazing residual dry matter in January. Stocking rate, time since pasture renovation, inclusion of a cropping phase prior to renovation, sowing rate during renovation, ryegrass under-sowing after renovation and cover of ryegrass, clovers, other dicots, annual grasses and amount of bare ground had no significant effect on YBG cover. Results suggest that while improved soil fertility and increasing pasture competition will enhance YBG control, YBG seeds can survive during pasture renovation, leading to rapid re-infestation of pastures.

Keywords: *Setaria pumila*, yellow bristle grass, weed control, dairy pastures.

INTRODUCTION

In the last decade, yellow bristle grass (*Setaria pumila*) has become more prevalent in Waikato and is causing great concern amongst the dairy community. The ingress of yellow bristle grass (YBG) in dairy pastures leads to a loss in pasture productivity, as YBG provides poorer quality forage than ryegrass and other sown pasture species. Further, once YBG panicles emerge from the leaf sheath, they are avoided by dairy cattle, which can lead to reduced forage intake and milk production (Fava et al. 2000; James 2007). YBG also raises animal welfare concerns; mouth ulceration has occurred when dairy cattle were fed hay containing a high content of YBG (Fava et al. 2000). In arable systems, YBG control strategies that rely on tillage techniques, cropping sequences, and grass-selective and knock-down herbicides have been well researched (Dekker 2003). In pastures, however, there are few selective herbicides available and no integrated weed management strategies have been developed. These problems (i.e. reduction in quality, grazing avoidance and animal welfare concerns) are commonly associated with the ingress of annual grass weeds (such as *Vulpia*, *Bromus* and *Critesion* spp.) in pastures and decline in the content of more desirable perennial species. This can result in significant economic loss (Burton & Dowling 2004).

Yellow bristle grass is a C4 annual grass originating from southern Europe. In New Zealand, seeds usually germinate from mid-October and panicles emerge from late December. The awns of YBG panicles can attach to machinery, birds and livestock, which enables it to spread to new paddocks and farms. YBG seeds are also spread by water and as contaminants in crops and hay. Seeds can remain dormant for several years in the soil. This makes YBG more difficult to control, as pastures can be reinfested from

this dormant seed. Establishment takes place predominantly in disturbed areas such as pugged sites, wheel ruts, dung and heavily grazed regions in paddocks (Dekker 2003; James 2007).

Little is known about the distribution of YBG in relation to key farm management variables in dairy pastures and in particular its prevalence with respect to pasture renovation practices. Therefore, a botanical and management survey of dairy pastures in Waikato was conducted to ascertain this information. Results from this survey will be valuable in developing management strategies for YBG and other C4 annual grass weeds in dairy pastures.

METHODS

Twelve farms were randomly selected from areas in Waikato known to have a high incidence of YBG and which were associated with the Yellow Bristle Grass Action Group. Farms were surveyed in February 2008 in Waikato near Hamilton, Te Awamutu and Ohaupo. Average annual rainfall in Hamilton (1975–2004) during November, December, January and February was 93.8, 98.2, 85.3 and 75.3 mm respectively. There was, however, a severe drought when the botanical survey was conducted; monthly rainfall from November 2007–February 2008 was 51.2, 71.8, 4.4 and 26.8 mm respectively.

On each farm three to four paddocks were selected that varied in their pasture renovation history (no renovation, undersowing only, cropping prior to renovation, renovation without a cropping phase and years since renovation). In total 39 paddocks were surveyed, each of which was 1.0–1.5 ha in size. Nearly all pastures were sown with Italian ryegrass (*Lolium multiflorum*), perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*), although some paddocks contained cocksfoot (*Dactylis glomerata*) and tall fescue (*Schedonorus phoenix*). The most frequent dicots were Californian thistle (*Cirsium arvense*), penny-royal (*Mentha pulegium*), dock (*Rumex* spp.), dandelion (*Taraxacum* spp.), plantain (*Plantago* spp.) and creeping buttercup (*Ranunculus repens*) and the most frequent volunteer grasses were three annual C4 grasses, YBG, summer grass (*Digitaria sanguinalis*) and crowfoot grass (*Eleusine indica*), and the perennial C4 grass paspalum (*Paspalum dilatatum*). YBG was present in 28 of the paddocks. All farms were rotationally grazed. The mean rotation length on the farms during January and February was 25 days.

Within each paddock, the proportion of YBG, ryegrass, annual C4 grasses, paspalum, clovers, other dicots and bare ground cover was estimated and the species recorded in four 2 m x 2 m quadrats. In addition, for each paddock, information on management variables (including stocking rate, time since renovation, cropping prior to renovation, sowing rate during renovation, undersowing after renovation, soil fertility levels and post-grazing residual DM) were recorded.

Botanical data were pooled for each paddock. Best subset regression analysis was undertaken to regress management and environmental factors (e.g. Olsen P, pH) and proportion of plant species cover data on the proportion of YBG cover. Botanical composition data (including YBG cover) were arc sine transformed to normalise the variance.

An initial Restricted Maximum Likelihood (REML) analysis (Genstat 2007) of the proportion of YBG cover with no explanatory variables fitted gave a non-significant farm variance component, so the best subset regressions were done as 39 independent paddocks. A final REML analysis using the models identified by the best subset regressions gave a zero farm variance component, confirming the paddocks are effectively independent.

A large number of statistical tests was undertaken to analyse associations between the many combinations of explanatory variables and the response variate. This increased the likelihood that one or more of these tests would produce a significant result merely by chance (i.e. $P < 0.05$, 1 in 20). Further, in these subset regressions, alternative models gave similar R^2 values. Therefore, only associations with up to four explanatory

variables of high significance ($P \leq 0.001$) and with plausible biological explanations have been reported.

The effect of cropping prior to renovation and oversowing after renovation on YBG cover was also analysed using REML (Genstat 2007).

RESULTS

Soil pH, Olsen P (mg P/kg soil), paspalum cover and post-grazing residual dry matter in January were significantly associated with the proportion of YBG cover ($P < 0.001$, Fig.1). These four variables accounted for 47.3% (R^2) of the variability. Other variables, such as ryegrass and calcium levels were significantly associated with the proportion of YBG, but only when more than four variables were included in the analyses.

FIGURE 1: Yellow bristle grass cover (%) plotted against (a) soil pH, (b) Olsen P (mg P/kg soil), (c) paspalum cover (%) and (d) post-grazing residual DM in January (kg DM/ha). Variates are listed in decreasing order of influence on YBG cover. Paspalum and YBG arc sine transformed data are presented. Other variables were not transformed.

Subset regressions were also run without proportion cover data, as paspalum cover is not completely independent of YBG cover. The corresponding model with the three explanatory variables, soil pH, Olsen P and post-grazing residual dry matter in January, accounted for 34.0% (R^2) of the variability in proportion of YBG cover ($P = 0.001$).

There was no significant association between YBG cover proportion and stocking rate (2.9–3.8 cows/ha), time since pasture renovation (1, 2, 3, 4, 5 or >5 years), inclusion of a cropping phase prior to renovation (with or without), sowing rate during renovation (21–35 kg/ha), ryegrass under-sowing after renovation (with or without), and proportion of ryegrass, annual grasses, clovers, other dicots and bare ground ($P > 0.05$). The average proportion of these vegetation classes in a paddock is shown in Table 1.

TABLE 1: Mean proportion (%) and range of YBG, ryegrass, paspalum, annual grasses, clovers, other dicots and bare ground in a paddock (expressed as a percentage of total paddock cover $\pm$ standard deviation). Arithmetic means are presented. Data were averaged across all paddocks surveyed.

Species	Proportion of total ground cover (%)	
	Mean $\pm$ s.d.	Range
YBG	3.6 $\pm$ 6.0	0-26
Ryegrass	55.2 $\pm$ 19.5	0-93
Paspalum	0.55 $\pm$ 1.2	0-6.3
Other annual grasses	5.1 $\pm$ 7.5	0-32
Clovers	7.4 $\pm$ 6.7	1-27
Other dicots	3.8 $\pm$ 3.4	0-19
Bare ground	22.7 $\pm$ 13.8	2-53

DISCUSSION

The survey was undertaken during an extreme drought, when there was much bare ground and little biomass present. YBG establishes in November/December, and it is unlikely that it was affected during establishment phase by the drought, as severe water deficit did not occur until January/February. While drought conditions may have influenced competitive interactions and YBG cover after its establishment, the influence of management remained highly significant. For example, increasing soil pH and higher Olsen P levels were associated with declining cover of YBG. Although *Setaria* spp. can grow well in acid soils (Weaver & Hamill 1985), higher soil pH ($\approx$ 6) and fertility are necessary for optimal ryegrass and white clover performance and dry matter production (Peeters 2004; Rosas et al. 2007). Higher fertility and higher pH (6.0-6.5) would most likely increase the vigour and competitive ability of sown species and enable them to suppress YBG populations, especially during YBG establishment, which occurs in late spring.

The inverse relationship between post-grazing residual biomass and YBG cover in this study further indicates that competition between YBG and sown pasture species can limit YBG population growth. Increasing post-grazing residual biomass (by less intensive grazing) can increase both the vigour of perennial grasses and their competitive effect on YBG. In contrast, grazing to a lower residual will create more canopy gaps (bare ground) that can be colonised by annual grasses (Kemp & King 2001; Mason et al. 2003). The influence of competition in suppressing YBG has been well researched in cropping systems (Dekker 2003), but there are no published data available on competitive interactions in pastures between YBG and sown species and how competition in pastures can be used to suppress YBG. These interactions will be influenced by the extent to which selective avoidance of YBG occurs, particularly after YBG seedheads emerge. This highlights that further research is needed to determine which perennial species are more resistant to YBG invasion and how best to manage sown species in grazed pastures to minimise YBG establishment and fecundity. It is proposed to investigate this in future studies, and to determine the YBG growth stage at which higher post-grazing residuals will have the greatest impact on YBG population growth rate.

An unexpected result from this survey was the significant inverse relationship between paspalum cover and YBG cover. Given its perenniality, paspalum would most likely be a stronger competitor than YBG and may prevent it from colonising bare ground, particularly in drought years where cool-season perennials such as ryegrass are prone to moisture stress. Paspalum is a C4 summer active grass that is often prevalent in weedy pastures as it replaces the more productive temperate species such as ryegrass and white

clover (Kemp et al. 2005). As paspalum can provide useful fodder over summer and its seeds are not known to cause welfare or production issues, it may be useful in limiting the spread of YBG in degraded pastures until renovation occurs. However, as paspalum is not currently commercially available, oversowing with this species would not presently be a viable control option. Other species, such as summer active tall fescue cultivars may provide a better alternative.

The lack of association between stocking rate, time since renovation, cropping prior to renovation, sowing rate of pasture species during renovation, ryegrass undersowing after renovation, and perennial ryegrass cover may demonstrate the ability of YBG to produce seeds under a range of management conditions and adapt readily to local conditions (Dekker 2003). As seeds can last for several years in the soil (Dekker 2003), recolonisation of treated and renovated sites can easily occur. Another possibility is that the poor association may be an artefact of the drought (summer 07-08) modifying interactions between perennial species, grazing livestock and YBG. Feed on offer was low (often < 1000 kg DM/ha by February 2008), mortality of sown species was high and their vigour was severely reduced. It follows that in the year after a drought such as has just occurred, or in the year following herbicide application to infested areas in a permanent pasture, YBG could easily recolonise these bare (disturbed) areas in the absence of vigorous competition from other pasture species.

An alternative explanation for the poor association between these factors is that YBG has not yet reached its potential distribution. YBG was first noticed approximately 10 years ago by many of the surveyed farmers. YBG populations are most likely in an expansion phase; they appear to be rapidly spreading and invading new sites. Therefore the significance of associations obtained in this study may change in the future as YBG reaches an equilibrium population density and saturates favourable habitats.

CONCLUSION

These results are useful in identifying potential causes of variation in the proportion of YBG and potential tools for YBG control. Achieving a high level of control will be difficult, given the ability of YBG seeds to survive during pasture renovation and rapidly re-infest pastures. Increasing soil fertility and modifying grazing management to enhance competition from desirable pasture species, however, warrant further investigation as methods to keep YBG at low levels in dairy pastures. Further, repeating the survey in a following summer (in non-drought conditions) would enable the importance of these associations to be determined under different climatic conditions. If these associations (e.g. with pH, Olsen P and residual pasture-dry matter) prove to be highly significant in non-drought years, soil fertility and grazing management would show even greater promise as tools that can be used to suppress YBG populations.

ACKNOWLEDGEMENTS

We thank the farmers who gave of their time to participate in this survey and MAF Sustainable Farming Fund for provision of funding.

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