CHANGES IN YELLOW BRISTLE GRASS (*SETARIA PUMILA*) ABUNDANCE AFTER DROUGHT: IMPLICATIONS FOR PASTURE MANAGEMENT

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ABSTRACT

Yellow bristle grass (YBG), which is a summer-active annual grass, reduces pasture quality, and becomes unpalatable to stock as panicles mature. Farmers are concerned that an extreme drought, from November 2007 to March 2008, may have facilitated the spread of YBG and other summer-active annual grass weeds. Botanical composition was assessed on 12 Waikato dairy farms in February 2009 and YBG abundance was related to key management factors. These findings were compared with data collected from the same farms (February 2008) during the drought. Between years, ryegrass cover and the proportion of bare ground decreased. These components were replaced by two summer-active annual grasses, YBG and summer grass, and to a lesser extent summer-active perennial grasses, clovers and dicots. In 2009, YBG cover was negatively associated with summer-active perennial grass cover and pH, and positively associated with YBG cover in the previous summer and soil calcium levels.

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

INTRODUCTION

Yellow bristle grass (*Setaria pumila*) is a summer-active annual grass originating from southern Europe. It has become more prevalent in Waikato over the last decade and is causing great concern amongst the dairy community. In New Zealand, seeds usually germinate from mid-October and panicles emerge from late December. Several bristles develop on the panicle beneath each seed and turn yellow as they mature. YBG competes with sown pasture species, provides poorer quality forage than sown pasture species, becomes less palatable as it matures and may be avoided by stock (Dekker 2003; James 2007). Mouth ulceration, reduced intake and decreased milk production have been recorded when dairy cattle were fed hay containing a high content of YBG (Fava et al. 2000).

While its control using chemical and cultural methods in arable systems has been well researched (Dekker 2003), there are no selective herbicides available for control of summer-active grasses in pastures and no integrated weed management strategies have been developed. Generally, the ingress of annual grass weeds (e.g. *Vulpia*, *Bromus* and *Critiesion* spp.) is problematical through pasture systems and is often associated with significant economic loss (Burton & Dowling 2004).

Measurements made in 39 Waikato dairy paddocks in February 2008 showed that Olsen P, paspalum cover and post-grazing residual dry matter (DM) were negatively associated with YBG presence (Tozer et al. 2008). The same measurements were made in these paddocks in 2009, to determine if the associations between YBG presence and botanical and management factors were consistent and to assess how botanical composition had changed after the severe summer drought during 2008. This would enable better understanding of the causes of variation in YBG presence and identification of potential management tools, such as grazing management.

METHODS

Twelve farms were randomly selected from areas in Waikato known to have a high incidence of YBG. The farms were situated between Hamilton, Te Awamutu and Pirongia and were surveyed in February 2009. There was a severe drought in early 2008, when Hamilton in Waikato received only 97 mm of rain (December 2007–February 2008), which is well below the long-term average summer rainfall of 259 mm (December–February, 1975–2004). This was the second driest summer in Hamilton since recording of rainfall began in 1920. However, summer rainfall in the year following the drought (December 2008–February 2009, 310 mm) was above the long-term average.

On each farm two 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 35 paddocks between 1.0–1.5 ha in size were surveyed. Nearly all pastures had been sown with perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*), although some paddocks contained cocksfoot (*Dactylis glomerata*), tall fescue (*Schedonorus phoenix*), Italian ryegrass (*Lolium multiflorum*) and chicory (*Cichorium intybus*). In both years, the most frequent dicots were penny-royal (*Mentha pulegium*), Californian thistle (*Cirsium arvense*), docks (*Rumex* spp.), dandelion (*Taraxacum officinale*), hawksbeard (*Crepis capillaries*), hawkbit (*Leontodon taraxacoides*), plantains (*Plantago* spp.) and creeping buttercup (*Ranunculus repens*). The most frequent volunteer grasses were four annual summer-active grasses, YBG, summer grass (*Digitaria sanguinalis*), crowfoot grass (*Eleusine indica*) and smooth witch grass (*Panicum dichotomiflorum*), and the perennial summer-active grasses paspalum (*Paspalum dilatatum*) and ratstail (*Sporobolus africanus*), which was present in small amounts. Soft brome (*Bromus hordeaceus*) and prairie grass (*Bromus willdenowii*) were present in some paddocks. YBG was present in 31 of the paddocks. All farms were rotationally grazed by dairy cows. The mean rotation length on the farms during January and February was 28 days.

Within each paddock, the proportion of YBG, ryegrass, annual and perennial summer-active grasses, clovers, other dicots and bare ground was visually estimated and species identity recorded in four randomly placed 2 m × 2 m quadrats, using stratified random sampling within each paddock, based on paddock topography. In addition, for each paddock, information was obtained from farmers 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 in November and January. Soil fertility levels were based on farmer soil tests taken over the whole paddock. The same data had been collected from these farms 12 months prior in February 2008 (Tozer et al. 2008).

Statistical analysis

Botanical data were pooled for each paddock. Best subset regression analysis was undertaken to regress management factors and the proportion of plant species cover data on the proportion of YBG cover in 2009. Cover of YBG in the previous year (2008) was also included as a potential explanatory variable for YBG cover in 2009. Botanical composition data (including YBG cover) were arc sine transformed to normalise the variance.

All statistical analyses were made using GenStat for Windows, Release 10.2, VSN International Ltd, Oxford. An initial Restricted Maximum Likelihood (REML) analysis 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 35 independent paddocks. A final REML analysis using the models identified by the best subset regressions gave a zero farm variance component, confirming the paddocks were effectively independent.

A large number of statistical tests was undertaken to analyse associations between the many combinations of explanatory variables and the response variates. 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, while changes in botanical composition between 2008 and 2009 were tested with a repeated measures REML analysis.

RESULTS

Change in pasture composition between 2008 and 2009

There were significant changes in the cover of vegetation classes between 2008 and 2009 ($P < 0.05$, Table 1). Yellow bristle grass, other annual grasses, summer-active perennial grasses (paspalum and ratstail), clovers (mainly white and red clover (*T. pratense*)) and other dicots (especially penny-royal) increased as a proportion of total ground cover, while the proportion of ryegrass and bare ground decreased. Summer grass was one of the most frequent annual grasses present, and its cover increased from 5 to 19% ($P < 0.001$), while ryegrass cover declined from 55 to 41% ($P < 0.01$). The average post-grazing residual DM during January (based on farmer estimates) was greater during 2009 (1540 kg DM/ha) than during 2008 (1170 kg DM/ha, $P < 0.01$).

TABLE 1: Mean proportion (%) and range (in parentheses) of YBG, ryegrass, summer-active perennial grasses, all other annual grasses, clovers, other dicots and bare ground in 2008 and 2009. Values presented are arithmetic means expressed as a percentage of total paddock cover, and the standard error of the difference between means is shown. Data were averaged across all paddocks surveyed.

Species	2008	2009	SED	P-value
YBG	3.7 (0-26)	13.6 (0-40)	1.7	<0.001
Ryegrass	54.8 (0-93)	40.6 (0-81)	4.5	<0.01
Summer-active perennial grasses	0.6 (0-6)	3.6 (0-47)	1.5	<0.05
All other annual grasses	5.3 (0-32)	20.0 (0-68)	2.9	<0.001
Clovers	7.4 (1-27)	11.5 (0-36)	1.9	<0.05
Other dicots	3.9 (0-19)	8.5 (0-54)	1.9	<0.05
Bare ground and dead vegetation	22.7 (2-53)	7.0 (0-30)	2.5	<0.001

Factors associated with YBG cover in 2009

Summer-active perennial grass cover (%), soil pH (5.3–6.5, mean = 6.2), YBG cover (%) in the previous summer (2008) and soil calcium levels (4–16, mean = 11, MAF QT units) were significantly associated with the proportion of YBG cover in 2009 ($P < 0.001$, $R^2 = 65.2\%$, YBG cover = $119 - (0.7 \times \text{angular transformed summer-active perennial grass cover}) - (19.7 \times \text{pH}) + (0.9 \times \text{angular transformed YBG cover in 2008}) + (1.7 \times \text{calcium level})$).

There was no significant association between the proportion of YBG cover in February 2009 and Olsen P or post-grazing residual DM – measured in November (when YBG was establishing) or January (during peak YBG flowering). There was also no association between YBG cover, time since pasture renovation (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) or stocking rate (2.5–3.8 cows/ha). There was a negative correlation between the proportion of ryegrass and YBG cover (correlation coefficient: -0.238). However, the proportion of ryegrass, annual grasses, clovers, other dicots and bare ground were not present in the multivariate regression that explained the greatest amount of variation in YBG cover.

DISCUSSION

Ryegrass cover decreased by 25% between February 2008 and February 2009 and was replaced by annual grasses (particularly the two summer-active annual grasses, yellow bristle grass and summer grass) and to a lesser extent by clovers and other dicots. Visual observations indicated that penny-royal increased between years and was the most prevalent dicot in 2009.

These large changes in summer botanical composition between 2008 and 2009 may have been exacerbated by the drought. During the 2008 survey, ryegrass 'pulling' and numerous dead ryegrass plants were frequently observed. This mortality contributed to the large proportion (23%) of bare ground present at that time (Tozer et al. 2008).

Ryegrass performs best in a mild, temperate climate. Summer drought, combined with high evaporation levels will severely limit ryegrass persistence (Waller & Sale 2001). Thom et al. (1986a) also concluded that summer temperatures and dry periods in Waikato may lead to restrictions in ryegrass growth, survival and competitiveness, even in non-drought years. They found that high ryegrass losses occurred over summer (Thom et al. 1986b). Fifty-one percent of these losses were caused by severe grazing, pulling, trampling, and dung and urine deposition. Pests can also severely limit ryegrass production and persistence (Waller & Sale 2001). Observations in central North Island pastures have shown that black beetle (*Heteronychus arator*) is prevalent and causes significant ryegrass pulling in late summer/autumn (e.g. Watson et al. 2000). All these factors that limit ryegrass persistence will make pastures vulnerable to the ingress of weedy annual grasses such as YBG. In this study, bare ground present in 2008 was colonised predominantly by annual grass weeds, of which YBG and summer grass were the dominant species. Dicots and clovers also appeared to occupy some of the canopy gaps made available during the drought, as these species increased between years, but to a lesser extent. Given the present results, ryegrass decline and ingress of YBG is likely to be an increasing problem, should more frequent droughts occur. Droughts will presumably increase perennial ryegrass mortality and create more and larger canopy gaps that invasive weeds such as YBG can occupy. Other pasture species that have greater drought tolerance than ryegrass, such as tall fescue, may be more successful in reducing the ingress of YBG.

As YBG is a summer-active grass, it will compete primarily with other summer-active grasses for available space and resources, during the period in which ryegrass is most vulnerable to moisture and heat stress. A major competitor for this space was paspalum, which comprised 0.6% and 3% of the total cover in 2008 and 2009 respectively. In addition to being a strong competitor, paspalum is better adapted to intense grazing, heavy treading and summer water stress than ryegrass. These characteristics of paspalum, which allow it to adapt to intensive grazing systems, may explain the negative association between YBG and summer-active perennial grass cover observed in 2008 (Tozer et al. 2008) and 2009. However, there are no commercial cultivars of paspalum available, and it shows little promise in being used as a management tool.

Soil factors were also associated with YBG cover in both 2008 and 2009. *Setaria* spp. grow well in acid soils (Weaver & Hamill 1985). Higher soil fertility and pH (≈ 6) will improve ryegrass and white clover performance and dry matter production (Peeters 2004; Rosas et al. 2007) and suppress YBG. This may explain why there was a negative association between YBG cover and soil pH in both 2008 (Tozer et al. 2008) and 2009. However, the correlation between annual grass weeds and soil pH may be symptomatic of other factors, such as the influence of soil pH on nutrient availability. Indirect associations may also be responsible for the positive correlation between YBG presence and calcium levels observed during 2009. Higher calcium levels would be expected to raise pH, soil fertility and competitive ability of sown species, rather than increase YBG presence. However, in some cases increasing soil fertility can increase the growth of *Setaria* species, without benefitting the sown species (e.g. Menalled et al. 2005).

There was no association between Olsen P and YBG in 2009, which was in contrast to 2008. Controlled studies would be required to ascertain the response of YBG to soil nutrients and ameliorants in ryegrass pastures and to identify causal relationships and

mechanisms. It is possible that environmental factors masked associations between YBG cover and nutrient levels such as Olsen P.

There was no association in 2009 between YBG cover and post-grazing residual DM, also in contrast to 2008. During the drought, post-grazing residual DM levels were much lower (1170 vs 1540 kg DM/ha respectively for 2008 and 2009). Higher post-grazing residual DM levels during 2009 may have negated the association detected in 2008. The higher post-grazing residual DM presumably occurred as farmers had more herbage available for grazing in 2009; farmers commented that paddocks were grazed to a lower post-grazing residual DM during the 2008 drought due to feed shortages. While overgrazing may increase YBG ingress, lax grazing may promote YBG by giving dairy cattle greater opportunity to avoid grazing YBG and preferentially graze more palatable species. In contrast, increasing the grazing pressure may increase grazing defoliation of YBG, which may reduce YBG panicle production and spread in subsequent years. Studies are currently underway to investigate the grazing preference of dairy cattle for YBG at different stages of development, the impact of grazing defoliation on subsequent YBG panicle production and the use of grazing attractants to increase grazing defoliation and reduce panicle production. For grazing management to be used as an effective control method, seed production will need to be significantly reduced.

In both 2008 (Tozer et al. 2008) and 2009, no association was detected between pasture renovation variables and YBG cover, suggesting that pasture renovation was unable to prevent, or slow, the ingress of YBG. This may be due in part to inadequate control of YBG present in the pastures prior to renovation. Work is currently in progress to develop renovation methods that prevent the carryover of YBG seeds into new pastures.

YBG presence in 2009 was associated with YBG presence in the preceding year. The stability of YBG patches in pastures is not known. Work in US crops demonstrated that the location of green bristle grass (*Setaria viridis*) patches in the current year could be used to predict their location in the following year, but not thereafter (Colbach et al. 2000). Most seeds fall to the ground and are only dispersed to a distance roughly equivalent of the plant's height (Cousens & Mortimer 1995). This emphasises the importance of vigilance in controlling known patches of YBG to minimise the seeds available for dispersal across the farm. Methods to control small patches of YBG in otherwise clean paddocks are currently being developed.

Seeds may be spread to new areas of a farm by cultivation equipment and cattle dung (Bray et al. 1998; Heijting et al. 2009). In one study, Bray et al (1998) found that 79% of giant rattail (*Sporobolus pyramidalis*) seeds obtained from cattle dung was viable. This equated to survival of 28% of the total amount of seeds fed to the cattle. Further, most of the seeds were recovered from the dung within 3 days of seed ingestion. Use of maize silage and intensive rotational grazing in Waikato dairy farms may be significant causes of YBG seed dispersal. Studies are currently underway to determine if YBG seeds survive in maize silage. Spread of YBG seeds to other paddocks in intensive dairy farms will be difficult to manage as YBG seeds also survive in dung and for up to 2 months in effluent stored in holding tanks (T.K. James, unpubl. data). Further, it has been shown that YBG seeds can survive for several years in turf (Masin et al. 2006), thus potentially providing a source of re-infestation of grass swards.

CONCLUSION

These surveys have been useful in identifying factors associated with YBG presence and demonstrating how summer-active annual grass weeds increase after a severe drought. Results from both years highlight the importance of a competitive sward of sown pasture species, to minimise the amount of bare ground available for colonisation by weedy annual grasses. Paspalum is also able to reduce the ingress of weedy grasses. In addition, soil factors (e.g. optimal pH) that enhance ryegrass vigour may reduce the ingress of YBG. The importance of controlling existing patches of YBG is highlighted. Results from this study may assist farmers in their decision-making regarding YBG management. Further research is underway to develop pasture renewal techniques that prevent YBG seeds from carrying over into new pasture. Pasture species mixtures and management practices that impede the ingress of YBG are also being investigated.

ACKNOWLEDGEMENTS

Thanks to the Yellow Bristle Grass Action Group farmers who made their paddocks available for the survey and gave of their time to instigate and participate in this project. Thanks also to MAF Sustainable Farming Fund for provision of funding.

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