Relative tolerance of *Microlaena stipoides* to glyphosate herbicide

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Abstract

Microlaena stipoides (meadow rice grass, weeping grass, pātītī) is a native grass of Australasia and Malesia and is reputed to have a high degree of tolerance to the herbicide glyphosate. We conducted a glyphosate application rate experiment on a set of 3m ? 3m plots covered with a mixed sward including *Microlaena* as a component, using rates varying from 0 – 8 L ha^{-1} equivalent of the product G Force Max? (54% glyphosate formulation) applied in May 2009. Foliage damage assessments over the following 8 weeks indicated that *Microlaena* was more tolerant of the herbicide than *Pennisetum clandestinum* (kikuyu) and *Agrostis capillaris* (browntop), with mean damage levels of 63% at 2 L ha^{-1}, a level which killed all other species in the plots. At 8 L ha^{-1}, damage to *Microlaena* at 8 weeks was highly variable, with a mean of 77%. Species cover assessments conducted in late February 2009 (pre-spray) and March 2010 (post-spray) showed that all three major sward components declined in cover at all herbicide rates over that year. However, for *Microlaena* there was no difference between the rates in terms of the magnitude of the decline, in contrast to kikuyu and browntop, which both had greater declines at higher herbicide rates. We conclude that it is possible to use low rates of glyphosate in autumn to discriminate in favour of *Microlaena* in a mixed grass sward.

Key Words

Microlaena stipoides, glyphosate, herbicide, tolerance, Pennisetum clandestinum, Agrostis capillaris

Introduction

Microlaena stipoides (meadow rice grass, weeping grass, pātītī) is a native grass of Australasia and Malesia and one of the few native grasses to become widespread in the pastoral landscape of lowland New Zealand (Stewart 2004). Anecdotal reports suggest that it was an important part of the vegetative cover on the Auckland volcanic cones following their habitation by Maori, and the species has persisted strongly through the early stages of European pastoral management of the cones, as they were transformed into urban farm parks (Esler 2004). However, adventive grasses (e.g., kikuyu, *Pennisetum clandestinum*; ryegrass, *Lolium perenne*) are now dominant (B.R. Burns, unpubl. data) and they have likely been encouraged by the modification of the soil environment through decades of fertiliser and lime application.

The volcanic cones are presently administered by the Auckland City Council using grazing lease contracts. There is an increasing community imperative to modify the vegetation cover to achieve a number of goals, including restoring native plant species, minimising livestock damage to sensitive soils and archaeological sites, minimising fire hazards from biomass accumulation and maintaining a grassland park environment for human recreation. *Microlaena* was identified as a key species in vegetation restoration to achieve these goals, leading to a research programme to explore ways of increasing its abundance on the cones. One potential approach is to use its purported tolerance to glyphosate (Anonymous 1996) as a tool for suppressing other pasture species. Therefore the present experiment aimed to: a) determine whether differential herbicide tolerance did exist between *Microlaena* and other species, particularly kikuyu; and b) identify what rates of glyphosate application would suppress these species and thus provide a competitive advantage for *Microlaena*.

Methods

Site and design

The experiment was located on the Unitec campus in north-west Auckland, on the site of a previous experiment examining techniques for establishing *Microlaena* by oversowing into a sward dominated by kikuyu on a basalt-derived soil similar to that found on the volcanic cones (Dodd *et al.* 2010). The legacy of this prior experiment was a set of 90 small plots (3 m ? 3 m) with varying botanical composition, but mainly dominated by mixtures of *Microlaena,* kikuyu and *Agrostis capillaris* (browntop). Other common species included white clover (*Trifolium repens*), Yorkshire fog (*Holcus lanatus*), ryegrass (*Lolium perenne*) and buttercup (*Ranunculus repens*). In late February 2009, the percent cover of all species in the plots was visually assessed, and 60 plots were selected for the present experiment. The plots were re-allocated into four blocks reflecting the cover of the dominant species: 1. High *Microlaena*/ low kikuyu; 2. high kikuyu/low *Microlaena*; 3. Moderate *Microlaena* /moderate kikuyu; and 4. Low *Microlaena* /low kikuyu (high browntop). These four blocks had three, five, three and one replicate(s) respectively.

Herbicide application

The experiment began on 5 May 2009 with the application of five rates of G Force Max? (a.i. 54% glyphosate) to the plots: 0 (control), 1, 2, 4 and 8 L ha^{-1}. No wetting agent was included. The herbicide was applied with a CO_2 backpack precision plot sprayer, attached to a 3m boom with four TT11002 nozzles delivering 150 L ha^{-1} of water at a pressure of 200 kPa.

Measurements

At two, four and eight weeks after herbicide application, visual estimates of percent damage to foliage were made for *Microlaena,* kikuyu and browntop. Damage was observed as chlorosis and necrosis, which can be attributable to both herbicide effects, winter chilling and leaf disease in these species at this location. A visual assessment of percent cover for *Microlaena,* kikuyu and browntop was made 10 months after herbicide application in March 2010. Damage and cover scores were also recorded for other common species noted above but there were insufficient data across the experiment to analyse these.

Statistical Analysis

The statistical analyses for the three species were performed using a linear mixed effects model in the R 2.11.0 statistical software package. The percent damage estimate data were analysed by a repeated measurements model. The difference in cover between February 2009 and March 2010 was analysed by a randomised block ANOVA. Statements about significant differences or effects refer to a $P<0.05$ significance level unless otherwise noted.

Results

Damage to species

For all three damage assessments (2, 4 and 8 weeks), *Microlaena* showed significantly less damage than both kikuyu and browntop (13-38 percentage points – Fig. 1). This effect occurred at all herbicide rates (data not shown). There was a significant species by week interaction, indicating that *Microlaena* took longer to respond to the herbicide than the other two species (Fig. 1).

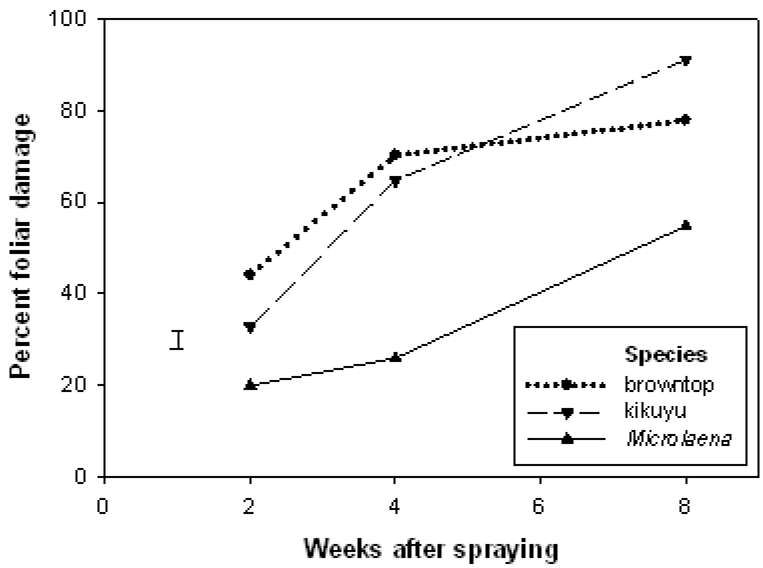

Figure 1: Damage response of browntop, kikuyu and *Microlaena* over 8 weeks, shown as the mean of 5 rates of glyphosate herbicide. Bar represents LSD.

At the 8-week assessment, damage to both kikuyu and browntop exceeded 97% at 2 L ha^{-1} and higher rates, while damage to *Microlaena* averaged 63% at the 2 L ha^{-1} rate (Fig. 2). At this stage there was also substantial damage to kikuyu (60%) at the nil herbicide rate. At the highest herbicide rate (8 L ha^{-1}) damage to *Microlaena* averaged 77% but ranged widely from 30-95% on individual plots.

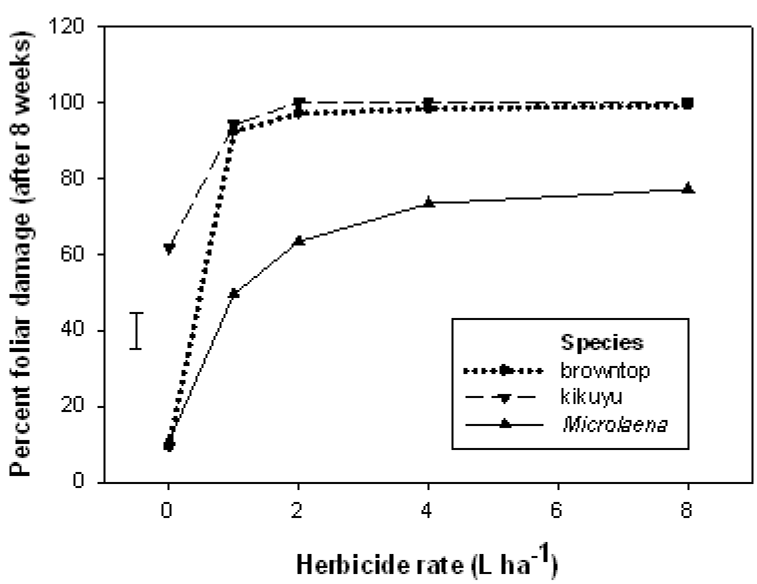

Figure 2: Damage response of browntop, kikuyu and *Microlaena* to five rates of G Force Max? herbicide (glyphosate) after 8 weeks. Bar represents LSD.

Vegetation cover changes

In February 2009, mean cover for the major species browntop, kikuyu and *Microlaena* was 30%, 20% and 15% respectively. Ten months after the herbicide application (March 2010), the percent cover of all three species was lower relative to the previous February prior to spraying (even on the nil herbicide plots, Fig. 3). Hence the analysis focussed on whether there was a greater decline in percent cover at the higher herbicide rates. There was no significant effect of herbicide rate on the change in *Microlaena* cover over one year. In contrast, the three highest rates of glyphosate appeared to result in greater declines in kikuyu and browntop cover, relative to the nil herbicide treatment. However, while there was a significant herbicide rate effect overall (greater declines at higher rates, P=0.06), there was no significant rate by species interaction.

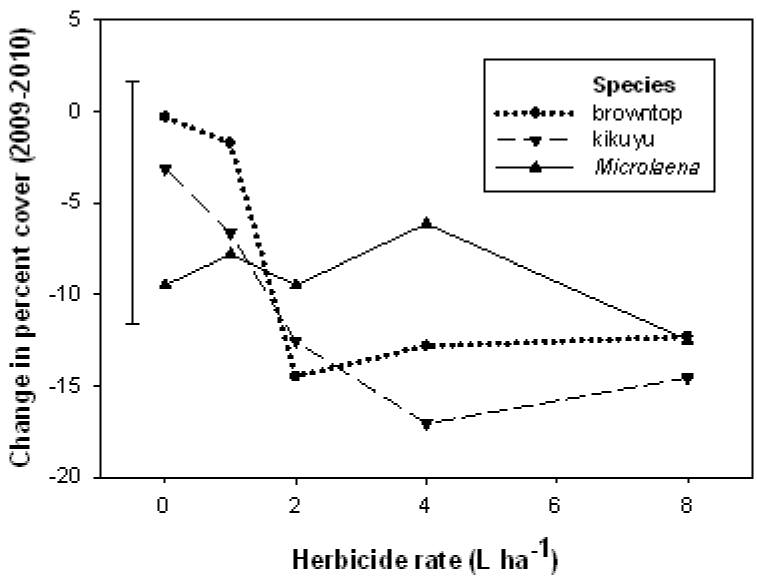

Figure 3: Change in percent cover of browntop, kikuyu and *Microlaena* ten months after application of five rates of G Force Max? herbicide (glyphosate). Bar represents LSD.

Discussion

The results show that *Microlaena* is susceptible to glyphosate damage, but that it is more tolerant than kikuyu or browntop (Fig. 2). The 4-week data also indicated that the damage to *Microlaena* took longer to manifest itself than for kikuyu and browntop, indicating a morphological resistance mechanism, perhaps related to leaf orientation or the structure of hairs on the lamina. Mechanisms of glyphosate tolerance in grasses remain unclear (Senem Su *et al.* 2009) though reduced absorbance has been identified as important (Nandula *et al.* 2009).

The damage to kikuyu after 8 weeks at the nil herbicide rate was attributed to winter chilling, as this assessment occurred in late June. While this factor potentially confounds the damage assessments at the higher herbicide rates, it is worth noting that by the 4th week, damage to kikuyu was already over 80% at the 2, 4 and 8 L ha^{-1} rates and it seems likely that this effect would overshadow any chilling effect.

On the basis of damage assessments over 8 weeks, the data suggest that at a 2 L ha^{-1} rate the herbicide used in this experiment would achieve a complete kill of kikuyu and browntop but not of *Microlaena*. The lowest rate (1 L ha^{-1}) would limit the damage to *Microlaena* to <50% and still achieve >90% damage to the other two species (Fig. 2). This indicates good potential for selective suppression of undesirable grasses in favour of *Microlaena* at relatively low rates of glyphosate.

However, over the longer term all species recovered to varying extents by the following late summer period. While there were some new seedlings of *Microlaena* in the spring of 2009, they were small and their cover was limited to <1% of the plots where they occurred. Therefore this was not a major factor influencing the recovery of *Microlaena* by the following March. The net changes in cover over a year suggest that higher rates of the herbicide (up to 4 L ha^{-1}) will adversely affect kikuyu and browntop dominance, but not *Microlaena*. This result suggests that *Microlaena* is also more resilient to glyphosate than these other species, though it cannot be determined from this study whether this is an inherent characteristic or the result of an induced change in the competitive balance in these mixed swards.

Overall, the experiment has shown that it is possible to use low rates of glyphosate in autumn to discriminate in favour of *Microlaena* in a mixed exotic grass sward (including kikuyu and browntop). Further research on the optimal seasonal timing of glyphosate application would be useful, e.g. there may be a period in late spring when kikuyu can be suppressed before its dominant growth period in summer.

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