Potential selective herbicides for kyllinga (*Cyperus brevifolius* Rottb.) in irrigated pastures

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Summary

This paper reports on field assessments of the potential of halosulfuron-methyl and imazethapyr to selectively control kyllinga in irrigated pastures. Halosulfuron-methyl applied at rates of 50 and 97.5 g a.i. ha^{-1}, and imazethapyr at 192 g a.i. ha^{-1} significantly suppressed kyllinga as a proportion of sward DM for more than one year after application. In April 1996 kyllinga accounted for around 26% of harvested DM in untreated plots, but only 1–10% in sprayed plots. Increasing rates of halosulfuron-methyl above 50 g a.i. ha^{-1} did not improve efficacy. Neither herbicide appeared to suppress white clover and perennial ryegrass or have an impact on other weed species. Seed was an important source of kyllinga re-infestation. Any effective control agent must, therefore, reduce seed production. All rates of halosulfuron-methyl suppressed seed head formation, but imazethapyr did not. Consequently, halosulfuron-methyl has the greater potential for selective control of kyllinga. Other weed management tools need to be investigated as halosulfuron-methyl is not registered for use in pasture.

Introduction

Kyllinga or Mullumbimby couch (*Cyperus brevifolius* Rottb.) is a perennial, rhizomatous sedge that produces large quantities of seed (Johnson and Evans 1976). It is widely distributed through tropical and subtropical regions (Holm *et al.* 1979, Komai and Tang 1989) and also occurs in temperate regions of Australia. Although probably native to Australia, kyllinga has only been identified as weed problem in northern Victoria over the last 5–10 years (Blaikie and Slarke 1993). Kyllinga is unpalatable to stock, which according to anecdotal evidence avoid grazing pasture in which it is present with consequent reductions in milk production (Blaikie and Slarke 1993). It is highly invasive and reportedly displaces sown species forming dense patches, which have been observed to double in size and number each year (Corrick 1977, Bell 1987, Blaikie and Slarke 1993). Consequently, kyllinga has the potential to reduce the productivity of individual paddocks and entire dairy farms where it is present.

Currently, there are no practical means of controlling kyllinga in irrigated pasture. Both chemical and non-chemical methods have failed to control infestations or prevent reinfestation of pasture (Blaikie and Slarke 1993). Seven of the eight herbicides that are currently registered in Victoria for use against kyllinga (Trinoc Turf Herbicide, Paspalum and Summergrass Selective Weedkiller, Methar, DSMA 550, Lawn Paspalum Killer turf herbicide, Passtox 500, Paspalum and summer grass killer) contain arsenic or arsenic derivatives (salts of methylarsonate) and are unsuitable for use in pasture. The remaining product (Lawnweeder Plus) is registered for turf only and is prohibitively expensive, \$560 ha^{-1} at a recommended application rate of 20 L ha^{-1} (1996 prices).

Preliminary field trials in 1992/93 indicated that the herbicides halosulfuron-methyl (Sempra, methyl 3-chloro-5-(4,6-dimethoxypyrimidin-2-ylcarbamoyl-sulfam oyl)-1-methylpyrazole-4-carboxylate) (Fallow unpublished data) and imazethapyr (Spinnaker, 5-ethyl-2-(4-isopropl-4-methyl-5-oxo-2-imidazolin-2yl)nicotinic acid) (Bell unpublished data) had activity against kyllinga. Both products inhibit acetolactase synthesis. Halosulfuron-methyl is registered in Australia for the selective control of purple nutgrass (*Cyperus rotundus* L.) and kyllinga in turf. It is not currently registered for use in pasture in Victoria. Imazethapyr is a broad spectrum herbicide that has activity against a range of broad leaf weeds and several annual grasses. It suppresses growth, nodulation and seed yield in subterranean clover cultivars and retards lucerne growth (Dear *et al.* 1992, Dear and Sandral 1994). Prior to this study, there were no data on the impact of halosulfuron-methyl on pasture species or the effect of imazethapyr on white clover-perennial ryegrass mixtures.

The study was designed to evaluate the potential of halosulfuron-methyl and imazethapyr for selective control of kyllinga in irrigated pastures during a single growing season and a year after the initial application. The duration of effective weed control provided by herbicides determines the frequency with which they need to be reapplied. This is of considerable importance and may determine whether a herbicide-based control strategy is economically justified or otherwise desirable

Materials and method

Field experiments were conducted on two dairy farms in northern Victoria, located at Harston (145° 30'E, 35° 59'S) on a Lemnos loam soil and at Katunga (145° 10'E, 35° 29'S) on a friable Moira loam, between October 1994 and April 1995. The experiment was continued at the Harston site until April 1996 to determine the long term impact of the herbicides on pasture composition. The experimental sites were not grazed, but were periodically mown (every 3–4 weeks at Harston and every six weeks at Katunga) to a height of approximately 60–80 mm and the cut material raked from the area using tractor-mounted implements. Irrigation during the summer and early autumn months was applied on a seven day cycle at both sites.

The experiments were laid out in a complete randomized block design with three replicates of each treatment. Five treatments were imposed; a no herbicide control (water only), halosulfuron-methyl applied once at a rate of 50 g a.i. ha^{-1}, at 97.5 g a.i. ha^{-1}, applied twice at 50 g a.i. ha^{-1} and imazethapyr applied once at 192 g a.i. ha^{-1}.

Plots measured 3 × 15 m and were separated by 1 m, untreated buffers. Blocks were separated by 3 m untreated buffers. Halosulfuron-methyl was first applied on 21 November at Harston and imazethapyr on 9 December. All herbicide treatments were applied on 9 December at Katunga. Plots receiving a second application of halosulfuron-methyl were retreated seven weeks after the first application. Herbicides were applied using a 3 m, pressurized hand-boom, fitted with 110 02 flat-fan nozzles and an operating pressure of 200 kPa (spray volume 120 L ha^{-1}). All solutions contained 0.2% (v/v) non-ionic surfactant (Agral 60).

The botanical composition of plots at the Harston site was monitored at approximately three week intervals during the first year and again in April 1996 to determine the ability of the herbicides to reduce kyllinga infestations between seasons. Assessments at Katunga were made on 29 January, prior to initial herbicide application; before the second application and about ten weeks later on 28 March. The botanical composition of each plot was determined from six 0.1 × 1 m random quadrats, hand-cut with electric shears to a height of about 1–3 cm above the soil surface. The samples were bulked in pairs and then sub-sampled and hand separated into kyllinga, clover, perennial ryegrass and other species fractions. Each fraction was oven dried at 60°C and weighed.

The number of seedheads in the kyllinga fraction of each harvest at Harston during the 1994/95 season were counted and used to estimate cumulative seedhead production in the plots. At the beginning of the experiment, and before and after the second herbicide application, kyllinga samples were dug up at both sites to determine whether shoots originated from the rhizomes of existing plants or from seed. Pasture composition data were analysed for changes in the percentage of sward dry matter (DM) of each component. Treatment comparisons were made using GENSTAT 5 ANOVA procedures and means are presented accompanied by their least significant difference (LSD 5%) values.

Results and discussion

Year one: 1994/95 growing season

At the beginning of the experiment kyllinga shoots originated exclusively from existing rhizomes. In October 1994 little kyllinga foliage was present. By late November/early December, rhizome buds had emerged to form rapidly expanding vegetative rosettes. Kyllinga grew vigorously over summer. Kyllinga in unsprayed plots increased from about 9% DM at Harston (Figure 1a) and 5% DM at Katunga in late November/early December 1994 to around 16% DM and 10% DM, respectively, in January 1996 (about 40 days after the first herbicide application). Flowering commenced in December and by late January seedlings had become established. Flowering and seedling recruitment occurred throughout the summer and early autumn months.

Kyllinga accounted for around 1–26% of sward DM in all plots throughout the experiment (Figure 1, Table 1). Animal production losses due to kyllinga are reported to be much higher than its relatively low dry weight indicates. Observations of areas adjacent to the sites, made during the experiment and anecdotal evidence (Blaikie and Slarke 1993), suggests that cows avoid pasture in which the weed is present. This means that consumption of sown pasture species is reduced. A greater proportion of the pasture may consequently remain ungrazed because it is contaminated with kyllinga than is physically occupied by the weed.

All rates of halosulfuron-methyl significantly suppressed kyllinga (Figure 1a). In untreated plots at Harston in late March 1995 (120 days after the first herbicide application), kyllinga accounted for approximately 20% of the harvested DM, but only about 2–6% DM in treated plots (Figure 1a). There were no differences in the efficacy of the various herbicide treatments in terms of per cent kyllinga in total DM

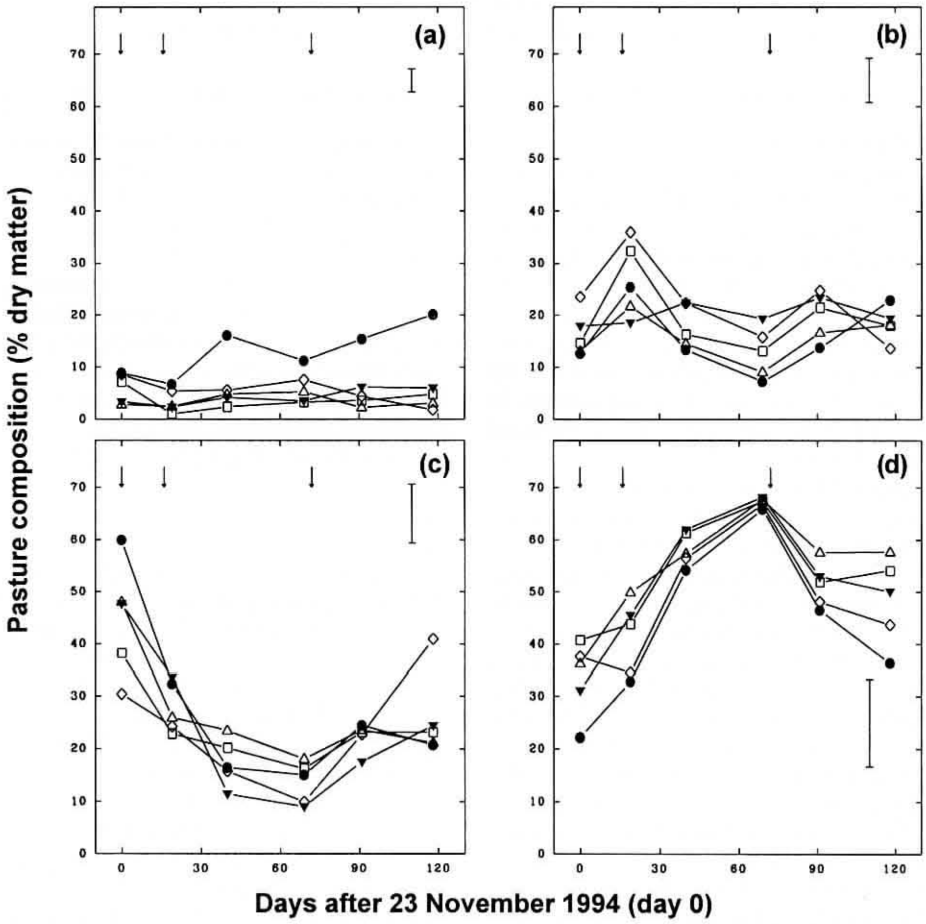

Figure 1. The effect of halosulfuron-methyl and imazethapyr on pasture composition (per cent DM) of (a) kyllinga, (b) white clover, (c) perennial ryegrass and (d) other species at Harston from November 1994 to April 1995. ● control, △ 50 g a.i. ha^{-1} halosulfuron-methyl, □ 97.5 g a.i. ha^{-1} halosulfuron-methyl, ◇ 50 g a.i. ha^{-1} double application of halosulfuron-methyl, ▼ 192 g a.i. ha^{-1} imazethapyr. The arrows indicate the application dates of halosulfuron-methyl, imazethapyr and the second halosulfuron-methyl treatment, respectively. Vertical bars indicate the LSD 5% value.

Table 1. The effect of halosulfuron-methyl and imazethapyr on pasture composition (change in DM percentage) of kyllinga, white clover, perennial ryegrass and other species at Harston at the end of the first growing season (April 1995) and one year later at the final assessment (April 1996) in terms of changes from initial composition prior to herbicide application (November 1994).

Change in DM percentage	Kyllinga			Clover			Ryegrass			Others		
Harvest date	Nov 94	Apr 95	Apr 96	Nov 94	Apr 95	Apr 96	Nov 94	Apr 95	Apr 96	Nov 94	Apr 95	Apr 96
Control	5.5	+14.6	+20.9	12.6	+10.3	- 9.4	59.9	-30.2	-34.5	22.1	+14.2	+22.9
50 g a.i. ha^{-1} hsm	2.8	+ 0.2	- 1.8	13.0	+ 5.1	-10.0	48.0	-26.9	- 4.0	36.2	+21.5	+14.8
97.5 g a.i. ha^{-1} hsm	6.5	- 1.7	- 5.3	14.6	+ 3.4	-10.1	38.2	-15.1	- 5.1	40.7	+13.4	+20.5
50 g a.i. ha^{-1} split hsm	8.5	- 6.7	- 6.1	23.5	- 9.9	-15.9	30.4	-10.5	- 2.3	37.6	+ 6.1	+19.8
Imazethapyr	3.3	+ 2.7	+ 6.7	17.9	+ 1.5	-14.5	47.7	-23.3	-12.3	31.1	+19.0	+20.1
LSD (5%)		**10.8**			**13.6**			**29.5**			**27.9**	

hsm = halosulfuron-methyl.

(Figure 1a). At Katunga, imazethapyr reduced kyllinga in plots during January (day 41) but by late March (day 109), gave little or no significant suppression of kyllinga growth. In March, kyllinga accounted for around 12% DM in untreated plots, and about 9% DM in those treated with imazethapyr (LSD (P=0.05) =3.0). Thus, although imazethapyr has activity against kyllinga, it may not reliably suppress weed growth over the entire growing season. There was no advantage in using rates of halosulfuron-methyl above about 50 g a.i. ha^{-1}. By the end of the season there was no difference between plots treated once with low and high rates of this herbicide.

None of the treatments suppressed white clover or perennial ryegrass DM in pasture (Figure 1b,c). Ryegrass plants in plots treated with imazethapyr, however, displayed visual symptoms of herbicide damage and the foliage appeared scorched. There was no evidence that either of the herbicides significantly suppressed other species in the pastures (Figure 1d). The other species fraction at Harston (Figure 1d) was primarily composed of paspalum (*Paspalum dilatatum* Poiret), umbrella sedge (*Cyperus eragrostis* L.), rumex species and annual grasses. Paspalum and umbrella sedge were the principal unsown species in pasture at Katunga. These data demonstrate that kyllinga is able to colonize a range of pasture types. The proportion of kyllinga in plots appeared to be independent of the expansion of other species throughout the experiment.

By January 1995, all treated plots were reinfested by kyllinga seedlings that had germinated since the first herbicide application. In sprayed plots, regrowth was almost entirely from seedlings and there was no old rhizome material present. The seedlings originated either from seed already present in the soil, from surviving plants or introduced from outside the plots. Seed may have been introduced from the untreated buffers and from outside the experimental area during the mowing and straw removal operations and also by seed movement in irrigation water. These findings demonstrate the importance of seed in kyllinga dispersal and persistence. Seed production must, therefore, be suppressed and seedbanks depleted if infestations are to be reduced. Multiple, strategically timed applications of herbicide may be required to kill growth from rhizomes in spring and kill seedlings later in the year. The impact of pasture management practices, such as topping, on kyllinga growth, seed production and dispersal need to be investigated further.

Kyllinga produced prolific quantities of seedheads in all plots (Figure 2). Cumulative seedhead production over the growing season in untreated plots was around 500 m^{-2}. Each seedhead contains 100–120 seeds (Sumaryono and Basuki 1986, Auld and Medd 1987), giving a cumulative seed production figure of 50 000–60 000 seeds m^{-2} a year. Although halosulfuron-methyl significantly reduced seedhead formation, plants in these plots produced the equivalent of 120–260 seedheads m^{-2}, or 12 000–31 200 seeds m^{-2} (Figure 2). Thus even relatively small populations of kyllinga can produce large quantities of seed and may generate a sizeable bank of viable seed in the soil that may be a source of future infestations. Imazethapyr did not suppress seedhead formation (Figure 2). Consequently halosulfuron-methyl has the greater potential to control agent for kyllinga.

Year two: 1995/96 growing season

At Harston, in late 1995 early 1996, kyllinga accounted for around 1–26% of DM in all plots (Table 1). In control plots the contribution of kyllinga to harvested DM did not significantly differ between the 1994/95 and 1995/96 growing seasons. In these plots kyllinga comprised around 20% DM in March 1995 and about 26% in April the following year (Table 1). This indicates that kyllinga was not noticeably displacing other species at this site. While this appears to conflict with reports of kyllinga displacing pasture species (Blaikie and Slarke 1993), it should be noted that the pasture at the Harston site was relatively unproductive and dominated by unsown species (Figure 1). Unlike kyllinga, the abundance of white clover and perennial ryegrass declined between November 1994 and April 1996 (Table 1) and the data suggests a possible trend of increasing dominance by unsown species, including kyllinga. Kyllinga populations, did not, however, appear to be actively expanding or increasing in density. These observations contradict reports from other of kyllinga patches doubling in size and number each year locations (Corrick 1977, Bell 1987, Blaikie and Slarke 1993) . Such estimates may thus not be reliable and overestimate the rapidity of expansion, at least in the pastures investigated. Rates of kyllinga invasion and ingress are, however, likely to vary considerably between locations and be influenced by the soil and climatic conditions and the competitive ability/vigour of existing vegetation. Reports of rapidly expanding kyllinga infestations continue, especially in productive pastures around Katunga/Numurkah (Bell 1997 personal communication) and more work is required to quantify this aspect of kyllinga's

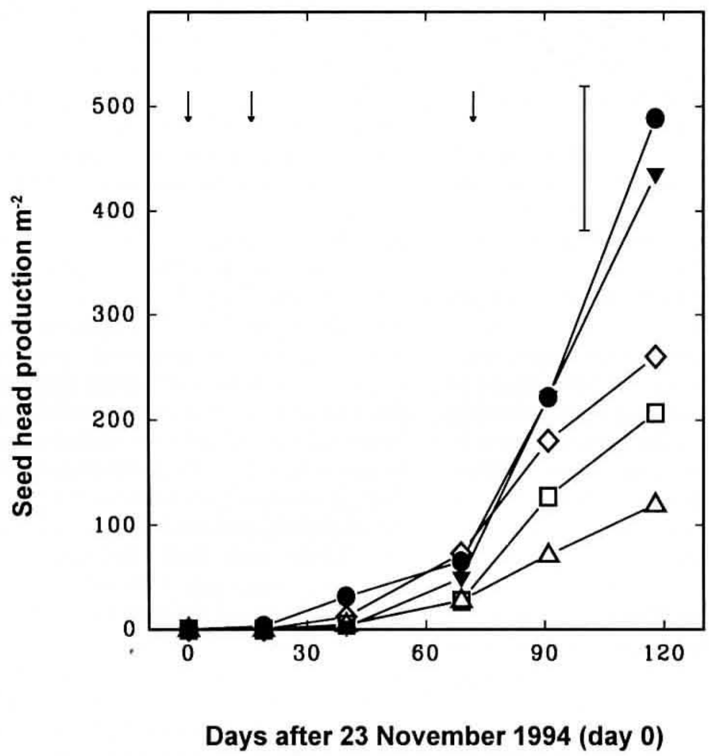

Figure 2. The effect of halosulfuron-methyl and imazethapyr on the cumulative seed production of kyllinga at Harston from November 1994 to April 1995. ● control, △ 50 g a.i. ha^{-1} halosulfuron-methyl, □ 97.5 g a.i. ha^{-1} halosulfuron-methyl, ◇ 50 g a.i. ha^{-1} double application of halosulfuron-methyl, ▼ 192 g a.i. ha^{-1} imazethapyr. The arrows indicate the application dates for halosulfuron-methyl, imazethapyr and the second halosulfuron-methyl spray respectively. Vertical bars indicate LSD 5% values.

ecology. The rate at which kyllinga infestations spread and colonizes new sites has important consequences for managing infested pastures, especially in terms of determining its potential impact on milk production.

More than one year after herbicides were initially applied at Harston, all plots treated with herbicides contained significantly less kyllinga than untreated plots (Table 1). In late April 1996 (about 18 months after the initial herbicide application), kyllinga in untreated plots accounted for 26% of the harvested DM, but only about 1–10% in treated plots. There were no differences in the efficacy of the various herbicide treatments in terms of per cent kyllinga in total DM. For all treated plots there were no significant differences in the proportion of kyllinga present between November 1994, March 1995 and April 1996 assessments. These results suggest that there had been little or no significant net recruitment or reinfestation between March 1995 and April 1996. This is unexpected, since by January in the previous season all plots were reinfested by kyllinga seedlings and visual assessments of treated plots showed that weed suppression declined in time after application (Henskens 1995). The apparent lack of reinvasion may be in part due to differences between the growing seasons and the ability of halosulfuron-methyl to suppress kyllinga seed production. The pasture at Harston appeared to be much less productive during the 1995/96 season, and little kyllinga was in evidence when the site was revisited in November 1995. Another factor in the apparent lack of reinvasion may be the low DM of individual kyllinga plants, which may mean that only very substantial changes in weed biomass/populations can be detected by the current monitoring technique.

White clover was a surprisingly small pasture component of all plots in April 1996 accounting for only approximately 3–8% of harvested DM as opposed to 14–23% the previous year (Table 1). These data demonstrate the considerable between-season variations in the pasture observed at this site (see above). As before, there was no evidence that either of the herbicides significantly suppressed the percentage of other species in pasture (Table 1).

Conclusions

Halosulfuron-methyl gave good control of kyllinga during the 1994/95 growing season. There is no advantage in using rates higher than 50 g a.i. ha^{-1} of halosulfuron-methyl. Halosulfuron-methyl had no effect on white clover or perennial ryegrass. Imazethapyr had no effect on white clover, but may have had an impact on perennial ryegrass. Seed germination was a major source of re-infestation and, thus, of weed dispersal and persistence. Consequently, any effective control strategy or agent must reduce seed production and dispersal and reduce accessions to the soil bank. The longevity of kyllinga seed in the soil will have important implications for management strategies and needs to be determined. Halosulfuron-methyl reduced kyllinga seedhead production at Harston, but imazethapyr did not. Consequently, halosulfuron-methyl has the greater potential for selective control of kyllinga in pasture.

Applications of halosulfuron-methyl and imazethapyr during one growing season can be sufficient to maintain kyllinga populations at low levels during the following growing season. These herbicides may not, therefore, need to be applied in successive years to achieve control and maintain pasture productivity. The duration of this suppressive effect is not known and the time kyllinga populations take to recover is likely to vary between locations and years.

Kyllinga recruitment and reinvasion may be less rapid than anecdotal evidence suggests since the per cent DM of populations had not recovered one year or more after the first herbicide application, neither had per cent DM increased significantly in untreated plots. Mowing was implicated in the dispersal of kyllinga seeds and the impact of management practices on the growth, reproductive potential and dispersal of kyllinga needs to be investigated. Herbicides will not provide the entire solution to controlling kyllinga in pasture, and further work is needed to identify and assess other management tools.

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Disclaimer

References

Auld, B.A. and Medd, R.W. (1987). 'Weeds. An illustrated botanical guide to the weeds of Australia'. (Inkata Press, Melbourne, Sydney).

Bell, R.A. (1987). '*Cyperus brevifolius* collection'. (National Herbarium of Victoria, Melbourne).

Blaikie, S.J. and Slarke, R.H. (1993). Survey of the presence of carpet grass and Mullumbimby couch on irrigated farms in northern Victoria. Agriculture Victoria Report to DRDC, 15 pp.

Corrick, M.G. (1977). '*Cyperus brevifolius* collection'. (National Herbarium of Victoria, Melbourne).

Dear, B.S., Pratley, J.E., Sandral, G.A. and Richards, M.F. (1992). Pasture management and herbicides. New South Wales Agriculture, 6 pp.

Dear, B.S. and Sandral, G.A. (1994). Herbicide options for sub clover pastures. New South Wales Agriculture, 8 pp.

Henskens, F. (1995). Within and between season control of *Cyperus brevifolius* by herbicides (experiment 1a) year 1 (1994/95). Agriculture Victoria Report to DRDC, 10 pp.

Holm, L.G, Pancho, J.V., Herberger, J.P. and Plucknett, D.L. (1979). 'A Geographical Atlas of World Weeds'. (John Wiley, Canada).

Johnson, L.A.S. and Evans, O.D. (1976). *Cyperus brevifolius* and allied species in eastern Australia. *Contributions from the National Herbarium* 4, 378.

Komai, K. and Tang, C. (1989). Chemical constituents and inhibitory activities of essential oils from *Cyperus brevifolius* and *C. kyllinga*. *Journal of Chemical Ecology* 15, 2171-6.

Sumaryono, G. and Basuki, S. (1986). Growth and reproduction of *Cyperus kyllingia* Endl. and *Cyperus brevifolius* (Rottb.) Hassk. *BIOTROP Special Publication* 24, 137-43.