Weed Technology. 1998. Volume 12:737–743

Cogongrass in the United States: History, Ecology, Impacts, and Management[1]

HALLIE DOZIER, JAMES F. GAFFNEY, SANDRA K. McDONALD, ERIC R.R.L. JOHNSON, and DONN G. SHILLING[2]

Abstract: Cogongrass is a weed throughout the tropics and subtropics. Introductions early this century have spread into forests, rangelands, reclaimed mined areas, roadsides, and natural ecosystems in the southeastern United States. Vegetative reproduction is the primary mechanism for survival and local spread, and sexually produced seeds of this obligate outcrossing species provide natural long-distance dispersal. Highly germinable ($\geq 90\%$) seeds have no dormancy, though spikelet fill may be low ($\leq 40\%$) in natural populations. Early seedling establishment, prior to rhizome development, is low ($< 20\%$), occurring in areas with little competition; $\geq 75\%$ bahiagrass sod cover is required to prevent cogongrass seedling establishment. Imazapyr and glyphosate are the most effective herbicides for cogongrass control. Younger cogongrass shoots are very susceptible to these herbicides; however, longer term control of adult plants requires translocation and thereby control of the rhizomes. Autumn applications of glyphosate and imazapyr provided greatest suppression of rhizome regrowth. Effective cogongrass management options exist and depend on integrating several control strategies. Mechanical control alone provides short-term control, whereas multiple discings plus herbicide application provide longer term control. Some combinations of herbicide, discing, and revegetation with desirable plant species provide excellent control. Because of the large geographic area infested with cogongrass and the often economically and environmentally unacceptable management techniques, biological control organisms also should be researched.

Nomenclature: Glyphosate, *N*-(phosphonomethyl) glycine; imazapyr, (±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3-pyridinecarboxylic acid; bahiagrass, *Paspalum notatum* Fluegge #[3] PASNO; cogongrass, *Imperata cylindrica* (L.) Beauv. var. *major* # IMPCY.

Additional index words: Perennial weed control, imazapyr, glyphosate, integrated management.

INTRODUCTION

Over the last several decades, land managers have become increasingly interested in impacts naturalized non-native plants have on natural and managed ecosystems. In some areas, naturalized non-native plants are prized in the landscape because they are considered useful (Cheatham et al. 1995). However, in many cases, these plants are unwanted because they have had a demonstrably negative effect on landscapes by forming monocultures, excluding native plants, or changing ecosystem functions and/or processes. Such disruptive non-native species are termed "invasive."

Cogongrass, also called Japgrass, blady grass, speargrass, *alang-alang,* and *lalang-alang,* is a serious pest throughout the tropical and subtropical regions of the world; it has been ranked among the most troublesome weeds worldwide (Falvey 1981; Holm et al. 1977). In the United States, cogongrass has become invasive in the southeastern gulf region (Dickens 1974; Elmore 1986). It does not survive in heavily cultivated areas but thrives on roadways and in pastures and mining areas, pine forests, parks, and other recreational areas (Coile and Shilling 1993; Willard et al. 1990).

DISTRIBUTION, HISTORY, ECOLOGY, AND BIOLOGY OF COGONGRASS

Geographic Distribution. *Imperata* is a genus of the tribe Andropogoneae, subtribe Saccharine. This broadly distributed genus has nine species worldwide (Gabel 1982). *Imperata cylindrica,* the most morphologically varied and cosmopolitan species in the genus, infests over 500 million ha in tropical and subtropical regions

[1] Received for publication August 29, 1997, and in revised form August 25, 1998, Contribution from the Department of Agronomy, University of Florida, Gainesville.

[2] Graduate Assistant, School of Forest Resources and Conservation, University of Florida, Gainesville, FL 32611; American Cyanamid, Princeton, NJ 08543; Pesticide Information Officer, Fort Collins, CO 80523; Graduate Research Assistant, Professor (corresponding author), Department of Agronomy University of Florida, Gainesville, FL 32611.

[3] Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds,* Revised 1989. Available from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

around the globe (Dickens 1974; Falvey et al. 1981; Holm et al. 1977). Taxonomists recognize several varieties of *I. cylindrica* (*major, africana, europa,* and *latifolia*) (Hubbard et al. 1944; Santiago 1980).

Two species generally are recognized as problematic in the United States, particularly in the southeast: cogongrass and a closely related new world species, Brazilian satintail, Brazilian bladygrass, or silver plume (*Imperata brasiliensis* Trin. # IMPBR) (Bryson and Carter 1993). Recent study (Hall 1998), however, has suggested that these two species are, in fact, one, with cogongrass believed to be a foreign genome of satintail that behaves more aggressively than the native genome of this species. Cogongrass comprises most of the recorded infestations, especially in southern Alabama, Georgia, Louisiana, and Mississippi and throughout Florida (Shilling et al. 1995), and Brazilian satintail has been reported to be invasive in Alabama, Florida, and Louisiana (Allen 1974; Allen et al. 1991; Lelong 1977). Cogongrass is also predominant in Southeast Asia, Australia, China, Japan, and the Philippines, as well as East Africa. Variety *africana* is found in West Africa. Variety *europa* is found in the Mediterranean and Central Asia, and var. *latifolia* is found in northern India. Varieties of *I. cylindrica* are distinguished by chromosome number (var. *major* $2n = 20$; var. *europa* $2n = 40$; var. *africana* $2n = 60$) as well as morphological differences, such as size of culms, leaves, and inflorescence or texture and width of leaf blades (Hubbard et al. 1944; Santiago 1980).

History. Several known introductions of cogongrass have occurred in the United States. Cogongrass was introduced inadvertently in Alabama in 1912 as packing material in boxes from Japan (Dickens 1974; Tabor 1949, 1952), and it was brought to Mississippi and Florida from the Philippines as a potential forage in 1921 (Dickens and Buchanan 1971; Hubbard et al. 1944; Patterson et al. 1983; Tabor 1949, 1952). Main points of introduction include university experiment stations, U.S. Soil Conservation Service reclamation sites, and U.S. Department of Agriculture plant introduction facilities (Hall 1983; Willard 1988). Following early introduction, forage trials were carried out in Texas, Mississippi, Alabama, and Florida although the Texas plantings died out in the first year, probably because of cold temperatures (Hubbard et al. 1944). Cattle ranchers desiring improved forage in Florida helped spread the grass throughout the state (Dickens 1976).

Ecological and Economical Importance. Cogongrass has little utility except for thatch, short-term forage production, soil stabilization and, in some areas, paper making (Watson and Dallwitz 1992). Silica bodies in the leaves contribute to its unpalatability to grazers (Coile and Shilling 1993). In the United States, an ornamental variety of the grass is promoted for landscape use (Greenlee 1992; Lang et al. 1997). Although the ornamental varieties, known as 'Rubra,' 'Red Baron,' or 'Japanese Blood Grass,' are not aggressive, plants grown from callus tissue may revert to the green, invasive form (Greenlee 1992).

Morphology. Cogongrass is stemless, growing in loose to compact tufts with slender, flat, linear-lanceolate leaves arising from the rhizomes. The scabrous leaves are 4–10 mm wide with prominent white midribs that are slightly off center. The leaves may be 15–150 cm tall, depending on habitat, with narrow, sharp, hard points. Stomata can be found on both surfaces (Bryson and Carter 1993; Hubbard et al. 1944).

Cogongrass and other varieties of *I. cylindrica* have flowers with two stamens, distinguishing it from *I. brasiliensis* that has only one stamen per flower (Hubbard et al. 1944; Patterson et al. 1980). Seed heads are branched but compacted into a dense, white, fluffy, spikelike panicle 10–20 cm long (Holm et al. 1977). The seeds are small and are attached to a plume of long hairs (Hubbard et al. 1944).

A fibrous root system arises from the rhizomes, which are long, white, tough, and scaly with very short internodes. The branched rhizomes form a dense mat that is able to exclude most other vegetation. The apical ends of the rhizomes are sharp and may grow through the roots of other plants, enhancing cogongrass' ability to interfere with other vegetation (Boonitee and Ritdhit 1984; Eussen and Soerjani 1975). Rhizome development generally starts between the third and fourth leaf stages. Early rhizome growth is plagiotropic, or vertical, with growth by the fifth leaf stage becoming horizontal when rhizomes develop scale leaves (cataphylls). The tips of the rhizomes grow upward (negatively orthogeotropic) between the fifth and sixth leaf stages. A second-generation shoot arises from the apical bud, and rhizomes form from subapical buds. Most buds are located at the distal end of the rhizome, in nodes in the apical region. No buds are formed until the diageotropic rhizome growth stage. Root development also begins at this stage, with a fibrous system forming at the rhizome nodes. Second-generation shoots and rhizomes form simultaneously on strong plants. In weaker plants, the shoot forms first, whereas buds on the convex side form shoots much later or remain suppressed (Ayeni 1985).

Physiology. Cogongrass is a perennial C_4 grass with persistent, aggressive rhizomes that are reported to be the main mechanism for survival and local spread. Cogongrass rhizomes are resistant to high temperatures and have characteristics that enable them to conserve water and resist breakage, thus making cogongrass difficult to control (Bryson and Carter 1993; Holm et al. 1977). Eussen (1980) reported that rhizomes may develop as many as 350 shoots in 6 wk and can cover 4 m^2 in 11 wk. Wilcut et al. (1988a) also reported that cogongrass is sensitive to burial, unable to send up shoots from deeper than 8 cm. Cogongrass has a low shoot-to-root/rhizome ratio, which contributes to its rapid regrowth after burning or cutting (Sajise 1972). Although rhizomes are very resistant to heat (either natural or artificial) they are susceptible to cold (Wilcut et al. 1988b).

Cogongrass is not restricted to high-light areas. The light compensation point of cogongrass is 32 $\mu mol/m^2/s$, approximately 2% of ambient sunlight in tests conducted in north central Florida (Gaffney 1996). Grown under 1% ambient light (15 $\mu mol/m^2/s$), cogongrass lost biomass.

Habitat. Cogongrass normally is found in warm areas and thrives where annual rainfall is 75–500 cm (Bryson and Carter 1993). Reports regarding minimum lethal temperatures are somewhat confusing. Early study (Hubbard et al. 1944) suggested that cogongrass could not survive temperatures of -8 C. However, later reports (Wilcut et al. 1988b) documented rhizome survival of temperatures as low as -14 C. Stands of cogongrass may be found on highly leached soils with low pH (4.7), fertility, and organic matter (Sajise 1980), although it is adaptable and grows on a variety of soils (Bryson and Carter 1993).

Cogongrass thrives in disturbed areas such as fruit crop systems, oil, tea, and rubber plantations, roadsides, and reclaimed mined areas (Bryson and Carter 1993; Willard et al. 1997) and has been reported in less disturbed noncrop areas such as pine and hardwood forests, grasslands, and recreational areas (Willard et al. 1997).

Reproductive Biology. The inflorescence of cogongrass is a 3–60-cm-long panicle (Bryson and Carter 1993; Holm et al. 1977; Shilling et al. 1997) that contains up to 460 individual spikelets (Shilling et al. 1997). Spikelets are 3–6 cm long and covered with silky white hairs no longer than 1.8 mm (Bryson and Carter 1993). Early studies on cogongrass reproduction suggested that flowering is rare, generally occurring after human disturbance or stress, such as burning, tillage, mowing, or cold (Sajise 1972), and that flowers produced in response to stress rarely produce seed (Eussen 1980). More recent work, however, indicates that cogongrass is a prolific producer of wind-blown seed (McDonald et al. 1996a).

Sexually produced cogongrass seed are the only propagules capable of natural long-distance dispersal (McDonald et al. 1996a). A single sexually reproducing plant may produce as many as 3,000 seeds contained in hair-covered spikelets. Aerodynamic properties of spikelet clumps facilitate wind dispersal of seeds up to 24 km over open country (Hubbard et al. 1944). The larger the spikelet clump and the greater the wind speed, the farther the expected dispersal distance (McDonald et al. 1996a).

Low Germination rates (31%) reported by Shilling et al. (1997) were caused by low spikelet fill. Seed production resulted from cross-pollination between geographically isolated, heterogeneous populations, never from self-pollinated flowers (McDonald et al. 1996b). Seed germination percentage is high (98%), and cogongrass seeds show no dormancy mechanisms (Shilling et al. 1997). Seedling emergence from soil samples collected in naturally infested sites lasted only 3 mo following flowering. A high proportion ($>$ 90%) of seeds stored in cool, dry conditions remained viable for up to 3 mo, after which seeds quickly lost viability, dropping to 50% by 7 mo and to 0 by 11 mo (Shilling et al. 1997).

Seedlings tend to emerge in a clumped pattern, reflecting the tendency of spikelets to disperse in clumps. Survivorship of cogongrass seedlings (up to 12 mo) is fairly low, with less than 20% of the emergent population surviving 1 yr; thus, there is little transition from juvenile to adult stage. Risk of mortality is likely reduced once an individual forms rhizomes, which occurs at about 8 wk (Shilling et al. 1997).

In Alabama, inland spread of cogongrass from introduction sites appears to have occurred via wind dispersal of seeds on northeasterly winds off the Gulf of Mexico along the rights-of-way bordering a major north–south highway (Shilling et al. 1995). In Mississippi, distribution patterns indicate that cogongrass establishes sporadically, possibly through wind dispersal or by rhizomes being carried in fill during road construction (Patterson and McWhorter 1983). Willard (1988) speculated that spread in Florida has resulted primarily from movement of soil contaminated with rhizomes.

Vegetative reproduction is believed to be responsible for localized spread of cogongrass populations as well as establishment of new populations when rhizome pieces are dispersed in fill dirt during road construction (Patterson and McWhorter 1983; Willard 1988). Regenerative capacity of rhizomes has been shown to be positively correlated with increases in age, weight, length, and thickness of the rhizome as well as the number of visible buds thereon (Ayeni 1985). Young rhizomes are not capable of regeneration because they lack roots, necessary for nutrient uptake.

Conflicting results have been reported about the role that apical dominance plays in cogongrass growth. The pattern of bud sprouting after herbicide treatment seems to indicate that cogongrass bud meristems are regulated by apical dominance (Sriyani 1992). Earliest reports (Hubbard et al. 1944), however, had indicated that shoots grow from even small rhizome segments. Subsequent work (Peng 1984) reported little to no sprouting from cogongrass rhizome segments. Four years later, Wilcut et al. (1988a) determined that cogongrass, unlike other weedy grasses, lacks axillary bud formation along the length of the rhizome, suggesting that cogongrass rhizomes are unable to send up new shoots following apex damage. More recent study (Gaffney 1996) has revealed that shoots with intact apices produce a small number of new shoots only in the area nearest the undamaged apex, whereas shoots that have had the apices removed produce, over several weeks, up to 31% more shoots that are located along the entire length of the rhizome.

Population Dynamics. Cogongrass seedlings tend to be found only in areas with little competition; establishment relies on disturbance to release them from competition with other grasses. Cogongrass seedlings generally are less competitive than bahiagrass seedlings, but cogongrass plants arising from ramets are more competitive than bahiagrass seedlings (Shilling et al. 1997; Willard and Shilling 1990). Cogongrass seedlings are unlikely to establish in areas with good ($\geq 75\%$) bahiagrass cover.

Cogongrass has been reported to compete for nutrients, light, water, and physical space and to cause physical injury (by rhizomes penetrating roots of other plants; Eussen and Wirjahardja 1973; Jagoe 1938). The ability of cogongrass to extract available soil moisture from shallow soil layers makes it difficult for other grass species to establish, particularly desirable perennial grasses. Plants that survive competition with cogongrass have a deeper root system than that of cogongrass and/or a taller canopy (Eussen and Wirjahardja 1973). In sites with very heavy, clayey soils, however, cogongrass roots may grow as deep as 80 cm (Gaffney 1996), possibly giving cogongrass greater competitiveness on those sites.

MANAGEMENT OF COGONGRASS

Response to Herbicides. The key to long-term chemical management of perennial weeds is to deliver a lethal dose of the appropriate chemical to the underground tissues. In the case of cogongrass, successful management requires killing the rhizomes. Symplastically translocatable herbicides follow the movement of photosynthate; thus, timing herbicide application to coincide with basipetal movement of photosynthate is essential to transmitting the herbicide to the plant's rhizomes. Technical parameters determining management success of perennial weeds such as cogongrass include type of herbicide used, diluent volume, and number of applications. Although source-to-sink movement is the main physiological parameter affecting chemical management success, others include leaf developmental stage and point of delivery. Careful consideration of environmental conditions and an understanding of how these conditions affect physiological parameters of the perennial weed are essential to successful control of cogongrass.

Technical considerations for managing cogongrass include herbicide selection, diluent volume, and the need to repeat applications. Extensive research with a variety of herbicides has shown imazapyr and glyphosate to be the two most effective herbicides for cogongrass control (Akobundu 1993; Dickens and Buchanan 1975; Lee 1985; Shilling et al. 1997; Shilling and Gaffney 1995; Sriyani 1992; Tanner et al. 1992; Townson and Butler 1990; Townson and Price 1987; Willard 1988; Willard et al. 1997). Although these herbicides have different mechanisms of action, both are readily absorbed and translocated throughout the plant (Dean et al. 1988).

Successful use of these herbicides depends, in part, on application rate, which affects herbicide uptake and translocation. For example, high rates of glyphosate that result in rapid foliar kill may diminish long-term control (Shilling and Haller 1989). Similarly, high application rates of imazapyr have given poor results. Townson and Price (1987) found action to be reduced in cogongrass by high concentrations of imazapyr. Shaner (1988) attributed a drop in translocation of absorbed imazapyr to the death of the leaves' growing points and the subsequent reduction of photosynthate sink strength. Maximum absorption, translocation, and accumulation of glyphosate may result from intermediate application rates, as seen in Canada thistle [*Cirsium arvense* (L.) Scop.] (Boerboom and Wyse 1988).

In general, multiple applications are needed to inhibit regrowth from the extensive rhizome system. A single application of neither glyphosate nor imazapyr successfully controls cogongrass; repeated applications give the greatest control (Dean et al. 1988; Townson and Butler 1990; Willard et al. 1996).

Developmental stage of cogongrass influences herbicide efficacy (Lee 1986). In greenhouse experiments with glyphosate, more effective and complete control was observed on plants in early developmental stages. With glyphosate under greenhouse conditions, Willard (1988) also found better control with young cogongrass. Foliage of plants at slightly older developmental stages was found to be susceptible to the herbicide, whereas primary rhizomes were somewhat more resistant. Nevertheless, in older leaf stages (≥ four-leaf stage), glyphosate continued to cause the decay of primary rhizomes in up to half of the treated plants. In these older plants, glyphosate caused secondary rhizomes to decay at the shoot apices and tertiary rhizomes to decay completely.

Herbicide absorption varies with location of contact. Townson and Butler (1990) found that the basal area of a cogongrass leaf was likely to absorb more imazapyr and glyphosate than either the middle or tip of the leaf, though position of application did not affect translocation of either.

Physiological responses to changing environmental conditions can affect delivery of herbicide to cogongrass rhizomes and, therefore, influence management success. Seasonal changes, for example, may have an impact on control. In Florida, glyphosate and imazapyr are more effective when applied in October or November than at any other time of the year (Gaffney 1996; Shilling et al. 1997; Willard 1988). Numerous possibilities exist for the increased efficacy achieved with autumn applications. Low rainfall levels and, thus, lower available soil moisture during this time may allow for greater concentration of herbicide in underground tissues. Furthermore, an increase in carbohydrate and, thus, herbicide translocation to the rhizomes may also occur during this time. Interference with normal nitrogen storage and remobilization mechanisms within the rhizomes may also occur, limiting shoot production and plant recovery. In addition, continued respiration and carbon loss from surviving rhizomes during the cool, dry winter months may limit carbohydrate available for shoot production the following spring.

Thus far, the most effective cogongrass management practice employing herbicides is evenly split application of 4.5 kg/ha glyphosate and 2.2 kg/ha imazapyr (Willard et al. 1996). These application rates were greatly improved by preapplication discing (10–15 cm) to break apical dominance and promote new leaf growth and by postapplication discing to incorporate herbicide in the soil.

Response to Nonchemical Manipulation. Discing alone has not been effective for cogongrass control although some biomass reduction was reported (Gaffney 1996; Willard 1988). Shallow tillage fragmented rhizomes, causing only short-term growth reduction and subsequent strong shoot growth. Although continuous discing may be effective in controlling cogongrass over the long term mechanical manipulation of this type is neither practical nor feasible in many areas, particularly in natural areas not completely dominated by the grass.

Integrated Management. An integrated management strategy using all available methods of control is needed to manage cogongrass effectively (Johnson et al. 1997). If the ecological niche created after cogongrass removal is not filled with other plant species, cogongrass will reinvade. Reliance on a single means of control generally will result in failure to manage cogongrass effectively. Integrated management, including burning, tilling, mowing, and chemical and cultural control, can increase the likelihood of cogongrass suppression. Removal of old growth and dead biomass by burning or mowing has two benefits. First, rhizomes are forced to reallocate starch storage reserves to produce new shoot growth, thereby weakening the rhizomes. Second, removal of the substantial biomass improves other management practices—tillage operations are more effective. A combination of discing followed by application of imazapyr, glyphosate, or both may provide greater than 90% control. Herbicide application to the flush of new plant tissues maximizes absorption and results in greater efficacy. Imazapyr applied to regrowth after burning was as effective as imazapyr combined with discing. Furthermore, if treatments are timed correctly (October/November) the rhizomes may be even stronger photosynthate sinks.

After suppression of cogongrass, the establishment of desirable plant species is essential for long-term control of cogongrass. The strategy is to replace cogongrass, not temporarily remove it. If a replacement plant species cannot occupy the site released after cogongrass suppression, cogongrass will simply refill the niche. Gaffney (1996) found that common hulled bermudagrass [*Cynodou doctylon* (L.) Pers.] and hairy indigo (*Indigofera hirsuta* Harvey) in combination with glyphosate or imazapyr, respectively, grew vigorously and remained free of cogongrass for up to 2 yr after seeding. Success of species establishment depends on tolerance to the herbicide, the system, soil type, and other factors. Other replacement species have yet to be identified and tested.

When invasive plant species cause problems over large geographic areas and affect low-maintenance and natural ecosystems, high-input control strategies will not work. An ideal scenario would be to develop biological control agents. Several endemic pathogens have been characterized in Florida and are undergoing further development (Shilling et al. 1997; Shilling and Gaffney 1995).

LITERATURE CITED

Akobundu, I. O. 1993. Chemical control of cogongrass (*Imperata cylindrica* (L.) Raeuschel) in arable fields. Weed Sci. Soc. Am. Abstr. 33:6.

Allen, C. M. 1974. Nineteen species of grasses (Poaceae) new to Louisiana. Proc. L. Acad. Sci. 37:18–20.

Allen, C. M., R. D. Thomas, and M. G. Lelong. 1991. *Bracharia plantaginea, Imperata cylindrica,* and *Panicum maximum:* three grasses (Poaceae) new to Louisiana and a range extension for *Rottboellia cochinchinensis.* SIDA Contrib. Bot. 14:613–615.

Ayeni, A. O. 1985. Observations on the vegetative growth pattern of speargrass [Imperata cylindrica (L.) Beauv.] Agric. Ecol. Environ. 13:301–307.

Boerboom, C. M. and D. L. Wyse. 1988. Influence of glyphosate concentration on glyphosate absorption and translocation in Canadian thistle. Weed Sci. 36:291–295.

Boonitee, A. and P. Ritdhit. 1984. Allelopathic effects of some weeds on mungbean plants (*Vigna raiata*). Proc. Trop. Weed Sci. Soc. 2:401–406.

Bryson, C. T. and R. Carter. 1993. Cogongrass, *Imperata cylindrica,* in the United States. Weed Technol. 7:1005–1009.

Cheatham, S., M. C. Johnston, and L. Marshall. 1995. The Useful Wild Plants of Texas, the Southeastern and Southwestern United States, the Southern Plains, and Northern Mexico. Austin, TX: Useful Wild Plants, Inc. 568 p.

Coile, N. C. and D. G. Shilling. 1993. Cogongrass, *Imperata cylindrica* (L.) Beauv.: A Good Grass Gone Bad! Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Botany Circular, Vol. 28. 3 p.

Dean, C. E., D. G. Shilling, and T. R. Willard. 1988. Management of Noxious-Exotic Grasses on Highway Rights-of-Way. 99700-7352. Tallahassee, FL: Florida Department of Transportation. 117 p.

Dickens, R. 1974. Cogongrass in Alabama after sixty years. Weed Sci. 22: 177–179.

Dickens, R. 1976. Weed watch—cogongrass. Weeds Today 7:5.

Dickens, R. and G. A. Buchanan. 1971. Old weed in a new home—that's cogongrass. High. Agric. Res. 18:2.

Dickens, R. and G. A. Buchanan. 1975. Control of cogongrass with herbicides. Weed Sci. 23:194–197.

Elmore, C. D. 1986. Weed survey—southern states. Res. Rep. South. Weed Sci. Soc. 39:136–158.

Eussen, J.H.H. 1980. Biological and ecological aspects of alang-alang (*Imperata cylindrica* (L.) Beauv.). Biotrop. Spec. Bull. 5:15–22.

Eussen, J.H.H. and M. Soerjani. 1975. Problems and control of "alang-alang" (*Imperata cylindrica* (L.) Beauv.) in Indonesia. Asian-Pac. Weed Sci. Soc. Fifth Conf., Bogor, Indonesia, pp. 58–65.

Eussen, J.H.H. and S. Wirjahardja. 1973. Studies of an alang-alang (*Imperata cylindrica* (L.) Beauv.) vegetation. Biotrop. Bull. 6:1–24.

Falvey, J. L. 1981. *Imperata cylindrica* and animal production in southeast Asia: a review. Trop. Grassl. 15:52–56.

Falvey, J. L., P. Hengmichai, and P. Pongpiachan. 1981. The productivity and nutritive value of *Imperata cylindrica* (L) Beauv. in the Thai highlands. J. Range Manage. 34:280–282.

Gabel, M. L. 1982. A Biosystematic Study of the Genus *Imperata* (Gramineae: Andropogoneae). Ph.D. dissertation. Iowa State University, Ames. IA. 94 p.

Gaffney, J. F. 1996. Ecophysiological and Technological Factors Influencing the Management of Cogongrass (*Imperata cylindrica*). Ph.D. Dissertation. University of Florida, Gainesville, FL. 128 p.

Greenlee, J. 1992. The Encyclopedia of Ornamental Grasses: How to Grow and Use Over 250 Beautiful and Versatile Plants. Emmausn, PA: Rodale Press. 186 p.

Hall, D. W. 1983. Weed watch—cogongrass. Fla. Weed Sci. Soc. Newsl. 5: 1–2.

Hall, D. W. 1998. Is cogongrass really an exotic? Wildland Weeds 1:14.

Holm, L. G., D. L. Plucknett, J. V. Pancho, and J. P. Herberger. 1977. The World's Worst Weeds: Distribution and Biology. Honolulu: University Press of Hawaii. 609 p.

Hubbard, C. E., D. Brown, A. P. Gray, and R. O. Whyte. 1944. *Imperata cylindrica:* Taxonomy, Distribution, Economic Significance and Control. Imperial Agricultural Bureau Joint Publication 7:1–63.

Jagoe, B. B. 1938. The effect of lalang grass (*Imperata cylindrica*) on the growth of coconut palms. Malay. Agric. J. 26:369–376.

Johnson, E.R.R.L., J. F. Gaffney, and D. G. Shilling. 1997. Revegetation as part of an integrated management approach for the control of cogongrass. Proc. South. Weed Sci. Soc. 50:141.

Lang, S., J. R. Dunmire, P. Edinger, J. F. Williamson, L. Walheim, and C. Overbeck Bix. 1997. Sunset National Garden Book. *In* K. N. Brenzel. ed. Sunset Books. Menlo Park, CA: Sunset Books, Inc. 656 p.

Lee, S. A. 1985. Bud development in the rhizomes of *Imperata cylindrica* (L.) Beauv. after glyphosate treatment. MARDI Res. J. 14:39–45.

Lee, S. A. 1986. Effects of dalapon and glyphosate on *Imperata cylindrica* (L.) Beauv. at different growth stages. MARDI Res. J. 14:39–45.

Lelong, M. G. 1977. Annotated list of vascular plants in Mobile, Alabama. SIDA. Contrib. Bot. 7:118–146.

McDonald, S. K., D. G. Shilling, T. A. Bewick, D. Gordon, D. Hall, and R. Smith. 1996a. Factors influencing cogongrass, *Imperata cylindrica* (L.) Beauv., dispersion, establishment and persistence. Weed Sci. Soc. Am. Absts. 36:46.

McDonald, S. K., D. G. Shilling, C.A.N. Okoli, T. A. Bewick, D. Gordon, D. Hall, and R. Smith. 1996b. Population dynamics of cogongrass, *Imperata cylindrica.* Proc. South. Weed Sci. Soc. 49:156.

Patterson, D. T., E. P. Flint, and R. Dickens. 1980. Effects of temperature, photoperiod, and population source on the growth of cogongrass (*Imperata cylindrica*). Weed Sci. 28:505–509.

Patterson, D. T. and C. G. McWhorter. 1980. Distribution and control of cogongrass *Imperata cylindrica* in Mississippi. Proc. South. Weed Sci. Soc. 33:251.

Patterson, D. T., E. E. Terrell, and R. Dickens. 1983. Cogongrass in Mississippi. Miss. Agric. For. Res. Exp. Sta. 46:1–3.

Peng, S. Y. 1984. The Biology and Control of Weeds in Sugarcane. New York: Elsevier Science. 336 p.

Sajise, P. E. 1972. Evaluation of Cogon (*Imperata cylindrica* (L.) Beauv.) as a Seral Stage in Philippine Vegetational Succession: I. The Cogonal Seral Stage and Plant Succession. II. Autecological Studies on Cogon. Ph.D. dissertation. Cornell University, Ithaca, NY.

Sajise, P. E. 1980. Alang-alang (*Imperata cylindrica* (L.) Beauv.) and upland agriculture. Biotrop. Spec. Bull. 5:35–46.

Santiago, A. 1980. Genecological aspects of *Imperata* weed and its practical implications. Proc. BIOTROP Workshop on Alang-alang. Bogor, pp. 23–34.

Shaner, D. L. 1988. Absorption and translocation of imazapyr in *Imperata cylindrica* (L.) Raeuschel and effects on growth and water usage. Trop. Pest Manage. 34:388–392.

Shilling, D. G., T. A. Bewick, J. F. Gaffney, S. K. McDonald, C. A. Chase, and E.R.R.L. Johnson. 1997. Ecology, Physiology, and Management of Cogongrass (*Imperata cylindrica*). Final Report. Florida Institute of Phosphate Research. 128 p.

Shilling, D. G. and J. F. Gaffney. 1995. Cogongrass control requires integrated approach. Rest. Manage. Notes 13:227.

Shilling, D. G., J. F. Gaffney, and P. Waldrop. 1995. Cogongrass: problem and solutions. Alabama's Treasured Forests 3:8–9.

Shilling, D. G. and W. T. Haller. 1989. Interactive effects of diluent pH and calcium content on glyphosate activity on *Panicum repens* L. (torpedograss). Weed Res. 29:441–448.

Sriyani, N. 1992. Glyphosate absorption, translocation, and rhizome bud kill in cogongrass (*Imperata cylindirca*). Proc. North Cent. Weed Sci. Soc. 47:108.

Tabor, P. 1949. Cogongrass, *Imperata cylindrica* (L) Beauv., in the southeastern United States. Agron. J. 41:270.

Tabor, P. 1952. Comments on cogon and torpedo grasses: a challenge to weed workers. Weeds 1:374–375.

Tanner, G. W., J. M. Wood, and S. A. Jones. 1992. Cogongrass (*Imperata cylindrica*) control with glyphosate. Fla. Sci. 55:112–115.

Townson, J. K. and R. Butler. 1990. Uptake, translocation and phytotoxicity of imazapyr and glyphosate in *Imperata cylindrica* (L.) Raeuschel: effect of herbicide concentration, position of deposit and two methods of direct contact application. Weed Res. 30:235–343.
Townson, J. K. and C. E. Price. 1987. Tropical weed control: an approach to optimising herbicide performance with very low volume application. Aspects Appl. Biol. 14:305–306.
Watson, L. and M. J. Dallwitz. 1992. Grass genera of the world: descriptions, illustrations, identification, and information retrieval; including synonyms, morphology, anatomy, physiology, phytochemistry, cytology, classification, pathogens, world and local distributions, and references. URL, World Wide Web: http://www.keil.ukans.edu/delta/.
Wilcut, J. W., R. D. Dute, B. Truelove, and D. E. Davis. 1988a. Factors limiting the distribution of cogongrass, *Imperata cylindrica,* and torpedograss, *Panicum repens.* Weed Sci. 36:577–582.
Wilcut, J. W., B. Truelove, D. E. Davis, and J. C. Williams. 1988b. Temperature factors limiting the spread of cogongrass (*Imperata cylindrica*) and torpedograss (*Panicum repens*). Weed Sci. 36:49–55.
Willard, T. R. 1988. Biology, Ecology and Management of Cogongrass (*Imperata cylindrica* (L.) Beauv.). Ph.D. dissertation. University of Florida, Gainesville, FL. 127 p.
Willard, T. R., J. F. Gaffney, and D. G. Shilling. 1997. Influence of herbicide combinations and application technology on cogongrass (*Imperata cylindrica*) control. Weed Technol. 11:76–80.
Willard, T. R., D. W. Hall, D. G. Shilling, J. A. Lewis, and W. L. Currey. 1990. Cogongrass (*Imperata cylindrica*) distribution on Florida highway rights-of-way. Weed Technol. 4:658–660.
Willard, T. R. and D. G. Shilling. 1990. The influence of growth stage and mowing on competition between *Paspalum notatum* and *Imperata cylindrica.* Trop. Grassl. 24:81–86.
Willard, T. R., D. G. Shilling, J. F. Gaffney, and W. L. Currey. 1996. Mechanical and chemical control of cogongrass (*Imperata cylindrica*). Weed Technol. 10:722–726.