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CONTROL OF *IMPERATA CYLINDRICA* (L.) BEAUV. IN RUBBER PLANTATIONS – A REVIEW

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Imperata cylindrica (L.) Beauv. is an aggressive, rhizomatous, perennial grass invader especially in perennial crops. It has linear to lanceolate leaves and the leaves originate directly from ground level and the length ranges from one to four feet. This weed has several features that encourage its profuse growth and persistence. It adapts to a wide variety of soil types and can form stout, extensively creeping, scaly rhizomes with sharp-pointed tips. It can reproduce sexually from seeds and vegetatively through rhizomes. Rhizomes have a high regenerative ability and seeds have the capacity to get dispersed by wind. Developing a rubber plantation in *I. cylindrica* dominated areas is a serious problem for the rubber farmers in most parts of South East Asia. The problem attributes in three respects: the high cost (labour for land preparation), its competitive effect on rubber and annual intercrops and the fire hazard it poses during the dry season. Integration of tillage, herbicide application and cover cropping provide better control than the independent effects of each practice. However, as a single option in the short-run, herbicides like glyphosate is the most effective, because it is cost-effective with less soil disturbance, preventing erosion. For the control of subsequent re-growth, an integrated approach, which emphasizes the use of multiple practices like tillage, cover crop, herbicide, *etc.* is the best option. This review article highlights two major topics; (1) the impact of *I. cylindrica* in immature rubber plantation and (2) integrated management approach.

Keywords: Cover crops, Glyphosate, Imazapyr, *Imperata cylindrica*, Rubber, Tillage

INTRODUCTION

Imperata cylindrica (L.) Beauv. has been ranked as one of the 10 worst noxious weeds of the world (Holm *et al.*, 1977; MacDonald, 2004) and is found in a wide range of habitats, which include degraded forests, grasslands, arable land and young plantations. It is native to South East Asia and infests nearly 200 million ha of plantation and agricultural land worldwide. This weed is seen in the warm tropical regions, from Japan to southern China, through the Pacific Islands, Australia, India, East Africa and the south-eastern United States (Holm *et al.*, 1977). It is known as speargrass in West Africa, alang-alang in Asia and cogongrass in America. In India, it is known by a variety of names like *ullu, sirhu, dabh, khans etc.* (Quattrocchi, 2006). Garrity *et al.* (1997) found that the area of *Imperata* grasslands in Asia is about 35 million ha which represents 4% of the total land area. The countries with the largest area of *Imperata* grasslands are Indonesia (8.5 million ha) and India (8.0 million ha).

A major percentage of global natural rubber is produced in South East Asia and smallholders play a key role in producing

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bulk of this. Thailand, Indonesia and Malaysia are the three prime natural rubber producing countries. In India, rubber has established its prominent position in the sector of plantation crops and it is of considerable significance to the economy. When rubber is planted in areas invaded with *I. cylindrica*, this aggressive light-demanding weed arrests the growth of young rubber trees through competition and may even threaten their survival through its combustibility in the dry season. According to Harja *et al.* (2005), *I. cylindrica* is a chief hindrance to reforestation efforts in South East Asia.

I. cylindrica (L.) Beauv. var. *major* is an early successional weed coming up in discarded fallows after slash - and - burn agriculture in the north-eastern hill region of India (Kushwaha *et al.*, 1983). It is popularly known as thatch grass in this part of the country and it occupies a vast area. It grows abundantly in the grasslands which have developed as a result of removal of natural forest cover due to improper shifting cultivation *(jhumming)*. Under shorter 'jhum' cycles, *Chromolaena odorata, Mikania micrantha* or *I.cylindrica* predominate at lower elevations in north-eastern India (Toky and Ramakrishnan,1983) while *Eupatorium adenophorum, I. cylindrica* or *Pteridium aquilinum* predominate at higher elevations. Rubber cultivation has been acknowledged as one of the thrust areas in north-eastern region of India, in view of its suitability to the terrain and the acceptability amongst the people. Hence, every year thousands of hectares are brought under rubber cultivation, most of them have degraded soil with *I. cylindrica* grass cover. As *I. cylindrica* extends the unproductive period of the rubber plantation, its management is a vital concern for the smallholder.

Biology of the weed

Biologically, *I. cylindrica* possesses numerous features that foster its stretch and persistence. It has the ability to effectively disperse, inhabit, multiply and subsequently compete with and displace desirable vegetation and disrupt ecosystems over an extensive range of environmental conditions. It is an upright perennial grass with linear to lanceolate leaves, mostly basal leaf blades up to 1.5 m long and 2 cm wide (Langeland and Burks, 1998). Bryson (1999) pointed out that it is a C_4 grass found mainly in tropical and subtropical areas with an annual rainfall of 75 to 500 cm. It reproduces asexually by rhizomes and sexually by seeds (Hubbard *et al.*, 1944). According to Bryson and Carter (1993), it can disperse over long distances into a variety of habitats by wind-borne seeds. The optimum temperature for seed germination has been reported as 30 °C (Dickens and Moore, 1974). Its rhizome is very resistant to heat, including that generated by fire. Fire also triggers flowering and seed production in the species (Wilcut *et al.*, 1988a; FIPR, 1997).

Rhizome biomass can reach 40 t of fresh weight per ha (Terry *et al.*, 1997) and regrowth potential of roots is a critical issue in development of control measures against this weed. Bennett (2006) stated that 75-85% of the total biomass of the *I. cylindrica* stand comprises of underground rhizome. Regeneration from rhizome segments as small as 2 mm has been observed. Success of segment regeneration is determined by the original location of the segment on the rhizome, including proximity to, or inclusion of, axillary and apical buds, as well as environmental conditions (Holm *et al.*, 1977; Wilcut *et al.*, 1988b). Vegetative reproduction from rhizomes is a significant factor in human spread of the species because these are often found in soil moved as earth fill (Ayeni and Duke, 1985; Shilling *et al.*, 1997).

I. cylindrica rhizomes exhibit apical dominance (English, 1998), which may be a significant factor both in limiting the local spread of this grass *via* rhizomes (Wilcut *et al.*, 1988a) and reducing the efficacy of herbicidal control due to sub-lethal herbicide sink activity in dormant axillary buds (Shilling *et al.*, 1997). Moreover, several authors (Casini and Vecchio, 1998; Koger and Bryson, 2004; Koger *et al.*, 2004) also have reported that *I. cylindrica* rhizomes and foliage produce and exude allelopathic chemicals that further inhibit the success of co-occurring native plants. Paul and Elmore (1984) reported that this grass does not tolerate shaded environments because it assimilates carbon *via* the C_4 photosynthetic pathway.

There are only a few localised benefits from this plant. These include use for thatching, forage, erosion control, paper making and bedding material for livestock. There are some insignificant traditional uses of this grass for human food and medicines (Holm *et al.*, 1977). In this context, Coile and Shilling (1993) and Colvin *et al.* (1993) reported that the leaves of this grass contain silica bodies. Razor-like leaf margins, relatively low yields and very little nutritive and energy values make this a poor forage.

Impact of weed growth on rubber

I. cylindrica is a major weed problem in immature phase of rubber, both in relation to competition and dry season fires in smallholdings of South East Asia. It is usually not a menace after 10 years of planting rubber as it is then suppressed by the shade produced by rubber canopy (Bagnall-Oakeley *et al.*, 1997). According to Hairiah *et al.* (2000), annual growth of rubber is reduced by more than 50% in the first five years after transplanting and the tapping is deferred by 2-4 years due to its depressing effect. Moreover, yields are also reduced during the economic lifetime and the rhizomes penetrate roots of rubber allowing the entry of disease-causing organisms (Hairiah *et al.*, 2000).

I. cylindrica competes strongly for soil moisture and nutrients. In the early stage of tree development, it can reduce growth of the tree by up to 50% (Menz and Wibawa, 1995). *Imperata* grasslands are broadly believed to be an indicator of poor soil fertility. Moreover, frequent burning of this weed by itself causes soil degradation (Santosa *et al.*, 1997). Increased *I. cylindrica* groundcover provides more competition for the trees which reduces tree growth and shading capacity in turn, thereby increasing the level of *I. cylindrica* groundcover. Competition from this weed restricts tree growth when planting rate is low (Menz and Grist, 1996). At higher planting density, weed growth is restricted, but there are pessimistic consequences from inter-tree competition. This finding was in conformity with the work done in Indonesia where it took over 10 years for rubber trees to reach tappable girth without proper *I. cylindrica* control (Wibawa, 2001).

Gunawan *et al.* (1997) found that some farmers consider the fire hazards posed by the weed to be as serious a threat to their immature rubber as the direct competitive effect of it on rubber growth. Susceptibility in this period of immature rubber relates to the highly flammable *I. cylindrica* growing as understorey (Pickford *et al.*, 1992).

According to a model prepared by Menz *et al.* (1998), fire is considered as an economic disincentive to rubber growing in weed-infested areas. The potential losses due to fire should also be considered in taking up weed control measures (Grist *et al.*, 1998).

Management strategies

The wide distribution of this weed and its potential to become a serious problem of major plantation crops have generated considerable interest in its management. Some management strategies are summarised below.

1. Tillage

Cultivation can be a part of control of *I. cylindrica* (Wilcut *et al.*, 1988b). Slashing followed by burning is very effective for removing its foliage but has limited effect on the rhizomes which rapidly regenerate new shoots (Akobundu *et al.*, 2000; Avav, 2000; Chikoye and Ekeleme, 2001). Hoe weeding is labour demanding and can consume at least 70% of the total labour budget (Chikoye *et al.*, 2002) and most small-scale farmers cannot afford this option. Moreover, tillage may not be an option on many sites such as steep slope and established tree plantings. Most smallholders intercrop their land during the first 1-3 years after planting rubber and during this period *I. cylindrica* is reasonably well controlled (Bagnall-Oakeley *et al.*, 1997). The disadvantages of using tillage to control *I. cylindrica* are: (i) manual tillage by hoes is laborious and does not affect the rhizomes; (ii) it takes a long time to get acceptable control; (iii) it has to be repeated several times; and (iv) it is expensive and may promote soil erosion (Townson, 1991; Terry *et al.*, 1997).

2. Chemical control

Many researchers like Brook (1989), Townson (1991) and Terry *et al.* (1997) reviewed the use of herbicides for the control of *I. cylindrica*. Several herbicides are available for control of this grass. Much of the chemical control involves use of dalapon, paraquat and glyphosate applied with knapsack sprayer or antiquated high-volume sprayer systems. Out of dozens of herbicides tested for activity on *I. cylindrica*, only two herbicides, glyphosate and imazapyr have much effect on this grass (Willard *et al.*, 1996).Willard *et al.* (1996) also found that glyphosate at 3.4 kg a.i./ha and imazapyr at 0.8 kg a.i./ha caused great reduction in shoot and rhizome biomass and the rhizome infestation was reduced to 43% by glyphosate and 51% by imazapyr as compared to the control. Samarajeewa *et al.* (2004) reported that in coconut, glyphosate at 2.88 and 1.44 a.i./ha gave a significant reduction of weed biomass compared to other treatments like harrowing, circle weeding with glyphosate and mechanical slashing, and thus nut yield increased by 54% in three consecutive years compared to the unweeded plots.

The systemic herbicide glyphosate, which is highly effective against *I. cylindrica*, is the most widely used in rubber producing countries. It has no residual activity in the soil and can be safely used around desirable vegetation, whereas, imazapyr treated areas will often be devoid of vegetation for six months to one year. Chemical control is cheaper, faster and more effective than hoe weeding or slashing (Chikoye *et al.*, 2002). For example, glyphosate [*N*-(phosphonomethyl) glycine] and imazapyr{2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3 pyridinecarboxylic acid} can suppress this weed for 3 to 12 months, depending on the rate of application and timing (Onyia,1997). Multiple applications are expensive, but necessary to achieve significant control. Application of effective herbicide can decrease the labour cost for maintenance during the immature stage.

3. Cover cropping

Cultivating a leguminous cover crop under rubber trees is a practice recommended in all rubber growing countries. The most common cover crops used are *Pueraria phaseoloides* and *Mucuna bracteata*. Herbaceous cover crops in the genera *Calapogonium, Crotalaria, Mucuna* and *Pueraria* have been shown to effectively suppress the weed growth and can be used to prevent, and in some cases, eradicate *I. cylindrica* (MacDicken *et al.*, 1997). Velvetbean as cover crop for *I. cylindrica* control may be a better alternative for farmers without the resources to purchase herbicides (Udensi *et al.*, 1999). Mulyoutami *et al.* (2005) combined results from over six years of monitoring in three experiment sites and indicated that legume cover crops have different potential in controlling *I. cylindrica* thereby influencing growth of young rubber. The creeping legumes were clearly the top performers with *P. phaseoloides* at the top of the list followed by *M. bracteata*. Moreover, it is also reported that rubber with no cover crop and infested with *I. cylindrica* had not reached tappable girth.

4. Integrated management

Rubber being a long duration and widely spaced crop, there is ample scope of using cultural/mechanical and chemical methods in combination. Moreover, weeds are less able to adapt to a changing system that utilizes different control practices. Integrated weed management approach uses all feasible control measures in proper combination at different stages of weed and crop growth to get the most practical and economical results. The main aim of such kind of approach is to destroy the rhizome which is the main organ enabling spread. Cox and Johnson (1993) reported that *I. cylindrica* could be effectively managed with an adequate supply of labour, machinery and herbicides. Although tillage and herbicides will provide some control and suppression, long-term eradication is seldom achieved. An integrated management approach that uses all available methods, such as burning, disking, mowing, applying herbicide and revegetating the area, is recommended as the key to achieving long-lasting control of *I. cylindrica* (Johnson *et al.*, 1997; Dozier *et al.*, 1998; Jose *et al.*, 2002). Similar results were also reported by McDonald *et al.* (2006). Chikoye *et al.* (2005) also found that integrating tillage, glyphosate and cover cropping with velvetbean gave better control of cogongrass than the main effects of each option.

Initially, grass should be burned or mowed to remove excess thatch and older leaves. This initiates regrowth from the rhizomes, thereby reducing rhizome biomass. It also allows herbicides to be applied to only actively growing leaves, maximizing herbicide absorption into the plant. Ideally, burning should take place in the summer. A one-to-four month regrowth period has been shown to provide a sufficient level of leaf biomass for herbicide treatment (MacDonald *et al.*, 2006). To control *I. cylindrica*, it is essential to reduce the number of viable buds and prevent them from forming new aerial shoots. A continuous cropping system is often very important to prevent the establishment of *I. cylindrica* or to control it in early stages (Hairiah *et al.*, 2000). Once good control has been achieved, it is essential to introduce desirable vegetation as quickly as possible to prevent the area from re-infestation. Chikoye *et al.* (2005) also reported that integrated management may be a sustainable approach to the control of cogongrass and other weeds in corn. In Bekwarra community of Nigeria, integrated approach of *I. cylindrica* control by glyphosate, hoe weeding and *Mucuna* cover cropping was a relief (Anyam, 2004).

CONCLUSION

The management of this invasive grass in rubber growing areas where it is rampant is of great concern. Substantial efforts have been made and extensive research has been conducted around the globe for its control. Using a proactive approach to manage *I. cylindrica* in a rubber plantation can decrease below ground direct competition for nutrients and moisture and also indirect competition from the risk of fire. Burning, cultivation, cover crops and herbicides have been used with varying degrees of effectiveness. For its control, integrated approach is the best. Burning followed by application of broad spectrum herbicide like glyphosate or imazapyr and also rapid establishment of cover crops which have already proven their efficiency is the best possible solution. Research needs to concentrate on developing more sustainable methods which promote a cost - effective, eco-friendly and long- term control of *I. cylindrica* in rubber smallholding.

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