Noxious Weeds in Asian Tropics and Their Control

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Abstract

Noxious weeds usually possess some characteristics in common, e.g., rapid multiplication, adaptation to changing circumstances, high competitive ability, and resistance to control measures. Dormant tubers of *Cyperus rotundus* L. which are small and hard to identify make the weed a serious one in the same way as a piece of rhizome of *Imperata cylindrica* (L.) Raeuschel in the soil. The tuber or rhizome under unfavourable conditions stays dormant underground. With its high competitive power and resistance to most preemergence herbicides plus its irritating hairs on leaves when touched, *Rottboellia cochinchinensis* (Lour.) Clayton is considered to be very serious in any crop.
Management of weed species mentioned above is discussed in the paper.

Key words: *Cyperus rotundus, Imperata cylindrica, Rottboellia cochinchinensis,* noxious weeds.

Introduction

Many people may wonder what a noxious weed is. According to WSSA (1989), a noxious weed is a plant regulated or identified by law as being undesirable, troublesome, and difficult to control. Mercado (1979) described noxious weeds as those which are highly competitive, persistent, and are difficult to control. She also mentioned five major characteristics which contribute to their aggressiveness and persistence. However, Cardenas *et al*. (1972) divided noxious weeds into two categories, the primary and the secondary. Primary noxious weeds are those which are widely distributed and established in a region, are very aggressive and difficult to control. Secondary noxious weeds are defined as either: (a) those which are aggressive, widely distributed and established in a given region, but are relatively easy to control, or (b) those which are aggressive and difficult to control but may not yet have become established. They also defined common weeds as those which are easy to control and in general, although well distributed, are not aggressive. Thus, aggressiveness (e.g., a plant with rank growth, rapid multiplication, and/or with highly competitive ability, or a plant equipped with harmful organs or toxic substances and tolerance substances) and tolerance to adverse environmental conditions (including control measures) are the key factors to determine whether it is noxious or not. In general, noxious weeds are noxious for many or most crops but may not be necessary noxious for all the crops. This is due to the difference of crop nature, cultural practices, and especially the herbicide use.

Although actually there are many noxious weeds in the Asian tropics, only three species are selected to suit time and pages allocated.

Cyperus rotundus L.

Common name: Purple nutsedge. Family: Cyperaceae

Origin. It is native to India and now a weed affecting 52 crops in 92 countries in the tropics and subtropical areas (Holm *et al.*, 1977).

Description. A perennial sedge with tuberous base producing rhizomes which later on give off tubers that may or may not develop shoots. Culm: slender, triangular as in most sedges, 15 to 50 cm tall. Leaves: erect, glabrous, linear, grass-like, 5 to 30 cm long and 2 to 6 mm wide. Infloresence: simple or compound

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umbel with spikelet clustered at the tips of branches, 1 to 3.5 cm long and 2 mm wide containing 10 to 40 flowers, and protected by reddish brown glumes with 5 to 7 nerves.

Reproduction. The weed mostly reproduces itself from tubers. Tuber germinates under appropriate conditions, by giving off a sprout or short rhizome that begins a new shoot, and a basal bulb develops just under the ground line. The basal bulb later on forms a new rhizome and becomes a new plant again (SEAWIC, 1992). Single tuber can produce 39 tubers in 4 months under favourable conditions (Ahmed, 1993). Under field conditions it produced about 4 times the number of original counts (from 120 tubers/0.25 m^2 and 20 cm deep) in a year (Thongma and Suwunnamek, 1988). There are many reports stating that tuber production is much higher than these figures (Mercado, 1979). This mechanism and tuber dormancy result in weed survival even under extreme conditions.

Problem. Infestation of *C. rotundus* mostly occurs in cultivated fields, and especially where herbicides are used repeatedly or routinely. So far in Thailand, infested crops are field corn, sugarcane, soybean, sorghum, and also lately vegetables, e.g., shallot, garlic. Modern field crop plantations and especially seed production fields are also affected. For the latter, herbicides are used because weed-free conditions are required to facilitate intensive farm practices, and also at the same time to avoid that seeds with a cost more than ten times that of grains become contaminated with weed seeds. The problem in soybean is slightly different, as tubers in paddy fields are not killed by the water level and when soybean is planted without tillage after rice, the infestation may resume. Again, herbicides used in soybean cannot control nutsedge. *C. rotundus* also causes problems in lawns and greens in golf courses. Nutsedge plant grows faster after mowing compared with grass.

Competition. *C. rotundus* usually absorbs more nutrients than the crops. Nutsedge plants growing with cotton in a 5 : 1 weed crop ratio can take up about twice as much N, one-third more of P and three-fourths more K from the soil compared with cotton (Guantes, 1974). However, crop species and even cultivars as well as seasonal changes determine the severity of the weed. Full season competition with *C. rotundus* population ranging from 600 to 1600 plants/m^2, caused 35 to 89% losses in vegetable crops in Brazil (William and Warren, 1974). Garlic is ranked first followed by okra, tomato, and carrot. Upland rice must often seriously compete with nutsedge. In Thailand, in sweet corn, ear weight was significantly reduced by the low density of nutsedge plants (10 to 20 shoots/0.25 m^2) compared with weed-free fields in the dry season, but not in the wet season during which medium density (20 to 40 shoots) reduced the yield. Grain yield of field corn Suwan 1 was significantly reduced by medium density of nutsedge in the dry season but required a high density (50 to 80 shoots) for the reduction in the wet season. There were also different responses among field corn cultivars (Ahmed, 1993).

Management. Established infestation of *C. rotundus* is very difficult to eradicate practically. Only temporary control from crop to crop at a high cost or with a larger number of operations, can be achieved. In planting management weak points of the weed are as follows: 1) shoot and tuber production is markedly reduced by 20% light intensity (Mercado, 1993), 2) tubers having been soaked in water for 200 days still retain full viability (Ester, 1932), 3) dried tubers with a moisture content of 12% (72 hr sun-drying) are unlikely to germinate (Rao and Nagamjan, 1963). Thus, practically management should integrate several methods together, i.e., preventive measures, physical control, habitat management, and also chemical control.

Preventive measures, (see in conclusion).

Physical control includes cultivation for land preparation, inter-row tillage (once or twice), and post-harvest follow-up. These practices at least can lead to tuber drying and germination decrease. Thorough disking at 2 to 3 week intervals, for growing seasons was recommended to eradicate *C. rotundus* (Westmoreland *et al.*, 1955). For a small area, forking to take out the bulbs or tubers is effective, but very laborious.

Habitat management involves techniques related to the environment to reduce or eliminate competition of the weed. Size and nature of crop plant, density per unit area and its response to the environment should be considered first.

Crops which can compete with nutsedge should grow fast and produce enough shade to suppress the weed. Even though mulching with rice hull or sawdust is not effective, with a thicker layer, new plants will develop within the layer and will be easily hand-pulled. This method is suitable for a small area.

Chemical control is so far the main tool for seriously infested areas during the crop season. Even though there are a number of herbicides effective on *C. rotundus* (Mercado, 1979) only those familiar and practically used in the tropics will be mentioned.

Glyphosate and also sulfosate, translocated and non-selective chemicals, are quite effective for the weed at 2.25 kg a.i./ha. Lower rate at 1.13 or 1.69 kg a.i./ha is effective too if combined with ammonium sulfate, 10 kg/ha at the spray volume of 500 l/ha (Ahmed, 1993). *C. rotundus* should be sprayed at 3 weeks after emergence of tubers, and mostly as preplant treatment in no-tillage method for any crops. Generally, there is no residual activity, but in certain crops and soils careful studies should be conducted in advance to confirm the safety.

2, 4-D is also translocated and selective for the control of' broadleaved weeds in graminaceous crops. As overall spray at 2 kg a.i./ha (very high) for the control of nutsedge in sweet corn at 25 days after planting, 2, 4-D also gave good results (Ahmed, 1993). In the case of pre-plant treatment, it should be combined with 10 kg urea (Thongma and Suwunnamek, 1988). Rate for some crops should be reduced. Some tubers are killed by 2, 4-D but with a lower percentage than with glyphosate.

Arsonates (DSMA, MSMA), even with some translocation, should be considered as contact chemicals and with only top kill. MSMA can also be used to control grasses in cotton and lawn (Meister Publishing Company, 1994).

Chlorimuron belongs to the sulfonylurea group for the control of broadleaved weeds and sedges. At 30 g a.i./ha it was effective when applied at preemergence in soybean. Chlorimuron (12 g a.i.) combined with glyphosate (1.5 kg a.i./ha) applied as pre-plant control led satisfactorily nutsedge (2 wk old) in soybean without affecting the yield (Faijaroenmongkol, 1995).

Imidazolinone herbicides (imazaquin, imazethapyr, and imazapyr), are also effective for *C. rotundus*. Imazaquin and imazethapyr were both effectively used as preemergence herbicides in soybean at 420 and 125 g a.i./ha, respectively. Imazaquin 280 g a.i./ha combined with glyphosate 1.5 kg a.i./ha applied as preplant also provided an adequate control of the weed (2 wk old) in soybean. Even though imazapyr at 40 g a.i. also gave the same degree of control, it decreased soybean yield (Faijaroenmongkol, 1995).

Imazapyr possesses a long residual activity ranging from 3 months to 2 years under field conditions and it is non-selectively used in uncultivated land (WSSA, 1989).

Uses. Nutsedge tubers can be used as they are or as an ingredient in quack remedies in antidysenteric and carminative (suffering from flatulence) preparations (Muanwongyat, 1985). In agriculture, for ridged plantations, (e.g., citrus) in the low land areas of Thailand, it has been observed that the farmers grow *C. rotundus* on the banks to prevent erosion.

Rottboellia cochinchinensis (Lour.) W.D. Clayton

Common name: Itchgrass. Family: Poaceae (Gramineae)

Origin. The grass is native to India and a weed in 18 crops in 28 countries within 20°C isotherms in the northern and southern hemispheres (Holm *et al.*, 1977).

Description. It is an aggressive annual grass belonging to the tribe Andropogonaceae. Culm: stout with still roots, hairy, erect branched, 1.5 to 2.5 m high; tillers produced at the basal nodes, branches arise at the axils of upper leaves. Leaves linear-lanceolate, about 1 m long, and 2.5 cm broad, tapering to each end, pale green color with well marked white midribs and rough sharp edges; sheaths with white bristles which can cause irritation when coming into contact with the skin. Inflorescence: spike-like, with cylindrical spikelets in pair compressed against the rachis and tapering towards the apex, spikelet glabrous and awnless, one sessile and the other on small stalk. Fruit: cylindrical caryopsis containing seed, at maturity falls off from the apex to the base.

Reproduction. The weed reproduces, by seeds in large numbers, ranging from about 4,500 to 50,000 seeds/plants/cycle depending on the growing season. Seeds show dormancy which is due to the presence of hull and immature embryo also. Intact seeds were found to germinate at the rates of 1 and 7% after 8 and 12 months of storage at room temperature, respectively, while dehulled seeds germinated at the rate of 56 and 85%, respectively (Jantawinyurag, 1995). Under field conditions dormancy period could be shorter. However, some seeds are still viable even for more than 2 years in soil if the conditions are not

suitable (Mercado, 1978).

Problem. The grass is a problem in upland and plantation crops in certain areas once it gains a foothold there by any means. It is very competitive and we can observe that it tends to dominate other weeds, even the very noxious ones like *Imperata cylindrica* (L.) Raeuschel and weeds like *Cyperus rotundus*. Therefore, we can find the grass both in cultivated and uncultivated land. It is a serious weed in sugarcane in the Philippines, Indonesia, Malaysia, and Thailand (SEAWIC, 1991). Problems and causes can be summarized as follows: 1) due to dormancy, seeds germinate continuously after the earlier flush has been controlled, 2) seeds can germinate even from deep soil (more than 50% from 20 cm deep), 3) bristles on leaf sheaths and blades cause severe itching in workers handling the weed or crop, 4) it is impossible to get rid of all the weeds by normal routine operations, which results in persistent infestation, 5) as no one wants to go into the infested areas, crop production sustains severe loss.

Competition. Studies with soybean showed that even a single plant of itchgrass in 1 m^2 can cause a significant reduction of yield (more than 30%) in the wet season, but not in the dry season during which two plants are required to reduce the yield. Sixteen plants caused 65% yield reduction in the wet season but only 25% reduction in the dry season (Jantawinyurag, 1995), because the weed does not grow very well in the dry season (plant height is about 60 cm compared with 165 cm in the wet season). Another reason is that soybean plants grow better in the dry season than in the wet season. Crops respond to itchgrass differently. Studies with field corn in the late wet season show that 5 and 40 plants/m^2 of the grass caused a yield reduction of 8 and 43%, respectively (Sukwiriyasatira, 1995). Compared with soybean mentioned above, field corn is more tolerant of itchgrass. Competition studies showed that field corn can tolerate itchgrass for 2 weeks at a density of 80 plants/m^2 while soybean can tolerate only 16 plants/m^2.

Studies on the area of influence of itchgrass in soybean showed that the grass can reduce seed yield significantly (more than 30%), if it grows close to crop plants at a distance of 7.5 cm and 50 cm in the dry season (Jantawinyurag, 1995). It is surprising that the effect was much more pronounced compared with the report in which soybean seed weight within 20 cm of the weed was reduced by only 15 to 21% (Lejeune *et al.*, 1994). However, there are a number of biotypes of itchgrass and each responds differently to the changes in the weather conditions.

Management. Actually preventive control should be considered where a farm is likely to be invaded by the grass (see in conclusion).

In newly infested areas, eradication measures are essential. Successful eradication of the grass can be obtained in three years or 18 months at least, so long as the areas are regularly checked and the weed plants removed all the time before seeding (Mercado, 1978). Studies by Richards and Thomas (Richards and Thomas, 1970) have shown that the seeds may persist in soil for three years at the utmost.

Unlike purple nutsedge, itchgrass is not sensitive to shade. Therefore, growing crops like soybean or field corn to suppress the weed's growth is not successful. Even when legume cover crops are grown, they must be supported at the beginning until they form a thick bush to suppress the grass. So far, a lesser amount of herbicides can be used in corn (practically only preemergence herbicides) whereas a larger amount is necessary for legume crops. Thus, crop rotation with legumes or other crops including both preemergence and a number of postemergence herbicides can be effectively used to decrease the infestation.

Interrow cultivation (disking, off-barring and hilling up) can be used in row crops. However, it should be followed by hoeing, especially for the crops in the row.

Herbicides play a key role in dealing with itchgrass as well as indirectly in spreading the grass. Very few residual chemicals can be used effectively on itchgrass, and among these are herbicides belonging to dinitroaniline group, e.g., pendimethalin, trifluralin, dinitramine, etc. (Mercado, 1978). Pendimethalin is well known and easy to use in many crops. It can control other grasses as well at 1.5 to 2.5 kg/ha, but is not much effective for certain broadleaved weeds, e.g. *Euphorbia heterophylla* L. The chemical if combined with atrazine at 1.5 kg/ha each was very effective in corn (Suwunamek *et al.*, 1990). In sorghum, the herbicides should be applied at 2 weeks after crop emergence and also after the destruction of the first flush of seedlings. In soybean adequate weed control was obtained with pendimethalin alone at 2.2 kg/ha and also with the combination of imazethapyr at 150 g/ha plus oxyfluorfen at 250 to 500 kg/ha or clomazone at 75 to 150 g/ha without affecting yield (Jantawinyurag, 1995).

For foliar-applied herbicides, it was found that most aryloxyphenoxy alkanoic herbicides were effective (Jantawinyurag, 1995), i.e., quizalofop-tefuryl and quizalofop-ethyl, fluazifop-butyl, haloxyfop-methyl, and fenoxprop-ethyl at 0.25 to 0.5 kg/ha. In soybean, double applications at 3 and 6 weeks after crop emergence can decrease the weed population, resulting in the increase of grain yield. However, still there was a new flush of seedlings coming up. Preemergence application of herbicide followed by postemergence application gave similar results.

Diclofop-methyl and cyclohexanedione herbicides e.g., clethodim, cycloxydim, and sethoxydim, did not provide a satisfactory control (Suwunnamek *et al.*, 1990).

Nicosulfuron is also active on itchgrass in field corn as direct spray, but overall application is still not sufficient. Ametryn at a high rate, 4 kg/ha plus surfactant, also can give the same results as glyphosate, glufosinate, asulam (Suwunnamek *et al.*, 1990), MSMA, DSMA, paraquat, and others (Mercado, 1978).

Therefore, itchgrass in cultivated and uncultivated land, if not established, for a long period of time should not pose any problem as many herbicides or methods of control can be selected depending on the circumstances.

Use. Some biotypes of itchgrass which are not very hairy and less itching, and do not germinate in the dry season, can be grown in the wet season, especially in lowland areas. In the dry season the plant is almost 2 m high and the seeds are mature. When it is pressed to the ground, vegetable crop seedlings, e.g., cabbage, Chinese cabbage, kale are transplanted without tillage. Itchgrass plant mulch can preserve moisture and repel other weeds as well as itchgrass itself. In most cases people can grow two crops before the rain comes.

Imperata cylindrica (L.) Raeuschel

Common name : Cogongrass. Family : Poaceae (Gramineae)

Origin. A native of the old world, it occurs in all the continents and is the worst weed of southern and eastern Asia. Seventy-three countries reported that it affects 35 crops (Holm *et al.*, 1977).

Description. Perennial grass, compact or loosely growing. Culms : erect, 15 to 120 cm high, arising from an extensive system of hard, scaly rhizomes, unbranched. Leaves : linear-lanceolate, up to 150 cm long, 4 to 18 mm wide : sheaths smooth or margins ciliated : ligule short, truncate, 0.5 to 1 mm long. Inflorescence : panicles, dense, and spikelike, 3 to 20 long, 0.5 to 2.3 cm wide, creamy-white or silvery-white silky hairs : spikelets 3 to 6 cm long surrounded by silky hairs 10 mm long. fruit : caryopsis, 1 to 3 mm.

Reproduction. Propagation occurs by seed or vegetatively from numerous rhizomes.

Varieties. *I. cylindrica* is widely distributed between latitudes 45° in both the northern and southern hemispheres. Following the examination of a large number of specimens. Rubbard *et al.* (1944) classified them in the five major groups :

1. var. *major* is most widely distributed from Japan, southern China through the Pacific Islands and Australia to India and eastern Africa.
2. var. *africana*, next is most widely distributed from Senegal and Sudan southward through Africa.
3. var. *Europa* extends from Portugal through southern Europe to the arid regions of Central Asia and Afghanistan.
4. var. *latifolia* is found only in northern India.
5. var. *condensata* is found in Chile in the coastal region between lat 30° and 40° N.

Var. *major* is most aggressive and found mostly in Asia. It has smaller spikelets than others and has hairy nodes unlike mostly others.

Problem. Cogongrass causes major problems in plantation crops, e.g., rubber, oil palm (Malaysia), tea (Ceylon, India, Indonesia), coconut (Ceylon, Malaysia) (Holm *et al.*, 1977). It is also a major problem in newly reforested plantations in Thailand. It affects fruit trees as well as perennial crops like pineapple and sugarcane. Annual upland rice is not much affected as the land is tilled every 3 to 4 months for soil preparation, and normally the soil is subjected to sun-drying for more than a week and then retilled, resulting in the eradication of a large number of rhizomes every time. Upland rice is usually infested with the grass when land preparation is inadequate. Sometimes farmers never perform land preparation because they practice no-tillage method. Another reason is due to the fact that most of the upland rice

fields are located in or near the forest and are usually surrounded by the grass as patches or as a sheet. The situation is the same for plantation crops. Normally the areas for newly planted plantations are close to the forests which are full of cogongrass. On the other hand sometimes crops are grown in areas once dominated by the grass. As it is not completely eliminated, problems arise.

Like purple nutsedge, cogongrass multiplies rapidly both sexually and asexually. Ivens (1975) estimated that the number of florets per inflorescence ranged from 500 to 1,000 and in a moderate infestation, there could be 10 to 20 inflorescences per m^2. Plume seeds can be carried by the wind and other factors, even flowing water.

Santiago (1965) reported 95% germination within one week of harvest and seeds viable for at least one year. Rhizomes developed after 4 wks of germination and plant grew fast then after dominating an area of 4 m^2 in 11 wks (Ester, 1932). A net of rhizomes is present underground, mostly at a 15 to 20 cm depth. Section with a diameter of 2 to 5 mm even at 1 to 5 cm depth can germinate to a new plant. Not all the rhizome nodes have buds and only those near the terminal one can germinate.

Cogongrass is tolerant of drought. Burning, cutting, and grazing can lower the rhizome weight, but not killed the weed while enhancing flowering (Soerjani, 1970). It can tolerate waterlogging on heavy soil (Holm *et al.*, 1977). Based on my own observation, even if the weed remains for 3 months in soil under water level, it may not be killed.

The weed is generally recognized as a light-loving plant which can be "shaded out" under a heavy canopy. Though it is weakened it remains ready to invade areas that are opened up as a result of disease or ant invasion. Soerjani (1970) found that even 50% shade did not eradicate the weed.

Cogongrass can thrive in a wide range of soils from poor to highly fertile ones. However, it becomes established most quickly on medium to good soils and is less frequently a pest.

Competition. Cogongrass is very competitive and the growers have realized this for a long time. Experiments in rubber plantations in Malaysia show that, for the first 5 years after being planted, the growth of trees surrounded by the grass was about 50% of the annual growth of trees which were free from the weed or which had a legume ground cover consisting of *Centrosema pubescens* (Anonymous, 1938).

In immature rubber, Yeoh and Pushparajah (1976) found that one year after the control of *I. cylindrica* by dalapon and glyphosate, the growth increment in untreated plots was 18% significantly lower than in the treated plots. Forest trees can suffer from the weed. Coster (1932) reported that the growth of teak trees, *Tectona grandis*, in the first year was 13 cm in plots of *I. cylindrica* and 100 cm in plots where the weed had been removed.

Management. Actually before planting farmers should ascertain that they do not have the grass in the area. Therefore, eradication is necessary as well as prevention (see in conclusion). In case it has spread already, control must be implemented.

Tillage method is used where the situation permits. Cross cultivation with a tractor (deep enough) to turn up the rhizomes to expose them to the sun 3 times at weekly intervals in the dry season gave 90% control of the weed (Prompuak, 1955). The first ploughing should take place after the last rain while soil is still soft. Kasasian (1971) also reported that the weed can be eradicated by successive cultivation (every 3 to 4 weeks). The fragment with a smaller number of nodes (short rhizome pieces) germinated less compared with those with a larger number of the nodes (longer piece). This method can be combined with others.

Slashing is still practiced by some fruit growers. Actually, they do not allow the weed to come close to the base of crops or canopy edges. The slashed leaves are collected and thrown under the tree canopy to preserve moisture, when drought is severe in the dry season. The use of *Vetiveria zizanioides* may be preferable,but research is needed.

For habitat management, one should know that cogongrass is sensitive to other weeds as mentioned earlier. *R. cochinchinensis* was reported to be grown to suppress cogongrass (Bamrungwate, 1981). In another case even now people still grow a small and climbing grass, *Microstogium oiliatum* (Trin.) A. Camus, to suppress this weed (Saiyupratham, 1959) and also other weeds in mangosteen plantations. In Thailand, sesame (*Sesamum indicum* L.) has been used for the control of the grass for a long time. Premasthira and Zungsontiporn (1993) also grew 2 sesame plants in association with 2, 3, and 4 cogongrass plants in a container 490 cm^2 with soil and they found that the dry weight of the grass was reduced by more than 50%

and tillering reduced by 21 to 44%.

Inter-cropping and growth of cover crops are commonly practiced in rubber or oil palm plantations due to the wide row space for these crops (7 to 8 m), otherwise weeds may grow. Legume cover crops mostly used consist of *Calopogonium mucunoides, Pueraria phaseoloides,* and *Centrosema pubescens* planted in a mixture in a ratio of 2 : 2 : 3 at the rate of 7 kg/ha, or only the last two species can be used at the rate of 2 : 30. Lately another legume plant which is very effective, *C. caeruleum*, can be added at 350 g/ha.

Chemicals are necessary for the control of the grass. Previously dalapon was the only effective chemical. Now, glyphosate (also sulfonate) is practical and almost without soil residues. Optimum rate depends on the location (possibly biotypes ?). In Thailand, the rate of 1.92 to 2.25 kg a.i. in 625 l/ha is enough (Boonsrirat and Lee, 1985) but in Malaysia (Lee, 1985) and Indonesia (Thongmee-arkom *et al.*, 1985) 2.16 to 4.32 kg a.i. in 550 l/ha are used. High spray volume causes problem in finding the water, especially in hilly areas. Lately modifications have been made to use a lower volume. Mist blower can also be used practically at 30 l/ha (Boonarirat, 1995, personal communication). However, a good quality surfactant with a sufficient amount is required.

Imazapyr is another compound which is very effective on *I. cylindrica*. Optimum rate is 0.5 to 1.0 kg a.i./ha (Boonsrirat *et al.*, 1985). Due to its residual activity the chemical is not very popular. However, it was selectively used for rubber trees from 9 months to 4 years at 0.375 to 1 kg a.i./ha. Also, 2 years old plants were tolerant to 6 applications of the chemical (0.75 to 1.5 kg a.i.) made at 90 day intervals (Boonsrirat *et al.*, 1985). Certain forest species, i.e., *Acacia mangium,Schima wallichii, Eucalyptus deglupta,* and *Swietenia macrophylla*, were found to grow better under imazapyr treatment compared with other treatments, because of the improved efficiency of imazapyr on cogongrass (Subagyo *et al.*, 1990). Imazapyr was applied 1 month before planting. For growing cover crops, one month delay after cogongrass application with imazapyr was sufficient as the treated plants slowly decomposed, and in the area few germinating weeds were observed (Boonsrirat, 1995, unpublished). The chemical did not exert a deleterious effect on rice either when applied 1 month or more before sowing of seeds (Cox and Johnson, 1990).

However, in addition to herbicide efficiency and selectivity, the cost should be considered too. Usually farmers combine physical and chemical methods, or chemical and habitat management together, e.g., herbicide application preceded by burning or slashing (herbicides applied to new regrowth), or growing legume covers after herbicide application.

Uses. *I. cylindrica* can be used for thatching for houses. The grass in large areas can be a standby forage crop for cattle, but only the very young plants after burning are suitable. Leaves can also be used as mulching material for vegetable growing, especially when grown by seedling. It can also be used as soil binder to prevent erosion (Holm *et al.*, 1977). For medicinal purpose, the grass rhizomes can be used as diuretic treatment (Muanwongyat, 1985).

Conclusion

As established infestation of noxious weeds is very difficult to control, preventive measures should be adopted. The field should be inspected regularly and the weeds removed when spotted every time. Escape weeds must be absolutely eradicated. Cover crops should be used both in cultivated and non-cultivated areas. *Dolichos lablab* is a good plant and young pods can be eaten as a food.

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Discussion

Prasan, V. (Thailand) : 1. I would like to mention that *Cyperus rotundus* is used as a cover crop in the plantations on the West coast of Thailand where it suppresses other weeds. It is also used as food by the villagers. 2. *Imperata cylindrica* which causes extensive damage to crops cannot easily compete with *Eupatorium odoratum* which in turn can be easily controlled.

Answer : 1. We do not have enough information about these aspects. 2. It depends on the conditions. Although *Eupatorium comellina* could be used, this weed is characterized by the presence of strong roots and moreover is thorny.

Morita, H. (Japan) : Is there any possibility that the lowland biotypes of *Imperata cylindrica* could eventually grow as noxious weeds in irrigated paddy fields in Thailand ?

Answer : We do not know yet. Under lowland conditions,the plant dies under water but when the water level decreases, weed growth resumes.

Moody, K. (IRRI) : In response to the previous question, a colleague of mine showed me a slide of a biotype of *Imperata cylindrica* growing in transplanted rice in the Philippines. I have never visited this area.

Tewari, A.N. (India) : 1. *Sesamum indicum* has been reported to suppress the growth of *Cyperus rotundus*. Is it because of allelochemicals released by *S. indicum* or due to smothering effect ? 2. Glyphosate has been found to be very effective for the control of Tiger grass (*Saccharum spontaneum*) and *Cyperus rotundus* (Purple nutsedge) when it is applied during the rainy season (August-September) in India. However the herbicide does not give satisfactory control of these weed when it is applied during summer when the temperature is very high and humidity is low. What could be the possible reason for this differential response ?

Answer : 1. I do not know. 2. In Thailand, we apply glyphosate in the rainy season as the compound is not effective under hot conditions.

Meylemans, B. (Belgium): *Mucuna pruriens* (Velvetbean) is used successfully by shifting cultivators in Central America as a cover crop to control *Imperata cylindrica*. Preliminary trials in Sri Lanka appear to be in 6 weeks time we observed a 50% reduction of the rhizomes.

Answer: The variety Japonica seems to be very effective.

Duong Van Chin (Vietnam): How do you plan to reduce herbicide use to promote sustainable production of rice when there is a shortage of labour due to the competition between industry and agriculture ?

Answer: As I mentioned in my presentation, wet-seeded rice can be grown as an upland crop to induce upland weeds to germinate and thereafter proceed to control some of the weeds. Herbicide can be applied randomly and emphasis should be placed on the use of postemergence herbicides.