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Wild Bitter Gourd, *Momordica charantia* L. (Cucurbitaceae): A Creeping Weed of Oil Palm and Its Management

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This paper reviews information on the biological aspects and discusses briefly the weediness of wild bitter gourd (WBG) including its management, in oil palm plantations. WBG is considered a serious weed in oil palm plantations because: i) it can grow into blanket sheet in the inter-row areas in immature and mature plantings, ii) it can encroach onto immature palms which is difficult to control and increase risks of herbicide phytotoxicity during routine circle spraying, and iii) it can grow as epiphytes on palm trunks requiring control (both as a weed and also sources of seeds for further infestation). The control of WBG in oil palm plantations involves various measures which include preventive measures (planting legume covers, maintenance of natural covers, mulching) and applied measures (manual and mechanised weeding, chemical control). The planting of legume covers and the maintenance of a less competitive natural cover of selected indigenous species in oil palm plantations are sound methods of weed management including the exclusion of noxious weeds (like WBG). When WBG encroaches onto immature palms, manual weeding or decreeping is the only safe method of weed control. Post-emergent chemical control of M. charantia *has been reported by many researchers and they make no recommendations for the efficacy or suitability of these herbicides against* M. charantia *in named crops. A WBG herbicide evaluation with six herbicide treatments gave effective control after three rounds of spraying. These are: (i) paraquat + metsulfuron-methyl at 2.8 L + 75 g per hectare, (ii) glyphosate + metsulfuron-methyl at 1.5 L + 75 g per hectare, (iii) glufosinate-ammonium at 3 L per hectare, (iv) fluroxypyr at 2 L per hectare, (v) dicamba at 1.5 L per hectare and (vi) triclopyr at 1.5 L per hectare. In any spraying programme to eradicate thick sheet growth of WBG in inter-row areas, three rounds of spraying were required to achieve complete eradication by killing off the original weed stand and killing off any regeneration/new seedlings from germination of seeds. However, the risks of crop phytotoxicity limits the choice of herbicide to only spraying of paraquat + metsulfuron-methyl at 2.8 L + 75 g per hectare and glufosinate-ammonium 3 L per hectare for the control of WBG and other weeds around the periphery of the immature palm during circle spraying. More important, careful spraying by trained operators to minimise lower frond contact is required. Paraquat is not available now and may be replaced with sodium chlorate (sodium chlorate + metsulfuron-methyl at 5.5 kg + 75 g per ha). Another approach can be the sequential spraying of the herbicide mixtures: two rounds of spraying glyphosate + metsulfuron-methyl and the third spraying with only a single selective broadleaf herbicide (fluroxypyr, or dicamba, or triclopyr) to kill any WBG regeneration in order to allow the growing of soft grasses as natural covers.*

Keywords*:* Momordica charantia*, wild bitter gourd, weed, oil palm plantations, management.*

The term wild bitter gourd (WBG) is used to differentiate the creeping weed variety from the cultivated variety which is eaten as a fruit vegetable. Similar term is used to describe other weeds e.g. wild banana, wild ginger, wild bamboo, etc. As mentioned in Wikipedia

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(Anon., 2021), the cultivar of bitter gourd common in China is 20–30 cm long, oblong with bluntly tapering ends and pale green in colour, with a gently undulating, warty surface. The variety more typical of India has a narrower shape with pointed ends, and a surface covered with jagged, triangular "teeth" and ridges that bear miniature fruits of only 6–10 cm in length.

WBG, *Momordica charantia* is listed as one of the many creeping broadleaved weeds of plantations and Chung *et al.* (2013) support the status of WBG in their book with several pictorial identifications. The WBG in the oil palm plantations has much smaller fruits which resemble the small fruits of the Indian variety. It is speculated that WBG may have been introduced by the early Indians working in rubber plantations. This fast-growing plant which has been widely introduced and grown to be consumed as a vegetable and to be used in traditional medicine, is believed to have escaped from human cultivation and has naturalised to become a serious threat for native plant communities (PIER, 2014).

In a lecture on weed management many years ago, the writer spoke about WBG as a serious weed in oil palm plantations (*Figure 1*). A participant from Papua New Guinea (PNG) responded that WBG was kept as a ground cover plant in oil palm plantations. However, this has not been confirmed. In some parts of PNG, *Momordica* growth is so vigorous that it rapidly removes the competition of all other ground flora and overgrows in young palms so densely that the palms are killed (Turner & Gillbanks, 2003). The fast-growing aspect of WBG is a favourable feature for its establishment as ground cover. However, its lush and invasive growth as a ground vegetation may be highly undesirable and competitive to the main crop as it is difficult to manage, especially when its encroaches onto immature

Figure 1 An almost blanket sheet growth of wild bitter gourd in the inter-row areas of immature oil palm plantation

oil palms.

Its lush growth into thick sheet in the inter-rows, undesirable encroachment onto immature palms, difficulty to control and rapid recolonisation from seed bank have made WBG a serious weed in many immature oil palm plantings. The weed problem has become more obvious after repeated rounds of spraying involving mixtures of systemic herbicides (grass and broadleaved weed herbicides). A normal field with ground covers of mixed species of grasses, soft ferns and broadleaved plants can be transformed into an almost pure stand of creeping weed, especially when weed succession favours the establishment and colonisation of WBG.

This paper reviews information on the biological aspects and discusses briefly the weediness of WBG, including its management, with reference to oil palm plantations.

PLANT DESCRIPTION

A brief account of WBG from various sources is compiled below for quick reference. It also includes specific observations by the author.

Scientific name

Momordica charantia L.

Synonyms

i. *Cucumis argyi* H.Lév.
ii. *Cucumis intermedius* M.Roem.
iii. *Momordica charantia* subsp. *abbreviata* (Ser.) Greb.
iv. *Momordica charantia* f. *abbreviata* (Ser.) W.J.de Wilde & Duyfjes
v. *Momordica charantia* var. *abbreviata* Ser.
vi. *Momordica charantia* var. *longirostrata* Cogn.
vii. *Momordica charantia* var. *muricata* (Willd.) Chakrav.
viii. *Momordica chinensis* Spreng.
ix. *Momordica elegans* Salisb.
x. *Momordica indica* L.
xi. *Momordica muricata* Willd.
xii. *Momordica sinensis* Spreng.
xiii. *Momordica thollonii* Cogn.
xiv. *Sicyos fauriei* H. Lév.

Classification

Kingdom : Plantae
Phylum : Tracheophyta
Class : Magnoliopsida
Order : Cucurbitales
Family : Cucurbitaceae
Genus : *Momordica*
Species : *charantia*

Common names

Bitter melon, bitter apple, bitter gourd, bitter squash, balsam-pear.

Malay names

Peria, Peria katak, Peria laut.

Chinese names

苦瓜 (kǔ guā)

Distribution

It is cultivated in many countries as a fruit vegetable. The wild forms of WBG "are distributed in tropical and subtropical Africa, S, E and SE Asia, Malesia, Australia and Pacific, India-Andaman and Nicobar Islands, South, North (except North West Himalayas), East and North East Pakistan, South East Asia: Thailand, Indonesia (Sumatra, Java, Borneo), Malesia, Vietnam, Laos, Cambodia, Myanmar,

Sri Lanka, parts of China (Yunan), Nepal" (CABI 2019).

Habitats

M. charantia grows under a very wide range of conditions throughout the tropics and subtropics (CABI, 2019). Its rapid growth and maturation allow it to colonise any area where there is sufficient soil moisture, whilst it can also survive as a perennial in wet conditions with plenty of soil moisture. WBG is a fast-growing vine and quickly covers the supporting vegetation or structure for climbing. In general, this species can be found growing in coastal areas, along small waterways and rivers, forest edges and disturbed grounds.

Plant features

The creeping WBG plant is a monoecious, herbaceous vine and can grow up to 5 m long. The creeping vine can grow into a thick sheet cover on ground, and is a good climber on support and climbs with the aid of tendrils (*Figure 2*). Each plant bears separate yellow male and female flowers. In tropical Malaysia, flowering occurs all year round.

Stem

The stems are slightly fuzzy with curly tendrils

Leaves

Leaves are simple, measuring 4-12 cm across and with three to seven deeply separated lobes (*Figures 3 a* & *b*). The leaves are single at each node and grow out along the stem alternately in an ascending spiral.

Flower

The male and female flowers are solitary and yellow and have five petals; the female flower

Figure 2 WBG is a climber on support and has a twining growth form and climbs with the aid of tendrils

(3 cm diameter) is smaller than the male flower (3.5 cm diameter). The stigmas are green in the centre of the yellow petals with pointed ends; the anthers are bright yellow in the centre of the yellow petals with flat end (*Figures 3 c* & *d*).

Fruit

The small fruit behind the yellow female flower is about 1 cm in length growing to 4 cm after 6 days. Unripe fruit is green and has a distinct warty surface. The fruit turns yellow first on ripening becoming orange when fully ripe, and turns soft, splitting into segments which curl back to expose seeds covered in bright red pulp (*Figures 3 e, f* & *g*).

Seeds

After removing the red pulp, the fresh seed is very light brown in colour (*Figure 3 h*). The dry seed is slightly brown with tiny irregular

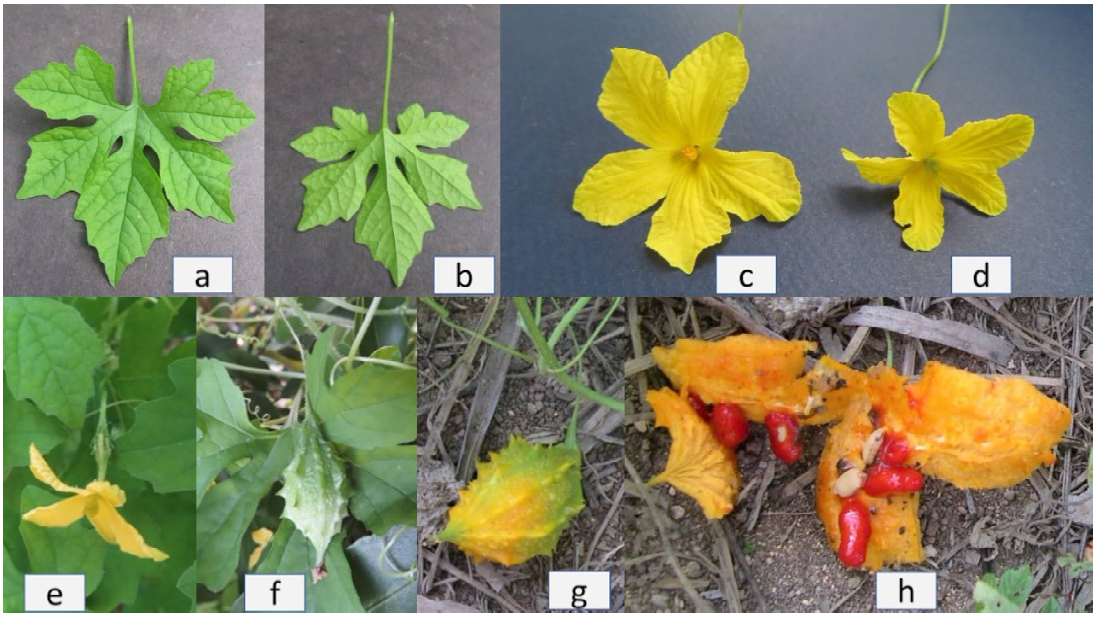

Figure 3 Several plant parts of WBG – a. leaf (upper surface), b. leaf (lower surface), c. larger male flower and darker yellow stamens, d. smaller female flower and green stigmas, e. female flower on top of green baby fruit, f. green developing fruits, g. yellow ripening fruit, h. seeds enclosed in red pulp (aril) and naked brown seeds after splitting of ripe fruit

dark marks. The length of the seed is 1.1 cm and the width is 0.5-0.6 cm and the seeds germinate readily 5-6 days after planting in moist soil. Seeds kept in dry storage remain viable for up to 24 months.

Pollination

When flowers are fully open, anthesis occurs between 3:30 and 7:30 a.m. and pollen viability is lost relatively rapidly. The stigma is usually receptive for a day before or after flower opening, and turns brown after drying up. Bitter gourd is a cross-pollinated crop, and transfer of pollens is required for fruit set. The flowers are pollinated by bees and other insects.

Bees (*Apis florea, Apis cerana, Apis dorsata*) are important pollinators of bitter gourd in India (Behera, 2004).

In India, a total of nine bee species of three families (Apidae, Halictidae and Megachilidae) were recorded as visitors to flowers of WBG. Amongst these, *Halictus* sp., *Megachile* sp. and *Apis dorsata* were found to be the most frequent visitors (Pavana *et. al.*, 2012). The giant honey bee (*Apis dorsata*) was the most efficient pollinator of bitter gourd, followed by sweat bee (*Halictus* sp.) and leaf-cutting bee (*Megachile* sp).

In Andhra Pradesh, 14 species were recorded in a foraging activity of insects on the flowers of WBG which included six Hymenopterans, five Lepidopterans and three Dipterans (Subhakar *et al.*, 2011). Among these insects, *Trigona iridipennis*, *Halictus gutturosus* and *Apis florea* were the most frequent and abundant visitors.

In Tamilnadu, India, field experiments were conducted in 2018 to record the diversity of

floral visitors/pollinators in bitter gourd during the Kharif season and insects belonging to various orders like Hymenoptera, Lepidoptera, Diptera, Hemiptera and Coleoptera were found visiting bitter gourd flowers (Yogapriya *et al.*, 2019). The species of pollinators were: for Hymenoptera (*Apis cerana*, *Apis dorsata*, *Apis florea*, *Tetragonula iridipennis*, *Amegilla zonata*, *Xylocopa violacea*, *Halictus* sp.); Lepidoptera (*Danaius chrysippus*, *Tirumala limniace*); Diptera (*Syrphus ribesii*), Hemiptera and Coleoptera (*Aulacophora* sp). The major pollinators were *A. cerana*, *A. florea*, *Tetragonula iridipennis*, and *Halictus* sp. The main activity of major pollinators occurred between 6 a.m. and 2 p.m.

In Malaysia, the author has observed several insect species visiting flowers of WBG, namely carpenter bee (*Xylocopa* sp) (*Figure 4a*), honey bee (*Apis* sp.) (*Figure 4b*), small bee (unidentified), and small butterfly Cycad Blue (*Luthrodes pandava*).

Dispersal

The ripe fruit of *M. charantia* or WBG splits and curls backward to expose the seeds covered in sugary bright red pulps. The arils are attractive to birds and animals which help to disperse the seeds (Holm *et al.*, 1997).

In Florida WBG seeds are covered in bright red fleshy tissue, and attract birds, which scatter them around (Juneau, 2011).

When the fruit ripens, it turns orange from yellow and splits open to expose the seeds, covered with the bright red pulp. Common bird species, Javan Myna (*Acridotheres javanicus*) and Yellow-vented Bulbul (*Pycnonotus goiavier*) (*Figure 5*) have been reported to feed on seeds covered in bright red pulp (Wee, 2019). These birds feed by swallowing the seed enclosed in the red pulp and help in dispersing them when the bird defecates.

Uses

Bitter gourd is generally consumed cooked when it is in the green or early yellowing stage. The young shoots and leaves of the bitter melon (bitter gourd) may also be eaten as green vegetable in many types of cuisines (namely Chinese, Indian, Burmese, Thai, Indonesian, Japanese cuisines, etc.) (Anon, 2021). Bitter

*Figure 4 Insects seen visiting WBG flowers: a. Carpenter bee (*Xylocopa *sp) (left) and b. Honey bee (*Apis *sp) (right)*

*Figure 5 Yellow-vented Bulbul (*Pycnonotus goiavier*) feeding on bitter gourd seed covered in bright red pulp (photo credit: Wee Y C)*

melon has been used in various Asian and African herbal medicine systems for a long time (Anon, 2021). *M. charantia* is a popular plant used for treating diabetes-related conditions amongst the indigenous populations of Asia, South America, India, the Caribbean and East Africa (Joseph & Jini, 2013).

Insect pests and natural enemies

M. charantia occurring as a weed in farms and plantations is also be affected by insects and pathogens as its cultivated relative that is grown as a crop.

Insects

Seven species have been recorded as leaf feeders of *M. charantia* by Yunus and Ho (1980), namely *Aulacophora flavomarginata* (Chrysomelidae, Coleoptera), *Empoasca flavescens* (Jessidae, Hemiptera), *Epilachna indica* (Coccinellidae, Coleoptera), *Epilachna 28-punctata* (Coccinellidae, Coleoptera), *Euthyplatystoma rigidum* (Otitidae, Diptera), *Leptoglossus membranaceus* (Coreidae Hemiptera) and *Margaronia indica* (Pyraustidae, Lepidoptera). Two species were recorded on the stem, namely *Epilachna 28-punctata* and *Megymenum subpurpurascens* (Pentatomidae, Hemiptera). The fruits are attacked by four species of insects, namely *Dacus (now Bactrocera) caudatus* (Tephritidae, Diptera), *Dacus (Bactrocera) cucurbitae* (Tephritidae, Diptera), *Margaronia indica* (Pyraustidae, Lepidoptera) and *Prodenia (Spodoptera) litura* (Noctuidae, Lepidoptera).

Nematodes

Root knot nematodes (*Meloidogyne* spp.) are soil pests (Paruthi *et al*., 1995).

Pathogens

Four pathogens have been recorded, namely *Pseudoperonospora cubensis* and *Alternaria alternata* (Bains *et al*., 1996), *Fusarium oxysporum* (Lin *et al*., 1996), and zucchini yellow mosaic potyvirus (Fukumoto *et al*., 1993).

Parasitic plants

Infestation of dodder (*Cuscuta* spp.) has been reported (Kondap & Kumar, 1993)

Weed status

WBG is considered a serious weed in oil palm plantations because:

i) it can grow into a blanket sheet in the inter-row areas in immature and mature plantings (*Figure 6*),
ii) it can encroach onto immature palms, which is difficult to control and increase risks of herbicide phytotoxicity during routine circle spraying (*Figure 7*), and
iii) it can grow as epiphytes on palm trunks requiring control (both as a weed and also sources of seeds for further infestation) (*Figure 8*).

In oil palm plantations, the immature cover crop policy favours the establishment and maintenance of selected creeping legume species. WBG and other undesirable weeds are excluded. The spraying of WBG involving several hormonal herbicides which are not safe to immature palms. Careful spot spraying of these herbicides by trained operators is strictly supervised in order to avoid causing damage to immature palms due to contact of spray

Figure 6 WBG growing in blanket sheet growth in the inter-row areas of mature oil palm plantation, especially near roadsides and also vacant spots

Figure 7 WBG encroaching onto one-year old immature oil palm

Figure 8 WBG creepers or vines growing on stem of mature palms; note the yellow flowers and the one orange split fruit

droplets. Any delay longer than 2 months allows the WBG to grow, flower and fruit. When the fruit ripens and seeds eaten by birds (or other animals), the spreading and re-colonisation of WBG can take place. At the same time, more WBG seeds are gradually deposited in the seed banks. The WBG seeds will germinate when the ground is exposed and fresh WBG growth will appear as weed succession problem.

Encroachment of WBG onto immature palms is usually due to delay in the weeding programme. The only means to rid the WBG from immature palms is to carry out manual weeding or de-creeping. The workers have to pull and remove all WBG and other creeping weeds. The operation is slow and labour intensive. To avoid WBG flowering, fruit maturing and depositing seeds back to soil, the de-creeping round has to be programmed at 45 days interval (not more than 2 months interval) and follow-up with a circle spraying round with mainly contact herbicide (e.g. glufosinate ammonium) to kill off any WBG seedlings and other weeds after de-creeping.

Many epiphytes can grow on stem/trunk of mature palms. The woody and climbing species have to be sprayed to avoid their luxurious growth which can interfere with harvesting of FFB, especially in preventing the sighting and cutting of FFB. In the case of climbing WBG, the spraying is more for removal of a source of seeds to prevent further infestation. Moreover, the herbicide mixtures (e.g. glyphosate + metsulfuron-methyl mixture) sprayed to control other creeping weeds and soft ferns, is effective against WBG. The spraying of triclopyr to control small woody epiphytes is also effective in killing WBG.

MANAGEMENT

Weed management in any plantations, especially the oil palm plantation, serves to counter the many negative effects caused by weeds in order to achieve healthy growth and high fresh fruit bunch (FFB) yield. Efficient weed management in oil palm plantations is a combination of preventive measures i.e. planting legume covers, maintenance of natural covers, mulching and applied measures i.e. manual and mechanised weeding, and legal, biological and chemical controls. Generally, the latter measure may be the only cost-effective measure for a particular weed species.

Ground covers (legume covers and natural covers)

Planting of legume covers and maintenance of a less competitive natural cover of selected indigenous species in oil palm plantations are sound methods of weed management including the exclusion of many noxious weeds (e.g. *Mikania micrantha* and WBG). Ground covers not only provide weed control by physical exclusion, they can also provide the good agronomic benefits such as prevention of soil erosion, conservation of humus, reduction of soil exposure to sunlight, aeration and recycling of nutrients.

Manual weeding

When WBG encroaches onto immature palms, manual weeding or de-creeping is the only safe method of weed control. This is carried out in oil palm plantations by workers manually pulling to get rid of WBG and other creeping weeds when encroachment is spotted.

Mechanical control

Motorised slashing machine mounted on tractor is often used to cut back weeds growing in the interrow-areas, especially the harvesting paths. The general practice of slashing is also beneficial in cutting back the sheet growth of WBG, but the control could be temporary.

Biological control

No biological control has been attempted against *M. charantia*.

Chemical control

Post-emergent chemical control of *M. charantia* has been reported by many researchers using a number of herbicides, namely 2,4-D + ametrine, fluroxypyr, fluroxypyr + 2,4-D, acifluorfen + bentazon, ametryn, asulam + diuron, ametryn + atrazine, betazone + MCPA, bentazon + paraquat, bifenox, bifenox + propanil, bromacil, chlorimuron-ethyl, dicamba, diquat, diuron, diuron + 2,4-D, diuron + MSMA, 2,4-D, 2,4-D + glyphosate, 2,4-D + picloram, fomesafen, glyphosate, ioxynil, ioxynil + 2,4-D, MSMA, paraquat, prometryne, and tebuthiuron (CABI, 2019). However, there are no recommendations for the efficacy or suitability of these herbicides against *M. charantia* in specific crops.

Triclopyr at 60 ml of 32 per cent product per 18 L water is listed for the control of WBG in mature palms and not safe for use in immature palms (Kuntum *et al.*, 2007). Glyphosate (41% w/w IPA product) at 120 ml per 18 L water and glyphosate (41% w/w IPA product) + metsulfuron-methyl (20% w/w product) at 60 ml + 3 g per 18 L are also recommended for control of WBG (*M. charantia*) by spot spraying (Chung *et al.*, 2013). Two to three rounds of spraying are required in order to kill WBG regeneration with follow up rounds of not more than 2 months apart.

Efficacy of six herbicide treatments (see *Table 1*) were evaluated to control thick sheet growth of WBG in the inter-rows of immature oil palm during 1999/2000 period. Brief details of the experiments are listed as the footnotes of *Table 1*. Due to the thickness of the sheet of WBG, weed control after first spraying was short and regeneration required a second follow-up spraying at 4 weeks after first spraying (WAFS). The herbicide treatments performed much better after the second round of spraying which lasted up to 12 WAFS. The third spraying was carried out at 12 WAFS and all treatments recorded 85 per cent weed kill and higher at 16 WAFS. In short, three rounds of spraying paraquat + metsulfuron-methyl at 2.8 L + 75 g per hectare, glyphosate + metsulfuron-methyl at 1.5 L + 75 g per hectare, glufosinate-ammonium at 3 L per hectare, fluroxypyr at 2 L per hectare, dicamba at 1.5 L per hectare and triclopyr at 1.5 L per hectare were effective in controlling WBG.

However, the risks of crop phytotoxicity limits the choice of herbicide to only spraying of paraquat + metsulfuron-methyl at 2.8 L + 75 g per hectare and glufosinate-ammonium 3 L per hectare for the control of WBG and other weeds around the periphery of the immature palm during circle spraying. More important, the operation requires careful spraying by trained operators to minimise lower frond contact. Paraquat is not available now. It is suggested that paraquat may be replaced with another contact herbicide, namely sodium chlorate (i.e. the treatment mixture is sodium chlorate + metsulfuron-methyl at 5.5 kg + 75 g per ha). It is important to do de-creeping before any spraying is carried out.

In any spraying programme to eradicate thick sheet growth of WBG, three rounds of spraying are essential to achieve complete eradication after killing off the original weed stand and killing off any regeneration/new seedlings from germination of seeds. The first two rounds of spraying must be completed no longer than 2 months, and preferably at 4 weeks apart as indicated in the present experiment. Failing to do that will lead to another rapid

TABLE 1
EFFICACY BASED ON % WEED MORTALITY OF SIX HERBICIDE TREATMENTS TO CONTROL THICK SHEET GROWTH OF WILD BITTER GOURD (*MOMORDICA CHARANTIA*) IN INTER-ROW AREAS OF IMMATURE OIL PALM

Herbicide treatments	*Product % ai w/w*	*Rate/ha*	*% weed mortality (week after first spraying; WAFS)*				
			4 #	*6*	*8*	*12 ##*	*16*
Paraquat + metsulfuron-methyl	20% + 20%	2.8 L + 75 g	31	94	76	28	94
Glyphosate + metsulfuron-methyl	41% + 20%	1.5 L + 75 g	48	98	86	38	98
Glufosinate-ammonium	13.5%	3 L	36	93	73	20	85
Fluroxypyr	29.6%	2 L	33	90	73	23	91
Dicamba	40.8%	1.5 L	36	48	88	38	90
Triclopyr	32.1%	1.5 L	30	85	88	34	98
Untreated control	-	-	0	0	0	0	0

Notes:
Experiment details: Randomized complete block design / 4 replicates / plot size = inter-row areas of 2x4 palms.
Spraying details: Conventional knapsack sprayer / Fanjet 5/64 / spray volume = 450 L per ha / re-spraying at < 50% weed kill;
Dates of spraying: First spraying – 03/11/1999 / Second spraying – 08/12/1999 (#) / third spraying – 02/02/2000 (##)

regeneration and regrowth of germinated seeds to seedlings, to become a new sheet growth of WBG.

Another approach can be the sequential spraying of the herbicide mixtures. For example, two rounds of spraying glyphosate + metsulfuron-methyl mixture to kill of WBG in pure stand or in mix weed situations, and in the third spraying use only a single selective broadleaf herbicide (fluroxypyr, or dicamba, or triclopyr) to kill any WBG regeneration in order to conserve/allow the growing of soft grasses as natural covers. This sequential spraying programme will effectively kill/eradicate WBG and allows the growing of soft grasses into acceptable natural covers.

CONCLUSION

WBG grows well in the tropical conditions, especially in oil palm plantations of Malaysia. If left unattended, it will grow fast into a sheet form in the inter-row areas of immature and mature plantings. Besides posing the various undesirable weed features including its competitiveness, it is difficult to control and eradicate. WBG encroachment onto immature oil palm can only be solved by manual weeding or de-creeping. Limited choices of contact herbicides are available for spraying WBG and other weeds in the periphery of the lower palm fronds. Most important, studies have shown that a spraying programme of three rounds is required to achieve complete eradication. For control of WBG as target weed, including in mixed weed situations in inter-row areas, spraying of one of the following mixtures (paraquat + metsulfuron-methyl at 2.8 L + 75 g per ha, or glyphosate + metsulfuron-methyl at 1.5 L + 75 g per ha, or glufosinate-ammonium at 3 L per ha) is recommended. For control of WBG in pure stand in inter-row areas, spraying

of one of the following mixtures (fluroxypyr at 2 L per ha, or dicamba at 1.5 L per ha, or triclopyr at 1.5 L per ha) is recommended. To conserve natural covers in mixed weed situations, a sequential spraying programme of two rounds of spraying glyphosate + metsulfuron-methyl mixture and the third spraying of only a single selective broadleaf herbicide (fluroxypyr or dicamba or triclopyr) is recommended. In spraying WBG in immature plantings, special attention and consideration must be given to crop safety especially with the use of some systemic herbicides and hormonal herbicides on immature oil palm.

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