R-2201
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REVIEW ARTICLE

Agricultural Reviews, Volume Issue : ()

Management Options of *Mikania micrantha*: A Review

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10.18805/ag.R-2201

ABSTRACT

The world's problematic perennial weed *Mikania micrantha* hampers in crop production and causes enormous losses due to its interference. Management of *M. micrantha* by mechanical and chemical methods has not met with any reasonable success. So, it has become a target for classical biological control. Numerous natural indigenous plant species, fungi and insects were tried as bio-control agents for effective control of *M. micrantha*. However, along with bio-control, appropriate mechanical, chemical and cultural methods are required to be integrated for controlling it. Thus, integrated management approaches for control of *M. micrantha* should be evolved against this invasive weed in long run.

Key words: Allelochemicals, Fungal inhibition, Herbicide, Invasive weed, *Mikania micrantha*, Weed management.

Mikania micrantha is an invasive weed belonging to the family Asteraceae and is commonly known as the bitter vine, climbing hemp vine, or American rope and native to the sub-tropical zones of North, Central, and South America. In India, It is known as *Japani lota* in Assam. It is a quick-growing perennial creeper that grows best in areas of high humidity and can adapt in less fertile soils. Seed dispersal is through the wind as the seeds are light and feather-like. A single stalk can produce around 20 and 40 thousand seeds a season. This invasive weed reported severe economic losses especially in forest lands and crops by climbing plants and covering the tree canopy, blocking the sunlight thereby creating the loss of genetic and species diversity, a decline in soil and food web stability and altering nutrient cycling.

Economic usage of this weed is less as compared to the loss due to its infestation in various ecosystems. It is used for fodder purposes in many countries for Sheep and other cattle. In Kerala, India, the weed is utilized as fodder, especially during summer when the availability of other fodder is limited. However, this weed has been found to cause hepatotoxicity and liver damage in dairy cattle. Few antibacterial effects of Mikania and its efficacy in wound healing have been reported in Northeastern regions of India. In the state of Assam, the leaf juice of Mikania is used as an antidote for insect bites and scorpion sting by the Kabi tribes. The leaves are also used for treating stomach aches. The juice obtained by crushing the leaves of Mikania leaves is used as a curative agent for itches in Malaysia. The benefits and its usage locally in India and other countries is not yet supported by any scientific studies. In Africa, Mikania leaves are also used as a vegetable for making soups. In Malaysia, it is used as a cover crop in rubber plantations and planted on slopes to prevent soil erosion. Green manure obtained from Mikania was reported to increase the yield of rice in Mizoram, India.

In moist tropical zones of the southwest and northeast India, *M. micrantha* poses a serious threat to natural and plantation forests which is evident in agricultural systems also. Various attempts to manage the weed through mechanical and chemical methods were unsuccessful due to various reasons. Several control measures against *M. micrantha* were tried in various countries. It was found moderately susceptible to the herbicides 2,4-D, 2,4,5-T and Paraquat. A parasitic weed Cuscuta was used against this weed to suppress its spread. Few biological control measures including the rust fungus *Puccinia spegazzinii* and the thrips species *Liothrips mikania* were also tried.

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How to cite this article: Bora, A.R., Babu, D.S., Chetry, S. and Kalita, S. (2021). Management Options of *Mikania micrantha*: A Review. Agricultural Reviews. DOI: 10.18805/ag.R-2201.

Submitted: 22-03-2021 **Accepted:** 27-08-2021 **Online:**

Effect of native trees on *M. micrantha*

Native tree species like *Cinnamomum burmanii*, *Heteropanax fragrans*, and *Macaranga tanarius* were found to be effective in controlling *M. micrantha*. Pathogenic soil fungi associated with the native trees promoted resistance to *M. micrantha* and caused a significant decrease in *M. micrantha* biomass production. These negative effects on biomass production were less pronounced under high nutrient compared to low nutrient level. As nutrient availability in the tree soil increased, fungal inhibition on *M. micrantha* biomass production diminished (Gao *et al.*, 2013). The flowers and leaves of *Delonix regia* exhibited strong phytotoxicity against *M. micrantha*. About 1-2 g of flowers or powdered leaves of the plant applied on the soil surface caused 75-90% mortality within 3 weeks in *M. micrantha* seedlings grown in pots. Spraying of 4% aqueous extract of leaves of *D. regia* on leaves of *M. micrantha* seedlings also resulted in some mortality. There is a possibility to use the allelochemicals present in the flowers and leaves *D. regia* as a natural herbicide to control *M. micrantha* (Kuo, 2003).

Control methods for *M. micrantha*

To control *M. micrantha* mechanical removal, chemical control, biological control, and ecological control have been developed (Kuo *et al.,* 2002; Fu *et al.,* 2003; Zhang *et al.,* 2004; Moran *et al.,* 2005; Ma and Qiang, 2006). Since the 1960s, various efforts to control *M. micrantha* have been developed *i.e*. mechanical, chemical and biological methods (Bogidarmanti, 1989). However, due to strong asexual as well as sexual reproduction, morphological plasticity, and adaptive evolution of *M. micrantha*, the use of a single control method cannot effectively alleviate the damage caused by the weed and requires to adopt more comprehensive prevention and control measures (Shen *et al.,* 2013).

Manual control

Sickle weeding, digging, and uprooting are the common mechanical control methods for *M. micrantha* (Waterhouse and Norris 1987). Temporary control was achieved by sickle weeding before flowering and seed set. But this method became ineffective due to quick re-growth from cut stumps. Uprooting before flowering and fruiting is the most effective mechanical control method. Mechanical control of *M. micrantha* by mowing and slashing was easy but was very labour intensive and uneconomical (Sankaran *et al*. 2001). Moreover, mechanical control was difficult as there was easy dispersal of *M. micrantha* seeds and roots with moist soil (Huang *et al.,* 2000; Kuo *et al.,* 2002; Zhang *et al.,* 2002). Periodic cutting once in every two months reduced the competitive ability of *M. micrantha,* changed the composition of the plant community and promoted the growth of native and other non-native species. This method was an easy, effective and safe method to control *M. micrantha* in forests and plantation crops (Lian *et al.,* 2006). Two consecutive cuttings within a 3-week interval before flowering resulted in 91% mortality of the *M. micrantha* vines. Cutting also promoted the regeneration of native plant species (Rai *et al.,* 2012). In Karbi Anglong district, Assam, India, *M. micrantha* infestation was negligible to low in coffee plantations that experienced at least two rounds of manual (sickle) weeding. The infestation was moderate to high in plantations with one or no manual weeding (Bora *et. al.,* 2019).

Chemical control

Both pre and post-emergence herbicides were generally used for control of *M. micrantha*. Control of this weed is difficult, due to the high production of viable seeds and because new plants could grow from even the tiniest stem fragments (Swarbrick, 1997). Herbicides are preferred over other control methods because of their quick, more effective, and relatively cheaper control of *M. micrantha* (Zhang *et al*., 2004). Applications of Aminocyclopyrachlor, Aminopyralid, Fluroxypyr, Glufosinate, Glyphosate, and Triclopyr resulted in 70% or greater control of *M. micrantha* in 8 weeks after treatment. (Seller *et al.,* 2014). Herbicides like Sulfometuron-Methyl, Atrazine, Glyphosate and 2,4-D have higher prevention efficiency on *M. micrantha* but lower selectivity and lower safety on crops, thus these herbicides should be applied by adopting some safeguard to protect neighbouring crops in fields (Shen *et al*., 2013).

Post-emergence herbicides like 2,4-D, Paraquat, and Glyphosate are mainly used for control of *M. micrantha* in most plantation crops. Use of Paraquat and/or 2,4-D amine was preferred to control *M. micrantha* in rubber and oil palm. In a 2-year-old *rubber* plantation, <10% Mikania and other weed regeneration were found in Glyphosate+Picloram treated plots two months after treatment compared to over 90% weeds re-growth in plots that had been grazed or slashed (Ahmad-Faiz, 1992). Use of a commercial preparation with a mixture of Glyphosate and Dicamba in the above one-year-old oil palm plantation in Malaysia resulted in a 90% *M. micrantha* control by 30 days after application and 40% by 120 days. A mixture of Paraquat + Diuron resulted in 95% control by seven days and 0% by 120 days (Teng and The, 1990). In Indonesia, best control of *M. micrantha* in immature oil palm was observed with 2,4-D amine, 2,4-D-sodium and ioxynil, applied six weeks apart, Hexazinone + Diuron at four weeks apart and 2,4-D-sodium followed by Glyphosate after six weeks (Mangoensoekarjo, 1978). In another study, Picloram + 2,4-D gave the best control of *M. micrantha* after four weeks whereas Glyphosate gave only moderate control (Hutauruk *et al*., 1982). In greenhouse experiments application of Aminocyclopyrachlor, Aminopyralid, Fluroxypyr, Glufosinate, Glyphosate, and Triclopyr resulted 70% or greater control of *M. micrantha* in 8 weeks after treatment (Sellers *et al*., 2014). In Yunnan, southwest China, Atrazine was recommended to control *M. micrantha* for sugarcane, orchard, and rubber land; Glyphosate for rubber and non-cultivated land; Sulfometuron methyl for forest land, and 2, 4-D for maize (Shen *et al*., 2013). In non-cultivated land, 162.0-202.5 g a.i./ha of 18% 2,4-D ME could be recommended to control *M. micrantha* due to its good control effect (Huang *et al.,* 2014). Triclopyr + Picloram showed the best results in controlling the weed in Indian forest plantations (Sankaran and Pandalai 2004). In Assam, India, control of *M. micrantha* in the young coffee plantation was recorded with the pre-emergence application of Oxyfluorfen (0.29kg ha^{-1}) followed by application of Glyphosate (0.99 kg ha^{-1}) 80 days after application of Oxyfluorfen (Bora *et.al.,* 2019).

Biological control

Soil microbes facilitate the successful resistance of native plant species against invasive plants. In China, the presence of pathogenic fungi in the rhizospheric soil of native tree species like *Heteropanax fragrans*, *Cinnamomum burmanii*, and *Macaranga tanarius* were effective in controlling *Mikania micrantha*. The biomass production of *M. micrantha* was significantly reduced in the presence of pathogenic soil fungi in association with the native tree species which results in a diminished capacity of *M. micrantha* to climb, cover and smother the native trees (Gao *et al.*2013). Tall grasses with long, elastic leaf blades or stalks on which the vine could not grasp and climb were found to decrease biomass of *M. micrantha* to a great extent. *Panicum maximum* and *Pennisetum purpureum* could reduce biomass of the weed at least 88.9% and 75.0%, respectively (Zhou *et al.*, 2016).

Sweet potato has a competitive advantage over *Mikania micrantha* in terms of plant growth characteristics and greater absorption of soil nutrients (Shen *et al.* 2015). In mixed culture, 70-90% of *M. micrantha* stems and leaves were covered by sweet potato. Flowering in both sweet potato and *M. micrantha* occurs at virtually the same time. By reducing pollinator visits (Apidae bees, and Calliphoridae or Syrphidae flies) to *M. micrantha* flowers and causing a delay in flowering, sweet potato suppressed sexual reproduction in *M. micrantha* (Shen *et al.,* 2016).

Case studies in China revealed that three species of *Cuscuta* have the potential in controlling *M. micrantha* (Wang *et al.* 2004). It significantly reduced the growth, total biomass, biomass allocation patterns and caused complete inhibition in flowering in *M. micrantha* (Shen *et al.*, 2005). A holoparasite *Cuscuta campestris* prefers *M. micrantha* as a host. The thread-like stem of *C. campestris* coils around *M. micrantha* and forms haustorium through which it extracts water and nutrients and ultimately kills *M. micrantha by its parasitic action* (Chiu and Shen, 2004). In a field experiment, *M. micrantha* cover was reduced to 10% in *C. campestris* treated plot compared to 80% at the untreated plots (Miao *et al.,* 2012). The average number of leaves m^{-2} and dry weight (g m^{-2}) of *M. micrantha* reduced drastically due to infestation by *C. campestris*. Further, the seed production of *M. micrantha* was completely stopped by *C. campestris* infestation (Anonymous, 2013). But, for successful parasitism, *C. campestris* must be within <0.3 cm distance from the host plant *M. micrantha* and the temperature best for the parasitism was 26-30°C (Wu *et al.,* 2013). Parasitism by *C. campestris* caused decrease in stomatal conductance, transpiration rate, and net photosynthetic rate in *M. micrantha* due to a rapid increase in ABA content in infected host leaves (Chen *et al.,* 2011). The parasite significantly reduced chlorophyll and Rubisco concentration of the host which ultimately resulted in reduced photosynthetic rate in *M. micrantha* (Shen *et al.* 2011).

A highly damaging microcyclic rust, *Puccinia spegazzinii*, naturally occuring in the neotropics causes damage to *Mikania* by causing necrosis and canker in all the aerial parts of the plant and ultimately kills it. The fungus was proved highly specific to *M. micrantha*. It was released during 2005 in tea plantations in North East India and agricultural systems in South India. It failed to establish in Assam probably due to the presence of a biotype of the weed that was partially resistant to the rust pathotype but was successful in Kerala (Ellison, 2008 and Kumar *et al.,* 2007). Among different enemies of *M. micrantha* in Kerala, the polyphagous tea mosquito bug (*Helopeltis theivora*) caused serious damage on the weed (Abraham *et al.* 2002). *M. micrantha* leaves infestation by lepidopteran defoliator *Actinote thalia pyrrha* (Fabricius) larvae resulted in a reduced function of the leaves, disturbed metabolism in the protective enzyme system and decreased antioxidative capacity (Lingling *et al.,* 2006).

CONCLUSION

M. micrantha is an invasive toxic weed which is dominating globally and is capable of over-run neighbouring young plantations. Thus, its removal through single management measure in isolation can have a striking negative impact on various ecosystem component. Mechanical control and use of herbicides, have not met with any reasonable success. Taking all these factors into consideration, it appears that if an integrated management approach for control of *M. micrantha* is evolved, that will prove most effective in the long run. This management process should not be stopped at one but continued till the existing weed menace is appreciably reduced.

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