RIU

Imported fungi help farmers defend themselves against invasive weeds

Validated RNRRS Output.

A rust fungus collected in Trinidad and Peru is helping to control Mikania micrantha in southwest and northeast India. Previously, this invasive ('mile-a-minute') weed smothered vegetation over vast areas of tropical forests. Smallholder farmers can now fight back using biological control methods. The Indian Government provided a national framework for the project and sponsored public awareness activities to promote understanding of the control technology. Indian scientists and extension workers received training and are now undertaking on-going monitoring programmes. The rust fungus is being mass-produced in specially built facilities for wide release on the continent. Scientists in China, Fiji, Taiwan and Papua New Guinea are also using the technique, and many other countries have expressed interest.

Project Ref: **CPP06:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **CABI, UK**
Source: **Crop Protection Programme**

Document Contents:

Description, Validation, Current Situation, Current Promotion, Impacts On Poverty, Environmental Impact, Annex,

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Description

Research into Use
NR International
Park House
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Geographical regions included:

China, Fiji, India, Papua New Guinea, Taiwan,

Target Audiences for this content:

Crop farmers,

CPP06

A. Description of the research output(s)

1. Working title

Mikania micrantha
Suggested title for output: *Sustainable management of* Mikania micrantha *in India, focussing on classical biological control*

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

Crop Protection Programme

3. Provide relevant R numbers (and/or programme development/dissemination reference numbers covering supporting research) along with the institutional partners (with individual contact persons (if appropriate)) involved in the project activities. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RIUP activities.

Mikania: (R6735), R8228, R8502

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*4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? **(max. 400 words)**. This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.*

This RNRRS output being proposed here, was the second phase of a project that aimed to develop a **classical biological control** (CBC) strategy for the **invasive alien weed** (IAW) ***Mikania micrantha*** (Asteraceae), or mile-a-minute weed, in **tree crop**, **ago-forestry** and small-holder farming systems in the moist tropical regions of southwest and northeast India. Phase II of this output (including the add-on Short Project R8502) ran from October 2002 to January 2006. *Mikania* is a perennial vine, originating from the neotropics, and was introduced for use as a cover-crop in oil palm plantations in Asia, but now indiscriminately smothers vegetation over vast areas in many countries within the tropical moist forest zones of South Asia. Currently, conventional weeding and cultivation adds around 10% to costs for **small-holder farmers** and reduces income by a similar amount. Under Phase I of the project (R6735, ran 1996-1999), CBC was identified by project partners as the most appropriate option to implement in India, to underpin an integrated management approach to *Mikania*. A tropical American **rust fungus** (***Puccinia spegazzinii***), collected in Trinidad, was selected and screened at CABI- UK ready for import into quarantine in India. The implementation phase of the project, under discussion here, culminated in the release of the rust in the field in Assam and Kerala, and required 10 main researchable constraints to be addressed; these are given below. The output was also enhanced by the production of promotional material that is helping scale-up and -out the results from this project.

a. Development of the **National Framework** and the linking of agricultural and **environment sector** interests for the introduction of fungal agents for the CBC of weeds in India.
b. Long-term live storage of *Mikania* rust pathotypes identified during project, to act as **voucher specimens**.
c. Introduction, establishment and **host specificity screening** of the *Mikania* rust under **quarantine** in India.
d. Issue of field **release permit** for *Mikania* rust in Assam and Kerala.
e. Development of *Mikania* **rust propagation techniques** and **release strategies**.
f. **Impact** and **economic assessment** of *Mikania* on tea production in Assam, using **farmer questionnaire** survey techniques.
g. Assessment of the density of *Mikania* in **permanent sample plots** in Assam.
h. **Public awareness** of IAW impacts and understanding of biocontrol technology. Farmer surveys revealed a high acceptance of biocontrol technology.
i. **Promotion** of weed biological control in Asia to aid scaling-up and -out of the project**.**
j. **Training** of Indian scientists and **extension workers** in CBC fungal technologies, via individual training at CABI and in-country **workshops** and field work.

5. What is the type of output(s) being described here?
Please tick one or more of the following options.

Product	Technology	Service	Process or Methodology	Policy	Other Please specify
X	X		X	X	

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other commodities, if so, please comment

Mikania affects a wide range of agricultural, plantation and forest ecosystems. The major commodities affected include; low altitude tea (Assam), oil palm, plantain, banana, pineapple, small holder (called 'homegardens' in Kerala) crops, bamboo, teak, eucalyptus and forest products (harvested by tribal people) including reeds. The policy area developed and biological control technologies tested under this ouput could equally be applied to other IAW affecting the same commodities (and other commodities).

7. What production system(s) does/could the output(s) focus upon?
Please tick one or more of the following options.
Leave blank if not applicable

Semi-Arid	High potential	Hillsides	Forest-Agriculture	Peri-urban	Land water	Tropical moist forest	Cross-cutting
			X			X	

8. What farming system(s) does the output(s) focus upon?
Please tick one or more of the following options (see Annex B for definitions).
Leave blank if not applicable

Smallholder rainfed humid	Irrigated	Wetland rice based	Smallholder rainfed highland	Smallholder rainfed dry/cold	Dualistic	Coastal artisanal fishing
X						

9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (max. 300 words).

Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.

Mikania micrantha and Control of *Parthenium* (R6695) outputs could be clustered. Both projects addressed IAW problems in India, focussing on biological control solutions. Their activities in government policy development and training were complementary. This has resulted in the establishment of a framework and expertise in India for the introduction of exotic fungal biological agents. The *Parthenium* output recommended the implementation of an 'off-the-shelf' CBC solution, and Indian government funding has been committed to this end. Both outputs have promoted CBC amongst the scientific community; extension services and general public; helping in acceptance and understanding of this approach.

Invasive alien weeds are now rampant in tropical Asia; *Mikania* and *Parthenium* are only two of a suite of species undermining development. A number of these species have had CBC successfully implemented elsewhere, and these could be exploited by India, as a key method of pest control, that is safe, sustainable and with the proven ability to aid poverty reduction though increased crop yields and reduced labour and pesticide costs.

For example, a number of other projects in the CPP address weeds as a constraint to productivity in small-holder systems, focussing on the complex of weeds affecting rice cultivation and cultural management of *Stiga*. Although *Mikania* and *Parthenium* are not part of the agro-systems studied, the concept of CBC may be applicable to the management of some of the IAW species in rice. Mycoherbicides were investigated under both *Parthenium* and *Mikania*, and have been studied for control of rice weeds and *Striga* by other programmes outside RNRRS. However, direct clustering of all weed projects under RNRRS, does not seem appropriate, due to the difference in technologies employed and promoted.

The *Mikania* CBC project has already been scaled-out to China with Department for Environment Food and Rural Affaires (DEFRA), Darwin Initiative funding. The implementation of the rust was 'fast-tracked' based on the results of the Indian RNRRS project. Similar project are being funded in Taiwan and the South Pacific.

Validation

B. Validation of the research output(s)

10. ***How*** *were the output(s) validated and* ***who*** *validated them?*

Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation ***(max. 500 words)****.*

The overall aim of the output was to implement a CBC strategy in India for the IAW *Mikania micrantha*. Project staff were involved in the development of the National Framework for introduction of fungal agents for the CBC of weeds in India, and through this the rust was introduced and released: validating this component of the output. The partner organisations in India, over the course of the project, took ownership of the technology, and successfully applied it in Assam and Kerala: this validated the training component of the project. An important aspect is that the ownership includes federal and state governments. The Indian organisations involved are considered intermediary; validating the central component of the output, field release of the rust, for the targeted end users: resource poor farmers, tribal people and small-holder tea producers. These target groups were canvassed during Phases I and II of the project, to ascertain attitudes and likely acceptance of the biological control technology; they were found to fully endorse the technology. This forms part of the validation of the public awareness component of the project.

The central component of the output was validated using replicated field plots where potted, rust-infected plants were placed, to allow for natural spread and infection of the fungus. These plots are being monitored, to record the spread of the infection. The validation of this output is a long-term process. It is too early following the establishment of the rust to be able to observe any increases in the productivity of the crops affect by *Mikania* in India. However, the rust is spreading from the release sites. It is anticipated that the rust will take from 3-10 years to achieve a sufficient concentration to impact on the density of *Mikania* (i.e. after 2010), once this stage has been reached, impact assessment will also be included in the monitoring.

Validation of the ‘promotion of weed biocontrol in Asia’ component of the output can be considered here: that of the uptake of the output by other countries affected by *Mikania,* e.g. China, Taiwan, Fiji and Papua New Guinea (PNG). In China, funding is from the DEFRA, Darwin Initiative. Following validation of the specificity and efficacy of the rust under quarantine conditions by scientists from the Chinese Academy of Agricultural Sciences in Beijing, the rust is being validated in the field in the south of China, by Guangdong Entomological Institute. In Taiwan, it is the Council of Agriculture who is providing the funding for the release programme, to be undertaken by Taiwan National University. In Fiji and PNG the Australian Centre for International Agricultural Research (ACIAR) is funding the project, and scientists from the Secretariat of the Pacific Community (SPC) will be carrying-out the project. In addition, other countries have requested implementing a rust release project, e.g. Nepal, Malaysia and Indonesia pending funding; although seed funding has already been secured for Nepal from the Darwin Initiative (DEFRA). In addition, the Indian government is also attempting to utilize the CBC fungal technology for other IAW, building on the experience of the *Mikania* project (see below)

*11. **Where and when** have the output(s) been validated?*

*Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above **(max 300 words)**.*

The central validation of this output, field testing of the *Mikania* rust, is being undertaken in Assam and Kerala in India; this started in mid-2005 and is on-going. Currently, the validation is being undertaken in smallholder rainfed, humid farming systems, focussing on tea plantations in Assam, and agroforestry and homegardens in Kerala. These farming systems lie within forest-agricultural and tropical moist forest production systems, and targets marginal and smallholder farmers, where there is significant investment in cash and/or tree crops.

In addition, the scaling-out of this project to Guangdong in southern China, in 2005, has further validated the output. It is also planned that the rust will be shipped from CABI-UK to Taiwan in late 2006 and Fiji in the South Pacific in early 2007.

Current Situation

C. Current situation

*12. **How and by whom** are the outputs currently being used? Please give a brief description **(max. 250 words)**.*

The current situation regarding the four major components of the *Mikania* output are discussed below:

- **Development of National Framework**. This component is currently being used by Indian scientists from PDBC to implement a CBC project against *Parthenium* weed (recommended under R6695). Indian Government funding has already been committed. The government policy developed though the *Mikania* output has provided the framework through which other project can be developed.
- **Training of Indian scientists**. Currently, Indian Scientists are undertaking an on-going monitoring programme, of the rust in the field in Kerala and Assam. In addition, the rust is soon to be released in the Andaman Islands by PDBC; and another isolate of the rust (from Peru) in being prepared for release in Assam by AAU: it is currently in quarantine at NBPGR, New Delhi.
- **Preparation and field release of the rust in Assam and Kerala**. The rust is still being mass produced in the purpose built facilities in Assam and Kerala, and being used for inundative field releases, in order to get the rust established at additional sites.
- **Promotion of weed biological control in Asia**. Scientists in China are currently using this output, by implementing a similar project. Projects are also underway in Taiwan, Fiji and PNG.

*13. **Where** are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used **(max. 250 words).***

The outputs are currently being used in lowland tea production in Assam and in forestry, plantations and homegardens systems in Kerala, India. Also, in Southern China (Guangdong), where *Mikania* is still mainly a weed of the natural environment (Zhang, 2004), the rust is being used to protect biodiversity. In Taiwan, Fiji and PNG the outputs are being used to facilitate projects to implement the rust for the control of *Mikania* in agro-ecosystems, forestry and the native habitats.

14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading (max 250 words).

Within India the scale of the current use is still at the trial stage (small plot field releases). However, usage is spreading, with the establishment of additional release sites in Kerala and Assam. In addition, the rust is soon to be released on the Andaman Islands.

The employment of the rust in other countries outside of the target country of India has been rapid. Uptake and scale-up occurred even before the RNRRS project had officially finished. More countries are expressing interest in importing the rust (eg Nepal, Malaysia, Indonesia and additional South Pacific Island Countries). The project has promoted the use of pathogens for the biological control of IAW throughout tropical Asia, and small scale follow-on project targeting other weeds in India and China are being developed and implemented.

*15. In your experience what programmes, platforms, policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you see as the key facts of success? **(max 350 words).***

- The Indian council of Agricultural Research (ICAR) institutional structure provides a nodal point for biological

control in India, namely the PDBC. This provided the national institutional framework for the import of the rust into India. They worked through ICAR to engage other sectors (e.g. environment) to develop a framework for the use of exotic fungal CBC agents in India.
- KFRI and AAU are institutions with a state mandate, field facilities, and direct connections to the extension services and farmers. This was necessary for the economic impact assessment of *Mikania,* farmer surveys, the field releases of the rust and public awareness components.
- NBPGR was fundamental to the success of this output, by providing their containment facility to import the rust into. Indian Government Regulations required that the rust be tested in India, by nationals, before release in the field. Although PDBC, does not have a functioning pathogen safe quarantine, a purpose built facility is, however, currently under construction.
- CABI, as an intergovernmental, independent organisation, with more than 80 years experience in biological control, helped support the Indian Government policy development needed, to allow the *Mikania* project to be successfully implemented.
- India does have a Government Framework for the import of insect biological control agents. This provided the basis on which the framework for the import of pathogens for the control of weeds was developed.
- The training of Indian scientists in biocontrol techniques, played an important role in the success of this output, that of the taking of ownership of the technology by the Indian collaborators.
- International Plant Protection Convention of FAO, provides the 'Code of Conduct for the Import and Release of Exotic Biological Control Agents', under the International Standards for Phytosanitary Measures. Most governments base their national framework for the import of biological control agents on these guidelines. Using this code CABI worked with India to draw up protocols specifically for India. The *Mikania* project provided a good case study, re fungal agents, for the process.
- In China, the Convention on Biodiversity (CBD) provided a platform for the Darwin Initiative project. Governments who sign-up to the convention, based on Article 8h, are committed to the protection of biodiversity from invasive alien species.

Current Promotion

D. Current promotion/uptake pathways

*16. **Where** is promotion currently taking place? Please indicate for each country specified detail what promotion is taking place, by whom and indicate the scale of current promotion **(max 200 words).***

In India the promotion of this output is taking place in Kerala and Assam, by collaborating scientists at AAU and KFRI, targeting scientists from other institutes, extension worker and farmers, through observations of the rust release sites. In Kerala, the project is also being promoted by articles in the local press, and a video has also been produced for local television

Regionally, the promotion of this output is currently taking place in most of the countries where *Mikania* is a serious problem. In China, scientists from Guangdong Entomological Institute are targeting the promotion of their project to local environmental groups. The project in India has been promoted though workshops, scientific papers, press releases and popular articles. As a result of this publicity, authorities, environmental groups and researchers, within countries affected by *Mikania,* are approaching CABI and the collaborative Indian Institutes, with a view to import the rust themselves. In the case of Taiwan, Fiji and PNG funding has already been allocated to implement a CBC project using the rust. Other countries such as Nepal, Malaysia, Indonesia and additional South Pacific Islands are still developing their proposals.

17. What are the current barriers preventing or slowing the adoption of the output(s)? Cover here institutional issues, those relating to policy, marketing, infrastructure, social exclusion etc. ***(max 200 words)****.*

Within India:

- In India, the most critical issue in delaying the state-wide implementation of the project is the inherent lag-phase of CBC agents, between release and impact. The MoA insist on evidence of efficacy (at the initial release sites), before a more extensive distribution and release programme can be implemented.

Within the region:

- Bureaucratic inertia of government institutions in providing permits.
- There is an element of ‘pathophobia’ when it comes to the use of fungal pathogens as CBC agents for weeds, fuelling the bureaucratic inertia.
- CBC technology does not tend to be funded by private industry, since profits can not be made from a self-perpetuating and naturally spreading technology. Therefore, government and aid agencies tend to fund CBC, and usually require significant impacts of a project within a relatively short timeframe. This is can be difficult for CBC due to the lag-phase, and hence can be a barrier to funding and thus adoption of the technology, particularly within the developing world.
- CBC requires the exploitation of the biodiversity of one country (centre of origin of the plant) for the benefit of another (where the plant has become an IAW). This raises the issue of exploitation and biopiracy with some countries less experienced in the principles of CBC, and the code that advocates free exchange of agents for mutual benefit.

18. What changes are needed to remove/reduce these barriers to adoption? This section could be used to identify perceived capacity related issues ***(max 200 words).***

- Promotion of CBC technology within national and state government departments. For example, the *Mikania* project worked carefully to build confidence, in the use of fungal pathogens for IAW control, especially in the environment sector, to help overcome the ‘pathophobia’.
- More investment in this sustainable weed control technology, will encourage this approach to be adopted more widely .e.g. new projects, targeting other weed of national significance.
- Promotion of CBC concepts amongst aid agencies, so there is a stronger appreciation that CBC is a long-term approach, and needs long-term investment. For example, the global experience shows that the lag-phase is not a long-term barrier to successful CBC; once a critical density of a successfully established natural enemy has been reached; there is an exponential increase in its abundance, and then impact on the weed.
- Press releases, news items etc bestowing CBC success stories.
- Investment in educational material for schools.

Some of the above is being addressed across the developing world, for example under the *Mikania* project, promotion was a key component. However, this work needs to be continued to enable a better exploitation of this technology.

19. What lessons have you learnt about the best ways to get the outputs used by the largest number of poor people? (max 300 words).

CBC technology for the management of weeds is self perpetuating. The biological control agents spread on their own, therefore poor people do not have to invest in using them. However, it is critical that the end users, i.e. in the case of *Mikania,* the resource poor farmers, tribal people and small-holder tea producers, are included in the decision making, before a CBC programme is implemented. It is fundamental that any potential conflicts of interest are identified and debated, or issues of perception clarified. The farmer surveys in Assam and Kerala revealed a high acceptance of biocontrol technology, since the rust will indiscriminately control *Mikania*, with no financial or time inputs required from the farmers. This supported the decision by the Indian regulatory authorities to allow the release of the rust for the benefit of the farmers.

Nevertheless, in order to benefit from the agent as soon as possible, farmers can participate in spreading it onto there farms, though promotion by extension services. CBC project in other countries have benefited greatly by such participation from end user groups.

Impacts On Poverty

E. Impacts on poverty to date

20. Where have impact studies on poverty in relation to this output or cluster of outputs taken place? This should include any formal poverty impact studies (and it is appreciated that these will not be commonplace) and any less formal studies including any poverty mapping-type or monitoring work which allow for some analysis on impact on poverty to be made. Details of any cost-benefit analyses may also be detailed at this point. Please list studies here.

It is too early following the establishment of the rust in the field, to be able to observe any impact on poverty, by a reduction in the *Mikania* infestation to below a level where weeding required. It is anticipated that the rust will take from 3-10 years to achieve a sufficient concentration to impact on the density of *Mikania* (i.e. after 2010). Once this stage has been reached, farmer surveys can be undertaken to establish the impact of CBC on income, by reduced weeding requirement.

However, under both Phases I and II of this output baseline data was collected on the impact and economic assessment of *Mikania*, by the establishment of weed permanent sample plots and the conducting of farmer questionnaires. This data will be used to compare with data that will be collect post establishment of the rust, once it is having an impact on the weed.

21. Based on the evidence in the studies listed above, for each country detail how the poor have benefited from the application and/or adoption of the output(s) (max. 500 words):

- *What positive impacts on livelihoods have been recorded and over what time period have these impacts* *been observed? These impacts should be recorded against the capital assets (human, social, natural, physical and, financial) of the livelihoods framework;*

- *For whom i.e. which type of person (gender, poverty group (see glossary `for definitions) has there been a positive impact;*
- *Indicate the number of people who have realised a positive impact on their livelihood;*
- *Using whatever appropriate indicator was used detail what was the average percentage increase recorded*

N/A

Environmental Impact

H. Environmental impact

24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? ***(max 300 words)***

This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

There are three main environmental benefits of controlling *Mikania* using CBC given below. The rust is highly selective, only infecting *a* limited number of *Mikania* species; in India no other *Mikania* species occur, it is a very damaging pathogen, infecting all aerial plant parts, and it spreads on its own by wind to infect new plant populations.

- **Protection of biodiversity**. *Mikania* indiscriminately invades both agricultural and natural habitats. It is a vine and thus can grow up in the canopy of trees, sometimes reaching sufficient density to actually fell trees. It swamps vegetation, cutting out light, and its roots also have an allelopathic affect on the surrounding vegetation. As a consequence biodiversity is reduced and natural habitats impoverished. The rust will gradually reduce the density and fecundity of *Mikania*, allowing the natural vegetation to recover.
- **Reduction in chemical use:** In some areas, herbicides are used to try and reduce the impact of *Mikania.* These chemicals do not discriminated between the different plants, and some herbicides can get in to groundwater, food products (e.g. tea) and be a risk to the operator applying them to the weed. The rust will only infect *Mikania.*
- **Prevention of spread to areas still free of *Mikania***. *Mikania* is still on an invasive front, CBC can effectively prevent invasion of new areas.

25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? ***(max 100 words)***

Classical biological control, when scientifically implemented following the established risk assessment procedures (Wapshere, 1974), poses no adverse environmental affects (Marohasy1996; Mc Fadyen, 1998; Barton, 2004).

26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? ***(max 200 words)***

It has been proposed by informed scientists that climate change is increasing the habitat available to invasive alien species, possibly by reducing the resilience of the local plant communities to invasion. By implementing a CBC strategy, the advance of the targeted IAW into new areas can be curtailed. *Mikania* infestation has resulted in the abandonment of agricultural land, by controlling the weed using CBC, it can be returned to productive agricultural use, and hence, potentially reduce deforestation, hence protecting water sheds and reducing the threat of natural disasters such as droughts and flooding.

Annex

Annex

Annex A:
Key References (in addition to references in Final Technical Reports, generated by Mikania project)

Barton, J. 2004. How good are we at predicting the field host-range of fungal pathogens used for classical biological control of weeds? *Biological Control* 31: 99-122.

Julien, M.H. and Griffiths, M.W. 1998. *Biological Control of Weeds. A World Catalogue of Agents and their Target Weeds.* Fourth Edition. CABI Publishing, Wallingford, UK, 223pp.

Marohasy J. 1996. Host shifts in biological weed control: real problems, semantic difficulties or poor science? *International Journal of Pest Management* 42: 71-75

McFadyen, R.E.C. 1998. Biological control of weeds. *Annual Review of Entomology* 43: 369-393.

Wapshere, A. J. 1974. A strategy for evaluating the safety of organisms for biological weed control. *Annals of Applied Biology* 77: 201-211.

Zhang LY, Ye WH, Cao HL, Feng HL. 2004. *Mikania micrantha* H.B.K. in China – an overview. *Weed Research* 44: 42-49.
