‘Off-the-shelf’ biocontrol for weeds in India

RIU

Validated RNRRS Output.

Scientists in India now have the skills to screen and use biological controls for pests. The exotic noxious weed Parthenium not only causes severe crop losses but also affects people—causing contact dermatitis and allergies. Already used in many countries, biological controls for weeds are sustainable and environmentally friendly. Now, Indian scientists have successfully imported, screened and released a rust to control Parthenium. Proven in UK and Australia, this opens the door for other ‘off-the-shelf’ pest controls to be introduced. Biological controls could have a major impact on raising incomes of the poor, helping them to use less pesticide and boost crop yields. Interest in these biological control methods is now spreading throughout Asia.

Project Ref: **CPP71:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **CABI, UK**
Source: **Crop Protection Programme**

Document Contents:

Description

CPP71

Research into Use
NR International
Park House
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Geographical regions included:

India,

Target Audiences for this content:

Crop farmers,

A. Description of the research output(s)

1. Working title

Control of Parthenium

Suggested title: *Developing a sustainable management strategy for* Parthenium *in India, focussing on biological control technologies*

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.

Control of *Parthenium*: R6695

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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.*

The aim of this output was to develop and promote a strategy for the control of the invasive alien weed (IAW) *Parthenium hysterophorus* (Asteraceae), in India using fungal pathogens. *Parthenium* is an herbaceous annual, originating from the neotropics, which has become invasive in both **agricultural** and **urban** situations throughout India. Food and fodder crop losses can be severe under high weed infestation (10-80%). *Parthenium* also constitutes a serious **health hazard** due to its **allergenic** properties causing high levels of contact dermatitis and allergic rhinitis (70-97%) in severely infested areas. This weed is now spreading at an alarming rate into new areas and densities in existing areas are increasing.

There were 5 main researchable constraints addressed in this output, which are discussed below.

a) Investigation of the **mycobiota** associated with *Parthenium* in India, and its potential for **mycoherbicide** development, using **survey, isolation** and **assessment techniques**.
b) **Socieconomic assessment** of *Parthenium* in India, particularly the effects on human affairs in peri-urban situations and cropping systems.
c) **Risk analysis** of previously identified rust **classical biological control** (CBC) agents (***Puccinia melampodii*** and ***Puccinia abrupta* var. *partheniicola***), for potential introduction into India. This included **host range testing tailored to native and economically important plant species in India,** both in the laboratory (CABI-UK) and in a field situation (Australia - where agents have been released).
d) **Training** of Indian scientists in classical biological control (CBC) techniques, both in the UK and in Australia.
e) **Promotion** of *Parthenium* project output via publication of scientific papers.

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*	

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

The major commodities affected include; sugarcane, sunflower, sorghum, maize, cotton, tomato, beans, brinjal, capsicum, mustard, cattle and sheep. The biological control technologies developed under this output are to a certain extent generic and thus could equally be applied to other IAW affecting the same, as well as 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			

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			*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.

Control of *Parthenium hysterophorus* and *Mikania micrantha* (R8228, R8502) outputs could be clustered (also see Proforma on *Mikania micrantha*). Both projects addressed IAW problems in India, focussing on biological control solutions. Their activities in training were complementary and under *Parthenium*, the issues that needed to be addressed in Indian government policy development with respect to implementation of biological control began to be realised. The *Parthenium* output recommended the implementation of CBC using an aggressive strain of the already screened rust, *Puccinia abrupta*, and Indian government funding has now been committed to this end. Since a number of other IAW present in India have been successfully controlled in other part of the world using CBC, this 'off-the-shelf' approach could now be further exploited as a key method of pest control that is sustainable and environmentally benign, with a proven ability to aid poverty reduction through increased crop yields and reduced labour and pesticide costs. Both outputs have promoted CBC amongst the scientific community; extension services and the general public; helping in the acceptance and understanding of this approach.

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 the cultural management of *Striga*. Although *Parthenium* and *Mikania* 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* through other programmes outside RNRRS. However, direct clustering of all weed projects under the RNRRS does not seem appropriate here, due to the difference of the technologies employed and promoted in the projects.

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)**.*

This output aimed to build capacity in India, through training, to enable biological control technology, based on the use of fungal pathogens, to be exploited. The validation of this output has been clearly demonstrated by the successful implementation of the *Mikania micrantha* CBC output (R8228, R8502). Scientists trained under the *Parthenium* output (end users) were able to apply their skills during the import, screening and release of the *Mikania* rust.

The two rust pathogens assessed for potential release in India for the CBC of *Parthenium*, had already been released in Queensland, Australia under a Department for Natural Resources, Mines and Water, funded project. The DfID *Parthenium* project ran simultaneously with the final part of this project: screening and field release of the second rust, *Puccinia melampodii* in Queensland. Indian scientists were able to exploit this by undertaking host specificity testing of Indian plants for the two rust species, under field conditions in Australia, thus validating the potential of the CBC component of the DfID project.

The government of India, Department of Biotechnology, commissioned a large, country-wide initiative to develop an integrated pest management (IPM) approach for *Parthenium.* PDBC was awarded funding as a component of this initiative, in March 2004, to implement the CBC strategy, using an aggressive strain of the rust *P. abrupta var. partheniicola*; that had been previously screened and released in Australia. This provided validation of the uptake of the recommendations of the *Parthenium* output; that this rust should be considered for release in India, once the *Mikania* rust has been approved for release.

*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 capacity building component of the output, validated by the successful implementation of the *Mikania* project, was undertaken in India (Assam and Kerala) in 2005/2006.

The validation of the implementation of a CBC strategy for *Parthenium* will be undertaken in India, focussing on the following states: Andhra Pradesh, Chattisgarh, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu and Uttar Pradesh; although *Parthenium* is a problem throughout India, apart from the west coast, high elevations and interior forest. The project has started, but the rust has yet to be imported into India, pending completion of the new quarantine facilities at PDBC. Since their unscheduled delay in completion, there are discussions about using the NBPGR facilities again, as were used for the *Mikania* project.

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 capacity building outputs are currently being used by PDBC scientists in India, to support follow-on biological control projects on *Mikania* and *Parthenium*. The implementation of a CBC strategy for *Parthenium* will be undertaken using Indian government funding by PDBC.

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 capacity building component of the output is currently being used in India under the *Mikania* output (Assam and Kerala). The Indian government funded *Parthenium* IPM project has started, but the rust has not yet been imported.

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

The uptake of the capacity building was immediate with the implementation of the *Mikania* CBC project. Funding for the implementation of a *Parthenium* CBC project was applied for by PDBC during the final stages of the *Mikania* implementation project. Interest in CBC is spreading throughout the Asian region as a direct result of these two CBC IAW outputs.

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

Mikania 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. This resulted in the obtaining of funding from the Indian Government for the CBC of *Parthenium* implementation project.

- For the mycoherbicide part of the *Parthenium* output PDBC, Kurukshetra University, Tamil Nadu Agricultural University and the National Centre for Weed Science have mycological expertise essential to gather and assess information on the mycobiota associated with *Parthenium* weed in India. Kurukshetra University and Tamil Nadu Agricultural University have the capacity to conduct socio-economic studies on the impact of *Parthenium* in India. KFRI and AAU are institutions with a state mandate, field facilities, and direct connections to the extension services and farmers. For *Mikania,* this was necessary for the economic impact assessment*,* farmer surveys, the field releases of the rust and public awareness components.
- NBPGR was fundamental to the success of the *Mikania* 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 conventions help in the implementation of CBC projects, e.g. 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, and The Convention on Biodiversity (CBD) provided a platform for the biodiversity issues arising from alien plant invasions.

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).***

CBC of *Parthenium* in India has been promotion by PDBC within government departments, resulting in the funding of the implementation project. The *Parthenium* output was partly responsible for the instigation of the "International Parthenium Research News Group" website acting as a discussion forum, including the promotion of an IPM approach to the weed (http://www.iprng.org/). The promotion of the *Mikania* 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. In addition, the *Mikania* project in India has been promoted though workshops, scientific papers, press releases and popular articles.

Regionally, the promotion of the *Mikania* output is currently taking place in most of the countries where *Mikania* is a serious problem. This is has happened as a result of the publicity generated under the Mikania output, given above. Government 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 China, Taiwan, Fiji and PNG funding has already been allocated to implement a CBC project using the *Mikania* rust. Other countries such as Nepal, Malaysia, Indonesia and additional South Pacific Islands are still developing their proposals.

Through the promotion of the *Mikania* output, other weeds are also being targeted using the pathogen technology, in addition to *Parthenium*; e.g. *Ageratina adenphora* in China.

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 implementation of the *Parthenium* CBC project is the lack of a functional quarantine facility at PDBC (still under construction).

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 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 *Parthenium and Mikania* projects 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 *Parthenium*, resource poor, peri-urban smallholders; and in the case of *Mikania,* 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 International *Parthenium* Research News Group website is acting as a discussion forum, and is helping to coordinate these types of issues. 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.

The impact of the *Parthenium* output on poverty will first be realised through the *Mikania* output, and subsequently through the Indian government funded *Parthenium* CBC project.

It is too early following the establishment of the *Mikania* 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 is 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 collected post establishment of the rust, once it is having an impact on the weed. Similarly, the economic assessment undertaken under the *Parthenium* output will be used to assess the impact of CBC on this 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* and *Parthenium* using CBC given below. The rusts are highly selective: *Parthenium* rust, *P. abrupta*, is species specific; *Mikania* rust only infecting a limited number of *Mikania* species and in India no other *Mikania* species occur. Both are very damaging pathogens and spread on their own by wind to infect new plant populations.

- **Protection of biodiversity**. *Parthenium* is known for its impact on agricultural productivity, and human and animal health; however, it also is an environmental weed. It can cause a total habitat change in native grasslands, the under-storey of open woodlands and along rivers and floodplains. It out-competes native species due to the allelopathic properties of its roots. *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 rusts will gradually reduce the density and fecundity of *Mikania* and *Parthenium*, 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. Application of herbicides to control *Parthenium* only gives temporary control, as the plant re-colonizes from the seed bank, particularly where land has also been cleared of non-target plants as a side effect of the herbicide use. The rusts will only infect their separate hosts; *Mikania* and *Parthenium.*
- **Prevention of spread to areas *still free of the weeds*.** *Mikania* is still on an invasive front, CBC can effectively prevent invasion of new areas. For *Parthenium*, reduction in seed set through CBC (i.e. rust infected plants won't set seed as extensively) will prevent further spread of the weed.

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, potentially reducing deforestation, and hence protecting water sheds and reducing the threat of natural disasters such as droughts and flooding. In impoverish peri-urban communities, the affect of the dermatitis and allergic rhinitis caused by *Parthenium* pollen has a significant impact on general human productivity. Thus, control of this weed using natural enemies, which require no inputs from the community, will increases the resilience of people to coping with other negative environmental impacts.

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.