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Management of white grubs in peanut cropping systems in Asia and Australia (CS2/1994/050)

John Rogers

Collaborating organisations	▪ Farming Systems Institute—Queensland Department of Primary Industries and Fisheries (QDPIF), Australia ▪ All India Coordinated Research Project on White Grubs, Rajasthan Agricultural University (RAU), India ▪ Department of Zoology and Entomology—The University of Queensland (UQ), Australia (until 30 June 2000) ▪ International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India; Agriculture Man Ecology (AME), India
Project leaders	Dr D. John Rogers (QDPI), Prof. C.P.S. Yadava (RAU)
Related projects	CS1/1992/016; CS1/1994/039
Principal researchers	Dr D. John Rogers (QDPI), Dr John Wightman (ex-ICRISAT), Mr Mans Lanting (AME), Prof. C.P.S Yadava (RAU), Dr David Holdom (UQ), Dr Anitha Reddy (ICRISAT)
Duration of project	1 July 1997 to 30 June 2001; project extension 1 July 2001 to 31 October 2002
Total ACIAR funding	$1,039,796

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Project objectives	The overall aim of the project was to improve the management of white grubs, a key insect pest of peanut (groundnut) in India and Australia. This was achieved through a series of specific objectives: ▪ Clarify the distribution and identity of white grub species damaging peanuts in southern India and Australia. ▪ Develop appropriate techniques and technology for the robust production of the insect pathogen *Metarhizium anisopliae* in India. ▪ Study the behaviour, ecology and population dynamics of white grubs on groundnuts to provide the biological information necessary for developing improved management processes. ▪ Determine the damage potential of key white grubs on groundnut in India and Australia. ▪ Extend, test and modify control strategies developed in India to Australian conditions. ▪ Isolate and identify semiochemicals such as sex-attractant pheromones and develop technology for using semiochemicals for the management of white grub adults in India. ▪ Strengthen linkages with and between appropriate extension agencies to enhance the transfer of technology.
Location of project activities	Hyderabad–Bangalore region (the Deccan region of Andhra Pradesh, Karnataka and Tamil Nadu) and Jaipur, India; and Kingaroy and Brisbane, Australia.

Overview

The project's scientists developed methods of reducing the yield loss caused by white grubs to peanut (groundnut) crops growing in Asia and Australia, and most especially in India. The improved management technology, which included options for both pesticide-free management and the use of minimal amounts of pesticide, is more effective than previous approaches. On-farm surveys and management trials were integral parts of the project and were organised in partnership with NGOs.

Peanut is a major crop in the tropics and semitropics and ranks 13th in the world's most important food crops. It is the fourth most important source of edible oil and the third most important source of vegetable protein, a combination that makes groundnut one of the most important crops in the developing world. It is particularly important in Asia, which produces 24 million tonnes of the global annual production of 36 million tonnes. Developing countries account for 96% of production area and 92% of global production. In India it is a major crop, with 5.7 million ha producing approximately 4.7 million tonnes of peanuts. The southern Indian states of Andhra Pradesh, Karnataka and Tamil Nadu grow 60% of India's peanuts. The Anantapur district of Andhra Pradesh alone grows three-quarters of a million hectares of groundnut. In

these southern Indian states groundnut is produced primarily under rainfed conditions and often under close-to-monoculture conditions by poor and marginal farmers. Peanuts are often the only source of cash income for these farmers, so core family health and educational outcomes hinge on successful production of the crop. Additionally, the haulms (vegetative plant parts) provide high quality hay for the small livestock that are an essential part of the farming system for these poor and marginal farmers.

White grubs, the soil-dwelling larvae of scarab beetles, feed on the groundnut plant's roots and pods, killing seedlings and sometimes older plants, as well as reducing drought tolerance and crop yield. This project sought to develop a better understanding of the white grub problems in the peanut-growing areas of India and Australia, leading to improved control strategies and reduced crop losses from the pest. The researchers also investigated the ecology, biology and behaviour of larvae and adults, and the relationship between crop loss and pest density, and tested improved control methods for the pest. Additionally, the team studied fungal pathogens of white grub larvae, especially *Metarhizium anisopliae*. They discovered strains with enhanced pathogenicity, and improved the production, formulation and application technology of the pathogen as a potential control agent. The efficacy of management techniques involving adult attractants, both insect sex pheromones and plant volatiles, was also assessed.

In southern India the project team extended the knowledge base required for the identification and effective management of white grubs on groundnut. This included pest identity and distribution, adult preferences for food-tree species, crop damage potential and minimal-rate chemical management techniques. This knowledge was developed with strong support from, and close collaboration with, NGOs (especially AME) and farmer groups. These collaborative linkages have enabled appropriate management information to reach a growing pool of poor and marginal farmers during the project, and subsequently through the FAO-funded Agriculture Man Ecology Foundation (AMEF) Farmer Field School Program, but much more remains to be done. In the Raichur, Madanapalle, Chittoor and Bellary districts, where farmers have embraced seed treatment and the use of good-quality organic matter, white grubs are now much less of a problem than they were 5–10 years ago. However, they still cause problems in neighbouring 'non-intervention' areas in these districts. In addition, the Kolar district has substantially changed over to vegetable production from groundnuts because of Bangalore's expansion, and white grubs are causing problems in vegetable crops there.

Meeting between the research group and farmers with major white grub problems

During the February 2007 visit to assess adoption, there was a series of specific and unsolicited requests from farmers' groups and NGOs for additional support for adoption/communication activities on groundnut white grubs, especially targeting illiterate and marginally literate farmers. An additional comment received at the same time was that the project had been terminated before it could achieve its maximum impact with growers. This indicates that project impact could be markedly enhanced with the input of additional investment in communication activities in southern India.

At the beginning of the project, considerable investment in equipment and facilities was made at Jaipur to facilitate research activities, especially for insect pathology. The insect pathology group at Jaipur established the requirements of a *Metarhizium anisopliae* product for use against the groundnut white grub *Holotrichia consanguinea* in northern India. High levels of pathogenicity were confirmed in several pathogen strains, and solid-state grain-based and liquid production methods were evaluated using local grains and additives, as were clay-based spore and mycelial formulations for field application. Optimum placement strategies for a soil-applied biopesticide for white grubs based on *M. anisopliae* were defined. Because of withdrawal of support from the lead agency, Queensland Department of Primary Industries and Fisheries, the project was terminated before this research could progress to pilot-scale production and larger scale field evaluation. However, the knowledge developed during the project remains highly relevant to the development of any fungal pathogen for an insect pest in India, be it a white grub, a caterpillar pest or a sucking pest. Other studies at Jaipur showed that the physiological effects of white grub damage mirrors the effects of water stress on the groundnut plant. Bioassays of leaf extracts from the host trees of *H. consanguinea* showed that neem and khejari were the best sources of plant attractants for adults. This research was terminated before any specific chemicals were identified as attractants.

Project achievements

The project team in southern India established close linkages with a major (nodal) NGO, AME, and through AME with a range of local NGOs. This ensured that the work program was closely connected to the needs of the final users, namely poor and marginal groundnut farmers. This arrangement also enabled effective two-way communication between the research team and end users throughout the project, ensuring that the researchers remained focused on important problems and that the farmers had access to new information as it became available. To December 2000, the total outreach of the AME groundnut participatory technology development (PTD) program was 9,000 farm families. Information and training on white grubs was provided by the project team, as required, in the AME programs with these farmer groups.

During the project an information booklet 'Why are my groundnut plants dying?' was published jointly by the project team and AME in English, Tamil, Kannada and Telugu. This booklet was the basis of communication and extension efforts by the project team and the collaborating NGOs in southern India. A total of 2,000 copies were printed on heavy-grade glossy paper to ensure longevity when used by farmer groups in the field. AME staff ensured that the printing plates of the booklet were preserved by the printer to allow economical reprinting, if required. The booklet was distributed to 'master farmers' in PTD groups and, in one training program alone, hundreds of farmers in Kolar district of Karnataka received copies.

It is still being used by farmers in Farmer Field Schools and by trainees in facilitator training programs. However, while supplies of the booklet are essentially exhausted, demand is ongoing. Existing copies are fragile and much valued.

All of the major findings of the project have been published in peer-reviewed, mostly international, scientific journals, ensuring that the key biological and management information from the project is available to other scientists in India, throughout Asia and elsewhere. Key project outputs included in refereed papers are in the areas of:

- white grub identity, distribution and management in southern India
- identification of the sex pheromone of a key Indian white grub species
- the damage potential of Indian and Australian pest species, leading to establishment of provisional economic thresholds
- the population ecology of Australian peanut white grubs
- information essential to the production and formulation of *M. anisopliae* as an insect pathogen using grains and additives locally available in India.

The difference the project has made

The project has delivered technology to provide better control of groundnut white grubs in southern India with minimal quantities of chemical insecticide. If it were to be fully implemented in this region, then the knowledge generated by the project would deliver significant economic, environmental and community benefits to one of the largest groundnut-producing regions of the world and, in the process, benefit millions of poor and marginal farming families. While there are some observable positive impacts from the project, to a large degree this potential benefit remains unrealised at the time of this adoption study. This is as a result of the timing of project termination and the absence of an appropriate follow-up communication/extension process.

The improved knowledge of white grub management has been incorporated by 'project farmers' into their practices, with different groups adopting different components of the management package to suit their preferences and world view. Farmer groups who wish to avoid/minimise chemical inputs are using collections of white grub beetles from trees at the start of the monsoon season to suppress white grub problems on groundnut, while more chemically oriented farmers use chlorpyrifos seed treatment as well as *Rhizobium* and *Trichoderma* inoculation of seed. Both types of farmers are now aware of the key aspects of white grub biology relevant to their preferred management options. For example, those groups using adult collection are aware of the connection between the appearance of the beetles on the trees at the beginning of the monsoon and the resulting larvae causing crop damage, and which tree species are hosts for the beetles in their locality. They are therefore able to focus their collecting efforts on those trees in the knowledge that the beetle collection activity will reduce damage to the subsequent groundnut crop. The experience of the farmer groups that met in February 2007 was that favourable seasons were associated with high white grub populations and poor years with reduced white grub incidence. Deep ploughing before the start of the monsoon to create a loose soil surface to reduce rainfall runoff is also widely recognised by 'project farmers' as contributing to white grub control because it exposes the pupae to bird predation.

Based on meetings with farmer groups and Dr A.R.V. Kumar from the University of Agricultural Sciences, Bangalore, during the February 2007 visit, the impact of farmyard manure (FYM) and other forms of organic matter on groundnut white grub incidence is a topic that requires further research. During the project small-pot experiments examined the impact of FYM on white grub growth and plant damage. For *Holotrichia serrata* the addition of FYM had little or no effect on larval growth or plant mortality on heavier soils, but on lighter soil it reduced both larval growth rate and plant damage. Additionally, FYM-enriched soil was preferred by *Holotrichia reynaudi* adults for oviposition in small-scale choice tests, but this effect was not apparent under no-choice conditions. Project funding finished before the impact of organic matter could be studied in more detail.

The observations of a number of farmer groups reported in February 2007 were that 'poor quality' organic matter/FYM was associated with an increase in groundnut white grub problems, and Dr Kumar supported this view. However, other groups indicated that 'good quality' organic matter was beneficial. What constituted 'poor' and 'good' quality was not clear, however, but the latter appeared to involve a mixture of cow dung and urine, plant biomass, phosphate-solubilising bacteria and soil mixed together and incubated for some time to produce high-quality compost. Additionally, some groups indicated that they now have sufficient knowledge of white grub identity and biology to be able to distinguish between plant-feeding white grubs and those that feed on FYM. Farmer groups who previously resisted adoption of practices such as FYM use have adopted composting, vermiculture and organic matter use, with benefits to water infiltration and storage and crop nutrition, and reductions in soil-borne plant disease incidence. This diversity of experience and belief, and the limited amount of experimental data generated during the project, indicates that additional research is required on this topic and is of critical importance to the overall farming system's sustainability.

A farming-system change being promoted in parallel with the increased use of organic matter is a diversification of the cropping system from a groundnut monoculture to one that includes dryland horticultural tree crops, pigeon pea, cowpea, millet and vegetables intercropped with groundnut. This increase in crop diversity, together with the increased use of organic matter, is working to produce a more ecologically and economically sustainable farming system. Thus, the white grubs project has provided a trigger for a cascade of broad-based positive changes in the cropping system for at least some farmers.

Project impacts

With the Indian project leader, Prof. C.P.S. Yadava, leaving the university, and other changes of staffing in Jaipur, long-term impacts from the project appear to be minimal at RAU. No information has been received directly from Jaipur despite a series of information requests between November 2006 and February 2007. Informal information sources indicate that all insect pathology research has ceased and the staff have retired or their work has been terminated. The white grub research laboratories are closed and locked pending the retirement of the current officer-in-charge, and white grub research at Jaipur has effectively ceased. This is disappointing given the capital expenditure in Jaipur and the degree of operational funding support received during the project.

Since 2000 a series of drought years has reduced groundnut plantings in southern India, and reduced white grub populations as well. This is a normal pattern of events for this region—a high proportion of drought years alternate with relatively few drought years on an approximately 30-year cycle. However, the adoption study visit in February 2007 indicated that pockets of damaging populations of white grubs remain. Farmers indicated that a return to average-to-good seasons would see both trends reverse, that is they would increase their groundnut area and there would be higher and more widespread white grub populations. An additional consequence of the series of drought years was increased migration of farm families and farm labourers away from the drought areas.

A post-project impact assessment was conducted in 2004 by T.S. Vamsidhar Reddy and Mans Lanting from ETC Consultants, India, using residual project funds. They found that farmers who were involved in project surveys and on-farm trials have retained their knowledge of the problem and are selecting white grub management strategies and tactics consistent with their farming philosophy. Some groups were using adult-collection procedures to reduce pest pressure without chemical insecticides, while other groups have adopted chlorpyrifos seed treatment as their tactic of choice. However, Vamsidhar Reddy and Lanting concluded that the lack of an extension mechanism after the primarily research phase of the project had impacted negatively on more broad-scale adoption at the time of the 2004 study. The February 2007 visit found that the trends identified in 2004 have continued.

Since 2005 information on the management of white grubs in southern India has been incorporated into the sustainable agriculture Farmer Field School and participatory technological development programs now being conducted in groundnut production areas by AMEF and associated local NGOs with funds from FAO. Additionally, the information has been included in the AMEF facilitator training programs and the Fellowship Course in Sustainable Agriculture course run by AMEF. Another communication method used was painted signs on walls in prominent locations in villages to display messages about sustainable agriculture. These activities establish ongoing communication of the outputs of the white grubs project on an increasing trajectory, as new farmer groups are established and more farmer-facilitators and NGO staff are trained.

One specific concern raised by the farmer groups in February 2007 was that the available white grub information is targeting only literate farmers, and that the needs of illiterate and marginally literate farmers have not been met. Posters and video/DVD presentation of information were specifically requested to meet the training needs of the illiterate and marginally literate farmers. Such a presentation would complement the sustainable groundnut production video/DVD project, which is currently well advanced within the AMEF. In May 2004 a scoping workshop for a video-based white grub training package was held in Kingaroy, Australia. Funding came from the Foundation for Development Cooperation, Brisbane, the Crawford Fund and the ACIAR Communications Program. The workshop was attended by a core group who had been involved in the white grubs project. This workshop identified key components of a video presentation, including the timing schedule for filming in India and key script components. Between 2004 and 2007, what is left of the white grub project team developed *pro bono* several proposals for communication projects to a range of potential funding bodies including ACIAR. All of these proposals have been unsuccessful. However, despite this lack of success, and based on the unsolicited requests received from farmer groups and NGOs during the February 2007 visit, the project team remains convinced that there would be significant potential for greatly increased adoption of project outputs in southern India if more training resources were available. The February 2007 visit only served to reinforce this belief.

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