CROP PROTECTION PROGRAMME

Novel controls for armyworm in East Africa adopted/demonstrated/disseminated - national/regional organisations

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FINAL TECHNICAL REPORT

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Executive Summary

African armyworm is a serious migratory pest of pasture and grain crops in Africa. Outbreaks begin every year in primary outbreak areas of Tanzania and then move across Tanzania before migrating in due course onto other countries in East and Southern Africa. Its impact is most pronounced on poor and smallholder households that grow cereals for food and lack the means to prevent larval armies damaging the newly planted crop in the main food growing season December-May. The existing controls based upon chemical insecticides are rarely able to meet more than 30% of the needs of poor farmers and subsistence growers due to high cost and limited availability.

This project, in collaboration with the Tanzanian Ministry of Agriculture and food security (MoAFS) has supported the adoption and promotion of a novel biological control of armyworm based upon the use of a natural pathogen of armyworm, the *Spodoptera exempta* nucleopolyhedrovirus (SpexNPV) as a replacement for chemical pesticides. The project has in the last year developed and validated the techniques for the local production of SpexNPV as a low cost stable clay formulation. Due to a failure of outbreaks in 2005 work on developing a mechanical mass harvesting system for SpexNPV could not be completed or a stock of NPV accumulated for large scale trials so further work finalising this remains to be undertaken in 2006 season by MOAFS staff with their own funding. The Pest Control Services laboratory at Arusha has been refurbished for producing the formulation and a manual for training production staff completed.

The SpexNPV application technology and project findings have been demonstrated to national armyworm control scientists from Kenya and Malawi at regional workshops in Kenya and South Africa. Regional armyworm control organisations DLCO and FAO have also been briefed. The director DLCO has agreed to champion SpexNPV technology and seek funding to scale out the technology to other armyworm affected countries in Eastern and Southern Africa.

The dissemination activities have also attracted support from donors such as USAID, who have part funded PCS fieldwork, and the attention of DFID CRD who have identified (O'Neil 2005) that CPP armyworm research has a major development impact. The project has also written up the scientific findings of the armyworm NPV research in a series of papers and a manual to disseminate project findings to migratory pest scientists, control organisations, the wider scientific and development community.

The project team are now actively engaging with national and regional armyworm control agencies and donors to achieve scale up and scale out of SpexNPV in SSA so that the benefits of improved armyworm can be realised by the large numbers of poor farmers and households whose income and food security this pest threatens.

1 large armyworm killed by NPV
2 Small larvae killed by NPV
3 SpexNPV x400 under microscope
4 Armyworm larvae attacking maize

Background

Armyworm, *Spodoptera exempta,* is a major cause of crop loses and food insecurity in East and Southern Africa. The current project was a follow on from a previous CPP project (R7954), which ended in July 2004. Under this project research was conducted in Tanzania to develop new controls for African armyworm based upon a natural pathogen, the *S.exempta* nucleopolyhedrovirus (SpexNPV) and the use of locally available botanical insecticides such as neem. This approach drew on earlier work funded by CPP which successfully developed and promoted NPV insecticides in India (R7004) and Kenya (R6615).

Through farmer surveys, the socio-economic team of the Tanzanian project showed that the existing strategy of reliance on chemical insecticides fails to protect 70% of farmers in major outbreak years due to the high cost and difficulties in supplying imported pesticides. The Government of Tanzania has adopted a policy of seeking new control strategies for major migrant pests such as armyworm and locust to replace the failing reliance on imported chemical pesticide whose costs and environmental damage are seen as unacceptable in the long term.

Since 1996 CPP has funded work with the Tanzanian Pest Control Services to identify and develop new environmentally acceptable control for armyworms. This work identified the endemic and very specific natural pathogen of armyworm SpexNPV and neem as safe promising alternative controls.

In a series of field trials in Tanzania run between 2000 and 2004 with the Ministry of Agriculture Pest Control Services, the project demonstrated that SpexNPV applied to armyworm outbreaks in the early stages can be as effective at controlling armyworm outbreaks as existing chemical insecticides. SpexNPV was effective when used with all types of application, from simple knapsacks on small plots to aerial application over large areas, and was thus suitable for local control or strategic area wide control. Trials showed local neem, widely available to farmers in outbreak areas, when used as a simple leaf or seed water extract also had limited but useful efficacy. This project was linked to projects (R 7966) improving the forecasting service for predicting outbreaks.

The project also indicated that it would, be a viable strategy in Tanzania to produce SpexNPV for armyworm control by spraying naturally-occurring armyworm outbreaks with an inoculating dose of SpexNPV and then harvesting the diseased larvae to then process into new biological pesticide. The project adopted a formulation technique first developed by the soybean research institute (EMBRAPA) in Brazil, in which NPV as produced as a low cost clay-based formulation. The system for harvesting infected field populations still needed some additional R & D work, as the Brazilian larval collection system is not appropriate for African armyworm. Nevertheless the strategy promised to enable Tanzania to control armyworm at a cost of 3-5 US$/ha in place of the current 16.5 US$.

On the recommendation of the Tanzanian Plant protection advisory committee the government of Tanzania has adopted developing the use of SpexNPV in place of reliance on chemical insecticides as national policy. Limited use of neem is also being promoted to farmers who lack access to other controls in districts where it is available and until SpexNPV is in mass production.

Project Purpose

The purpose of the project and how it addressed the identified development opportunity or identified constraint to development.

It is a specific requirement of the Semi-arid system to reduce use of synthetic chemicals and a general principle across the whole CPP to replace the use of synthetic chemicals with biorational safe controls.

The purpose of the current project was to support a policy initiative by Tanzania to adopt the SpexNPV biological pesticide in place of chemicals for controlling armyworm and promote the technology regionally by demonstrating and promoting the technology to National ministries and the regional organisations dealing with armyworm, principally Desert Locust Control Organisation East Africa DLCO-EA and FAO. In addition the Tanzanian Ministry of Agriculture and Food (MOAFS) expert committee had requested this project to develop local mass production systems for SpexNPV as low cost local production had been identified as an essential element for widespread adoption and sustainable use by poor SSA countries such as Tanzania. Finally this phase was to publish scientific findings of the armyworm NPV research and promote the findings in the wider scientific and development community. This proposal completes the research cycle undertaken by the previous CPP projects and moves the technologies onto a final user.

Research Activities & Outputs

The activities conducted should be listed. Lessons learnt from them should be provided and the outputs that they have achieved. Were any intended outputs not achieved, were any additional outputs achieved? Please keep this as succinct as possible.

1. Novel controls adopted and implemented as government policy in Tanzania.
   1.1. The project will provide the technical advice and support to PCS which is needed to ensure effective adoption as national policy.
   1.2. Development of manuals, publicity and information material, electronic presentations etc to inform senior policy makers, district pest control officers and farmers

This phase has been successful and at all levels in Tanzania interest in and support for the new technology is firm and growing.

To support the embedding of the technology various information products including manuals, publicity and information material have been produced (see appendices 2 and 3) and electronic presentations were given to senior policy makers, district pest control officers and farmers group (appendix 5). Posters and leaflets are being used to raise awareness at local level in districts and among national policy makers. In the previous project longer briefing notes were developed as a briefing tool for the project outputs but in this project more emphasis was placed on the posters and short leaflets that delivered the messages in simple non technical way as the project staff found this approach to be more effective at attracting interest and getting the message across at all levels.

1. Development trials on local production of novel controls completed and assessed.
   1.1. Development of mass harvesting systems for the cheap mechanical collection of NPV infected armyworms as a source for mass producing SpexNPV. The existing EMBRAPA harvesting system is not appropriate for transfer to Tanzania so a new armyworm specific technique needs to be developed. This activity will involve inputs from EMBRAPA expert.
   1.2. Establishing production facilities to produce EMBRAPA type NPV formulation of SpexNPV. With Dr Moscardi of EMBRAPA a pilot production unit will be established for low cost field production. Quality control protocols will be

established and PCS staff trained in their use. This work will also produce a stock of NPV for validation and demonstration trials in 2005 and after.

The absence of armyworm outbreaks in 2005 despite a prolonged stay by the team including Dr Moscardi of EMBRAPA hindered work on developing the infected insect harvesting system. The mechanical harvesting system used for mass collecting NPV infected larvae could not be tested evaluated and finalised. However protocols for carrying out such trials are drawn up and staff trained to do this when armyworm outbreaks occur as they now seem likely to do in early 2006.

The refurbishment of the PCS laboratories as a pilot scale production facility was a subsidiary but important step in enhancing local capacity to produce SpexNPV. It can now also play a stronger role as a demonstration unit for training researchers, extension staff and other potential scaling up agencies from within Tanzania and in other SSA countries.

Despite the absence of armyworm outbreaks the techniques for the low cost production of SpexNPV clay formulation using local ingredients were tested and developed by the team in the 2005 season using infected armyworm collected manually in the 2004 field production trials.

Trial work showed that the EMBRAPA protocols could be used, with some adaptations, to successfully formulate SpexNPV as a low-cost clay formulation. Simple homogenates of infected insects could be filtered, absorbed onto pulverised local china clay then air dried successfully within 12 hours at ambient temperature. It can then be ground and used stored for use as a bio-insecticide. The system does not require expensive centrifugation, freeze drying or deep freeze storage and gives a stable product (> 6 months at 20^{o}C, >2 years at 4^{o} C) that can be supplied directly by farmers as a substitute for chemical insecticides in all common application systems currently used in Tanzania. This production work is reported and discussed more fully in the published paper Appendix 7 (Mushobozi et al 2005).

The production of a 70 page manual detailing the SpexNPV production techniques developed (appendix 4) and quality control procedures was completed. This manual is an important advance in building the local capacity to produce and use NPV. It will be used as the basis for training staff from Tanzania in SpexNPV production as well as from other national systems. Once tested and validated through pilot production trials it can be used as part of a technology transfer dossier to help train producers from the private sector. The final system and scaling up approach is a product of previous NRI experience with local partners in commercialising NPV in Thailand and India as well as EMBRAPA's experience at establishing local commercial production of NPV in Brazil.

(3) Novel controls demonstrated and promoted to appropriate control organisations in East Africa and Kenya.

Armyworm organisations in 12 SADC countries were briefed on the progress of the project at the ICOSAMP meeting in Pretoria where the work of the project attracted considerable interest. Control organisations in East Africa were briefed as part of workshop on armyworm held in Nairobi in September hosted by the community forecasting project R8407. Project findings and progress were also presented at the ICOSAMP workshop held in Pretoria, 12 – 16 September delegates from 12 SADC member countries were presented with the armyworm work being carried out in Tanzania, the results from these trials were received with great interest by the

delegates. Mr Mushobozi has also separately visited DLCO headquarters Addis and presented CPP work (visit report appendix 6). DLCO were highly impressed and suggested they would be happy to help identify funding for new regional scaling up proposals for armyworm control with SpexNPV to be developed by PCS and project team. A delegation from FAO Headquarters and regional representatives was due to visit PCS Arusha in January for briefing on the technique and demonstrations but this has been postponed, at their request until a later date. Project staff will visit Rome in February to brief FAO headquarters staff.

Additional dissemination of the project was through television and radio programmes by WREN media and the associated web pages (Appendices 9 and 10). An article has also been written up about the work of the CPP projects for the new volume of Perspectives in Pests (appendix 11).

4. Full scientific papers on the armyworm trials held in Tanzania 2001-2004 will be written up and submitted for publication in a peer reviewed high impact journal by March 2006.

A paper on the field trials conducted in Tanzania during 1999-2004 using SpexNPV has been completed and submitted to a scientific journal (Grzywacz et al Appendix 12). A paper detailing the SpexNPV field production work was published as part of the CPP sponsored AAB publication of the proceedings of the pathways out of poverty conference held in Cambridge in 2005 (appendix 7).

Two other papers on the ecology of SpexNPV and armyworm (1) “High levels of sublethal covert, vertically- transmitted nucleopolyhedrovirus baculovirus infection in field populations of a migratory tropical insect (the African armyworm, Spodoptera exempta)” and (2) “The influence of larval phase on the costs of sublethal infection and vertical transmission of disease” are at an advanced stage and will be submitted for publication by April 2006 (full details in PCSS). These papers are outputs from a PhD study on SpexNPV and armyworm ecology part financed by the previous CPP R 7954 project based at Institute of Virology and Environmental Microbiology by Ms E Redman supervised by Professor J S Cory (IOVEM) and Dr K Wilson. Ms Redman’s thesis has been submitted and will be examined in February 2006. One further paper on the SpexNPV ecology work planned to be produced in late 2006.

Finally an article was invited and published (Grzywacz 2005,appendix 8) by the editor of Project analysing the particular problems and identifying key factors for success in managing research projects focussed on developing countries and natural threats such as plague pests. This drew on the CPP funded armyworm work as a case study and identified key success factors in the identification, development, implementation and management of the project that contribute to a successful outcome within the context of research consortia collaborations with developing countries that involve developing new technology and then achieving successful adoption by developing countries.

(5) Consortium of partners to support regional adoption and set up pilot project developed.
The PCS, NRI, EMBRAPA Brazil, University of Lancaster and CABI ARC research team is developing joint proposals for a variety of specific funding agencies detailed section 8. DLCO has agreed to join in regional scaling up work in East Africa. A workshop for potential donors to support scaling up will take place in Dar es Salaam in February (postponed from the autumn to allow national elections to be completed and possible changes staff in MOAFS to be finalised post election).

Contribution of Outputs to developmental impact
How is the knowledge promoted benefiting the poor? What coverage has been achieved (numbers of farmers, institutions and production areas adopting the technology). What is the potential for wider scale impact. What follow up action/research is necessary to promote the findings of the work to achieve their development benefit?

The existing system for armyworm control fails to protect poor farmers in Tanzania and generally in Southern and Eastern Africa. The high cost of imported pesticide means that in severe outbreak years only 30% of poor farmers can be protected from crop losses and pasture damage. This is especially acute for small subsistence farmers in marginal areas producing maize and other grains on small plots for subsistence. In SADC region ICOSAMP have estimated that 67% of the SADC population are vulnerable to the effects of migratory pest attack. Donor support for migratory pest control using traditional chemical pesticides has been reduced in the face of concern about the negative environmental impacts of chemical insecticide use and the massive problem of disposing of the large stocks of out of date chemicals, much of it aquired originally for control migratory pests principally armyworm and locust. Tanzania alone has an 1,200 ton stockpile of chemical insecticides awaiting disposal.

By adopting a cheap, safe, locally produced technology for armyworm control the benefits of Tanzania's existing investment in armyworm control can be greatly increased and the drawbacks of chemical insecticides avoided. This will primarily benefit the poor farmers and rural households that rely on cereals produced on their own plots as a major part of the food they consume and rely on the government PCS to co-ordinate and suppress outbreaks either by direct application of control or organising supply of insecticide to poor farmers in outbreak districts.

Tanzania has decided to pursue the development of SpexNPV with a view to the adoption and scaling up subject to validation in national trials programme as soon as sufficient NPV can be made available. The adoption by Tanzania, which with Kenya is the starting point for the annual armyworm outbreaks that subsequently spread too many other countries in East and Southern Africa, could enable the annual armyworm outbreaks to be suppressed at source reducing the need for control by other countries that are attacked later by moths moving on from Tanzania. The use of a self replicating infectious agent like SpexNPV to inoculate primary outbreaks could lead to the breaking of the outbreak cycle before these pests move to other countries. There is real potential for using SpexNPV as a strategic control the work has attracted considerable interest in East Africa and SADC countries scaling it up for much larger scale adoption in SSA. DLCO has agreed to promote the technology in East Africa and FAO offices at national level in armyworm effected countries e.g. Malawi are also interested.

There is still a need to validate the use of SpexNPV for large area application, which can start as soon as the new PCS laboratory can get mass production underway. This will require some continuing outside support from donors to develop the research into a national then regional control project but the current efforts to promote the research outputs are attracting donor interest and the winning of further support to complete the research into use process is considered very likely.

Biometricians Signature

The projects named biometrician must sign off the Final Technical Report before it is submitted to CPP. This can either be done by the projects named biometrician signing in the space provided below, or by a letter or email from the named biometrician accompanying the Final Technical Report submitted to CPP. (Please note that NR International reserves the right to retain the final quarter's payment pending NR International's receipt and approval of the Final Technical Report, duly signed by the project's biometrician)

I confirm that the biometric issues have been adequately addressed in the Final Technical Report:

Signature:
Name (typed):
Position:
Date:

Appendices

Appendix 1 O'Neil P (2005) UK support to research addressing poverty reduction in developing countries. Key Note address CPHP Workshop Harare 25-28th September 2005

Appendix 2 Mushobozi W and Grzywacz D (2005) "NPV a new biological control for armyworm in Tanzania" 20 copies. NRI, Chatham, [Poster] [Field & Policy] [English]

Appendix 3 Mushobozi W and Grzywacz D (2005) "A new biological control for armyworm in Africa" 200 copies NRI, Chatham [leaflet] [Field] [English] p2

Appendix 4 Mushobozi, W., Grzywacz, D., Moscardi, F., and Wilson, K., (2006) The African Armyworm *Spodoptera exempta* nucleopolyhedrovirus (NPV) production and application manual. Natural Resources Institute. University of Greenwich, UK pp 70.

Appendix 5 Mushobozi W (2003) New methods for control of armyworm in Tanzania. Ministry of Agriculture and Food Security Armyworm Control & Forecasting Services Tanzania [Oral presentation to Tanzanian Government and ICOSAMP

Appendix 6 Wilson K and Mushobozi W (2005) Maize Trial Report. [Internal report] pp .

Appendix 7 Mushobozi W, Grzywacz D, Wilson K., Musebe K, and Kimani M. (2005) New approach to improve livelihoods for poor farmers and pastoralist in Tanzania through monitoring and control of African armyworm, *Spodoptera exampta.* Aspects of applied biology 75, "Pathways out of poverty" pp 37-45.

Appendix 8 Grzywacz D (2005) Army that Marches on its stomach. Project, 18, (1) p18-20.

Appendix 9 Mushobozi W (2005) Turning the worm- Tanzania Green beginnings Series 6 programme 3, BBC World. September 2 2005. 10 mins [TV report] [international] [English]

Appendix 10 Mushobozi, W., Grzywacz, D., Moscardi, F., Cory, J. S. C., Ray R., and Wilson, K.,(2006) Novel Technologies for control of African Armyworm on smallholder cereals in East Africa. In *Perspectives on Pests*. (Sweetmore A., Ed) Natural Resources International (in Press)

Appendix 11 Mushobozi W (2005) Visit report to Desert Locust Control Organisation East Africa 20-23rd November 2005 Pest Control Services, Ministry Of Agriculture and Food Security. Tanzania. p3.

Appendix 12 Grzywacz, D., Mushobozi, M., Parnell M., Jolliffe F., and Wilson K., (2006) Laboratory and field evaluation of *Spodoptera exempta* nucleopolyhedrovirus (SpexNPV) for the control of African Armyworm in Tanzania. (Submitted to Crop Protection).