Pesticides that come naturally

RIU

Validated RNRRS Output.

Plants with pesticide properties are helping farmers to improve their earnings by reducing the impact of insect pests in storage. Previously, farmers were forced to minimise their losses by selling grain soon after harvest, when market prices are low. Natural pesticides are cheaper than commercial chemicals. They are also readily available, and safer and easier to use. Traditional methods of using these pesticide plants are, however, highly variable. Farmers need reliable information to support their decision making. Participatory trials in Ghana have yielded new knowledge that can revive and modernise farmer practice by optimising the use of botanical pesticides. With this knowledge, farmers can make informed decisions on application concentrations and methods, preparation of the botanicals and the duration of control.

Project Ref: **CPH14:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **Natural Resources Institute (NRI), UK**
Source: **Crop Post Harvest Programme**

Document Contents:

Description

CPH14

Research into Use
NR International
Park House
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Geographical regions included:

Ghana,

Target Audiences for this content:

Crop farmers,

A. Description of the research output(s)

1. Working title of output or cluster of outputs.

Optimising the indigenous use of pesticidal plants

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

Crop Postharvest Programme
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.

R7373 (Apr 1999 to Mar 2002)
R6501 (Jan 1996 to Mar 1999)

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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.*

Subsistence farmers continue to have problems with insect infestation during storage. Because of the risks associated with **grain storage**, farmers try to minimise their losses by selling their grain soon after **harvest**. Since most farmers sell their grain at this time, market prices are low. Farmers could achieve a much higher price if they were to sell their grain later in the season, but they must control **insect infestation** during this time period.

Botanicals with **pesticidal** properties are already used by farmers as a means of reducing the impact of insect pests on stored commodities. Farmers often prefer to use botanicals as opposed to commercial synthetics because botanicals do not need to be purchased and are, therefore, low-cost. Many farmers believe that botanicals are safer and more flexible in their usage than synthetics. Botanicals are more available because they grow in the local environment, while synthetics that may be available are sometimes adulterated, past their sell-by date, or inappropriate for treating grain, leading to their misuse, risks to human and environmental health and promoting insecticide resistance.

Pesticidal plants can offer a safe, low-cost and dependable method of **storage protection**. However, farmers need reliable information on botanicals to support their decision making with respect to the quality of control they can expect when using a particular plant material. Farmers' traditional methods of botanical use are highly variable; the subsequent degree of success is equally variable. The outputs of the research project have been able to show through **farmer participatory trials** that some botanicals used by farmers for stored product protection offer comparable protection to commercial synthetics when following best-practice application methods. Farmers were able to make botanical selections due to their own comparative analyses and base further decision making with this new knowledge.

Research outputs involved surveying farmers for **ethnobotanicals** they used, and then carrying out a series laboratory, field and farm trials to assess their efficacy in replicated trials. The **chemistry** and **bioactivity** of plants was assessed to understand how active ingredients may vary depending on where, when and how plant materials were collected. Mode of action trials assessed the mechanisms of efficacy (e.g. repellency, toxicity), and potential dangers to people (vertebrate toxicity) were evaluated.

Reviving and modernising farmer practice through the optimisation of ethnobotanicals has shown that farmers can make **cost-beneficial post-harvest pest management** decisions when appropriate application guidelines are followed. Outputs showed that botanicals can be used reliably and safely to treat food stored at the farm level. Knowledge on application concentration, method of application, preparation of botanicals and duration of control expected can be used to promote botanicals as cost-effective and environmentally sustainable pest management for small-scale farmers.

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

Project research evaluated botanicals against maize, millet, sorghum, rice, cowpea, bambara nuts and wheat. Botanicals are commonly used for the protection of all grains and legumes stored at the farm-level with research showing effects against all common insect species attacking stored products. Botanicals are also commonly used pre-harvest in kitchen gardens and vegetable plots for a range of crops and pests and some additional research in the project was carried out on African army worm and cabbage moth. Often the same plant species used in crop protection have uses in livestock protection (ecto and endo parasites, wound healing) and for human medicine. Some pesticidal plant materials are common food additives and spices (chilli, pepper, basil, orange peel)

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	X	X	X	X	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			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.

The theme of integrated pest management in crop production would be a natural clustering for which the project research outputs could be integrated. Pesticidal plants work best when integrated with other management tools as part of a range of options available to farmers when making decisions. The are particularly useful for small-scale vegetable production. (e.g. R8408, 8449, 8212, 8342, 8425, 7484, 6964)

Outputs would be relevant for clustering around on-farm storage systems for a variety of durable crops that tend to be stored for several months. Botanicals would act as part of an integrated tool box for post-harvest pest management. (e.g. R6658, 6502, 6684, 8265, 7486, 7442, 7520, 8179,)

Pesticidal plants can also be grown as crops themselves as a means of income generation. The production, harvesting, processing and marketing of pesticidal plants could tie in with crop diversification programmes, post-harvest value-adding programmes regarding processing and marketing and small enterprise development. (e.g. R8438, 8297, 8413, 8275, 8498, 8432)

As plant materials are often collected from the wild, they offer a key incentive for habitat conservation which is easily grasped by local stakeholders. They can, therefore, be tied into agricultural production programmes related to land use, including land preparation technologies, forestry programmes, biodiversity conservation programmes, livestock programmes (related to grazing land and their veterinary use) and human health programmes (export of medicinals, traditional medicine). (e.g. R7446, 7889, 7975, 7962, 6153, 6621, 7798, 7424,7351, 6954, 6774)

Farmer training platforms focussed on subsistence level or food insecure small-holders can easily benefit from knowledge on how to manage insect pests using plant materials. Although many farming communities will have traditional knowledge about how to use pesticidal plants, our research showed that these can be significantly optimised and standardised to give more reliable and predictable pest control. Our research also showed that knowledge about plants can be geographically and ethnically constrained, so programmes that provide farmer training on a large scale can help promote plant materials wherever particular plants species grow. Platforms that target the service providers and policy makers that deliver knowledge to farmers (NGOs, national extension) would be highly appropriate. (e.g. R8430, 8299, 8452, 8366, 8447)

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 project was validated at several levels.

i. Farmers were involved in several on-farm storage trials carried out over several storage

seasons in several rural subsistence-level villages. These replicated trials involved using farmer's own household granaries and harvested grain and allowing farmers to choose from a number of plant materials. Application methods and quantities were standardised in order to make farmer results comparable among farmers and against untreated controls. The farmers then evaluated to effects of the plant materials over several months of storage in collaboration with extension and scientific staff.

ii. Outputs were scientifically validated by the project researchers through a series of laboratory trials carried out in the UK and field trials carried out in Ghana. Laboratory trials evaluated how application method, concentration and storage period affected efficacy against a range of target insect species. The mode of action of the plant materials was also evaluated to understand whether the plants were repellent or toxic and which insect life stages were most susceptible. Field trials in Ghana were carried out to ensure that the plants worked under local climatic conditions when commodities were exposed to natural infestation pressures. These field trials were carried out at agricultural research stations using small quantities of grain stored in clay pots that were replicated in random block designs. These bioassays were backstopped by considerable phytochemical and toxicity research carried out in the UK. This research was carried out to determine whether the plants were safe to use as many natural products found in plants can be extremely harmful if ingested by people or other vertebrates. Chemical analysis helped to identify compounds present in botanicals with known biochemical activities. Research to identify active ingredients was also used to help inform application methods (e.g. if compounds were water soluble) and assess variability (e.g. amount of compound changing in response to collection and processing methods). Further UK research to assess toxicity was carried out by feeding laboratory rodents with food that had plant materials mixed in. This research showed that some plant species could cause potential long-term health problems if ingested at high concentrations, while lower concentrations were generally considered to be safe.

iii. Further validation occurred through international conferences and peer-reviewed publications.

Laboratory, field and farm trials showed that insect damage could be significantly reduced and that this was independently observed by farmers involved in the demonstration trials. Many factors affected the percentage level of control, particularly the plant species used, amount applied and how it was applied. A shortlist of plant species and application protocols were developed that would result in result in a 50-95% reduction in pest damage when compared to untreated controls.

*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 project took place in the Northern and Upper East Provinces of Ghana with some laboratory research taking place at the University of Ghana in Accra. More than twenty subsistence level

villages were targeted and involved in the research. As commodities are often gender biased, with women involved in legume production and men involved in grain production, the project ensured that equal numbers of men and women were involved in on-farm trials.

Current Situation

C. Current situation

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

No further follow-up has occurred since the project completed in 2002. To date, funding to extend the project outputs through a promotional staff and farmer training and extension phase has not been obtained. As local partners (Ministry of Agriculture and Forestry Research Institute) do not have sufficient extension capacity, the outputs are only available in those villages where the original research took place. It is not known to what extent farmers in these villages continue to use the project outputs as no subsequent independent assessments have been made.

Of course, botanicals are widely used by subsistence farmers throughout sub-saharan Africa. Our research in Ghana indicates that usage is variable with some ethnic groups having more of a tradition than others. Therefore, there is significant scope to optimise the way farmers currently use botanicals (through the adoption of the project outputs) as well as promoting their use to areas with less tradition of botanical usage.

*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).***

As per question 12, outputs are probably only being used in the original villages where the research was carried out in the Northern and Upper East Provinces of Ghana. It has not been confirmed to what extent farmers in these villages continue to use the project outputs.

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

This is not known. Funding has not obtained to carry out these studies and there is no local capacity to manage this within existing frameworks.

As above at question 12, botanicals are widely used following local traditions throughout sub-saharan Africa by subsistence farmers for pest management in pre- and post-harvest and livestock sectors. Surveys carried out the Ashanti Region of Ghana with small- to large-scale farmers indicated that botanicals were used by 26% of all farmers with significant variation dependent on education level and locality. Studies in the three provinces in North of Ghana showed that 74% of

farmers used botanicals, with 95% of farmers in the Upper East Region using pesticidal plants. Although comparative studies are not available, West Africa tends to have the highest rate of botanical usage followed by East Africa and then southern Africa.

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 project activities were not specifically about promotion and adoption, instead focussing on validation of the various biological factors and constraints that were limiting the promotion of botanicals. The project had reached the stage where many of the constraints to promotion had been addressed, but further funding to promote or adopt project outputs has not been secured since the end of the project.

In Ghana, promotion of agricultural extension is provided by NGO programmes and the Ministry of Food and Agriculture. Promoting the optimised use of botanicals should be relatively straight forward through any extension platform. This is because most farmers are generally aware about the uses of pesticidal plants, and rate them highly in comparison to synthetic pesticides because botanicals are cheaper to use, less likely to be adulterated and more widely available. However, awareness may be low regarding which plants work best for particular problems in their local area and farmers may not use them through lack of experience. Farmers need guidance and training on how best to harvest, process and apply botanicals and information on what results they can expect to achieve. Training and demonstration trials managed by extension can be back-stopped by large-scale promotion at farmer days, radio and other mass media.

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.

Subsistence farmers often lack the financial resources to buy good quality commercial insecticides to protect their stored food, and their inappropriate use of conventional pesticides can result in risks to human and environmental health and promote insecticide resistance. Traditional storage methods using indigenous plants with insecticidal properties can offer a safer, low-cost and more dependable method of storage protection while reducing the increasing reliance upon conventional pesticides. In this regard, direct environmental benefits accrue through the use of botanicals because they are less likely to result in environmental residues, non-target poisoning and

insecticide resistance when compared to commercial synthetics.

The use of wild plant materials gives an incentive and economic value associated with natural habitats and generates a competitive reason for their maintenance. The economic potential of pesticidal plants can, therefore, be used to enhance environmental management and conservation.

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

Plants may be harvested unsustainably (e.g. uprooting, ring barking, seed collection). High demand can lead to scarcity, which is compounded by bush clearing, overgrazing, agricultural expansion, deforestation and uncontrolled fires that also affect the regeneration of some plant species. These potential problems can be mitigated against by encouraging sustainable harvesting techniques through farmer training and demonstration, encouraging propagation and cultivation of highly sought after plants and through improved policies and management of natural habitats, e.g. reducing the use of fire for bush clearing, preventing overstocking of livestock.

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)***

Insect pest populations may become more unpredictable in the future due to climate change, with new species arriving or damage levels increasing through higher pest populations. Botanicals are an important part of integrated pest management strategies, and their improved use by farmers could help reduce the impact of adverse climatic factors on insect population dynamics.

On the other hand, climate change may also positively or negatively affect the abundance of indigenous plant species currently used in pest management. In this regard, the outputs do have the potential to increase farmer resilience as knowledge on a range of pesticidal plant species has been made available, so farmers could switch plant species if one species became relatively rare while others became more common.
