World Agroforestry Centre

Training workshop Proceedings

Sustainable production, harvesting and conservation of botanical pesticides

January 28 - 31, 2013

World Agroforestry Centre (ICRAF)

Nairobi, Kenya

UNIVERSITY of GREENWICH

Kew
ROYAL BOTANIC GARDENS





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United Nations Avenue, Gigiri
PO Box 30677, Nairobi, 00100, Kenya
Tel: +254(0)20 7224000, via USA +1 650 833 6645
Fax: +254(0)20 7224001, via USA +1 650 833 6646
Email: worldagroforestry@cgiar.org
Website: www.worldagroforestry.org

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ORGANIZERS

Organization

World Agroforestry Centre (ICRAF)

Members of the organizing committee

Dr. Daniel Ofori – Coordinator

Ms. Anne Mbora

Dr. Alice Muchugi

Dr. Parveen Anjarwalla

Dr. Ramni Jamnadass

Ms. Lucy Mwaura

Mr. Moses Munjuga

Ms. Sallyannie Muhoro – Logistics

Resource persons and their affiliated institutions

Prof. Philip C. Stevenson– The University of Greenwich

Dr. Kate Gold– Millennium Seed Bank Partnership, Royal Botanic Gardens Kew

Dr. Daniel Ofori– World Agroforestry Centre (ICRAF)

Dr. Alice Muchugi– World Agroforestry Centre (ICRAF)

Dr. Patrick Muthoka– National Museums of Kenya

Dr. Emily Wabuyele– National Museums of Kenya

Dr. Desterio Nyamongo– National Genebank of Kenya

Ms. Janet Mwangi– Farm Concern International, Kenya

Proceedings recorded by:

Dr. Parveen Anjarwalla

Mr. Robert Kariba

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CONTENTS

LIST OF ABBREVIATIONS

ACP	African Caribbean Pacific
ADAPPT	African Dryland Alliance for Pesticidal Plant Technologies
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CVM	Commercial Village Model
EU	European Union
FCI	Farm Concern International
GBK	Gene Bank of Kenya, KARI
ICIPE	International Centre of Insect Physiology and Ecology
ICRAF	World Agroforestry Centre
IUCN	International Union for Conservation of Nature
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
KFS	Kenya Forest Service
MC	Moisture Content
MoA	Ministry of Agriculture
NGO	Non-Governmental Organization
NMK	National Museums of Kenya
RBG	Royal Botanic Gardens
RH	Relative Humidity
eRH	equilibrium Relative Humidity
SSA	Sub-Saharan Africa
ST	Science and Technology
UN	United Nations
UNEP	United Nations Environment Programme
WHO	World Health Organization

EXECUTIVE SUMMARY

Background

For the past 50 years, sub-Saharan Africa's (SSA) population has been growing at an annual rate of nearly 2.7% and it is projected to increase a further 1.3 times between 2010 and 2050 (United Nations medium projections, 2010). More than 70% of the SSA population subsists on less than US$2 per day. Most of the region's population and labour force continue to rely on agriculture for their livelihood. Throughout Africa, the main aim of most poor farmers is to achieve food security. This entails sufficient production of food for livelihood and additional yields for income generation.

Whilst there are many factors limiting food production, one important constraint is insect pest management. The conventional method is to use commercial synthetic pesticides. Although pesticides are effective, they are costly, have limited distribution to rural areas, can be adulterated by dilution, mixed incorrectly and sold beyond their expiry date. They can be toxic and affect the health of farmers and consumers. WHO estimates that 200,000 people are killed worldwide every year as a direct result of pesticide poisoning. In sub-Saharan Africa, the potential cost of pesticide-related illnesses between 2005 and 2020 could reach US$90 billion, according to a United Nations report released in 2012. Over time pests can build resistance to synthetic pesticides. More than 500 insects and mites species are resistant to one or more insecticides. Furthermore, repetitive use of synthetic pesticides has resulted in pesticide residue hazards, upsetting the balance of nature through disruption of natural enemies, pollinators and other wildlife and extensive groundwater contamination.

Some poor rural communities have, for generations, been using their knowledge about plants to protect their field crops, stored grain and livestock from damage caused by insect pests. The use of these pesticidal plants provides farmers with an effective, low cost, sustainable and environmentally friendly pest management strategy. However, many pesticidal plants are collected from the wild in natural forest stands, by use of their leaves, fruits, seeds, bark, twigs and roots, without considering their sustainability. Thus there is a risk of declining wild habitats and overharvesting. There is a need for more sustainable and productive agriculture (World Summit on sustainable Development in Rio de Janeiro in 1992; Millennium Ecosystem Assessment in 2005; Global Environmental Outlook 4 and the Comprehensive Assessment of Water Management in Agriculture in 2007; International Assessment of Agricultural Knowledge, Science and Technology for Development and The Royal Society in 2009). The challenge is how to improve farming systems while alleviating poverty, hunger, malnutrition and also reducing environmental degradation

The African Dryland Alliance for Pesticidal Plant Technologies (ADAPPT) project was set up with the overall aim of promoting the use of indigenous plants for

food security and poverty alleviation. The project is supported by a European Union grant through the ACP Science and Technology Programme to establish a network of scientists and agricultural technicians, from NGOs, agricultural institutes, ministries and universities from Kenya, Ghana, Malawi, South Africa, Tanzania, Zambia, Zimbabwe and the United Kingdom with a focus on pesticidal plants as environmentally benign and safer alternatives to synthetic pesticides.

The World Agroforestry Centre (ICRAF) was invited to work on the development and promotion of sustainable production of botanical pesticides through propagation and conservation. The study was aimed at developing protocols for propagation, study growth behaviour and document information on management and conservation of some selected botanical pesticides. The potential to cultivate these species in farmland provides farmers with on-site supply of botanical pesticides and raising and diversifying revenues.

Objectives

To this end, a training workshop was organized from 28-31 January, 2013 at ICRAF, Nairobi. The event brought together scientists, farmers and technicians with common goals of bridging the gap between research and application and to share experiences and knowledge on the sustainable use of pesticidal plants and their cultivation and conservation.

Workshop organization and facilitation

The workshop was facilitated by ICRAF in collaboration with The University of Greenwich, Kew Botanical Gardens, and various national organizations (National Museums of Kenya, Genebank of Kenya, Farm Concern International). It was funded by the ADAPPT project.

Outcomes and key messages

The meeting was officially opened by Dr. Ravi Prabhu, Deputy Director General of ICRAF. Through presentations and discussions, participants engaged in sharing their knowledge of pesticidal plants. There were 20 participants from the farming community and 20 from various academic and research institutions, relevant government offices, development organizations and NGOs (Annex 1). Dr. Kate Gold, seed scientist from RBG Kew's Millennium Seed Bank, closed the meeting.

WELCOME ADDRESS

Dr. Ravi Prabhu–Deputy Director General, Research, World Agroforestry Centre

Dr. Prabhu welcomed the participants. He informed the participants that ICRAF is keen to look at the wealth of species available and try to harness them to build on traditional knowledge by advancing its literacy in food security and improving farm income by substituting for artificial pesticides. He applauded the Royal Botanic Gardens Kew (RBG Kew) and the University of Greenwich for helping ICRAF develop this programme and guaranteed the participants that they would discover a wealth of knowledge as they moved forward.

He noted that he was particularly pleased with the fact that participants comprised a range of professionals, including farmers, scientists and technicians. He mentioned that ICRAF would be very interested in the workshop outcomes as the results could be used to support farmers and the programme as a whole.

OPENING SESSION

Course introduction

Prof. Philip C. Stevenson –The University of Greenwich

Prof. Stevenson introduced the course by stating how the current project started in 2009. He highlighted the disparity between the interests and the driving forces for farmers and scientists and stressed on the efforts made to bring the two groups together. He noted that the project was funded by the European Union through the African Caribbean Pacific Science and Technology (ACP-ST) Programme. The initiative puts emphasis on the importance of interdisciplinary approaches to sustainable development and capacity building, and particularly in the establishment of networks.

The project is referred to as African Dryland Alliance for Pesticidal Plant Technologies. Its overall aim was to promote the use of indigenous plants for food security and poverty alleviation. He listed some of the main objectives of project as follows:

- To strengthen science and technology capacity of African nations to exploit pesticidal plants and optimize their use for smallholder farmers.
- To establish pesticidal plant network of scientists, agricultural technicians and farmers.
- To develop and optimize plant-based insect management technologies.
- To coordinate applied research activities on pesticidal plants.
- To bring together multidisciplinary teams from a range of institutions.
- To identify constraints to promotion and uptake and raise awareness.

- To investigate policy hurdles in terms of promotion of safe and effective plant pesticides, compliance with convention on biological diversity, promotion of conservation and commercialization.
- To train in filling knowledge gaps identified by the network, to transfer skills and exchange visits and to train on research project design and scientific writing.

Prof. Stevenson highlighted the importance of validating the activity of the plants, failing which efficacy is questionable. He said this could be done by looking at the chemistry to identify the active chemicals, and looking at the variations in activity to optimize the application of the material. He noted that ICRAF has expertise in plant propagation, thus this work package was selected for the organization and that many of the pesticidal plants are found in East Africa. By studying the cultivation of these plants, there would be less pressure on sourcing materials from the wild.

Prof. Stevenson cited the rationale for pesticidal plants in Africa. He reminded participants of the drawbacks of using chemical pesticides: toxic to farmers and consumers, potential negative environmental impacts, high cost, difficulty in supply and transport and the risks of developing pest resistance. In identifying pesticidal plants, he emphasized the need to shift focus to finding the best ones and actually making them useful rather than continuing to dwell on research in pesticidal materials. He noted that pesticidal plants are cost effective, cannot be adulterated if used properly and their toxicity and persistence is low. However, they can exhibit variable efficacy across seasons and locations, their application need optimizing, their collection is time consuming, some plants may be toxic and need to be used with caution and they may have variable susceptibility to pests.

He gave examples of three important pesticidal plants:

Tephrosia vogelii (Hook f). Participants were informed that it is popular as it improves soil and has pesticidal properties. It is efficient in controlling Bruchids in beans and cowpeas. Research shows two isolated chemicals– Degueline (effective at controlling insects) and Tephrosine R (not effective). Research also shows that there are two types of *Tephrosia vogelii*, Type 1 which is more effective than Type 2, and that the efficacy is dependent on the harvesting season, January being the month when the active compound is more plentiful in Malawi. He stressed the importance of identification and correct taxonomy since wrong species leads to wrong activity. He mentioned that out of the 2500 herbarium materials submitted to RBG Kew every year, one-third is incorrectly identified.

Lippia javanica, which is effective in controling ticks on cattle and against *Sitophilus zeamais* at high concentrations. Perialdehyde and ipsdienone are the chemicals extracted from *Lippia javanica*. There are two varieties of *L. javanica*; one has more perialdehyde and the other, more ipsdienone. Knowledge of the chemistry would lead to more effective use.

The last species he illustrated was *Securidaca longepedunculata*, which is effective against *Sitophilus zeamais*. The roots are rich in the biologically active compound, saponins and thus comes with issues of conservation and sustainability. He mentioned field trials in Zambia where the maize grains are dipped in the extracts, dried, then stored, a process which is tedious and the need to make it more practical by, for example, spraying.

He concluded that botanical pesticides have not gathered momentum due to issues with sustainability of the botanical source, standardization of the complex extracts and the need for regulatory approval.

Finally, Prof. Stevenson outlined the expectations of the workshop:

- To support environmentally benign, safe and effective pest control using plants
- To train in propagation, use and application of plants for pest control
- To improve production and storage of agricultural produce
- To discuss and share current experiences in research and utilization of plant pesticides
- To learn about new approaches to pest control
- To develop innovations for up-scaling and outreach.

Questions and responses

Questions	Responses
Are there books available on pesticidal plants?	There are no books available at present with updated protocols on their cultivation and information on their application.
Are most pesticidal extracts soluble in oil?	Many are soluble in oil but some in water too like *Tephrosia.* Farmers should not use it to kill fish.
Are scientists looking at the toxicity of the plants and their effect on the consumers?	Pesticidal plants are moderately toxic but are safe for farmers and consumers provided they are correctly handled.

Introduction and expectations

All participants introduced themselves and stated their expectations (See Annex 2).

GROUP WORK I

Indigenous knowledge on pesticidal plant species

The aim of this session, led by Dr. Muchugi, was to share knowledge and experiences on different pesticidal plant species, the pests they are active against, the plant parts used, their preparation, level of efficacy and limitations. Participants formed six mixed groups comprising farmers, scientists and technicians. At the end of the discussion a volunteer from each group presented their results. Table 1 summarizes feedback from the groups.

Table1: Group feedback on pesticidal plant species

Scientific name	Pests	Part used	Preparation	Effectiveness	Source	Limitation
Tithonia diversifolia	Aphids, weevils, white flies	Leaves, seeds	Cold infusion	Effective	Wild/ farm	Seasonal, poor knowledge
Tagetes minuta	Aphids, lice, fleas, ants, white flies	Whole plant, leaves, stem	Planted along the plot as repellant, ground and mixed with water, dry plant placed on grains	Very effective	Wild/ farm	Seasonal, limited knowledge
Cordia latifolia	Maize weevil, butterfly	Leaves	Dry plant leaves placed on grains	Very effective	Wild	Toxic
Aloe secundiflora	Newcastle in chicken	Sap	Cold infusion	Very effective	Wild/ farm	Availability of materials
Teclea nobilis	Vegetable and fruit insects	Leaves	Leaves mixed with ash and water	Very effective	Wild	Availability of materials
Lantana camara	Weevil, tuber moth	Leaves	Dry plant leaves placed on grains	Very effective	Wild/ farm	Toxic
Psidia punctulata	Lice, fleas, mites	Leaves	Infusion	Effective	Wild	
Commiphora holtiziana	Ticks, skin diseases	Bark resin	Mixed with milk, urine, boiled and smeared	Effective	Wild	Availability of materials
Ocimum kilimandscharicum	Mosquito, fleas	Leaves, flower	Smashing, sweeping with twigs, planted near the house, burning	Medium	Wild	Availability of materials, limited knowledge

Mondia whitei	Cut worms	Leaves	Warm water concoction used	Medium	Cultivated	Other uses
Azadirachta indica	Cockroach, weevils, aphids, termites	Seeds, leaves and bark	Seeds dried and crushed, crushed leaves extract	Good	Wild	Poor knowledge, availability of materials
Melia volkensii	Termites	Fruit pulp	Mixed with water	Medium	Wild	Availability of materials
Senna didymobotrya	Nematodes	Leaves	Crushed and soaked in water	Medium	Wild	Availability of materials
Desmodium spp.	Stalk borer	Whole plant	Intercropping	Effective	Wild	Limited knowledge

Dr. Muchugi thanked all the groups and concluded that it was important for the different groups to learn from each other. Prof. Stevenson noted that most of the species mentioned were exotics and nobody had mentioned pyrethrum, which is grown in Kenya and has commercial pesticidal products in markets.

KEYNOTE PRESENTATIONS I

Sustainable use of the potent East Africa medicinal tree, *Warbugia ugandensis*

Dr. Alice Muchugi –World Agroforestry Centre

Dr. Muchugi gave a background on *Warbugia ugandensis* Sprague. She noted that it is widely distributed across some parts of eastern Africa region (Kenya, Uganda and Tanzania) and is known to cure many ailments for example malaria, leishmaniasis, African trypanosomiasis, measles, common cold, toothache and stomach ache, and therefore it is highly valued in traditional herbal therapy (figures 1 & 2). Some of its pharmacological activity has been proven scientifically (Tables 2). She mentioned that there are three known *Warbugia* species and although they sometimes refered to as synonames, they have been shown to be genetically distinct. *Warbugia salutaris* is found in South Africa; *Warbugia stuhlmannii* occurs in East Africa along the Tanzanian and Kenyan coasts while *Warbugia ugandensis* is predominantly found across the east African highlands. Some commercial herbal preparations from these species are available in the markets (Figure 2).

Table 2a: Ethnopharmacology of *W. ugandensis*

Disease	Plant part used	References
Stomach ache, constipation, toothache, cough, fever, muscle pains, weak joints	Stem bark extracts	ICRAF, Henke, 1994, Kareru et al, 2007, Diederick, N. 2006.
Diarrhoea	Boiled roots	ICRAF, Kokwaro, 1976
Skin diseases	Leaf decoction bath	ICRAF, Olila et al., 2011
Cold, sinusitis, emphysema, chest complaints	Inner bark	ICRAF, Kareru et al., 2007
Malaria	Leaf and stem bark extract	Kokwaro, 1976.
Erectile disfunction and venereal disease	Boiled leaves	Kareru., 2007, Kiringe, 2006.

Table 2b: Pharmacology studies on *W. ugandensis*

Pharmacological activity tested	Plant part used	Active against (Pathogens)	Active compound identified	Reference
Antibacterial	Stem bark extract	*E. Colis, S. Aureus*	Warbuganal, Muzigadial	Olila et al., 2011; Rabe and Staden, 2000
Antifungal	Stem bark extract	*Candida albicans, C. neoformans*		Olila et al., 2011; Mbwambo et al., 2009
Antimycobacteria	Stem bark	*Mycobacterium aurum, M. fortuitum, M. phlei* and *M. smegmatis*	6α,9α-dihydroxy-4(13),7-coloratadien-11,12-dial, 4(13),7-coloratadien-12,11-olide, and 7β-hydroxy-4(13),8-coloratadien-11,12-olide	Wube et al., 2005
Trypanocidal	Stem bark and leaf extract	*Leishmnia major, L. donovani*	Deacetylugandensolide, muzigadiolide, cinnamolide-3β-ol, cinnamolide-3β-acetate, Flavanol glycosides and monoterpenes.	Githinji et al., 2010; Ngure et al.2009; Kioy et al., 1990; Xu et al., 2009
Antiplasmodial (Malaria)	Stem bark extract	*Plasmodia knowlesi, P. berghei*		Were et al., 2010; Muregi et al., 2008
Anti-inflammatory	Stem bark			Leshwedi, 2008

Figure 1 : Commercial herbal preparations from Warbugia species.

Figure 2: Traditional herbal market. Dried Warbugia bark on sale.

She noted that there is very little documentation on Warbugia as a biopestide. There are, however, reports from Kwale, Kenya that hanging maize cobs and treating them with *Warbugia stuhlmannii* smoke protects them from weevil attack. The high phytoactivity recorded from various extracts from the tree points to a great possibility of wide usage of this species in pest control. The few studies that have been documented show scientific evidence that *Warbugia ugandensis* is active against a number of phytopathogens (Tables 2).

Dr. Muchugi then discussed the challenges of herbal therapy and sustainable use of *Warbugia ugandensis.* She noted that controlled harvesting of the stem bark and the use of the leaves are possible ways of using this species sustainably.

Questions and Discussions

Questions	Responses
How are you trying to address the challenge of efficacy reduction especially where we are talking of cultivation of *Warbugia* species because it is known that the level of secondary metabolites responsible for efficacy in most cases vary when you remove the plant from its natural habitat to cultivated land?	A study is currently comparing the efficacy of the wild and the cultivated material. It is true that soil properties influence the level of phytochemicals in a plant. After the said study, we will be able to identify the kind of management that will make the leaves retain the potency.
Where do you get seeds if you want to propagate *Warbugia* species?	*Warbugia* seeds are recalcitrant. However, they are available. A problem commonly encountered is obtaining seeds from plants cultivated on farm due to pest infestation which results in loss of viability. Seeds can however be sourced from the forest but can only be stored for 3-4 months. In the trials we have been conducting, we have looked at alternative methods of propagation and rooting of cuttings has worked very well. Tissue culture has also been tried though not for mass propagation but at research level.
How high should one go when debarking? Also please advise on the seasonality when it comes to harvesting; when is the right time to harvest? During rains or after rains? In the morning, noon or evening?	For *Warbugia*, we have no records about how high one should go but there is information on *Prunus africana* from a study done in Cameroon where sustainable harvesting involved removing a quarter of the bark. This method has however not been very successful as debarking of remaining side is down before the tree fully recovers due to market demand. A study was done a few years ago in Kakamega Forest, Kenya on the bark regrowth. However it was not conclusive enough because the section monitored for regrowth was very small and it was found that within a year, the plant had recovered the 10x10 cm wound. There is therefore no concrete data on how big or how long this debarking can be done. On seasonality and harvesting of *W. ugandensis*, a PhD student from Kenyatta University is evaluating this aspect. Most herbalists mentioned that they harvest early in the morning.

Innovative pest control treatment methods using pesticidal plants

Prof. Philip C. Stevenson – The University of Greenwich

This session was aimed at addressing the challenge of grain storage through innovative use of pesticidal plants. Prof. Stevenson indicated that the key factor in storage of grains is dryness. Grains are considered dry enough for storage when they have a moisture content of 15% or less. Grains that are not dry enough have higher chances of fungal and insect pest attack.

He illustrated a simple salt and glass bottle test method for checking humidity in grains, which he later demonstrated during the practical session in the nursery. He also explained 'Solarization' as the most effective low cost method to dry grains before storage. He then took the group through the process of thoroughly mixing pesticidal plants with grains. He went on to explain the chemistry of the active components in pesticidal plants, described methods of extraction and how the polarity of the active ingredient determines the type of solvents used for extraction. He gave examples of the inefficacy of using water as a solvent for extraction of fatty, carbon-rich substances and the efficient use of organic solvents like methanol and the use of soapy water to extract active ingredients like degueline. Three times less amount of material would be needed when 1% soap is used in extraction. Soap also acts as a surfactant, spreading the extract on the target surface with more coverage and thus increasing absorption by insects.

The techniques of extracting and use of pesticidal materials from pyrethrum and pymarc were highlighted. Drying the leaves and then grinding to a powder and using soap and hot water, leaving the extract for a few hours and then spraying in the evening increases the efficiency of the plant material.

Prof. Stevenson noted that pesticidal plants are potentially effective as alternatives like Actellic in stored products. *Tephrosia* is toxic and care should be taken to avoid consuming it. This can be done by washing the food material that has been treated before consuming it. The plant material can also be separated from the grains during storage or treatment.

He outlined some of the approaches used and current experimental ideas on how to avoid contact of the plant materials with food products:

- Soaking absorbent sacks in plant extracts, drying them and storing grains in them
- Storing grains in typical clay pots and treating a small portion of the grains at the bottom being as effective as treating the whole lot
- Covering the top of the pot with a muslin barrier containing some treated grains which acts as a trap for the invading insects.

Domestication and conservation of pesticidal plants: principles and practices

Dr. Daniel Ofori –World Agroforestry Centre

In his presentation, Dr. Ofori introduced the participants to the concept of tree domestication and conservation. He highlighted on the key processes involved in domestication as; identification, collection, evaluation, propagation, management and adoption of high quality germplasm. He noted that there is a need to harvest sustainably to preserve the genetic integrity of the species.

He emphasized that tree domestication is done to get the right genotypes to produce the right products; hence careful identification of the species is essential. He also stressed that it is important that the species is grown at the right place since environmental conditions affect the production of chemical compounds and their efficacy. The right people to manage the species are also crucial as plants are well maintained if they fit in the livelihood strategies of farmers. He then proceeded to expound the various processes involved in tree domestication.

Priority species: For each priority species, it is important to note the following; the correct identification, the source of the plant, its characterization (does it contain the active chemical?), production through seed or vegetative propagation, management on farm, and value chain from producers to processors to markets.

Germplasm collection: Collections are done to raise seedlings/other propagules for distribution to farmers, tree management research, genetic improvement programmes and for ex-situ conservation. Emphasis was made on the need to maintain diversity in collections and field planting.

Sampling procedures: Materials are either sampled as seeds or vegetative parts. The essence of adopting the right sampling design is to ensure that the material is representative enough to capture as much diversity as possible. Random or targeted designs can be used in collection of materials. Random sampling is representative and captures a large genetic base, providing an adaptive capacity to varying farmer requirements and changing environmental conditions but it is time consuming and is also prone to possible collection of low quality materials. Targeted sampling is more likely to capture superior germplasm, for improvement purposes if heritability of targeted characters is high. It is however not representative of a population, and can make future recollections difficult. There is also a possibility of narrowing the genetic base. When collecting samples from species with a wide ecological distribution, sampling should be done in all the ecological zones to capture as much provenance variations as possible.

Plus tree selection: This is the process of selecting germplasm that are capable of consistently producing good quantities of high quality product and active

compounds in the case of pesticidal plants. Chemical characterization is useful in such selection. Selection can also be done based on cluster analysis where traits are partitioned according to populations sampled.

Propagation, evaluation and management: Once the right material is selected, propagation is done. Propagation can either be done in the laboratory or in the nursery. There are three types of nurseries namely; permanent nurseries, temporary nurseries and extension nurseries. A permanent nursery supplies plants for a long time on a permanent basis. It is normally established for large and extensive work and is intensively managed. It is established where all facilities are available and is used for large scale afforestation works or distribution to villages. A temporary nursery is maintained for supplying stock for shorts periods. It is suitable for home gardens, for on-farm planting and is suited for individual farmers to cater for their own seedling needs. Either or both can be modeled for extension nurseries. A good nursery site should be easily accessible, has permanent water supply and have easy drainage. Propagation can be done through seed germination, rooting of cuttings, grafting, air layering or in vitro tissue culture. Variations found in trees propagated by seed are also reflected in the type and concentrations of active compounds. Plants propagated vegetatively are true to type and hence exact copies of the mother plant. Pictures were shown to explain the different methods of propagation (Figures 3, 4, 5, 6, 7). He also mentioned that evaluation for species x site matching interaction is very important since the concentration of active compounds may vary depending upon the environment.

Figure 3: Marcotting

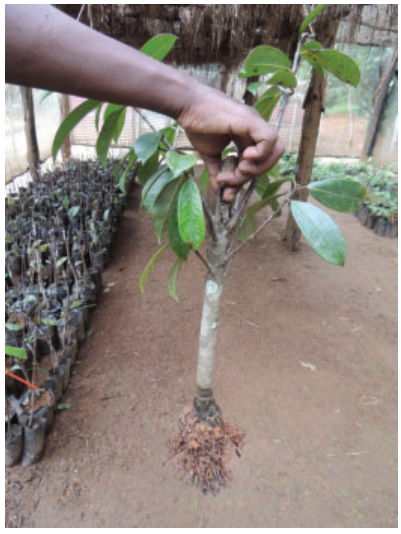


Figure 4: Marcotts shooting

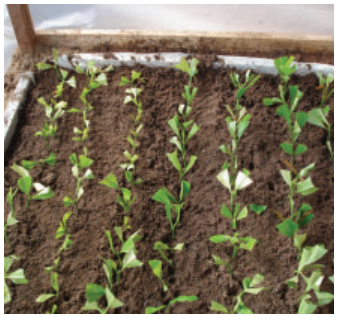


Figure 5: Cuttings

Figure 6: Side grafting

Figure 7: Top grafting

Questions and comments

Questions	Responses
What cost would one incur to determine the chemical ingredients of a tree species?	It may not be worth your while because it is expensive. There is however quite a lot of information on websites that will allow you to check what people have studied. Research institutions and universities with chemical laboratories should be able to help but they also need to have a reference of pure chemical for every compound in question.
What is the difference between marcotting and air layering?	They refer to the same technique.
Do you have an alternative to liquid soap?	I have talked about liquid soap because I know it works. I have not looked at anything else but bar soap can also be tried. Some pyrethrum farmers in Kenya use diesel.
When recommending liquid soap, did you take into consideration the effect that perfume may have?	They could potentially have an effect of adding unwanted flavours to stored grains but the most important thing is the ability to extract the active compound and knock off the insects.

PRACTICAL SESSIONS

This session was conducted at the ICRAF nursery. It was aimed at training participants on processing and application of extracts of pesticidal plants and propagation of plants by grafting, marcotting and cuttings.

Propagation by cuttings

Mr. Moses Munjuga – World Agroforestry Centre

This was demonstrated with *Warbugia ugandensis* cuttings. When collecting cuttings, one can use a cool box so as not to lose moisture from the cuttings. Alternatively the cuttings can be put in moistened polythene bags or wrapped in newspapers. One can also cut the leaves in half to reduce water loss.

Sand, peat moss or vermiculite rooting media can be used. This media should be sterilised to prevent infections to the cuttings. The cuttings are raised in propagators. The propagators should have the following profile; it should be stacked with 8cm of large stones at the bottom followed by 11cm of small stones and finally 11cm of the rooting media. At the bottom of the cutting, the cut should be completely horizontal to ensure even distribution of rooting. At the top, the cutting should have a slanted cut to avoid water settling and rotting. The non-mist propagator should always be covered to maintain high humidity.

Questions and responses

Questions	Responses
Can cuttings be used for all fruit trees?	Yes and they have also been used with timber and medicinal trees.
Can propagators be kept in an open place?	No, it should be provided with about 50% shading.

Marcotting

Mr. Moses Munjuga – World Agroforestry Centre

Mr. Munjuga demonstrated how air layering is done (Figure 8). He said that depending on the species, this could take 2-6 months to root. First a ring of the bark is completely removed. Then damp media (sand or sawdust) is placed around the cut area and secured in place with a polythene sheet and rubber band or tape or twine. Once rooted the marcotts should be severed off the parent plants before the roots harden. Once they start browning, they are already too old and the marcotts will not grow well. During potting, care should be taken when removing the polythene cover to ensure that the ball of soil on the roots is not broken.

Question and responses

Question	Response
Is there an age limit for the plants to be marcotted?	You need to select a suitable branch that is vigorously growing fresh shoots. It can be induced by pruning or pollarding of the mother tree.

Grafting

Mr. Valentine Gitonga – World Agroforestry Centre

Mr. Gitonga demonstrated the propagation technique where scions from plants with the desired traits are inserted on rootstocks to form a new plant, true-to-type to the mother trees (Figure 9). Importance of grafting include reduction of gestation period, use of disease resistant rootstocks, use of rootstocks adapted to the ecological conditions of the locality where grafts are to be planted (e.g. drought tolerant).

Question and response

Question	Response
Can you graft plants of different species?	Unless they have been tested and proved to be safe. It is advisable to graft species of the same family.

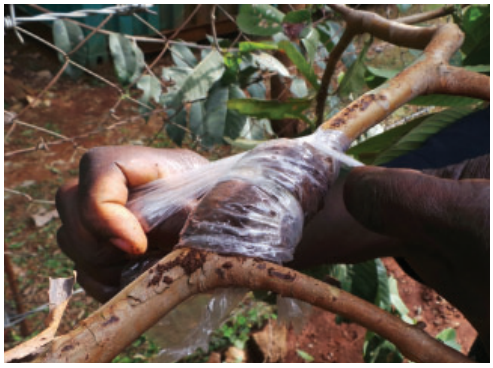


Figure 8: Demonstration of Marcotting.

Figure 9: Demonstration of grafting.

Preparation of materials for storage

Professor Philip C. Stevenson – The University of Greenwich

Aflatoxins are a huge problem with maize and other grains. Moisture also predisposes grains to insect and other fungal attacks. To ascertain dryness of grains, farmers can use low cost methods like the glass bottle test method where a third of a bottle is filled with grains and two spoonfuls of dry salt added. The bottle is capped tightly, shaken and left for 15 minutes. The grains are not dry enough if the salt sticks on the bottle sides.

Extraction of chemicals from plants using different media

Professor Philip C. Stevenson– The University of Greenwich

Prof. Stevenson demonstrated (Figure 10) varying efficiencies of different extraction media. Ground plant materials were dissolved in:

- Methanol: Like petrol it is good for extracting fat.
- Soapy water: 1% liquid soap, then dilute 10 times. The plant material move to the bottom of the container.
- Plain water: The plant material stays in suspension in the container.

He mentioned that liquid soap has two uses; to extract chemicals and to spread the extracts on the plant and insect evenly (surfactant).

Questions and responses

Questions	Responses
Can soap be used as a surfactant in synthetic pesticides?	Yes.
What kind of soap is effective?	Normally 0.1-1% soap is used and the final extract diluted. There is no scientific evidence as to which type of soap is better.
Can insects develop resistance to pesticidal plants?	The mixture of chemicals in these plants make it difficult for the insect to develop resistance.

Figure 10: Prof. Stevenson demonstrating extraction of pesticidal materials.

GROUP WORK II

Dr. Daniel Ofori welcomed the participants to the second day of the workshop. He gave a brief summary of the previous day's events. Participants were asked to form groups and exchange views on the constraints to farmer uptake of pesticidal plants. Some of the views expressed by participants are listed below.

Constraints to farmer uptake of botanical pesticides

- Lack of knowledge about the identification, propagation, processing and application
- Uncertainty about efficacy
- Unavailability
- Some are invasive weeds
- Some regions have unfavourable climatic conditions
- Inadequate germplasm
- Lack of markets for botanical pesticides
- Cumbersome extraction process
- Pesticidal plant materials are bulky and cannot be easily transported
- Inadequate farmer extension services and research linkages
- Storage time of pesticidal materials is not well documented.

Figure 11: A group of the participants during the discussion.

KEYNOTE PRESENTATIONS II

Management of invasive species

Dr. Emily Wabuyele –National Museums of Kenya

Dr. Wabuyele defined invasive species as those that occur in areas outside their bio-geographical range. They are introduced for various reasons but some introductions are accidental. She said that in either case these species become established in the new environment, proliferate and persist in ways that are destructive to biodiversity and human interests. The upsurge of these species is due to globalization – through increased travelling, trade and transport of goods across borders. Invasive species could be animals, plants, fungi, bacteria or virus. She mentioned the three important stages to invasion as: introduction, naturalization and invasion.

She highlighted the characteristics of invasive species as follows:

- Invasive species tolerate a wide range of environmental conditions
- They have few known natural enemies that may be non-existent in invaded ecosystems

- They produce large numbers of offspring, grow and spread rapidly
- Their seeds may remain dormant for extended periods.

She elaborated on the impacts of invasive species in natural and agro ecosystems as follows:

- In natural ecosystems like forests, woodlands and grasslands invasive species can seriously affect the integrity of the ecosystem by:
    - Changing community structure
    - Changing ecosystem function and services through extinction or reduction of native species
    - Threatening native species as competitors for space and nutrition
    - Alteration of edaphic conditions
    - They may cause general loss of biodiversity as a result of lost habitats.
- In agro-ecosystems, invasive species may result in:
    - Increased cost of production due to increased weeding time and effort
    - Reduction of yields due to competition for space and nutrients
    - Health issues as a result of allergic reactions by man and livestock
    - Loss of habitat leading to loss of suitable pasture species.

She then discussed the defense measures against invasive species:

- Prevention: this is the first line of defense against invasive species. Often the most cost effective approach to combating invasive species is to keep them from establishing in the first place.
- Early detection and rapid response efforts increase the likelihood that invasions will be halted and eradicated. Once a species becomes widely established, the only action possible is the partial mitigation of negative impacts.
- Control and management: for widespread invasive species control efforts reduce the species to more acceptable levels and management prevents their spread or re-emergence. Control and management efforts are species-specific and site-specific making identification very crucial.

Possible control measures:

- Mechanical control: here uprooting and clearing is recommended
- Chemical control: use of selective herbicides
- Biological control: use of natural enemies such as fungi and insects
- Several complementary methods: integrated pest management.

Invasive species management planning:

- Approaching invasive plant problems through a strategic process can help achieve management goals and objectives
- A plan is developed that should guide management in direction and time
- A plan can serve as a reference while management progresses and can support decision-making and problem solving needed to achieve desired conditions
- Having a plan in place also ensures consistency in management efforts as personnel change, helps engage stakeholders and citizens, and is useful as supporting material for writing grants and soliciting partnerships.

Questions and responses

Questions	Responses
Can one manage invasive species through utilization?	As long as the utilization is faster than its establishment.
Some indigenous plants are becoming invasive. How do we control them?	We need to look at the factors which make them invasive, such as climate or transport.
Is there data on invasive species?	There is a website on invasive species of East Africa: www.keys.lucidcentral.org/keys.

FIELD WORK

Dr. Kate Gold – Royal Botanic Gardens, Kew

Dr. Patrick Muthoka– National Museums of Kenya

Ms. Anne Mbora- World Agroforestry Centre

This session was carried out in Karura Forest and was aimed at giving participants the opportunity to assess potential seed collection and show them how to carry out quality collections in a natural environment. The exercise was led by Dr. Kate Gold supported by Dr. Patrick Muthoka, Ms Anne Mbora, Mr. Mathias Mbale and Mr. Charles Ndiege.

Dr. Gold noted that although availability of germplasm is one of the problems facing uptake of pesticidal plants, there is a possibility of collecting seeds from the wild and propagating them. She however added that some of these species have particular ecological ranges and therefore model plant species should be sought to help one decide whether to collect or not. Some of the plant species encountered in the forest were *Venonia* spp*., Ocimum* spp*., Tithonia diversifolia*

and *Tagetes minuta*. Dr. Muthoka called on the participants to go around observing plant species especially the type of fruits, flowers, number of individuals in a population and the possibility of pockets of sub-populations. The participants selected *Vernonia* and *Tithonia.* They noted the presence of browning flowers of *Vernonia*, indicating that they had mature seeds. Some *Tithonia* flowers had seeds while others were immature. In such a case, Dr. Muthoka indicated that one could choose to collect at a later date. He highlighted that a sample should be representative enough and that one should consider the number of plants available and the area covered. If the plants are too few, the collection will not capture enough genetic diversity. At least 50 individuals should be sampled for conservation collections.

Question and discussions

Questions	Responses
Should one collect in bulk or as individuals?	If it is a common species, collect from at least 50 individuals and then bulk them. If rare species, keep collections as individuals.
Farmers should be guided to understand what a population is so that they can sample correctly.	Most farmers have associations. They are advised to collect seeds, bulk them with their neighbours' seeds and then divide.
How do you ensure that farmers collect from high quality trees?	Research institutes, government organizations and NGOs can provide advice on where one can obtain seeds.

Guidelines to decision-making

Dr. Gold took the group through some guidelines to decision-making in a form of a pre-collection checklist using the model plant species, *Vernonia amygdalina*. The checklist had the following parameters against which the collector should evaluate the suitability of collection.

Assess population and seed dispersal:

- Approximate area of population
- Approximate total number of individual plants present and accessible
- Evidence of disturbance or damage
- Readiness of population for collection
- Estimate the number of individual plants at natural dispersal stage
- Is the population a single population?

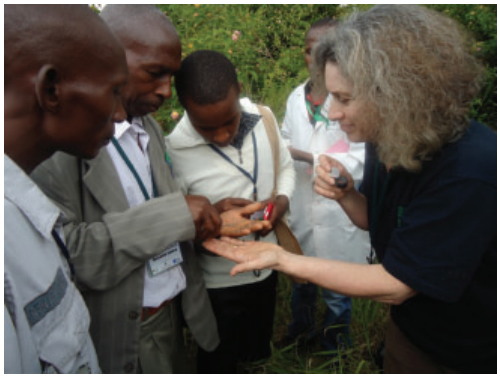
Assess seed quality and availability:

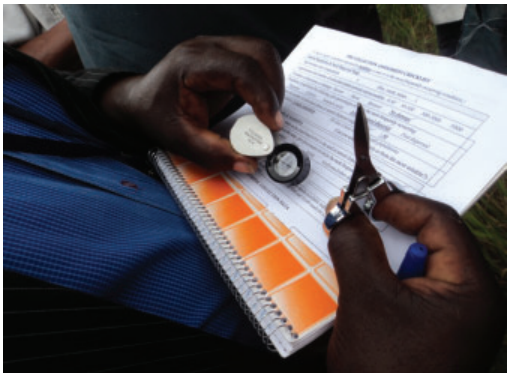
- Where on the plant/branch/fruit is the seed at natural dispersal stage
- Use a cut test to check the seed quality (Figures. 12, 13)
- Estimate the number of healthy seeds per fruit
- Estimate the number of fruits per individual plant.

At this point, the collector should decide to collect or not.

Mr. Mathias Mbale observed that if one chooses to collect, a voucher specimen should accompany the collections. A voucher specimen is a plant specimen or a piece of a plant which is processed through drying and then placed in a herbarium. The specimen can survive for hundreds of years if it is correctly prepared. Proper identification of the species is vital. He demonstrated how to prepare a good voucher specimen.

The arrangement should be; a hard board, followed by a blotter, a newspaper and then the plant specimen. A newspaper should then be placed on top followed by a blotter and a hard board on top and then tied tightly.





Figures 12 and 13: Demonstration of the cut test procedure

KEYNOTE PRESENTATIONS III

Status and availability of germplasm of pesticidal species

Dr. Patrick Muthoka –National Museums of Kenya

Dr. Muthoka started his presentation by giving an overview of pests, pesticides and pesticidal plants. He noted that information about pesticidal plants can be obtained from online databases, publications and research institutions.

He highlighted the sources of germplasm:

- Natural sites (*in-situ*): national parks, forest reserves, national monuments, biosphere reserves or heritage sites
- Off-site (*ex-situ*): seed banks, botanic gardens, arboreta, DNA banks, *in vitro* pollen cultures
- On-farm *(circa situ*): seeds maintained within farming systems.

He mentioned the two types of collections in a seed bank. The active collection which is short term and by scientists and farmers and the long term collection which can be used after a long time out of necessity.

He then discussed some of the challenges of botanical pesticides:

- Taxonomic challenges in that not all materials have matching and updated vouchers
- The data about these species is not harmonized and is not available online
- Low duplication with other seed banks
- Poorly known storage and poor documentation on uses and diversity
- Some are invasive species hence their acceptability for domestication is low
- Poor understanding of seed physiology and how to propagate and store the seeds.

Questions and responses

Questions	Responses
You talk about orthodox seeds. What about recalcitrant seeds? What about seeds of *Zanha Africana* for example?	*Zanha* cannot be kept in a conventional genebank. Recalcitrant species can be kept in field genebanks, botanical gardens and *in vitro* cultures
Data on pesticidal plants are not online, why?	It is an expensive task. There are not many taxonomists in the country.
Are storage materials in the genebank checked periodically?	Banking is a science with many challenges. The viability of these materials are checked periodically. Once handled and stored correctly, they can stay for a long time even if the name is updated. For crop species, diversity is picked from farmers' field and new accessions are brought to be stored. For cross-pollinated species 12,000 seeds are kept and for self-pollinated species 6000 seeds are kept. Some are also kept for distribution.
There is a gap between scientists and farmers.	That is why these kinds of workshops which bring farmers and scientists together are beneficial. Often information is passed on to farmers by scientists but only 1 in 35 will adopt new techniques

Ensuring seed quality: understanding seed moisture status, seed storage behaviour and seed longevity

Dr. Kate Gold –Royal Botanic Gardens, Kew

The focus of this session was to help in understanding some underpinning theories on conservation of seed. The objectives were to understand the seed-air moisture relations and the key factors that affect storage.

Dr. Gold indicated that seeds are hygroscopic and therefore water status in the seed is dependent upon the relative humidity (RH) of the air. The water uptake and therefore moisture content (mc) depends on whether the seed is an oily seed, starch seed or non-oily seed. The equilibrium relative humidity eRH can be determined using a digital humidity sensor in a non-destructive way. There is always a positive correlation between the moisture content and equilibrium relative humidity of seeds. Temperature and seed composition also affects the relationship between MC and eRH. At 15% eRH, moisture content will be 3-7% depending on seed composition and temperature. She demonstrated how to use a hygrometer to measure moisture content (Figure 14).

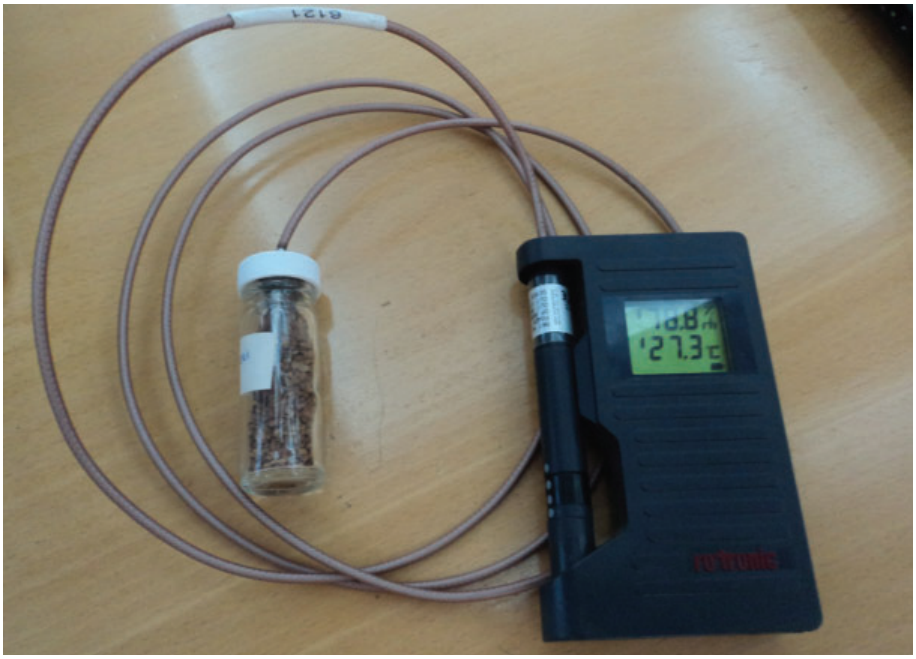


Figure 14: Measuring of seed moisture content using a hygrometer

Dr. Gold talked about the water binding regions and that water in seeds is of three types:

1. Predominantly strongly bound water – trying to dry this is destructive to the seed
2. Weak and loosely bound water
3. Predominantly loosely bound (bulk or free water) – if seeds are frozen, this water will form ice and destroy the seeds.

She then moved on to seed storage behaviour. Based on response to water removal, seeds can be categorized as orthodox/desiccation tolerant seeds, intermediate/partially desiccation tolerant seeds or recalcitrant seeds. The latter can be identified in the literature (seed information databases), in laboratory experiments (screening for desiccation tolerance), by their taxonomy (recalcitrant seeds are recorded in 65 families and their frequency varies), by their ecology (they are common in wet environments and are shed during wet periods) or by their physical attributes (they tend to be large with thin seed coats).

Seed longevity refers to the length of period that seeds remain alive or viable under a set of conditions. It is important because seed death leads to loss of genetic diversity. There are three factors that affect seed survival; the storage conditions (moisture and temperature), initial seed quality and the species. Drying seeds to 3-7% level of moisture and keeping the temperature cool (-20^{0}C)

is best for longevity. She described Harrington's rules of thumb that for every 1% reduction in moisture content or 10% reduction in eRH, the longevity doubles and that for every 5^0C reduction in temperature, seed longevity doubles. Furthermore seeds from warm dry regions and with large embryos tend to have longer longevity than those with small embryos from moist regions.

Questions and responses

Questions	Responses
With some species, the viability start with 80% but increases during storage. Why?	These seeds have dormancy which gets broken during storage. Initial viability was actually nearer 100% even if germination was 80%.
How do we protect the short-lived and recalcitrant seeds in genebanks?	They can be kept for 2-3 months in seed banks but they can be kept as live collections in field genebanks, cryopreserved. Embryo can be removed, treated then stored at -190^{0}C like coconuts but it is difficult to develop protocols for each individual species. We need to conserve *in situ*, in the wild.

Planning seed collection

Dr. Kate Gold – Royal Botanic Gardens, Kew

The objective of this session was to learn how to compile information about target species and how to plan a seed collecting expedition. Dr. Gold said that when embarking on a seed collection project, the following steps should be followed:

- Define your project purpose
- Select target species
- Compile available information.

A successful seed collection exercise is a factor of meticulous preparations for the project. Detailed preparation involves carrying out the following:

- Gathering data on target species and area
- Assessing phenology and rainfall. Here, the peak flowering and fruiting phases are estimated so that the duration of fieldwork can be timed. Historical and recent precipitation data is used to predict the rainfall patterns
- Organizing and grouping targets
- Preparing itinerary options. This involves planning accommodation, meals, transport, equipment and personnel
- Obtaining permits.

Assessing a potential collection

Dr. Kate Gold – Royal Botanic Gardens, Kew

This session was geared towards understanding how to evaluate a potential seed collection in order to maximize the quality of the collection. Dr. Gold outlined the steps to take into consideration as follows:

- The target species: the identity of the species should be ascertained before collection
- Assessing the population: the number of individuals in the population should be examined
- Assessing suitability for collection: the phenological traits of the species should be examined
- Indicators of fruit and seed maturity: these can either be physical indicators for example, change of colour, or chemical indicators for example, the level of stored food reserves. Seeds can be classified as:
    - Dry indehiscent fruits for example, *Bobgunia madagascariensis*
    - Dry dehiscent fruits for example, *Vernonia amygdalina*, Aloe spp. and *Tephrosia vogelii*
    - Fleshy indehiscent fruits for example, *Solanum incanum* and *Zanha Africana*
    - Fleshy dehiscent fruits for example, *Aesculus hippocastanum* and *Caltha palustris.*
- Assessing seed quality: a cut test is used to check the quality of seeds before collection; 10-20 seeds are cut and the percentage of full, empty or infested seeds estimated
- Assessing seed availability: this is done by checking the number of seeds per fruit, the number of fruits per tree and establishing the number of seeds that can be collected. The target is always to collect at least 10,000 seeds of one species.

Dr. Gold informed the participants that if a target species is not ready for collection, one should collect a herbarium specimen to confirm identity and return to the same population later. The next target species can also be assessed or a non-target species can be collected.

Making quality collections

Dr. Kate Gold – Royal Botanic Gardens, Kew

Dr. Gold informed the participants that by the end of her presentation they would know how to make high quality conservation collections of seeds, vouchers and data. She then gave an overview of the prerequisite considerations to making quality collection:

- Sampling strategy is chosen to capture as much genetic diversity of the population as possible. In general, at least 10,000 seeds from at least 50

individuals per population are collected. Population sampling options could either be simple random and even, stratified random or systematic sampling. These are aimed at avoiding biased sampling.

- Collecting techniques. A method that is safe and useful to collect seeds efficiently should be used. Commonly used techniques are: plucking, stripping, pruning, shaking branches, tree climbing and collecting from the ground.
- Risk assessment is important and some of the risks could emanate from:
    - The collecting site: it might be a rocky terrain or a steep escarpment
    - Rare flora and fauna: care should be taken not to damage the other plants
    - Toxic plants: some plants can cause irritation, while others have dangerous thorns
    - Dangerous animals and venomous snakes.
- Teamwork promotes successful seed collection.
- Collecting herbarium vouchers are important for the following reasons:
    - They are useful for specialist identification
    - They help resolve mixed collections and labeling problems
    - They are crucial in taxonomic and evolutionary research and nomenclature updates
    - They help in plant distribution studies
    - They are important historical records of biodiversity and help to track changes in climate and human impact.

Dr. Gold then outlined the process of how to prepare good herbarium vouchers:

- Select typical individual(s) from the population
- Try to capture all plant parts in specimen. Include stems, leaves, roots and flowers
- For annuals, collect several complete individuals
- For large perennials, collect all material from one individual
- Record perishable characters, for instance, scents and colours, presence of latex
- Expose all potentially relevant characters, for example, both sides of leaves
- Take photographs of plants and habitat if practicable.

The specimen should be pressed with care and labeled immediately. Four duplicates are always recommended. Herbarium material should not be collected for a species that is threatened and the population very small. In this case, photos and description are used instead. If the material is inadequate in terms of the number of flowers and leaves, a recollection should be made within four weeks of the initial collection.

Recording relevant data in hard copy data forms or electronically can be used to record the details.

Post-harvest handling, drying and storage of seeds of pesticidal plants

Dr. Kate Gold – Royal Botanic Gardens, Kew

This session was aimed at fostering understanding on how to maximize seed quality by handling post-harvest seeds appropriately and drying seeds safely using low cost, locally available materials. She started by reviewing the determinants of seed longevity; storage conditions, seed moisture status, storage temperature, initial seed quality and the species.

She noted that there is a correlation between progressive seed development and relative longevity. At post-abscission ripening, seeds may be immature and therefore not fully desiccation tolerant. They will therefore not have attained maximum storage potential. In the field, seeds can be dried through ambient drying, silica gel or charcoal. She explained that flowering and fruiting times varied, that seeds could be of varying maturity in a population and that harvested seeds of different maturities should be separated. Post-harvest handling of ripe seeds must be informed by knowledge of ambient and seed conditions. Seeds in danger of unacceptable rate of deterioration must be dried as soon as possible. Premature seeds should be allowed to continue to maturation and ripening while still attached to the severed branches. In such cases, mimicking the ambient conditions gives the best results. It was mentioned that drying prolongs seed storage, prevents germination and reduces pest damage. Seeds can be kept dry by keeping them in sealed suitable containers. She then demonstrated how to dry seeds using charcoal.

Question and responses

Question	Responses
How do you preserve seeds that require very cold conditions like apple seeds?	Apple seeds are orthodox and can be dried and stored at sub zero temperatures. They need a period of chilling to help break dormancy.
	When collecting seeds from places of high RH like Mombasa, dispatch seeds to low RH places like Voi. When packing seeds, less air above seeds is better. Lack of water prevents pests and fungal infections.

Sustainable harvesting of pesticidal/ medicinal plants

Dr. Nyamongo –National Gene Bank of Kenya, KARI

Dr. Nyamongo started his presentation by giving a background on traditional knowledge about pesticidal plants and their importance. He noted that the principles for pesticidal plants are similar to those of medicinal plants. He also noted that herbalists have been using materials from the wild for generations, to protect their crops, stored grains, livestock and themselves. This knowledge should be fully explored. He mentioned that the parts used are roots, bark, fruits and leaves and discussed sustainable harvesting. Sustainability is the utilization of pesticidal plants in such a way that one meets the present needs without compromising the ability of future generations to meet their own needs. Sustainability is important for posterity. It guards the species against extinction. It is also important in ensuring a continuous supply of the pesticidal plant resource. Sustainable use of these pesticidal plant species is a precursor to preservation of indigenous knowledge and conservation of other ecosystem services. He mentioned that drivers for non-sustainable harvesting are commercialization and loss or non-appreciation of cultural values and practices like taboos, religious beliefs and seasonal and social restrictions.

Dr. Nyamongo outlined the sustainable harvesting guidelines and the factors to consider:

- When to harvest: the optimum time to harvest would ensure quality and efficacy. Deteriorated materials should be avoided.
- What to harvest: correct identification and healthy, well developed materials should be harvested.
- How to harvest: depletion of the materials should be avoided to ensure regrowth.
- Nature and quality of the equipment used to harvest is important.

Dr. Nyamongo gave guidelines on how to harvest the various parts of the plants. He mentioned that when collecting roots, one should dig away from the tap root and avoid severing the tap root. Only lateral roots should be harvested and the hole filled after collection. When collecting bark, one should never ring bark but use vertical stripping of small sections leaving the inner bark intact. A thin flexible blade should be used. When harvesting leaves, one should pluck individual leaves, regularly prune branches and injure a limited number of roots to encourage sprouting of new root suckers. When collecting fruits, one should avoid collecting all good quality fruits but leave adequate quantities for regeneration.

Questions and comments

Questions	Responses
Some communities seal the de-barked area of trees with cow dung. Won't this introduce infections?	There is always that danger but the motive is to prevent the plant from water loss from the wounded area.
Are there guidelines about the percentage of leaves, roots or bark that one is supposed to harvest?	There are no guidelines, but harvesting should also be regulated. You are supposed to rely on the biological knowledge especially of the rooting system of the particular plant and personal judgment.
Do we have policies on protection of these rare species?	We don't have but we have had presidential decrees issued. There are however policies against export of CITES-recognized species

Farmer training in seed collection, conservation and propagation

Dr. Nyamongo –National Genebank of Kenya, KARI

Dr. Nyamongo stressed the importance of farmer training in seed collection, propagation and conservation of pesticidal plants. He pointed out the key issues in efficient farmer training as; identifying the target group, training needs assessment, assembling a training team and assembling training materials. Specific issues under these should cover:

- Background information: what pesticidal plants are and examples
- Why plants? Farmers should be made aware of the products and services offered by pesticidal plants so that they can appreciate why they need to undertake conservation
- What are good seeds? They should know what good seeds are, why go for them and how to obtain and process them
- Advantages of good seeds: they should be informed that good seeds store longer and are free of diseases
- Seed collection: they should be trained on how to collect high quality seeds
- Seed processing: they should be introduced to the guidelines of seed extraction, seed cleaning and seed drying
- Seed storage: they should be encouraged to use hermetic containers in place of gunny bags
- Seed germination: they should be trained on nursery establishment
- At the end of the training programme, farmers should be issued with certificates. This serves as an immense motivator.

Questions and responses

Question	Responses
How long does training take? Is it better to train on-site or extension?	In extension farmers can be trained for a maximum of three days as they start worrying about their farms. On-site is best under their conditions. It also depends on the knowledge of the farmers. Some attend every workshop and have a lot of exposure. Training farmers in hotels and towns are unproductive. They should be trained in local churches, schools and farms. Peak farming seasons should be avoided.

The commercial villages model of value chain development

Ms. Janet Mwangi –Farm Concern International

Dr. Mwangi started by introducing Farm Concern International (FCI), the institution that masterminded the integrated smallholder commercialization. She said that it is a market development agency implementing smallholder commercialization interventions in sub-Saharan Africa. She noted that the mission of the agency was to build and implement innovative pro-poor market and business models that catalyse solutions for smallholder commercialization and competitiveness in the value networks for household economic growth and community empowerment in Africa and beyond. Its vision is commercialized smallholder communities with increased incomes for improved, stabilized and sustainable livelihoods in Africa and beyond.

She informed participants that FCI operated on the basis of a number of business models key among which is the commercial village model (CVM). This is a hybrid model through which typical social administrative villages are designed and systematically graduated into commercialized competitive market-led agricultural production units branded as commercial villages. The model promotes collective proactive action that is market-led, thus responding to customer needs. Commercial villages are farmer organizations based on households at the village level aimed at developing a structured smallholder commercialization system. Villages are empowered to operate like business units to achieve significant volumes of farm produce, supply consistently, improve their supply and outsourcing logistics and achieve efficiency. Commercial villages are farmer-driven for the interest of all members. They grow in levels from households to commercial producer groups and then commercial villages.

She went through the process of setting up commercial villages:

- Site identification/site mapping
- Start up and commercialization campaigns
- Community engagement and mobilization
- Commercialization structure development
- Growth of commercial villages
- Sustainable enterprises phase.

She highlighted the advantages of commercial villages as the farmers benefit from the collective action in terms of access to farm inputs, access to markets and access to market information. It is important in production planning since farmers operate as a trading block and contributes to community development in terms of infrastructure. There is efficiency in provision of extension services.

Questions and responses

Questions	Responses
Is it possible to commercialize pesticidal plants?	Yes, years ago no-one thought that traditional vegetables could become commercial crops. The challenge is awareness and packaging the commodity.
Do you specify the minimum size of land farmers should have? What if the farmers do not produce adequate quantities? Where do you work in Kenya?	There is no minimum acreage. We target smallholder and not large scale farmers. We work with those who appreciate working together. Activities are market-driven. We work with the forestry department to identify trees which can be intercropped. We encourage farmers to cultivate, intercrop and rotate crops. FCI works in western Kenya, Nyanza, Busia, Central Kenya, Kiambu County, Nyeri, Meru, Eastern and Southern, in Embu, Makueni and Kitui.
How is gender represented in FCI?	We have a model where 40% representation should be women and 10% youth. However, land is a challenge since many youth don't own land. By building capacity they may afford their own land.
How do you ensure standards? Who caters for logistics?	Logistics are initially taken care of by the project. Once farmers make their money, they plan their own logistics. Standards are kept by a buyer/seller forum where buyers specify their quality.
Would FCI be interested in botanical pesticides?	We would be interested in those which control spider mites and integrated pest management. The market wants organic produce. We are keen to introduce botanical pesticides to farmers.

GENERAL DISCUSSIONS/REFLECTIONS

Robert Kariba and Parveen Anjarwalla led the participants through the reflections from the four-day workshop in form of a summary presentation. The session was a concise spotlight that touched on the key issues from all the presentations and practical sessions. They revisited processing and application of extracts, domestication and propagation techniques, seed collection, handling and storage, sustainable harvesting of pesticidal plants and management of invasive species. Participants then provided feedback about the training in terms of whether or not their expectations were met and how the knowledge acquired could be valuable to their immediate areas of operation.

Generally all participants said that their expectations were met and they all looked forward to sharing the information with the rest of the community (Annex 3). The pertinent issues they brought forward were the need to strengthen research-extension-farmer linkages, promotion of community-based genebanks, arboreta and nurseries, documentation of highly valued species, packaging the information on identification, processing and application into a booklet so as to reach more extension officers and farmers. They specially pointed out that the highly graded presentation on value chain analysis was also an eye opener and applauded the workshop organizers.

CLOSING REMARKS

Dr. Daniel Ofori – World Agroforestry Centre

Dr. Kate Gold – Royal Botanic Gardens, Kew

Dr. Daniel Ofori thanked the participants, resource persons and organizers for their contributions. He emphasized that, without them, the workshop would not have been successful. He then welcomed Dr. Gold to give the closing remarks.

Dr. Gold noted that she had enjoyed the workshop and that her expectations of learning about pesticides were met. She said that she knew a lot about seeds, little about pesticidal plants. She also specially enjoyed the value chain development presentation. She thanked Prof. Stevenson for inviting her to the ADDAPT programme and thanked the ICRAF team and the resource persons from National Museums of Kenya, Gene Bank of Kenya and Farm Concern International and all the participants. She expressed hope that each participant would return to their place of work with increased knowledge about botanical pesticides and the many issues related to their propagation, use and conservation. She mentioned that as the project drew to a close, she was sure that ICRAF and everybody else would continue to work together to advance the same cause.

Finally, Dr. Gold presented certificates to all the participants. Dr. Ofori encouraged them to go and practice what they had learnt and create awareness in their respective communities.

ANNEXES

Annex 1: List of participants

Name	Address	Email
Alex Mutuku Munyao	P. O. Box 301 Machakos	
Alfred Mbiti	P. O. Box 1341 Kitui	
Angela Ndanu	ICRAF- ECA P. O. Box 30677-00100 Nairobi	a.ndanu@cgiar.org
Annastasia Syomwai Mutuku	P. O. Box 8061-00200 Nairobi	mutukuannasfacia@yahoo.com
Anne Brunste	Biovision- ICIPE P. O. Box 107 -00621 Nairobi	abruntse@ymail.com
Anne Mbora	ICRAF P. O. Box 30677-00100 Nairobi	a.mbora@cgiar.org
Anthony Tabot	Kenya Forest Service P. O. Box 30513-00100 Nairobi	tabot.tabot@gmail.com
Charles Githae	Integrated Partnership for Community Prosperity P. O. Box 3287 Nakuru	cgithae@gmail.com
Charles Kipserem Kipkoskei	P. O. Box 2182 Eldoret	
Charles Ndiege	Genebank – KARI P. O. Box 30148-00100 Nairobi	charlesndiege@gmail.com
Dr. Ahmed Mohamed	IUCN P. O. Box 1556-70100 Garissa	ahmed.mohamed@iucn.org/ maalimm4@yahoo.com
Dr. Alice Muchugi	ICRAF P. O. Box 30677-00100 Nairobi	
Dr. Daniel Kisangau	South Eastern University College P. O. Box 170-90200 Kitui, Kenya	Kisangau@yahoo.com/ pdkisangau@seuco.ac.ke
Dr. Daniel Ofori	ICRAF P. O. Box 30677-00100 Nairobi	d.ofori@cgiar.org
Dr. Desterio Ondieki Nyamongo	KARI National Genebank of Kenya P. O. Box 30148-00100 Nairobi	dnyamongo@yahoo.co.uk

Dr. Eliud Kireger	Tea Research Foundation of Kenya P. O. Box 820 Kericho	limorotuk@yahoo.co.uk
Dr. Emily Wabuyele	National Museums of Kenya P. Box 45166 – 00100 Nairobi	ewabuyele@yahoo.com ewabuyele@museums.or.ke
Dr. Kate Gold	RBG Kew Seed Conservation Department, Wakehurst Place Ardingly, Westsussex, RH17 GTN UK	k.gold@kew.org
Dr. Parveen Anjarwalla	ICRAF P. O. Box 30677-00100 Nairobi	p.anjarwalla@cgiar.org
Dr. Patrick N. Muthoka	National Museums of Kenya P. O. Box 40658-00100 Nairobi	muthoka2000@yahoo.com
Dr. Ramni Jamnadass	ICRAF P. O. Box 30677-00100 Nairobi	r.jamnadass@cgiar.org
Francis Gachathi	Kenya Forestry Research Institute P. O. Box 20412-00200 Nairobi	gachathif@yahoo.com
George Kamau	Ena Farm Embu P. O. Box 19849-00100 Nairobi	geoworks.aes@gmail.com
Gerald Juma Gichohi	Katresno group P. O. Box 35 – 10111 Gakindu	geraldgichohi@yahoo.com
Gil Kamau Mungai	Kagundui-ini Dairy Goats P. O. Box 837 Thika	
James Kandugu	ICRAF P. O. Box 30677-00100 Nairobi	jkandugu@ymail.com
Jane Celina Wawira	Karia Group Mbeere P. O. Box 677 Embu	
Janet Mwangi	Farm Concern International P. O. Box 15158-00100 Nairobi	janet@farmconcern.org

Joan Sang	World Vision Kenya P. O. Box 50816-00200 Nairobi	joan_sang@wvi.org
John Maganju M'Ikiera	P. O. Box 250 Meru	
John Nyaga	ICRAF P. O. Box 30677-00100 Nairobi	j.nyaga@cgiar.org
Joshua Ndungu Mwangi	Katreseno P. O. Box 60 Gatura	jomwangi2009@gmail.com
Josephine Wanjiku	Kenya Forestry Research Institute P. O. Box 20412-00200 Nairobi	jwanjiku@yahoo.com
Joyce Manoti Ondicho	Kenya Medical Research Institute P. O. Box 54840-00200 Nairobi	jondicho@kemri.org
KhatraYakubKorane	North Eastern Forest Conversation P. O. Box 341 Garissa	Khartra.korane@yahoo.com
Lilian Anyango Owiny	Forestry 41 Garissa	lmidega@gmail.com
Linus Kanga	KARI – Embu P. O. Box 27-60100 Embu	linuskanga@yahoo.com
Lucia Keter	Kenya Medical Research Institute P. O. Box 54840-00200 Nairobi	lketer@kefri.org
Lucy Mwaura	ICRAF P. O. Box 30677-00100 Nairobi	l.mwaura@cgiar.org/ mwaura66@cgiar.org
Margaret Oluoch	Planet Associates – Smejak Project P. O. Box 40615-00100 Nairobi	agutuoluoch@gmail.com
Martha Njama	PROMETRA Kenya P. O. Box 772-00242 Kitengela-Kenya	nyambugu@yahoo.com/ prometrake@yahoo.com
Mary Mugo	Ministry of Agriculture P. O. Box 30028-00100 Nairobi	wangechimugo@yahoo.com
Mary Wanjiku Gichuki	KATRESNO P. O. Box 443 Limuru	marywanjiru2006@yahoo.com

Mathew Kiptoo Limo	Agroforestry Kitale P. O. Box 2006 Kitale	matlimokip@yahoo.com
Mathias M. Mbale	National Museums of Kenya P. O. Box 45166-00100 Nairobi	ngilamuindi@yahoo.co.uk
Michael NdwigaNjeru	Kiamiatu SHG Kithunguriri P. O. Box 532 Embu	
Moses Munjuga	ICRAF P. O. Box 30677-00100 Nairobi	m.munjuga@cgiar.org
Otieno S. Owino	Science Africa P. O. Box 57458-00200 Nairobi	oti.owino@gmail.com
Paul Njuguna	Ministry of Water and Irrigation P. O. Box 996 Embu	njugunapmacharia@yahoo.com
Peter Mbogo	Kamurugu Agricultural Development Initiative (KADI) P. O. Box 2020 -60100 Embu	pmbogo@yahoo.co.uk/kadi@jambo.co.ke
Prof. Philip Stevenson	Natural Resources Institute University of Greenwich, Chatham UK	p.stevenson@kew.org
Robert Kariba	Kenyatta University P. O. Box 48870-00100 Nairobi	karibarob@gmail.com
Ruth M. Nyangacha	Kenya Medical Research Institute P. O. Box 54840-00200 Nairobi	rnyangacha@kemri.org
Sallyannie Muhoro	Administrator ICRAF P. O. Box 30677-00100 Nairobi	s.muhoro@cgiar.org
Silas Peter Mwaura	Africa Community Initiative P. O. Box 1213 Village Market	silassike@yahoo.com
Zipporah Gaceri Matumbi	County network Forests P. O. Box 110 Meru	zipporahmatumbi@yahoo.com

Annex 2: Participants' list of expectations

Listed below are the expectations reported by the participants:

- To acquire knowledge and skills to be a better farmer in terms of nursery management, seed collection and acquisition and seedling production
- To know how best to restore the integrity of the ecosystems and conserve natural resources that are under continuous threat from mankind.
- To understand the science of grafting fruit trees and other methods of propagation.
- To get quality education on sourcing for funds, marketing and networking in tree farming enterprise.
- To acquire hands on skills through practical sessions to enhance understanding on propagation, processing and use of pesticidal plants.
- To interact adequately with other farmers, scientists and technicians in order to exchange opinions and experiences in propagation, processing, use and conservation of pesticidal plants.
- To learn how to make tree planting a viable income generating program.
- To know some of the pesticidal plants and how to use them for crop protection and as human medicine.
- To know the pesticidal plants that can be used in fodder crops and fruit trees.
- To get more information on value chain and know a variety of pesticidal plants to use in riparian areas.
- To know more about pesticidal plants that can control thrips, great grain borer and fruit flies.
- To learn how to propagate and harvest pesticidal plants especially for urban and peri-urban agriculture.
- To learn and extend the knowledge to other nursery operators and farmers.
- To share and document indigenous knowledge and technologies.
- To be able to undertake value addition and actualize production and processing of natural products.
- To be able to correctly identify pesticidal plants because there is a lot of confusion at the moment.
- To get more knowledge on sustainable harvesting and conservation of pesticidal plants.
- To have discussions on value chain analysis with a view of having product development.
- To have an idea of some of the pesticidal plants that can survive in northern Kenya.

Annex 3: Participants' comments after the workshop

1. My expectations were met thanks to the trainers and organizers of the workshop. The way forward is; sharing the report with IUCN and KFS-Northeastern forest conservancy. There is also need to strengthen research extension farmer linkages and to promote conservation of high value species including pesticidal plants through on-farm, school demonstrations, catchment area and regional conservation efforts, Promotion of community-based genebanks and nurseries, documentation of high value species including, pesticidal plants and strengthening ICRAF-IUCN/KFS Northeastern forestry conservancy through working together in conservation, food security and climate change.
2. My expectations were met and information gained will be shared with technicians, extension workers and farmers who attend training at KEFRI under the outreach programme. The priority will be promotion of domestication of pesticidal plants, processing, application and seed collection.
3. Thanks very much for the organizers of the workshop and all the resource persons. My expectations were surpassed. The information gained will be shared with farmers through farmer forest field schools to encourage the establishment of pesticidal plants.
4. My expectations were met. One area I found interesting and very useful is the preparation of the pesticidal solution by use of soapy water. I hope to share this information with my community.
5. I applaud the workshop organizers. I have shared and learnt a lot about pesticidal botanicals and obtained in-depth knowledge on seed longevity dynamics.
6. I appreciate having attended this workshop. I have learnt a lot and made a lot of contacts. My expectations were surpassed and my mind opened up to the many other uses of medicinal plants and as a scientist I will definitely come up with many proposals on the same.
7. My expectations were met and I will be going to the community to advocate for conservation and encourage the community to make use of pesticidal plants as cheaper alternatives to synthetic pesticides.
8. I have gained insightful information on botanical pesticides. Science Africa will be running an issue focusing on the use of botanical pesticides and therefore this workshop was timely for us. I hope we can strengthen partnerships that can facilitate more awareness of the efforts in research on agroforestry especially to the end users.
9. My expectations were met and I have learnt how to propagate, extract and conserve pesticidal plants and now I can advise farmers about all these.

10. My expectations were met. I will extend the information to the others and plant more botanicals while I use what I already have.

11. The workshop expectations were fully met. We should now explore the possibility of conserving plant species by having arboreta in every county. Farmers will always take up any initiative that brings in income. Botanical pesticides can be commercialized using models such as the commercial village model by Janet Mwangi.

12. My expectations were met and surpassed. I have known more bio-pesticide plants that I can use in tea. I have known people and organizations we can collaborate with and it is clear that there is a commercial potential for bio-pesticides especially in the tea industry.

13. My expectations were met. I have advanced knowledge in seed biology and sharpened the principles of seed handling and conservation. The highly graded presentation on value chain analysis was also an eye opener.

14. My expectations were met and mostly on propagation of pesticidal/ medicinal trees and seed conservation. Am looking forward to disseminate these insights to others.

15. My expectations were met fully. I have acquired new skills on seed extraction and best practices as a nursery operator and extension officer. I work with local herbalists and am looking forward to train them on how to harvest botanicals sustainably.

16. My expectations were met and exceeded. The infonet-biovision website is a good way of communicating the documented bio-pesticides but we require packaging the information in a booklet so as to reach more extension officers and farmers.

17. I have learnt much on seed biology and aspects of quality seed collection. The issue of value chain analysis has been well addressed. There is need for action plan to establish seed collection centers in various institutions and working centers.

18. I have learnt a lot and I can now actively engage in conservation of these botanicals and dissemination of this knowledge to others.

20. My expectation was to learn more about how farmers can substitute chemical pesticides with pesticidal plants and this was extensively met. There is need to integrate this knowledge in the university curriculum as this would help bring the professionalism required. We can also look into more integration of pesticidal plants in agroforestry systems.

21. Thanks for the invitation to this training workshop. There was so much knowledge to share. We should explore the possibility of identifying more indigenous pesticidal plants to add to the list.

22. Thanks for the excellent organization of the training. I have learnt a lot especially on extraction and determination of seed moisture content. I hope to share this information with my colleagues in KARI.

23. Thank you for inviting me. I am looking forward to the whole document with which as ICIPE we can document useful farmer technologies. We would like to partner with ICRAF on a lot of these technologies.

24. Thanks to the workshop organizers. As a seed collector, my expectations were adequately met and clearly conveyed.

Annex 4: Workshop programme

Day 1: 28 January 2013		
Time	**Activity**	**Presenter/Responsible**
Session 1: Opening Session **Moderator: Dr. Daniel Ofori**		
08:30 – 09:00	Registration	Sallyannie Muhoro
09:00 – 09:15	Welcome remarks	Dr. Ravi Prabhu
09:15 – 10.00	Course introduction and expectations	Prof. Phil Stevenson
10.00 – 10:30	Self-introduction/expectations	All participants
10:30	Group photo	
10:30 – 11.00	**Coffee/Tea**	
11:00 – 11:30	Pesticidal plants: an alternative to chemical pesticides	Dr. Alice Muchugi
11:30 – 12:00	Sustainable harvesting	Dr. Nyamongo
12:00 – 12:30	Sustainable harvesting of *Warburgia ugandensis*	Dr. Alice Muchugi
12:30 – 13:00	Questions and discussions	All participants
13:00 – 14:00	**Lunch**	Sallyannie Muhoro
Session 2: Moderator - Dr. Kate Gold		
14:00 – 14:30	Processing and application of extracts	Prof. Phil Stevenson
14:30 – 15:00	Domestication of pesticidal plant species	Dr. Daniel Ofori
15:00 –17:00	Practical session (at ICRAF nursery)	Phil/Daniel/Lucy
17:00 – 17:30	**Coffee/Tea**	
17:30	Logistics/transfer to hotels	Sallyannie Muhoro
Day 2: 29 January 2013		
Time	**Activity**	**Presenter/Responsible**
Session 3: Moderator – Anne Mbora		
08:00 – 08:30	Registration	
08:30 – 09:00	Constraints to farmer uptake of botanical pesticides	Dr. Jeremias Mowo
9:00 – 9:30	Management of invasive species	Dr. Emily Wabuyele
9:30 – 10:00	**Coffee/tea**	
10:00	Bus leaves ICRAF for Karura Forest	
10:15 – 14:15	Field practical • Assessing a potential collection • Making quality collections	Dr. Kate Gold Dr. Patrick Muthoka Charles and Mathias
14:15	Bus leaves Karura Forest	
14:30 – 15:30	**Lunch**	
16:00	Bus leaves for hotels	
Day 3: 30 January 2013		
Session 4: Moderator - Dr. Alice Muchugi		
08:00 – 08:30	Registration	
08:30 – 09:45	Status and availability of germplasm of pesticidal species	Dr. Patrick Muthoka
09:45 – 10:45	Seed moisture status and seed longevity; seed storage behaviour	Dr. Kate Gold

10:45-11:15	**Coffee/tea**	
11:15-12:15	Planning seed collecting: • Collating information • Resources • Logistics • Equipment	Dr. Kate Gold
Session 5: Moderator – Dr. Nyamongo		
12:15 – 13:15	Assessing a potential collection: • Population • Phenology	Dr. Kate Gold
13.15 – 14:15	**Lunch**	
14:15 –15:15	• Physical quality • Seed quantity	
15:15 – 17:15	Making quality collections	Dr. Kate Gold
17:15	Logistics/hotel transfers	Sallyannie Muhoro
Day 4: 31 January 2013		
Session 6: Moderator – Dr. Patrick Muthoka		
08.00 – 08.30	Registration	Sallyannie Muhoro
08.30 – 09.45	Post-harvest handling, drying and storage of seeds of pesticidal plants	Dr. Kate Gold
09.45 –11.00	Case study of delivering farmer training in seed collecting	Dr. Nyamongo
11.00 –11.30	**Tea/Coffee**	
11:30 –12.45	The commercial villages model of value chain development	Janet Mwangi
13.00 –14.00	**Lunch**	
Session 7: Moderator – Dr. Daniel Ofori		
14.00-14.30	General discussions/Reflections	
Closing session		
14.30 – 15.00	Closing remarks	Dr. Ofori
15.00 –15.15	Closing remarks	Dr. Kate Gold
15.15	Logistics	Sallyannie Muhoro

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United Nations Avenue, Gigiri, PO Box 30677, Nairobi, 00100, Kenya
Tel: +254(0)20 7224000, via USA +1 650 833 6645, Fax: +254(0)20 7224001, via USA +1 650 833 6646
Email: worldagroforestry@cgiar.org
Website: www.worldagroforestry.org