World Agroforestry Centre

UNIVERSITY of GREENWICH
Natural Resources Institute

Proceedings of the training workshop on

Optimisation of Pesticidal plants: Technology Innovation, Outreach & Networks (OPTIONs)

27–30 October 2014
World Agroforestry Centre (ICRAF)
Nairobi, Kenya

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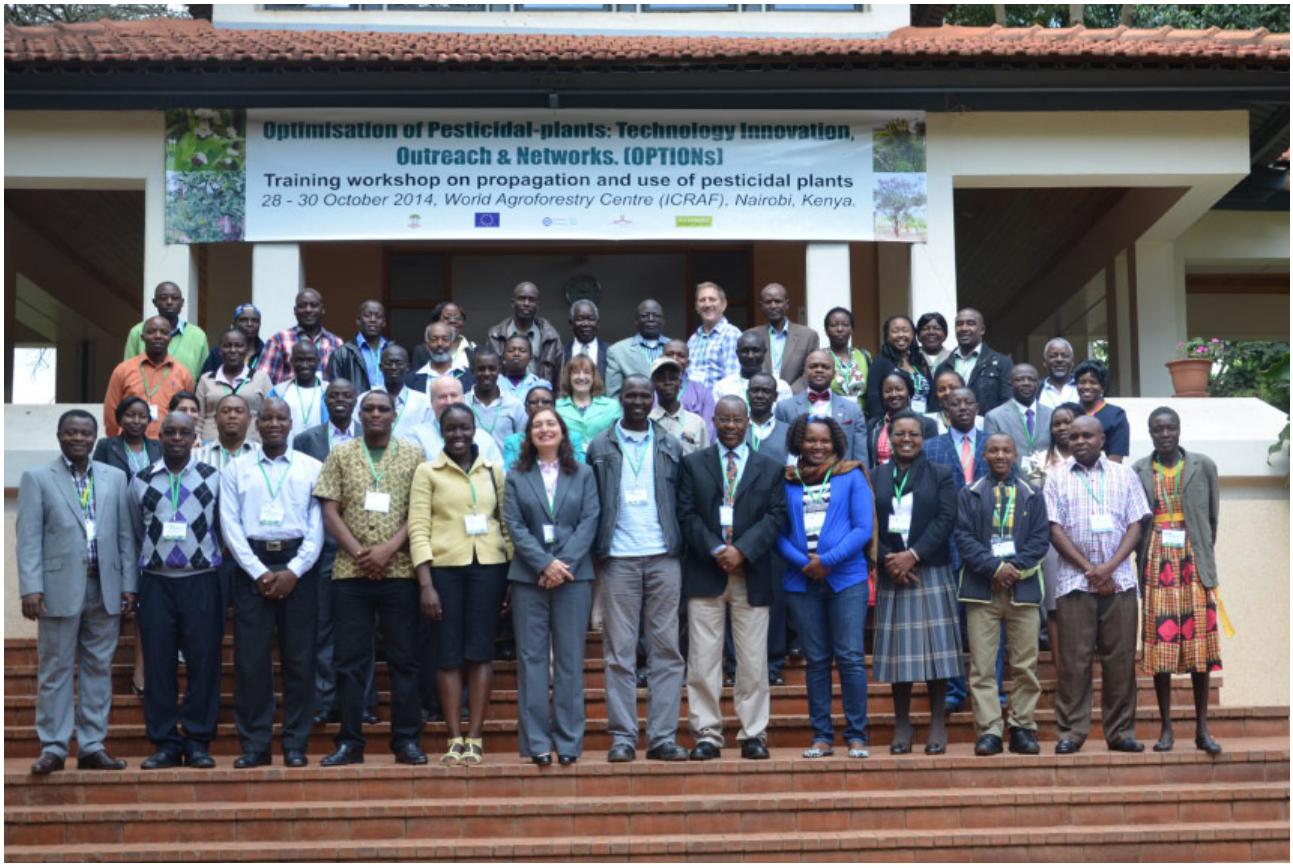
We wish to thank everyone who contributed to the success of this workshop. Special thanks to Prof Steve Belmain of University of Greenwich and Dr Daniel Ofori of the World Agroforestry Centre. Many thanks to Sallyannie Muhoro for her tireless efforts in organizing the logistics. We would also like to recognize the contributions of the presenters, moderators, the organizers and all the participants.



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LIST OF ABBREVIATIONS

ACP	African Caribbean Pacific
AKDN	Aga Khan Development Network
AKF	Aga Khan Foundation
BioNET-EAFRINET	East African Network for Taxonomy
CBD	Convention on Biological Diversity
CBO	Community-based organization
CEO	Chief Executive Officer
CIFOR	Centre for International Forestry Research
CGIAR	Consultative Group on International Agricultural
CPG	Commercial Producer Group
CVM	Commercial Village Model
DoHoMa	Domestic Horticulture Market
EA	East Africa
EC	European Commission
EPZ	Export Processing Zone
EU	European Union
FCI	Farm Concern International
GeRRI	Genetic Resources Research Institute
GPS	Global Positioning System
GR	Genetic Resources
IAS	Invasive Alien Species
ICIPE	International Centre of Insect Physiology and Ecology
ICRAF	World Agroforestry Centre
IP	Intellectual Property
IPM	Integrated Pest Management
IPR	Intellectual Property Right
ITPGR	International Treaty on Plant Genetic Resources
KALRO	Kenya Agricultural and Livestock Research Organization
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forest Research Institute
KESSFF	Kenya Small Scale Farmers Forum
KOAN	Kenya Organic Agriculture Network
KTDA	Kenya Tea Development Agency
MC	Moisture Content
MMO	Maendeleo Mashinani Organization
MoA	Ministry of Agriculture
NGO	Non-Governmental Organization
NMK	National Museums of Kenya
NRI	Natural Resources Institute
OA	Organic Agriculture
OPTIONS	Optimisation of Pesticidal plants: Technology, Innovation, Outreach & Network
PAFRI	Preserve Africa Initiative
PBK	Pyrethrum Board of Kenya
PGA	Pyrethrum Growers Association
PP	Pesticidal plants
PPP	Pesticidal Plants and their products
PRI-Kenya	Permaculture Research Institute Kenya
RBA	Right-based Approach
SGG	Sustainable Global Gardens

SME	Small and Medium-sized Enterprises
S&T	Science and Technology
STI	Science and Technology Innovation
SSA	Sub-Saharan Africa
TAV	Traditional African Vegetable
TRIPS	Trade-Related aspects of Intellectual Property rights
UN	United Nations
UK	United Kingdom
WHO	World Health Organization

EXECUTIVE SUMMARY

Most poor farmers in Africa depend on their agricultural produce to achieve food security. A factor limiting food production is insect pest management. Pesticidal plants have been used for thousands of years by man until the 1940s when chemical pesticides were introduced. Plant materials are known by farmers to be environmentally benign, safer and cost-effective compared to synthetic pesticides. They are also difficult to adulterate when produced or harvested by farmers. However, the realization of the full potential of pesticidal plants, especially for the poorest farmers, is constrained by inadequate product quality evaluation and development, which, if improved, will increase the reliability of pesticidal plants.

The overall objective of the Optimisation of Pesticidal plants: Technology, Innovation, Outreach & Network (OPTIONS) is to promote and facilitate the uptake of innovative technologies for improved food security based on pesticidal plants that can be effectively deployed within the context of local needs and resources. It aims to build the capacity of stakeholder institutions to promote scientific and technology innovations which could be achieved by formulating and revising policies in science and technology innovation (STI) that enable effective outreach of different approaches on the use of plant materials in pest management and food security.

Specific project objectives include: 1) To consolidate an existing regional partnership of stakeholders from farmers to ministries to exploit STI in the use of pesticidal plants; 2) To provide a forum for raising awareness about the use of pesticidal plants, particularly the livelihood benefits to poor farmers and potential for commercial exploitation; 3) To create an environment for cross-training and skill-transfer through practical demonstration workshops on propagation and optimised application of plant-based pesticides and building individual and institutional capacity; 4) To develop policy guidelines and trial innovations to ensure validated marketing and promotion of safe and effective plant-based pesticides.

The main activities include training and capacity building workshops (bioassays, quality control, propagation, incentives, IPR and product registration, micro-propagation, cultivation, conservation, regulation, marketing and SME business development), and information dissemination via journals, leaflets and policy documents.

The target groups/beneficiaries are community-based organizations, educational and research institutions, government and non-governmental organizations, extension agents, SMEs, rural farming communities and small-scale farmers (>4000 directly through training schools) throughout partner countries (Eastern and Southern Africa, particularly Kenya, Malawi, Tanzania, Zambia and Zimbabwe).

The project results are S&T policies evaluated and formulated to enable the exploitation of pesticidal plants through commercialized propagation using farmer incentives, novel STIs trialled, developed and promoted, introduction of pyrethrum cultivation to new areas with guaranteed markets for successful farmers and innovative application protocols for livestock and food grain storage. Others include consolidation of stakeholders with training provided in propagation and application of pesticidal plants, and production and distribution of training information sheets for famers, extension services and organic grower NGOs.

Activities are implemented in eastern and southern Africa, particularly Kenya, Malawi, Tanzania, Zambia and Zimbabwe. In Kenya, ICRAF leads work package 3 on strengthening the capacities of government agencies, research institutions and the private sector in pesticidal plant STI through collaborative outreach programmes workshops and training.

Objective of the workshop

A training workshop was organized from 27–30 October 2014 at the ICRAF campus in Nairobi. The event brought together scientists, farmers, nursery operators, extension workers, national research institutes and private sector representatives to share knowledge and strengthen capacities in the optimisation of pesticidal plants through technology innovation, outreach and networks.

Workshop organization and facilitation

The workshop was hosted by ICRAF, in collaboration with the University of Greenwich, Natural Resources Institute, the National Museums of Kenya, Sustainable Global Gardens and the Aga Khan Development Network.

INTRODUCTION AND WELCOME REMARKS

Dr Margaret Kroma - Assistant Director General, Partnerships & Impact, World Agroforestry Centre (ICRAF)

Dr Kroma welcomed all the participants to the campus on behalf of the Senior Leadership Team. She stated that the workshop's focus beyond science and the technology was timely. Highlighting the main aim of the event, which was to to share knowledge and strengthen capacities in the optimisation of pesticidal plants she noted that it clearly reflected the recognition and growing appreciation among scientists of the key role of strategic partnerships across the innovation to impact continuum. In her view, the focus on the promotion of indigenous pesticidal tree species to farmers for pest and disease control would also have huge implications on both environmental and ecological resilience. She observed that despite the push for conventional monoculture agricultural production which is currently preferred, even in the face of climate change, all efforts to promote alternative strategies had to be applauded and supported.

Dr Kroma stressed on the strategic importance of boundary partners who engage directly on the ground in technology adoption and capacity development efforts at various levels and with policy makers in bringing about the changes crucially needed to develop economically-viable and resilient systems through bio-pesticide use in smallholder tree-based production. She concluded her presentation by wishing all the participants success in achieving the objectives and outcomes of the workshop.

OPENING SESSION

Course introduction and expectations

Prof Steven R. Belmain - University of Greenwich

Prof Belmain began by putting OPTIONS in the context of the larger ACP science and technology programme which involves the African, Caribbean and Pacific group of states. He presented the summary and objectives of ACP S&T, the first and second call aims and the overall objective of the initiative in supporting ACP countries in the formulation and implementation of science and technology (S&T) policies that could lead to sustainable development and poverty reduction through economic growth and progressive integration in the world economy. He mentioned that the ACP S&T call was aimed at eradicating poverty, building S&T capacities to support research, development and innovation and enabling the activities, and promoting processes and policies critical to sustainable development.

Prof Belmain also discussed the problems associated with synthetic pesticides. Some of those highlighted include the fact that they are costly, can cause health and safety issues, could have a negative impact on the environment, can be adulterated (mixed incorrectly), can cause resistance in pests and kill beneficial insects, can be difficult to access and end up in accumulation of redundant chemicals. As result of these, he informed participants that the sustainable production and use of pesticidal plants could be an alternative way to manage and control pests in field crops and stored grains and livestock.

He then explained some of the advantages of using pesticidal plants as being cost effective, accessible if farmers plant and harvest themselves, appropriate for small-scale farming, ease of preparation using rudimentary techniques with unprocessed plant materials and having relatively low toxicity and persistence in nature. However, he also noted that their efficacy could vary across seasons or locations, and that their availability and application needed optimizing.

Prof Belmain gave two perspectives of botanical pesticides in industrialized nations where pesticides were highly regulated and controlled and in developing countries where there was high plant diversity and where food production was paramount. He mentioned that despite hundreds of papers on entotoxic/deterrent plants as potential products, only five had been commercialized to date – Tancetum spp. (Pyrethrum), Derris spp. (cube resin-rotenone), Azadirachta indica (Neem), Nicotiana (nicotine) and Lamiaceae (essential oils). He observed that most existing botanical insecticides were neurotoxins or muscle poisons focusing on acute toxicity whilst insect-plant chemical interactions in nature were more subtle in that most of the plant's defensive chemicals discouraged insect herbivory, rather than killing outright.

He noted that the overall objective of the workshop was to promote and facilitate uptake of pesticidal plant technologies for improved food security that are deployed effectively and capacities of stakeholder institutions enabled to promote Science and Techology Innovation (STI). It specifically aimed to achieve the following:

- Support environmentally-benign, safe and effective pest control using plants.
- Conduct training on propagation, use and application of plants for pest control.

- Promote improved production and storage of agricultural produce.
- Discuss and share current experiences.
- Learn about new approaches to pest control.
- Develop innovations for up-scaling and outreach.
- Provide participants with the skills to train farmers on growing and using PPs.

Prof Belmain also listed the main partners of OPTIONS: University of Zimbabwe, Sokoine University of Agriculture, Mzuzu University, World Agroforestry Centre, National Museums of Kenya, Sustainable Global Gardens, Royal Botanic Gardens Kew, Natural Resources Institute, University of Greenwich, and associates from a wide range of other institutions.

SESSION ONE

Pesticidal plants: an alternative to synthetic chemical formulations

Dr Daniel Ofori – World Agroforestry Centre

Dr Ofori gave a short presentation titled, "The use of pesticidal plants as an alternative to synthetic chemical pesticides." He listed some of the pesticidal plants which were part of the project: *Tagetes minuta, Azadirachta indica, Lippia javanica, Tithonia diversifolia, Securidaca longepedunculata* and *Zanthoxylum holtzianum* (Figure 1). He then defined a pest as an organism with characteristics that people see as damaging or unwanted, as it harms agriculture through feeding on crops or parasitizing livestock. Dr Ofori gave three possible ways of pest control – chemical control, integrated pest management (IPM) and non-chemical alternatives including cultural practices, use of resistant varieties, biological control using natural enemies of pests and use of biological products. He described the risks associated with chemical pesticides and the benefits of using pesticidal plants.

Figure 1: Some of the most common pesticidal plants: **A.** *Tagetes minuta,* **B.** *Lippia javanica,* **C.** *Azadirachta indica,* **D.** *Tithonia diversifolia,* **E.** *Securidaca longepedunculata and* **F.** *Zanthoxylum holtzianum*

Baseline survey

Paul and Carole Keeley – Sustainable Global Gardens, UK

A baseline survey was performed with workshop participants to assess and establish knowledge and gaps in accessibility and use of pesticides. The survey was administered through a questionnaire (See Annex 2).

Indigenous knowledge on the pesticidal plant species

Dr Parveen Anjarwalla – World Agroforestry Centre

The aim of the group session was to share knowledge and experiences on different pesticidal plant species. Six groups were created, each comprising participants with different expertise (Figure 2). After the discussions, each group presented their results. The summary of the feedback from respective groups is given in Table 1.

Table 1: Group feedback on pesticidal plant species

Scientific & common name of plant	Pests	Parts used	Preparation & application	Effectiveness	Source	Limitations
Allium sativa (Garlic)	Whitefly, caterpillar & mites	Bulb	Pound the bulb & mix with water	Effective	Cultivation	Availability
Azadirachta indica (Neem tree)	Pest life cycle interrupter, weevils, termites & ticks	Oil, bark & roots	Extract oil. Dry the roots & bark, (grind into powder & mix with water or as it is)	Moderate	Wild or domesticated	Dosage, availability & misidentification
Capsicum annuum (Hot pepper)	Aphids & white flies	Fruit (whole fruit)	Dry the fruit & grind into powder; mix with water or soap	Moderate	Cultivated	Less longevity, dosage & bulkiness
Lantana camera	Weevils & bore worm	Leaves	Dry the roots & bark, grind into powder & mix with water or as it is	Effective	Wild	Invasive
Ocimum kilimandscharium	Weevils, fleas & beehive pests (lice)	Whole shrub	Cut & make bundles – broom-like, use it to clean (sweep)	Moderate to high	Wild	Propagation, dosage & misidentification
Melia volkensii	Termites	Fruit pulp	Mixed with water	Moderate	Wild & sometimes cultivated	Availability of materials
Pyrethrins (Pyrethrum)	Various pests	Flowers & seeds	Dry flowers/ seeds and grind them then mix with water	Effective	Cultivation	Volumes of this crop has drastically declined

Scientific & common name of plant	Pests	Parts used	Preparation & application	Effectiveness	Source	Limitations
Securidaca longepedunculata	Weevils	Roots	Pound the roots and mix with water	Effective	Cultivation	Kills plants, seeds difficult to germinate
Solanum incanum	Ticks & slugs	Fruit	Crush the fruit and mix with water, then spray	Moderate	Wild	poisonous in nature (extract)
Symplytum officinale	Aphids	Leaves roots	Crush leaves & mix with water & spray, Intercrop	Moderate	Wild	May be scarce
Tagetes minuta	Aphids, white/ red flies & cabbage worms	Flowers, leaves (separately and all together)	Chop, soak and add soap, then filter and spray	Effective	Wild	Not easily available all season
Tephrosia vogelii	Ticks & aphids	Leaves	Pound the leaves, mix with water and spray	Effective	Cultivation	Scarce, lack of knowledge & skills on preparation & use
Tithonia diversifolia	Flies, aphids, scales & cabbage worms	Leaves	Chop, soak, add soap, then filter and spray	Very effective	Wild	Invasive

Figure 2: Two group discussions on pesticidal plants during the workshop

Dr Parveen Anjarwalla thanked all the groups and urged the participants to continue sharing their knowledge, both during and after the workshop.

SESSION TWO

Propagation and cultivation of pesticidal plants: principles and practices

Dr Daniel Ofori - World Agroforestry Centre

Dr Ofori began by introducing some of the pesticidal plant species. He said that roots, seeds, fruits and barks were the parts of plants harvested and explained the need for propagation and cultivation being necessitated by the constraints of sustainability and natural regeneration. He noted that propagation and silvicultural techniques were also unknown to many, and reiterated the fact that we needed the right tree (species, varieties, mixture of species) to obtain the active ingredients to use in the right place (climatic conditions, ecological suitability, market access, comparative advantage, landscape role, farm niche) and for the right people (fit in with livelihood strategy, tree planting habit, group membership, comparative advantage).

Dr Ofori mentioned that the first step, germplasm collection, aims to raise seedling/other propagules, for tree management research (seed or vegetative propagation), for genetic improvement programmes (for the establishment of provenance field trials from superior material through exploiting intraspecific variation in species), for breeding and ex-situ conservation (establishment of field genebanks for long term management of genetic resources).

He observed that plus tree selection was key. This would ensure that planting material would consistently producing good quantities of high quality products (active ingredient in the case of pesticidal plants). He informed participants that propagation could be done in a laboratory, in controlled conditions or in a nursery, where plants are raised with special care until they are ready for the field. A nursery can also be used as a centre to train people and transfer knowledge. He discussed different types of nurseries: permanent ones which can produce large quantities of seedlings, temporary ones which can be established for a short period, mostly less than five years to meet a specific but temporary local need, and extension nurseries which were established to produce seedlings of many species useful to the local community for firewood, fodder, posts and poles.

To establish a nursery, one would need to consider the following: accessibility, permanent water supply, and good drainage. The nursery site, he said, should ideally be on a gentle slope of about 2-4 degrees.

Figure 3: Setting cuttings in a non-mist propagator

Dr Ofori also made a presentation on some propagation techniques. He briefly mentioned the process of cuttings (figure 3), grafting (Figure 4) and air-layering (Figure 5), and informed the participants that the same would be demonstrated at the ICRAF nursery. He also discussed propagation by in vitro tissue culture for ex-situ conservation and showed how seeds are stored for medium term storage at ICRAF. He also showed how true to type trees, identical to their mother trees, are obtained with vegetative propagation compared to variability and diversity shown with propagation by seeds. Dr Ofori stressed on the need for quality planting materials and silvicultural techniques. He also showed how pesticidal plants can be planted with crops for protection.

Figure 4: Collection of scions, setting grafts and grafted seedlings

Figure 5: Setting marcots, girdled branch with ball of rooting medium and successful marcots in pots

Figure 6: In vitro culture

Figure 7: Application- *Tagetes minuta* intercropped with Kale

Using pesticidal plants in crop protection

Prof Steven R. Belmain - University of Greenwich

Prof Belmain began his presentation by outlining the factors that affect the use of plant material: cost, effectiveness, availability, toxicity, ease of use, acceptability and versatility. He mentioned that cost was considered the most important factor in Ghana and that farmers did not always choose the best plants. He discussed the general rules and guidance on the use of pesticidal plants:

1. Pesticidal plants do not kill insects fast and some insects may take several days to die. PPs could act through repellency, anti-feedancy and growth regulation.
2. Taxonomy, the time of collection, location of certain species and processing methods are important. Farmers were encouraged to experiment and try various plants and various dosages on pests.
3. For field crops, shade drying of plant material is better than the hot sun, which could harm the active ingredients. Storage should be in dry, dark conditions. Grinding plant materials should be done just before use to avoid losing volatile compounds over time. Grinding helps improve extraction by increasing surface area. Once dry powder is obtained, extraction can be done overnight. Concentration varies with species, and 10% concentration is the higher limit. For a 1% concentration, farmers can add 10 grams of plant powder in one litre of water, for 10% solution, 100 grams of plant powder can be added to a litre of water. Farmers can have a ratio to work with and consistency would encourage future use. Filtering can be performed using cloth material to remove big particles which may clog the sprayer.
4. Use of soap as a surfactant to help spread the extract on the plant surface and to optimise extraction of active chemicals. A 0.1% soap solution is made by adding 1 ml liquid soap per litre. To make an extract at low concentration for spraying on field crops, one can make up a solution with 10 ml liquid soap, 100g plant powder and a litre of water to make up a 10% PP with 1% soap solution. This can then be diluted 10 times with water to obtain a 1% PP with 0.1% soap solution for spraying.
5. Spraying in shade is advisable as UV rays can break down the active compounds, thus late afternoons or evenings are optimum times. The night maximizes the duration of the active compounds on pests.
6. Frequent spraying is advisable as PP extracts break down fast. Weekly spraying is advisable for effective control. Farmers can experiment on frequency of application too.
7. Safety is key as although PP are less toxic than synthetics, farmers must be encouraged to be careful and use protection measures.

Prof Belmain then went through the rules and guidelines for applying PP for post-harvest storage:

1. The grains need to be dry; less than 15% moisture content. Solarisation can be used to dry grains. Testing for dry grains can be done by filling 1/3 of a clean bottle with grain and adding 2 tablespoons of dry salt. The bottle is closed, shaken vigorously for 1 minute and left to rest for 15 minutes. If salt sticks to the sides of the bottle, the grains are not dry enough. If salt does not stick to the bottle, then the grains have a moisture content of less than 15% and are safe for storage.
2. The PP materials should be dried in the shade and stored in dark, dry conditions. They can be ground/pounded/sieved to a fine powder shortly before use. Sometimes, the whole leaves/plants may be suitable for use.

3. Application of PP may need repeating.
4. Grains should be thoroughly washed before grinding, cooking and consumption.

He explained various ways of using PP against grain storage pests: combining solarisation with PP extracts, mixing 1-2 cups of powdered PP material with 100 cups of grains and mixing thoroughly on plastic sheeting on the ground and sprinkling PP powder in between layers of maize cobs or unthreshed millet or sorghum.

Prof Belmain also presented an overview of some pesticidal species, which he classified as:

1. Weeds, invasive, fast growing, perennials, easy to propagate, for example,
2. Woody, slow-growing, rare, difficult to propagate, over-collected
3. Cultivated, food, spice, waste products

Azadirachta indica, Melia azedarach, Melia volkensii, Tephrosia vogelii, Dolichos kilimandscharicus, Neorautanenia mitis, Lippia javanica, Lantana camara, Vernonia amygdalina, Dysphania ambrosioides, Tithonia diversifolia, Tagetes minuta, Tanacetum cinerariifolium, and *Solanum incanum* were considered weeds, invasive, fast-growing, perennials and easy to propagate. On the other hand, *Securidaca longepedunculata, Zanha africana, Bobgunnia madagascariensis, Euphorbia candelabrum, Euphorbia tirucalli, Cissus quadrangularis, Aloe ferox* were classified as woody, slow-growing, rare, difficult to propagate and over-collected. Other species he discussed include *Khaya senegalensis*—considered rare and *Capsicum annuum, Piper nigrum, P. guineense, Nicotiana tabacum, Citrus sinensis, C. limon, C. paradisi, Allium sativum, Ocimum gratissimum, O. americanum, O. kilimandscharicum, O. africanum, Cymbopogon citratus, C. nardus, C. schoenanthus, Annona senegalensis,* and *A. squamosa,* which are classified as cultivated, food, spice or waste products.

He concluded his presentation by saying that, many of these plant species were used by farmers, but there were bottlenecks in knowledge transfer among farmers. He advised that farmers needed to understand that PPs were not perfect solutions and could be slow acting, requiring repeated application, and laborious to collect, process and apply. He however, said that using PPs was better than doing nothing and would reduce insect damage. He further noted that farmers needed to be encouraged to increase supply of PP materials which they discovered were effective in tackling their pest problems. He also encouraged them to conduct their own experiments.

Further reading

- Flint ML. 2012. IPM in Practice: Principles and Methods of Integrated Pest Management. UCANR Publications, 292 pages
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- Stoll G. 2000. Natural Crop Protection in the Tropics. Margraf Verlag, NL 376 pages
- Prakash A, Rao J. 1997. Botanical Pesticides in Agriculture. CRC Press, Boca Raton, USA, 461 pages

Questions and responses

Questions	Responses
Can one mix, for example, chillies and garlic together?	Yes, farmers can do their own experiments and tests.
What is the shelf life of most of these extracts?	Dry material can be stored, but fresh extracts should be made right away to retain the active ingredients.
Has any research been conducted on traceability?	We are planning to do chemistry backstopping in Africa and Mzuzu University will be given equipment to verify the chemicals.
There is stem borer in cotton and we are embracing genetically modified crops in Africa due to its perceived resistance. Would PP offer an alternative to GM crops?	We have not done any comparative studies to that effect.
Is there a link between medicinal and pesticidal plants?	Many of them are used for both.
What could be done by governments in developing countries to promote the use of pesticidal plants?	Countries need to put in place policies and regulatory frameworks to guide the use of pesticidal plants. The scientists and policy makers must work together. I would also add that improving our knowledge on variability of efficacy, conservation and regulations is critical.
Why would one prefer solarisation as a method of drying grains and controlling pests, when special treatments and synthetic pesticides can be used?	If well applied, solarisation is one of the most reliable and effective way of drying grains. Solarisation is the extension of grain drying and most farmers already know about it. Secondly, this method requires minimal inputs; as plastic sheets are easily and cheaply obtained locally; and it can be implemented without external support. In contrast to special treatments such as fumigation or application of the pesticide, solarisation is natural and environmentally friendly.

PRACTICAL SESSION

This session was conducted at the ICRAF nursery. Participants observed propagation of pesticidal plants in the ICRAF nursery – propagated *Securidaca longepedunculata* from seeds, *Azadirachta indica* from seeds, *Tagetes minuta* from seeds, *Tithonia diversifolia* from cuttings, *Solanum incanum* from seeds, *Tephrosia vogelii* from seeds, *Strychnos spinosa* from coppiced shoots, *Zanthoxylum holtzianum* from cuttings, *Cymbopogon citratus* from root divisions and *Euphorbia tirucalli* from cuttings (Figure 3). Demonstrations on processing and application of extracts of pesticidal plants and propagation of plants by grafting, marcotting and cuttings were conducted by Prof Belmain and ICRAF staff.

Figure 3: Propagated pesticidal plant species in ICRAF nursery

Propagation by cuttings

Mr Julius Mosocho – World Agroforestry Centre

This was demonstrated with *Warburgia ugandensis* cuttings (Figure 4). Julius Mosocho, the ICRAF nursery assistant, stressed that all working surfaces and tools must be cleaned and sterilized with a diluted solution of bleach or methylated spirit. When collecting cuttings, one can use a cool box to keep germplasm fresh. Alternatively, the cuttings can be placed in moistened polythene bags or wrapped in newspapers. Usually, it is advisable to cut leaves in half to reduce water loss in the cuttings. Sand, coco peat or vermiculite rooting media can be used. Such media should be sterilized to prevent infections.

The cuttings are raised in propagators, which should have the following profile: 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 hence rotting.

The non-mist propagator should always be covered to maintain high humidity. Cuttings may take 4-10 weeks or longer to root, depending on the species.

Questions and responses

Questions	Responses
Can the initiation of the roots be assisted in the cuttings?	Yes, sometimes it may be necessary to assist the initiation of the roots using a rooting hormone that is applied to the base of the cutting.
Is this propagation method suitable for fruit trees?	Yes, it can be applicable to fruit trees. It has also been found to be very suitable for timber trees.

Marcotting

Mr Moses Munjuga – World Agroforestry Centre

Mr Munjuga demonstrated how air layering is done (Figure 4). He said that it was important to first choose the branch (good, healthy stock). He took the groups through the steps in marcotting: a ring of the bark is completely removed and then damp media (sand or sawdust) placed around the cut area and secured in place with a polythene sheet and rubber band, tape or twine. Depending on the species, it could take 2-6 months to root after air layering. Once rooted, the marcots should be severed off the parent plant before the roots harden. When the roots start browning, it is an indication that they are too old and the marcots will not grow well. He also explained that care must be taken in planting the marcots. They must not be planted with a large ball of peat or the media used adhering to the roots, as this would give rise to fungus. Mr Munjuga therefore advised that the media should be removed as much as possible without damaging the young roots.

Questions and responses

Questions	Responses
What are the advantages of this propagation method?	In marcotting, you get an exact replica of the parent plant, fast fruiting time and low mortality rate.
When do the marcots start recovering and what should be done before they are transplanted in the field?	Marcots seldom recover once they have lost their leaves. Fertilizers can be applied once the young plants begin to produce new growth. The marcots should be gradually hardened off after completing two leaf flushes under full sun; they can then be transplanted in the field.

Grafting

Mr Valentine Gitonga – World Agroforestry Centre

Mr Gitonga, ICRAF's nursery technician, started by informing the groups how important it was to ensure that there is no cross-contamination of the area to be grafted by using a clean working environment and sterilized to0ls such as the cutting knives. He demonstrated the propagation technique where scions from plants with the desired traits are inserted on a suitable rootstock to form a new plant, true to type to the mother trees (Figure 4).

He outlined the importance of grafting: reduction of gestation period, use of disease-resistant rootstocks, and use of rootstocks adapted to the ecological conditions of the locality where grafts are to be planted (e.g. drought tolerant). He mentioned various grafting methods, for example, top cleft grafting, side veneer grafting, etc. Top cleft was demonstrated during the practical session.

Figure 4: Demonstration of marcotting, cuttings and grafting by ICRAF staff

Questions and responses

Questions	Responses
Why is grafting and budding the most important means of propagating fruit and nuts?	Grafting and budding allows use of stocks of desirable characteristics (tree of the same root). In addition, not all species can be propagated using other methods, i.e., many cultivars.
Are there other types of grafts?	There are other types though they are not very common, e.g. bark graft, side-veneer graft, splice graft, whip and tongue graft, saddle graft and bridge graft.
What are some of the things that may make grafting or budding unsuccessful?	Budding and grafting often fail because of incompatibility between the scion and stock, or grafting technique, grafting at the wrong physiological stage. Poor care in the nursery can also cause problems.

Preparation of materials for storage

Prof Steven R. Belmain – The University of Greenwich

Prof Belmain noted that aflatoxins were a huge problem affecting maize and other grains. He also said that moisture also predisposed grains to insect and fungal attacks. He demonstrated how the dryness of grains may be ascertained by using lo- cost methods like the glass bottle and salt test method, where a third of a bottle is filled with grains and two spoonful 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 to the sides of the bottle. Once grains are dry enough, less than 15% moisture content, then grains can be stored in dry, cool conditions.

Extraction of chemicals from plants using different media

Prof Steven Belmain – The University of Greenwich

Prof Belmain demonstrated (Figure 5) varying efficiencies of different extraction where ground plant materials were subjected to three treatments:

- Methanol: like petrol, it is good for extracting fat.
- Soapy water: 1% liquid soap, then dilute 10 times. The plant material usually moves to the bottom of the container. The liquid is sieved so as not to clog the sprayer.
- Plain water: the plant material stays in suspension in the container.

Prof Belmain mentioned that the liquid soap had two uses: 1) To extract chemicals and 2) To spread the extracts on the plant and insect evenly (surfactant).

Figure 5: Demonstration of preparation and application of extracts

Questions and responses

Question	Response
Does growing a plant in organic fertilizers affect its chemical compounds?	This has not been proven yet; but studies have shown that moving the plants to a different ecological area could alter its chemical compounds compositions.
Does using liquid soap affect the chemical composition of the PPs extracts rendering it ineffective?	No, not at all. It has actually been proven that liquid soap enhances the effectiveness of extraction (compounds) and use of PPs as pesticides.

DAY 2

Dr Anjarwalla summarized the presentations and discussions of the previous day.

SESSION THREE

Sustainable harvesting of pesticidal/medicinal plants

Dr Desterio Nyamongo – Genetic Resource Centre

Dr Nyamongo informed participants that KARI (Kenya Agricultural Research Institute) was now called KALRO (Kenya Agricultural and Livestock Research Organization). He then recounted the following story, from his Kisii community: when becoming a man one does not shower for a month and uses a plant, *Ocimum suave*, as a mattress to keep away insects and pests. He added that such knowledge presented an effective, low cost, sustainable and environmentally friendly pest management strategy, and that natural products were a goldmine and their potential was yet to be exploited. He also mentioned that Kenya had launched a flagship programme in 1930 to utilize natural resources to produce pesticides, human medicines and livestock medicine like India and China.

Dr Nyamongo explained that sustainability was about utilizing resources in such a way that present needs were met without compromising the ability of future generations to meet their own needs. He outlined the need for sustainable harvesting of PPs: to avoid species extinction, for sustainable supply, to preserve indigenous knowledge and help retain other ecosystem services. Commercialization leading to increased demand and loss or non-appreciation of cultural values and practices, were some of the things he mentioned as drivers for non-sustainable harvesting.

Dr Nyamongo gave a few guidelines on important factors to consider for sustainable harvesting: weather conditions, when to harvest, what to harvest, how to harvest, identification of species, which species to harvest, if the plant can grow again, nature and quality of equipment and containers used when harvesting. He specified that for root harvesting, lateral roots should be harvested, away from the main tap root and the hole dug should then be covered. For bark harvesting, small sections of vertical stripping and not ring bark, using sharp blades leaving the inner bark intact and covering the wound after harvest. In harvesting leaves, only a few should be harvested leaving enough leaves on the plant for survival. For fruit harvesting, up to 25% of available fruits on the plant can be harvested. Fruits can be harvested from several plants to capture genetic diversity.

Questions and responses

Questions	Responses
What is the future of PPs considering that over-exploitation is imminent?	A change of attitude on how we view nature in general is required—people must think about sustainability, and not just the end product. Indigenous knowledge must not be ignored either as it can go a long way in supporting management and protection of PPs.
Can we guarantee supply of the PPs for the industry?	That depends on how we go about regeneration (growing), utilization and of course the policies that are in place.

Status and availability of germplasm of pesticidal Plants

Dr Patrick Muthoka – National Museums of Kenya and Mr Desterio Nyamongo – Genetic Resource Centre

Dr Muthoka began his presentation by informing the participants that pesticidal plants were widely used in the tropics, especially in developing countries compared to synthetics — as they were affordable, available and environmentally-friendly. He noted that the area of the pesticidal plants had been widely reviewed, and that identification, which was important, could be done through pictures, keys in botanical books, herbariums, dichotomous keys and reference literature. Dr Muthoka noted that management of the pesticidal species was critical.

He outlined some of the approaches in managing pesticidal plants:

- Site-based approaches – natural habitats (in-situ) where species have evolved e.g. national parks, forest reserves, national monuments, biosphere reserves and heritage sites.
- Off-site (*ex-situ*) approaches which includes seed banks, botanic gardens, field genebanks, arboreta, DNA banks and in vitro/pollen cultures.
- On-farm *(circa situ*), where the seeds are maintained within farming systems.

Dr Muthoka gave a brief history of seed banks terming them as base collections for long-term use with opportunities especially in land degradation, the need for habitat vegetation and mass germination to provide germplasm. He noted that the Kenyan genebank was one of the key facilities for conserving germplasm in the region, and explained that botanical gardens were places for living collections and their role as an avenue for driving international agreements for conservation. He also gave the current status and availability of germplasm.

Finally, Dr Muthoka outlined the challenges of germplasm management: databases not being compatible and in some cases not online (ICRAF, GeRRI, NMK); lack of taxonomic updates i.e. *Solanum incanum*, *Carissa edulis, Millettia leucantha* which were then considered as synonyms, lack of botanists/plant physiologists and inadequate appreciation of the potential value of GR at policy level.

Questions and responses

Questions	Responses
With all the technology and development of databases going on, why has it not been easy to get the PPs database online?	First, having this in place will require investment, both financially and in expertise. There are few taxonomists and funding is a problem. It will require concerted effort by all stakeholders to achieve this.
For food security, how important is germplasm storage/conservation?	As we may all be aware, loss of the genetic diversity of some of the world's crops has accelerated in recent decades, with many crops becoming increasingly susceptible to diseases, pests, and environmental stresses. Storage of germplasm in the genebanks makes sure that we have genetic resource necessary for developing more resistant crops that will enable farmers to maintain high yields and hence boost food security.

Plant species identification, potential use and invasiveness

Dr Itambo Malombe – National Museums of Kenya

Dr Malombe gave a brief introduction on taxonomy, naming, identification, nomenclature, classification, species diversity, floral distribution, ecology and uses. He explained the concept of naming taxa where identification keys, pictures, illustrations and asking experts were cited as methods used in plant identification. To identify plants, Dr Malombe also mentioned reference materials, plant glossaries, hand lens, microscope, dissecting kit and ruler as some of the tools used.

Dr Malombe further said that, taxonomists relied on various characters (attributes) — to be able to identify and separate different taxa. These attributes included the plant morphology, which he described as "the way in which plants are constructed". He gave examples of those characters: habit (herb, shrub, tree, and liana/climber), sap, leaf (simple, compound, etc.), stipules, hairs and glands, floral fruit and seed.

Dr Malombe also discussed the diversity of plants in Kenya: vascular plants, bryophytes and fungi, among others. He went further to state five different vegetation ecosystems in Kenya, noting that the highest diversity of plants was found in the Somali-Maasai zone (especially hilltops) with 4721 species, followed by coastal forests (e.g. Shimba Hills) with 3000 species.

On plant endemism, Dr Malombe noted that 577 species which accounts for 8% of all endemics were found only in Kenya or East Africa, with high endemism in both the central highlands and coastal region. Plants had many uses and he listed a few including food, fodder and forage, medicine, pesticides, fibres and dyes, building materials, ornaments, soil erosion protection and ecosystem services.

Dr Malombe defined invasive species as *non-indigenous species* that have been deliberately or accidentally introduced to new biogeographical system and which then spread beyond cultivation and human care to impact biodiversity. The most common invasive plant species cited were *Salvina, Eichhornia, Pistia, Azolla* and *Nicotiana* in aquatic ecosystems, *Opuntia, Tarchonanthus,* and *parthenium* in forests, grassland and woodlands and *Tithonia*, *Catharanthus* and *Calliandra* in farms.

He noted the various levels at which the impacts of plant invasive species could be experienced i.e. community and population level where the impacts of invasive species included: resource competition and reduced recruitment (altered succession), competition for pollinators, seed dispersers and other mutualists, population reductions and eliminations, alterations in community composition and vegetation structure and hybridization with native species. At the ecosystems level, the impacts of the invasive species included: alterations in disturbance regimes (e.g. fire, hydrology, etc.), geomorphologic processes (erosion, sedimentation) and soil chemistry (nutrients, nutrient cycles and pH).

Dr Malombe mentioned assessment of current and potential threats and pathways, prevention practices and policies, early detection and rapid response, management, control and restoration, secured and maintained funding, as effective strategies that could be employed to manage invasive species. He noted that in Kenya for instance, some efforts had been made where NMK's EA herbarium through BioNET-EAFRINET and the East African partnership for Taxonomy had developed an IAS fact sheet of the Priority 100 IAS in the region.

He concluded his presentation by explaining how one could access assessment data and information on invasive species through information from field surveys, literature and internet database searches, collection records, remotely-sensed data, experts and local professionals (academics, partners, etc).

Questions and responses

Questions	Responses
Why would taxonomy be important in PPs?	We can only use what we already know and taxonomy plays this role. Mis-identification is and will always be a major setback in the use of PPs. Farmers must know what plants are used for what purpose in the application of PPs to control pests.
Do invasive species threaten the PPs?	Yes, like any other plants, invasives are taking over and putting much pressure on other vegetation since they can easily adapt to changing climatic conditions and survive under minimal conditions, i.e. water, nutrients, etc. Dealing with invasives should be an agenda when it comes to natural vegetation regeneration, and this includes PPs.

Making Quality Seed Collections

Dr Patrick Muthoka – National Museums of Kenya

Dr Muthoka started his presentation by explaining the different types of seeds based on storage behaviour:

i **Orthodox seeds**: typically small seeds; many from dry tropics and can be dried to 3-7% MC, stored at minus 20 degree Celsius and can stay viable for hundreds of years. Examples are from *amaranthus* and *solanum* plants.

ii **Intermediate seeds:** relatively big seeds that can survive moisture content of 7-10%. Examples are seeds from *Carica papaya* and most of the Rubiaceae family.

iii **Recalcitrant seeds:** mostly from moist forests, aquatic and temperate eco-systems. The seeds cannot withstand drying below 20-50% moisture content depending on species. They are best conserved as living collections e.g. mango, coconut and Securidaca.

Dr Muthoka listed the factors which ensure quality collection of orthodox seeds:

- Know the targeted species to be collected.
- Assess the extent of species in the natural range and observe the number of plants producing mature seeds. Ideally sample from 20-25 individuals. Determine readiness to collect: note the changes in seed fruit colour, seed coat and splitting fruits. Seed collection is best at the point of natural dispersion.
- Preliminarily on-site assessment of the seed quality. Visual observation followed by using tools such as secateurs for inspection of, e.g., pest damage or deformity or empty seed, assess seed numbers. For NMK, 40,000 seeds are targeted, 25% of which are collected and the rest left for biotas.
- Fill a detailed data sheet and later capture it electronically for sharing—the data sheet should capture all the information i.e. collector's name, date of collection, the species and genus name, number of individuals per species, habitat and locality among others.

Mr Fabian Kioko and Ms Joyce Kyaa (NMK team) also made a short presentation on seed germination techniques using *Securidaca longepedunculata* and *Azadirachta indica* as case studies. Mr Kioko explained that seeds of *S. longepedunculata* were collected from various localities and processed immediately by opening the pods with a scalpel to release the seeds. Their average moisture content was 32.9%. Different sowing mediums (i.e. coco peat, sand, sawdust, fine and coarse grit, habitat soil, sawdust) were then used in various ratios.

Germination occurred within 14 days in vermiculite and in fine grit media and 21 days in habitat soil.

Ms Kyaa explained that multiple seed collections of *A. indica* were done in Kilifi and Tharaka Nithi counties. The average moisture content of the seeds was 18%. Seeds were sown in sand media and germination recorded after 14 days, transplanted, and later distributed to farmers in Tharaka Nithi County.

From the case studies above, it was concluded that both species were relatively easy to propagate. For *S. longepedunculata,* collection time (at the incipient dispersal) was important. Recalcitrant seeds of Securidaca needed careful handling epigeal germination meant use of deeper medium to avoid root coiling. For *Azadirachta indica,* seedlings cannot survive in Nairobi hence, the need for further investigations on the relative humidity conditions.

Dr Muthoka then stressed the principles of seed handling and mentioned a few basics. He mentioned that seeds were hygroscopic; they desorbed and adsorbed water from the environment to attain equilibrium. Orthodox seeds were desiccation tolerant, should be harvested at maturity point and dried as a thin layer on absorbent material. They should be kept in a well-ventilated area and in appropriate storage containers. He explained that seeds could be stored long-term (base collection) and short-term (active collection).

Further reading

Ellis RH, Roberts EH. 1990. Improved equations for the prediction of seed longevity. *Annals of Botany* 45: 13-30

Hay FR, Smith RD. 2003. Seed maturity: When to collect seeds from wild plants. Seed Science – Turning Science into Practice pp 97-133

Probert RJ. 2003. Seed viability under ambient conditions. The importance of drying. Seed Science – Turning Science into Practice pp 337-365

Muthoka PN, Hay FR, Dida MM, Nyabundi JO, Probert RJ. 2009. Moisture content and the longevity of seeds of six Euphorbia species in open storage. *Seed Science and Technology* 37: 383-397

Questions and responses

Questions	Responses
Is it possible to get banked seeds that one can use for propagation?	Yes, you can access them from the genebank but you will not get enough for planting. Usually only a few will be given. In case one needs more seeds, it might take time and there are a lot of procedures to follow. Currently there is no proper policy on seed sharing in the country.
Which country has the largest genebank and which policies guide genebanking?	In terms of collections, USA has the largest genebank collections. There are a number of legislations controlling genebanks, e.g., ITPGR, Nagoya Protocol, ABS access to genetic resources. The KALRO Act also proposes establishment of a genetic resources centre. Biopiracy is taken care of by the legal framework.

Overview of the Organic Agriculture Sector in Kenya: Opportunities and Challenges for Biopesticides

Ms Wanjiru Kamau – Kenya Organic Agriculture Network (KOAN)

Ms Kamau made a brief presentation on KOAN. It is a national representative body for organic agriculture activities in Kenya with nation-wide membership. KOAN's mandate is to facilitate and provide leadership and professional advisory services to all members and stakeholders in the areas of production, training, marketing, certification, lobbying and advocacy with the aim of transforming the organic movement into an industry. It also provides technical expertise on organic certification and inspection services, and facilitates access to organic markets and businesses. To influence the policy on organic farming, KOAN lobbied and participated in pro Organic Agriculture (OA) policies and was actively involved in creating awareness on the benefits of OA with the Ministry of Agriculture.

Ms Kamau highlighted some of the farmers' concerns on the use of conventional pesticides:

- Health and environmental hazards posed by the misuse of synthetic pesticides.
- Synthetic products were unaffordable or unavailable.
- Synthetic products were packaged, frequently adulterated and sometimes sold after the expiry date.
- Poorly labelled and therefore difficult to use.
- Sustainable pest management was crucial for successful farming in sub-Saharan Africa since many people were heavily dependent on agriculture which had intensified the use of pesticides.
- The demand for botanicals is poised to grow due to an increasing shift in consumer demand for safe food.
- Increase in organic farming.
- Lobbying from environmentalists.

She presented a case study from Zambia where a survey was carried out on ethno-botanical knowledge of termiticidal plants. The study revealed that a total of 23 species in Chongwe and Muswishi districts as well as the central and southern province were believed to contain termiticidal toxicity. The study showed that farmers' indigenous knowledge of termicidal plants could become part of the integrated pest management (IPM) strategy for poor farmers. She said that the opportunities for botanical pesticides were numerous considering that botanicals were biodegradable, less persistent in the environment and their potential of lowering risks to health and development of resistance.

Ms Kamau mentioned the challenges associated with development of biopesticides: lack of data on efficacy and safety, no ready-to-use products, inconsistent performance of crude extracts, lack of clear practicable registration and lack of knowledge and misconceptions about Intellectual Property Rights (IPRs) leading to limited use of IP information in research and development

She said that there was a big disconnect between the number of successful botanical insecticides in use and the volume of research publications on the subject. She noted that, there were already enough candidate plants available to improve the livelihoods of smallholder farmers in Sub-Saharan Africa.

Ms Kamau said that in the development of products, scientist had to cover issues that relate to the access of biological resources for testing and the use of any intellectual property. The traditional uses of these resources had to be considered as critical. On IP from a regulator perspective, they had to ensure that integration of an IPR system in the innovation system in Kenya and Africa was done—as it had generally not been effective.

In summary, Ms Kamau noted that greater emphasis had to be placed on demonstrating the practical utility of these plants, more knowledge about how to deal with Trade-Related aspects of Intellectual Property rights (TRIPS) and the Convention on Biological Diversity (CBD) in the early stages of a project. That would assist scientists focus on finding robust new leads and addressing the IP challenge, which would in turn foster commercialization and leveraging of research outputs, regulations and protocols for production.

Questions and responses

Questions	Responses
It is now becoming very difficult to really tell whether foods displayed on supermarket shelves are organic or not. What is your comment on this?	We try as much as possible to provide our expertise in organic certification and inspection services. We know however, there may be cases where what is known as organic is different, but right now we believe much of what you find in shelves is true.
What determines the consumer behaviour towards organic foods; as their popularity is increasing?	First are the health benefits which are more strongly related to attitudes and behaviour toward organic foods. In addition, there are perceived environmental benefits e.g. use of biopesticides and biodegradable material to improve the soil fertility. Those are two main drivers to organic food demand.
Is there a price advantage for organics produce?	There is usually a 10-30% premium on price but no ready market, so the cost of supply can be high. We need more entrepreneurs to come up. Our role is to facilitate and support them.

FIELD DEMONSTRATION

Dr Patrick Muthoka, Mr Fabian Kioko & Ms Josephine Kyaa – National Museums of Kenya

This session was carried out in ICRAF, and was aimed at giving participants the opportunity to know how to conduct quality seed collections. The exercise was led by Dr Muthoka and his team. Participants were taken through collection of *Markhamia lutea* seeds (Figure 6).

Dr Muthoka went through the steps for seed collection:

- Tools and equipment required: camera, secateurs, plastic bags, writing materials, GPS unit, containers for collection, labels, data collection sheets.
- Know the target species and collect a voucher specimen for taxonomic identification, label voucher and enter the data: name of species, number of individuals, locality, GPS location, habitat, number of seeds collected.
- Check whether seeds are ready for collection in terms of maturity. Make a cutting test. See if seed is firm, clean, not infested.
- Check how many individuals of the species are present in the area to capture as much diversity as possible and collect only 25% of seeds.
- Seeds can be collected in well-ventilated cotton bags and spread as a thin layer for drying in the evening.
- Seeds can continue ripening for another 10 days.

Figure 6: Field demonstration of quality seed collection

Questions and responses

Questions	Responses
How can seed collection be done to ensure that there is no bias, i.e. the number of trees per species, etc.	Collect seeds from different individuals of the same species to ensure the collection is representative.
Can you please tell us more about the things one needs to consider to make a quality seed collection?	To add on what I had mentioned earlier, sampling strategy is important in capturing genetic diversity as much as possible; teamwork gets the job done exhaustively; and one should not forget to collect herbarium voucher specimens as they will be used as reference material in future. In addition, the collecting technique should be in such a way that there is minimal damage to the mother plant and no seeds wasted. In collecting herbarium voucher specimens, photos and descriptions could be used in cases where a species is threated and the population is very small.
I'm a farmer in Kajiado. Can you train us on how to obtain difficult seeds and where to get them?	The best place to obtain seeds is KEFRI, although their focus is mostly timber species. The genebank can also supply some seeds but not in thousands. For specific needs, NMK can provide information on where the trees are located.
Are there different quality and maturity of seeds on a tree?	On an inflorescence, the mature seeds will be at a lower height and the younger ones will be higher on the tree.
Do you have a seed map?	We have an atlas.

DEMONSTRATION AND PRACTICALS AT THE NURSERY

As a follow-up to the practical session performed the previous day, participants had the opportunity for hands-on practicals on propagation of plants by grafting, marcotting and cuttings, and on preparation of the materials for storage and extraction of chemicals from plants using different media. The aim of this session was to allow the participants apply the skills and knowledge they had previously learned on different methods of plant propagation and preparation of PPs. They were guided by the facilitators (Figure 7).

Figure 7: Participants experimenting on propagation techniques and preparation and application of pesticidal plant extracts

SESSION FOUR

Potential for Small-Scale Marketing of Pesticidal Plant Products in Africa

Dr Phosiso Sola – Centre for International Forestry Research (CIFOR)

Dr Sola presented a brief background on the potential for PPs use by stating that more food was needed to feed the growing population. This required effective pest management to ensure food security. She observed that being ecologically-friendly, biopesticides could increase food production and safety, and one way of increasing access to these technologies and raising the profile of PP would be trade.

Dr Sola gave some statistics on the demand for pesticides. She mentioned that the value of the world pesticide market was about US$32.8 billion in 2010 with Africa's market share being 3%. On the demand for biopesticides, Dr Sola said that the biopesticides sub-sector remained small and fragmented, and was valued at US$1.3 billion in 2010, but expected to reach US$3.2 billion by 2018. North America accounted for about 40% of the global biopesticides demand in 2012. She, however, noted that in Africa the markets remained small and undeveloped with limited production for local use, apart from pyrethrum in East Africa. She further informed participants that large companies were sceptical due to lack of guarantee of return on investment, unreliable raw material supply and often less than absolute efficacy. She mentioned other bottlenecks in production: lack of standardization and documented protocols, variability especially with traditional methods, hence inconsistent efficacy and existing inherent differences in plant chemistries.

Dr Sola explained the status of the existing legal framework on pesticides: 1) The pesticide legislation in most countries state that no pesticides may be imported, exported, manufactured, distributed, advertised, sold or used unless they are registered according to the national pesticide regulations. 2) All pesticides to be registered must have documented data on efficacy, toxicity, persistence, shelf life and safety. She mentioned successes in countries with specific and dedicated procedures and guidelines for registration and trade in biopesticides, for example in India, from where lessons can be learnt. India has a strong presence of multinational companies; an estimated 150,000 players in 2013 and each large manufacturer maintaining a distribution network of 400 to 1000 distributors supplying 25,000 to 30,000 wholesalers and retailers, with only 10% of the enterprises operating on a commercial basis, providing quality products for export. Dr Sola moved to the small-scale business potential for Africa and proposed the need to invest in rigorous research that would assure policymakers and the public about human and environmental safety and efficacy. There was already a number of PP that had been partly researched. Neem and pyrethrum could be used as models.

She noted that investing in local production and distribution, development of low cost technologies and value chain development was critical. She mentioned the challenges faced by primary processors in small-scale businesses, secondary and tertiary processors, and proposed the formation of processor groups.

Dr Sola demonstrated the value chain for pyrethrum and neem. She concluded that the main challenge would be to bring PP products from the forest/farm to the shelves at a reasonably low cost that is affordable to smallholder farmers who produce the bulk of the food in Africa.

Further reading

Sola P, Mvumi BM, Stevenson PC, Belmain SR, Ogendo JO, Mponda O, Kamanula JF, Nyirenda SP. 2014. Botanical pesticide production, trade and regulatory mechanisms in sub-Saharan Africa: making a case for plant-based pesticidal products. Food Sec. (2014) 6:369–384

http://blog.cifor.org/24631/in-fight-against-african-pests-researchers-point-to-natural-born-killers

Questions, responses and comments

Questions	Responses and comments
What would you consider as key to unlocking the potential for small-scale marketing of PP products in Africa?	First, rigorous investment in research is critical to assure policymakers and the public about human and environmental safety and efficacy. Secondly, PP undertaking must be packaged in such a way that they make economic sense. That way, small-scale farmers are assured of good returns.
There is huge opportunity for farmers to be involved in pyrethrum production. Local market has limited use at present. How do you plan to create new markets?	Most pyrethrum production in Kenya is exported. The new legal framework aims to promote local market use. Our focus is to create local market demands first before exporting to other countries.
	In terms of landscape restoration we can use pyrethrum, but farmers should also be encouraged to plant trees together with pyrethrum.
We can't do this alone. Sola has been looking at the regulations in different countries. Do we work with the existing regulations or can we influence policy to come up with different regulatory pathways. Probably some people in the workshop here can have some influence and can help.	We should not only look at pyrethrum. There are other marketable products. It is important to engage with the private sector as they know the way to develop it further and the value chain.
We need to look at various factors including shelf life which may be short for certain PP.	We can start with the easier species like Tephrosia whose rotenoids are very stable. It is also species-specific.
My question lies in the value chain approach with PP. Farmers want to concentrate on production. Scientific knowledge of efficacy and safety need a lot of work. Partnership with ICIPE who have worked on it can help. Now that we have the new act on pyrethrum, there may be need for some affirmative action.	There are a number of issues in the act. Product being sold in foreign currency. The issue of nursery operators is well formulated in the new act. There are also other stakeholders like MOA, genebank. Farmers need to be trained on producing quality material. The average age of a farmer in Kenya is 60 years, while in Europe it is 35.

The Pyrethrum Sector in Kenya – Current Status

Mr Justus M. Monda - Pyrethrum Growers Association of Kenya (PGA)

Mr Monda began his presentation by explaining that PGA is a registered organization with a membership of 6000 covering 18 pyrethrum-growing counties. He said that PGA was striving to promote the interests of pyrethrum farmers through lobbying and advocacy using the Right-based Approach (RBA). He then took participants through pyrethrum production volumes trends where PGA as a sector had grown exponentially since it was started in 1928 to 1990, supplying more than 90% of the world's pyrethrum.

Mr Monda said that there was a sharp decline in pyrethrum production from a position of controlling over 90% of world pyrethrum production in the late 1990s to currently where it produced less than 2% of world pyrethrum, resulting in massive financial losses to farmers. The government has also lost significant revenue. He mentioned the new player in pyrethrum production, Tasmania Australia, which started commercial pyrethrum growing and processing in early 2000. By 2010, the island controlled 65% of world pyrethrum production.

Mr Monda noted that Kenya needed to plan its comeback to the pyrethrum industry carefully by looking at the problems that had previously caused the decline of the sector and discuss ways on how those problems could be overcome. He further said that control measures needed to be discussed to keep the industry healthy and commercially sustainable.

He pointed out that failure by the Pyrethrum Board of Kenya (PBK) to pay farmers, reliance on one processor and lack of investment in planting materials had contributed to the decline in the industry. He informed the participants that the new Act was now in place and stakeholders wanted to see how it would be implemented and how it would affect the pyrethrum sector.

Mr Monda concluded by stating the seven steps that could be taken to redeem the pyrethrum sector:

- Full implementation of the Pyrethrum Act 2013.
- Establishment of a quality seed farm.
- Attracting investors for private seedling nurseries.
- Giving farmers a guarantee or an assurance that all flowers from contracted farmers will have a ready market.
- Providing farmers with financial assistance either through loans or aid to assist with the start-up costs of purchasing seedlings and input materials.
- Setting up a formal system to encourage farmers to sell clonal splits to their neighbours.
- Public relations and media campaign to encourage farmers to return to pyrethrum farming.
- Encouraging local formulators to invest in new registration for pyrethrum products in order to maximize the local value add-on on pyrethrum.

Question and response

Question	Response
We know that most parastatals in Kenya (PBK being one of them) collapsed due to corruption, mismanagement and bad politics; what is your comment on this?	It is not a secret that PBK like most parastatals collapsed partially due to the issues you have mentioned. We hope that when the new Pyrethrum Act 2013 is fully implemented, the sector will be revived again.

Botanical Extracts EPZ Ltd

Mr Patrick Henfrey - CEO

Mr Patrick Henfrey made an impromptu speech during the workshop as he was asked to talk about the private sector in the commercialization of botanical pesticides. He mentioned that a representative of the company, Samuel, was also attending the workshop. He then introduced the botanical plant based in Kitengela, as a fairly modern extraction plant that produces Artemisia (medicine used against malaria). The plant has equipment for extraction and production. He mentioned that even if a product was very effective, it could be difficult to commercialize as the world market was very competitive. He informed the audience that the critical things to put in the context of a viable market were: the commercial reality of the product, identification of the plants, value chains and sale. He mentioned that Artemisia was a multipurpose plant which was now moving to diversification, and that they had had a long struggle with farmers and industries until a licence to produce, which had taken over 10 years to obtain, was obtained. He also mentioned that the company was looking to diversify and to work with farmer and industry groups. He encouraged participants to consider the issues that could be solved to bring something to the within a reasonable timeframe.

Questions and responses

Questions	Responses
What is the demand?	Good question and one that we ask ourselves. What would make a viable product? Without market needs there will be no commercial value. Look at the supply chain. Timeframe, regulatory framework, supporting documents to sell something, cost effectiveness in production. The pesticide industry has its own unique products which can be toxic and are subject to regulations. We look at and share existing regulations. Growers and processors should be working together.
Do you have a simple way to prolong shelf life?	We have a reasonable laboratory for science and technology. We can reach out to countries where the technologies are already there.

The Commercial Village Model of Value Chain Development

Mr Dennis Muchiri – Farm Concern International (FCI)

Mr Muchiri stated the mission of FCI which is 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. He also stated FCI's vision which is commercialized smallholder communities with increased incomes for improved, stabilized and sustainable livelihoods in Africa and beyond.

He then went ahead and discussed FCI's business models: Commercial Village Model (CVM) (Figure 8), which he said promoted collective proactive action that was market-led and responded to customer needs. He further said that models aims to: evolve social villages into trading blocks, mobilize farmers to form Commercial Producers Groups (CPGs), integrate smallholder farmers and villages into mainstream value chains, increase the competitiveness of smallholders; and enhance the capacity of African villages as respectable market players.

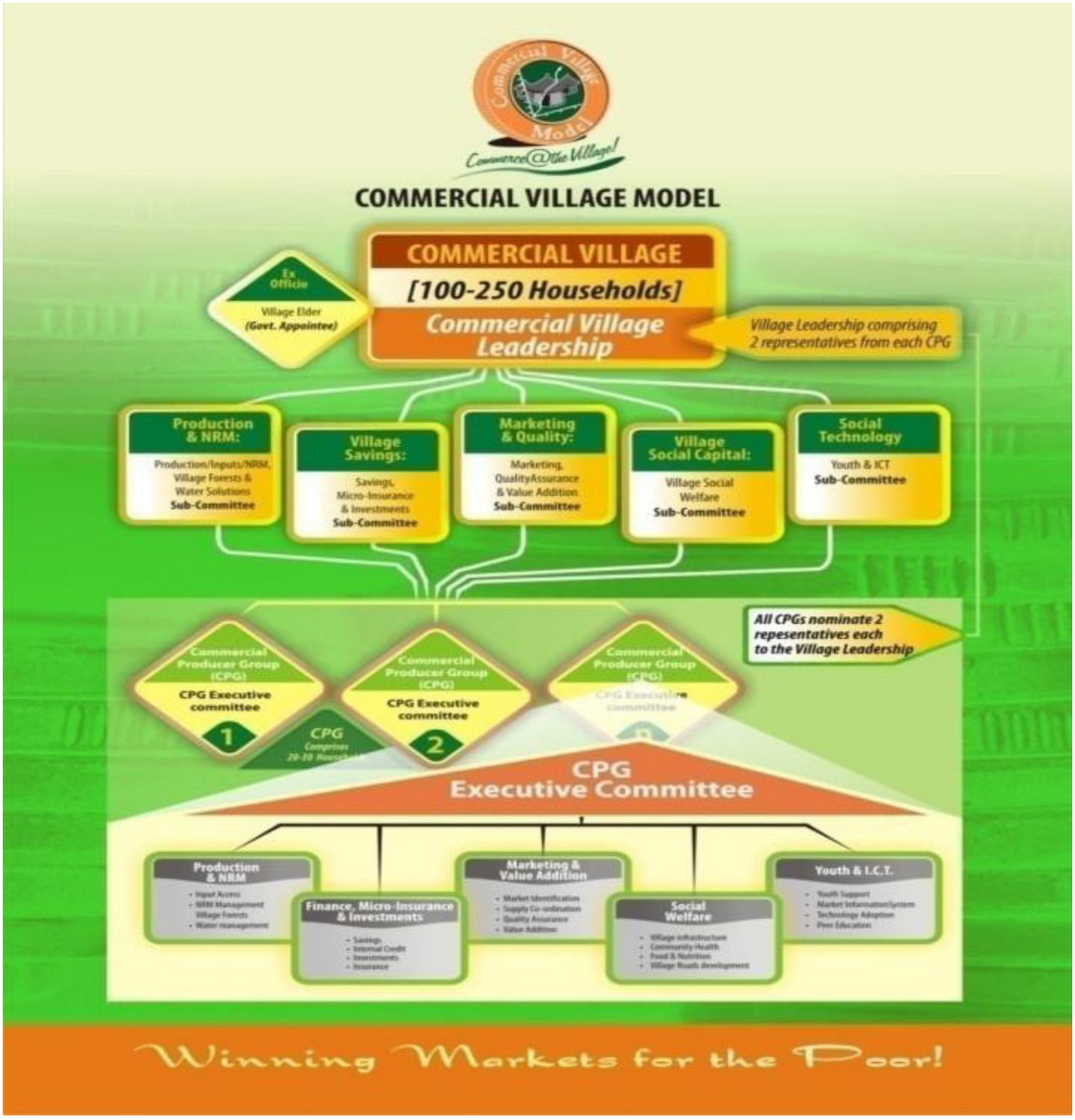

Figure 8: Commercial Village Model

Mr Muchiri discussed the impact on the market development of Traditional African Vegetables (TAVs), saying that weeds had been turned into money and a delicacy with over 900% increase in consumption. He also added that TAVs changed forever from being the poor man's vegetable to a delicacy of nutritional value amongst all income groups as a result of marketing through the mass media.

Mr Muchiri also addressed the Domestic Horticulture Markets (DoHoMa) saying that 113,575 households (500,000 beneficiaries) from Tanzania, Rwanda, Malawi and Kenya had participated with total sales for targeted value chains of US$160 million in 2011-2013, with over 1000 active buyers. He gave a case study in Kieni, Nyeri County where the onion 'revolution' saw the prices for a kilo go up by over 500% and also an increase in the value of the land as an asset between 2005 and 2014. He gave specific examples of farmer John Gakuo, who made Ksh8 million (US$94,000) annually with onions through the same initiative. Mr Muchiri mentioned regions outside Kenya; Kilimanjaro in Tanzania and Thyolo and Zomba Districts in Malawi which had been turned into economic hubs from rice and potatoes, respectively.

Mr Muchiri said that the greatest challenge in value chain development was the independence of various actors within a value chain. He however noted that the FCI through the CVM had greatly influenced the synergy between the various actors hence increased effectiveness. He added that the FCI upgraded value chains through technologies; citing Commercial Villages in Northern Tanzania who installed rice grading equipment after support by FCI which in return increased productivity and boosted markets. He stressed on the need for value chain integration to communities and gave examples of changes experienced after value chain integration e.g. agriculture and environmental conservation; where a significant improvement is a reality.

Questions and responses

Questions	Responses
Are you a profit-making organization; and how does that affect the way you reach out to the farmers, most of whom are of lower cadre?	We're not a profit-making organization. We are for pro-poor initiatives in marketing and business— to commercialize the smallholder communities. That makes farmers of lower cadre our most important clients.
I belong to a small-scale farmer village network similar to your CVM. We had issues in our group in terms of markets, policies and prices. What drives prices for small-scale products?	Apart from the leadership, we also engage many people. We have a marketing and value addition subcommittee. The production committee can predict what will be produced and start looking at markets and storage facilities, etc.
How do you ensure transparency?	Transparency is a challenge. One issue is side trading by farmers. The farmers deal directly with the traders and also negotiate prices directly without our help. The trader transfers money to a bank so that farmers can directly access their payments.

GENERAL DISCUSSIONS/REFLECTIONS

Dr Daniel Ofori and Prof Steven Belmain led the participants through the reflections on the three-day workshop. All the participants reflected on the presentations made, emerging issues (especially on policy) and practical sessions. Some of the specific areas they revisited included: processing and application of extracts, domestication and propagation techniques, seed collection, handling and storage, sustainable harvesting of pesticidal plants and management of invasive species. Some of the key issues that emerged during the discussions, reflection and questions time include:

i Intellectual Property Rights (IPR): the need for this was emphasized as the biopesticides sector was expected to grow. However, some participants felt that the IPR may apparently not be very necessary since we need to share the knowledge and promote the sector. Prof Belmain gave an example of *Eucalyptus* fr0m Australia which had since been grown in Kenya and had been utilized for many things.

ii Policy regulations: could we influence policy making to take care of our interests? It was proposed that a committee be formed to spearhead this process. The participants noted that without proper policy it would be difficult to sell the group's interests to authorities and locals.

iii The issue of sustainability of the PPs (raw materials): there were concerns that there is ongoing destruction of flora in general and propagation of some PPs is difficult. This was seen as a challenge in supply of PPs as raw materials for the industry. Everyone agreed that such a concern could not be ignored as it would determine the future of the PP sector.

iv Legal framework: to address the issues of exportation and importation of biopesticides.

v The conservation status of some PPs, especially the ones under CITES; and if this has long-term implications on the sector.

vi Investing in PPs: look at the market and secondary processing, from a market perspective.

Prof Belmain noted that such issues were key to the growth of the biopesticides industry. He mentioned that the workshop was organized to give farmers information on which species to grow, how and what to propagate, how to harvest and use them, and their marketing potential. He mentioned that *Securidaca* now had a propagation protocol. He further discussed the activities the team could undertake as a network:

1. Seed supply and access: sharing of seeds among farmers and nursery growers.
2. Commercial product development and links to entrepreneurs.
3. Policy regulations: influence on policymakers. Development of a sub-committee for policy influencing.
4. Shelf life: participants were interested in experimenting on shelf life.

He informed the group that he would reach out to them by email. Participants commented about mobilization to achieve critical mass and the need for a media strategy. They also commented on taking the project forward beyond domestic use and looking at market potential depending on the species, and the need for market potential and business sense.

Discussions

Comments
We need mobilisation to achieve critical mass. Policymakers listen to the mass. We need a mechanism for dissemination of information. We also need a media strategy, which would make us reach further with less effort.
As we take the project forward, we need to look beyond domestic use. Farmers and groups will look at something with market potential. Organic farmers will grow and meet needs but how do we move, for example, Securidaca as an industry? We need capacity building and support.
Securidaca will take years to achieve quality but pyrethrum is already there. We can focus on Securidaca, pyrethrum, Tephrosia plus 2 other species.
Speaking as one from a corporate sector, everything must make business sense and income. It's a journey. We have resources like phone access and are already planting many of these trees. I plant Tephrosia for fodder. The products go beyond what is there and have other uses.
The Pest Control Act is being reviewed. In terms of policymaking, we may want to look at the act where biologicals are concerned.
In terms of policy, we can go on debating for years unless we have the policy people on board. For example, we need the National Biosafety Lab people, the National Council for Science and Technology and the relevant ministries. We need to assemble 4-5 people to drive the process forward. For seed supply, we have a formal seed system. If funds are available, then KEFRI is the right place to obtain seeds. However, some PP seeds are not easily accessible from our genebanks. NMK will also be collecting and banking these seeds in the genebank.
We should not mix issues here. As OPTIONS, we should produce evidence to lobby policies but we do not do the lobbying. We need to identify and fill the gaps for advocacy.
PP plants have been in Kenya for many years. Our challenge is lack of documentation. We should package this information in formats that will be useful to a wide range of audiences.

Participants were then asked: 1) Were your expectations met? 2) What knowledge have you gained? 3) What will you do differently in your area of operations after this workshop? The feedback is given in Annex 3.

Generally, all participants said that their expectations had been met and they all looked forward to sharing the knowledge and skill they had acquired with their community.

PROPOSED ACTION POINTS ON THE WAY FORWARD

Prof Belmain led the participants in discussing what they thought could be done to make the biopesticides sector a reality. Proposals mentioned include: mobilize all the stakeholders, lobbying for the policy change in biopesticides industry, dissemination of information through media and, in the long-term, think beyond biopesticides for domestic use only but also commercialization in order to attract investments.

Prof Steve Belmain then promised to contact all the participants to follow up on this.

CLOSING REMARKS

Dr Daniel Ofori – World Agroforestry Centre

Dr Ofori gave the closing remarks on behalf of Dr Jamnadass, the unit head, who said that she was happy to see so many participants, from different countries and backgrounds, attending the workshop and that she hoped that the knowledge gained would be put to good use and shared with others.

Prof Steven R. Belmain - University of Greenwich

Prof Belmain began by thanking all the participants. He observed that the expertise among the participants was quite diverse and hence the need to maintain a strong network in the area of PPs. He encouraged the participants to keep in touch and disseminate the knowledge and skills they had acquired during the workshop.

Finally, Prof Belmain presented certificates of participation to all the participants and wished them well in all their future endeavours.

ANNEXES

Annex 1: Participants' list of expectations

- To know how I can do seed collection, acquisition and conservation.
- To understand how grafting (and other methods of propagation) is done, especially for fruit trees.
- To understand how policymaking could be influenced to enhance the growth of the biopesticides sector in the country.
- To acquire skills through practical sessions to enhance my understanding on propagation, processing and use of PPs.
- To interact with other participants with the aim of exploring possible future collaborations.
- To know some of the PPs and how to use them for crop protection and as human medicine as well.
- To learn how to propagate and harvest PPs.
- 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 enhance my skills in identifying PPs as sometimes one can use the wrong species.
- To get more knowledge on sustainable harvesting and conservation of PPs.
- To understand value chain on commercialization of the PPs.
- To have an idea of which some of the PPs can survive in dry lands.
- To learn about PPs which work with pine and Grevillea.
- To learn how to empower our community on PPs.
- To learn how to use PPs to avoid diseases and improve food security.
- We are currently working on Artemisia but would like to learn more about other pesticidal plants, especially pyrethrum and how they can be used sustainably.
- Our work is based in the national parks where we cannot use synthetic pesticides, so this workshop will allow us to learn about PPs which we could use in the parks, and also about plant propagation as sometimes our germination rate is less than 50%. We want to plant many trees in the conservation areas.
- We engage with 70,000 farmers and have an agroforestry programme. We would like to know more about pesticidal plants and how it can be integrated into our programmes.

Annex 2: Baseline survey form

Name: **Group:** **Mobile phone:** **Date:**

1. What is the scale of use of Pesticidal Plants & their Products [PPPs] in your group?
   a. No use
   b. Few farmers
   c. Many farmers
2. What/who has been the main source of knowledge used by your group?
   a. Government extension
   b. Pesticide companies
   c. Any UN/NGO programmes [name them if you choose this]
   d. Farmer groups
   e. Own tradition

What crops are affected by which pests? When are they affected? [The answer is 'in the field/pre-harvest' or in storage/post-harvest.] How badly are these crops affected? [The answer is 'only slightly' or 'moderately' or 'badly-affected'.]

CROP	PEST	WHEN AFFECTED?	HOW BADLY?

What are the major pesticidal plants used, in what form. List in order of most commonly used. Continue over the page if necessary.

PESTICIDAL PLANT USED	AGAINST WHICH PEST	HOW IT IS PREPARED & USED

Do you use anything other than plants e.g. Agrovets, cow manure, ash, etc.

PESTICIDE	PEST	HOW USED

Do you **always** get the desired results? YES/NO

3. If you do not **always** get the right results do you know why? Describe what you think would improve the effectiveness of pesticides.
4. What are the major problems faced in **obtaining** pesticidal plants/products? List them here.
5. What are the major problems faced in **using** pesticidal plants/products on your crops? List them here.

Do you know any farmer groups who produce PPPs for sale? List them here and say if they are high, medium or low level producers	Level of production

What are the difficulties (challenges) and benefits (opportunities) faced when increasing production of pesticidal plants or their products?

Challenge	Opportunity

Do you know of any farmer groups or individuals involved in marketing and trade in PPs?

Group/individual	Sales volume	Income

What should be done to increase awareness, scale of adoption, trade and effectiveness of PPPs. Continue over the page if necessary?

Action	Who should do this?

Annex 3: Participants' comments after the workshop

All the participants said that their expectations had been met, and that they had acquired knowledge and many skills on the biopesticides. Asked what they would do differently (after the workshop); this is what they had to say:

1. Many thanks to the organizers of the workshop and all the resource persons. I've learnt a lot, I'll try to grow, conserve and protect pesticidal plants.
2. I thank the workshop organizers. I'm now in a position to share the information I got from the workshop; I'm also keen to keep in touch with my new friends and explore possible collaborations.
3. My expectations were met and I now know that biopesticides are more environmental friendly than the synthetic pesticides. So I will encourage people to use them.
4. I would now be actively involved in influencing policy to enhance the growth of the biopesticides sector in the country.
5. Training is something I am going to do, now with all this information. My group needs to know about biopesticides. Use of biopesticides will save them some money.
6. It is time for to start networking more—the workshop had people with diverse expertise. This may result in collaboration on mutual interests.
7. I have really learnt a lot and my next course of action will be to implement, train, practise and share the knowledge I now have.
8. Setting up a nursery and involving the locals is my next course of action.
9. I'll create a commercial village model to produce and sell more trees.
10. I'll try and establish a seed bank.
11. It was a privilege to attend this training workshop. There was so much knowledge to share; and I hope this will trickle down to the grassroots where we've come from.
12. I'll personally get involved in any initiative that will lead to documentation, legislation and commercialization of pesticidal plants.

Annex 4: Workshop program

Day 1: 28 October 2014		
Time	**Activity**	**Presenter/Responsible**
Opening Session 1- Moderator: Daniel Ofori		
08:30 – 09:00	Registration	Sallyannie Muhoro, ICRAF
09.00 – 09:15	Welcome remarks	Margaret Kroma, ICRAF
09:15 – 09 45	Course introduction and expectations OPTIONS	Steve Belmain, Project Leader, NRI, University of Greenwich
09.45 – 10:15	Self-introduction/expectations	All participants
10:15 – 10:45	**Coffee/Tea , Group Photo**	
10:45 – 11:15	Pesticidal plants: an alternative to pesticides	Daniel Ofori, ICRAF
11:15 – 11:45	Baseline survey with participants	Carole and Paul Keeley, SGG
11:45 – 12:15	Group work on knowledge of pesticidal plants	Parveen Anjarwalla, ICRAF
12:15 – 12:45	Presentation of group work	All participants
12:45 – 13:45	**Lunch**	Sallyannie Muhoro, ICRAF
13:45 – 14:15	Propagation and cultivation	Daniel Ofori, ICRAF
14:15 – 15:00	Common pesticidal plants and current best practice with respect to preparation, utilization and application	Steve Belmain, NRI
15|:00 – 15:15	**Coffee/Tea**	
15:15– 17:30	Practical demonstrations at the nursery: Propagation of plants Processing and application of extracts	Moses and team, ICRAF Steve Belmain, NRI
Day 2: 29 October 2014		
Time	**Activity**	**Presenter/Responsible**
Session 2 - Moderator: Steve Belmain		
08:30 – 09:00	Registration	Sallyannie Muhoro, ICRAF
09:00 – 09:10 09:10 – 09:30	Summary of previous day. Questions and discussions	Parveen Anjarwalla, ICRAF All participants
09:30 – 10.00	Sustainable harvesting	Desterio Nyamongo, Genetic Resources Research Centre, KALRO
10:00 – 10:30	Status and availability of germplasm of pesticidal plants	Desterio Nyamongo, Genetic Resources Research Centre, KALRO Patrick Muthoka, NMK

10:30 – 11:00	**Coffee/Tea**	
11:00 – 11:30	Species identification and uses &Management of invasive species	Barnabas Malombe, NMK
11:30 – 12:15	Making quality collections: • Sampling strategies • Seed collection techniques • Seed germination techniques, including handling, storage	Patrick Muthoka, NMK
12:15 – 12:45	Organic farming in Kenya	Wanjiru Kamau, KOAN
12:45 – 13:45	**Lunch**	
13:45 – 14:30	Field demonstration on making quality collections, ICRAF grounds	Patrick Muthoka , NMK
14:30 – 15:00	**Coffee/Tea**	
1500– 17 30	1) Demonstration and practice at the nursery: propagation of plants. 2) Processing and application of extracts	Moses and team, ICRAF Steve Belmain, NRI
Day 3: 30 October 2014		
Time	**Activity**	**Presenter/Responsible**
Session 3 - Moderator: Daniel Ofori		
08:30 – 09:00	Registration	Sallyannie Muhoro, ICRAF
09:00 – 10:00	Marketing potential for pesticidal plants in Africa	Sola Phosiso, CIFOR
10:00 – 10.30	The pyrethrum sector in Kenya	Justus Monda, Pyrethrum Growers Association
10:30 – 11.00	**Coffee/Tea**	
11:00 – 11:45	The commercial village model of value chain development	Farm Concern International
11:45 – 12:15	General discussions/Reflections/ Farmer uptake of pesticidal plants	Steve Belmain (NRI)/ Lars Graudal (ICRAF)
12:15 – 12:30	Closing remarks	Ramni Jamnadass, ICRAF
12:30 – 13:00	Closing remarks	Steve Belmain, NRI
13:00 – 14:00	**Lunch**	Sallyannie Muhoro, ICRAF

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