The 2nd International Conference on Pesticidal Plants

6th to the 9th February 2017, The Elephant Hills Resort, Victoria Falls, Zimbabwe

# Book of Abstracts

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# Sponsors

OPTIONs is a project funded by the European Union's ACP Science and Technology Programme. The project is about optimising the use of pesticidal plants, particularly in sub-Saharan Africa. OPTIONs is officially led and managed by Professor Phil Stevenson from the Natural Resources Institute of the University of Greenwich. The project is a collaboration with many experts from the UK, Kenya, Tanzania, Malawi and Zimbabwe.

The OPTIONs partners are

OPTIONs is funded from the European Development Fund of the European Union.

The Africa, Caribbean and Pacific Secretariat implements the ACP Science and Technology Programme. More information about the ACP S&T can be found here: http://www.acp-hestr.eu

The FAO has kindly provided sponsorship to the ICPP2

The DAAD has kindly provided sponsorship to the ICPP2

The Government of Zimbabwe kindly provided sponsorship to the ICPP2

# Welcome

On behalf of the Organising and Scientific Steering Committees, I extend to all of you a warm welcome to the 2nd International Conference on Pesticidal Plants, 6-9 February 2017 in Victoria Falls, Zimbabwe. The theme for ICPP2 is *Harnessing Pesticidal Plant Technologies for Improved Livelihoods*, which will provide an excellent opportunity to discuss and learn about recent advances in the science of pesticidal plants and related disciplines, and to address basic issues such as food security and conservation of the environment. ICPP2 will also provide an opportunity for delegates to interact with others from different continents, establish contacts, and initiate collaboration among scientists from different parts of the world. ICPP2 is being hosted by the University of Zimbabwe under the umbrella of a European Union funded research project: Optimising Pesticidal Plants: Technology Innovation, Outreach and Networks (OPTIONs).

ICPP2 has attracted more than 80 abstracts and many displays, with delegates arriving from more than 15 countries representing researchers, scholars, traditional herbalists, farmer organizations, NGO/CBOs, industry and suppliers (scientific & general).

We are grateful to the journal *Industrial Crops and Products* which will be producing a special issue based on the selected presentations at the ICPP2 but subject to normal peer review system.

On behalf of the OPTIONs team I would like to give a special thanks to Prof Murray Isman from the University of British Columbia. Murray has been a guiding light and advisor to the OPTIONs and the ADAPPT project teams and we are all grateful for his help and support over the last 6+ years

The support received from the National and International Organising Committees to make this event happen is greatly appreciated.

I sincerely welcome you to Zimbabwe and wish you a fruitful and refreshing time during this second international conference on pesticidal plants.

Prof Brighton Mvumi
ICPP2 Organising Chair

# ICPP2 Committee Members

**National organising committee**
Prof Brighton Mvumi, University of Zimbabwe - Chair
Mr Emmanuel Nyahangare, University of Zimbabwe
Mr Tinashe Nyabako, University of Zimbabwe
Mr K Mashingaidze, Fambidzanai Permaculture
Dr C Gadzirayi, Bindura University of Science Education
Prof M. Gundidza, Harare Institute of Technology
Mr W Chakuzira, Zimbabwe Tourism Authority
Ms F Nyakanda, Zimbabwe Organic Plant Producers Association
Ms E Machetu, Scientific and Industrial Research and Development Centre
Ms L Munyaradzi, Scientific and Industrial Research and Development Centre
Mr C Chapano, National Herbarium and Botanic Garden
Dr E Nyakudya, University of Zimbabwe
Prof L Chagonda, University of Zimbabwe
Ms R Matumbu, National Biotechnology Authority
Mr I Chibaya, PhytoTrade
Mr E Mazhawidza, University of Zimbabwe
Mr L Matarirano, World Agroforestry Centre
Dr J Mufandaedza, National Biotechnology Authority

**Scientific steering committee**
Prof Phil Stevenson, Natural Resources Institute, University of Greenwich and Royal Botanic Gardens Kew, United Kingdom
Prof Steve Belmain, Natural Resources Institute, University of Greenwich, United Kingdom
Prof Brighton Mvumi, University of Zimbabwe
Prof John Kamanula, Mzuzu University, Malawi
Prof Paul Kusolwa, Sokoine University of Agriculture, Tanzania
Dr Parveen Anjarwalla, World Agroforestry Centre, Kenya
Dr Phosiso Sola, World Agroforestry Centre, Kenya
Mr Paul Keeley, Sustainable Global Gardens, United Kingdom
Dr Patrick Muthoka, National Museums of Kenya

# Conference schedule at a glance

| Time | Sunday 5 Feb 2017 | Monday 6 Feb 2017 | Tuesday 7 Feb 2017 | Wednesday 8 Feb 2017 | Thursday 9 Feb 2017 | Friday 10 Feb 2017 |
|---|---|---|---|---|---|---|
| 08:00 | Delegate arrival to Victoria Falls | Registration | Registration | Registration | Symposia sessions | Delegate departure |
| 08:30 | | | Keynote | Keynote | | |
| 09:00 | | Opening ceremony and Keynote | Symposia sessions | Symposia sessions | | |
| 09:30 | | | | | | |
| 10:00 | | Symposia sessions | | | | |
| 10:30 | | | | | | |
| 11:00 | | Tea break & posters | Tea break & posters | Tea break & posters | Tea break & posters | |
| 11:30 | | Symposia sessions | Symposia sessions | Symposia sessions | IPPS discussion and Closing | |
| 12:00 | | | | | | |
| 12:30 | | | | | | |
| 13:00 | | Lunch | Lunch | Lunch | Lunch | |
| 13:30 | | | | | | |
| 14:00 | | Symposia sessions | Symposia sessions | Symposia sessions | Excursion | |
| 14:30 | | | | | | |
| 15:00 | | | | | | |
| 15:30 | | Tea break & posters | Tea break & posters | Tea break & posters | | |
| 16:00 | | Symposia sessions | Symposia sessions | Symposia sessions | | |
| 16:30 | | | | | | |
| 17:00 | | | | | | |
| 17:30 | | | | | | |
| 18:00 | | | | | | |
| 18:30 | | | | | | |
| 19:00 | | Welcome cocktail | | | Conference dinner | |
| 19:30 | | | | | | |
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# Detailed Daily Timetable

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| **Monday 6th February 2017** | |
| **Master of Ceremony: Prof. Lameck Chagonda**<br>***Chair - Pof. Mazuru Gundidza; Rapporteurs: Dr Jonathan Mufandaedza & Dr Elijah Nyakudya*** | |
| 08:00 | Registration |
| 08:30 | Welcome by Professor Brighton Mvumi, OPTIONs Zimbabwe, Chair National Organising Committee |
| 08:35 | Welcome by Professor Phil Stevenson OPTIONs PI, Chair International Organising Committee - Overview of the ACP S&T programme |
| 08:50 | Welcome by Mrs Joyce MulilaMitti, FAO Subregional Office for Southern Africa |
| 09:00 | Welcome by Professor Levi Nyagura, Vice Chancellor, University of Zimbabwe |
| 0915 | Official Opening by Dr. Joseph Made, Minister of Agriculture. Mechanisation & Irrigation Development |
| 09:30 | *Keynote address*<br>Professor Murray Isman, University of British Columbia, Canada<br>Bridging the gap: moving botanical insecticides from the laboratory to the farm |
| **Symposium 1 Field Pest Management**<br>***Chair –Prof Phil Stevenson; Rapporteurs – Dr Gadzirayi/Ms Nyakanda*** | |
| 10:15 | *Symposium 1 Plenary*<br>Zibusiso Sibanda<br>The status of pesticide management in Southern Africa: Challenges, and Opportunities for safer alternatives |
| 11:00 | **Tea break and poster viewing** |
| 11:30 | Maria Jesus Pascual-Villalobos<br>Nanoemulsions of plant essential oils as aphid repellents |
| 11:45 | Angela Mkindi<br>The efficacy of pesticidal plants for field crop pest management |
| 12:00 | Lakpo Koku Agboyi<br>Field efficacy of Neem, *Azadirachta indica* A. Juss oil and two synthetic insecticides against sorghum major pests, *Poophilus costalis* (Walker) and *Stenodiplosis sorghicola* (Coquillett) in Togo |
| 12:15 | Edwin Mazhawidza<br>On-station and on-farm evaluation of aqueous plant extracts against *Plutella xylostella* L. and Brevicoryne brassicae L. in brassica production |
| 12:30 | Happy Daudi<br>Effect of biopesticide on the control of sesame flea beetle, *Phyllotreta striolata* F. |
| 12:45 | Maulid Mwatawala<br>Responses of two fruit fly species (Diptera: Tephritidae) to doses of *Derris elliptica* extracts |
| 13:00 | **Lunch – group photo just before lunch** |
| | ***Chair- Azucena Gonzalez-Coloma; Rapporteurs - Dr Gadzirayi/Ms Nyakanda*** |
| 14:00 | Sylvia Bassey Umoetok<br>Evaluation of two plant oils for the management of *Aphis craccivora* on cowpea |
| 14:15 | Gabriel O Adesina |

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| | Phytotoxic effects of aqueous extracts of *Olax subscorpioidea* Oliv. On seed germination and growth parameters of maize (*Zea mays* L.) |
| 14:30 | Balan Deepa<br>Wild tobacco *Lobelia nicotianaefolia* Roth ex Roem. and Schult., a promising plant for developing botanical insecticide |
| 14:45 | Joshua O. Ogendo<br>Bioefficacy of selected plant extracts against two-spotted spider mite, *Tetranychus urticae*, in French beans |
| 15:00 | Lewis Mashingaidze<br>Efficacy evaluation of pesticidal plant extracts and effects of geographical location, extraction method and plant part used: A case of Mashonaland East province, Zimbabwe |
| 15:15 | Maurille T. Elegbede<br>Effect of neem oil produced locally on the control of two major cotton pests in Benin: *Helicoverpa armigera* Hübner and *Aphis gossypii* Glover |
| 15:30 | **Tea break and poster viewing** |
| | ***Chair –Prof John Kamanula; Rapporteurs - Dr E Nyakudya & Ms E Machetu*** |
| 16:00 | Simon Idoko Okweche<br>Management of wood termites, *Cryptotermes cavifrons* Banks (Insecta: Isoptera: Kalotermitidae) using biotermiticidal plants powders admixed with cow urine in Cross River, Nigeria |
| 16:15 | Balan Deepa<br>A botanical oil-based product to control termites attacking wood and wood products |
| 16:30 | Balan Deepa<br>Development of a new botanical formulation to control the stem borer, *Zeuzera coffeae* Nietner in the sandal wood plantations in Karnataka, India |
| 16:45 | Naomi Boke Rioba<br>*Ageratum conyzoides* L.: A review of its use as an agricultural resource |
| 17:00 | Brighton M. Mvumi<br>Ecotoxicological effects of citrus processing waste on earthworms *Lumbricus terrestris* L. |
| **Symposium 2 Postharvest pest management**<br>***Chair –Prof B. Mvumi; Rapporteurs -- Dr E Nyakudya & Mr T. Nyabako*** | |
| 17:15 | Symposium 2 Plenary<br>Steven R. Belmain<br>Evidence of the ecosystem services and economic cost-benefits of using pesticidal plants in Africa |
| 18:00 | **End of scientific sessions for the day** |
| | |
| 19:00 | **Welcome cocktail** |
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| **Tuesday 7th February 2017** | |
| 08:00 | Registration |
| 08:30 | Keynote Address<br>Philip C. Stevenson<br>Optimising pesticidal plants in Africa: A global view from local use |

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| **Symposium 2 Postharvest pest management - continued**<br>***Chair –Prof B. Mvumi; Rapporteurs -- Dr E Nyakudya & Mr T. Nyabako -*** | |
| 09:15 | Paul M Kusolwa<br>Crude powder extracts from sisal *Agave sisalana* Perrine stem inhibits growth and development of major bean bruchids |
| 09:30 | John F. Kamanula<br>*Lippia javanica*: Variety, chemical composition and insecticidal activity of essential oil against *Sitophilus zeamais* |
| 09:45 | Antoine Sanon<br>Potential of botanicals to control *Callosobruchus maculatus*, the main pest of stored cowpeas in Burkina Faso |
| 10:00 | Philip K. Bett<br>Residual contact toxicity and repellence of essential oils of *Cupressus lusitanica* Miller and *Eucalyptus saligna* Smith against major stored product insect pests |
| 10:15 | Katamssadan Tofel Haman<br>Cameroonian insecticidal products from *Azadirachta indica* and *Plectranthus glandulosus* for the protection of stored cowpea and maize against their major insect pests |
| 10:30 | Simon Idoko Okweche<br>Insecticidal and Insect Reproductive Inhibition Capacities of Citrus Peels Powder on *Tribolium castaneum* |
| 10:45 | Appolonia Hove<br>Pesticidal effects of local plants as an alternative to synthetic pesticides in stored cowpeas, *Vigna unguiculata* |
| 11:00 | **Tea break and poster viewing** |
| 11:30 | Esther Kioko<br>Stored grain insect pests and practical implications for use of pesticidal plants in two dryland counties, Tharaka Nithi and Makueni in Kenya |
| 11:45 | Philip Stevenson<br>The identification of compounds in *Maerua edulis* with biological activity against storage pests |
| 12:00 | Paul Green<br>Biological activity of extracts of *Vernonia amygdalina* and *Tithonia diversifolia*: pinpointing the compounds responsible |
| 12:15 | Kasirayi Makaza<br>Pesticidal plant use as maize grain protectants in Bikita district, Masvingo province, Zimbabwe |
| **Symposium 3: Plant disease and weed control**<br>***Chair –Prof P. Kusolwa; Rapporteurs –Dr E. Ngadze & Mr K Mashingaidze*** | |
| 12:30 | Symposium 3 Plenary<br>Jacobus N Eloff<br>The use of plant extracts and plant based compounds to protect plants against plant fungal pathogens |
| 13:15 | **Lunch** |
| 14:15 | Wilson Nene<br>The effect of selected botanical pesticides for the control of cashew powdery mildew disease in Tanzania |
| 14:30 | Daouda Kone<br>Antimicrobial activities of Ivorian flora on southern blight, *Sclerotium rolfsii* |
| 14:45 | Joseph Djeugap Fovo |

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| | Postharvest fungi associated with kernels of *Ricinodendron heudelotii* and Garcinia kola in the highlands of western Cameroon and bioactivity of some medicinal plant extracts |
| 15:00 | Maria Goss<br>Black rot, *Xanthomonas campestris* pv *campestris* control using *Moringa oleifera* Lam. extracts |
| 15:15 | Yonli Djibril<br>Use of allelopathy properties of local plants for controlling *Striga hermonthica* in Burkina Faso |
| 15:30 | **Tea break and poster viewing** |
| 16:00 | Karim Dagno<br>Protecting Mali's aquatic resources: eco-management of water hyacinth with a bio-herbicide |
| 16:15 | Farai Shelton Chihobvu<br>The pesticidal activity of Cat's whiskers, *Cleome gynandra* L., plant tissue on weeds and soil borne pathogen incidence and severity in the field |
| 16:30 | Farai Shelton Chihobvu<br>The herbicidal activity of Cat's whiskers, *Cleome gynandra* L. plant tissue on plant weeds (*Rottetboelia cocchinensis*, *Setaria verticilata*, *Amaranthus hybridus* and *Bidens pilosa*) |
| 16:45 | Handsen Tibugari<br>Quantification of sorgoleone in 353 sorghum accessions from Africa |
| **Symposium 4: Livestock and human diseases vectors**<br>***Chair –Prof. K. Eloff; Rapporteurs -*** Mr Emmanuel Nyahangare; Ms L Munyaradzi | |
| 17:00 | Symposium 4 Plenary<br>Azucena Gonzalez-Coloma<br>Botanicals: The future pest/parasite control? |
| 17:45 | **End of scientific sessions for the day** |
| | |
| **Wednesday 8th February 2017** | |
| 08:00 | Registration |
| 08:30 | Keynote Address<br>Leandro Prado Ribeiro<br>Botanical pesticides in Brazil: regulatory advances, market opportunities, and research innovations |
| **Symposium 4: Livestock and human diseases vectors - continued**<br>***Chair –; Rapporteurs -*** | |
| 09:15 | Leonard Malweyi<br>Prioritised medicinal plants of Kaimosi area on the outskirts of Kakamega Forest, western Kenya |
| 09:30 | Hamisi Masanja Malebo<br>Mosquito repellent effect of natural volatiles from *Ocimum suave* growing wild in Dar es Salaam, Tanzania against *Anopheles mosquitoes* |
| 09:45 | Thanyani Emelton Ramadwa<br>Anthelmintic, antifungal and cytotoxic activities of acetone leaf extracts, fractions and isolated compounds from *Ptaeroxylon obliquum* |
| 10:00 | Emmanuel T. Nyahangare<br>Indigenous acaricidal plants and cattle tick control |
| 10:15 | Phabey Chaitezvi |

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| | Formulation of a herbal cream incorporating *Pterocarpus angolenses*, *Adansonia digitata* and *Bulbinella frutescens* extracts to alleviate impetigo |
| 10:30 | Mazuru Gundidza<br>Physicochemical characterisation and essential fatty acid profiling of a fixed oil extracted from *Bridelia mollis* seeds |
| 10:45 | Ronald Mutangi<br>Preliminary study on the extraction and antimicrobial activity of *Phytolaca dioica* seed oils |
| 11:00 | **Tea break and poster viewing** |
| 11:30 | Joey Chifamba<br>Development and optimisation of veterinary antihelminthic treatments and pesticides incorporating the extracts if indigenous *Cissus quandrangularis* |
| 11:45 | Josphat Matasyoh<br>Antishistosomal Secondary Metabolites from *Tecla nobilis* and *Rapanea melanophloes* |
| 12:00 | Jacob Gusha<br>Efficacy of *Terminalia sericea* (mususu) aqueous leaf extracts as an anthelmintic |
| 12:15 | Jacob Gusha<br>Minimum inhibitory concentrations of methanol extracted *Lantana camara* plant material extracts for selected clinical bacterial isolates in Zimbabwe |
| **Symposium 5: Soil invertebrate pests, bio-fertilisers and biopesticides technologies**<br>***Chair –Prof. P. Mafongoya; Rapporteurs – Mr E. Mazhawidza &*** Ms R Matumbu | |
| 12:30 | Symposium 5 Plenary<br>Pierluigi Caboni<br>Potent nematicides of botanical origin |
| 13:15 | **Lunch** |
| 14:15 | Brighton M. Mvumi<br>Ten years of pesticidal plant activities in southern and eastern Africa: Approaches, successes, challenges, gaps, lessons and the future |
| 14:30 | Christopher Tafara Gadzirayi<br>The effects of biochar – vermicompost mixes (biofertiliser) on crop productivity |
| 14:45 | Ernest R. Mbega<br>Seed treatment with extracts from False Daisy, *Eclipta alba* L. improves seedling emergence, vigour and yield of sorghum in Tanzania |
| 15:00 | J. K Nzuma<br>Integrating microbial-based fertiliser into nutrient management systems for sustainable agricultural productivity |
| 15:15 | **Tea break and poster viewing** |
| **Symposium 6: Propagation and conservation**<br>***Chair –Dr P. Sola; Rapporteurs – Mr C. Chapano & Mr E. Mazhawidza*** | |
| 15:45 | Symposium 6 Plenary<br>Lameck S. Chagonda<br>Research and development of pesticidal herbal plant products in Zimbabwe: a pharmaceutical perspective |
| 16:30 | Sarah Arnold<br>Multiple ecosystems services derived from pesticidal plants in field margins |
| 16:45 | Peter Kingoo<br>Commercial cultivation of *Melia volkensii*: A case study of a timber and pesticidal plant in the dryland of Makueni County, Kenya |

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| 17:00 | Josephine Kyaa<br>The OPTIONs Project in Kenya - Propagation and outreach of pesticidal plants in Kenya |
| 17:15 | Itambo Malombe<br>Seed development and germination of a pesticidal plant *Securidaca longepedunculata* |
| 17:30 | Itai Chibaya<br>Biotrade's contribution towards socio-economic development and biodiversity conservation |
| 17:45 | Faith Kadema<br>An analysis of the conditions that favour the germination of the seeds of two invasive goldenrods; *Solidago canadensis* and *Solidago gigantea* |
| 18:00 | End of scientific sessions for the day |
| | |
| **Thursday 9th February 2017** | |
| **Symposium 7: Commercialization, policy and sustainability**<br>***Chair –Prof. S. Belmain; Rapporteurs – Mr. I Chibaya & Ms R. Matumbu*** | |
| 08:00 | Symposium 7 Plenary<br>Maria Jesus Pascual-Villalobos<br>Botanical insecticides: a perspective on regulations in Europe, commercial products in Spain and research worldwide |
| 08:45 | Jonathan Mufandaedza<br>Genetic fingerprinting, a regulatory tool for genetic conservation in BioTrade |
| 09:00 | Paul Keeley<br>Outreach issues and strategies in promoting the use of pesticidal plants to smallholder farmers |
| 09:15 | Itambo Malombe<br>The OPTIONs story in Kenya: The identification and use of pesticidal plants, successes and challenges |
| 09:30 | Phosiso Sola<br>Regulatory challenges and opportunities for wide scale production and use botanical pesticides in sub-Saharan Africa |
| 09:45 | Fortunate Nyakanda<br>Empirical evidence and scientific support - missing links in organic food value chain |
| 10:00 | Kwadzanai Mushore<br>Pesticide legislation in Zimbabwe: Implication for pesticidal plants registration |
| 10:15 | Itai Chibaya<br>Potential business models for up-scaling natural products from pesticidal plants in southern Africa |
| 10:30 | Justus M. Monda<br>Enhancing pyrethrum productivity for higher incomes through research |
| 10:45 | Yolice Tembo<br>Are plant pesticides safe for the four Hs? |
| 11:00 | **Tea break and poster viewing** |
| 11:30 | Discussion about the International Pesticidal Plants Society and future conferences |
| 12:30 | Closing |
| 13:00 | **Lunch** |

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| 14:00 | Excursion departure for Victoria Falls |
| 19:00 | Conference dinner |
| | |
| **Friday 10th February 2017** | |
| Delegate departures, post-conference tours | |

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# Keynote Speakers

# Bridging the gap: moving botanical insecticides from the laboratory to the farm

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Interest in, and research on botanical insecticides has surged since 2000 according to a recent bibliographic analysis of scientific literature. Thousands of papers have now been published documenting the bioactivities of botanicals such as neem (from *Azadirachta indica*), various plant essential oils, and innumerable plant extracts to insects and related pests, although the majority of these simply report screening studies and other observations made within the confines of laboratories. In contrast, with few exceptions, little of this knowledge has been translated to practice, i.e., utilized directly by farmers for pest management. What, then, are the prerequisites to realizing the benefits of botanical insecticides, particularly for smallholder farmers in sub-Saharan Africa? I have previously argued that there are a number of plant species widely occurring in Africa – both endemic and introduced – that are suitable for the production of botanical insecticides, and that less attention should be paid to further discovery of bioactive plant species and more attention placed on the development of botanicals from those plants we already know. To put those plant species to work for pest management, we need the following: 1. methods for local propagation and cultivation to ensure a sustainable supply of biomass; 2. simple methods for extraction utilizing available resources at minimal cost; 3. simple methods (e.g., bioassay) to validate bioactivity and ensure some measure of efficacy; and 4. field trials and demonstrations to learn timing and application strategies that can optimize efficacy. Some examples of these will be provided and a critical path forward will be discussed.

# Optimising pesticidal plants in Africa: A global view from local use

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Smallholder farming provides ~ 80% of the food in developing countries so is critical to feeding a growing global population, particularly in Africa where population growth outstrips the rest of the world. Agricultural intensification and management of production constraints is therefore global in relevance. Insect pests are key constraints to food production but their control is often challenging. Field losses to insect impact yields severely but around 40% of all food produced is then lost in storage. Synthetic pesticides, if available, may be effective but equally may be adulterated, used incorrectly through poor training or out of date/illegal. Pesticides are also persistent, impact beneficial insects negatively and may be directly toxic to farmers and consumers. Many wild plants produce defence chemicals that are deterrent or toxic to herbivores and where harvestable are alternatives to synthetic pesticides, especially because for many poorly resourced farmers plant materials are often readily available, effective, low cost, familiar, safer, and therefore highly relevant to smallholders. Farmers across the world have for centuries exploited these plants and continue to do so. However, plants are natural materials and susceptible to variation in biological activities, overharvesting and misidentification which in turn affect efficacy and benefits. Our work over the past 10 years has approached these hurdles methodologically, identifying the chemical basis of activities, validated pest control effects reported by farmers and sought ways to improve their use for more effective and more reliable use. Here we report how plant use can be optimised particularly through understanding the chemical basis of activity and can help understand the limitations and priorities for wide-scale use in Africa. In particular chemotype variation is critical while information about the chemistry of plants can facilitate optimising application and availability of plant material.

# Botanical pesticides in Brazil: regulatory advances, market opportunities, and research innovations

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Brazil has a diversified agriculture including food production systems ranging from large growers to small family farmers. Most of these agricultural systems demand eco-friendly products for sustainable pest management due to increasing issues concerning insect resistance, environmental contaminations and health problems caused by excessive use of synthetic agrochemicals of which Brazil is the world's largest consumer. In this context, alternative control measures, including the use of biological control agents, natural plant resistance inducers, and botanical pesticides, are attaining great relevance for producers and consumers. Despite the advantages of botanical insecticides and market demand for them, registration issues of these phytochemicals in Brazil have been very difficult for small pesticide producers due to restrictive costs, procedure complexity and time-consuming process to obtain marketing license. However, the recent approval and implementation of specific legislation for registering products for organic agriculture have enabled the registration of new biopesticides developed from sources of the Brazilian flora as well as the introduction of formulations already commercially available in other countries. Consequently, this simplified process is boosting the creating of new companies, or even new lines of business assumed by traditional chemical companies, and new trends for deployment of phytosanitary products mainly in small crops, which increase concerns about maximum limits of pesticide residues. I will discuss some market opportunities for commercialization botanical insecticides in Brazil and the current challenges faced by these alternative products. Moreover, I will show research advances on identification of new botanical pesticides sources based on industrial wastes as well as innovations in procedure formulations using nanotechnology as an approach to improve their effectiveness and stability.

# Symposium 1: Field Pest Management

# S1 Plenary Speaker The status of pesticide management in Southern Africa: Challenges, and Opportunities for safer alternatives

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Many countries in Southern Africa are in the process of intensifying their agriculture in order to meet national demands for food, feed and fibre as well as to increase agricultural exports. As was the case with the Green Revolution, this has led to increased reliance on external inputs including synthetic chemical pesticides. There are growing concerns worldwide on the detrimental effects of this model and FAO is at the forefront to promote a global shift towards sustainable production intensification to produce more from the same area of land while conserving resources, reducing negative impacts on the environment, strengthening resilience to climate change and enhancing natural capital and flow of ecosystem services. Pesticide management in the southern Africa is fraught with challenges throughout the pesticide life cycle including outdated pesticide legislation; inadequately resourced pesticide registration systems with weak enforcement capacities; illegal trafficking and marketing of unregistered and counterfeit pesticide products; widespread use of very toxic pesticides including highly hazardous pesticides (HHPs); suspected pesticide resistance; weak agricultural extension systems; low literacy among users; poor inter-sectoral collaboration and huge stockpiles of obsolete pesticides. All these have adverse effects on agricultural production, human health, the environment, economics of production as well as international trade. FAO with various development partners has for the past three decades been supporting member states to strengthen sound pesticide management. Interventions focus on field projects on promotion of sustainable production intensification, climate smart agriculture and ecologically compatible pest management products, disposal of obsolete pesticides; phasing out HHPs; capacity building; provision of guidelines, tools and policy support. FAO promotes regional collaboration and harmonization efforts for sound pesticide management. With FAO support, the Southern African Pesticide Regulators Forum (SAPReF) has developed a Strategic Action Plan which identifies areas for possible regional collaboration and prioritizes Integrated Pest Management and development of registration guidelines for biological pesticides.

# Nanoemulsions of plant essential oils as aphid repellents

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It is expected that climate change will have an impact on the relative importance of pests. The birdcherry-oat aphid, *Rhopalosiphum* padi L., attacks all cereals and uses its piercing.sucking mouthparts to penétrate plant tissues, ingesting phloem sap and leading to leaf contortion and Barley Yellow Dwarf Virus (BYDV) transmission Milder winters aid in insect survival and earlier migration and possibly in increasing the severity of damages.Systemic insecticides are effective but only sprayed during significant infestations. The organic sector needs alternative aphicides or products that prevent the pest. In spite of the properties of plant volatiles as insect repellents, there is a lack such commercial products on the market used in the agricultural sector. In this work we tested a group of essential oils (coriander, mint, basil, anise) and pure compounds (carvone, citral, trans-anethole, estragole, linalool, pulegone) in a laboratory choice bioassay with *R. padi* (20 replications per product). Treated (0.15µl/cm$^2$) and untreated barley leaves were offered to groups of 10 apterous aphids and the Repellency Index (R.I.) was computed after 24 h. Water emulsions of the active products were prepared and applied at increasing volumes using a Computer Controlled Spraying Apparatus to study the effects on R.I., mortality and settlement of aphids. Finally formulations with the active substances and lecithins were characterized at the nanoemulsion scale measuring particle size and Z potential to anticípate its stability and the correlation the activity. Anise or mint essential oil were toxic to the aphids but had repellent effects at lower doses or when the volátile action was reduced. Carvone induced an increased mobility in *R. padi*. Citral, linalool and estragole had repellence index values over 75. The smaller the particle size of the active products in the nanoemulsions, the greater activity was kept after storage for 2-3 months. The addition of lecithin and glycerol in the formulations gave larger values of Z potential and therefore an improvement of the stability.

# The efficacy of pesticidal plants for field crop pest management

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Infestation by insect pests is termed as a serious cause of food loss to small scale farmers during production and on storage. Use of synthetic pesticides has been practiced but its implications on human health and environment is prominent. Use of pesticidal plants remains a viable alternative because of its less heath impacts, less cost and its less harm to the environment. In Moshi, Tanzania, 40 farmers were involved to evaluate efficacy of the pesticidal plants in the mono-cropped and intercropped bean fields. Pesticidal plants species used were *Tephrosia vogelii*, *Tithonia diversifolia*, *Bidens pilosa*, *Lantana camara*, *Lippia javanica*, *Vernonia amygdalina*, *Lippia javanica* and *Bidens pilosa* at concentrations of 0.1%w/v, 1%w/v and 10w/v and were tested for their efficacy to control pests infestation and damage, impacts on beneficial insects and their contribution to yield of common beans. Field assessments were conducted on weekly basis for 10 weeks starting from the second week after plants germination and yield close to and during harvest. Results showed that pesticidal plants have significant efficacy against field insect pests compared with the negative control (untreated). *T. vogelii* is the most effective by reducing abundance of insect pests and contributing to higher yield.

# Field efficacy of Neem, *Azadirachta indica* A. Juss oil and two synthetic insecticides against sorghum major pests, *Poophilus costalis* (Walker) and *Stenodiplosis sorghicola* (Coquillett) in Togo

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*Sorghum bicolor* (L.) Moench is the second most important staple in Togo after maize. However, its production suffers serious damages and crop losses by a wide range of insect pests, especially the spittlebug *Poophilus costalis* (Walker) (Hemiptera: Aphrophoridae) and the sorghum midge *Contarinia sorghicola* (Coquillett) (Cecidomyidae: Diptera). The species *P. costalis* is an emergent major pest of sorghum at vegetative stage while *C. sorghicola* attacks the reproductive stage. This study was conducted on station and farm in northern Togo to evaluate the efficacy of botanical insecticide, Neem oil and synthetic chemicals, cypermethrin and chlopyrifos ethyl against *P. costalis* and *C. sorghicola*. Three doses of Neem oil (964, 2892 and 5784 ml/ha), cypermethrin (128, 384 and 768 ml/ha) and chlorpyrifos ethyl (38, 114, 228 ml/ha) were sprayed on sorghum plots against *P. costalis* and *S. sorghicola*. Untreated plots were considered as a control. The experiment was set as a randomized complete block design with 4 replications. The results showed that Neem oil, cypermethrin and chlorpyrifos ethyl were able to provoke 67%, 70% and 93% reduction of *P. costalis* density respectively on station or farm, compared to control. About the protection of sorghum panicles against *C. sorghicola*, Neem oil was less effective than cypermethrin and chlorpirifos ethyl.

# On-station and on-farm evaluation of aqueous plant extracts against *Plutella xylostella* L. and *Brevicoryne brassicae* L. in brassica production

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Pests are a major constraint in vegetable production in many parts of Sub-Saharan Africa. Cabbage, *Brassica oleraceae* L. and rape, *Brassica napus* L. are widely grown cash crops and form an important part of the daily diet of most consumers. However, attack by insect pests affects their quality and marketable yield and yet there are growing concerns on safety and environmental impact of the conventional synthetic pesticides normally used against the vegetable pests. On-station and on-farm experiments were conducted during summer and winter season of 2014/15 to explore the use of the two plant extracts, *Maerua edulis* L. and *Bobgunnia madagascariensis* Kirkbr. & Wiersema in the management of diamondback moth (DBM), *Plutella xylostella* L. and aphids, *Brevicoryne brassicae* L. in cabbage and rape respectively. The treatments included water extract of *M. edulis* and *B. madagascariensis* powder at application concentration 3, 5, 10, 15 and 20 % w/v. The chemical pesticide, dimethoate® 36 % E.C and tap water were included as positive and negative controls, respectively. A liquid soap surfactant (0.1% v/v) was added at point of spraying. On both rape and cabbage, there were no significant differences among *M. edulis* plant extracts 5, 10, 15 and 20 % w/v while the concentrations of 15 and 20 w/v for *B. madagascariensis* differed significantly from 3, 5 and 10 % w/v. Further tests were conducted under on-farm conditions, using *M. edulis* at 5 and 10 % and *B. madagascariensis* at 15 and 20 % w/v. *Maerua edulis* 5% w/v and *B. madagascariensis* 20% w/v were as efficacious as commercial synthetic pesticide in controlling rape and cabbages pests. Plots treated with plant extracts had significantly higher cabbage and rape yields compared to untreated control. Therefore there is scope for using the pesticidal plants tested in the current study for vegetable pest management on smallholder farms and in organic vegetable production systems.

# Effect of biopesticide on the control of sesame flea beetle, *Phyllotreta striolata* F.

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Sesame is an important oilseed crop in Tanzania. It is grown by stallholders in mixed and pure stand. It is essentially an export crop and therefore source of income to farmers. It is the leading export earner among the oilseeds. In Tanzania, sesame production is affected by many factors including insect pest. Observation trials were conducted at Naliendele Agricultural Research Institute to study the effects of different insecticide to control Sesame (*Sesamun indicum* L.) flea beetle (*Phyllotreta striolata*). Treatments applied were Chinyenye, Karate, Mucuna and the control without any insecticide. Variety used was Ziada 94 and karate applied at the rate of 5ml/L, Mucuna and Chinyenye applied at the rate of 1lts/5lts of water, all these pesticides were applied every three days. Results from the observation trial showed that yield was higher when karate is applied (110kg/ha) but also when Chinyenye and Mucuna used sesame yield was higher (900kg/ha) compared to control plot which didn't yield higher (750kg/ha). Therefore this observation trial showed that pesticidal plant can suppress the effect of flea beetle in sesame crop and to increase the yield although their effect of control sesame flea beetle is not higher as karate. This observation study calls for further experiments using different bio pesticide in the control of sesame flea beetle and to increase sesame yields.

# Responses of two fruit fly species (Diptera: Tephritidae) to doses of *Derris elliptica* extracts

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Efficacies of *Derrris elliptica* extracts on mortalities of two fruit flies (Diptera: Tephritidae) were determined in a laboratory at Sokoine University of Agriculture (SUA). The Normal Soaking Extract method (NSE) was used to extract rotenone using four solvents of different polarity indices (Petroleum ether P=0.1, Dichloromethane P=3.1, Methanol P=5.1 and Water P=10.2). The extracts were incorporated into a molasses based liquid baits and administered to the adult populations of *Bactrocera dorsalis* and *Bactrocera cucurbitae* (15:15 sex ratio). Doses of extracts were 0mg/L, 3mg/L, 6mg/L and 9mg/L and mortalities were recorded from 12 to 72 hours. The experiments were laid in a factorial design replicated three times.

# Evaluation of two plant oils for the management of *Aphis craccivora* on cowpea

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A field experiment to evaluate repellency effects of *Azadirachta indica* and *Jatropha curcas* oil extracts on *Aphis craccivora* on cowpea was carried out at Ikot Edem Ndarake in Akpabuyo, Cross River State. The treatments included *A. indica*, *J. curcas* oils each at three concentrations (1, 2 and 3 %), Lambda cyhalothrin (2.5 EC) as standard check and untreated replicated three times in a randomized complete block design. The result indicated that 3 % concentration of *J. curcas* and *A. indica* oil significantly reduced the population of *A. craccivora* and number of leaf curl per plant. Also, significantly ($p \leq 0.05$) longer vines (1.90m, 1.90m), higher number of pods (12.22, 11.11) and weight of 100 seeds (11.6 g, 11.29 g) were obtained from cowpea plants treated with *J. curcas* respectively compared with the untreated (1.24m, 5.10, 10.02g). Application of 1, 2 and 3 percent concentration of *A. indica* oil led to 8.66, 34.46, and 61.59 % increase in the total grain yield, while 1, 2 and 3 % concentration of *J. curcas* oil resulted in 20, 41.41 and 66.76 % increase in the cowpea total grain yield, respectively when compared with untreated control. Both *J. curcas* and *A. indica* did not show significant ($p \geq 0.05$) difference in terms of pod length and number of seeds. *Jatropha curcas* oil resulted in higher grain yield than *A. indica* oil. The results suggest that both extracts can be used by cowpea farmers for effective management of *A. craccivora* infesting cowpea.

# Phytotoxic effects of aqueous extracts of *Olax subscorpioidea* Oliv. On seed germination and growth parameters of maize (*Zea mays* L.)

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Phytotoxic effects of aqueous extracts of *Olax subscorpioidea* were examined on maize crop. The experiment was laid out in a complete randomized designs (CRD) replicated five times. Ten seeds of maize were sowed in separate petri-dishes with 2 ml water extracts of *Olax subscorpioidea* plant parts and 2 ml of distilled water as control. Maize seedlings were treated with 100 ml of extracts at seven day intervals for eight weeks. Data were collected on number of germinated seeds daily and lengths of five randomly selected seeds after 7 days of sowing (7 DAS). Number of leaves, plant height, root dry weight and shoot dry weight of seedling were measured using standard methods. Data were analysed by analysis of variance and showed statistically significant differences in mean values.

# Wild tobacco *Lobelia nicotianaefolia* Roth ex Roem. and Schult., a promising plant for developing botanical insecticide

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The indiscriminate use of synthetic insecticides has turned out to be hazardous to earth and life on it. This provides an impetus to search for environmental friendly alternatives for synthetic insecticides. There is enormous scope in developing eco-friendly insecticidal formulations from plants. Although, nearly 2000 plants are reported to possess insecticidal properties, neem is extensively used commercially and is available as a botanical insecticide product. In our studies, we found that the bioefficacy of the leaf extracts of *Lobelia nicotianaefolia* is on par with neem extracts. *Lobelia nicotianaefolia*, commonly known as Indian tobacco or wild tobacco, is distributed along the Western Ghats of south India and is also found in Deccan and Konkan at altitudes of 900-2100m. *L. nicotianaefolia* is an annual shrub which grows to a height of up to 1.2-3.6m. Leaves and flowering tops of the plant is a rich source of alkaloids of the lobeline group. Hence, this study was taken up with the objective of developing novel botanical pesticidal formulations from *Lobelia nicotianaefolia*. The water, methanol and ethyl acetate extract from the leaves of *L. nicotianaefolia* were tested for their bioefficacy on the 3rd instar larvae of *Spodoptera litura* through leaf disc bioassay and contact toxicity in the laboratory. The result showed larval mortality, pupal mortality and developmental malformations. Further, different oil based formulations were developed from leaf extracts of *L. nicotianaefolia* and tested against *S. litura* in the laboratory. The formulations showed 100% larval mortality at 10% concentration on the 2nd instar larvae of *S. litura*.

# Bioefficacy of selected plant extracts against two-spotted spider mite, *Tetranychus urticae*, in French beans

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The two-spotted spider mite, *Tetranychus urticae*, has been identified as a major biotic constraint to French bean production by smallholder farmers in Kenya. *Leonotis nepetifolia* (LN) and *Ocimum gratissimum* (OG) plant extracts were evaluated for bioactivity against two-spotted spider mites (TSSM), *Tetranychus urticae*, and effects on growth and yield of French bean. Contact toxicity, repellence and oviposition inhibition bioassays, at five concentrations ((0.0, 1.5, 3.0, 6.0 and 12.0 % w/v) each replicated four times arranged in a completely randomized design (CRD), were conducted at Egerton University. Abamectin ((0.6 ml/L DW) and methanol were used as positive and negative controls, respectively. The same treatments were evaluated under field conditions in randomized complete block design (RCBD) with 3 replicates per treatment. Data were collected on adult mortality, percent repellence, number of eggs laid, French bean growth and yield. Results showed dose-dependent efficacy in which LN and OG extracts at 12.0% w/v and 72 h, were equally efficacious causing 94-96% mortality, 94-100% repellence and 93-100% reduction in the number of eggs laid by adult female TSSM. Significant dose-dependent reductions were observed in adult TSSM population and increase in yield and yield components of French bean. At 12% w/v, the LN and OG extracts caused 59-83% and 69-78% reductions in adult TSSM population during both seasons. The same treatments equally resulted in increased pod yields by ≥400% (LN: 076-0.88 t/ha; OG: 0.86-0.90 t/ha) compared to the untreated control (0.13-0.16 t/ha). The application of *Leonotis nepetifolia* and *Ocimum gratissimum* as botanical miticides holds good promise for TSSM control in smallholder French bean production in Kenya.

# Efficacy evaluation of pesticidal plant extracts and effects of geographical location, extraction method and plant part used: A case of Mashonaland East province, Zimbabwe

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The main cause of food insecurity for many communal households in Zimbabwe is their reliance upon a form of subsistence-based agriculture which is dependent on a limited range of inputs often poorly suited to local conditions. Application of natural pesticides an alternative to synthetic chemicals in agriculture has been practised since time immemorial as a way to combat pests and diseases at small-scale level by resource-poor farmers. This paper reports of a study set out to ascertain farmers' claims of pesticidal activity against selected pests and further explore the effects of geographical location, extraction method and plant part on the efficacy of the plants used as botanical extracts by smallholder farmers in Mashonaland East province of Zimbabwe. Samples were collected from 32 farmer association from 8 districts of Mashonaland East province of Zimbabwe. Through a farmer-led process of pesticidal plant identification, according to their experience and practice in agroecology, a total of 20 samples were collected for mass spectrum analysis. Analysis of coded samples in all samples concurred with farmers' suggestion of pesticidical activity though cited pesticidal activity varied for the same plant depending on geographical location. Variations in pesticidal activity among samples collected from different locations indicated interaction effects of geographical location and efficacy of plant samples. Results also suggest variations in efficacy on samples being attributed to method of active ingredient extraction with recommended chemical extraction method based on chemistry rather than routine aqueous extraction by farmers.

# Effect of neem oil produced locally on the control of two major cotton pests in Benin: *Helicoverpa armigera* Hübner and *Aphis gossypii* Glover

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*Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae) and *Aphis gossypii* Glover (Homoptera: Aphididae) two polyphagous pests, with two different types of mouthparts, are responsible of significant damage to cotton crops. As part of the implementation of alternative methods, the insecticidal effect of neem oil produced locally was studied. The objective of this study was to evaluate the effect of different doses of neem oil on the development of chewing insect and a sucking pest on cotton without contact. Third stage larvae of *H. armigera* were fed for 24 hours on cotton leaves treated with different concentrations (5, 10, 25, 50 and 75%) of neem oil and then surviving larvae were transferred to an untreated artificial diet to assess the physiological effects caused by post-digestion of treated cotton leaves. For *A. gossypii*, first instar larvae were fed for 24 hours on leaves treated with six concentrations (1, 2, 3.2, 6.2 and 10%), thereafter survival larvae are transferred on healthy leaves. The study indicated a potential for field control of *H. armigera* and *A. gossypii* by using neem. For *H. armigera*, leaf consumption for surviving larvae was significantly lower than that of the control.

# Management of wood termites, *Cryptotermes cavifrons* Banks (Insecta: Isoptera: Kalotermitidae) using biotermiticidal plants powders admixed with cow urine in Cross River State, Nigeria

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A field trial was conducted to determine the termiticidal efficacy of three plants (*Denattia trepitala*, *Jatropha curcas* and *Cedrela odorata*) at the forestry orchards of the Department of Forestry and Wildlife Resources Management, University of Calabar, Nigeria. Two levels each 5 and 10 % w/w (10 and 20 g) of the plant powders were dissolved in 50 ml of cow urine. Previous studies have worked with human urine. The mixture was applied to termite susceptible wood species, *Alstonia congensis*, and each weighing 200 g in a "graveyard" and the untreated which serves as control. The wood species were left for natural infestation by the wood termites and treatments introduced after one week. The treatments were arranged in a randomized complete block design with four replications. Parameters assessed included mortality rates of the termites at 12 hourly intervals, nymphal development and weight of the wood before and after treatment. Results showed that 10 % w/w of the treatments significantly increased mortality and reduced nymphal development compared with 5 % w/w. However, *J. curcas* at 5 % was as effective as *D. trepitala* and *C. odorata* at 10 % w/w compared with the untreated. The untreated showed significantly higher weight loss as a result of heavy infestation by the wood termites compared with the treated. In conclusion, *J. curcas* can be recommended for the management of wood termite in the field even at lower concentration. However, increased concentrations of *D. trepitala* and *C. odorata* could also serve as alternatives.

# A botanical oil-based product to control termites attacking wood and wood products

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Timber is a renewable resource with multi-purpose utility and plays major role in the day to day activities of man's life. It also plays an important role in the world economy. The value of timber and timber products is often reduced by physical or biological damage. Biological damage to timber and timber products is mainly caused by mould, stain, decay fungi, and insects. Among insects, termites form the most troublesome pests of wood and wooden structures. Although a variety of effective and inexpensive chemicals are available for wood protection from these insect pests, their toxicity to man and environment is of major concern. Developing effective and low environmental impact technologies for termite control is imperative. Neem seed oil, *Pongamia pinnata* seed oil, Jatropha seed oil, *Calophyllum inophyllum* seed oil, water extracts of the leaf of *Lobelia nicotianaefolia*, *Acacia concinna*, *Chromolaena odorata* were tested against termites (Grave yard test) following Bureau of Indian Standard. Based on the encouraging results, an EC formulation was developed from leaves of *L. nicotianaefolia* in combination with Neem seed oil, *Pongamia pinnata* seed oil and Jatropha seed oil and tested against the termites (Grave yard test) following Bureau of Indian Standard. The result revealed 100% protection of wood from termites for 3 years. The study shows that these plant seed oils and products developed from them can be used for safe, eco-friendly and effective management of termites infesting timber and its products.

# Development of a new botanical formulation to control the stem borer, *Zeuzera coffeae* Nietner in the sandal wood plantations in Karnataka, India

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The Indian sandalwood, *Santalum album* L., is indigenous to Peninsular India and its heartwood possesses extraordinary value in medicinal, perfumery and artefacts industries. The high demand for sandalwood tree is encouraging community and private entrepreneurs to cultivate *S. album* in agro-forestry, farm forestry and varied agri-silvi-horticultural and mixed plantation systems. Currently in the newer plantations the stem-boring pest, red stem borer *Zeuzera coffeae* Nietner is becoming a potential threat. *Z. coffeae* is widely distributed in India but it is mostly confined to tea and coffee producing parts of the country. But as sandalwood started coming up with many agroforestry species pest shift is occurring and as of now *Z. coffeae* is becoming potential pest of younger plantations of sandalwood. They totally kill the young saplings and often resulting in failure of sandalwood plantations. An average infestation of 47.6 % of sandalwood plants in natural forest areas by *Z. coffeae* is reported. The survey of sandalwood plantations revealed that there is use of chemical insecticides in the forefront against this wood-borer. Realizing the great value of sandal wood products, an EC formulation was developed from leaves of *L. nicotianaefolia* in combination with Neem seed oil, *Pongamia pinnata* seed oil and Jatropha seed oil please explain the formulation process!!. The formulation was tested against the stem borer give application rates, *Zeucera coffea*, infesting sandal wood trees by stem injection method. The result revealed 100% control over the stem borer at what rate of application.

# *Ageratum conyzoides* L.: A review of its use as an agricultural resource

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*Ageratum conyzoides* L. (Family: Asteraceae) is an aromatic, annual herb which grows as a weed commonly known as Billygoat weed or Goat weed and is generally found in cultivated fields and other ecosystems. This species has been widely studied with respect to the biological properties of its extracts and their subsequent application in medicine and agriculture. Due to its importance and use in folk medicine across regions in the treatment of various conditions such as burns, wounds, arthrosis, piles, malaria, asthma, headaches, sore throat leprosy dermatitis among many others, there has been a series of reviews summarizing data regarding various studies that have been conducted on this species with reference to its application to medicine. It has also been reported that this species has shown insecticidal activity against a range of crop pests including *Callosobruchus chinensis*, *Chilo partellus*, *Sitophilus oryzae*, *Panonychus citri*, *Sitophilus zeamais* etc as well as antifungal activity on *Fusarium Oxysporum*, *Phytophthora citrophthora*, *Pythium aphanidermatum*, *Fusarium solani*, *Fusarium graminearum* and others. Many of the reviews that have been done have had a bias to studies conducted on biological properties and their application in medicine. There is however limited information on studies targeting the use of this species in agriculture. This review therefore seeks to bridge these gaps by assembling data from researches that have been conducted to harness the various biological properties of this species into agricultural production. The review presents systematically a detailed review of information on the use of this species as an agricultural resource rather than a weed or a medicinal plant. The review established that currently there is limited documentation on safe application rates of various extracts of *A. conyzoides* on stored grains considering the potential toxicity of alkaloid compounds (Pecocene I and II) and the need to explore the potential use of *A. conyzoides* extracts on the management of plant diseases and weed control for increased agricultural productivity and hence enhanced food security.

# Ecotoxicological effects of citrus processing waste on earthworms *Lumbricus terrestris* L.

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Land disposal of agro-processing wastes containing potentially toxic compounds may lead to adverse ecotoxicological effects. Compared to agrochemicals, limited data is available on the ecotoxicological effects of biowastes such as those from citrus fruit processing. The objectives of the study were to determine: (1) selected soil chemical properties of contaminated field plots compared to those uncontaminated (control); (2) the effects of varying concentrations of citrus waste extract on mortality, reproduction and avoidance behaviour of the earthworm species, *Lumbricus terrestris* under laboratory simulation; and (3) earthworm abundance on contaminated and uncontaminated soils under field conditions. Laboratory simulation results showed that the concentration of citrus extract had a significant effect on mortality, reproduction and avoidance behaviour. Mortality and reproduction rate as indicated by number of cocoons, varied significantly among all treatments. Linear and exponential relationships were observed between citrus extract concentration, and earthworm mortality and reproduction rate, respectively. Laboratory avoidance tests showed that citrus waste induced avoidance behaviour in earthworms compared to the control. Soil application of citrus waste significantly increased the concentration of mineral nitrogen, available N and exchange Ca, Mg and K, but significantly reduced pH relative to the uncontaminated control. Field data showed that the contaminated site had 80% significantly lower earthworm counts than the uncontaminated control, evidently supporting results of laboratory simulated contamination. Overall, the study revealed that citrus waste has adverse ecotoxicological effects, which could threaten the soil biota.

# Symposium 2: Postharvest pest management

# S2 Plenary Speaker Evidence of the ecosystem services and economic cost-benefits of using pesticidal plants in Africa

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Research on pesticidal plants has largely focussed on the broad screening of plants through bioassays that assess efficacy to kill or repel insects, understand which plant species works best on certain crops and/or target pest species, and sometimes has involved more detailed studies on their mode of action and phytochemistry. Relatively little research has been conducted on the economic efficacy of using pesticidal plants where many simplistic assumptions have been made in the literature without confirming the costs and benefits of using pesticidal plants in comparison to synthetic commercial pesticides or no treatment at all. Previous research on the use of pesticidal plants by smallholder farmers in Africa has shown that farmers do not make pest management decisions exclusively based on efficacy and do consider other issues such as ease of use, resource availability, and time needed to collect and prepare plant materials. Providing farmers with compelling evidence that using pesticidal plants will save them money whilst increasing their yields should help incentivise smallholder farm use of pesticidal plant materials. Similarly, researchers have been guilty of claiming that pesticidal plants are safer for the environment in comparison to persistent synthetic chemicals without providing comparative evidence of ecosystem impact. Recent research on bean crop production in Tanzania and Malawi will be presented that shows pesticidal plants are indeed financially beneficial as well as less detrimental to beneficial insects (pollinators, parasitoids and predators). This work is helping to convince farmers that pesticidal plants make economic sense and are safer to use.

# Crude powder extracts from sisal Agave sisalana Perrine stem inhibits growth and development of major bean bruchids

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Bruchids are a major and growing problem in stored beans in all bean producing regions of Tanzania. Bruchids cause significant seed losses just few days after harvest once beans are kept in stores. The effects of sisal extracts and bean genotypes on development and damage by *Acanthoscelides obtectus* and *Zabrotes subfasciatus* were evaluated in the laboratory at Sokoine University of Agriculture for 42 days. Four genotypes, AO-29-3-3A, ML2, ML8, ML10 and a susceptible variety Soya were tested. Dry powder extracts from the core pith of sisal stem were admixed with 20g of bean seeds in glass bottles containing 16 newly emerged adults. The experiments were laid down in a factorial design replicated four times. Sisal extracts significantly ($P< 0.05$) reduced damage and emergence of adult *A. obtectus* and in all genotypes and the susceptible variety Soya. However, the effects of sisal extracts on emergence and damage of beans by of *Z. subfasciatus* were not significant. The effects of genotypes on emergence and damage by both species were also significant ($P< 0.05$). The germplasm AO 29-3-3A was consistently not damaged by both bruchid species followed by the moderate resistant genotypes whose damage were also reduced by the efficacy of sisal extracts.

# *Lippia javanica*: Variety, chemical composition and insecticidal activity of essential oil against *Sitophilus zeamais*

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In sub-Saharan Africa, *Lippia javanica* is used as a herbal tea, pesticidal plant and medicinal plant for treating numerous ailments. A study was conducted to determine the chemical composition of *L. javanica* essential oils extracted from two varieties growing in Nchenachena, Chikangawa and Jenda in northern Malawi. The oils were then evaluated for efficacy against *Sitophilus zeamais*. Confirmation of the plant species identity was done at the Royal Botanic Gardens, Kew in UK. *Lippia javanica* leaves were collected at different times during 2010/2011. Steam distillation was used to extract the oils while gas chromatography-mass spectrometry and gas chromatography-flame ionization detector techniques were employed to characterize the oils. *Lippia javanica* collected from Nchenachena was identified as *L. javanica* var. *javanica* while Chikangawa and Jenda *Lippia* were identified as *L. javanica* var. *whytei*. Perillaldehyde was the major constituent in Nchenachena *Lippia* oil while ipsdienone was identified as the major compound in Chikangawa and Jenda *Lippia* oils. Other constituents that were identified in both varieties included myrcene, linalool, carvone, β-caryophyllene and germacrene D. Bioassay results showed that oils, perillaldehyde, linalool and carvone were active against adult *S. zeamais*. After 48 h contact exposure, the highest concentration (10 mg/mL) of Nchenachena *Lippia* oil, Chikangawa oil, linalool, perillaldehyde and carvone produced 85, 83, 100, 99.5 and 100 % mortality of adult *S. zeamais*, respectively. Ipsdienone was not effective (6.5 % mortality). The high efficacy of *L. javanica* oil against *S. zeamais* suggests its suitability to be used as a botanical insecticide to control *S. zeamais* in stored maize. The study highlights the importance of correct plant species identification. However, further research is required to evaluate its activity against *S. zeamais* and other storage insect pests under farm conditions.

# Potential of botanicals to control *Callosobruchus maculatus*, the main pest of stored cowpeas in Burkina Faso

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Cowpea is an essential food legume in the tropics and particularly for sub-Saharan African populations. Postharvest grain storage, however, is a major constraint for crop expansion and year-round availability due to attack by the cowpea weevil, *Callosobruchus maculatus* F., the main storage pest of cowpeas in West Africa. In Burkina Faso, several scientific investigations have focused on the control of *C. maculatus* using botanicals during the past ten years. The studies demonstrated that several plants and/or their extracts were active against eggs, larvae and adults of *C. maculatus*, through dose-dependent mortality responses. Essential oils extracted from native aromatic plants have produced the most promising results, some of them being very toxic to bruchid adults. Other potentially effective essential oils tested include: *Hyptis suaveolens*, *H. spicigera* and *Lippia multiflora*. Based on these results experiments to optimize the use of essential oils for cowpea storage were carried out in the laboratory and under field conditions. The results reported here are discussed in the context of practical use of botanicals and essential oils as safe alternatives for IPM in stored cowpeas.

# Residual contact toxicity and repellence of essential oils of *Cupressus lusitanica* Miller and *Eucalyptus saligna* Smith against major stored product insect pests

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Laboratory studies were conducted to evaluate residual contact toxicity and repellence of *Cupressus lusitanica* and *Eucalyptus saligna* leaf essential oils against adult *Tribolium castaneum*, *Acanthoscelides obtectus*, *Sitotoroga cerealella* and *Sitophilus zeamais*. Bioassays were conducted under controlled conditions of temperature (28±2°C) and relative humidity (65±5%) and 24h darkness. The experiments were laid out in a completely randomised design with four replicates per concentration. In residual contact toxicity each test oils at rates of 0.00, 0.05, 0.10, 0.15 and 0.20% v/w was applied on 10 g wheat and 20 g beans or maize grain treated and stored for 120 days. At 0.20% v/w and 120 days storage, grains treated with *C. lusitanica* oils caused a mortality of 5.0, 17.5 and 65.0% against *S. zeamais*, *T. castaneum* and *A. obtectus*, respectively 168 h post-introduction of test insects. Similarly, *E. saligna* oils caused a mortality of 5.0, 60.0 and 64.2.0% against adult *T. castaneum*, *S. zeamais* and *A. obtectus*, respectively 168 h post-introduction of test insects. In residual repellent test essential oil was evaluated in an alternate untreated (control)-treated choice bioassay system. The grains used were treated and stored for 30, 60, 90 and 120 days. *Cupressus lusitanica* leaf essential oil, at 0.20% v/w and 120 days grain storage duration, was moderately repellent with PR values of 37.9, 47.6 and 51.1% against adult *A. obtectus*, *S. zeamais* and *T. castaneum*, respectively 12h post-introduction of test insects. In *E. saligna* leaf essential oil, at the same concentration and after 120 days of storage; moderate repellence was recorded with a PR value of 52.4% in *T. castaneum* but weakly repellent to *A. obtectus* (34.0%) and *S. zeamais* (36.6%), 12 h post-introduction of test insects. Results point to *C. lusitanica* and *E. saligna* essential oils as promising natural contact toxicants and repellents of stored product insect pests for possible inclusion in insect pest management options.

# Cameroonian insecticidal products from *Azadirachta indica* and *Plectranthus glandulosus* for the protection of stored cowpea and maize against their major insect pests

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Botanical insecticides are more biodegradable and could be a source of more environmental-friendly insecticides. Accordingly, the effectiveness of oils from *Azadirachta indica* seeds and pulverized leaves and seeds of this plant and that of *Plectranthus glandulosus* were tested against *Callosobruchus maculatus* on cowpea seeds and *Sitophilus zeamais* on maize grains. The azadirachtin A contents of *A. indica* seed oils and powders from sun-dried seeds and shade-dried seeds, and the chemical composition of *P. glandulosus* powders from sun-dried and shade-dried leaves, were determined, before admixing each product with cowpea seeds or maize grains for the toxicity and progeny reduction bioassay studies. Mortality counts were determined for up to 6 d (*C. maculatus*) or 14 d (*S. zeamais*). After the mortality counts, the grains were kept until all the emerging F1 progeny were recorded. From the results, the average content of Azadirachtin A in the seed powder was 1.20 g/kg, and this was not influenced by sun-drying. On the contrary, the oil from the sun-dried seeds (2.89 g/kg) had a lower azadirachtin A content than that from the shade-dried seeds (3.69 g/kg). Sun-drying did not affect the diversity of volatile compounds in the leaves of *P. glandulosus*, as the same 50 compounds were found in the sun-dried and shade-dried leaves, although in different proportions. Generally, *P. glandulosus* powder caused greater mortality to *C. maculatus* and *S. zeamais* than *A. indica* seed powder, but the seed oil was more active towards both insects than the powders. The *A. indica* products were more effective in suppressing progeny emergence in both insects than *P. glandulosus* leaf powders. Insecticidal products from the present study could form a major component of the integrated storage protection package for cowpea and maize against beetle infestations.

# Insecticidal and Insect Reproductive Inhibition Capacities of Citrus Peels Powder on *Tribolium castaneum*

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Laboratory experiment to evaluate the insecticidal efficacy of citrus peel powders against *Tribolium castaneum* (Herbst) was carried out in the Department of Zoology and Environmental Biology, University of Calabar. The experiment consisted of different types of citrus powder (orange, tangerine, lemon, grape and lime) admixed with maize grain (popcorn) at different dosages of 1, 2, 3, 4, 5 and 6 g treatment per 50g. The treatments were laid out in a completely randomized design with four replications. Parameters assessed included adult mortality, larval development, number of adult emergence and grain weight loss. Result shows that sweet orange and Tangerine peel powder at 5 and 6 g treatment were efficacious of all the 5 different plant treatments as it had significant effects on mortality of adult *T. castaneum*, reducing oviposition and larval development on the maize grain, inhibiting the emergence of adult *T. castaneum* and as well reducing the grain weight loss respectively. This was closely followed by grape and lemon peel powders that killed 4.38±1.43 and 3.87±1.28 adult *T. castaneum* respectively. The untreated maize recorded higher insect reproduction rate, low mortality, compared with lower values obtained from the maize grain treated with the citrus peel powders. Therefore citrus peel powder can serve as a protectant against *T. castaneum* at a higher concentration.

# Pesticidal effects of local plants as an alternative to synthetic pesticides in stored cowpeas, *Vigna unguiculata*

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Cowpea grain is highly susceptible to bruchids during storage. Three locally available plants, *Acacia rhehemiana*; *Colophospermum mopane*; and *Ocimum gratissimum*, were evaluated in contrasting agro-ecological zones under farmer conditions, to determine their effectiveness in reducing cowpea losses due to *Callosobruchus rhodesianus*. These plants, already being used by smallholder farmers in Zimbabwe, were compared to two commercially available synthetic pesticides and untreated control. The treatments were admixed with the dried grain and placed in polypropylene bags which were stored in smallholder farmer stores. Based on the field trial findings, further laboratory experiments were conducted at the University of Zimbabwe to determine the contact action of the pesticidal plants. Germination tests were also conducted to determine possible effects of these treatments on seed viability. Parameters measured from the field experiment included grain moisture content, % insect-damaged grain, % grain weight loss and insect numbers at 8-week intervals for ten months. In the field trials, the plant parts used included the fresh root bark of *A. rhehemiana*, leaves of *C. mopane* and the whole plant of *O. gratissimum* each at 0.1%w/w, 0.5%w/w, 1%w/w and 1.5%w/w. The parts of the plants were dried, ground into powder and used at the rate of 250g/50kg except for *A. rhehemiana* root bark which was used in its wet form as per farmer practice. Among the indigenous methods evaluated, *C. mopane* showed potential and this was further confirmed by laboratory experiments where a rate of 1% w/w was effective at managing the F1 emergence of *C. rhodesianus*.

# Stored grain insect pests and practical implications for use of pesticidal plants in two dryland counties, Tharaka Nithi and Makueni in Kenya

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As the world populations grow, it requires a high increase in food production but the prevalence of storage insect pests is a major constraint to food and nutrition security. The problem is more severe in remote dryland areas where resource-poor farmers can hardly afford the commercial synthetic insecticidal grain protectants. A wide range of insect pests have been recorded attacking stored grain in the two target counties of Tharaka Nithi and Makueni in Kenya. They include primary cereal insect pests such the angoumois grain moth (*Sitotroga cerealella* (Olivier); maize weevil (*Sitophilus zeamais* Motschulsky, the larger grain borer (*Prostephanus truncatus* (Horn); among others. For the legumes including beans, cowpeas, pigeon peas, and green grams commonly grown in these two counties, the major beetles attacking them are the bruchids (*Acanthoscelides obtectus* (Say), *Zabrotes subfasciatus* (Boheman), *Callosobruchus maculatus* F. and *C. chinensis* L. Since 2014, the Optimising Pesticidal Plants: Technology Innovation, Outreach and Networks (OPTIONs) project has been implemented in Kenya in two dryland counties of Tharaka Nithi and Makueni. About 300 smallholder farmers have been involved and have shared their grain storage challenges and their knowledge on use of local pesticidal plants species in controlling insect pests in their stored grains. Storage management has greatly influenced insect pest control and encompassed decisions upon the location of stores and storage periods.

# The identification of compounds in *Maerua edulis* with biological activity against storage pests

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Agricultural Intensification in smallholder farming is crucial to feeding the growing population of Africa. Smallholders are particularly vulnerable to crop losses to insects but are critically important since they provide 80% of food production to the developing world. While field losses to insects impact yield around 40% of all food produced is lost in storage. Synthetic pesticides, may be effective but may be unavailable, adulterated, and not effective. Pesticides also persist in the environment affecting beneficial insects, and can be poisonous to farmers and consumers alike so alternatives are required. Plant materials have been part of the farmer's armoury against pests for generations and are still a relevant alternative to synthetics as they are readily available and are typically less toxic to humans and beneficial insects. Blue bush-berry, *Maerua edulis*, is a shrub native to Southern Africa. Recent work reported bioactivity in this species to cattle ticks, vegetable pests and storage beetles but little is known about the chemistry underlying the bioactivity. Chemical information is essential to understand the nature and variations of activity from different locations and also help develop ways of optimising use for farmers. Here we report the identification of cinnamoyl and 2 hydroxycinnamoyl amides of agmatine ((4-aminobutyl)guanidine) that occur in the leaves of *M. edulis*. Their structures were elucidated by various spectroscopic techniques. Stachydrine and 3-hydroxystachydrine were also identified in the leaves at high concentrations. We tested these compounds on the cowpea bruchid *Callosobruchus maculatus* and show that these compounds are biologically active against this pest and may account for the activity reported in this plant to other pests. We report also a synthesis of the amides which can help produce adequate quantities for testing against other pests and may even lead to a commercial synthesis.

# Biological activity of extracts of *Vernonia amygdalina* and *Tithonia diversifolia*: pinpointing the compounds responsible

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*Vernonia amygdalina* and *Tithonia diversifolia* are widely used as pesticidal plants in sub-Saharan Africa to protect crops and as admixtures in stored grain. In a contact-toxicity bioassay dried methanol extracts of these two species at 10, 1 and 0.1% w/v displayed dose-dependent effects on mortality and inhibited oviposition of *Callosobruchus maculatus*. Semi-purified fractions and an isolated compound (tagitinin A) displayed similar effects. High resolution mass spectrometry tentatively identified sesquiterpene lactones and saponins in the fractions. It is concluded that the fractions and compound at 10, 1 and 1% w/v equivalent concentrations were at least as effective as the whole extracts, supporting (1) the use of these plants as pesticides and (2) further efforts to optimize the extraction of these insecticidal components.

# Pesticidal plant use as maize grain protectants in Bikita district, Masvingo province, Zimbabwe

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Farmers' indigenous knowledge of storage insect pests and management practices in stored grain protection against insect pests are critical for sustainable food security in the smallholder sector in Zimbabwe. A survey of 99 maize smallholder farmers was conducted in Bikita district to evaluate their knowledge, attitudes and traditional storage management practices against storage insect pests. Problem storage pests listed in order of prevalence were maize weevil (*Sitophilus zeamais)* 49%, lesser grain borer (*Rhyzopertha dominica*) and maize weevil (*Sitophilus zeamais*) complex 25.5%, lesser grain borer (*Rhyzopertha dominica*) 17.7% and larger grain borer (*Prostephanus truncatus*) 7.3%. The commonly used botanical pesticides in the two wards were gumtree (*Eucalyptus* spp) (24.6%), tamboti (*Spirostachys africana*) (7.2%), lilac tree (*Melia azedarach)* (4.1%), sunflower (*Helianthus annuus*) ash (5.1%), cow dung (3.1%), lemon bush (*Lippia javanica*) (2%), murwiti (*Rapanea melanophloeos*) (1%), sweet basil (*Ocimum basilicum*) (1%), finger millet (*Eleucine coracana*) chuff (1%),wood ash (4.1%) and mixtures of the botanicals (4.5%) mentioned above. The botanicals are mixed with maize grain before storage either in sewn polypropylene bags or as loose grain placed in the granary plastered with cow dung. Farmers resort to the use of cheap and locally available botanicals when there is no money to buy synthetic insecticides. There is an urgent need for laboratory evaluation of the efficacy, chemical composition and mode of action in order to come up with dosage guidelines of these ethnobotanicals for the resource-poor smallholder farmers.

# Symposium 3: Plant disease and weed control

# S3 Plenary Speaker 1 The use of plant extracts and plant based compounds to protect plants against plant fungal pathogens

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Plant fungal pathogens cause enormous problems in plant and food production at different stages from germination of seed to post-harvest problems. Fungi may lead to large crop losses but some also produce mycotoxins in food causing serious health problems in humans. Many fungicides are used to combat fungal infections with varying efficacy due to the development of resistance by the fungal pathogens. Because plants are subject to fungal attacks, many plants produce antifungal compounds. Plant based compounds may be useful in the organic production of crops. It may also lead to a lower development of resistance because in most cases plant extracts contain several different antimicrobial compounds. Examples will be discussed on how plant extracts and isolated compounds have led to products with a potential commercial application against plant fungal pathogens. In one case an invasive plant species had excellent activities and a very high yield. The extract from 1 g of dried leaves could be diluted to 60 L and would still inhibit some fungal pathogens. In a second example a plant extract could be used to protect oranges against infection with different fungi. In a third example a plant extract had a higher safety and efficacy than the commercially used product against Aspergillosis in poultry. Finally a plant extract could be potentized to increase the activity beyond that of most commercial fungicides. The product was much better than the commercially used product in *in vitro* studies but also in field trials. The product had low water solubility that means that it would not easily be washed off by rain after spraying. In considering its environmental safety, it also had low toxicity to earthworms. Several endophytes were isolated from the plant and some of them had good antifungal activity. It is therefore possible that the antifungal activity may be caused by endophytes. Toxicity of extracts may be applied in the horticultural industry.

# The effect of selected botanical pesticides for the control of cashew powdery mildew disease in Tanzania

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Cashew production in Tanzania is severely constrained by biotic factors and fungal disease caused by *Oidium anacardii*, cited as the leading devastating disease causes significant cashew crop loses. Farmers rely heavily on synthetic fungicides which most contain Triademenol, Bayfidane®. Synthetic pesticides can cause negative effect to the environment and the public human health. Thus, alternative environmental friendly control method such as the use of botanicals in controlling powdery mildew disease (PMD) is essential. We conducted surveys to search for potential botanicals in six districts. From the collected botanicals, five of them namely *Opuntia ficus-indica*, *Opuntia vulgalis*, *Euphorbia tirucalli*, *Azadirachta indica* and *Bobgunnia madagascariensis* were tested and compared to the recommended conventional fungicide, Triadimenol (Bayfidane®) in controlling PMD in cashew. Based on farmers' perception a total of 29 plant species were identified as potential botanicals for controlling either fungal diseases or insect pests in various crops. The efficacy test of these botanicals indicated that cashew trees treated with botanicals and Triadimenol recorded lower PMD infections compared to untreated cashew trees. Due to human health problem and negative environmental effects posed by these synthetic pesticides, plant extracts from *O. ficus-indica* can be considered as the potential candidate to smallholder farmers for cashew treatment against the fungal disease caused by *Oidium anacardii*.

# Antimicrobial activities of Ivorian flora on southern blight, *Sclerotium rolfsii*

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Tomato is one of the most consumed vegetables in the world. However, growth and development are limited by constraints. In addition, chemical fungicides are a threat to man and the environment in terms of toxicity. To propose alternatives to synthetic fungicides, a study was conducted on essential oils to test their antifungal activity *on Sclerotium rolfsii*, southern blight, which is one of the most important diseases of tomato. Essential oils extracted from *Monodora myristica*, *Quinquenervia Melaleuca*, *Eucalyptus torelliana*, *Chenopodium ambrosioides*, *Zingiber officinalis* and *Zingiber officinalis* and synthetic fungicides (Callicuivre, Banko+ and Mancozeb) were used by incorporating in to the PDA culture medium. The colonies of *Sclerotium rolfsii* present several outcomes depending the products and their concentrations. At the end of the tests, the activities of the essential oils of *Eucalyptus* and *Monodora* were similar to that of Callicuivre. Mancozeb inhibited the growth and production of the fungal colony. However, oils from *Chenopodium ambrosioides*, *Zingiber officinalis* showed more inhibitory activities on mycelial growth. The number of sclerotia produced varied depending on the concentrations. This study offers the possibility of using essential oils in the control of *Sclerotium rolfsii*.

# Postharvest fungi associated with kernels of *Ricinodendron heudelotii* and *Garcinia kola* in the highlands of western Cameroon and bioactivity of some medicinal plant extracts

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Kernels of *Ricinodendron heudelotii* and *Garcinia kola* are two edible non-timber forest products (ENTFP) commonly consumed and sold in the western highlands of Cameroon (WHC). However, during storage, these edible products are generally colonized by fungi which are responsible for high postharvest losses. The objective of this study was to control postharvest diseases *of R. heudelotii* and *G. kola* kernels using extract of some medicinal plant. Kernels were collected from markets of three sub-divisions in the WHC for fungi isolation and identification. *Carica papaya* leaves, *Citrus sinensis* pericarp and *Zingiber officinale* rhizomes were collected, dried and crushed to fine powder which were used to prepare aqueous and ethanolic extracts. Results show that *Aspergillus niger* (36.8%), *A. flavus* (24.0%) and *Rhizopus nigricans* (18.6%) were more frequent in *R. heudelotii* kernels while *A. niger* (38.6%), *Penicillium citrinum* (14.9%) and *Trichoderma* sp (12.0%) were the most common species in *G. kola*. *In vitro* tests reveal that all the aqueous extracts at 50, 75 and 100 mg/ml and ethanolic extracts at of 20, 25 and 30 mg/ml have significantly inhibited ($P<0.05$) the growth of *A. niger*, *P. digitatum* and *P. citrinum* isolated from *R. heudelotii* and *Cladosporium* sp, *Verticillium* sp, *Stemphylium* sp isolated from *G. kola* compared to the negative control (0 mg/ml). Ethanolic extracts *of C. sinensis* and *Z. officinale* at 30 mg/ml have totally inhibited the growth of *Cladosporium* sp, *Verticillium* sp and *P. citrinum* as much as the reference fungicide mancozeb at 1 mg/ml. *In vivo* test show that the disease developed on *R. heudelotii* kernels inoculated with *A. niger, P. digitatum* and *P. citrinum* was significantly inhibited by the aqueous (100 mg/ml) and ethanolic (30 mg/ml) extracts compared to the negative control. Ethanolic extracts of *C. papaya, C. sinensis* and *Z. officinale* can be used as alternative to synthetic fungicides in post-harvest protection of *R. heudelotii* and *G. kola* kernels in order to reduce risk of toxicity.

# Black rot, *Xanthomonas campestris* pv *campestris* control using *Moringa oleifera* Lam. extracts

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A field experiment was carried out in the 2015/2016 season at Victory Farm in Beatrice to evaluate the efficacy of *Moringa oleifera* leaf, bark and seed aqueous extracts in controlling black rot in cabbages. Black rot is caused by the bacterium *Xanthomonas campestris* pv campestris, a pathogen of economic importance worldwide. Three Moringa extract concentrations of 60, 100 and 140% were sprayed as foliar applications weekly and the antibacterial activity for each of the different Moringa extract efficacy was evaluated by recording number of totally defoliated plants once every fortnight. The experiment was laid out as a split plot design in two blocks with three replications. The results indicated high significance in antibacterial activity of all the three Moringa extracts as they were able to achieve control of *Xanthomonas campestris* at varying levels in the cabbage plants. However, Moringa seed extract had the highest antibacterial activity against the black rot disease in cabbages in this study. Further studies need to be carried out to assess if the utilization of the Moringa seed extract as a seed dressing would not increase its antibacterial effects against the test pathogen.

# Use of allelopathy properties of local plants for controlling *Striga hermonthica* in Burkina Faso

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*Striga hermonthica* (Del.) Benth. is a major biotic constraint to cereal productions in sub-Saharan Africa. The 10% aqueous extracts of height local plants: *Acanthospermum hispidum* de Candolle, *Cassia obtusifolia* L., *Eucalyptus camaldulensis* (Dehenhardt), *Faidherbia albida* (Del.) A. Chev., *Lippia multiflora* (Moldenke), *Stereospermum kunthianum* Cham., *Tridax procumbens* L. and *Vitellaria paradoxa* C. F. Gaertn, were also screened in bio-assay to evaluate their allelopathic properties to induce or inhibit Striga seed germination elicited by GR 24. The 10% aqueous extract from *E. camaldulensis* (roots) and *L. multiflora* (leaves) significantly reduced Striga seed germination with 86.3% and 46.5% inhibition rates, respectively. The 10% aqueous extracts of all plant species stimulated Striga seed germination. The most effective in stimulating Striga seeds were the 10% aqueous extracts from *E. camaldulensis* (leaves) and *F. albida* (bark) leading to Striga germination rates more than 50%. The 10% aqueous extracts from the four other ones significantly stimulated Striga germination and the rates varied between 25.2% and 48.1%. The results suggested that local plant products may be used in controlling Striga as bio-herbicides and would also be a safe alternative approach. Indeed, the prolonged use of local plant extracts that stimulate or inhibit *S. hermonthica* seed germination may reduce or inactivate its seed-bank in the soil, respectively. Plant products that induce or inhibit *S. hermonthica* seed germination at least 25% may be recommended for use in cropping systems, particularly in an integrated management approach against *S. hermonthica*.

# Protecting Mali's aquatic resources: eco-management of water hyacinth with a bio-herbicide

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As a landlocked country in the heart of West Africa, Mali's agriculturally-based economy revolves around two rivers, the Senegal and the Niger. These rivers are a vital source of energy, transport, irrigation, and livelihoods. However, water hyacinth, *Eichhornia crassipes*, invasion in the Senegal and Niger rivers is threatening food security and power generation. Over the last 20 years, water hyacinth infestation has affected 80% of the River Niger, hampering fishing, boat transport, hydro-electric power generation and irrigation facilities. The bioherbicide is fungal formulation. It is formulated with *Carapa procera* oil (35%), soya lecithin (15%), Tween 20 (5%) and biological agent. Within 4-6 weeks over 60% of the plants were dead when using the bio-herbicide. Greenhouse-based tests were even more effective, causing up to 90% destruction of the leaves. It is recommended that 60L of bioherbicide is applied with a concentration of 5,000,000 spores ml/ha. Two annual sprays are required, in July and January.

# The pesticidal activity of Cat's whiskers, *Cleome gynandra* L., plant tissue on weeds and soil borne pathogen incidence and severity in the field

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Commercial management of soilborne pathogens, pests and weeds is often reliant on use of chemical pesticides. However, pesticide registration and approval is becoming increasingly stringent and the likelihood of non-environmentally friendly pesticides being retracted from commercial use is now more probable. Biofumigation represents a potential alternative. The attention for biofumigation has been strongly augmented because public opinion considers them as a mild, safe and reliable option to prevent or to fight several soilborne plant diseases. The process involves growing a green manure for maceration and incorporation into soil whereby intracellular glucosinolate (GSL) molecules are hydrolyzed to pesticidal volatiles such as isothiocyanate gases for the management of a variety of pests including weeds, insects and plant pathogens as reported through several researches. This study aimed to determine the efficacy, produced by *Cleome gynandra* species, have on two economically important soil borne fungal pathogens, *Rhizoctonia solani* and *Pythium ultimum*, and weeds. Statistical differences gave major evidence of disease suppression in plots amended with purple *C. gynandra* species in both tomato and sweet pepper. These results demonstrate that the incorporation of *C. gynandra* plant tissue into soils affected weed growth and weed evenness.

# The herbicidal activity of Cat's whiskers, *Cleome gynandra* L. plant tissue on plant weeds (*Rottetboelia cocchinensis*, *Setaria verticilata*, *Amaranthus hybridus* and *Bidens pilosa*)

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The suppressive effects of different *Cleome gynandra* plants on weeds were investigated in the laboratory. Two different biofumigant crops (green spider plant (*C. gynandra*), and purple spider plant (*C. gynandra*)) and four weed species (*Rottetboelia cocchinensis*, *Setaria verticilata*, *Amaranthus hybridus* and *Bidens pilosa*) were studied as model organisms. *C. gynandra* species are rich in glucosinolates and are used for biofumigation, a process based on releasing enzymatically toxic isothiocyanates into the soil. These hydrolysis products are volatile and often reactive compounds. Moreover, glucosinolates can be degraded also without the presence of the hydrolytic enzyme myrosinase which might contribute to bioactive effects. Thus, in the present study the herbicidal activity of *C. gynandra* plant tissue was studied using a rate of 0, 5, 10 and 15 % per weight of plant tissue on a weight to volume basis. The results showed that *R. cocchinensis, S. verticilata*, *A. hybridus* and *B. pilosa* responded in a varied fashion to the different *C. gynandra* plant tissue rates. This study provides important information for choosing a green manure crop with the purpose of managing weeds. More work still needs to be done to come up with conclusive results.

# Quantification of sorgoleone in 353 sorghum accessions from Africa

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Sorghum [*Sorghum bicolor* (L.) Moench] has the potential to suppress weeds naturally in the ecosystem by producing and liberating phytotoxic secondary compounds. The major allelopathic compound produced by sorghum is the lipophilic benzoquinone, sorgoleone. 353 sorghum accessions comprising 11 wild sorghums and 7 sweet stem sorghums from Zimbabwe, 9 varieties released in Zimbabwe, Mozambique, Malawi, Botswana, Tanzania and Zambia; 148 landraces from South Africa, 97 landraces from Botswana, 66 landraces from Namibia and 15 landraces from Zambia, were screened for sorgoleone content by high performance liquid chromatography in 2016. Sorghum seeds were planted in petri dishes in the Weed Science Laboratory (Department of Crop Science, University of Zimbabwe). Six days after germination, roots of seedlings were excised from the shoots and immersed in HPLC-grade methanol (1:20) w/v for 3 minutes to extract the sorgoleone. The crude extract was filtered and evaporated in a water bath with temperature set at 45°C. The dried extract was dissolved in mobile phase (1mg/ml) and the solution filtered through a poly filter 0.45µm prior to HPLC analysis. Quantification was based on a calibration curve using purified sorgoleone as an external standard. Differences in sorgoleone concentration among accessions from the same country or group, as well as across countries/groups were observed. High levels of sorgoleone were detected in accessions that included a Zimbabwean wild sorghum IBS749 (355.24 µg/mg RFW or 0.35524); a Botswana landrace IS19450 (464.43 µg/mg RFW) and three South African landraces IS14002, IS14003 and IS9456 (381.20 µg/mg RFW, 472.69 µg/mg RFW, and 584.69 µg/mg RFW respectively). Sorgoleone was not detected in 11 of the 353 sorghum accessions tested. In the majority (316) of accessions, sorgoleone was in the range of 0.01 – 200 µg/mg RFW. In many of the accessions, another compound that was eluted at about ≈0.3 minutes after injection featured distinctly. A number of trace compounds which were indicated by small chromatographic peaks were also detected. The results indicate that sorghum from many parts of Africa contains sorgoleone. The sorghum also contains other compounds which may be of interest. There is great potential for use of sorghum allelopathy for weed control in Africa.

# Symposium 4: Livestock and human diseases vectors

# S4 Plenary Speaker Botanicals: The future pest/parasite control?

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The indiscriminate use of synthetic pesticides has generated environmental and public health problems. In recent years, the use of these products and the number of active ingredients has been limited by very restrictive legislation in the EU and other countries. Therefore, there is a growing need for alternative control agents, including natural products and biocontrol. In this context the Biopesticides Group-CSIC has screened hundreds of botanical species from the Iberian Peninsula, the Canary Islands, Chile and Peru, selected based on biodiversity and ethnobotanical criteria. The ethanolic extracts of these species have been tested against a broad spectrum of targets including crop pests and diseases (insects: *Spodoptera littoralis*, *Leptinotarsa decemlineata*, *Myzus persicae*, *Rhopalosiphum padi*; phytopathogenic fungi: *Fusarium oxysporum*, *Botrytis cinerea*, *Alternaria alternate*; phytopathogenic nematodes: *Meloydogyne javanica*), plants (*Lactuca sativa*, *Lolium perenne*) and animal ecto-parasites (ticks: *Hyalomma lusitanicum*), all responsible for significant economic losses in crop and livestock production. Several species of interest have been identified for crop protection and tick control. Standing out above the rest are *Artemisia absinthium* var. Candial® for fungal, insect and nematode control and *Lavandula luisieri* for weed and tick control. The bioguided chemical study of these species resulted in the chemical isolation and characterization of their active molecules. Furthermore, both plant extracts have been patented and licensed to small and medium-sized enterprises for the development of new products. In this presentation we will outline the discovery, development and future prospects of the most promising plant species of the research group pipeline.

# Prioritised medicinal plants of Kaimosi area on the outskirts of Kakamega Forest, western Kenya

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A prioritised list of useful plants to humans for pest and disease control in Kaimosi area on the outskirts of Kakamega forest in western Kenya was studied in terms of importance, types, uses and methods of utilization. Semi-structured interviews and ranking in organized workshops by herbal practitioners were used to collect ethno-medicinal knowledge from plant pesticide users. One hundred and eighteen species in 104 genera, 48 families were identified and collected. Of the collection, 26 species in 17 families were documented for pesticidal use. Voucher specimens for pesticidal plants were deposited at Ol'lessos Technical Training Institute Herbarium. Most species belonged to the *Asteraceae* family (19.2%), followed by *Fabaceae* and *Solanaceae* (11.5%). Among pesticidal plants, the leaves were the most frequently used plant part for pesticidal purposes (65.4%), followed by fruits and whole plant (11.5%). Common preparation methods for pesticides included infusions (65.4%) and dry powders (26.9%). In terms of use and preference, were *Lippia javanica* and *Tephrosia vogelii* and *Desmodium* spp. The most important plant was found to be *Tephrosia vogelii*. The results of this study support the prioritization of pesticidal plant uses in Kenya for development of the countries' pharmacopoeia and the use of pesticidal plants in the management of pests and infectious plant diseases.

# Mosquito repellent effect of natural volatiles from *Ocimum suave* growing wild in Dar es Salaam, Tanzania against Anopheles mosquitoes

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Mosquitoes are not only a nuisance to humans as they bite to get their blood meal but, also transmit disease causing parasites and viruses in the process. Female mosquitoes are responsible for the transmission of a number of human blood-borne diseases. Mosquitoes have been shown to transmit the mostly fatal and disabling diseases, the most prevalent being malaria, *bancroftian filariasis*, yellow fever, dengue fever and several arbovirus infections. In this study, the potential of essential oil repellent tactics as a tool to reduce malaria transmission is explored. Essential oil was extracted from *Ocimum suave* Willd leaves by water distillation and tested for repellence effectiveness against *Anopheles gambiae* adult mosquitoes. The percentage yield of the essential oil was 0.2%. Six concentrations of *O. suave* essential oil were applied on human skin of four volunteers, and the repellence effectiveness which was analyzed by PoloPlus (LeOra software version 1.0, 2002-2014), revealed promising RC50, RC75, RC90 and RC99 with their confidence limits as 0.1161 mg/cm2 (0.02067 - 0.1767 mg/cm2), 0.2823 mg/cm2 (0.22328 - 0.3654 mg/cm2), 0.4319 mg/cm2 (0.35226 - 0.58862 mg/cm2) and 0.98934 mg/cm2 (0.54731 - 0.99972 mg/cm2), respectively. *O. suave* essential oil exhibited high Anopheles mosquitos' repellence effectiveness which merits further scientific attention for the development of natural repellents for the control of malaria and other mosquito borne diseases. These findings provides a scientific evidence and base for formulation for further mosquito repellence semi-field and field trials for the development of cheaper and affordable new mosquito repellent product(s) to meet human healthcare needs in the prevention and control of malaria and other mosquito transmitted infections.

# Anthelmintic, antifungal and cytotoxic activities of acetone leaf extracts, fractions and isolated compounds from *Ptaeroxylon obliquum*

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*Ptaeroxylon obliquum* is traditionally used to treat many ailments including for ethnoveterinary purposes to treat parasitic infections in South Africa. In this study the antiparasitic, antifungal and cytotoxic activities of acetone leaf extracts of *P. obliquum*, fractions and isolated compounds were determined. The in vitro anthelmintic activity was investigated against *Haemonchus contortus* ova and larvae using egg hatching and larval development assays. The antifungal activity was determined by serial microplate dilution method against *Aspergillus fumigatus*, *Cryptococcus neoformans* and *Candida albicans*. The cellular toxicity of the crude extracts, fractions and isolated compounds was determined against the Vero African green monkey kidney and human liver (C3A) cell lines. Three compounds were isolated from the chloroform fraction using silica gel open column chromatography and characterized as obliquumol, lupeol and β-amyrin mixture, and eranthin. The anthelmintic activity of the extract and obliquumol against *H. contortus* ova and larvae indicated that the compound was more effective than the crude extract with an EC50 as low as 95 µg/ml against the larvae. Obliquumol and eranthin had good antifungal activity against the fungi with minimal inhibitory concentrations (MIC) values ranging from 2-16 µg/ml. The anti-candidal activity of obliquumol which was more active than amphotericin B, the positive control used confirms previous studies done on the compound. The acetone crude extract was toxic with an IC50 value as low as 14.2 µg/ml against the Vero cells. However, the isolated compounds were not toxic against both Vero and C3A cells and had good selective index against the opportunistic fungal pathogens in HIV patients. The results of the anthelmintic activity demonstrated potential in the management of *H. contortus* which may explain some of the ethnoveterinary use of this plant in South Africa. The activity of bioactive compounds may provide relief against opportunistic fungal pathogens in immuno-compromised patients.

# Indigenous acaricidal plants and cattle tick control

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Recent surveys showed that some indigenous plants were used by smallholder livestock farmers against cattle ticks. Crude water extracts of three of these plants: *Cassia abbreviata* (leaf), *Maerua edulis* (leaf and tuber) and *Monadenium lugardiae* (leafy stems) were evaluated at 10% w/v against cattle ticks under field conditions. Liquid soap (1% v/v) was added as a surfactant during the plant material extraction process. Ordinary water and an amitraz based synthetic acaricide Tickbuster® were used as positive and negative controls, respectively. Thirty-six Mashona steers were randomly allocated to the six treatments in a completely randomized design experiment at Henderson Research Station. Each animal was an experimental unit replicated six times. The animals were each sprayed with 5 litres of each treatment on a weekly basis and full body tick counts recorded every other day for 7 weeks. Results showed that *M. edulis* tuber aqueous extracts reduced the tick populations with weekly mean efficacy ratios of 60.1, 61.7, 61.6, 65.5, 61.0, 57.1 and 62.7% from week 1 to week 7 respectively. There was no significant difference between the positive control (Tickbuster®) and *M. edulis* tuber treatment. *Monadenium lugardiae*, *C. abbreviata* and *M. edulis* leaf aqueous extracts were not significantly different from the negative control throughout the trial period. We conclude that *M. edulis* tuber aqueous extracts are efficacious against cattle ticks and have the potential to effectively control cattle ticks at 10 % w/v.

# Formulation of a herbal cream incorporating *Pterocarpus angolenses*, *Adansonia digitata* and *Bulbinella frutescens* extracts to alleviate impetigo

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Impetigo eruptions are a commonly seen dermatological manifestation in humans and animals. Often, the eruptions become superinfected with *Staphylococcus aureus*. The available treatments have numerous shortfalls including low availability and high costs. The purpose of this study was to formulate an herbal cream incorporating the extracts from *Pterocarpus angolenses*, *Adansonia digitata* and *Bulbinella frutescens* to alleviate the symptoms associated with this condition. The extracts were obtained by solid liquid extraction, liquid-liquid extraction and expression respectively. *Adansonia digitata* and *Bulbinella frutescens* were included in this formulation for their known antifungal and antimicrobial properties. The anti-staphylococcal effect of the *P. angolenses* extract was tested using the Kirky-Bauer disk diffusion method. For the MIC, 10%w/v of the *P. angolenses* extracts showed inhibition zone of 16mm for *S. aureus*. A cream was consequently formulated and its stability was evaluated using various methods including window ledge tests, accelerated stability tests and freeze-thaw tests. Acute skin irritation tests on rats were conducted and the cream was observed to be safe as no irritation and redness was observed. However, detailed further studies are underway to determine the efficacy of the formulation on both humans and animals.

# Physicochemical characterisation and essential fatty acid profiling of a fixed oil extracted from *Bridelia mollis* seeds

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*Bridelia mollis* bark, root, fruit and leaf extracts, decoctions, infusions and crude drugs are widely used in traditional medicine throughout Africa. However, no examination of physicochemical characteristics and essential fatty acids profile of the *Bridelia mollis* seed oil have been reported. *Bridelia mollis* seeds collected from the foot of a hill near Bikita Fashu Primary School in Bikita District in Zimbabwe were dried in an oven at 40°C, dehulled and pulverised using pestle and mortar. A fixed oil was extracted from the pulverised seeds using hexane as the extraction solvent. The total fixed oil yield of the seed dry mass was 7.10%. The fixed seed oil was subjected to physicochemical analyses to determine its acid and saponification values. Gas chromatography was used for essential fatty acids profiling of the extracted fixed seed oil. *Bridelia mollis* seed oil was found to contain 41,428% alpha-linolenic omega-3 essential fatty acid, 21,357% trans elaidic fatty acid,14,650% linoleic omega-6 essential fatty acid, 11,528% palmitic acid and 8,268% stearic acid which could be used as industrial ingredients in the manufacture of phytopharmaceuticals, nutraceuticals, personal hygiene products. Some fatty acids such as propionic and arachidonic acids have been shown to have antifungal activities against pathogenic fungi. Although fatty acids may not be as effective as chemical fungicides, they pose less environmental risks. They are not only biodegradable, but exhibit a high degree of specificity. These fatty acids are biodegradable and hence cannot pollute the environment if used to protect crops or animals. It is therefore necessary to screen African plant seed oils for antifungal activities as is the case with our next series of studies in this regard.

# Preliminary study on the extraction and antimicrobial activity of *Phytolaca dioica* seed oils

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Plant seed oils can be a source of fatty acids with antimicrobial activity and hence can be used to formulate pharmaceutical products targeting the treatment of skin diseases. In this study, the seeds of *Phytolacca dioica* were collected from in and around Harare, cleaned in the laboratory and dried in an oven at 40$^{o}$C to constant weight. They were then dehulled, pulverized, weighed and discharged in a bottle containing n-hexane for the extraction of the fatty acid. The oil was extracted until no further oil remained in the seeds. The hexane was driven off using the rotor vapour to remain with the pure oil. The percentage oil yield of *P. diioca* was 21.43%. The oil was tested for antibacterial activities. Bacterial species used were *Staphylococcus aureus* and *Staphylococcus pyogenes* .The Kirky-Bauer disc diffusion method was used for MIC tests. The values of the inhibition zones obtained for *P. dioica* were 3.5mm for *S. aureus*, 4.95mm for *S. pyogenes*. These results indicated that plant seed oil is effective against the selected bacteria and hence can be used in the formulation products to treat skin conditions caused by these organisms. However further studies are required for comprehensive antibacterial and antifungal activities as well as toxicity tests.

# Development and optimisation of veterinary antihelminthic treatments and pesticides incorporating the extracts if indigenous *Cissus quandrangularis*

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Helminths are parasitic 'worms' that affect up to 24% of the world human population and billions of livestock. Soil-transmitted helminths infections are attributed to various species of parasitic worms including *Ascaris lumbricoides* (roundworm), *Ancylostoma duodenale* (hookworm), *Necator americanus* (hookworm), and *Trichuris trichiura* (whipworm). Clinically, most of the initial infections are asymptomatic, and depended on the infection "worm population". However with larger infection population of the helminthes, pulmonary, intestinal discomfort, anemia chronic protein deficiency, blood loss, dysentery and rectal prolapse may all lead to organism death. The range of drugs indicated for veterinary and human use includes albendazole, mebendazole and praziquantel. New drug discovery has been very limited due to the lack of funding due to prevalence bias towards impoverished nations. This small range of drug options for both veterinary and human use has led to widespread drug resistance. *Cissus quadrangularis* a natural succulent plant, known locally as (Muvengahonye) has been used for aeons as a natural antihelminthic pesticide in its crude form. This research project sought to develop and optimise antihelminthic treatments and pesticides using *Cissus quadrangularis*. The research objectives included to extract active components of the plant and to evaluate the toxicity potential of the components leading to the formulation of: 1. antihelminthic veterinary oral dosage forms and 2. fodder pesticidal sprays. The stability and shelf life of the developed products were also evaluate. Stable cost effective and efficacious anti-helminthic treatments products were developed according to OECD, EU SCCNFP, WHO, RSS and Medicines Control Authority of Zimbabwe guidelines within the University of Zimbabwe School of Pharmacy which are ready for commercialization

# Antishistosomal Secondary Metabolites from *Tecla nobilis* and *Rapanea melanophloes*

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The helminthosis burden, in terms of prevalence, is equivalent to 50% of that of Malaria and 25% of that of HIV/AIDS with approximately 2.9 billion people being affected worldwide. Shistosomiasis, which is caused by the helminth *Shistosoma mansoni*, is one of the neglected tropical diseases and is a public health problem in sub-Saharan Africa. There is an estimated 200 million people living with shistosomiasis and most of them in Africa. One of the strategies in combating shistosomiasis is through the interruption of the life cycle by the control of snails, miracidia, cercaria and adult worms. This research study focused on the control of shistosomiasis by interruption of the life cycle at the miracidia stage using secondary metabolites from plants. The medicinal plants *Teclea nobilis* and *Rapanae melanophloes* are used in African traditional herbal medicine to treat helminthosis. Benzoic acid derivatives myrsonic acids B and C were isolated from *R. melanophloes* and evaluated for miracidicidal activity against *S. mansoni* miracidia. The myrsonic acid C was the most potent with an LC50 of 98.1 µg/ml. Furoquinoline alkaloids isolated from *T. nobilis* were also evaluated for miracidicidal activity but were not as active as the benzoic acid derivatives with the best LC50 value of 270 µg/ml for a mixture of tecleoxine, methylnkolbisine, and kokusaginine. This could be due to synergism between the compounds.

# Efficacy of *Terminalia sericea* (mususu) aqueous leaf extracts as an anthelmintic

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The development of gastrointestinal nematodes resistance to modern proprietary anthelmintics has made the search for alternatives to control of small ruminant helminths vital. Among these alternatives are several medicinal plants traditionally used as anthelmintics. This study was carried out to evaluate the possible anthelmintic effects of aqueous extracts of *Terminalia sericea* leaves. In a completely randomised design, 18 ewes were grouped according to egg count and randomly assigned to three treatments: *T. sericea* aqueous extract, albendazole (positive control) and distilled water (negative control). The anthelmintic efficacy of the leaf extract was evaluated through faecal egg count reduction (FECR). The maximum FECR recorded in sheep treated with *T. sericea* aqueous leaf extracts was 85% while it was 97% for those treated with albendazole (@ 7.5 mg/kg bodyweight) with averages of 41% and 74% respectively. The overall *T. sericea* FECR was less than 95% and therefore it is an ineffective anthelminthic in the preparations and forms that were used. Incidentally it was found that GI nematodes have developed resistance to albendazole. It is concluded that T. sericea leaf aqueous extract have some anthelmintic properties though it was less effective than the commercial product.

# Minimum inhibitory concentrations of methanol extracted Lantana camara plant material extracts for selected clinical bacterial isolates in Zimbabwe

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Despite the invasiveness and negative impact on range lands of *Lantana camara*, it can also have benefits to the communities. The plant has been found to possess antifungal, antibacterial, nematicidal, insecticidal, antioxidant and anti-tumour activities. However, these properties vary according to geographical areas, the presence other plants in the same family, the species of the *L. camara* and plant part. In the current study, we have evaluated the antimicrobial properties of *L. camara* obtained from different agro ecological regions in Zimbabwe, to determine if the plant can be of benefit to the local community. The antimicrobial properties of *L. camara* extract was evaluated by broth micro-dilution method whereby two-fold serial dilutions of a 40 mg/ml prepared stock solution of the methanol extract was carried out and the minimum inhibitory concentration (MIC) that inhibited a visible microbial growth were determined. Methanol extracts of plants from three different agro-ecological regions in Zimbabwe were tested on two gram positive and two gram negative bacteria. While the root and bark extracts showed little to no antimicrobial activity, the leaf extracts were more potent irrespective of the region. Therefore, we concluded that *L. camara* leaf methanol extracts have potent antimicrobial properties with no regional variation. Thus, the results suggested potential benefits for exploiting the ethnoveterinary medicinal properties of the plant, especially in the resource poor communities, where it is found in abundance in the management of septic and bacterial infections in livestock following further clinical trials.

# Symposium 5: Soil invertebrate pests, bio-fertilisers and biopesticides technologies

# S5 Plenary Speaker Potent nematicides of botanical origin

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With the ban of synthetic nematicides such as methyl bromide, organophosphates, and carbamates the need for developing new nematicidal compounds is growing. The repetitive use of the few available commercial nematicides and the subsequent increase of microbial biodegradation in soil, led to low efficacy on root knot nematode control. Thus, new and safe compounds with high nematicidal activity are needed as potential prototypes for synthesis of new nematicidal compounds by the industry. We considered different botanical extracts in terms of their nematicidal properties and mode of action. Moreover, we report an untargeted metabolomics study of tomato plants after root-knot nematode infestation.

# Ten years of pesticidal plant activities in southern and eastern Africa: Approaches, successes, challenges, gaps, lessons and the future

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Most adaptive research tends to lack involvement of technology end-users, with possible limited uptake of technologies or outright rejection by farmers and/or service providers. We report how a network of scientists in African universities and national agricultural research institutes worked together with advanced research institutes, rural communities and other stakeholders to generate and disseminate pesticidal plant research results, knowledge and skills at various levels through multidisciplinary collaboration. This diverse network has acquired unique knowledge and expertise in chemical-free agricultural pest management, which strengthened knowledge and practice about use of pesticidal plants for smallholder farming. The paper draws specific lessons and learning from progress made by researchers in Southern Africa working with stakeholders in the development of safer, effective and environmentally-benign options of managing stored-grain pests, cattle ticks and vegetable pests. The network held numerous workshops through which priority pesticidal plants were identified and some of which have since been tested and found effective. Through these learning platforms, the network has produced, shared and disseminated research and development ideas, protocols, results and skills. The quality of research has been raised considerably as evidenced by the number of published refereed papers, popular articles and conference proceedings and submitted project proposals. Since inception, research projects and several other synergistic associations have been forged, propagation materials collected, and techniques for propagation and conservation of botanical pesticides developed. We report practical experiences and strategies for co-learning and co-innovation among stakeholders in agricultural research and development and opportunities for increasing availability of safer food through capacity building and use of locally available pesticidal plants and knowledge.

# The effects of biochar – vermicompost mixes (biofertiliser) on crop productivity

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This study sought to establish the effect of biochar/vermin-compost application on growth and yield of maize, tomatoes and cabbages. Biochar application rate in pot plant experiments was at 3 to 4% of soil weight. Experimental pots were filled with the sieved soil. All the pots were watered to field capacity before sowing of seed. Biochar was mixed in various proportions to come up with treatments which were 100 % vermicompost, 50 /50 % biochar:vermicompost, 75/ 25 % biochar:vermicompost and 100 % biochar. The experiment was arranged as a completely randomized design and replicated three times. The study established that maize yield increased with increasing application of biochar from 25% to 50%. The biochar:vermicompost tomato trial showed no differences on growth rate and yield of tomatoes when biochar was applied at 50% compared to compost alone. In the cabbage trial under biochar:vermicompost application, comparable results in plant height, leaf numbers and final yield was obtained with 100% vermicompost application, 50% and 75% biochar inclusion. When biochar was applied at 100%, noticeable reduction in plant performance was noted. The study proved that biochar works in combination with other soil components in maize and cabbage production although the mixes did not influence tomato productivity. It is recommended to use biochar as a bio-fertiliser at 50 /50 % biochar: vermicompost in maize and cabbage production

# Seed treatment with extracts from False Daisy, *Eclipta alba* L. improves seedling emergence, vigour and yield of sorghum in Tanzania

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Trials were conducted at Sokoine University of Agriculture (SUA), Agricultural Research Institute (ARI) Ilonga, ARI Hombolo and in farmers fields in Dodoma and Singida regions, Tanzania from 2012 to 2014 to assess the effect of a 20 h aqueous extract (10% w/v) of false daisy, *Eclipta alba* L. on seedling emergence, growth and yield of sorghum. *Sorghum bicolor* L. var. Pato in central Tanzania. Experimental controls included seeds treated with sterile distilled water (negative control) and Apron star 42 WS (positive control). The results indicated that treatment of sorghum seeds with Apron star 42 WS had significantly ($p < 0.001$) higher number (81%) of emerged seedlings followed by that of *E. alba* (61%) and sterile distilled water (37%). Such results could imply that, *E. alba* possess antimicrobial properties against seed-borne and or soil-borne pathogens. Experiments involving testing effects of *E. alba* concentrations and extraction periods and on seed-borne and soil-borne microbes are going on and are promising. It also seems promising that sorghum seeds treated with *E. alba* at lower concentrations and reduced extraction periods result in increased seed germination, vigorous plants and consequently higher sorghum yields compared to those originating from water treatment only.

# Integrating microbial-based fertiliser into nutrient management systems for sustainable agricultural productivity

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The development and use of microbial-based fertilisers has gained significance in sustainable agricultural productivity and particularly in the effort of reducing the negative environmental effects from excessive and or improper application of chemical fertilisers. Bio-fertiliser super grow is a cock-tail of co-existing beneficial micro-organisms mainly species of *Bacillu*s spp, *Pseudomonas* spp, *Rhizobium* spp, *Trichoderma* spp, azotobacteria and *Azospirillum* spp.) which enhances crop growth and yield by mobilising nutrients making them available for plant uptake, producing bioactive substances, controlling soil diseases and accelerating decomposition of organic materials in soil. We assessed efficacy of biofertiliser super grow in improving growth parameters (number of leaves and plant height) and yield attributes (head weight, diameter, length and girth) of cabbage crop. A fundamental objective was to determine the effectiveness of super grow in reducing the fertiliser nitrogen requirements of the crop without affecting productivity. The soil used was classified as Fersiallitic (5G) or Haplic Lixisol (FAO) derived from granite and commonly cultivated by smallholders. There were five treatments, with 3 replicates. These were: (i) control (without fertiliser), (ii) super-grow as a sole treatment, (iii) super grow plus ½ rate chemical fertiliser (iv) super grow plus full rate chemical fertiliser (v) chemical fertiliser (conventional rate). The experimental design was completely randomized. The results suggest a significant difference in the effectiveness of bio-fertiliser and chemical fertiliser for the growth traits. Synergetic effects of super grow bio-fertilizer and ½ dose of recommended chemical fertiliser significantly resulted in increasing number of leaves, plant height, and consequently yield attributes. A cost benefit analysis suggest high investment returns with bio-fertiliser super grow. This implies that bio-fertiliser super grow could allow obtaining a crop production similar to that obtained with mineral fertiliser but with significant reduction of their use at a relatively low cost. We conclude that bio-fertiliser super grow can play a key role to develop an integrated nutrient management system, sustaining agricultural productivity with low environmental impact.

# Symposium 6: Propagation and conservation

# S6 Plenary Speaker Research and development of pesticidal herbal plant products in Zimbabwe: a pharmaceutical perspective

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Zimbabwe has an active herbal traditional practice with over 500 medicinal plants. Many indigenous aromatic plant species in the families Apiaceae, Asteraceae Compositae, Gramineae, Lamiaceae, Rutaceae and Verbenaceae have medicinal and pesticidal activities and some of their chemical constituents and potential medicinal uses have been reported. The No-arm in choice method for 20% essential oil extracts gave insect repellency against *Aedes aegypti* mosquitoes ranging from 23.8-92.1% for *L. javanica, C. validus, L. viridis, O. urticifolia*, and *E. muticus* respectively against 10% DEET control. Lethality ($LC_{99}$ to *Rhipicephalus appendiculatus* tick larvae in the larval packet test for essential oil solutions in trilene was 0.0pph for *L. viridis*, 72.0pph for *C. validus* and 85.0pph for a chemotype of *L. javanica*. Acetone solutions of *Cleome gynandra* (500µg/ml), and essential oil solutions in DMSO *L. javanica* and *L. viridis* (1000µg/ml) and *C. validus* (2000µg/ml) had ovicidal effect against sheep nematoidal eggs developing into L3 larval stages. A trial D gel formula containing *C. winterianus*, *L. viridis* and *M. alternifolia* showed similar repellent result with a 20% DEET lotion for 4h. Aqueous extracts of *Albizia amara* and *O. urticifolia* displayed hypertensive properties on Sprangue Dawley rats with the latter fatal to them at above 75mg/kg body weight, a potential rodenticide? Studies on selected non-aromatic indigenous plants such as *Elephantorrhiza goetzei, Flacourtica indica, Gymnosporia senegalensis, Khaya anthotheca, Kigelia africana, Sclerocaryia birrea* and *Terminalia sericea* indicated antihelmintic and antiparasitic properties. Their plant extracts displayed lethal toxicity in the BLST test showed $LC_{50}$ = 66.66-1112.37 µg/ml, were cytotoxic to the HSV-2 but may have low therapeutic indices. Their EPPT ($RF_s \geq 10^3$) make them potential antiviral plants. There is active research in medicinal and pesticidal plants in Zimbabwe for both aromatic and non-aromatic plants. The issue of IPR and IKS has to be addressed for sustainable plant material supply, product marketing, benefit-sharing and conflict resolution. The paper will present ongoing research and its implications for the research and development of pesticidal botanicals.

# Multiple ecosystems services derived from pesticidal plants in field margins

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While much research explores the chemical and insecticidal properties of pesticidal plants, it is easy to overlook other beneficial properties of some pesticidal plant species. Sustainable eco-intensification of agriculture depends upon floristic diversity underpinning invertebrate biodiversity, delivering essential ecosystems services such as pollination and pest regulation. Many established and prospective pesticidal plant species, e.g. *Tephrosia vogelii*, *Tithonia diversifolia*, *Ageratum conyzoides,* are good sources of nectar and pollen when they are in flower. Consequently, they can provide valuable resources of food and shelter to a diversity of beneficial insect groups, including pollinators (e.g. bees), parasitoids (e.g. Braconid wasps) and predators. Ongoing research in Tanzania is exploring the value of cultivating pesticidal plants in bean field margins for the delivery of multiple ecosystems services, by supporting populations of pollinators and natural enemies in addition to being a source of botanical insecticides if needed by the farmer. Insect and plant surveys of the crop and field margin were carried out over a field bean cultivation season. These revealed relationships between plant and beneficial insect diversity and a wide range of insect groups present in fields with field margins containing pesticidal plant species. Some plants, especially *A. conyzoides* and *Bidens pilosa*, which possess some pesticidal properties, also proved to be key species in the fields' pollination networks, being especially valuable in supporting the major pollinators of beans. These plants are especially crucial as nectar sources outside the crop's own flowering season. We suggest that encouraging farmers to grow pesticidal plants in field margins may deliver other benefits to the crop which should be measured and promoted.

# Commercial cultivation of *Melia volkensii*: A case study of a timber and pesticidal plant in the dryland of Makueni County, Kenya

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Makueni Ginneries is situated within the drylands of southern east lowlands of Kenya in Makueni County. The Ginneries has ginned cotton for the last 16 years and recently acquired a farm at Nzouni village facilitating diversification from ginning to planting of *Melia volkensii* (Mukau), a multi-purpose plant species. Wood from the species is resistant to insect infestation and is highly valued for timber, carvings while seeds have also a great potential for pesticide production. Notwithstanding, the plant is difficult to propagate on-farm since the seeds are oily and do not take up water readily posing challenges to seed handlers. Through a partnership approach with the National Museums of Kenya (NMK), under the Optimising Pesticidal Plants: Technology. Innovation, Outreach and Networks (OPTIONs) project, quality seedlings were procured from the Kenya Forestry Research Institute, Kibwezi. Compliance with operational forestry tree planting guidelines was ensured by collaborating with the Kenya Forestry Service and NMK OPTIONs experts with respect to plant density, land harrowing, general plant husbandry and mitigating biodiversity conservation. To-date, 20 ha have been planted with an estimated 5,000 *M. volkensii*, planted predominantly using local labour therefore offering the farm as a field school for the local community. The local communities including the youth have also been trained and offered seedlings for planting by NMK OPTIONs project through outreach tailored as a farmer exchange programme. Staff from the Ginneries also participated in the National workshop organised by the NMK and University of Greenwich in Nairobi on how to use plants as pesticides. Currently, the farm accepts visitors and stakeholders from many parts of Kenya willing to learn about the potential use of *M. volkensii* as a pesticide plant and/or timber. This season, we are currently expanding the area planted to 36 ha to attract commercial scale investment on *Melia volkensii*. This presentation shares challenges encountered in commercial tree planting processes and future opportunities.

# The OPTIONs Project in Kenya - Propagation and outreach of pesticidal plants in Kenya

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The Optimising Pesticidal Plants: Technology. Innovation, Outreach and Networks (OPTIONs) project is involved in the propagation of pesticidal plant species; *Securidaca longepedunculata*, *Zanha africana* and *Strychnos spinosa* which are widely distributed in Kenya. Different types of media were selected and used in partnership with local communities. For the three species, fruits containing seeds were collected at maturity. Seed germination as a method of propagation for the three species was executed using 1% water agar under laboratory conditions and on-farm, in sand. Findings of this study suggest that sand enclosed in a non-mist propagator is a widely common medium ideal either for on-farm or on-station propagation for the three species. Results recorded have been disseminated through outreach networks such as the Kenya broadcasting TV news, the standard newspaper, the people's daily, posters and leaflets. This was in addition to on-farm outreach through local workshops, demonstration plots and field visits. The successes and challenges of this outreach is reported in this presentation.

# Seed development and germination of a pesticidal plant *Securidaca longepedunculata*

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*Securidaca longepedunculata* in the family Polygalaceae is a medium sized shrub or small tree widely distributed in tropical Africa. The roots, bark and leaves of the plant are used as a plant derived pesticide by local communities for post-harvest grain preservation. This has resulted to the species declining in the wild since successful propagation protocols for the species are poorly known and / or not customized. This study therefore investigated parameters of seed development with potential use as tools for marking optimum seed maturity in-situ. Bulk seed quantities were collected at specific seed development intervals and assessed for moisture content, fresh weight, weight of water, dry weight and germination. Concomitantly, single trees were marked in the wild and the same parameters quantified over the same intervals to the point of natural seed dispersal. Of the different seed development parameters monitored, moisture content and maximum dry weight were absolute markers for maximum seed maturity especially at the third and fourth harvests. Evidence submitted here suggests that *S. longepedunculata* seeds should be collected at the point of natural dispersal precisely when moisture content is as low as 30% and dry weight at maximum levels. When propagating the species using seeds, a porous media preferably vermiculite should be used at room temperature. A range of recommendations useful to seed conservationists, farmers, foresters and land use managers are outlined.

# Biotrade's contribution towards socio-economic development and biodiversity conservation

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PhytoTrade Africa is a trade association with the aim of facilitating the development of an enduring and equitable natural products industry based on resources accessible to rural communities in southern Africa. It acts as a representative body for more than 60 small to medium-sized enterprises (SMEs) who works closely with smallholder farmers for the promotion and export distribution of several ingredients and consumer products derived from plant species native to southern Africa. Land degradation on scarce agricultural lands, unreliable rainfall and frequent droughts seem to suggest that agriculture alone may be unsustainable, thus alternatives such as biotrade are needed. In an effort to conserve biodiversity, this research builds on enquiries made over the past decade on the impact of biotrade on conservation and socio-economic development at community, national and regional levels. Impact of biotrade on conservation of biodiversity is surrounded by certain challenges. These include among others, a lack of scientific data on the impacts of resource use and on the status of biological resources. This paper will focus on comprehensive assessment of impact of biotrade on socioeconomic development and biodiversity conservation and draw on experiences from several studies conducted across southern Africa. The research focuses on plant-derived natural products being traded as ingredients into thousands of global products including cosmetics, foodstuffs and pharmaceuticals. Species under review will include Mongongo/Manketti (*Schinziophyton rautanenii*); Mafura (*Trichilia emetic*); Sour plum (*Ximenia* spp.); Marula (*Sclerocarya birrea);* Baobab (*Adansonia digitata*); African Sausage Tree (*Kigelia africana*); Devil's Claw (*Harpagophytum procumbens*) Kombe (*Strophanthus kombe*) ; and Kalahari melon (*Citrullus lanatus*).

# An analysis of the conditions that favour the germination of the seeds of two invasive goldenrods; *Solidago canadensis* and *Solidago gigantea*

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Invasive species have shown the ability to overcome biotic and abiotic barriers. They have established, occupied, proliferated and dispersed in environments depending on habitat invasibility. The Biodiversity Target aimed to stop or significantly reduce the rate of decline in biodiversity by the end of the year 2010. The aim of this study was therefore to determine some conditions that favour the germination of invasive *Solidago canadensis* and *Solidago gigantea* seeds. Seeds of these species were germinated in media with different pH values, in varying densities and in different plant extract solutions. Results were collected after one week and experiments were observed for a further three weeks in which no further changes occurred. These experiments were repeated over a period of 6 months in a controlled greenhouse environment. Solidago seeds had over 50% mean germination percentage rates between pH 4 and 9 and 0% outside that range. Over 50% mean germination percentages were also achieved in each density from five to twenty five seeds per 5 $cm^2$ petri dish in distilled water. Echinochloa crus-galli extract media solution had no significant effect on germination of Solidago seeds. *Convallaria majalis* and *Juglans nigra* extract media solutions exhibited some allelopathy, they negatively reduced mean germination percentages of the Solidago seeds. A basic foundation for controlling the spread of these invasive weeds from seed dispersal therefore now exists.

# Symposium 7: Commercialization, policy and sustainability

# S7 Plenary Speaker Botanical insecticides: a perspective on regulations in Europe, commercial products in Spain and research worldwide

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The Regulation 1107/2009 of the European Parliament and of the Council concerning the placing of plant protection products (PPP) on the market and the implementing Regulation 540/2011 as regards the list of approved active substances and basic substances (under article 23) establish a framework that has to be taken into account during development of commercial botanical insecticides. In addition, the organic sector has its own list of authorised (Regulation EC 834/2007) PPP of plant origin. In spite of the strict legislation, there are good prospects in this field because of the decreasing number of agrochemicals available, the increasing insecticide resistance in pests, and the evidence that biological control is not enough as an alternative. The push from consumers towards organic and zero residue foods is achieving the placing of pesticidal plant-based PPP on the market. A review of published literature concerning natural insecticides in the Journal "Industrial Crops and Products" will be presented as an example of active research in: potential pesticidal plant species, target pests, extraction and chemical technologies, identification of compounds etc. It is expected that papers presented at the Second International Conference on Pesticidal Plants during 6-9 of February 2017 in Zimbabwe, will contribute to advances in cultivation and application technologies and in dissemination of studies showing the ecosystem services provided particularly in Africa and for smallholder family systems.

# Genetic fingerprinting, a regulatory tool for genetic conservation in BioTrade

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BioTrade involves the collection or production, transformation and commercialization of goods and services derived from native biodiversity in a way that advances social, economic and economic sustainability. BioTrade is also premised on conservation; sustainable use; fair and equitable benefit-sharing; social-economic sustainability; and legal compliance. BioTrade activities have the potential to benefit all value chain actors within the natural resources sector and can create employment through commercialization of genetic resources. In accordance with the Convention on Biological Diversity, equitable benefit sharing of genetic resources should be done based on sustainable use of biodiversity ensuring the protection of genetic germplasm. Rights to access of biological resources is key for any economy in order to trigger long-term investments and for the implementation of sustainable resource management measures. In particular, the access to biological and genetic resources should be subject to conservation and prior informed consent. The consent of all relevant authorities in the country of origin should be obtained prior to the use of the genetic resource. In line with the BioTrade concept, there is a need to setup a genetic fingerprinting database which will serve as a receptacle of a country's plant genetic information which aids in the proper trade of biological materials such as cells, tissues or whole organisms. Genetic finger printing will act as a means of ascertaining the origin and nature of specific biological materials. It will enable countries to track and get royalties emanating from BioTrade of genetic resources. It is therefore imperative for a country like Zimbabwe, endowed with rich biological diversity to develop a biodiversity genetic finger database.

# Outreach issues and strategies in promoting the use of pesticidal plants to smallholder farmers

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What is outreach? What is effective outreach? How can effective outreach be best measured? These issues will be considered in this discussion paper, where the aim is to provide suggestions relevant to future project planning. The paper is based mainly on field observations in Kenya, noted since 2014 during implementation of the Optimising Pesticidal Plants: Technology, Innovation, Outreach and Networks (OPTIONs) project. Outreach involves learning and change, and effective learning requires a lasting change in attitude and/or behaviour of the recipient. How can that learning be confirmed within a project? The number of farmer beneficiaries trained, and the number of pesticidal plants grown and used seem the best criteria for validating that change. During OPTIONs implementation, various outreach strategies and farmer incentives have been used. Each of these has advantages and limitations with reference to their contribution to the initial OPTIONs target of 4,000 participating farmers growing 40,000 pesticidal plants. Sustainable Global Gardens experience is that practical-based training, ready availability of seeds, strong communication links, regular monitoring visits, financial incentives, and above all else real commercial opportunities provide the most fruitful conditions for effective outreach.

# The OPTIONs story in Kenya: The identification and use of pesticidal plants, successes and challenges

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A number of plants have been recognised to have potential in pesticide production against crops pests. Correct identification of the right species is a priority towards a successful pesticide production and pest control. The National Museums of Kenya with over 4.5 million biological collections of plants and insects, preserved at the East African herbarium and Invertebrate Zoology respectively, has been pivotal in identification, collection, propagation and building capacity on pesticidal plants and pests for the OPTIONs project. The tools for species identification, diversity of local species used and pests, resource mapping and conservation awareness, as well as success and challenges by farmers are demonstrated.

# Regulatory challenges and opportunities for wide scale production and use botanical pesticides in sub-Saharan Africa

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Conventional pesticides are a key technological innovation for enhancing agricultural production and ultimately food security. Pests are known to result in losses 20% of potential food during pre and post-harvesting periods. However, inspite of their importance there are campaigns against their use as they are associated with numerous environmental and health risks. This has called for the development and promotion of eco-friendly technologies such as the pesticidal plant products. Unfortunately, these are not always readily available as their production, distribution and use is beset with challenges. The industry in SSA is still under developed and does not have adequate enabling legal framework in most countries. In fact, the legal framework in most SSA countries is the major constraint to the development of this subsector. For instance, the registration of pesticides is dependent on rigorous research to provide various site pre-requisite information including efficacy, human safety, toxicity, persistence and shelf life. The costs associated with the generation of this information remains yet another major constraint. Multinational companies in SSA are still skeptical to engage and or invest in the production and distribution of these pesticidal plant products. This paper is a review of progress made in instituting regulatory mechanisms for production and use of botanical pesticides in selected SSA countries. There are indications that significant progress has been made in some countries like Kenya and Tanzania in the last decade. One of the key interventions has been the enacting of specific procedures and guidelines for registration and trade in bio pesticide. This has allowed small to medium enterprises to participate in the development, production and distribution of botanical pesticides. Therefore the development of this subsector in SSA is contingent on having enabling regulatory mechanisms and investments in rigorous research. This will usher a new era of formalized wide scale production and use of botanical pesticides.

# Empirical evidence and scientific support - missing links in organic food value chain

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Worldwide, the organic market share has been increasing at a rate of 20 % per annum and the increase in demand has also been recorded in Zimbabwe as people become health-conscious. Producers are unable to take advantage of the growing demand because of inadequate quantities, good quality and consistency of the product on the market. A value chain analysis of the Zimbabwe organic sector explored by Zimbabwe Organic Producers and Promoters Association unearthed underlying causes of the challenges that the sector is facing. Value chain analyses involved about 80 organic stakeholders including academics, researchers, farmers, support service providers, extension services, and policy makers. The analyses were conducted in a series of discussions that lasted six months. Chief among the underlying causes to the challenges were: lack of empirical evidence to convince policy makers and business to support organic agriculture development; lack of readily available inputs for soil fertility management and pest and disease management; lack of readily available and usable pest and disease management packages; lack of appropriate extension support for organic agriculture production; educational curricula devoid of organic agriculture aspects. It therefore became very apparent that farmers need adequate information on options for soil fertility management and pest and disease control, with clearly spelt out dosages and application rates. Knowledgeable extension staff are required to provide technical support in organic farming. Scientific evidence is required if the Zimbabwean organic sector is to continue growing. Biopesticides can only be fully used in organic agriculture if science is embraced as a missing link in the development of this sector. Researchers work with farmers and other value chain actors to identify problems along the chain and translate research into information usable by all actors.

# Pesticide legislation in Zimbabwe: Implication for pesticidal plants registration

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Pesticides use in Zimbabwe is governed by the Fertilizers, Farm Feeds and Remedies Act (18:12) of 1996 and Pesticide Regulations cited as Statutory Instrument 144 of 2012. The legislation applies to all pesticides used for crop protection, public health and wood preservative regardless of whether they are chemical or biological in origin. Its covers pesticide registration, imports, exports, distribution, disposal, advertising and pest control services. Requirements for registration includes' efficacy trial data, evidence of registration from country of origin, active ingredient analysis, draft Zimbabwean label, application for registration form, letter of authorisation from source of pesticide, safety data sheet. The registration is valid for three years and costs 300 US dollars. In Zimbabwe currently the Botanical Pesticides registered for use are Neem Oil (a derivative of *Azadirachcta indica)* and Pyrethrum. The legislation in Zimbabwe fully supports commercialisation of pesticidal plant derivative as long as the application meets the criteria laid down in the responsible acts of parliament. One of the major challenges when using Pesticidal plant based formulations is achieving the correct ratio between ingredients as well as correct dosage when used. This is major stumbling block when it comes to local commercialisation and subsequent registration of Pesticidal plant. The government is aware that many farmers would like to use natural pesticides since they are concerned about the health hazards of chemical pesticides.

# Potential business models for up-scaling natural products from pesticidal plants in southern Africa

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Over the past few years, several research efforts have been undertaken to inform the potential of pesticidal plants to protect crops and enhance production in small scale agricultural production. This research theme has a strong focus on the broader use of biodiversity by rural communities, and links to agriculture, livelihoods and poverty alleviation. The results of such research efforts offer interesting inroads to experimenting and up-scaling of natural pesticidal products through technology transfer and product innovation by linking communities to the sophisticated bio-trade industries. However such concepts are not easy and as smooth as they seem, inherent inequalities in value chains, weak consideration of social justice concerns, and poor recognition of traditional knowledge holders and custodians of biodiversity resources often underpin linkages between industry and biodiversity use. Approaches to reduce inequality in value chains that help address these injustices are emerging through requirements for benefit-sharing agreements, market demand for ethically traded products, and improved organisation and entrepreneurship among rural producers, but there remain significant knowledge and conceptual gaps preventing effective implementation. This presentation thus will assess a few cases and business models that have worked and not worked, whilst unpacking the complexities of indigenous plants, the communities that use them, and the paths they travel as indigenous knowledge, identities and how resources get transformed into finished products for the domestic and global consumer market. The research also aims to build capacity and awareness about approaches to trade in plant based pesticidal products that enable producer communities and agro-biodiversity-rich countries to receive a fairer deal that protects and enhances agricultural productivity; alleviates poverty; improves environmental sustainability and triggers industrial growth through product innovation and trade.

# Enhancing pyrethrum productivity for higher incomes through research

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The growing Demand of organic and natural pesticides has increased international demand for pyrethrum. Pyrethrum is one of the major cash crops in Kenya grown in the former white highlands. It grows well in the cold areas with high rainfall and altitude above 1700m ASL. Kenya has been the highest producer of pyrethrum because of its favorable climate and other factors such as availability of cheap human labour. It is actually the custodian of the world standards of pyrethrum. Pyrethrum contains pyrethrins which is an active ingredient in formulation of a natural insecticide. Superior quality is because the following properties, repellent to insects at very low concentrations, a property used in the protection of stored products ,bio-degradable ,non-pollutant , rapidly degraded by sunlight into harmless by-products , minimal insect resistance to pyrethrins is documented, broad spectrum of activity, effective against a wide range of insect pests , mosquitoes , cockroaches, fleas , aphids,etc.. It is one of the safest insecticides known flushing action. Pyrethrum has greater flushing power than any other commercial insecticide. Fast action against insects, it has a very rapid paralytic action knocking the pests down followed by kill. Pyrethrum by product, py-marc are used for animal feed and has high nutritional value. Potency of Py- Marc in control of internal parasites is documented. Further value additions on the primary technical products can result in the end use products usually with higher profit margins in business. Currently the Pyrethrum Board Of Kenya (Main Processor) makes six value added products formulated with Pyrethrum and registered in Kenya, Tanzania, Democratic Republic of Congo, and Sudan. These products targets pests/vectors in key sectors eg. agriculture (horticulture), public health and animal health. More than 90% of pyrethrum is produced by the small-scale farmers who always have no option but continually have pyrethrum throughout the year. More research is needed

# Are plant pesticides safe for the four Hs?

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Lilongwe University of Agriculture and Natural Resources, Department of Crop and Soil Sciences, Bunda Campus, P.O. box 219, Lilongwe, Malawi. Use of plant extracts as remedial measure against insect pests and diseases of people, plants, animals and households is increasing in many parts of the world. Many consumers in developed countries are becoming more careful to avoid the deleterious effects of synthetic pesticides and hence preference for organically produced food products is increasing. Plant pesticides are considered a natural way of controlling pests. Smallholder farmers in developing countries turn to pesticidal plants for pest control because they are readily available and considered safe to use. A review of work on different plant species that are used as pesticides was made to investigate safety of the plant pesticides for human health, plant health, animal health and environmental health (four Hs). Scientific papers and reports of interest were those reporting remedial abilities, toxicology and degradation of the plant pesticides. Efficacy of some plant pesticides and their potential dangers are highlighted. The mode of action and form of toxic substance are discussed. For example, extracts of *Strychnos spinosa* fruits and *Vernonia armygdalina* are efficient plant pesticides in killing certain pests and/ or healing certain human/ animal diseases but have been reported to have mammalian toxicity at high concentrations. They are therefore potentially very harmful to humans.

# Posters Presentations

# Exploitation of selected plant-based insecticides for field control of aphids in organic cabbage production

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Large colonies of cabbage aphids are capable of stunting and or killing small plants. They are also capable of contaminating the harvested crop. Every farmer desires to increase yield and quality of their produce. To achieve this, many farmers have resorted to adopting a range of techniques including the use of synthetic insecticides; which are restricted in organic farming. In recent years, concerns have been raised about the hazardous impact of many synthetic insecticides. The use of biodegradable botanicals is now considered by many to be one of the best alternatives. Botanicals are also believed to be safer and ecologically-friendly. The current study was conducted to evaluate the effect of three plant based extracts and their mixtures for their efficiency in the control of aphids in a cabbage field. Extracts from *Azadirachta indica*, *Chrysanthemum* and *Quassia amara*, were compared to a positive and a negative control. Two experiments were carried out in a planting season; one in early part and another in the later part of the season. Four weekly application of the extracts was carried out in each of the experiments. Number of plants infested with aphids, and number of aphids per plant was determined before and after each treatment application. All extracts and their mixtures decreased aphid population on the experimental field. A decrease in population of 60-100% and 70-100% was recorded for both number of aphid per plant and plants infested with aphids, respectively; in the first two treatments and in both experiments. A statistically significant effect was also produced within treatments, the concentrations and the treatment application number, in both the first and second experiment numbers for number of plants infested with aphids and aphid population per plant.

# Laboratory screening of plant extracts for insecticidal properties against *Antestiopsis orbitalis* Bechuana

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Several laboratory experiments were carried out to screen different plant extracts: *Capsicum annum L.; Euphorbia antiquorum L.; Nicotiana tobacum; Tagetes* spp.*; Annona senegalensis, Datura stramonium; Azadirachta indica, Melia azaderach* and *Jatropha curcas* oils for efficacy against Antestia bugs *(Antesitiopsis orbitalis* Bechuana*)* at Coffee Research Institute, Chipinge, Zimbabwe between 1990 and 2016. Aqueous leaf and seed extracts of *A. senegalensis* and oils of *A. indica* and *J. curcas* were prepared and diluted into concentrations of 100%, 50%, 25% and 12.5%. Thunder (Imidacloprid + beta cyfluthrin) at 20ml/100 litres water and distilled water were used as the positive and negative controls, respectively. The experiments were laid out in a Randomized Complete Block Design with 6 treatments replicated 3 times. The number of dead Antestia bugs was recorded 24h, 48h, 72h and 96h after treatment application. Different plant extract concentrations gave significant *($p<0.05$)* to highly significant *($p<.001$)* differences in Antestia bug mortality. Neat (100%) concentrations of *N. tobacum, C. annum, E. antiquorum, A. indica, A. senegalensis* showed great potential at controlling Antestia bugs under laboratory conditions with 100% mortality for some neat extracts. Some neat extracts gave comparable efficacy to the standard chemical which were significantly different from those of lower concentrations and the control. Efficacy increased with increased extract concentration for most of the botanicals. However, more work still needs to be done to evaluate the plant extracts under greenhouse and field conditions, to determine active ingredients and mode of action for potential extracts and food safety for conclusive results. For extracts that have shown potential, there will be need to develop new sustainable pesticides and incorporation of effective plant extracts into Integrated Pest Management programmes.

# Acaracidal effect of foam soap containing essential oil of *Ocimum gratissimum* leaves on *Rhipicephalus lunulatus* in the western highlands of Cameroon

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Acaricidal effect of foam soap containing essential oil of *Ocimum gratissimum* leaves was tested on *Rhipicephalus lunulatus* in the western highlands of Cameroon. Five doses of essential oil (0.00; 0.04; 0.06; 0.08; 0.10 µl/g) with four replications for each dose were tested in vitro. Each replication consisted of 10 ticks in Petri dish with filter paper impregnated uniformly with the foam soap on the bottom. Four of those doses (0.00; 0.06; 0.08; 0.10 µl/g) in three replications were used in vivo. In this case, each replication was made up of 10 naturally ticks infested goats. Results of this study indicated that foam soap containing essential oil of O*. gratissimum* leaves is toxic to *R. lunulatus*. The in vitro mortality rate was observed to vary from 0 to 30% during the treatment with the controls as compared to 80% with the lowest dose (0.04 µl/g) on day 8 and 100% with the highest dose on day 6. Meanwhile, the in vivo mortality rate was observed to be 22.7% with control on day 8 after treatment whereas the highest dose killed 93.9% of the ticks by this day 8. The $LD_{50}$ of the foam soap containing essential oil was 0.061 µl/g for in vitro and 0.066 µl/g for in vivo on day 2. This indicates that this medicated soap is potentially highly efficient on this ecto-parasite.

# Analysis of phenolic compounds in *Carica papaya*, *Zingiber officinale*, *Ipomoea batatas* and *Myrothamnus flabellifolius* and evaluation of antifungal activity on plant pathogenic fungi

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*Botrytis cinerea*, *Rhizoctonia solani*, *Macrophomina phaseolina* and *Alternaria alternata* are polyphagous fungi of economic importance with severe yield and quality losses worldwide. The antifungal activity of plant phenolic extracts: *Carica papaya* leaves and bark; *Zingiber officinale* rhizomes; *Myrothamnus flabellifolius* above ground parts; and *Ipomoea batatas* leaves were investigated against the plant pathogenic fungi. Qualitative and quantitative analyses of extracts were done through Reversed-Phase High Performance Liquid Chromatograph, Ultraviolet-Visible light Diode Array Detector (RP-HPLC-UV/VIS-DAD) analyses. In antifungal *in vitro* assays, Potato Glucose Agar (PGA) in petri dishes was incorporated with three concentrations (250 ppm, 500 ppm and 1000 ppm) of sample plant phenolic compounds and active ingredients of fungicides (as positive control); the negative controls were incorporated with diluent used to reconstitute plant phenolic compounds. Antifungal *in vitro* assays, plant phenolic extract and extract concentrations interacted significantly (all $\rho < 0.05$) at all the time intervals for all the species except for *B. cinerea* 96 h interval where only the plant phenolic extract were significant ($\rho < 0.05$). Percentage mycelial reduction (PMR) varied amongst phenolic extracts and phytopathogenic fungi. Generally, the phenolic extracts showed less antifungal activity compared to the positive control treatments (fungicides). *Carica papaya* bark and *Z. officinale* rhizomes showed the highest PMR against *M. phaseolina* ($30\% \leq PMR \leq 40\%$) at the 1000 ppm concentration. *Zingiber officinale* showed the highest PMR ($45.3\% \leq PMR \leq 54.7\%$) for all the concentrations on *A. alternata*. *Myrothamnus flabellifolius* showed the highest PMR ($26.5\% \leq PMR \leq 53.9\%$) for all the three concentrations on *R. solani*. Only *M. flabellifolius* had limited PMR of 0-5.9%, whilst other plant phenolic extracts showed a 0% PMR against *B. cinerea*. The result of PMRs shows that plant phenolic extracts have potential use *in vivo* as crop protectants. However, further research may consider reduced fungicide dosages by using both synthetic and plant phenolic extract as mixtures.

# Mycorrhiza consortia suppress the fusarium root rot (*Fusarium solani* f. sp. Phaseoli) in common bean (*Phaseolus vulgaris* L.)

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The ability of arbuscular mycorrhizal fungi (AMF) to alleviate the lethal effects inflicted by root pathogens in a range of plant hosts has been demonstrated. Available evidence suggests that multiple rather than single AMF species could exhibit greater potential against pathogens and could mimic natural systems. In the present study, four AMF formulations, made up of three strains each (1:1:1 w/w) from propagated units of selected AMF strains, *Glomus intraradices*, *Glomus hoi*, *Gigaspora margarita*, and *Scutellospora gigantea* were evaluated in enhancing growth and suppression of Fusarium root rot (FRR) in common bean (*Phaseolus vulgaris* L.) under greenhouse conditions. The results revealed that all the mycorrhizal preparations significantly reduced the levels of disease incidence and severity in infected plants, the biocontrol level being a function of AMF genera diversity with AMF2 (*Glomus hoi*, Gig*aspora margarita*, and *Scutellospora gigantea*) exerting the best effect. Though, either neutral or significantly increased growth parameters were recorded upon mycorrhization. The rhyzospheric competence (root colonization and spore density) of the mycorrhizal formulations was negatively affected upon *Fusarium solani* inoculation. The comparative analysis of the HPLC profiles of seedling ethanol extracts treated with the promising consortium (AMF2) and infected with *F. solani* and non-treated showed significant metabolic changes, evidenced by the appearance of three new compounds in the AMF-treated extract compared to the non-treated one. The changes were further supported by the triggered biosynthesis of soluble phenols, flavonoids and the specific activity of Phenylalanine Ammonia Lyase (PAL) after mycorrhizal colonization, indicating the strengthening of plant immune system against the pathogen. Further studies should confirm our formulations after open field assays as alternatives to agricultural pesticides.

# Diversity of pesticidal and veterinary plant species in five districts of Zimbabwe

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An assessment on species diversity of useful plants (pesticidal and veterinary) was done in five districts within eight vegetation types. From the total species recorded in all the areas assessed, 21.9% were useful that include 68 species representing 58 genera and 35 families. The assessment was done in miombo, disturbed miombo, Andristachys, mopane, disturbed mopane, Acacia, Terminalia-Combretum and *Baikiaea plurijuga* woodlands. The family representation of useful plants as compared to all the species recorded in each vegetation community was quite high having ≥45% representation apart from Acacia woodland with10% (Lupane district), Androstachys woodland with 14.29% (Chiredzi district), *Baikiaea plurijuga* woodland (Lupane district) had 20% and mopane and disturbed mopane woodlands had 35.7% family representation. Species richness of useful plants was only high in both miombo (Mutasa district) and disturbed miombo woodlands (Shurugwi distrist) as compared to the other vegetation types assessed. The species recorded were all indigenous. Mopane woodland had the least species diversity due to dominance by *Colophospermum mopane* tree and often forms pure stands to the exclusion of other species. Few useful species were concentrated in the mopane woodland such as *Maerua edulis*, *Cissus quandrangularis* and mopane itself. Androstachys woodland was recorded on rocky outcrops and hillsides in deciduous woodland where *Androstachys johnsonii* formed dense stands. Due to variation in the relative density of useful plant species as compared to the rest of the species in each vegetation community, Mopane woodland had the highest relative species density because of the dominance made by mopane tree. Disturbed miombo woodland recorded a higher relative density than miombo woodland as other species occupied open niches created by disturbances within the vegetation community. Both in-situ and ex-situ conservation of useful plant species is therefore important.

# Pesticides adoption: Implications on agricultural land use in Zimbabwe's smallholder farming sector

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Abandoning of agricultural land in Zimbabwe's communal areas is on the increase against a backdrop of agricultural land shortages. Among the different challenges leading to this phenomenon are acute labour shortages as a result of rural-urban migrations, livelihood diversification and deaths; and decline in ownership of livestock used for draft power as a result of recurring droughts. This has negatively affected farming activities which are labour demanding such as mechanical weed control. Smallholder agricultural production is also affected by the prevalence of pests and diseases in both crop and livestock production which could be linked to climate change and variability among other factors. These challenges of weed, insect pests and disease prevalence have contributed to the decline in agricultural production in a country faced with challenges of food insecurity and poverty. Given such a background, the need for organic pesticide use in smallholder farming systems cannot be over emphasized. This paper makes a review on adoption of synthetic pesticides by smallholder farmers and the implications of the current synthetic pesticide use on the utilization of agricultural land.

# Antifungal activity of indigenous plant extracts against phytopathogenic fungi affecting stored cowpeas grain

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High grain moisture content, associated with mould development in storage are associated with grain rotting and mycotoxin contamination during storage. A study was conducted to identify and manage fungal pathogens associated with the cowpea grain using some selected pesticidal plants commonly used to manage bruchids in Zimbabwe. *Fusarium oxysporum* and *Aspergillus nigger* were identified as the common fungal pathogens from the grain obtained from Mbire district and Department of Research and Specialist Services. These were isolated from infected cowpea seeds using the agar plating method and Potato Dextrose Agar (PDA) was used. *Acacia rhehemiana* root bark, *Ocimum gratissimum*, *Colophospermum mopane* leaf extracts collected from Hwedza and Mbire districts of Zimbabwe were dried, ground into powder before extraction using the aqueous extraction method and applied at three levels (10, 15 and 20 %). The experiment had a positive control (Captain), a synthetic fungicide, and a negative control where no control option was used. These control treatments were incorporated into the agar medium, incubated in an experiment arranged in Completely Randomised design, and fungal diameter recorded at 24, 48 and 72 h. All fungal control options managed to suppress fungal growth within the first 24 h, except where no control materials were used. Thereafter, significant differences in the performance of treatment options used were recorded with Captain demonstrating superiority over other control options against both *A. niger* and *F. oxysporum*. *Ocimum gratissimum* applied at 20 % proved to be more effective than the captain (fungicide) against *Aspergillus niger*. Extraction of active compounds of *O. gratissimum* can be useful against fungal pathogens.

# Preliminary in-vitro acaricidal efficacy screening of acaricidal plants against Rhipicephalus (Boophilus) microplus ticks

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From time immemorial plant extracts have been used by farmers to control agricultural pests and parasites but with modernisation and the evolution of the chemical pesticide industry, these ancient practices were dying. In recent times, however, there has been renewed interest in the use of plant extracts because of the emerging challenges associated with the use of synthetic acaricides. Consequently, ethno-botanical surveys from knowledgeable people across the world have produced databases of scientifically unproven plants with reported acaricidal properties against cattle ticks. In the current study, some of the plants identified in a survey in some dry areas of Zimbabwe were screened for acaricidal efficacy *in-vitro*. A total of 18 plant species collected from Chiredzi, Muzarabani, Sanyati and Matopo districts were shade dried ground and extracted using either acetone or distilled water. The extracts at 10% w/v were tested against adult ticks using the contact toxicity assay where 1µL of the test extract was put on the dorsal part of the ticks using a micropipette. The ticks were observed for mortality after 24 and 48 h. The results showed that acetone leaf extracts of *Maerua edulis* (90%), *Monadenium lurgadae* (100%), *Cassia abbreviata* (97%) were the most effective with no significant difference with the amitraz-based positive control (100%). Water extracts of all the plant species did not cause any tick mortalities; same as the negative control (distilled water). This initial study shows that not all plants claimed to have acaricidal properties may be effective against ticks. Contrary to farmer practice of using water as a solvent, organic solvents like acetone gave better results and should be used for increased efficacy. Overall, there is scope to develop acaricidal products from these locally available plants.

# The potential of botanical and diatomaceous admixtures for management of *Acanthoscelides obtectus* (Say) in commercial dried beans

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The bean weevil *Acanthoscelides obtectus* (Say.) is the main causative agent for losses incurred on stored beans in Africa. A study to investigate the on-farm efficacy of a botanical and a diatomaceous earth (DE) synergy on bean damage by this pest and the consumer and market acceptability of treated grain was conducted on-farm at 20 farms in Akalo sub-county in the Apac district of Uganda. Treatments included admixtures with 100% DE, 50% DE + 50% dried tobacco powder and 75% DE + 25% dried tobacco and 100% Tobacco applied at 2% w/w. These were then cooked and scored using sensory analysis panels on-station and by farmers and grain consumers on-farm, for taste, appearance and colour compared to untreated and undamaged sample after four months of storage which is the longest duration which an average farmer stores beans in the country. There was significant reduction ($P< 0.05$) in damage levels on beans after storage. Treatment with 100% DE, reduced level of damage to 0.6%, 50%DE + 50% dried tobacco powder synergists to 2.5% and 75%DE + 25% tobacco to less than 2% damage and 0% damage for 100% Tobacco admixtures , compared to 10% damage in the untreated beans. On-farm and on-station palatability studies of all these treated grain found all of them acceptable to the consumers and there was no difference in the taste, appearance and colour of treated and untreated undamaged beans. All botanical treated grain was acceptable to grain buyers and there was no difference between the taste, flavour and cooking time of the treated and the untreated beans. Acceptability of treated grain by produce buyers presents a new opportunity for farmers to use this environmentally safe, effective, affordable and user-friendly alternative to chemical pesticides for grain protection, which provides an opportunity to reduce postharvest losses on beans and enhance farmer incomes at small holder level.

# Use of plant extracts by smallholder famers in Zimbabwe

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The emergence of insects resistant to chemical insecticides and the growth of organic agriculture are prompting an increase in studies on insect toxic, plant-derived compounds, which are considered to be a valuable alternative to the usual synthetic pesticides widely used in agriculture. In Zimbabwe farmers in Makoni and Marondera districts have practiced organic agriculture since 2007 through the assistance of non-governmental organisations. Farmers are using plant extracts in their organic farms and 19 different plant species were used against vegetable pests. Plant extracts were mainly applied in crucifers against aphids and on tomatoes against red spider mites. Farmers applied pesticidal plant extracts at varied rates. A three pronged approach has been used in order for famers to adopt organic farming; capacity building initiatives, establishment of organic demonstration gardens and organic certification of participating farmers to enable international marketing of organic produce. Guidance was given on how to transition away from heavy synthetic chemical pesticides dependence and 255 farmers were organically certified by Zimbabwe Organic Producers and Promoters Association in the two districts. This enabled farmer associations to secure a contract with an organic export company. The associations have managed to export 1580 kg over one season of organically certified peas in 2014 to international market. In addition to the food security benefits, which are substantial, the sale of organic produce has created an average revenue stream per farmer of USD50-100 per growing season (about 4 months). The majority of farmers agreed that pesticidal plant extracts were affordable and becoming more available as many plants with pesticidal properties are rediscovered through research by researchers through the ADAPPT/OPTIONs networks. The future for organic farmers looks bright especially with more organic pest management options being availed.