THE ROLE OF KEFRI IN THE PROPAGATION AND CONSERVATION OF BOTANICAL PLANTS GERMPLASM

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ABSTRACT

The use of botanicals in the management of agricultural pests is rapidly gaining prominence worldwide because they are less costly, less toxic, more readily available and easier to use than chemical pesticides. Furthermore, agricultural production of pyrethrum, the biopesticide of choice in many countries has gradually declined overtime and no longer meets the increasing global demand. This calls for urgent measures to improve productivity of pyrethrum while seeking alternative sources of safe and affordable pesticides. Although KEFRI's mandate comprises research in forestry and allied natural resources, focus has previously been on wood and non-wood forest products and services other than botanicals. However, many of the tree and shrub species being investigated and promoted under various Research and Development (R&D) programmes posses immense pesticidal properties and harbour great potential for research and development in this important flagship area. In this paper, some of the current flagship areas of research and a few of the priority tree and shrub species are listed and reviewed for their pesticidal properties. Given the current demand for alternative biopesticides, there is opportunity for more research on tree and shrub species with potential as alternatives to current pesticidal plants and synthetic pesticides.

INTRODUCTION

Botanical plants are plants with pesticidal properties which produce naturally occurring compounds that can be extracted and processed into various pesticide formulations. Pesticides are substances or mixture of substances intended for preventing, destroying, repelling or mitigating pests. Plant-derived pesticides or 'botanicals' have long been used by farmers in remote regions of the world but have gained popularity in recent years, even among civilized societies because they are cheaper, readily available, safer and easier to use than commercial chemicals. In a survey conducted in Northern Malawi and Eastern Zambia, over 70% of the respondents were aware of pesticidal plants, and more female (75%) than male (55%) respondents reported using them (Nyirenda et al., 2011). Pyrethrum is the best natural pesticide available, and pyrethroids have been the insecticide of choice for consumers, replacing organo-phosphate pesticides, which are far more toxic to people and wildlife. However, annual production of this commodity has gradually declined to worrying levels, and there have been concerted efforts to seek alternatives, while appropriate measures are taken to improve production.

According to its mandate, the Kenya Forestry Research Institute (KEFRI) carries out research in forestry and allied natural resources. Through its Research and Development (R&D) programmes, the institute works with stakeholders to generate data and information needed to improve, propagate and conserve tree and forest resources. Due to the dangers posed by the continued degradation of our forest resources and loss of biodiversity, focus is currently on

rare, endangered and socio-economically important wood and non-wood forest components. Key among these is the propagation and conservation of priority trees, shrubs and aloes for their role in provision of human and livestock medicines, environmental protection, and rehabilitation of degraded areas.

PROPAGATION AND CONSERVATION OF MEDICINAL PLANTS

Research and demonstration plots of *ex situ* conservation of priority indigenous medicinal plants have been established under the various regional research centres of KEFRI in different districts across the country including Kericho, Bomet, Keiyo. Uasin Gishu, Thika, Kiambu, Kilifi, Malindi, Kitui, Nakuru and Kisumu (Table 1). The institute seeks to replicate these research/demonstration activities in other areas country-wide.

Table 1: Some priority medicinal plants propagated and conserved by KEFRI with local communities

Botanical name	Common name	Ecology (ICRAF, 1992)	Parts used
Albizia gummifera	Smooth-barked flat crown	0-2400 m a.s.l from coastal hills to Marsabit, Kakamega, Mara.	Pods, roots, bark
Azadirachta indica	Neem	Long grown at coast, now being tested elsewhere. Drought-resistant, does well on poor soils, roots grow deep and wide, 0-1500m.	Leaves, bark, roots
Croton macrostachyus	Broad-leaved croton	Widely spread in wetter areas of Eastern Africa, 600-2000m.	Sap, leaves, roots, bark
Croton megalocarpus	Croton	A dominant upperstorey tree in some forested areas, widespread from Kakamega, to Nyeri, Samburu, Taita.	Bark
Dombeya goetzenii	-	A timber tree of wetter highland forests of East Africa above 2200m, but can be grown at lower altitudes.	Bark and roots
Erythrina abyssinica	Flame tree	Found all over Kenya in open woodland or grassland, 0-2000m, not found in very dry or high altitude areas.	Bark, roots
Kigelia africana	Sausage tree	Found in wet savanna and along rivers in arid areas, from the Kenya coast to the highlands, 0-1850m.	Fruit, leaves
Melia azedarach	Persian lilac	Grows in most soils, both acidic ad saline, from the coast to 2000m.	-
Olea europaea (*O. africana*)	African wild olive	Widely distributed in dry forest and forest margins, 700-3000m. Does best in good forest soil, but hardy and drought resistant once established, even in poor soils.	Stem, bark
Podocarpus falcatus	Podo	A large tree of upland rain forest in a restricted range, 1500-2400m in Kenya from Mount Elgon to Baringo and West Mount Kenya.	Bark
Podocarpus latifolius	Podo	Often dominates the higher forests of Mount Kenya but also grows at lower altitudes, 900-3200m.	Roots
Polycias kikuyuensis (*P. fulva*)	Parasol Tree	Widely distributed in wetter highland forests into the bamboo zone, 1750-2750m. Found in the tea-growing areas of Kenya, often left in plantations (Mau, Nandi, Elburgon, Tigoni, Nyabeni, Solai, Kakamega).	Leaves
Prunus africana	Red stinkwood	Widespread from West to Southern Africa, usually in high rainfall areas, 1500-2300m. It is a common tree in Kakamega and Nyahururu forests, Limuru and Kericho.	Leaves, Bark
Syzygium guineense	Waterberry	Occurring from coastal areas to 2100m. Requires >1000 mm a year. It	Bark, Roots

		prefers moist soils with a high water table beside rivers but will also grow in open woodland.	
Teclea nobilis		Found in bushland and savanna, Nakuru, Baringo. It extends from Ethiopia down to Southern Africa, 900-2600m.	Leaves, roots
Warburgia ugandensis	(East African greenheart)	Widely distributed in lower rain forest and drier highland forest areas, 1000-2000m. Common around Nairobi, in the Masai Mara, Londiani and south-west of Mt. Kenya.	Bark, roots

DOMESTICATION AND CONSERVATION OF ALOES

Out of the about 450 species globally known in the genus, about 60 have been identified in Kenya including 23 that are endemic (Newton, 2003). Trade in Aloe products value chain supports livelihoods of thousands of people in drylands, including West Pokot, Baringo, Turkana, Samburu, Laikipia, Marsabit, Wajir, Moyale, Garissa, Taita-Taveta, Kwale and Kilifi districts. In order to streamline production and marketing for the Kenyan Aloe products, KEFRI is involved in efforts to domesticate and propagate the species through identification, selection, management and certification. Aloe species grown in Kenya and their products and services are outlined in Table 2.

Table 2: Aloe species grown in Kenya and their products and services

Aloe species	**Products/services**
Aloe vera var. barbadensis *Aloe vera* var. chinensis	Aloe gel
Aloe ferox *Aloe secundiflora* varieties *Aloe turkanensis* *Aloe scabrifolia*	Aloe bitter gum
Aloe confusa	Aloe dye
Aloe kedongensis *Aloe nyeriensis*	Ornamental and fencing
Most Aloe species	Range rehabilitation
All Aloe species	Bee-forage
Aloe lateritia and most of the aloe leaves are browsed by wild and domestic animals in dry seasons	Fodder production
Roots of *Aloe secundiflora*	Production of local brews
Most aloes	Human and livestock medicine

Source: Mukonyi and Oduor, 2008.

TREES AND SHRUBS IN OTHER KEFRI PROGRAMMES

Research at KEFRI is demand-driven, and the tree and shrub species listed under various programmes have some bio-physical or socio-economic significance attached to them. Table 3 lists some of these species together with their significance basis.

Table 3: Some tree and shrub species in KEFRI programmes

Species	Significance/remarks	Common name	Focus of research
Cuppressus lusitanica	Timber, poles. Dominant industrial plantation species in Kenya	Mexican cypress	Tree improvement, inadequate clonal seed orchards
Eucalyptus grandis	Timber, poles. Constitutes 30% of commercial forest plantations in Kenya	Rose gum	Tree improvement, inadequate clonal seed orchards
Pinus patula	Timber	Mexican weeping pine	Tree improvement, inadequate clonal seed orchards
Prosopis juliflora	Poles, posts, charcoal, pods. Invasive weed	Prosopis	Develop strategies for management and control
Melia volkensii	Timber, agroforestry	Melia	Propagation studies
Bamboo (several species)	High utility uses, Important for protection of soils and water resources in forested catchments	Bamboo	Establish bamboo demonstration plots
Croton macrostachyus	Timber, Potential not fully exploited	Broad-leaved croton	Evaluation as alternative plantation species
Zanthoxylum gillettii (East African Satinwood)	Timber, Medicinal	East African Satinwood	Evaluation as alternative plantation species
Gmelina arborea	Timber	Gmelina (White teak)	Evaluation and demonstration as alternative timber tree in dry areas
Grevillea robusta	Timber	Silky oak	Farm forestry
Acacia senegal	Gum arabic	Gum arabic tree	Management and market chain analysis
Commiphora campestris, C. holtiziana, Lawsonia inermis, Acacia bussei	Natural dyes and resins	Commiphora	Survey to document sources of dyes and resins
Dalbergia melanoxylon	Wood carving	African black wood	Evaluation for wood carving
Jatropha curcas	Oil	Jatropha	Development of bio-fuels
Crotalaria spp.	Cover crop, improved fallows	Crotalaria	Improvement of soil fertility
Sesbania sesban	Improved fallows	Sesbania	Improvement of soil fertility

OPPORTUNITIES FOR RESEARCH AND DEVELOPMENT IN BOTANICALS

The foregoing information shows that KEFRI has previously focused on other key flagship areas of forestry and allied resources, and gave little emphasis on the equally important area of botanical plants. Results obtained from research elsewhere (Gebreselase and Getu, 2009; Nyirenda et al., 2011) indicate that many of the species already being investigated and promoted under the institutes R&D programmes posses substantial pesticidal properties, and have great potential for research and development as botanicals. Table 4 highlights known pesticidal properties of some of the trees and shrubs commonly listed under various programmes of KEFRI.

Table 4: Tree and shrub species under KEFRI programmes that have been reported to contain pesticidal properties

Botanical name	Common name	Parts used	Mode of action	Target organisms
Tephrosia vogelli	Vogel tephrosia	Leaves, roots	Antifeedant, insecticidal, acaricidal, ovicidal, fish poison, contact and stomach poison.	A range of field pests and for general stored product protection (maize weevils and larger grain borer, bean bruchids).
Azadiracta indica	Neem	Seeds, leaves, fruit, oil, kernel, bark	Contact, stomach poison, repellents	All pests: Most efficient on insects of the orders: Coleoptera, Lepidoptera, Orthroptera
Melia azaderach	Persian lilac	Berries	Insect repellent	Fleas and insects
Gliricidia sepium	Gliricidia	Roots, seeds, leaves	Poisonous to rats and other small animals. Also an insecticide against aphids.	Rats, other small animals, aphids
Acacia nilotica L.	Gum arabic tree	Flowers, stem	Contact action, antifeedant	Termites, store pests of paddy, sorghum and pulses.
Aloe vera L.	Aloe	Leaves, oil	Repellent	Fruit flies, Rice pests, fruit tree pests
Casuarina spp.	Casuarina (Whistling pine)	Leaves	Contact action	Store pests on paddy, sorghum and pulses.
Delonix regia	Flamboyant	Flowers	Contact action	Store pests
Eucalyptus globulus L.	Tamanicin blue gum	Leaves	-	Store grain pests
Tithonia diversifolia	Mexican sunflower	Flower buds.	-	Oriental fruit flies

Vogel's Tephrosia (*Tephrosia vogelli*)

Tephrosia vogelli is a popular pesticidal plant used across Africa. In Kenya, it is common among improved fallow experiments conducted by KEFRI in the medium to high potential areas of western Kenya. Of the 20 plant species mentioned in Malawi and Zambia, it accounted for 61 and 53% of the pesticidal species known to respondents, respectively (Nyirenda et al., 2011). Its leaves contain at least four insecticidal compounds collectively known as rotenoids. It has been reported that mature leaves of *T. vogelli* contain 80-90% rotenoids. Other Tephrosia species contain flavonoid compounds which are also known to have profound effects on insect development and behavior. The biggest concentration of the

active compounds in Tephrosia is found in the leaves. In experiments conducted in Zambia, Tephrosia leaf powder admixed at a rate of 0.1% (w/w) with cowpea seeds proved highly effective in controlling the bruchids, *Callosobruchus rhodesianus*, which is an important pest on cowpea seeds (The SAPP Project website). It was also more potent than the officially recommended Malathion, given that germination was between 46 and 63% compared with 4.2 and 0% for Malathion.

Neem (*Azadirachta indica*)

Pest control using extracts from the neem tree is currently practiced in more than 55 countries throughout the world, and neem products have been in use in parts of Asia (e.g. Burma and India) for over 2,500 years. Plant parts with insect-controlling properties are seeds (Azadirachtin), and leaves (Azadirachtin A and B). Neem also has other chemical substances such as salanin and meliantriol which have primarily repellent effects, and Nimbin and Nimbidin, which have anti-viral effects. Powder treatments of *C. ambrosiodes* and *Azadirachta indica* at all tested rates and *Datura stramonium* at higher levels (10 g and 15 g) gave more than 97% inhibition of F1 progeny production by *Z. subfasciatus* (Gebreselase and Getu, 2009).

Other tree and shrub species

Other tree and shrub species that contain pesticidal properties, have been reported from all over the world. In a laboratory experiment conducted in Ethiopia to evaluate the efficacy of botanical powders of six plant species against *Zabrotes subfasciatus* (Boheman), more than 90% mortality of adult *Z. subfasciatus* was observed for bean seeds treated with *Jatropha curcas*, *Datura stramonium* and *P. dodecandra* 96 hours after treatments at the rate of 15 g/150 g of grain application (Gebreselase and Getu, 2009). Other tree and shrub species that have been mentioned as having pest-control properties include *Euphorbia tirucalli* (Finger euphorbia, Euphorbiaceae, insect repellent), *Commiphora africana*, *Trema orientalis* and *Kigelia africana* (Euphorbiaceae).

CONCLUSION

Given the rapidly emerging preferences for organic farming and increasing demand for natural pesticides worldwide, KEFRI is well placed according to its mandate to give more emphasis to botanical germplasm in its research and development agenda. Biodiversity in forestry and allied natural resources is not currently fully exploited for pesticidal properties, and there is great potential that needs to be exploited and strengthened in future research.

REFERENCES

Gebreselase, A. and E. Getu. (2009). Evaluation of botanical plant powders against *Zabrotes subfasciatus* (Boheman) (Coleoptera: Bruchidae) in stored haricot beans under laboratory condition. *African Journal of Agricultural Research* **4**(10): 1073-1079

Gilden, R.C., K. huffling and B. Scuttler. (2010). Pesticides and health risks. *J. obst. Gynecol Neonatal Nurs* 39(1) 103-10

ICRAF. (1992). A selection of useful trees and shrubs for Kenya: Notes on their identification, propagation and management for use by agricultural and pastoral communities. 226 pp.

Jacobson, M. (1986). The Neem tree: natural resistance per excellence. *Amer. Chem. Soc. Symp. Ser.* **296**: 220-232.

Kamrin, M.A. (1997). Pesticide profiles: toxicity, environmental impact, and fate. CRC press.

Mukonyi K.W. and N.M. Oduor. (2008). *Guidelines for Growing Aloes. KEFRI Guidelines Series: No. 8.* Kenya Forestry Research Institute, Nairobi, Kenya.

Newton, E. (2003). *A checklist of Kenyan Succulent Plants.* Succulenta East Africa-East African Natural History Society, Nairobi. 40 pp.

Nyirenda, S.P. G.W. Sileshi, S.R. Belmain, J.F. Kamanula, B.M. Mbumi, P. Sola, G.K.C. Nyirenda and P.C. Stevenson. (2011). Farmers' ethno-botanical knowledge of vegetable pests and pesticidal plants use in Malawi and Zambia. *African Journal of Agricultural Research* **6**(6): 1525-1537.