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The Potential of Using Indigenous Pesticidal Plants for Insect Pest Control to Small Scale Farmers in Africa

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Abstract

Pesticidal plants are scientifically proven for their effectiveness in controlling insect pests. Their activity is enhanced by active compounds contained, which are known for their repellant and antifeedant potentials to the insects. Use of pesticidal plants by local small scale farmers has been a point of concern following information that majority of farmers do not widely use pesticidal plants despite of an indigenous knowledge that they possess. Improvement of the technologies used by local farmers in previous times, that are easy and effective need to help farmers abstain from the use of synthetic pesticides that are detrimental to the environment and to their own health. This paper reviews the potentiality of pesticidal plants to small holder farmers. It also gives the status of pesticidal plants use, their possible effectiveness against insect pests, persistence as well as the knowledge that indigenous people possess in their use. Again, the paper suggests the need for more instrumental research on practical improvement of indigenous knowledge on the use of pesticidal plants with scientific evidences.

Keywords

Insect Pests, Pesticidal Plants, Environment, Health, Indigenous Knowledge

1. Introduction

The awareness and use of pesticidal plants in developing countries is growing over time following the scientific proof of damages caused by synthetic pesticides.

In developing countries where massive poisoning due to the use of pesticides is increasing and posing envi-

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ronmental and health risks; use of pesticidal plants is gaining priority [1].

Pesticidal plants as an alternative to synthetic pesticides are recognized because of their non-cytotoxicity, easy of biodegradability and simulator nature of host metabolism [2] [3]. Compounds in pesticidal plants break down rapidly, making them more environmental friendly compared with synthetic compounds [4]. Therefore, they are a good alternative in crop production.

Across Africa, there is a massive availability of plants which have been identified for their pesticidal effects [5] [6]. Their growth, proliferation and cheap availability encourages a history of their use [5]. It is understood that the culture of relying on botanical pesticides vanished after the introduction of synthetic DDT in the 1940s [7]. By the 1960s, their adverse impacts on the environment and human health's were becoming evident [8]. Reasons for the use of synthetic pesticides are their immediate impacts against pests which with time resulted into trading of agricultural products with pesticides residues [9] [10]. This scenario is realized to have severe impacts to environment and to people's health [11] because such pesticides are used improperly and without protective gears. Use of pesticidal plants is hence beneficial for the reasons that firstly, they are relatively cheaper and easily available and secondly their formulations are less persistent to the environment and have less toxic effects [12]. Therefore, innovation in the use of pesticidal plants is a means of reducing production cost and improving existing knowledge on the use of the pesticidal plants in agricultural pest control.

Since long in history, small holder farmers have been knowledgeable on the use of pesticidal plants. In many developing nations, especially in parts of Africa, there are several indigenous groups who despite of the available knowledge on the usefulness of botanical pesticides have not fully accepted the use of pesticidal plants as a more environmentally friendly and cost-effective alternative [13]-[15]. In India [11] reported that only 2.89% of the bio pesticides used in India that are registered between 2005 and 2011, there are only 12 types of plant botanical pesticides. Generally, there is a massive research on plant extracts against insect pests that have not been communicated to local farmers, hence this appears to be a major reason for farmers not to use the technology [16].

Conversely, there are other literatures that reported the potential use of crude extracts, simply prepared and to great extent less concentrated to amounts that turn more toxic [1]. The objective of this review is to argue for more direct investment in research that can support the use of simply prepared plant extracts that have shown positive impacts against insect pests in terms of ease of use, compared with results from laboratory bioassays.

2. Review Method

Information in this paper is identified through Mendeley and Google scholar databases using key words like "synthetic pesticides and health", "indigenous knowledge and botanical pesticides", "efficacy of botanical pesticides", agriculture, Pollinators and environment that were used interchangeably for a clear information searching. Studies obtained focused on the impacts of synthetic pesticides to pollinators, human beings and environment, indigenous knowledge that rural small holders possess on pesticidal plants use in agricultural production as well as scientific information on the efficacy of various plant species against insect pests and diseases.

3. An Overview of Pesticidal Plants Use Research

Pesticidal plants compounds can naturally degrade easily in the environment hence rendering them less persistent [2]. Compounds from the plants are reported to break down into harmless compounds within hours or days [12]. Literatures indicate effects of climate factors which are daily average temperature and relative humidity in a sense that persistence of the compounds, reduce with their increase [17]. Being less persistent, these compounds are important in the environment as they pose less harm to non-target organisms. However, plants contain a mixture of chemicals that may have similar or antagonistic activities [18]. There is less information on the extent of breakdown or rather the persistence of each chemical in a mixture.

Breakdown of the compounds in hours or days is not enough to justify persistence of the chemicals and hence more information on time length that these chemicals persist in the environment is required.

Pesticidal plants application rates, persistence of the compounds in the environment and the preparation mechanisms indicate important aspects in the use of pesticidal plants in agriculture. Literatures have reported varied intervals of application of extracts such as three times throughout a growing season [19], twice for the season [20] and fifteen days intervals [21]. Contrary to synthetic pesticides that can last longer in the environment,

pesticidal plants require more frequency if they are to work best. However, intervals for different plants in different seasons variations stipulated by [19]-[21] offers a chance to study about the persistence, and favorable time intervals that will be effective for the control of the pests without causing damages to non-target organisms and environment.

3.1. Importance of Enhancing Small Scale Farmer's Knowledge in Africa on the Use of Pesticidal Plants in Controlling Agricultural Pests

Pesticidal plants are proven to be perfect alternative against insect pests. For many years, indigenous Africans have been using the available pesticides at their disposal from plants and other organisms for different purposes including insect pest control [22]-[24]. However, findings from the developing countries show that small scale farmers suffer from poor knowledge on the use of introduced synthetic pesticides [25]-[27] and this is associated with detrimental effects to them and the environment. Therefore, research on pesticidal plants is needed to strengthen local knowledge that farmers have been aware of since long time in history.

In Africa, many of the pesticidal plants are found without difficulty. For example, they grow in the wild or even at homesteads and in farm boundaries. In this case, there is almost no cost of growing the plants. Therefore, it is worth promoting their use because synthetics have negative impacts as they are costly to eco-health and the economy [28]-[30]. A better choice to help growth of African agriculture would be to start from the baseline knowledge on pesticidal plants of the Africans themselves. This can be achieved through the improvement of the available knowledge on the use of pesticidal plants that would even disappear if not used and disseminated widely.

3.2. Environmental and Human Health Impacts of Synthetic Pesticides

Synthetic pesticides are known for their toxicity to the environment and to non-target organisms including wildlife, insects and human beings [31] [32]. Organochlorines, organophosphate and carbamates are the major groups of chemicals that are used as synthetic pesticides in developing countries despite the ban of others like DDT [33]. Their impacts threaten the food safety systems [34], human health [35] [36] and the environment.

Synthetic pesticides have been reported to reduce population among birds [33], and insects [37] [38]. The fact that synthetic pesticides are less selective treatments to insects in agro ecosystem practices gives a caution on the impacts that pesticides may have to non-target and beneficial insects [39]. Human beings are strongly affected during application and handling of the chemicals in the farms. Reports have revealed several types of cancer that results from improper use of synthetic pesticides such as Leukemia, Lung cancer, Pancreatic cancer, Colon and Rectal cancer, Lymphohematopoietic cancer, on-Hodgkin lymphoma, Bladder cancer, Breast cancer, multi Plemyeloma, Prostate cancer, Kidney cancer and Oral cavity cancer [40]. Pesticides are reported to enter into the cells and alter cell's cycles and hence resulting into some cancer [32]. Pesticides are also known for the ability to disrupt endocrine systems in humans and wildlife [41] [42]. Apart from cancer; skin pill off, hardness in breathing, stomach ache and vomiting as well as farmers collapsing have also affected users [43]. These effects then result to high health costs [44].

Generally, environmental organisms including plants, fish, birds, snakes and insects are affected massively. Farmers in Malaysia reported 80% reduction in number of fish in two cropping seasons during a study conducted to identify impacts of pesticides in paddy farming [42]. Studies also show biota uptake of pesticides [25] which also imply soils contamination. There are therefore more detrimental effects caused by using synthetic pesticides for various agricultural purposes.

3.3. Indigenous Knowledge on the Use of Pesticidal Plants for Field Control of Insect Pests

Indigenous knowledge refers to the informal knowledge, skills and practices that are obtained not in schools, universities and research institutes but rather in local heritable ways normally in rural areas [45]. Developing countries are rich in such knowledge [46]. Indigenous knowledge on insect pest control is perceived as important because it was witnessed as useful in food security and survival of the users long before the invention of synthetic pesticides [45]. However, maintenance of the indigenous knowledge is found to be difficult because the majority of farmers have turned to modern agriculture that involves use of synthetic pesticides.

Pesticidal plants have been used for more than 150 years ago [47]. Majority of African small holder farmers have been using various botanical pesticides to control insect pests. For example, in the Victoria basin in Uganda, farmers have used *Capsicum frutescens*, *Tagetes* spp., *Nicotiana tabacum*, *Cypressus* spp., *Tephrosia vogelii*, *Azadirachta indica*, *Musa* spp., *Moringa oleifera*, *Tithonia diversifolia*, *Lantana camara*, *Phytollacca dodecandra*, *Vernonia amygdalina*, *Aloe* spp., *Eucalyptus* spp., [22]. In addition to the pesticidal plants, farmers in Tanzania have been using other products such as cow's urine, cow dung, and ashes [23]. However, in these areas, there exists little information that this knowledge is used in an effective way in comparison to ancient practices. Research based efforts need to be undertaken to retrieve the knowledge.

During farming, indigenous knowledge in insect pest control involves direct spraying, intercropping pesticidal plants with the crops to be protected, and also using the botanicals based on the synthetic formulations [48]. Researchers have come up with some application techniques. This includes: the use of the freshly ground leaves, mixed and soaked overnight [19] [49]. Also, boiling plant parts and adding soap for extraction [14] has been practiced. [19] used fresh leaves pounded and mixed with water and 0.1% soap to make 3% w/v of the extract. [21] used another technique where sun dried plant materials were soaked in acetone and stirred for 30 minutes. Thereafter the mixture was left for 24 hours, filtered and stored under 4˚ temperature before use.

All mentioned application techniques demonstrated positive results in controlling certain insect pests. These efforts have been done in few parts of developing countries despite presence of pesticidal plants in diverse areas. These calls for diverse research of plants with pesticidal properties coupled with indigenous knowledge from different domains and develop tangible solutions on the use of pesticidal plants to control insect pests.

4. Characterizing Toxicity in Selected Botanical Plants

Four plant species, *Tephrosia vogelii*, *Vernonia amygdalina*, *Tithonia diversifolia* and *Lantana camara* will be described. The mentioned plants have been tested for their efficacy in the control of insect pests in field and on storage of food crops [50]. They are also massively available in rural environments on roadsides and farm boundaries. Research that builds up from what small scale farmers understand about these plant species is needed in order to improve knowledge with a scientific basis for more reliable use of the technology. Therefore, it is worthy conducting research basing on the preparation techniques suggested in the literatures to several other crops and insect pests as well as introducing more favorable techniques that are reliable to small scale farmers.

4.1. *Lantana camara*

Lantana camara is reported to have toxicity effects to animals and is also a noxious plant species that has been cited as invasive in need monitoring [51]. Literatures report that *Lantana* causes less mobility, dehydration and constipation, congested heart and lung, nephrosis, general reproductive performance and teratology to mice [52]. Lantana is also reported to have a fumigant effects [53] [54] and has been revealed for its water purification potential. *Lantana camara* contains a compound known as ursolic acid stearoylglucoside (UASG) depicted in **Figure 1**, that is associated with toxicity and which includes triterpenoids in the apolar phase [54].

In agriculture, *Lantana camara* has been used for the control of insect pests in stored grains [56] [57]. *Lantana* has also been tested for its repellent, antifeedant and toxicity against termites [58]. All these experiments are laboratory based. Hence there is a need for more practical research on the field to test for the effectiveness of *L. camara* against field insect pests. Furthermore, use, use, use of *Lantana camara* for beneficial effects will help reduce its invasive property to farm lands.

4.2. *Tephrosia vogelii*

Tephrosia vogelii is widely used for control of pests and as a source of nutrients to the soil [59]. Leaf extract of *T.vogelii* is reported to exhibit toxicity against *Tilapia nilotica* [60]. This is practiced in remote areas of Africa, commonly regarded as illegal fishing [61]. It is reported that leaves of *T. vogelii* contain high amounts of rotenone and deguelin [62] responsible for the toxicity to fish. *Tephrosia vogelii* has however a great potential in agriculture in the control of insect pests and in soil enrichment through nitrogen fixation [59].

Diverse compounds exist in the plant and according to [63] this plant consist of chemotype 1 (C1) and chemotype 2 (C2) (**Figure 2**) of which C1 is found to be active against insect pests. In additional to insect pest

Botany picture of *Lantana camara*.

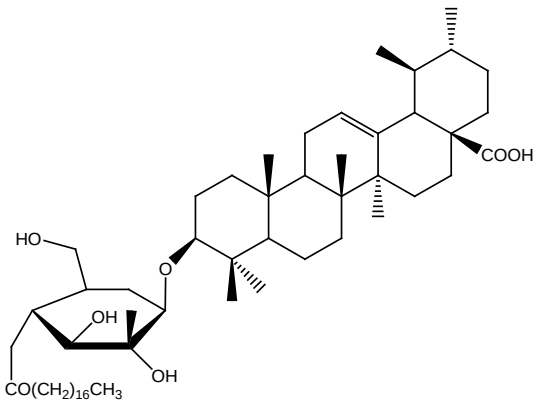


Figure 1. A chemical structure of ursolic acid stearoylglucoside (UASG) (Source, [55]).

Botany pictures of *Tephrosia vogelii.*

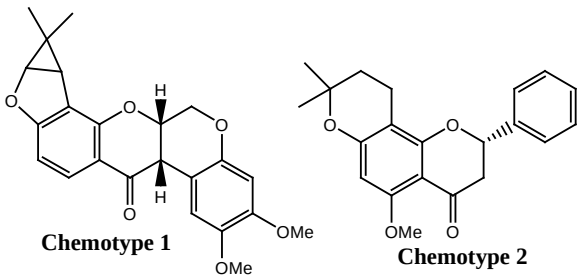


Figure 2. Compound structure of chemotype 1 (C1) and chemotype 2 (C2) of *Tephrosia vogelii* (Source: [59]).

control, mulches of the plant have increased maize biomass while decreasing the weed biomass [63]. Therefore, this makes *T. vogelii* to have herbicidal, pesticidal effects and again as a fertilizer [64]. More studies support the activity of *T. vogelii* in insects. [65] has confirmed its insecticidal, antifeedant and repellent effects against golden flea beetle that represent a group of insects.

Tephrosia vogelii is a legume, that has higher proliferation rates and this is potential to small scale farmers that has less cost to grow and process for insect pests control in agriculture.

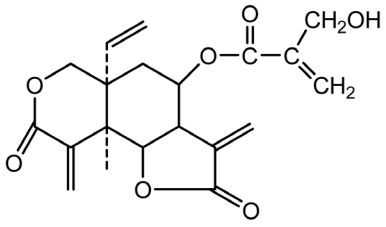
4.3. *Vernonia amygdalina*

Vernonia amygdalina is reported to contain useful compounds such as vernolide and vernodalol, epivernodalol [66]; **Figure 3**), kolaviron [67] as useful phytochemicals.

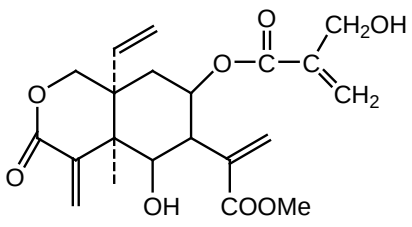
Vernonia amygdalina is reported to be effective against bacteria, fungi and virus species [66], as an anticancer, anti-malaria and as anti-diabetic antioxidant agent and also used as vegetable [68]-[70].

Vernonia amygdalina has been reported as a pesticidal plant, in the treatment of been weevils where ethanoic extracts showed activity [71]. Several other compounds such as saponins and alkaloids, terpenes, steroids, coumarins, flavonoids, phenolic acids, lignans, xanthones, anthraquinones, edotides and sesquiterpenes have been identified from this plant [67] [72]. More studies on identification of useful compounds from *V. amygdalina* and testing their efficacy against field and storage crops is of paramount importance.

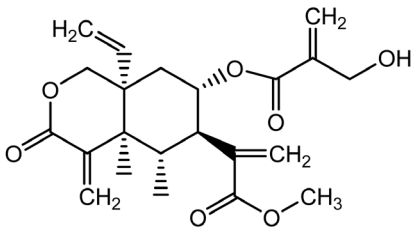
Botany picture of *Vernonia amygdalina*



Vernodalin



Vernodalol



Epivernodalol

Figure 3. Structures of isolated compounds from *Vernonia amygdalina* (Source: [67]).

4.4. *Tithonia diversifolia*

Tithonia diversifolia is a well known traditional plant in developing countries. It is renowned to have agricultural benefits such as higher phosphorous contents in the above ground biomass [73], insecticidal effects [74], anti-malarial, and anti-inflammation. It is also used as ruminant fodder [75] [76]. *T. diversifolia* contain many compounds. [77] found about 16 compounds while [78] review about 150 compounds of *Tithonia* and 150 compounds of *Tithonia diversifolia*. Some of them are shown in **Figure 4**.

T. diversifolia has been tested for its biochemical and toxicological effects. In China, *T. diversifolia* has been reported to treat, diabetes, hepatitis, and hepatocarcinoma although the mechanism involved is not yet understood [79]. In agriculture, chopped pieces of stem and leaves of *T. diversifolia* have showed a significant increase in soil P, Ca, CEC, K and soil organic matter content [73].

Another study by [80] showed that *Tithonia diversifolia* has phytoremediation potential with a capacity to accumulate Pb and Zn from the soil to the shoots. This ability gives room for study on the possible capacity of the plant in the remediation of degraded soils from synthetic pesticides contamination.

Botany picture of *Tithonia diversifolia*.

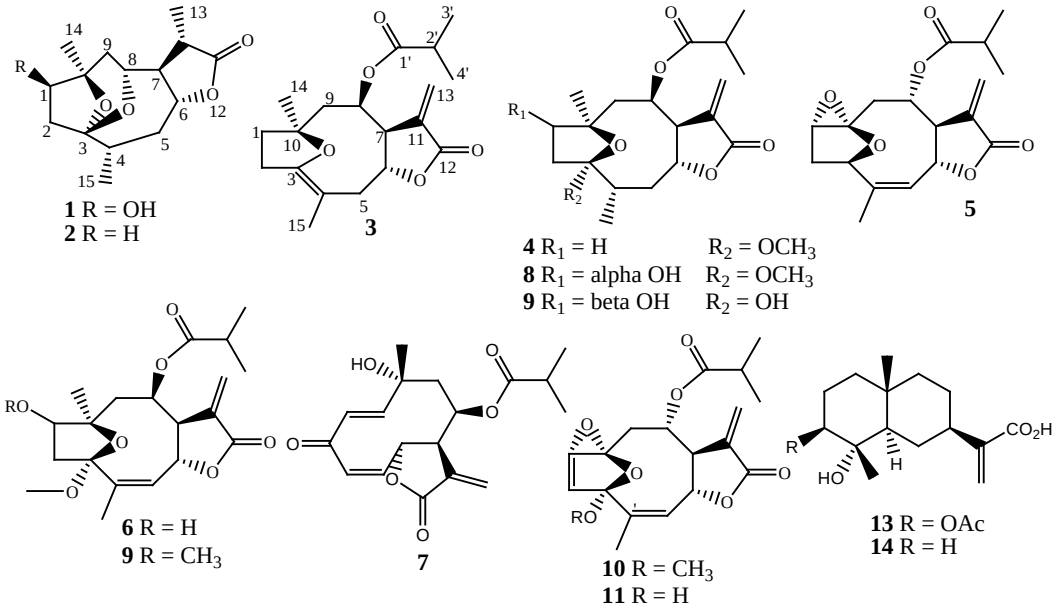


Figure 4. 1-14 compounds found in *Tithonia diversifolia* (Source: [77]).

5. Research Needs and Conclusion

The fact that small holder farmers have the knowledge of using pesticidal plants which they hardly use, there is a need of a research based solution on better ways to make the knowledge useful. Practical research based in field situation and that directly involve small scale farmers is important to put into practice experts' understanding. Pesticidal plants contain some degree of toxicity. It is important to understand their persistence to the environment in order to establish clear intervals of application and to make farmers aware of proper ways of preparation and use for health and environmental safety.

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