MERIT RESEARCH JOURNALS
www.meritresearchjournals.org

Merit Research Journal of Agricultural Science and Soil Sciences (ISSN: 2350-2274) Vol. 8(12) pp. 197-205, December, 2020
Available online http://meritresearchjournals.org/asss/index.htm

DOI: 10.5281/zenodo.4395131

Original Research Article

Scientific Bio-pesticides; Is it the 21st Century Agricultural solution to Tragedized Commons in Kenya?

Dr. Eliud Garry Michura

Kabarak University

Email: emichura@kabarak.ac.ke

Abstract

Pesticides have been extensively used in modern agriculture and are effective and economical in enhancing the yield quality and quantity, thus ensuring food security for the ever-growing population around the globe. In recent times, excessive use of both synthetic pesticide and herbicides has overwhelmed the ecosystem function and ecological food chain has been interrupted resulting in degradation of the environment. In this research article, an attempt has been made to critically review the global usage of different pesticides and their major adverse impacts on ecosystems and application of biopesticides as alternative to already tragedized commons. Historically, botanical pesticides have been used in the early dawn of domestication of agricultural products and are being development every day in search of alternatives to synthetic chemicals. Long use of chemical pesticides although effective in eliminating most of the known pests are on the other hand are toxic to the biodiversity including human health. Continuous accumulation of residues and non-biodegradable state has contributed to negative developments besides their effectiveness in eliminating the pests. Some of the pests have also developed resistance and become hard to control. In the wake up of these facts, the environmentalists and scientists are in both in agreement to collaborate to lean towards the safe use of biodegradable and non-toxic alternatives which can be both effective and less harmful to the environment. Botanical (organic) pesticides extracted from plant materials are likely to fill this gap and help mitigate environmental concerns arising from the use of synthetic materials as pesticides. In Kenya, close to 70% of household activities are in farming and 65% of agricultural production is practiced by small holder farmers. Majority (60%) of farmers use both synthetic pesticides and organic fertilizers despite the fact that, these chemicals present serious challenges to the environment and human health. Biopesticides are not being used by farmers in Kenya is because their formulation and commercialization are a challenge in chemical data and positive control. Besides that, smallholder farmers may be less aware of the potentiality of the biopesticides or they may have the perception that, synthetic pesticides act quickly and more effective. The study used various scientific research platforms and analysis tools to collect recent findings which has been perused and synthesized. The goal is to find ways of mitigating environmental concerns arising from overuse and misuse of inorganic chemicals in agricultural industry which threatens the sustainability of the planet earth.

Keywords: Biopesticides, Chemical companies, Food basket, Tragedy of the commons, Small scale farmers

INTRODUCTION

Although Kenya has a relatively high number of registered biopesticide products, they are sparingly used by small scale farmers. A survey found that chemical pesticides are used widely by smallholders despite awareness of the risks to human health and the Environment (Kate et al., 2020). This paper examines the biopesticide industry, their effectiveness, efficacy, impacts and future on the environment and human health. The human population expansion in recent times has led to high food demand hence, increased agricultural production. This implies that there is need to produce more food. Farmers therefore apply very high doses of synthetic pesticides and herbicides to control and get rid of pests and weeds which they believe works more effectively than biopesticides (Geraldin et at., 2020). In addition, it has also become difficult to manage pests in recent times because of the environmental and biological changes within the pest ecology. Besides, there is also farmers slim knowledge on pest behavior and toxicology of pesticide. Every day new strains of pests develop and result in resistance hence rendering the pesticides ineffective. The agricultural industries have relied heavily on synthetic chemical pesticides and fertilizers to produce more food to combat hunger and nutrition. However, overreliance on synthetic pesticides has caused a profound negative effect on biodiversity and human health (Muhamed et al., 2020; Nkechi et at., 2020).

Synthetic pesticides have been used for a long time and this has left tons of millions toxic residues on the environment leading to environmental degradation. Some concentrations of these chemicals have remained in food products which eventually reach the table and finally into the human system causing health complications and even death. The lifestyle diseases such as cancer, diabetes, among others are impacting negatively on the human population. The logical argument here is that, synthetic chemicals have been overused and misused in their application hence making them more dangerous to the environment and human health (Surendra, 2019). When used in small recommended amount and in combination with other organic chemicals, they may not cause danger and at the same time help to increase food productivity. The question is why do we produce unhealthy foods instead of producing foods free from chemicals? Due to all these problems caused by synthetic pesticides, the new way of thinking is to produce healthy foods and reduce the environmental pollution which result to loss of biodiversity. The increasing demand for organically produced foods, stimulated search for alternative approaches such as botanical pesticides which are now gaining importance. Botanical pesticides are efficacious in managing different crop pests, less expensive, easily biodegradable, have varied modes of action, their sources are easily available and have low toxicity to non-target organisms (Parsa, 2014). Biopesticides varied modes of action are due to the phytochemical composition in different plants. The organic pesticides can be easily integrated into Pest Management (IPM) systems and can contribute to sustainable agricultural production. Botanical pesticides have not been fully adopted due to challenges in formulation and commercialization which are attributed to lack of chemical data and positive controls (Geraldin et al., 2020). The organic compounds offer many environmental advantages addressing sustainability question. But the use of these Botanical in the 20th century have been rather slow with complexity of understanding their efficacy in comparison with synthetic chemicals. Development of new technology in the understanding and improvement of plant allelochemical mechanisms of activity offer new prospects for using these substances in crop protection. (El-Wakeil, 2013).

Many publications have featured botanical pesticides with skewed interest towards management of insect pests. It is argued that, it is not just the above-mentioned reasons, but it may be due to chemical company cartels who have put their interest first in making huge profits from chemical manufactures. In human health, pharmaceutical industry controls the medical industry and dictates their interests. This has made it difficult to come up with other natural medicinal products which are more effective and environmentally friendly. The same trend is also seen in agricultural pest management companies (El-Wakeil, 2013).

Chemical companies developing synthetic pharm-chem products have the same capacity of developing natural botanical products and reduce competition between synthetic and botanical products. There is need to address challenges facing the planet earth in regard to the negative impacts of pesticides on the environment by application of environmentally friendly pesticide products that are safe (Anket, 2019). Quite a number of global challenges have a risen as a result of pesticide use. The gaps in international and national pesticide risk assess-ment procedures and the lack of awareness amongst farmers and the public about the effects of pesticides, leads to unsustainable farming techniques which threatens food security and food safety in Kenya. The Government of Kenya has the constitutional obligation to protect the right to safe food for its citizens. Despite this, many pesticides currently being used in Kenya, are highly toxic to human health and the environment, where at least 32% of all active ingredients registered in the country are already withdrawn from the European market (Rezae et al., 2019).

Justification for Integration

The justification for this research study is to bring out scientific reasoning as to why in the 21st century Kenyan farmers should produce food chemicals but ignore producing foods that are friendly to environment and human health. New life style diseases are now threatening human race arising from consumption of unhealthy foods grown using excessive synthetic chemicals. 50 percent of the 3.5 million commercial small holder products are normally rejected on the international market due to high level of crop residue from excessive use of chemicals which are unacceptable (Muhamed, 2016; Kenis, et.at,2017).The importance of botanical pesticides is attributed to their efficacy, biodegradability, varied modes of action, low toxicity as well as availability of source materials. They also have short pre-harvest and re-entry intervals. Commonly used botanical pesticides are popular in organic farming where organically produced food fetches premium prices. Therefore, botanical pesticides are gaining popularity because they are safe to use on crops produced for human consumption and recently there is a lucrative market among consumers willing to pay more for organically produced food. There are many studies involving the known and yet to be exploited plant species with pesticidal properties. Examples of plants that are sources of commercially available botanical pesticides include pyrethrum (*Tanacetum cinerariifolium*), neem (*Azadirachta indica*), sabadilla (*Schoenocaulon officinale*), tobacco (*Nicotiana tabacum*) and ryania (*Ryania speciosa*). Traditionally, farmers have used crop protection products of plant origin in post-harvest pest management especially in preservation of grains during storage (Aliyu and Majeti, 2020).

METHODOLOGY

The study used various scientific research platforms and analysis tools to collect recent findings which have been perused and synthesized.

FINDINGS AND DISCUSSIONS

The documented dawn of pesticide use

Shivakumara et al. (2020) established the historical development of pesticides over the years. First farmers on the planet earth did not apply pesticides on their farms because the low human population hence, low food demand. Lack of industrialization and technology contributed to low environmental pollution. In 2500 B.C. Ancient Sumerians used sulfur compounds to kill insects indicating the earliest record of insect pest control. Egyptians and Chinese used herbs and oils to control insect pests. Around 300 B.C. Chinese recognized link between climate and periodic biological phenomena as a science-led to timing the planting of a crop to avoid pest attacks. Chinese used natural enemies to control pests, for example ants on citrus to reduce pest infestations (Biological control). 1101 A.D, the Chinese discovered the use of soap as a pesticide. In 1600 tobacco infusions (nicotine), herbs and arsenic were used in insect pest control. In 1700s, Reaumur published work on the importance of temperature as it determines insect phenology plant resistance to insects. In 1860s Paris green (mixture of arsenic and copper sulfate) was used for the control of Colorado potato beetle. In the late 1800s, and early 1900s Boom led to the development of insecticide application equipment.1920-30s, it was discovered that, pesticides were largely ineffective, expensive, hazardous and somewhat phytotoxic. This establishment indicate that, even when the earlier users of the synthetic pesticides knew their toxicity, but they still promoted its use and marketed it widely in the mid19th century. During the 2nd World War synthetic pesticides were widely used to protect crops from pest damage. Prior to this time, insecticides were formulated from petroleum, coal tar distillates, plants or inorganic compounds (Anket et al., 2019).

1930s a German graduate student Paul Muller produced insecticidal activity which saved many soldiers' lives during world war two, the body lice -typhus which attacked human body and caused health hazard which led him win1948 Nobel prize in medicine. In 1950s and early 60s"The Green Revolution" there was Synthetic pesticides and fertilizers to solve the world hunger. By getting rid of pests reducing crop yields and fertilizers to replenish the fertility of the soil and increase crop production (Handley, 2019)

In early 1960s, the world was becoming more polluted and many plants and animal species were disappearing and human health was being challenged. This was a result of using excessive chemicals. Environmentalists such as Rachel Carson came out strongly to speak against the use of nonbiodegradable chemicals to control pests and weeds. Rachel Carson published the book "Silent Spring" and brought into the lime light the issue of pesticide safety to the attention of the public. This earned her A Nobel peace prize winner of 1962 (Anket et al., 2019). The pesticide caused a lot of adverse effects on wildlife, water quality, human and health. The DDT was found in milk and foods (biomagnification) Pests also became resistant to pesticides such as super bugs and weeds. The international community responded to the book “The Silent Spring” this led to eventual development of public policy changes in 1970s regarding the effects of pesticides on environmental health and human (El-Wakeil, 2013). During 1970s, the scientists developed other approaches. in controlling pests. The research led to development of IPM to pest control. USDA created nationwide IPM Program in Land Grant Universities,

Environmental Protection Authority (EPA) and given jurisdiction over pesticide registration and regulation Institutes Pesticide Education Programs in Land Grant Universities.1980s increased in IPM research and saw the beginning of genetic engineering applications in agriculture. How did genetically engineering development fit into IPM programs? Food Quality Protection Act (FQPA) brought changes to pesticide laws in US. This led to the proposal of New emphasis on softer, and/or more specifically targeted, low-volume chemicals. Issues of children's health emphasized became a focus. In 2000 and beyond pest management has always been changing and the future cannot be predicted. Different people have had different ideas about how pest management should be carried out (El-Wakeil, 2013).

Identification of novel effective insecticidal compounds is essential to combat increasing resistance rates. Botanical pesticides have long been thought of as attractive alternatives to synthetic chemical pesticides for pest management because botanicals reputedly pose little threat to the environment or to human health. The body of scientific literature documenting bioactivity of plant derivatives to arthropod pests continues to expand, yet only a handful of botanicals are currently used in agriculture in the industrialized world, and there are few prospects for commercial development of new botanical products (Anket et al., 2019). Pyrethrum and neem are well established commercially, pesticides based on plant essential oils have entered the marketplace, and the use of rotenone appears to be waning (Smith et al., 2019). A number of plant substances have been considered for use as pest antifeedants, repellents and toxicants, but apart from some natural mosquito repellents, a little commercial success has ensued for plant substances that modify arthropod behavior. Several factors appear to limit the success of botanicals, most notably regulatory barriers and the availability of competing products (newer synthetics and fermentation products) that are cost-effective and relatively safe compared with their predecessors. In the context of agricultural pest management, botanical pesticides are best suited for use in organic food production in industrialized countries but can play a much greater role in the production and postharvest protection of food in developing countries (Sharma et al., 2019). Worldwide, the use of natural insecticides has increased because of regulatory actions that control the indiscriminate use of synthetic pesticides that have harmful effects and negative impacts on air, soil and water. It is argued that, abuse, misuse and overuse of synthetic chemical pesticides are the reasons for looking for alternative's botanical pesticides (Isman, 2020)

Adoption of biopesticide in the Rift valley Kenya

One of the studies done in Kenya found that, only 10 per cent of farmers surveyed in Central, Eastern and Rift Valley regions use biopesticides. 90 per cent do not use them because they are slow to act, not readily available and are expensive, study says. In another study It was also found that, recommendations by advisory services and perception of safety were the key reasons why they took initiative to adopt biopesticides which they found effective while those who did not adopt claimed that the biopesticides were not available and ineffective (Ngotho, 2020)

Consumers Cheats

Further findings have revealed that, there are more hidden facts about the composition and toxicity effects of pesticides. The following are a few case studies considered in this paper;

Case 1: It was found that;

i. There are no adequate monitoring and reporting systems for health and environmental impacts of pesticides on agricultural and horticultural communities. Absence of poisons information centers and limited medical facilities to diagnose, treat and report pesticide poisoning solution. Information on chemical use amount, time of application, type of species targeted and their toxicity and life cycle among others.

ii. Higher budget and political will as well as more capacity for institutions like KEPHIS, KEBS and NEMA to implement monitoring strategies of food and water.

iii. Monitoring is not regular, therefore there is need include regular farm inspections to ensure that recommended mitigation measures are implemented

iv. Most of the labels did not have necessary information e.g. bee toxicity, mutagenicity for pregnant women, but labels are often written in small letters and there is no information on inert ingredients. It is recommended that; Pesticides industry should respect the "right to know" as well as the "right to comprehend" and withdraw all pesticides products with inadequate labels (Kenis, 2017).

v. Lack of PPE in most of the agricultural industry especially to small scale farmers need to be addressed to protect pesticide handlers and their families from getting contaminated.

vi. In addition, companies should train dealers, distributors and salespersons who sell their products to market them responsibly.

vii. Pesticide industry should refrain from selling pesticides if the availability of adequate protective equipment cannot be guaranteed and if mitigation measures cannot be met (ROOT TO FOOD, 2019).

Case 2: In another study, it was found that, there is lack of coordinated farming in the food chain which is

causing pesticide exposure. Farming systems need to be redesigned or adjusted based on the available knowledge on agro-ecology. Agroecological farming systems prevent pesticide exposure; enhance biodiversity; help to improve air, soil, and water quality; and mitigate climate change. Farmers and policy-makers in county governments are encouraged and supported in transitioning to and understanding agroecological practices like crop rotation, soil fertility management, push–pull technology, and crop selection adapted to local conditions (Harina et al,

Case 3: The study established that, fields treated with the biopesticide, fruit infestation was 7.2%, compared to 54.9% in untreated orchards. These outcomes present one of the strongest possibilities for the complete elimination of chemical pesticides in fruit fly control in Africa. With this success, players in the biopesticide production are now calling on African governments to start supporting local production by subsidizing bio-pesticides reagents. The research done by (Aliyu and Majeti2020) developed bio-pesticides for use in the fight against fall armyworms. Researchers said the products obtained from natural sources like fungi, manage both eggs and early larval stages of the pest.

Case 4: In the new development in synthetic pesticide application**,** Scientists at the Universities of Bath and Sussex have developed a new system that slowly releases ant pheromones to attract pests to an insecticide bait. This means that instead of spraying the whole crop with pesticides, traps can be placed in specific areas for more targeted protection (Harina et, al, 2020)**.** Leaf-cutting ants are major pest species of agriculture and forestry in many areas of the tropics causing an estimated $8 billion damage each year to eucalyptus forestry in Brazil alone. Traditional pesticides often degrade quickly and are not specific to particular pests, resulting in substantial wastage of pest control products, environmental contamination and harmful effects on other insects (Harina et al., 2020). They found that by altering the chemical groups within the basic framework structure, they could adjust the speed of release of the pheromones so that the chemicals could be released over a period of several months rather than days.

Case 5: The study at Cardiff University in Wales used genetic engineering to repurpose a strain of beneficial bacteria to provide a safe, sustainable alternative to chemical pesticides. The research team found that *Burkholderia ambifaria* bacteria, when altered with genomic tools, have the potential to act as effective biopesticides, replacing synthetic pesticides that can harm human and environmental health. It is hoped that, *Burkholderia* will be viable as an effective biopesticide, with the ultimate aim of making agriculture and food production safer, more sustainable and toxin-free (Kate et al., 2020)

Case 6: Through the analysis of the involvement of major pesticide manufacturing companies, it was revealed that, there is a race between Bio-pesticides and Synthetic pesticides. So, which is a better Promise? Currently, major multi- million companies such as Bayer and Start-up are spending billions to identify fungi, bacteria and organic compounds in plants that can control the pests (weeds, insects and diseases) which have devastating effect on farmers growing wheat, canola, potatoes, apples and other crops (Arnason,2020). In another finding U.S. molecular biologist Baerson at Oxford, Mississippi is studying a unique bio-chemical in sorghum grain sorgoleone a natural herbicide that kills weeds and other plants (Arnason, 2020). Despite the encouraging innovations to advance in biopesticides to replace synthetic chemicals will these lead to a promising way of keeping pests away from destruction of agricultural products and at the same time reduce environmental degradation?

Case 7: Other studies have found that biopesticides, can solve problems but has several challenges such as climate variations such as dry, hot, cool or windy conditions. Other selected biopesticides can perform wonderfully in greenhouse conditions but poorly in the natural conditions raising issues of protection. Further to this, there is general feeling that, it is more expensive to produce, more expensive to apply (Arnason, 2020). It has been noted that, Syngenta and Bayer, both those organizations are investing billions into natural (and) bio-pesticides," Bletsky said. "Over the long-term, you are going to see new things (products) and that cost come down." Some of the biopesticides regarded as successful include strobilurin fungicides, glufosinate, Callisto, Bt and a few others. There is no reason to expect biopesticides will be any more effective than chemical pesticides.

Case 8: Alexandre Latchininsky, a FAO expert specializing in chemical pesticide locust control farmers are used to buying one chemical pesticide that they can use to kill multiple pests throughout the year. With biopesticides, farmers need to buy different kinds of products to fight different pests, so it requires a change of habit. Additionally, biopesticides are more complicated to use, in terms of transportation, storage, and mixing. All this actually requires more training than the use of the conventional pesticides. Both specialists and the general public should be well educated on this paradigm shift from curative to preventive means (FAO, 2020).

Case 9: A survey found that small holder farmers prefer using chemical pesticides despite awareness of the risks to human health and the environment. In a study carried out in USA, almost half of respondents showed awareness of biopesticides, but current use in the survey localities was low (10%). The main reasons for the low use of biopesticides by smallholders in this study were: perceptions of effectiveness, primarily speed of action and spectrum of activity, availability and affordability. Smallholders who used biopesticides cited reduced risk of exceeding residue limits, ability to manage the diverse residue requirements of the food chain, new modes of action help to reduce risks of resistance among pests and diseases, higher consumer reassurance and satisfaction through promotion of more transparent production systems. Although farmers (Kate et al., 2020). To solve the problem of farmers not using biopesticides as expected, there is need to address farmers' awareness and their perceptions of effectiveness, as well as increasing the knowledge of those providing advice and ensuring registered products are available locally at competitive prices (Kate et al., 2020).

Case 10: The study has shown that, microbial products such as *Bacillus subtilis* strain QST 713 (Serenade ASO), *Coniothyrium minitans* strain CON/M/91-08 (Contans WG) and *Bacillus pumilus* strain QST 2808 (Sonata) provide crop protection and can promote plant health via multiple pathways. Serenade ASO works with the plant by colonizing the root as it feeds on exudates, it builds a dense biofilm around the root that has been demonstrated to lead to increased root growth and ability to search out nutrients. This has been found to lead to a stronger, healthier plant. Contans WG is used for the control of sclerotia of *Sclerotinia sclerotiorum* and *Sclerotinia minor* when used as a soil treatment prior to planting any edible and non-edible crops. Whereas conventional foliar treatments target Sclerotinia disease in-season, Contans WG decreases Sclerotinia loading from the start (Aliyu and Majeti, 2020). Based on a naturally occurring fungus, it neutralizes and eliminates the source of the disease, limiting the potential for infection and spread through crops. As a foliar spray, biologicals provide effective contact activity against diseases and pests to protect yield. The carboxylic fatty acids C7-C20 (Flipper) when applied to aphids and troublesome spider mites, provides control by disrupting the metabolic processes leaving the pest unable to feed. As it is derived from olive oil it is kind to beneficial species, is not subject to residue limits or harvest internals and as it holds numerous EAMUs it can be applied to a range of glasshouse Hajek and Eilenberg (2018).

DISCUSSIONS

The Future Role of Technology

The study established that, farmers have a big, task to bring healthy, nutritious and affordable food to market and finally to the table. Every farmer has unique responses when it comes to producing organic foods to their families and also to the market. Environmental variations such as in soil, weather, and farming practices, just as there are a thousand natural forces working against a crop at any given time. Insects, weeds, and diseases evolve relentlessly to overcome whatever farmers throw at them. Zymergen, a biomanu-facturing, FMC, Bayer, Syngenta, Startup have partnered to manufacture biological pesticides to respond to the problems caused by synthetic chemicals. There is need for growers to be pretty receptive and synergy in order to use the right solution for their problems and make local solutions to local problems so that, farmers can make the most profitable use of their land. It is also echoed that, genetically modified (GM) species have provided a solution to several challenges related to crop protection over the years. However, whenever these GM plants are found in unwanted places on the farm, removing them becomes a challenge since they are herbicide-resistant (Bayer Crop Science, 2020).

It was also established that, market-based challenges are, toxicology for testing the new products is higher, market opportunities of the botanical pesticides have unique problem of higher cost for registration because of their complex mixtures of bioactive constituents. Since most of the botanicals are generally biodegrade within few days or sometimes within a few hours, application rate will be higher and requires frequent application coupled with exorbitant cost of production (Sola et al., 2020). Other Market challenges include economical supply of plant product, quality control and lack of stability, as well as competition from other bio pesticides and bio control agents. The grading of botanicals is another issue which lies with the supply of homogeneous plant material with biomolecule which is largely influenced by method of cultivation, harvest stages, post-harvest storage and primary processing and manufacturing aspects. It is alluded that, plants produce a variety of secondary metabolites including various alcohols, terpenes and aromatic compounds which are influenced by the geographical areas and climatic conditions (e.g. sunshine hours, rain fall, and soil). Weighing between the two types of pesticides, However, synthetic chemicals have diverse effect on human health and environment hence the need to develop botanical pesticides, with lesser market hurdles (Sola et al., 2020).

What Lessons to Learn from this Findings?

It is a known fact that, human population is overstretching and yet the land size remains constant. This means that, agriculture must be intensive and use more synthetic pesticides to keep off pests so that more food to feed the population can be realized. The more the conventional agriculture production is practiced, the more the degradation of the environment and lifestyle diseases.

The impetus for wealth creation and greediness to make huge profits by companies producing dangerous synthetic pesticides is increasing with regardless of environmental sustainability (Abimbola et al., 2020).

The chemical pesticide manufacturing companies are capable in stopping to trade on toxic and non-degradable pesticides and engage in sustainable trading. Small scale farmers do not care about what chemicals are in the market but look for effective ones to get rid of the pests and weeds quickly with ease. The blame therefore goes towards manufacturers.

There are several ongoing innovations advancing in biopesticides to replace synthetic chemicals, but there are several hurdles to this effect. Will these efforts yield or promise solutions to keep pests off from farm environments without reducing environmental degradation?

Is there is no reason to expect biopesticides will be any more effective, less costly than chemical pesticides to small holder farmers.

Debate on Kenya Toxic Pesticide Ban Whether to Use or Not

The ban on toxic pesticides of pesticide farming has caused a lot mixed reactions in Kenya. The Kenya parliament on 21st October 2020 gave an order to three state agencies agriculture ministry, the Pest Control Products Board (PCPB), and the Kenya Bureau of Standards (Kebs) to conduct analysis of all pesticides in the market and ban those containing cancer-causing ingredients (Mutai, 2020). The petition was filed on behalf of Biodiversity and Biosafety Association of Kenya, Kenya Organic Agriculture Network, Resources Oriented Initiative Kenya and Route to Food Initiative. There has been a public outcry on the increase in the prevalence of pesticides in Kenya, posing a risk to health and the environment. It has been found from members of the public that have raised an alarm, singling out 24 products in the Kenyan market that are carcinogenic, 24 that can cause damage to genetic changes, 35 that can interfere with the hormonal system, 140 that can affect the nervous system and 262 products that show effects on reproduction toxicity(Mutai, 2020). This finding indicates that it is not all well with synthetic pesticide industry. The question raised is, why should the companies concerned produce toxic pesticides that cause damage o human life. These residues from toxic pesticides enter the plant and animal system and finally reach the members of the family and finally into the human body damaging the tissues. Can these types of pesticides production continue to be produced or can there be other safe ways of producing pesticides when used in agriculture results in healthy and nutritious foods for safe consumption?

CONCLUSION

The study concludes that, the logical and sound sustainable pathway is to produce foods with no toxic chemicals and prevent further environmental pollution by practicing principles of sustainability. The review in this article shows that natural products have gained reasonable ground in crop protection and food preservation. Various extracts from different plant sources have shown effective protective and preventive properties from known classes of secondary metabolites that they contain. Several studies directly employed crude extracts, while some studies fractionated the extract into less complex forms before application. A few in-depth studies, however, isolated the active constituents, which were responsible for the activities under review. The challenge is that active natural molecules are usually present in little quantities but have proven to be better alternatives compared to their synthetic counterparts which have been used for a long time. It is a common knowledge that natural remedies are safer than synthetic chemicals. The growing interest of scientists in authenticating the efficiency of natural products in crop protection, food preservation, and other medicinal applications will solve environmental degradation and reduce the risk of toxified food consumed. This approach deserves more scientific attention in the future. The current application of nanoparticles in agriculture is producing quite impressive results. For example, silver nanoparticles (AgNPs) have been applied in crop protection and food preservation. However, the rising toxicity and environmental concerns about AgNPs are also worthy of further research. The government policies should be put in place to encourage the commercialization of natural-based pesticides, expanding crop insurance for adoption of integrated pest-management and ecologically based pest-management systems practices.

Suggestions for further research

With the increasing number of cases of diseases arising from toxified foods produced from agricultural products grown using inorganic pesticides, the government should take it seriously and stop the use of unsafe synthetic pesticides. This is the reason why food consumers now turn to safe organic food products. The challenge again

is that organic foodsare quite expensive and cannot be afforded by poor families. How can the government help and encourage farmers to produce food healthy for human life? All the stakeholders should be involved in realizing the importance of life and sustainability of the environment and reverse the already tragedized and unsustainable commons. Everyone has a right to live and consume food that will not endanger one's life and be the steward of environment for sustainable society. Let us stop the greed of making huge profits at the expense of life.

RECOMMENDATIONS

- The government should ease the registration as incentive to promote biopesticides. In current practice, registration protocol is quite tedious in biopesticide products which has led to reluctance adoption as safer alternative hence reducing the risk of conventional pesticides.
- There is need to expand crop insurance for adoption of integrated pest-management and ecologically based pest-management systems practices.
- Any farmer or pesticides companies producing toxic synthetic pesticides without nay regulation followed should be heavily taxed and polluter pay principle applied.
- Trading permit protocol should be introduced to reduce pollution emission.
- Ensuring availability of funds in support of resource conservation and reward self-effort to green the planet earth.
- The government should protect human health and the environment by strictly assessing and enforcing regulations designed to protect worker health and safety.
- Through sound practical policies to increases food production and fight food insecurity in the country, the government should revisit the agricultural subsidies, reduce tax on farm inputs and ways of motivation of farmers in order to produce more healthy and nutritious foods both for domestic consumption export.
- There is need for Kenyan farmers to regain confidence in world market by producing and exporting food free of synthetic chemicals since a lot of food products from Kenya have been rejected in the European market.

ACKNOWLEDGMENT

My profound attitude goes to my co-scholars, Dr. Anne Michura, Peter, June and Millard who have supported me in this research.

REFERENCES

Abimbola PO, Temitope AO, Adewumi OD, Oluwole SO, Adejumoke AI, Godshelp OE (2020). Promising Natural Products in Crop Protection and Food Preservation: Basis, Advances, and Future

Aliyu AW, Majeti N, Vara P (2020). African perspective of chemical Usage in agriculture and horticulture—their impact on human health and environment. Agrochemicals Detection, Treatment and Remediation. Pesticides and Chemical Fertilizers 2020, Pages 401-436

Anket Sharma(October (2019). Worldwide pesticide usage and its impacts on ecosystem SN Applied Sciences 1(11):1446. DOI: 10.1007/s42452-019-1485-1

Arnason R (2020). Promise of bio-pesticides: can they replace synthetic chemicals? The Western Producer. Glacier FarmMedia. Published April 9, 2020. https://www.producer.com/2020/04/promise-of-bio-pesticides-can-they-replace-synthetic-chemicals/

Bayer Crop Science (2020). Understanding biologicals: the future of crop protection. https://cropscience.bayer.co.uk/blog/articles/2020/09/understanding-biologicals/Cambridge University Press, Cambridge, United Kingdom Hajek, A. E., and J.Eilenberg. 2018. Natural enemies: an introduction to biological control. Cambridge University Press, Cambridge, United Kingdom.

El-Wakeil N (2013). RETRACTED ARTICLE: Botanical Pesticides and Their Mode of Action. *Gesunde Pflanzen* 65, 125–149 (2013). https://doi.org/10.1007/s10343-013-0308-3

FAO (2020). Biopesticides for locust control. http://www.fao.org/emergencies/fao-in-action/stories/stories-detail/en/c/1268774/

Hajek AE, J. Eilenberg (2018). Natural enemies: an introduction to biological control.

Handley J (2019). Pesticides - A brief history and analysis C Pitch Care. https://www.pitchcare.com/news-media/pesticides-a-brief-history-and-analysis.html

Harina AH, Daniel R, Joseph Paul-Taylor, Huan VD, Christopher D, Gavin WR, Arun S, Claire LH, Charlie W, Tina D, William OHH, John S, Andrew DB (2020). Inclusion and release of ant alarm pheromones from metal–organic frameworks. *Dalton Transactions*, 2020; 49 (30): 10334 10.1039/D0DT02047Hhttps://onlinelibrary.wiley.com/doi/10.1002/ps.5896 https://www.the-star.co.ke/news/2020-06-08-farmers-shy-away-from-biopesticides-due-to-high-cost/

Isman BM (2020). Botanical Insecticides in the Twenty-First Century—Fulfilling Their Promise? Annual Review of Entomology Vol. 65:233-249 (Volume publication date January 2020). First published as a Review in Advance on October 8, 2019 https://doi.org/10.1146/annurev-ento-011019-025010

Isman MB (2019). Challenges of Pest Management in the Twenty First Century: New Tools and Strategies to Combat Old and New Foes Alike. *Front. Agron.* 1:2. doi: 10.3389/fagro.2019.00002

Kate LC, Monica KK, Mugambi WN, Duncan CH, Rware F, Makale JM, Julien L, Godwin FW, Steve ERD (2020). Why don't smallholder farmers in Kenya use more biopesticides? Pest Magement Science'

Kenis M, B. Hurley, A. Hajek, M. J. W.Cock. (2017). Classical biological control of insect pests of trees: facts and figures. Biol. Invasions19: 3401–3417.

Muhammad IK, Helmholtz-Zentrum für Umweltforschung, Muhammad AS, Sardar A, Hafiz NA (2020). UseContamination and Exposure of Pesticides in Pakistan: A Review January 2020. Pakistan Journal of Agricultural Sciences 57(1):131-149. https://www.researchgate.net/publication/330184717_Use_Contamination_and_Exposure_of_Pesticides_in_Pakistan_A_Review

Mutai E (2020). Parliament orders crackdown on toxic farming pesticides. The Economy. https://www.businessdailyafrica.com

/bd/economy/parliament-orders-crackdown-on-toxic-farming-pesticides-2485914.

Ngotho A (2020). Farmers shy away from biopesticides due to high cost. Pest Control. Star News. https://www.the-star.co.ke/news/2020-06-08-farmers-shy-away-from-biopesticides-due-to-high-cost/

Parsa S, S. Morse, A. Bonifacio, TCB Chancellor, B. Condori, V. Crespo-Pérez, S. L. A. Hobbs, J.Kroschel, M. N.Ba, F.Rebaudo (2014). Obstacles to integrated pest management adoption in developing countries. Proc. Natl. Acad. Sci. U.S.A. 11: 3889–3894.

Peterson RKD, LG Higley, LP Pedigo (2018). Whatever happened to IPM? Am. Entomol. 64: 146–150.

Prospects. Review Article |", International Journal of Agronomy, vol. 2020, Article ID 8840046, 28 pages, 2020. https://doi.org/10.1155/2020/8840046.

Rezaei R, L. Safa, CA Damalas, MM Ganjkhanloo (2019). Drivers of farmers' Intention to use integrated pest management: integrating theory of planned behavior and norm activation model. J. Environ. Manage. 236: 328–339

ROUTE TO FOOD (2019). Pesticides in Kenya: Why our health, environment and food security are at stake. https://routetofood.org/wp-content/uploads/2019/08/RTFI-White-Paper-Pesticides-in-Kenya.pdf.

Shivakumara Kt, Manjesh Gn, Satyajit Roy (2019). Botanical insecticides; prospects and way forward in India: A review January 2019 Project: Good plant protection practices in medicinal and aromatic plants Klumper, W., and Qaim, M. (2014). A meta-analysis of the impacts of genetically modified crops. *PLoS ONE*9: e111629. doi: 10.1371/journal.pone.0111629M. Frazier; IPM in the Classroom 1997 in March 3, 2010A Short History of Pest Management. The development of the field of Integrated Pest Management.

Smith WK, Nelson E, Johnson JA, Polasky S, Milder JC, Gerber JS, et al. (2019). Voluntary sustainability standards could significantly reduce detrimental impacts of global agriculture. *Proc. Natl. Acad. Sci. U.S.A.* 116, 2130–2137. doi : 10.1073/pnas.1707812116.

Sola P, BM Mvumi, JO Ogendo, O Mponda, JF Kamanula, SP Nyirenda, SR Belmain, PC Stevenson (2014). Botanical pesticide production, trade and regulatory mechanisms in sub-Saharan Africa: making a case for plant-based pesticidal products. Received: 4 June 2013 /Accepted: 13 March 2014#Springer Science Business Media Dordrecht and International Society for Plant Pathology 2014

Surendra KD (2019). The New Integrated Pest Management Paradigm for the Modern Age. *J. Int. Pest Manag*. Volume 10, Issue 1, 2019, 12, https://doi.org/10.1093/jipm/pmz010.

UN *(*2018). United Nations, Department of Economic and Social Affairs, Population Division (2018). *World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP.241. United Nations New York, 2018.*