ADOPTION OF INTEGRATED PEST, DISEASE AND WEED MANAGEMENT FOR SUSTAINABLE AGRICULTURAL PRODUCTION IN NIGERIA

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Abstract

Man's efforts at containing the effects of garden and store pests date back to prehistoric times due to losses that accrue from them. These losses range from destruction in the farm, store and at the consumers' place. These pests destroy crops by boring holes into seeds and fruits, eat up young seedlings, fruits and roots, and interfere with the natural physiology of plants thereby reducing both the quality and quantity of produce. Due to the injuries caused, man's effort has been to kill, control or repel the pests using various methods and strategies including chemical, biological, cultural, mechanical among others. They all yielded results at various rates, however, chemical method left serious hazards on human health and environment. Then the introduction of a combination of methods at varying times and quantities, hence the use of integrated pest management (IPM). The basic components of IPM include determination of types and levels of infestation, acceptance level, cultural and regulatory practices for control, monitoring and scouting, genetic modification of crops and animals. Other methods include mechanical, physical, biological and lastly, regulated pesticide application when other methods proved abortive. The study adopted review of relevant literature through various search engines in a narrative form within a time range of 2015 – 2023. Areas such as components, sustainability elements, challenges and strategies for sustainable use were discussed. Effective adoption and proper coordination of all IPM strategies in agricultural, residential, public areas and wild lands, gives a more cost-effective means of managing pests with low risk to natural resources and sustainable healthy food production.

Key Words: Adoption, Environment, Healthy Food Production.

Introduction

Pests and diseases are some of the most important issues plaguing our society, leading to deaths of all including humans. This condition results in serious incapacitations in farming activities and lowered production. When disease attack occurs, whatever is infected (plant, animal or man) becomes less active, unproductive and may even lead to death. Weeds on their part cause harm to planted crops, reduce yield and increase cost of production. In his quest to contain this disturbing situation and losses, man, from pre-historic times, has been making frantic efforts at controlling the effects of these pests and diseases. Some of the methods adopted yielded good results while others left more serious hazards to human health and that of the environment. There is therefore need to seek for ways of managing pests, diseases and weeds in ways that man and other living organisms are protected and sustained at minimal costs with less injury to the environment. Falade, Labaeka and Oladipo (2019) reported that at the 23rd Food and Agricultural Organization of the United Nation's Conference, it was recognized that increasing food production is a priority in many parts of the world, and this cannot be achieved without some indispensable agricultural inputs such as pesticides. However, the indiscriminate use of pesticides has left marks of harmful side effects on the environment, consumers and sometimes, the pests became resistant to its application. Various methods were used singly but the needed results were not being got, due to higher demand in commercial and large-scale farming. The search continued until the art of combining various methods and strategies at different levels and times to achieve protection from pests called Integrated Pest Management (IPM). IPM, involves the use of various methods and strategies that are safe, cost effective and environmentally friendly to reduce the negative impacts of disease pathogens, pests and weeds in the farm or store. This paper reviewed the concept of IPM, its principles, components, challenges and benefits.

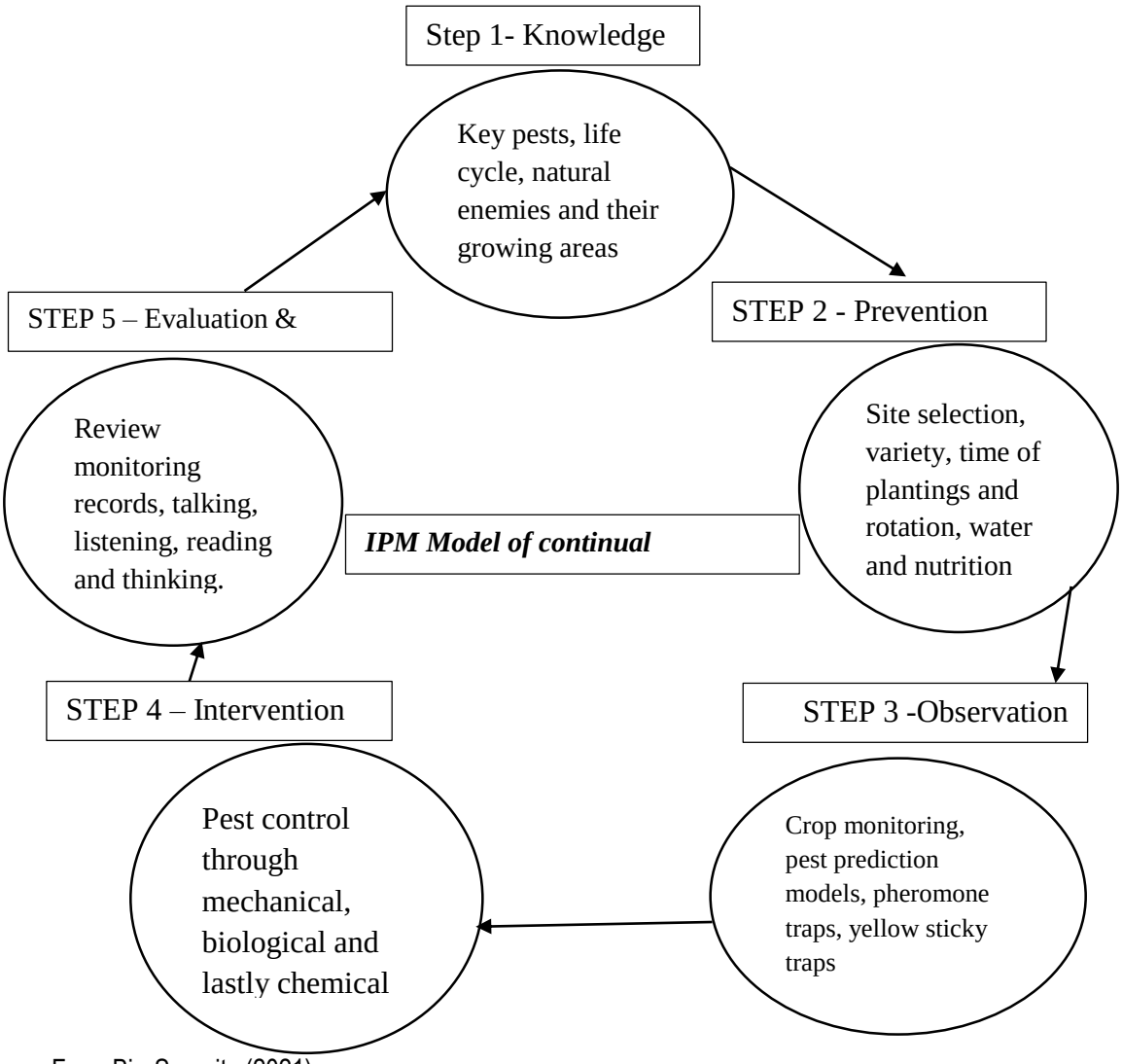
Methodology/Search method

This review was designed to explore adoption of IPM in managing pests, weeds and diseases for sustainable agricultural production in Nigeria. Literature search was conducted through data bases such as google scholar, research gate, directory of open access journals (DOAJ) among others. Such terms as management of weeds, pests of crops and animals, managing pests in Nigeria, solutions to the challenges of pests, health implication of pests among other terms were sought for. A total of 106 results were returned from the search, 80 articles were relevant while 26 were not accessible to the author. From the reviewed articles, although many farmers were aware, but had constraints that hindered the adoption of IPM. Full texts of the available articles were assessed and reviewed through narrative synthesis. The articles that had relevance (within the period 2015 - 2023) to the topic were reviewed.

Concept of Integrated Pest Management (IPM)

IPM is the acronym for Integrated Pest Management. It is a long-standing, science-based decision-making process that identifies and reduces risks from pests, diseases and weeds through various management-related strategies. IPM encourages the synergy between the knowledge of pest biology, environmental information and available technology to prevent high level pest damage with minimal risk to human life and other resources in the environment. It ensures that adopted measures are safe, natural and cost effective resulting in sustainable level of pest control. According to Carmelo and Guiseppe in Carmelo and Guiseppe (2017), IPM emphasis is on the maintenance of ecosystem balance through research and training. It is environmentally sensitive, which Greenberg and Parajulee (2017) in Carmelo and Giuseppe (Ed) saw it as a long-term, knowledge-based decision-making process that anticipates, limits and prevents pest problems in a sustainable form, using methods, disciplines and approaches that minimize environmental impacts/risks and optimize benefits. On their part, Rezaei-Moghaddam and Samiee (2019) opined that IPM is a combination of tactics that manages and protects the economic, social and environmental condition so that losses are minimal. Conceptually, IPM is seen as the adoption of two or more of surveying, scouting, mechanical and good agricultural practices that brings pests to minimal level and at the same time ensures safety of man and his environment. Some of the key programs in successful IPM practice include information gathering, education, proper waste management, structural repair, biological and mechanical techniques and pesticide use when necessary. Many authors have different number of steps (4, 5 or even 6) as components of IPM such as types and levels of pest infestation, threshold/acceptance level, cultural and regulatory practices, monitoring and scouting, genetic modifications and finally control (mechanical, physical, biological and lastly chemical). The diagram presented is a 5-step model.

Figure 1: Five Step Model of IPM



Source: Farm Bio-Security (2021)

Historically, according to Carmelo and Giuseppe (2017), the idea of IPM was birthed between 1940 to 1960, however, its use was intensified after the Second World War. This was when the effects of synthetic pesticides on the agro-ecosystem coupled with the consequent technical, environmental and health impacts became obvious. On his part, Carlos (2020) stated that IPM is a response of the scientific community to solve problems (on ecological, economic and social well-being) originating from the abusive use of pesticides. IPM is an innovative strategy that is not static, but evolving and improving continuously as no one single method can handle all pests or even a single pest for every crop, in every locality or country. At the beginning of IPM, many farmers were reluctant to adopt it, however, as the negative effects of broad-spectrum pesticides on production increased, the adoption rate increased. According to Horne and Page (2008), some of the challenges of farmers from pesticide use made them turn to IPM. In the contemporary environment, although pesticide is still being used, however, more people are tending towards the use of local manures (animal dung, kitchen wastes and compost), organic pesticides (wood ash and extracts from some plants), use of pepper and other chilies for storage of grain as well as minimal/zero tillage of crop lands.

Components of IPM

The basic components of IPM according to Horne and Page (2008) is cultural and biological measures while pesticide use is only a support tool, never the primary control option. IPM is not a single control method, but a combination of evaluations,

decisions and controls based on current and relevant information. Hamadttu (2018) stated that IPM is a flexible and holistic system, which views the agro-ecosystem as an interrelated whole, using different strategies to hold pests below economically damaging levels. On his part, Ojeleye (2016) stated that IPM co-ordinates the use of organisms' biology, environmental information and available technology to prevent unacceptable levels of damage by the most economical means, while posing the least possible risk to people, property and resources. When well managed and efficiently carried out, IPM provides effective strategies for pest and disease management in almost all areas of life such agricultural, public, residential, industrial and wild environments. FAO is at the forefront of promoting IPM as a preferred approach in crop protection and a pillar of both sustainable intensification of crop production and pesticide risk reduction. As such, IPM is being mainstreamed in FAO activities involving crop production and protection.

Reasons for IPM

The use of Integrated Pest Management did not just happen, certain hazards caused by pesticide use led to it, some of which are increasing world population growth, limited portions of land accompanied by pests and diseases, health implications of pesticide use on man's health and the effects on the environment among others. Rezaei-Moghaddam and Samiee (2019) reported that improper use of pesticide leads to food poisoning, negative impact on consumers and environmental health, ban on export of some agricultural produce among others. Firstly, the higher population growth with the consequent demand for more food on fixed land has placed pressure on farmers to produce more food while protecting bio-diversity. IPM provides farmers with tools and strategies to sustainably maximize production of healthy food and minimize losses due to insects, weeds and diseases.

-Secondly, the devastating effects of pests and diseases in crop lands despite the application of broad-spectrum pesticides accompanied by lower quality produce made farmers to start thinking of better ways of solving the problem. According to Horne and Page (2008), there were significant disadvantages in the use of pesticides-based-strategy (though these may vary due to place, farmer, crop and system in operation) which include insecticide resistance, residues in produce, poor workers' safety, destruction of non-target but beneficial pests, induced secondary pests, environmental contamination and drift of pest into neighboring farms/properties.

- In a bid to reduce postharvest losses of crops, pesticides of different types, life span and concentrations are used. Due to improper use and disregard to guidelines, many deaths have been reported in Nigeria through consumption of beans. Okunade and Okunade (2017) called it 'killer-beans' while Carlos (2020) called this abusive use of chemicals. These beans were preserved with pesticides which were not allowed to exhaust its life-span before bringing it out for consumption.

-The higher levels of crop resistance to pesticide, multiplication of new of pests, hence many farmers resorted to increasing the dosage, changing or adding more of the active ingredient, increasing the frequency of use or do something more hazardous, to health of consumers and environment. All the latter approaches will increase the harm of these pesticides on consumers and the environment. Hence other approaches to handling of pests became inevitable.

-In terms of residues of pesticides in food materials, Daudu and Adebowale (2016) reported that the residues of aflatoxin and its metabolites in poultry products (meat, egg, gizzard and liver) affect public health, hence being indirect source of aflatoxin to human consumers. Aflatoxin and OTA has been rated as Class 1 human carcinogen by International Agency for Research in Cancer (IARC) (Filazi, Yurdakok-Dikmen, Kuzukiran & Ufuk (2017) and Thuita, Tuitoek, King'ori and Obonyo 2019). Due to these hazards, the EU passed a Legislation on Maximum Residual Levels (MRLs) especially in foods and this came into effect in Nigeria in September 2008 (Olasunkanmi, Oguwade, Olaniran, Afolabi and Sofoluwe 2022). This non-compliance is costly to Nigeria as huge sums of foreign exchange is lost due to non-export of, especially of honeybee products, to the European Union countries.

Pesticides use does not distinguish what is useful or not but destroys all, including non-target but beneficial organisms within the area. Many biological organisms such as honeybees (pollination of crops), butterfly and even predators that are used in natural and biological control of obnoxious pests are all destroyed when pesticides are used. (Carlos, 2020). When synthetic pesticide is wrongly applied, every other thing within the vicinity is affected, soil water and even rocks. Other issues include workers safety, environmental pollution and drifting of pesticides into neighboring farms. The proper and accurate use of Integrated Pest Management and NOT Integrated *PESTICIDE* Management will help solve most of these pest problems. Although IPM strategies eventually kills the pest, the strategies are on managing them in

sustainable manner by determining why a pest occurred and what cultural or biological approach can help remedy the effects.

Principles of IPM

The basic principle in IPM is information gathering on the type of pest, life cycle, severity in the area and level of destruction. Hence, disease pathogens, pests and weeds are studied to identify their level of occurrence and harms caused to plants, animals and the environment. Such findings give rise to principles that identify actions to be taken by stakeholders. Crop-Life International (ND) stated that that a competency-based IPM program should involve: prevention, monitoring and intervention. It stated that IPM is a site-specific strategy for managing pests in the most cost-effective, environmentally sound and socially acceptable ways. These principles according to Jolene (1993), Horne and Page (2008), EPA (2021) and Klassen, Curtis and Hendrichs in Dyck, Hendrichs and Robinson (2021) include Identifying the acceptance level of pests/set action thresholds, Preventive level, Monitoring, identifying and scouting, Genetic control, Sterile Insect Technique (SIT), Mechanical, Physical, Biological and finally Chemical methods of control.

Acceptance Levels of Pests/Threshold for action

This principle focuses on determining the quantity of various pests in the environment in order to classify their impact level on cultivated crops or other beneficial organisms. Pest occurrence in farms or forest areas happen at different levels: starting at the initial stage in small quantity that is manageable and not of injury to plants and animals, hence no major activity on it by the farmer, nature itself controls the effects. At first, the insects/pests are few; however, the farmer has to watch out so that this level is not exceeded. However, a time comes when the effect begins to increase and its impact felt, this is called the threshold (Horne and Page 2008). It is the number of pests that trigger for action (spraying) and cause economic damage. At this time, there is need for speedy action for control. Some of the ways of determining economic threshold is to count, using various devices the number of the pest in a particular place or on a plant. Another method is by the use of traps baited with pheromones, the pests attach themselves to the trap and the number within an area is counted to determine their population and action to be taken. Good understanding of pest biology, life cycle, behavior and early detection will offer good non-chemical approaches on pests. Since their life cycle is predictable, scouting and monitoring should focus at certain times of the year.

Cultural Control: This is a non-chemical management that makes the environment less attractive to pests and less favorable to their survival, dispersal, growth, reproduction and at the same time promotes natural control of pests. Abu (2016) stated that one of the objectives of cultural preventive method is to achieve a reduction in pest population either below the economic injury level or sufficiently allow natural or biological controls to take effect. Choice and care for healthy plants should be intensified because prevention is the first line of defense. Plants that are healthy and properly nurtured resist pests and pathogens while otherwise gives rise to low productivity and loss to the farmer. Some of the cultural measures according Horne and Page (2008) include choice of plants suited to the area, selection of pest and disease-resistant varieties, genetically modified crops, properly sequenced crop rotation, planting and harvesting at appropriate times and maintaining good sanitation measures, tree planting, variety selection, inter-cropping/trap crops and provision of alternative food sources. Others include choice of proper sites, proper seed treatment and destruction of infected plant tissues, ensuring the use of clean tools and avoid overhead watering/flooding, but watering early in the morning, checking and maintaining good soil pH. Okunade & Okunade (2017), identified non-chemical methods of pest control in stored grains to include the use of hermetic (air-tight) storage structures such as silos, storage of grains on head/cob/pod, smoking un-threshed grains over cooking areas, regular sun-drying, reduced (low) temperature (freezers or earthen pots), use of mixture of botanicals (plant extracts) such as neem, citrus peels, basils, lemon grass, garlic and pepper among others. By these methods, the pests can no longer get the needed conditions for survival and multiplication, hence control is easier and produce healthy.

Biological Control: This involves a deliberate attempt by man at using identified natural enemies or predators as agents of control and management of pests that have reached a population of damage to crops. Every living thing has a natural enemy which naturally controls it. These enemies should be identified; conserved, supported and encouraged to increase (to a particular level) and then used to control the obnoxious pests, weeds and pathogens. The use of predator and parasitic insects are important in controlling many insects of different types by killing or disrupting their breeding cycle. Abu, (2016) identified some of these biotic agents to include predator (lady bird beetle),

parasitoids (parasitic wasp), parasites (nematodes), pathogens (*Basillus thurigiensis*). Predator insects: adult lady beetle and their larvae are voracious aphid-eaters. Green lacewing larvae feed on all kinds of pests including mealy-bugs, whiteflies, mite and thrips. Parasitic insects (parasitic wasps lay their eggs on and in their living targets). The eggs hatch and feed inside the pest. *Bacillus thuringiensis* is a soil-born bacterium that fights mosquitoes and insects in the larval and caterpillar stage. This and other pathogens are effective biological pesticides for very specific pests. It is essential for every IPM practitioner to be able to distinguish good and bad bugs, nurture, conserve and grow the good bugs for future use. Biological control reduces the introduction and use of other measures of control for pests. Antagonistic control is a term used for the biological control of plant diseases (Carlos 2020). Beneficial insects are encouraged and their number regularly measured using beat sheets, sweep nets, traps or vacuums. Biological control measures have been effective in managing some pests; however, it is one of the most controversial methods due to the challenge of managing the predators. When the real (first) pests has been handled by the predators, sometimes the predators turn out to become pests, start eating/destroying the crops they were supposed to protect. The farmer has to, as a matter of urgency find ways of controlling them because their number has increased thereby increasing cost.

There are other activities carried out by farmers to reduce the entry of pests into farms termed as Farm Bio-Security. It is a set of measures designed to protect a property from the entry and spread of pests and diseases. Almost everything moved into the farm has a potential of introducing pests and disease, hence, it is the responsibility of all persons in the farm to ensure that proper monitoring of water source, feed, fertilizer, pesticides and even the humans is ensured. www.farmbiosecurity.cm.au (2021) stated that farm bio-security is a way of protecting the economy, environment and community from the bad impacts of pests, disease, weeds and contaminants. According to the Australian Government Department of Agriculture, Water and the Environment (2021), some of the practices used in farm bio-security include disinfecting, maintaining boundary fences, checking for strays, restricting visitor and vehicular movements, ensuring all machinery brought into the farm is clean, practicing good husbandry and ensuring that purchases are from reputable and reliable sources. Regular inspection of herds for pests and quarantine all new stock and ensuring farm sanitation.

Mechanical and Physical Control: These methods go directly after the pests by creating barriers, capturing or killing them and preventing their attack on plants. David and Pat in Abu (2016) stated that mechanical method involves the use of hand-on techniques as well as simple equipment, devices and natural ingredients that provide a protective barrier between crop plants and pests. Some of the measures, according to them, include field scouting, surveying, trapping, use of attractants, handpicking, hand smashing, vacuuming and trapping and exclusion devices. Some other measures include: style of crop cultivation, mulching garden areas to prevent weeds growth, hoe/pull weeds before they establish, stretch netting over some fruit plants to stop marauding birds from settling in and helping themselves in our harvest of ripe banana/plantain. Other measures include the use of heat, cold, light, humidity, carbon dioxide, sound and ventilation. Freezing can be used to kill wax moth and small hive beetle. Information collected from proper scouting and surveying assist stakeholders to identify when other actions need to be taken. Also use mechanical traps for rodents and hand-pick pests. Weeds could be slashed, rogued or hand-picked. These mechanical and physical controls in addition to other IPM methods keep different type of pests at damage low.

Chemical/Pesticide Control: Every effective and efficient IPM program includes pesticides for prevention and active treatment especially when other methods have not given the desired result. These chemicals/pesticides are toxic/poisons that could be in the forms of liquids, solids (granulated, compressed gas or powder), and or gas or combination of these. These are deliberately applied to control pests/pathogens. Its use, therefore, should be the last option when the damaging effects of pests have exceeded the acceptable manageable point. Horne and Page (2017) stated that the use of pesticides should just be a support tool to other strategies and not the primary control tool. Choice of pesticides (broad spectrum or selective) should not just on effects on pests or costs only, but also on their effects on beneficial organisms. However, whether broad spectrum or selective pesticides, method of application brings in different effects. For instance, a broad spectrum sprayed on a field will kill a range of both pest and beneficial organisms. However, when used in seed dressing or as bait, effects on beneficial organisms will be minimal. Many pests which do not respond to other measures of control are usually handled with pesticides. Conventional pesticides are synthetically produced compounds that are poisons and

are direct toxins (nerve poison, stomach poisons) There is need for precaution in the use of pesticides. IPM-appropriate pesticides include traditional/synthetic pesticides. These may be botanically-based pesticides extracted from different types of plants such as neem oil, pyrethrin from chrysanthemum blossoms. They may or may not be organic; hence they also require precautions in their use. There are guidelines and precautions in the use of pesticides as contained in the handbook of Federal Ministry of Agriculture and Rural Development. These include to study and follow the manual of instruction, choose pesticide based on type of pests, accurate measurement and proper mixing preferably outdoors/well ventilated areas, no eating/smoking/children in the vicinity. Other precautions include avoid using expired or wrong/fake chemicals, select appropriate nozzle to reduce volume of spray, use calibrated/graduated measuring cup, maintain appropriate nozzle height and ensure uniform spray. Although pesticides are useful in controlling pests, its effects on beneficial organisms should be noted.

Regulatory Control: These are usually government agencies mandated to stop the entry or spread of pests into an area or country via inspection, quarantine, destruction of infested materials and other methods. According to Okunade, Abiodun and Kanu (2017), the government has a role to play in ensuring that agricultural pests and disease pathogens are controlled. Some of these responsibilities especially pest control is being handled by the Produce Inspection Unit/ Institutions of the Nigerian Government. They are responsible to ensure that agricultural products are checked on arrival at registered produce stores/warehouses, proper fumigation of premises and processing factories; spraying and disinfecting produce stores, ship holds, hatches and containers with appropriate pesticides as well as advising government and other stakeholders on produce quality control and fumigation matters. Quarantining is one of the ways government controls spread of pests and disease pathogens across countries or regions (or at the local level, farms). New entries of crops or animals into the country/regions are observed by trained quarantine officers, scientists, experts and personnel for at least two weeks to determine their health status, if infected, the items are either sent back to their original home or destroyed, without allowing it into the new country. For migratory pests such as grasshopper and locust, there is usually collaboration between nations on measures of managing the scourge. National and regional governments pull their resources together and engage experts to find solution to confront such emergencies.

Sterile Insect Technique (SIT) or Genetic Method: Various attempts at reducing the effects of pests on agriculture have taken diverse ways as discussed earlier. This current technique started at about 1930 and 1940s in three extremely diverse intellectual environments as reported by Klassen, Curtis and Hendrichs in Dyck, Hendrichs and Robinson (2021). The idea was by releasing insects of pest species to introduce sterility into wild population, thus controlling them. According to the authors, SIT is usually applied as a component of Area Wide Integrated Pest Management (AW-IPM). Through auxiliary methods, the mated females are eliminated thereby reducing the density of their population. The procedure involves rearing large population of the target species and exposing them mainly to gamma rays to induce sexual sterility. They are then released into the target population. The released sterile males' mate with the wild females to prevent them from reproducing. This leads to the death and proper elimination of such pests. Although several approaches of IPM has been identified, the farmer has option of choice of the one to adopt in the farm. The farmers' decision to adopt or otherwise, therefore, will be influenced by knowledge level, capability and access to resources.

Sustainability Elements of IPM

The sustainable and successful IPM program has positive impacts on three main areas including sustenance of the ecosystem or positive environmental impact, economic empowerment of farmers and social equity that encourages friendliness and peace. These are discussed briefly.

Environmental Impact: The use of resources in acceptable form devoid of synthetics ensures the growth of bio-diversity. Soil fertility is maintained which encourages soil-organisms growth and productivity. Natural crop ecosystem balance helps to conserves the under-laying natural resources (soil, water and bio-diversity). They give their best when managed well. IPM also enhances ecosystem service delivery through pollination and the growth of healthy diversity of species. The beneficial effects of honeybees and other pollinating organisms is enhanced in environments devoid of synthetics and other chemicals. This means production of more healthy food. Ecosystem balance is maintained with different organisms attaining their peak levels without being injurious to other organisms in the environment.

Social Equity: IPM ensures that the environment is protected from destruction through the efficient

protective practices used in controlling pests, weeds and diseases. Interpersonal relationship is improved through healthier standard of living with the consumption of good organic foods, without fears of cancers and other terminal ailments. FAO in Daudu and Adebowale (2016) reported that about 25% of world's grain supply is contaminated by mycotoxins, with aflatoxin ranking highest. Aflatoxin is a potent carcinogenic material. In the case of natural nutrient recycling, the farmer has better understanding on the use of organic materials in maintaining and boosting nutrient supply through organic materials application at the right quantity. IPM promotes farmers stewardship through sound knowledge of ecosystem functioning adapted to their local context.

Economic Profitability: It increases farm productivity and food availability by reducing pre- and postharvest losses. Sawicka (2019) stated that about one-third of world's food production (1.4 billion tons) estimated at $1 trillion, is lost annually during postharvest operations and treatments. The loses, which occur at various stages of harvesting, drying, processing, threshing, transporting and storing, can be minimized with proper application of IPM from planting to the last stage of consumption. Equally, the quantity of residues of pesticides in water and food is reduced thereby providing healthy crops and animals for man's use. There is increase in farmer's income since cost of production is reduced. Healthier crops and animals are produced with minimal or no cases of 'killer beans', adulterated products such as honey or animal organs that have residual aflatoxins.

Challenges of IPM

Some of the major challenges of IPM include high technical know-how and cost hence and many of the local farmers are not willing to key into it. Other challenges are improper and inadequate practices of the program as against properly sequenced IPM program. Actually, what they do is Integrated PESTICIDE Management (Adulterated IPM). This puts IPM in a bad light, thereby discouraging new farmers from practicing it. IPM is labor intensive if all the activities are to be properly done (surveying, scouting, measuring and recording). Many farmers may not see it as a worthwhile exercise; hence adoption may be affected. Many of the activities may be affected by weather factors such as high rainfall, floods and fierce winds. In addition, IPM requires that the farmer quick decisions due to prevailing circumstances. This may be difficult for a number of (especially) local farmers. This hinders adoption.

Strategies for sustainable use of IPM

In order to encourage the use of IPM, farmers should be exposed to proper enlightenment on the proper use and the benefits derivable from engaging in it. Proper extension information on the various levels and stages of the practice so as to properly identify the most appropriate action to take at every point in time (identification of injury levels of pests). Information is also required on weather forecasts for good planning and management. Ezeh and Haliru (2017) and Rezaei-Moghaddam and Samiee (2019) observed that farmers adopted more IPM strategies when they worked with informed people who has social acceptance. Hence more of such persons should be identified and linked to farmers. In addition, if the harmful effects of synthetic pesticide use on health and environment is properly known by farmers, they will opt out and go for IPM. Farmers should always be encouraged to form co-operatives so that they can easily access resources (fund, inputs, information, loan). Extension agencies should organize exhibitions, field-days, workshops where some of the produce of IPM will be showcased so that more farmers will learn and adopt better. Equally, in the last option, (which is chemical use), appropriate measurements, dilution level and quantity spread at a point in time should be properly explained.

Conclusion

IPM is an effective and environmentally friendly approach to pest management with the least possible hazard to people, property and environment. It relies on a combination of common-sense practices involving current comprehensive information on the life cycles of pests and their interaction with the environment. However, from the articles reviewed, the researcher found out that chemical use was predominant, despite its hazards such as cancer, death as a result of food poisoning, emission of greenhouse gases, pollution of water, soil and air among other hazards. To curtail these, farmers should be encouraged by extension agents to use combination of environmental-friendly methods including cultural, biological, mechanical and improved varieties of crops and animals. IPM takes advantage of all appropriate pest management options including, but not limited to, the minimal use of pesticides. Effective use and proper coordination of all IPM strategies in agricultural, residential, public areas and even wild lands, gives a more cost-effective means of managing pests with low risk to natural resources.

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