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Implementation Strategies for Pest Management in Maize Crops in Uganda

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Abstract: *To reduce insect incidence on maize crops and increase farmers' yields and returns, "an integrated pest management (IPM)" method emphasizes the use of non-chemical inputs and the judicious use of chemical inputs in production. Pest management strategies have been studied, but there is little research on implantation strategies for pest management in maize crops in Uganda. There is a general lack of understanding of how technologies are implemented and used in farming systems. The major goal of this study is to evaluate the implementation strategies for integrated pest management in maize crops in Uganda. This study was guided by the specific objectives, namely; examining the philosophy of integrated pest management, assessing the strategies for integrated pest management among maize farmers in Uganda and identifying the pest management practices for lepidopteran maize stemborers in maize fields. Chemical, biological, host plant resistance, semiochemicals, and cultural control approaches such as crop rotation, intercropping, and planting date manipulation are the most frequently employed management options. The study concluded that there is a need for long-term stemborer management, especially given that the vast majority of Ugandan farmers are smallholders with limited resources. The study recommends that systematic destruction of maize residues must be avoided, mostly in areas with reduced wild habitat in order to preserve natural enemies for biological control.*

Keywords: Integrated Pest Management, Crops, Implementation, Strategies, Maize, Uganda

1. INTRODUCTION

Globally, maize production employs about 660 million person-days in farming and related businesses producing over 9% of total agricultural output, and maize is grown by over 15 million farmers. Due to its tremendous genetic yield potential, maize has earned the title of "Queen of Cereals." According to Fathipour and Sedaratian [1], "Integrated Pest Management (IPM) is an ecological pest management approach in which all available necessary procedures are consolidated into a cohesive program so that pest populations can be managed in a way that avoids economic loss and minimizes undesirable side effects."

According to Koppenhöfer *et al*. [1], IPM is a science-based decision-making strategy for identifying and mitigating pest and pest management-related dangers that has been around for a long time. It combines the use of pest biology [2], environmental data, and available technology to prevent unacceptable levels of pest damage while spending the least amount of money and posing the least amount of risk to people, property, resources, and the environment [2].
According to Sam *et al*. [3], maize (*Zea mays* L.) is a cereal crop grown in a wide range of climatic conditions around the world, from latitudes N 56 ° to S 40 °, below sea level to the Caspian plains at about 3000 m in the Andes forest and arid regions. A study conducted by Jilani *et al.* [4] found that maize is the most significant cereal crop in the tropics, and it is farmed in both irrigated and rainfed agricultural systems.
According to De Groote *et al.* [5], maize production varies by area, with global yields estimated at 1.014 billion metric tons per year. The United States of America and China are the world's top two maize producers, accounting for roughly 40% and 20% of total production, respectively [7]. In addition, other large-scale maize producers include Brazil, Mexico, Argentina, India, and France [8]. Maize is also used as a base for a range of cuisines and has strong preservation properties [9].

Eastern and southern Africa produce over two-thirds of all the maize produced in Africa [10]. Smallholders produce the majority of maize in these areas, accounting for more than 70% of total production and more than 80% of the total maize producing area [11].

Kenya consumes an average of 5.67 kg of maize products per adult each month [12]. By infesting the crop at all stages of growth, lepidopteran stemborers severely reduce potential maize yields [13]. Maize yield losses owing to lepidopteran stemborer attacks in Kenya have been calculated at 12.9 percent, or 0.39 million tons of the country's total annual maize crop [14], and local crop farmers have no knowledge on how to control stemborer. Hence, a big gap that needs more assessment.

Furthermore, to better manage these pests, an integrated pest management approach incorporating control components such as chemical, host plant resistance, biological, and cultural practices has been created [15]. Despite the fact that all of these control strategies are vital in the management of stemborers, the majority of them have inherent limitations that have a negative impact on resource-poor farming communities where they are often used. The cost of inputs, insect resistance, and inefficiency in reducing the pest population to economic damage thresholds have all been identified as important limitations of current approaches [16].

The paper provides an in-depth understanding of the implementation strategies for integrated pest management in maize crops in Uganda, the philosophy of integrated pest management, and the pest management practices for lepidopteran maize stemborers in maize fields. Sokame *et al.* [17] noted that in maize fields, a variety of approaches have been employed to control lepidopteran stemborers. However, their implementation strategies and their effects on maize productivity in Uganda were not fully addressed. The success of IPM in maize crop production in Uganda is critical in that it may add to existing knowledge in the search for the success of integrated pest management on maize crops for smallholder farmers, which is of great interest to policymakers and the general public in order to increase maize productivity; it may also be useful to the Ugandan government in order to sensitize the community against the use of integrated pest management in maize production.

2. LITERATURE REVIEW

2.1 Philosophy of Integrated Pest Management

IPM combines the best techniques of all control measures that apply to a specific problem caused by insect activity into a viable combination.

IPM has been characterized in a variety of ways, but the most scholarly definition is "the practical management of pest populations using solid ecological principles to limit pest numbers below a level that causes economic injury." "Practical" and "ecological" are the keywords here [18]. There are many methods for managing insect pests, but only a few are feasible and even fewer are environmentally friendly, resulting in an unwanted outcome.

It comprises a number of solutions, each of which may or may not greatly lower the Pest population, but when taken together, they will provide sufficient reduction to avoid economic losses. The use of all available methods in the design of a program to manage, but not eradicate, insect populations so that economic damage and detrimental environmental side effects are minimized, could be a modern definition of IPM [19].

2.2 Strategies for IPM among maize Farmers in Uganda

Participation of farmers in maize cultivation

Farmers' field schools, such as maize, have improved ways of cultivating crops via successive innovations to boost output [20], resulting in reduced famine.

Before the creation of crop-protection sciences and even before the major contours of pest biology were recognized, farmers devised numerous cultural methods for the protection of agricultural crops from insects and non-insect pests. Mechanical and physical control methods are employed [21]. Hence, farmers in Uganda should participate in plant breeding initiatives to promote the adoption of new enhanced pest-resistant varieties and, as a result, enhance productivity [22].

Until the late 18th and 19th centuries, when official study by on-station scientists began to promote farmer inventions in crop production and protection technology [21], farmers' innovations were the only source of improvements in crop production and protection technology. Farmers have been fully superseded in the research and development process by private industry and government agencies with the emergence of contemporary high-tech agriculture, which includes high yielding varieties, fertilizers, and pesticides. Agricultural experts develop technology, which is then distributed to farmers through extension services. As a result, researchers, extension workers, and non-governmental groups serve as consultants, facilitators, and partners to farmers, encouraging and empowering them to assess their own situation, experiment, and make well-informed decisions [23].

Legislative Measures

IPM stands for Integrated Pest Management, and it aids maize growers in saving money on insect treatment (Bueno *et al*., 2020). The indiscriminate application of broad-spectrum synthetic organic pesticides is an alternative to IPM. Unfortunately, while pesticide manufacturers and users (farmers) profit handsomely from their use, the expenses of pesticide use are passed on to the rest of society [25]. Hence, integrated pest management is a more cost-effective and tempting alternative [26].

Farmers are free-ride on the costs of implementing and monitoring a program, passing those costs to a group of farmers [27-28].

Improved Institutional Infrastructure

IPM is ineffective until a country's basic plant protection system is in place [26]. Wani *et al.* [27] noted that capacity for on-farm testing and technology extrapolation must be created and supported at the national level (use the facts for another situation). Babendreier *et al.* [28] added that the establishment of an IPM working group at the international level should help to organize and monitor the funding of IPM initiatives while also assisting in their implementation.

In addition, IPM is largely a knowledge-based technology, it demands the training of a wide range of stakeholders [29]. The majority of these groups, such as farmers, extension workers, and academics, today have only rudimentary training materials [30].

The majority of successful IPM programs in both developed and developing nations include a fairly precise system of monitoring and measuring many biological and environmental factors in the agro-ecosystem, which is a challenge in Uganda [31], and thus a need to fill.

Improved awareness among maize farmers

According to Dhawan and Peshin [31], more education and knowledge of the objectives, techniques, and impact of IPM initiatives are required at all levels, including legislators (Dara, 2019).

Policymakers and planners must be influenced that current agricultural production systems cannot be sustained without IPM [32]. Similarly, a lot of crucial information that could encourage a farmer to use IPM isn't readily available, therefore the farmer doesn't look for it. A pesticide manufacturer has no financial motivation to promote a program that employs fewer pesticides or even selective insecticides [33].

2.3 Successful IPM Implementation

Pest management practices for lepidopteran maize stemborers in maize fields

In maize fields, a variety of approaches have been employed to control lepidopteran stemborers [17]. Chemical, biological, host plant resistance, and cultural control approaches such as crop rotation, intercropping, and planting date manipulation are the most frequently employed management alternatives [37].

Most maize varieties are currently susceptible to stemborer infestations, which have resulted in substantial production losses [38]. Chemical pesticides are the most commonly used strategy in maize fields for controlling a variety of insect pests. Chemical mixtures of pyrethroids and chlorpyrifos, according to Schaafsma *et al*. [39], even at lower rates than advised, effectively reduce stemborer and autumn armyworm invasions in maize fields.

To control armyworm and stemborers, smallholder farmers in Ethiopia and Kenya use dry mixtures of sand and trichlorfon, formulated as granules or powder [40], applied into whorls with a plastic bottle, while mixtures of chlorpyrifos and sawdust reduce the amount of pesticide needed by 20% without sacrificing control [41].

Methyl and dimethyl carbamates of heterocyclic compounds, organochlorines, organophosphates, and carbamates such as carbofuran are all examples of chemical insecticides [42]. Chemical control can be used early in the season by applying appropriate insecticides, such as trichlorfon, as granules or dust to the leaf funnels of young plants.

Neem powder can be useful and should be added to the plant's funnel in a 1:1 ratio of dry clay or sawdust. For example, 1 kg of neem powder can treat 1500–2000 plants [43]. The majority of African farmers, on the other hand, cannot afford to purchase insecticides, which are rarely available on time [44].

Cultural Control

Stemborer thrives in maize-only cropping systems, which provide an ideal setting for it to proliferate quickly. This is accomplished by employing a combination of cultural and chemical control techniques [45], but they do use cultural control approaches such as maize intercropping to dissuade or kill pests [46].

Appropriate agricultural residue disposal after harvest might diminish diapause larvae of stem borers' carry-over populations, limiting their initial establishment in the following season's crop. Maize that is planted later in the season is less impacted by stem borer larvae than maize that is planted earlier in the season [47].

In Ethiopia, late-sown maize infestations by the second generation of Busseola fusca were observed to be larger (22-100 percent) than early-sown maize infestations by the first generation (0-22 percent) [48]. The genetic feature that allows a plant to avoid, lessen, tolerate, or recover from an injury caused by pests is known as host resistance to insects. These plants have genetic features that cause antibiosis, in which the pest's biology is harmed as a result of feeding on the plant. Furthermore, they may have hereditary features that appear as antixenosis (non-preference), in which the pest rejects the plant as a host and seeks other hosts [49].

Semiochemicals

The use of semiochemicals in habitat management systems referred to as "push-pull" has also been developed to repel the pests from maize plants and subsequently lure them to a more attractive barrier around the maize crop (Khan *et al*. [50]. The two most important trap crops that have since been used are *Pennisetum purpureum* and *Sorghum vulgare sudanense*, both fodder crops of economic importance. Two non-host plants repulsive to stemborers, namely *Melinis minutiflora* and *Desmodium uncinatum,* have been extensively used in the 'push-pull' system. These non-host plants grow alongside maize fields and emit volatile substances that repel (push) gravid female stemborers out of the field. The active chemicals detected in Melinis minutiflora and Desmodium uncinatum are (E)-ocimene, (E)-4,8-dimethyl-1,3,7-nonatriene, ß-caryophyllene, a-terpinolene, humulene, and a-cedrene, which are not found in trap plants.

However, the effectiveness of these attractive and repulsive plants towardslepidopteran stemborers is still not fully convincing (Calatayud P.-A., Le Ru, B., Sétamou M. & Schulthess F., pers. Comm.). Moreover, it has been recently observed that the use of *Desmodium uncinatum* might also be effective in the control of fall armyworm infestation, especially in the early and tasseling stages of maize growth phases [51].

Biological

The main attraction of this control is that it lowers the need for chemicals and there is limited environmental pollution, which may affect non-targeted flora and fauna. It usually offers a sustainable management of stemborer populations, hence beneficial to both smallholder and commercial farmers [52]. Dentichasmiasis busseolae (Heinrich) (Hymenoptera: Inchneumonidae), Pediobus furvus (Gahan) (Hymenoptera: Eulophidae) and Lepidoscelio spp. Xanthopimpla stemmator (Thunberg) (Hymenoptera: Ichneumonidae) are parasitoids of stem borers [53-54].

CONCLUSION

Pests inflict significant damage to maize crops in Uganda, owing to the fact that maize is planted during the warmer and wetter summer season, which provides an ideal habitat for the insect pests to proliferate swiftly and move to new areas. As a result, effective control should be done, as avoiding this pest is impossible without adopting long-term management.

Stakeholder engagement to ease on the understanding of the stages of the crop on which stemborers in Uganda can cause high economic damage, and the time for management application, as well as implementing low-cost agronomic practices and other landscape management practices for long-term pest management. There is need for long-term stem-borer management, especially given that the vast majority of Ugandan farmers are smallholders with limited resources.

RECOMMENDATIONS

Systematic destruction of maize residues must be avoided, mostly in the areas with reduced wild habitat in order to preserve natural enemies for biological control.

Further review should be conducted to develop female biased kairomonal lures from specific volatile signatures maize plants.

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