PROMISING IPM METHODS APPLICATIONS IN SUB-SAHARAN AFRICAN COUNTRIES

A.L. Marini[1]* , I. J. Presse[2], J. C. Thoméo[3]

[1] *São Paulo State University Institute of Biosciences Languages and Exact Sciences (UNESP - IBILCE), São José do Rio Preto, São Paulo, Brasil.*
** Correspondence: ana-laura.marini@unesp.br*

ABSTRACT

Integrated pest management (IPM) is a comprehensive approach that utilizes a variety of tools aimed at producing agricultural goods with minimal impact on human and animal health, as well as the environment. These tools include biological, mechanical, physical, and chemical controls, as well as cultural management, monitoring, and decision-making strategies. By integrating these approaches, IPM aims to increase productivity, reduce chemical usage, and improve food quality. However, in sub-Saharan Africa, IPM is still in its early stages of development, and agricultural pest control often relies heavily on the extensive use of agrochemicals. As a result, low productivity and poor food quality are common issues in these countries. Therefore, the primary aim of this work is to illustrate the feasibility of IPM techniques by presenting successful applications within Sub-Saharan African countries in order to encourage collaboration between practical and scientific knowledge and innovation within the realm of environmental biotechnology through the facilitation of knowledge exchange.

Keywords: Crop protection. Low-cost. Smallholder friendly.

1 INTRODUCTION

The dawn of agriculture marked a significant turning point in human civilization, representing the transition from nomadic hunter-gatherer lifestyle to settled agricultural societies. Through deliberate cultivation of crops and domestication of animals, early agricultural communities achieved important milestones such as food security, surplus production, and the capacity to sustain burgeoning populations. This change laid the groundwork for the development of complex societies and the growth of urban centers. In contemporary times, amidst the projected global population growth expected to reach 9.7 billion by 2050, with countries in sub-Saharan Africa expected to account for over half of the global population increase anticipated by 2050[1], the imperative of ensuring food security for the future world populace emerges as a major concern. As agriculture serves as the primary means of food production, the growth of global population necessitates not only an expansion of cultivated land, but also heightened agricultural productivity per unit area.

Among the array of challenges confronting agricultural crop production, pest infestations stand out, precipitating economic losses through diminished productivity and compromised product quality. As global temperatures continue to rise, there is an observable trend towards increasingly dissemination of plant pests and diseases. In response, agricultural practitioners have embraced intensive farming methods, which encompass the application of fertilizers, pesticides, and genetic enhancement techniques. However, the widespread utilization of synthetic pesticides and fertilizers has been linked with detrimental impacts on human health, biodiversity, and the resurgence of secondary pest populations and diseases[2]. Furthermore, the implementation of these methods frequently requires the utilization of specialized equipment, leading to a substantial escalation in production costs, thereby rendering their application unaffordable for small-scale producers. Another concern is the necessity for staff training in the usage of chemicals to prevent personal injuries and environmental damage. Consequently, the pursuit for sustainable alternatives to mitigate these challenges has arisen as a pressing global concern, with Integrated Pest Management (IPM) emerging as a prominent solution in this regard.

The practice of Integrated Pest Management (IPM) involves considering various pest control methods and integrating them appropriately to prevent pest population growth whereas minimizing the use of pesticides and other interventions that could be harmful to the environment[3]. The aim is to minimize disruption to ecosystems, maintain crop health and encourage natural pest control mechanisms while reducing risks to human health and the environment.

The main goal of this work is to present successful applications of IPM within sub-Saharan countries and other potential low-cost strategies that have been proven effective, in order to encourage the adoption of resembling strategies by smallholder farmers enduring pest issues in similar climatic conditions, cultural standards and crop plantations. This endeavor empowers local stakeholders including farmers, researchers, government authorities, and policymakers to glean insights from exemplary practices, novel technologies, and scientific breakthroughs in the domain of IPM encompassing the social and ecological dimensions of agricultural activities[3].

2 MATERIAL & METHODS

For the bibliographic survey of this review, articles were search using Google Scholar (https://scholar.google.com/) and ScienceDirect (https://www.sciencedirect.com/) to identify studies that examined the application of one or more Integrated Pest

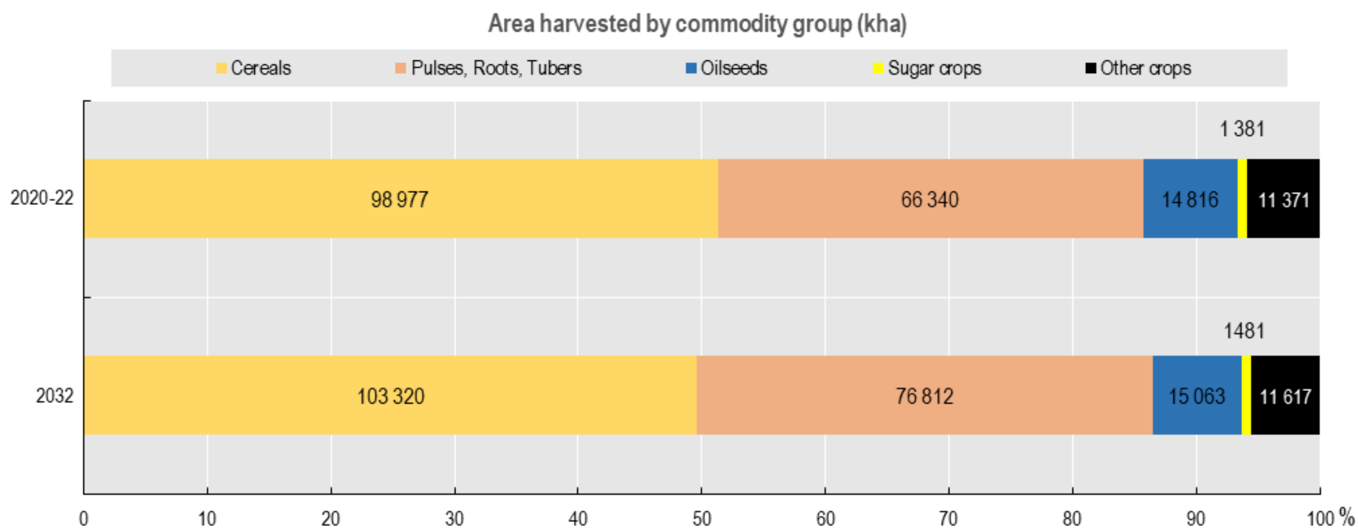
Management (IPM) methods in any of the Sub-Saharan African countries, regardless of publication year, land area, crop type, or pest species.

3 AGRICULTURE IN SUB-SAHARAN AFRICA

The agricultural sector exerts a significant influence on economic development across most sub-Saharan African countries, as evidenced by its substantial contribution to GDP. Economies in the region are heavily reliant on resource-based commodities like agriculture, oil, and mining, with agriculture contributing around 15% to economic output[4]. From 1990 to 2013, the total value of agricultural production, measured in constant US dollars, experienced a notable increase of 130%. The crop sector predominates, constituting nearly 85% of the total production value on average over this period. Smallholder farms comprise 80% of all agricultural holdings in sub-Saharan Africa, directly employing approximately 175 million individuals[4]. Defining a small farm is challenging and depends on several factors that may vary from country to country, but it is common for farms to be smaller than 20 ha. Despite high commodity prices, average per capita income levels are the lowest globally, ranging from less than USD 1,000 in the Least Developed Countries to USD 7,810 in South Africa and the region experienced a contraction of 5% in per capita GDP growth in 2020 due to the COVID-19 pandemic. Recovery has been slow due to global economic slowdown, tighter financial conditions, and limited funds for recovery efforts[4].

By 2032, the sub-Saharan Africa region is projected to account for 42% of global production of roots and tubers, 22% of pulses, 6.5% of cereals, 2% of oilseeds, and 6% of cotton[4] A 27% growth in food crop production over the next decade is expected, driven by a combination of intensification, productivity gains, and changes to the crop mix. Besides intensification, there is also an anticipated expansion of area in several crops, including roots and tubers, maize, rice, pulses, and other coarse grains. However, these increases will be partly offset by reductions in wheat and cotton production[4] (Figure 1).

Figure 1 Change in area harvested and land use in Sub-Saharan Africa.



Source: OECD/FAO (2023), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

4 IPM APPROACHES TO PEST MANAGEMENT

Biological Control (BC) stands out as one of the most employed and studied methods within the realm of Integrated Pest Management (IPM), not only within Sub-Saharan Africa (SSA) but also on a global scale. This approach involves the utilization of parasitoid, predator, pathogen, antagonist, or competitor populations to suppress a pest population, thereby reducing its abundance and minimizing potential damages[5]. A notable instance of successful BC implementation in SSA is exemplified by a program spearheaded by the International Centre of Insect Physiology and Ecology (ICIPE). This initiative aimed to mitigate the deleterious effects of stem borers by introducing larval, egg, and pupal parasitoids across Zambia, Mozambique, and Kenya[6]. Through the application of an economic surplus model, the program's efficacy and economic ramifications were evaluated, revealing a substantial positive influence on welfare valued at $1.4 billion across the aforementioned countries. Moreover, the program demonstrated commendable cost-effectiveness, boasting an internal rate of return (IRR) of 67% and an impressive benefit-cost ratio (BCR) of 33:1[6].

Another example is the application of BC against the weed parthenium in Ethiopia involving the utilization of two natural enemies: the leaf-feeding beetle *Zygogramma bicolorata* and the stem-boring weevil *Listronotus setosipennis*. A study conducted in two regions of Ethiopia one year after the release of these agents revealed contrasting outcomes: in one region, *L. setosipennis* thrived while *Z. bicolorata* was not detected, whereas in the other area, significant numbers of *Z. bicolorata* were found but *L. setosipennis* was absent[7]. This disparity suggests varying degrees of adaptation to environmental conditions, emphasizing the importance of selecting specific methods tailored to each type of region and its unique conditions.

An innovative, effective, low cost and environmentally friendly method is the push-pull technology, which aims to redirect insect pests, such as stem borers, away from the primary cereal crop and field. This technique combines intercropping and managing field margins strategies by interspersing the main crop, typically cereals, with a pest-repellent forage legume, exerting a 'push' effect. Simultaneously, an attractant fodder (such as *Napier grass*, *Pennisetum purpureum*, or *Brachiaria* spp), which exerts a 'pull' effect, is planted along the perimeter of the field[8]. The effectiveness of climate-adapted push-pull technology has been demonstrated in some studies. For instance, in maize farms in East Africa, the control of the *Spodoptera frugiperda* pest resulted in an 86.7% reduction in yield damage by utilizing drought-tolerant plants as both 'push' and 'pull' crops[9].

Methods intended at maintaining soil quality, such as minimum tillage, application of manure, compost and residue mulching, can be seamlessly integrated with ongoing efforts to promote a favorable microclimate[8]. Positive outcomes were observed following the implementation of these methods, leading to a significant reduction in the damage in maize caused by the Fall Armyworm (FAW) in Eastern Zimbabwe[10]. Cultural practices that foster the growth of robust plants are crucial because healthier plants tend to be less vulnerable to attacks by insects and pathogens. For this purpose, practices aimed at increasing the diversification of the farm environment, through the adoption of crop rotation, enhanced structural diversity provided by trees and shrubs, are beneficial for improving soil and crop health and protecting them from pests[8]. These practices can promote the increase of natural enemy communities, natural soil fertilization, and the supply of woodfuel, timber, and fodder. In essence, diversity is a crucial element, as different natural enemies may excel in controlling various pests, targeting it at diverse developmental stages or during different seasons[8].

5 CONCLUSION

The review highlighted the urgent need for more research and studies on this subject, given the significant knowledge gap resulting from neglect towards developing countries. It is essential to support small-scale producers through investments in agricultural research and development, extension programs aimed at educating and empowering farmers, and facilitating the transfer of technologies and knowledge.This work addressed the successful implementation of integrated pest management in sub-Saharan African countries, such as other potential low-cost approaches, demonstrating that IPM can be a powerful strategy to increase productivity and mitigate social problems. Techniques such as biological control, crop rotation, intercropping, and natural fertilization have been used, and the results have been promising economically, socially, and environmentally. Therefore, it is essential to support small-scale producers through investments in agricultural research and development, extension programs aimed at educating and empowering farmers, and facilitating the transfer of technologies and knowledge. In light of the foregoing, the importance of continued investment in IPM research to enhance food production and reduce poverty levels in affected regions becomes evident.

REFERENCES

1. U. N. Population Division (2020). World Population Prospects 2022: Summary of Results.

2. SAMANTA, S. et al. 2023. Impact of pesticides on beneficial insects in various agroecosystem: a review. Int. J. Environ. Clim. Change, v. 13, n. 8, 1928-1936.

3. DEGUINE, J. et al. 2021 Integrated pest management: good intentions, hard realities. A review. Agronomy for Sustainable Development, v. 41, n. 3. 38-73.

4. OECD-FAO. 2023. 'OECD-FAO Agricultural Outlook 2023-2032', Technical report, OECD, and Food and Agriculture Organization of the United Nations).

5. VAN DRIESCHE, R; BELLOWS JR, T. S. 2012. Biological control. Springer Science & Business Media.

6. SOUL-KIFOULY, G. M. et al. 2016. Assessing the long-term welfare effects of the biological control of cereal stemborer pests in East and Southern Africa: Evidence from Kenya, Mozambique and Zambia. Agriculture, Ecosystems & Environment, v. 230. 10-23.

7. ALEMAYEHU, L; MERSIE, W. 2019. Survival and dispersal of the stem-boring weevil, *Listronotus setosipennis*, and the leaf-feeding beetle, *Zygogramma bicolorata*, one year after their release for the control of the invasive weed, *Parthenium hysterophorus*, at two locations in Ethiopia. Journal of Biological Control. 178-184.

8. HARRISON, Rhett D. et al. 2019. Agro-ecological options for fall armyworm (*Spodoptera frugiperda* JE Smith) management: Providing low-cost, smallholder friendly solutions to an invasive pest. Journal of environmental management, v. 243. 318-330.

9. MIDEGA, Charles AO et al. 2018. A climate-adapted push-pull system effectively controls fall armyworm, *Spodoptera frugiperda* (JE Smith), in maize in East Africa. Crop protection, v. 105. 10-15.

10. BAUDRON, F. et al. 2019. Understanding the factors influencing fall armyworm (*Spodoptera frugiperda* JE Smith) damage in African smallholder maize fields and quantifying its impact on yield. A case study in Eastern Zimbabwe. Crop protection, v. 120. 141-150.

ACKNOWLEDGEMENTS

We acknowledge with gratitude the financial support of the senior author's fellowship provided by Coordination of Superior Level Staff Improvement – CAPES.