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Pest Control in Agroecological Systems

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Abstract— *Agriculture changes and adds technology to increase production, the impact on ecosystems also increases, causing degradation and important losses of its main functions. These functions are represented by ecosystem services, including biological control of pests and diseases. This article aims to identify and report mechanisms triggered and responsible for the effective control of pests and diseases in an agroecological system. The pursuit of this objective took place through a bibliographic survey in databases, by subject, through the use of strings and operators to refine the searches in a previous eleven-year horizon. These searches revealed some strategies that can be used to control pests and diseases without the need for more aggressive management with the use of industrial inputs. The functionality and permanence of ecosystem services, such as pollination, nutrient cycling, microclimate regulation and increased soil fertility, depend on maintaining biodiversity in Agro-ecosystems. The adoption of such strategies by small farmers depends to a great extent on the work of Technical Assistance and Rural Extension that can promote the dissemination of the necessary knowledge for the adoption of these practices.*

I. INTRODUCTION

Perhaps the first big moment for humanity was the emergence of agriculture. From then on, man began to leave nomadism to devote himself to the domestication of plant and animal species, with the aim of producing their food. From a passive condition towards nature, exercising activities of gathering and hunting, the human species starts to develop activities that will change the landscapes.

As a producer, man experiences significant and successive improvements in his living conditions. The improvement in living conditions resulting from better and abundant food causes an increase in the world population. And the need for more and more food. This spurs agricultural activity to seek technology that will increase production and productivity to feed an ever-growing human population. This succession of discoveries and incorporation of more and more technology in the field took the world, from the mid-nineteenth century and culminating in the second half of the twentieth century, the so-called Green Revolution (Velho, Stadnik, Poltroniere, &Mondino, 2019). Mainly characterized by the energy use of industrial inputs (Vieira et al., 2020), this revolution significantly increased the production of commodities, in extensive monocultures, radically changing the relationship between man and the countryside. Ecosystems undergo profound changes to provide Agroecosystems capable of meeting the requirements of modern industrial agriculture.

Agriculture, more than a sector of economic activity, is a treaty on the relationship between man and nature. This relationship needs to be a two-way street. There needs to be a balance in the flow of this

path. Since the Green Revolution, with the advent of industrial agriculture, this balance has been undone.

Over a long period of his life Marx wrote many letters and notes that reported on his studies in areas such as biology, chemistry, agriculture, geology and mineralogy. In these, the breaking of this balance was referred to, as the need to rehabilitate the metabolism between human beings and nature in the production of food and other materials:

> This metabolism refers to the set of transformations of material exchange that occur in the complex interdependent relationships between man and nature. With the concentration of people in urban centers and large-scale agricultural production, this metabolism was disrupted and we are experiencing the consequences, especially related to environmental degradation, social exclusion and food insecurity. (Steenbock, Vezzani, Coelho, & Silva, 2020, p. 49).

As agriculture changes and adds technology to increase production, the impact on ecosystems also increases, causing degradation and important losses of their main functions.

In this process of more and more intervention in the natural environment, with the resulting loss of biodiversity, there seems to be a real *trade-off* between food production and nature preservation.

In the impossibility of making such a choice, man looks for alternatives to produce food with environmental preservation. In this case, the preservation of the environment implies the maintenance of the agroecosystem's biodiversity. To produce food and maintain biodiversity, it is necessary to understand the functioning and relationships between organisms that inhabit a given environment.

In view of the above scenario, the question that arises is which mechanisms are triggered and responsible for the effective control of pests and diseases in an agroecological system?

This article proposed, as an answer to that question, to identify and relate the mechanisms that are triggered and responsible for the effective control of pests and diseases in an agroecological system.

II. METHODOLOGY

In pursuit of this objective, a bibliographic survey was carried out in databases, by subject, through the use of *strings* and operators to refine the searches. (Pizzani, Silva, Bello, & Hayashi, 2012)

The search *strings* were obtained from the research questioning, using synonymous terms that were related in terms of content, combined through "OR" and "AND" operators. Thus, expressions such as: "pest management" AND "Agroecology" OR "agrobiodiversity" were used. At times, the return was very high, requiring some refinement. For example, when searching for the descriptor "agroecology" AND "pest management" in Google Scholar, we had the return of more than 19,000 (nineteen thousand) publications. In view of such an offer, we reduced the research horizon to the last four years. We obtained important contributions through Capes Periodicals, via institutional access using the following descriptor: "agroecology" AND "pest management". In this same portal, a search by base was carried out, using the following itinerary: Search base => by Areas of knowledge => Agricultural Sciences => subcategory => Agronomy => Bibliographic Base of Brazilian Agriculture – AGROBASE.

Searches performed outside the Capes Portal, directly on the *Web of Science* site , used the following descriptors: "agroecology" OR "pest management" OR "ecosystem services", " *pest management* " AND " *strategy* " AND " *agrobiodiversity* ", and also, " *integrated pest management* " AND " *biological control* " AND " *agrobiodiversity* ".

The longest horizon used by the above-referenced searches was 11 years, that is, from 2010 onwards. According to the return, this time was reduced, according to the situation previously reported.

The table below summarizes the databases consulted, with their respective *strings* and operators.

Table 1: Bases and descriptors

base	Descriptors
Capes Periodicals via CAFE	"agroecologia" AND "manejo de pragas"; "agroecology" AND "pest management"
Google Scholar	"agroecologia" AND "manejo de pragas" "agroecology" AND "pest management"

Web of Science	"agroecologia" OR "manejo de pragas" OR "serviços ecossistêmicos";
	"*pest management* " AND "*strategy* " AND "*agrobiodiversity* ";
	"*integrated pest management* " AND "*biological control* " AND "*agrobiodiversity* ".

Source: Authors

Based on the problem and, consequently, on the objective of the research, and also using the descriptors defined in the bases presented, a selection of articles was carried out to be used as subsidy for the present work. This choice and exclusion process considered the relevance of the article to the research, translated into its ability to respond to the question presented. This selection was initially made by consulting the abstract, and later deepened according to its importance. The chosen ones were read in records for citation.

The figure below illustrates, in summary, all the stages of carrying out the research, as described in the previous paragraphs.

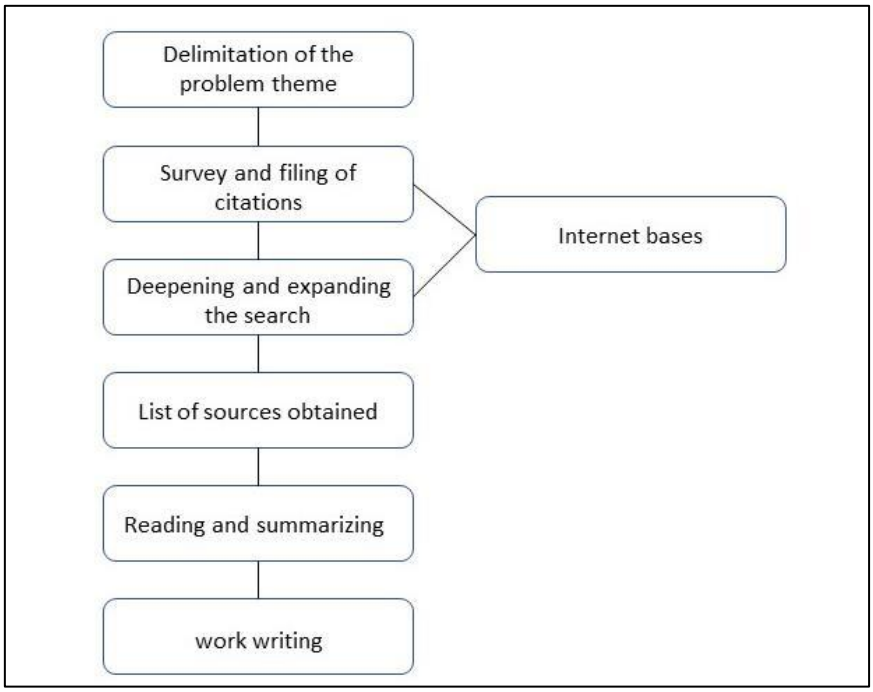

Fig.1: Stages of the literature review (adapted from Pizzani et al., 2012)

It is opportune to inform that the work did not dare to exhaust the theme, but to seek in the literature the mechanisms triggered in ecologically-based agroecosystems that have the property of maintaining control of organisms that may cause damage to crops. Given the multiplicity of relationships that can occur between organisms and the environment, it would be very pretentious for these authors to seek the exhaustion of the subject. However, the contribution presented here may support further research on a topic of fundamental importance and increasingly relevant to technological development, both in agriculture and biology and other areas of human knowledge.

III. RESULTS AND DISCUSSIONS

According to Foley et al. (2005 apud Pumariño et al., 2015) deforestation and agricultural intensification are the main causes for the loss of biodiversity and associated ecosystem services. It is known that the conventional model, based on monoculture and the intensive use of chemical inputs and heavy machinery, by promoting simplification and aggressive management of the natural ecosystem, ends up impoverishing it, interfering with its biological balance. In the future, this impoverishment promotes a loss of productivity, as more and more chemicals are used to correct imbalances to correct the soil and compensate for nutrient deficits.

In addition to these environmental and productivity aspects, the growing global awareness of the dangers exposed to human health through the use of

chemical inputs, especially insecticides to control pests and diseases, deserves special mention.

According to Pérez-Consuegra, Mirabal and Jiménez (2018), in the last 20 years the number of actions promoted by numerous organizations and institutions around the world has grown. Also according to the authors, among the most recent actions, it is worth mentioning that on the occasion of the 34th round of sessions of the Human Rights Council of the United Nations, which took place between February 27 and March 24, 2017, the Special Rapporteur on the right to Hilal Elver recommended going beyond voluntary instruments for the international community to craft a comprehensive and binding treaty that includes *developing policies to reduce pesticide use worldwide and a framework for the prohibition and phasing out of highly hazardous pesticides* .

A balanced environment provides the necessary conditions for plants to harmoniously coexist with pests and diseases, without harming crops. Thus, it is observed that in these situations:

> The plants are well adapted to the place they are living, there is sufficient quantity and quality of nutrients in the soil. It has an abundance of life, has good humidity conditions, there is an incidence of light in the system and the presence of predators and biological pests and diseases controllers. (Zanuncio et al., 2018).

This imbalance that impoverishes the Agroecosystem's biodiversity ends up leading the system to a loss of productivity.

All elements, biotic and abiotic, of an ecosystem play a role. An ecosystem in balance is one in which its components live in harmony, providing the existence of so-called ecosystem services.

For Cabral and Fukuda (2015), ecosystem services are the direct and indirect contributions of nature to the economy and human well-being, developed in a sophisticated way over millions of years. The same author also lists some of these services, such as: regular rain replacing the supply of water, CO_2 sequestration, pollination by insects and other animals, and corals and mangroves that prevent the sea from advancing on islands and continents.

The occurrence of these services depends on the diversity of organisms present in the ecosystem, in addition to a harmonization between biotic and abiotic elements. Furthermore, biodiversity is one of the basic principles of sustainable agriculture, food security and health, as well as a necessary strategy to manage systems towards sustainable Agroecosystems (Kazemi, Klug,&Kamkar, 2018). These authors further reinforce that "today, the most important challenges of modern agriculture include pest control, CO_2 emissions and genetic erosion.

In terms of agroecological control of pests and diseases, unlike what happens in conventional agriculture, the aim is to attack the causes and not the effect. The use of strategies that avoid pest attacks and the action of pathogens requires knowledge about the functioning of agroecological systems, in order to promote their diversity and balance. As stated by Zanuncio et al. (2018) the agroecological pest management seeks to promote the balance of the system, reducing the pest insect population and increasing the population of beneficial insects.

Berte Filho (2010 p. 7, apud Caetano, 2020) conceptualizes biological control as "a natural phenomenon that consists in the regulation of the number of plants and animals by natural enemies, which constitute the agents of biotic mortality".

With regard to insects, when proposing a management strategy, it is important to note that they are present in nature in order to maintain biological balance.

> Alternative management seeks to holistically observe natural cycles, respecting the interrelationships and proportions of the environment, working with systems where all factors are interdependent. (Zanuncio et al., 2018).

In an ecologically-based agricultural environment, therefore, with a high degree of biodiversity, there are a variety of ecosystem services of great importance in the production process, at least for this production model, such as pollination, nutrient cycling, microclimatic regulation and increased soil fertility. (Sugii et al, 2010, apud Venzon et al., 2019).

Also according to those authors, the functionality and permanence of ecosystem services depend on the maintenance of biodiversity in Agroecosystems. Table 2, below, presents the strategies studied by the authors for the maintenance of biodiversity.

Table 2: Biodiversity maintenance strategies

Strategy	Characteristics	Action to control pests and diseases
Agroforestry Systems	• Consortium of agricultural crops and tree species; • Microclimate moderation; • Increased water and nutrients;	• Increase the population of natural enemies; • It makes it difficult for pests to find crops; • Use plants with characteristics that favor biological pest control.
Consortium with aromatic plants	• Produce and spontaneously release repellent, deterrent or toxic organic compounds	• Attract predators and parasitoids; • Provide food and shelter; • Oviposition site and alternative prey.
Management of wild plants	• Uncultivated areas close to cultivation; • Secluded places, around and between crops.	• They attract natural enemies; • Management can increase the effectiveness of biological control.
Cover plant management	• Green fertilizers - pulses, grasses	• Improve the physical, chemical and biological characteristics of the soil; • They attract predators.
Management beyond the cultivated area	• Diversity of habitats within the property: native, varied crops, permanent, perennial, fallow, etc.	• The diversity of environments and stages of their evolution favors a greater abundance of natural enemies and greater biological control.

Source: adapted from Venzon et al.(2019).

The table above shows that pest and disease control mechanisms occur through a process of interaction between species of organisms, plants and the environment. Thus, in the structuring of a given Agroecosystem, these relationships must be deeply known, so that the result obtained is what is really expected.

A study by Togni, Venzon, Souza, Santos andSujii(2019) demonstrated a positive relationship between biodiversity conservation and the provision of biological control ecosystem services in small farms. Less aggressive and more diversified management promote the maintenance of biodiversity and more sustainable pest control.

In the case of plants specifically, they can repel, attract and even be used as traps.

For example, when cultivating cassava, the sweet potato can be used to attract the ant and thus protect the main crop. Of course, other situations must be evaluated, as usually only cassava is cultivated. In addition, sweet potato is an attraction for ants, but it is still necessary to assess what other implications may arise from this association of crops. (Marti, Küster,&Quemel, 2010).

To illustrate, Table 3 below presents some plants that can be used to protect gardens.

Table 3: Plants for the protection of vegetable gardens

Plant	control action
Basil	The smell repels flies and mosquitoes. However, it should not be planted near the rue
Garlic	Effective as a tomato pest repellent
Rosemary	Keeps away the cabbage butterfly and the carrot fly
Anise	Moth repellant
little hood	Repels nematodes and insects
citronella	It repels insects, including mosquitoes such as Aedes aegypti

Coriander	Controls aphids and mites
marigold	Protects from nematodes (attractive)
Geranium	Natural insect repellent. It's always good to have them in your garden, they beautify and protect
Sunflower	Excellent insect repellent, through its leaves and flowers and attracts pollinating insects
Mint	The smell repels Lepidoptera such as the cabbage butterfly, ants and rats. It can also be planted as a border for crops
Basil	Fly and Mosquito Repellent
masthead	Repels aphids and other insects
Sage	Repels the cabbage moth
Tagetes	Natural repellent of many insects and protects against nematodes
Thyme	Keeps the butterfly away from the cabbage
Nettle	Repels the tomato bug. Also try planting green onions, lavender and marjoram around them.

Source: Adapted from Marti, Küster and Quemel(2010).

A study by Andrade et al. (2020), with the planting of sweet potato in Sergipe concluded that Integrated Pest Management can result in a significant reduction in the use of organosynthetic insecticides with a consequent reduction in social, environmental and ecological problems, provided by the survey of the main pests and natural enemies that occur in cultivation.

IV. CONCLUSIONS

The agroecological management of pests is increasingly finding support from the consuming public, which seeks healthier food, free of chemical products, produced through environmentally sustainable and socially responsible management. In this aspect, in addition to the production process (conventional or organic) the origin of the product (local family or regional industrial) becomes relevant.

Another important aspect in the dissemination of biological pest management strategies is related to the need to popularize the knowledge of techniques among small producers, mainly. In this sense, the role of public, class and private entities to promote Technical Assistance and Rural Extension actions becomes fundamental. Universities, public authorities, especially at state and municipal levels, Unions and producer associations need to mobilize efforts to promote the dissemination of this knowledge.

Reinforcing the above aspects, as a way of showing the importance of ecosystem services, is their valuation. The incorporation of these services by the economic system can reinforce their importance and the need for preservation. When we begin to understand that the cost imposed by the loss of productivity and the time to recover degraded areas by conventional agriculture could be avoided with the ecological management of Agroecosystems, we will be able to get a sense of the value of the services provided by ecosystems in balance.

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