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Territorialization of the Agroecological Pest Management System in Cuba

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Abstract

The fight against agricultural pests in Cuba has gone from control to the substitution of chemical inputs with biological ones, the integral management of the crop, the production system and the agricultural territory. As a result, in the last 20-25 years it has been converted to a Pest Agroecological Management (APM) system. Several factors are contributing to the territorial scope of the APM system, although this transformation would not have been possible without the massive accumulation and experience since the creation of the ETPP network in 1974-75, the regulations on the use of chemical pesticides, the biological control program since 1988 and the implementation of IPM since 1989. The APM has been consolidate from the ends 20-25 years and it is applied in the 70-75% of the agricultural cultivated area in the country, which mainly includes peasant systems, urban and suburban agriculture, among others that are in agroecological transition, facilitate the conservation of natural enemies that inhabit the systems and of the biological control agents that are released or applied.

Keywords: Agroecology; Transition; Pest management; Territories; Cuba

Introduction

Modern agriculture has been set on the path of a pesticide treadmill. However, the appearance of about 586 species of insects and mite's resistant to 325 insecticides and about 195 species of weeds resistant to 19 herbicide modes of action, coupled with secondary pest outbreaks that commonly occur in pesticide-loaded crops due to elimination of natural enemies, indicate that chemical technology is reaching its limits [1]. In recent years, attention has been drawn to the pest control approach with pesticide products, which is known internationally as protection and defense of crops. This technological approach, which was developed since II World War and characterized the period of the green revolution, has been highly criticized, mainly because it contributes to what is called the vicious cycle of pesticides, by creating a high dependence on these products by farmers, in addition to the undesirable effects they cause on the environment and biodiversity, among others. There is an urgent need for sustainable pest control and crop production methods that can allow croplands to provide multiple ecosystem services that are being lost with the current agricultural practices [2,3].

In Cuba, research on agricultural pests dates back to the beginning of the last century, with the creation of the former Agronomic Experimental Station in Santiago de Las Vegas, on the outskirts of Havana in 1905 [4], which continued later and were reinforced since the seventies, with the creation in the Ministry of Agriculture of the Institute of Plant Health Research (INISAV-Instituto de Investigaciones de Sanidad Vegetal) and several specialized institutes (soils, irrigation, mechanization, fruit trees, rice, vegetables, roots and tubers, tobacco, pastures and forages, coffee and cocoa, forestry), who in addition to universities and their research centers, have studied pests, methods of control and crop management in various research programs, which have contributed to a transition in the management of pests. During the last 50-60 years, agriculture in Cuba has been characterized by two contrasting production models:

a. The development of conventional agriculture, green revolution type, between 1965-1994 and

b. The conversion to an agroecological agriculture, since 1995, whose influences on pest management have been significant.

Precisely, in 2019 the Pest Agroecological Management (APM) system developed in Cuba received an award from the World Future Council (WFC) (https://www.worldfuturecouncil.org/food-security/), under the call Outstanding Practices in Agroecology 2018, based on criteria on the ten elements of agroecology promoted by FAO and the Technology for Agroecology in the global South (TAgS) initiative. This article provides an overview of the transition to agroecological pest management at the agricultural territories of Cuba.

Transition of Pest Management

The fight against the causal organisms of agricultural pests in Cuba has transited with the predominance of different strategies:

a. chemical control (scheduled applications) before 1974;

b. optimization of chemical control by the plant health service, since 1974;

c. integration of biological control (local productions) since 1988;

d. integrated crop management (integrated pest management programs) since 1989;

e. adoption of agroecological pest management since 1993

f. territorialization of agroecological pest management since 2008 (Figure 1).

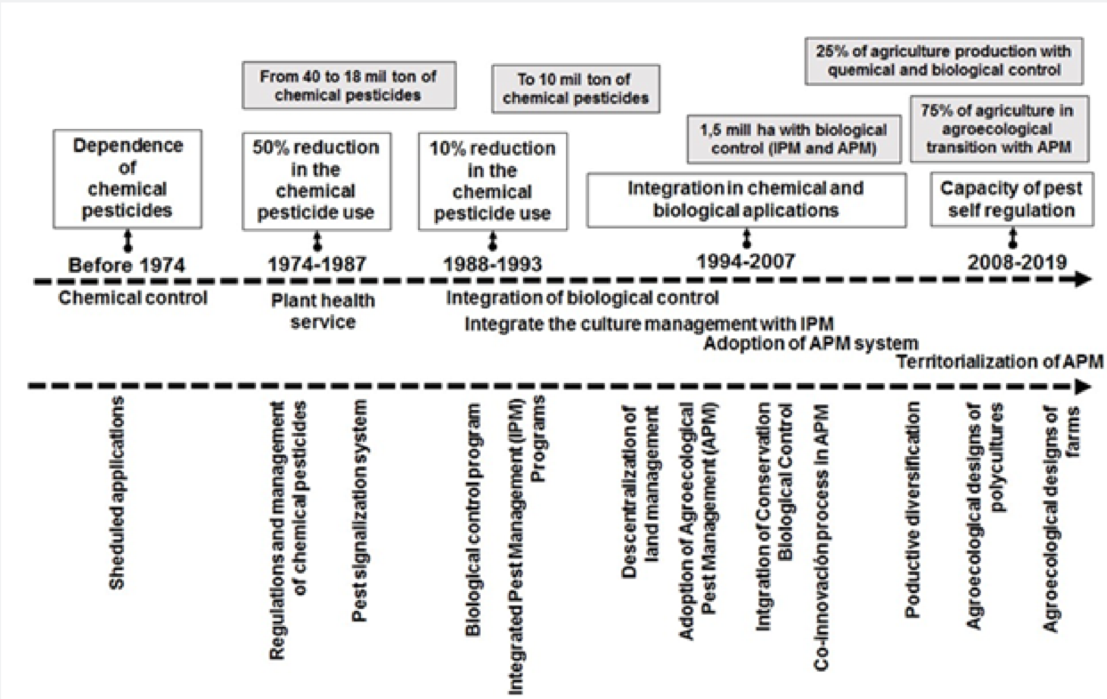

Figure 1: Timeline representing the transition of pest management in the agricultural production of Cuba.

Chemical control and plant health service. Agrochemicals were introduced in Cuba in the 1940s and eventually became a cornerstone of Cuban agriculture. Cuba, like many other developing nations, was highly dependent on imports of these products. The government promoted the ever-increasing use of pesticides in an effort to boost production of both exports and locally consumed crops [4]. In 1964, the first technical standards aimed at the programmed applications of chemical products in crops began to be edited, as an unavoidable need for the fight against pests, which had increased because of the progressive increase in planting areas, the low technical level prevailing in the farms and cooperatives and the need to guarantee the indispensable food for the population [5]. This led to a new import line for the country, since in this period the control of pest organisms was based almost exclusively on the use of synthetic pesticides [6]; as a consequence, negative externalities began to manifest themselves, mainly resistance of populations of insect pests, effects on soil biota, pollution and high import costs.

For this reason, during the years 1974-1975 the Ministry of Agriculture (MINAG) reorganized the plant health service as a system, stratified into three levels: national (a National Directorate and several central laboratories of Diagnosis, Pesticide Chemistry, Biological Control and Experimental Station); in each province (by a Provincial Directorate and Laboratory of Plant Health-LAPROSAV) and in 76 agricultural areas by Territorial Plant Protection Station-ETPP [7], this being the beginning of the territorial management of plant health. The ETPP perform functions of inspection of phytosanitary legislation (Decree-Law 153 of the State Council On plant health regulations, August 31, 1994) in the lines of plant protection, plant quarantine, diagnostic services, pest signaling and plant health education, articulated with productive organizations (companies, cooperatives) and farmers [7].

As a result, during the 70-80 years a system to regulate the use of chemical pesticides was consolidated, which has allowed management the types of products to avoid the emergence of

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resistance, gradually replacing products with high residual and broad spectrum of action, privilege new generations of products with lower application doses and faster degradation once applied [8] and perform good practices in the applications of these products [9]. On March 23, 1987, a joint resolution was issued MINAG-MINSAP (Ministry of Public Health) that created the Central Registry of Pesticides. So that chemical pesticide applications do not constitute risks to the health of agricultural workers and the consumption of food of agricultural origin, there is a research system to determine the degradation kinetics of these products and establish national maximum residue limits (MRLs) [8] and the waiting time for entry to the fields [10].

The first impact of the plant health system was the reduction in 1974-1975 of 50% or more in the use of chemical pesticides, which amounted to 40 million tons annually [6], because of the system of pest signaling, which consists of the ten-days monitoring of representative fields of the territory and the issuance of notice to farmers to review their fields and decide on the start of pesticide applications [8]. Integration of biological control. The success of the program of biological control of the sugar cane borer (*Diatraea saccharalis*) with the parasitic fly *Lixophaga* diatraeae, generalized in the producing areas of this crop in the country since the late forties, contributed to not using chemical insecticides in this crop (Fuentes et al 1998) and influenced a positive perception of this pest control method.

The fact that in the 1960s the first biological products that were based on *Bacillus thuringiensis* (Bt), the subsequent entry into the country of some Bt formulations, the success of the Bt, also influenced the biological control in Cuba, achieved in the first tests in the control of the tobacco bud (*Heliothis virescens*) and the false grassworm (*Mocis latipes*), stimulated interest in the search for native strains and the development of technologies for national production [11]. From various interdisciplinary research that had been carried out since the mid-1970s, in 1988 the MINAG created the National Biological Control Program, which is based on mass production technologies generated in the country, which were implemented in redesigned facilities to operate as laboratories that are named: Entomophages and Entomopathogenic Reproduction Centers (CREE), which during the 1990s amounted to 220 and subsequently four Biopesticide Plants were created. All these facilities are located in the main agricultural territories of the country and are managed by the agricultural companies and cooperatives themselves.

13 species of entomophages are multiplied, of these *Trichogramma spp*. and *Lixophaga diatraeae* for augmentative releases and the rest inoculative; four species of predatory mites for inoculative releases; the ant *Pheidole megacephala*, which multiplies in reservoirs for inoculative releases; a kind of entomonematode (*Heterorhabditis bacteriophora*) for augmentative applications; *Bacillus thuringiensis* bacteria for augmentative applications; four species of entomopathogenic fungi (*Beauveria bassiana, Metarhizium anisopliae, Lecanicillium lecnii, Paecilomyces fumosoroseus*) for augmentative and inoculative releases; two species of Trichoderma for inoculative and augmentative applications [12,13]. These productions work through a certified strain delivery system, production quality control and determination of their effectiveness in fields, that cover annually an area of 1.7 million ha of crops.

Integral crop management and IPM. From the second half of the seventies years, with the rise of the then named Integrated Struggle, promoted by Professor [5], cultural practices, the use of varieties and others as components in the fight against pests were revalued, until that since the mid-1980s several Integrated Pest Management (IPM) programs began to be proposed, which contributed to the optimization of the use of chemical pesticides and the integration of biological control [14,15]. The IPM programs developed in Cuba, due to their degree of complexity, can be for a key pest in a crop, for a polyphagous key pest, for several key pests in a crop, for several key pests in polycultures and consider, among their components of greater importance are the following:

a. Training,
b. territorial coordination,
c. scientific-technical services,
d. legal and organizational regulations,
e. monitoring for decisions,
f. agronomic practices,
g. biological control,
h. physical-mechanical control,
i. ethological techniques,
j. pesticide management.

In conventionally based farming systems, IPM has contributed to the integration of chemical and biological pesticides, such as tomatoes (*Solanum lycopersicum*) and cabbage (*Brassica oleracea* var. Capitata), crops in which, ten years after the massive use of biological control agents and its integration in IPM programs has been generalized, the average of chemical applications was very similar to the biological ones in tomato cultivation and higher for the latter in cabbage (Figure 2). However, it is evident that the substitution of inputs, although reducing the pressure of selection of resistant populations and the toxic load by the use of chemical molecules, is not a sustainable practice in these systems, because a high number of applications is required, which means greater soil compaction, use of water and energy. the objective is to overcome the limiting factor, although this time it is done with alternative and non-agrochemical inputs. This type of management ignores the fact that the limiting factor (a pest, a nutritional deficiency, etc.) is nothing more than a symptom that an ecological process does not work properly, and that the addition of what is missing, just recently optimize the irregular process. The substitution of inputs has lost its agroecological potential, as it does not go to the root of the problem but to the symptom [16].

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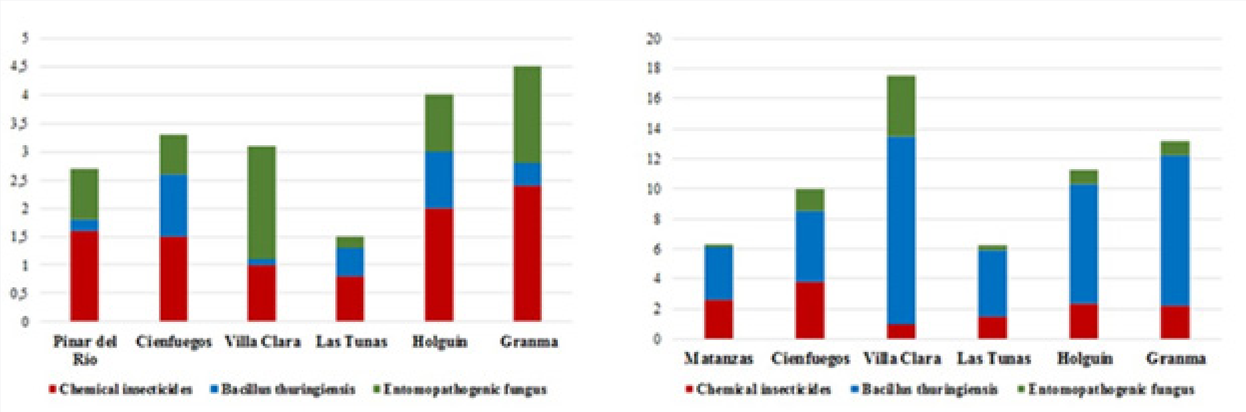

Figure 2: Average foliar applications of chemical insecticides, B. thuringiensis and entomopathogenic fungi in six provinces during the tomato (left) and cabbage (right) crop cycle in conventional systems under IPM. 1998-1999 (Source: CNSV 2000).

The implementation of IPM in a sustainable way in agricultural practice is still insufficient and actions that promote the optimal use of local resources are required, according to their socio-economic and agroecological characteristics, by combining the traditional experiences and skills of producers within the context of the new technology. In addition, it is limited for small-scale systems, mainly peasant and urban agriculture, because in these the farmers appropriate the system approach, to integrate traditional designs and practices at the production system level, among other components that are based on the principles of Agroecology. However, because of the implementation of the IPM, between 1991 and 1998 chemical pesticide imports had dropped considerably and fluctuated between 6 thousand and 12 thousand tons, for an average of 8 375 t/year, in addition to reduce the toxic burden on agroecosystems where food is produced for fresh consumption and the people who work and live in them. Adoption of agroecological pest management. During the period of economic crisis in the country of the early nineties, as a result of the disappearance of the former socialist camp in Eastern Europe, which led to the collapse of conventional agriculture, the adoption of agroecology was facilitated as an emerging alternative for agricultural production [6].

The rise of agroecology during the 1990s triggered participatory innovation by farmers in the peasant systems and the urban agriculture movement, processes in which the IPM moved quickly towards Agroecological Pest Management (APM). Several innovation projects facilitated by INISAV, with the collaboration of the units of the plant health service (LAPROSAV and ETPP), other scientific centers and universities, were carried out during the years from 1993 to 2014, with the participation of 17 663 people, 75.6% farmers (peasants and urban agriculture) and 24.4% technicians, who also acted constantly as multipliers of the results obtained.

These projects were co-financed by several national programs that emerged in response to the conventional agriculture crisis in the country, mainly the following:

1. Science and Technological Innovation programs (since 1986);

2. National program of Urban, Suburban and Family Agriculture (since 1994);

3. strengthening of the National Biological Control Program of the MINAG (since 1993);

4. Peasant to Peasant Agroecological Movement (MACaC) (since 1997).

In order to contribute to the facilitation of the projects carried out in the different provinces, various technical materials on APM were generated and distributed, mainly the following:

a. guide of biological media in compact disc, which contains the biological control agents with reproduction technologies in the country (1 300 copies),

b. master classes in video cassettes (1 200 copies);

c. manuals of agroecological pest management at different times (six books and 9 200 copies),

d. manual of agroecological pest management for agricultural polytechnics (seven editions with 6 000 copies), among other documents such as: memories of the courses-workshops on compact discs, technical and folding newsletters.

The participation of farmers in the processes of participatory innovation for the adoption of the APM has been enriching, among other reasons for the willingness and ability of these farmers to make innovations under their particular conditions and for their contributions in the integration of traditional practices and appropriate procedures. The experiences of collaboration between the plant health service and the farmers, which the Phytosanitary Activist, consolidated in each cooperative since the mid-1980s and the rise of the Agroecological Movement from Peasant to Peasant (MACaC) since 1997, have facilitated the active participation of these farmers in the innovation projects carried

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out for the adoption of the APM system in the country. The first result obtained was the adaptation of several programs that existed under the IPM approach an innovation process that led to the adoption of the following APM programs in the country (percentage of farmers who have adopted the program or its most important components): Urban agriculture (90%), *Diaphania spp*. (*Pyralidae*) in cucurbits (60%), *Erinnyis ello* (Sphingidae) in cassava (95%), *Heliothis virescens* (Noctuidae) in tobacco (78%), *Plutella xylostella* (Plutellidae) in cabbage (80%), *Cylas formicariu*, (Curculionidae) in sweet potato (98%), *Bemisia tabaci* (Aleyrodidae) in tomato (75%), *Spodoptera frugiperd*, (Noctuidae) in corn (90%), Aphididae in horticulture, root and tubercles (75%), *Pseudacysta perseae* (Tingidae) in avocate (40%), *Ips* spp. (*Scolytidae*) in pine (38%), *Hypothenemus hampei* (*Scolytidae*) in coffee (76%), *Leucoptera coffeella* (*Lyonetiidae*) in coffee (98%) and *Atta insularis* (*Formicidae*) in ornamental plants (20%).

These were the first and only, because from this experience and the rise of agroecology, the APM moved towards a system that is based on the design and management of the production system, considering as components the following:

a. management of the soil,

b. design and management of the cultivation system,

c. integration of ecological control methods,

d. functional integration of auxiliary vegetation structures and

e. design of the production system matrix. The demands to increase and diversify of food production have favored the increase in the number of crops per unit area (Land Use Index), which has an impact on the reduction of pest effects, mainly due to effects such as: dissolution, repellency, reduction of the concentration of resources, favor of natural enemies, among others.

Crop rotation, which is a traditional agronomic practice, has had great scientific support and has become widespread in the country as an agroecological practice, mainly to reduce levels of weeds, soil pathogens, nematodes in tobacco cultivation. With the advances in APM, crop rotations that integrate functional species have been promoted, such as sweet potato, a crop that covers the soil, improves its structure and has an allelopathic effect on the weeds that predominate, in addition to facilitating the activity of natural enemies of pests that inhabit the soil. A study conducted on polycultures by in different territories of Cuba, found that the types of designs that predominated were in herbaceous polycultures (75%), followed by arboreal-herbaceous and polyfrutal with 12.5% each. The highest functional coefficient of ecological pest regulation was achieved by the design that integrates yucca-corn-beans (86.7%); They are followed by cassava-corn (76.7%), bananas-yucca (73, 3%), bean-corn, banana-bean-corn (70%) and avocado-mamey-coffee (66.7%) designs.

Farmers have adopted other practices that contribute to the diversification of auxiliary vegetation and its use at the level of the production system, such as plants with functions of: repellency, refuge of natural enemies, allelopathic, living barriers, properties such as botanical preparations, among others [17]. Several crops are sown associated with others or as barriers in the fields, such as corn, millet, sunflower, cassava, which have proven to be the most efficient sources of refuge and multiplication of natural enemies of pests in cultivated fields. In addition, the levels of infestation of harmful organisms have decreased because of multiple and cumulative effects of practices aimed to

a. conserve soils,

b. promote diversification and integration of crop and cattle systems,

c. manage non-crop vegetation, and other tactics that favor ecological services that help reducing pest populations and that increase regulation of pests.

An important research approach of the last 20 years concerns conservation biocontrol and consists of protecting and stimulating the development of beneficial organisms that are spontaneously present in agroecosystems. The purpose is to increase the pest control activity of the most efficient naturally occurring species, or by a complex of beneficial species. Complementary, released biocontrol agents may benefit by conservation biocontrol. Various natural enemy conservation practices have been developed in Cuba, and were integrated into the APM approach. They can be classified as:

a. chemical compounds management (signaling system, replacement of chemical pesticides by biocontrol agents, use of ecologically selective pesticides);

b. management of auxiliary plant diversity (semi-natural habitat, living barriers, etc.);

c. mixed-crop systems (polycultures, agroforestry, livestock-forestry, etc.);

d. tolerance to weeds;

e. integration with green manure;

f. crop rotation;

g. cropping system mosaic;

h. promotion and management of natural enemy reservoirs (artificial and natural);

i. management of epizootics.

More than 50% of the annual crop area is in agroecosystems where crop mosaics, small fields, polycultures and other spatio-temporal arrangements predominate, whose results are seen in:

a. the number of farmers (more than 60%) that they carry out crop associations, mainly with corn; they manage different plants, cultivated or not on their farms (more than 80%);

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b. practice field rotation systems (more than 70%);

c. carry out soil conservation practices (more than 75%);

d. replace synthetic pesticides with biological ones (more than 900,000 ha annually);

e. adopt biological nutrition practices (more than 45%);

f. perform conservation tactics of natural enemies of pests (more than 30%);

g. execute cultural and sanitation practices as a component of pest management (more than 90%), among others (Vazquez 2007).

In 70-75% of the agricultural area cultivated in the country, which mainly includes peasant systems, urban and suburban agriculture, among others that are in agroecological transition, the APM facilitates the conservation of natural enemies that inhabit the systems and of the biological control agents that are released or applied. On the other hand, in the rest of the agricultural area (25-30%), which is basically in intensive systems with a conventional base, the IPM contributes to the integration of augmentative biological control and chemical pesticides.

As a result of more than 25 years of massification in the substitution of chemical inputs with biological ones, the agroecological transition in the design and management of crop and production systems and complexification in the matrix of agricultural territories due to decentralization in administration of the lands, there is a tendency to decrease the state of key pests of certain species of insects, which is evident in the gradual increase of production systems (farms and family plots) where farmers manage their crops with a minimum of applications of biological products or do not use any control method to reduce populations of these pests. The agroecological transition is a process that not only substitutes chemical inputs, diversifies the production and complexes the design of the systems, but must lead to a reduction in the need to carry out interventions against pests, progressively increasing the self-regulation capacity of these systems. For this reason, the APM should be adopted as a strategy that contributes to the transition of the evaluation to determine the effectiveness of applications during the crop cycle, to determine the annual capacity for self-regulation of pests.

Territorialization of the Agroecological Pest Management System

Several factors are contributing to the territorial scope of the APM system, although this transformation would not have been possible without the massive accumulation and experience since the creation of the ETPP network in 1974-75 (Figure 3), the regulations on the use of chemical pesticides, the biological control program since 1988 and the implementation of IPM since 1989. Since the early 1990s, agricultural policies on the subdivision of large state-owned companies specialized in Basic Unit of Cooperative Production (UBPC) in 1992, the rise of urban agriculture since 1994 and suburban since 2009, as well as the massive usufruct delivery of idle land to new farmers during the years 2008-2012, which led to changes in the structural matrix of agricultural territories, moving from large land areas dedicated to specialized conventional productions, to mosaics of cooperatives and diversified farms in agroecological transition.

Figure 3: Territorial functions of the ETPP.

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The diversification of agricultural production, a process initiated as a result of the special period of the early nineties, has had various impacts and lessons, since in addition to reducing the size of productive entities (splitting large state enterprises into cooperatives), it is valued the traditional model of farms inside those cooperatives, contributing to a greater diversity of people who manage the land, The territorialization of the APM system in Cuban agriculture was evident in a participatory diagnosis carried out at the end of 2011 in 12 provinces (80%), with the assistance of 514 people, of which 73.7% technicians and 20.1 % farmers. As a result, (Table 1) 14 procedures were modified or adjusted from those included in the base document and 115 new ones were proposed, of the latter 33 on management at the agricultural territory level, according to experiences developed by the provinces. A contribution of territorial management is the diversification in the use of biological control agents, because in the country 30 species of biological controllers are used or have been used for releases or augmentative applications against 175 crop-pest combinations, mostly represented by immature parasitoids with respect to the number of species used (46.66%) and entomopathogenic fungi in relation to the total number of pests-crops to be controlled (29.7%), being the biological controller of greater diversity of use B. thuringiensis against 25 pests -cultures.

Table 1: Synthesis of the results of the process of experiences systematization in practices and procedures of agroecological pest management.

Components[1]	Procedures[2]			
	Base document3		News proposed by the provinces	Total
	Total	Modifications[4]		
Management of agrarian territories	0	0	33	33
Design and management of the production systems	73	2	32	105
Management of the soil	23	8	12	35
Design and management of the cultures systems	36	1	31	67
Methods of ecological control	192	3	7	199
Total	324	14/ (4,3 %)	115/ (26,2 %)	439

I. APM components (mailing components);

II. procedures (different ways of carrying out the practices under the participatory conditions and experiences of each territory);

III. base document, which contained the procedures for the different agroecological practices (designs and management) with effects on the regulation and control of pest populations, generated during the processes previously, for a total of 324;

IV. the modifications or adjustments to the list of proposed procedures and

V. the new procedures proposed by the provinces.

Also, greatest success and sustainability in biological control programs is achieved when the productions are carried out in the agricultural territories themselves, using native species, strains, and ecotypes or of proven efficacy under local conditions. Unlike commercial bio products that are offered as technological packages, these biotechnologies are appropriate because the production process and the utilization system are decentralized at the scale of the territories, where collaboration networks between biotechnologists and farmers are facilitated, which contribute to understanding and achieve a quality habitat for the application or release of these organisms. The territorialization of the APM system is valued in two dimensions:

a. the territorial scope in the adoption of agroecological designs and management that increase self-regulation capacities of pest populations and

b. the territorial management functions performed by productive organizations, entities that act at the level of municipality and agricultural territory.

These are mainly based on four levels of action:

i. production system (farm or others);

ii. productive organizations (cooperatives),

iii. municipality and

iv. agricultural territory.

The APM appropriates the system approach and the principles of Agroecology, as a scientific basis to understand the need to change the strategy in which these organisms are controlled or managed in conventional agriculture (Figure 4); that is, gradually move from the method of waiting for them to increase to control them with a product, be it chemical or biological (control and substitution of inputs integrated to crop management) and move towards a system that consists in acting on the causes for which these organisms increase and affect the crops.

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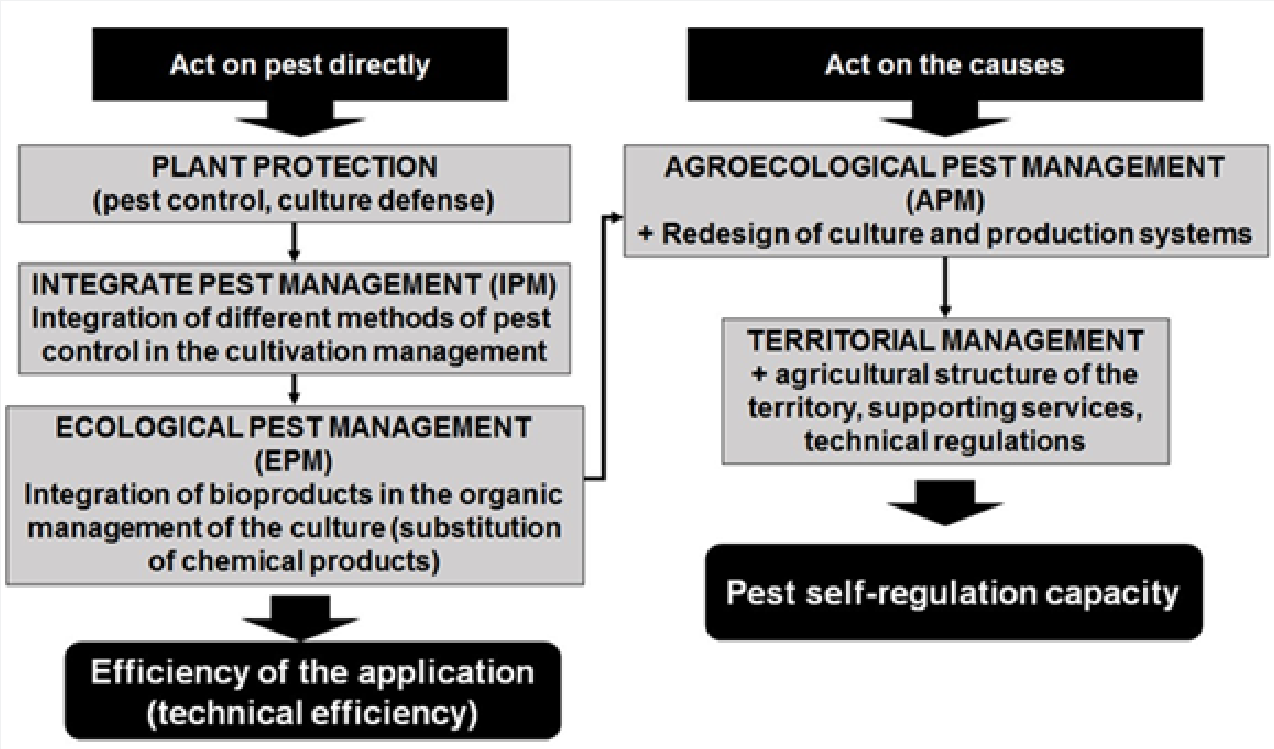

Figure 4: Transition of pest management under the principles of Agroecology.

The APM system means a transformation process with very specific objectives:

a. optimize the use of chemical pesticides, with integration of alternative control methods, to reduce the selection pressure of tolerant and resistant populations to these molecules, at the same time that the toxic load that affects the natural enemies of pests is reduced;

b. complexity the cultivation system through agroecological designs and management, which reduce the possibility of establishment and multiplication of harmful organisms, while becoming a higher quality habitat for the regulatory activity of biological control agents, natural enemies, the epiphytic and rhizospheres' microbiota;

c. redesign the spatial and structural matrix of the production system, based on the principles of agroecology, to facilitate processes of ecological self-regulation of pests.

The process of converting conventional systems characterized by monocultures with high dependence on external inputs to diversified systems of low management intensity is transitional and consists of three phases [18]:

i. Progressive elimination of agrochemical inputs through rationalization and improvement of the efficiency of external inputs through integrated management strategies for pests, weeds, soils, etc .;

ii. substitution of synthetic inputs with alternative or organic ones;

iii. redesign of agroecosystems with a diversified and functional infrastructure that subsidizes the operation of the system without the need for synthetic or organic external inputs.

Over the past 50 years, rapid development, urbanization and agricultural intensification have resulted in extensive conversion of land cover, resulting in habitat loss and fragmentation of rural and semi-natural landscapes, which has in turn reduced biodiversity and natural biocontrol in agroecosystems [19]. This has been the result of change both in crop fields and, at the landscape level, changes around crops. In fields, the increased use of fertilizer and pesticides has changed plant nutrition levels and soil structure in ways that favor agricultural pests [20,21]. Agroecology is a science that studies the agroecosystem as a whole (holistically) and considers this as a complex system [22,23], achieving an integral approach to the processes that occur in it and in this way, overcome the approach simplistic of industrial agriculture [4]. A complex system can be described as a system composed of multiple elements that interact in multiple ways, in which many properties depend on these interactions and are known as

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emergent properties, of which the stability (homeostasis) of an agroecosystem is a classic example and it does not depend solely on the identity of the components of biodiversity.

Property redesign attempts to transform the structure and function of the agroecosystem by promoting diversified designs that optimize key processes. The promotion of biodiversity in agroecosystems is the key strategy in property re-design, as research has shown that (Power 1999):

a. greater diversity in the agricultural system leads to greater diversity of associated biota;

b. biodiversity ensures better pollination and greater regulation of pests, diseases and weeds;

c. biodiversity improves the recycling of nutrients and energy;

d. complex and multi-specific systems tend to have greater total productivity.

In recent years, the need to pay greater attention to the effects of diversity on stability [23] and the occurrence of harmful organisms and their natural enemies in agroecosystems as well as favoring interactions that contribute to the ecological services of functional biodiversity [24] including the connections between production systems and natural ecosystems. Several ecological theories argue that the efficient functioning of agricultural production systems does not depend solely on the elements of biodiversity that are introduced and inhabit it, because diversity is not always something inherent to stability, and as noted by connectivity and habitat quality are essential. Therefore, the integration and diversification of productive items is not the only solution to increase the functional complexity of agroecosystems. When using habitat management to recover the biocontrol potential of natural enemies in modern agroecosystems, it is important to understand the effects of agricultural intensification, including agrochemical inputs, within the context of field and cropland expansion at the landscape scale. Ecosystems in which plant species are intermingled possess an associative resistance to phytophagous, in addition to the resistance of individual plant species. Suggest that in addition to their taxonomic diversity, polycultures have a relatively complex structure, a chemical environment and associated microclimatic patterns. These mixed vegetation factors work synergistically to produce an associative or collective resistance to attack by pests. The movement of individual insects will respond to a wide range of landscape factors, including the scale of the habitat (plant, crop and landscape), habitat permeability, size and shape of the plots and degree of isolation. The landscape structure influences the microclimate and crop growth, as well as other factors that affect the movement patterns of insects.

The level of internal regulation of agroecosystems depends greatly on the degree of diversity of plants and animals, and in addition that agrodiversity is the result of the interaction between the environment, genetic resources and management, which modifies their functioning and allows greater adaptability to extreme situations [25-27].

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