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Theoretical study of alternatives for the control of Rupella albinella in rice cultivars (Oryza sativa).

Estudio teórico de alternativas para el control de Rupella albinella en cultivares de arroz (Oryza sativa)

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Abstract:
The objective of this work was to investigate theoretically the alternatives for the control of Rupella albinella with biopesticides in rice cultivars. In this work a qualitative research was used, through a documentary research, where information was collected about the alternatives for the control of Rupella albinella in rice cultivars. The information was obtained from publications of scientific articles in indexed journals, books and specialized bibliography available in Google Scholar. The results obtained allowed concluding that: the rice bride (Rupella albinella Cramer) is the most important drilling pest in rice cultivation causing significant losses, and greatly reducing crop yields; the indiscriminate use of chemical pesticides was an alternative used to control important pests in rice cultivation; however, it has caused environmental contamination, animal intoxication and many problems for humans; biological control of pests in rice cultivation is an excellent alternative to reduce the use of chemical pesticides.

Keywords: Rice, Bioinsecticide, Biological Control, Baculovirus.

Resumen:
El objetivo de este trabajo fue, investigar teóricamente las alternativas para el control de Rupella albinella con bioplaguicidas en cultivares de arroz. En este trabajo se empleó una investigación cualitativa, a través de una investigación documental, donde se recopiló información acerca de las alternativas para el control de Rupella albinella en cultivares de arroz. La información fue obtenida de publicaciones de artículos científicos en revistas indexadas, libros y bibliografia especializada disponible en Google académico. Los resultados obtenidos permitieron concluir que: la novia del arroz (Rupella albinella Cramer) es la plaga de perforación más importante en el cultivo de arroz causando pérdidas significativas, y reducir en gran medida los rendimientos del cultivo; el uso indiscriminado de los plaguicidas químicos fue una alternativa utilizada para controlar plagas importantes en el cultivo de arroz; sin embargo, ha provocado contaminación ambiental, intoxicación animal y muchos problemas para los seres humanos; el control biológico de plagas en el cultivo de arroz es una alternativa excelente para reducir el uso de plaguicidas químicos.

Palabras clave: Arroz, Bioinsecticida, Control Biológico, Baculovirus.

1. Introduction

Rice (Oryza sativa) is one of the most important cereals in human nutrition, being consumed by more than half of the world's population and recognized as the most ancient crop in history. The crop is one of the 3 most important grains in the world, predominating in surface area and production, together with wheat and corn. 50% of the world's population depends on rice as an important part of their diet [1].

In 2016, world rice production reached 488.2 million tons of milled rice with an average of 4.44 tons per hectare [1].

In Ecuador, the area planted in rice in 2017 was 370,406 hectares, with a production of 1'440,865 tons, being Guayas with 70.11% and Los Ríos with 24.14% the provinces that

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produce the most. Los Ríos represents the second rice province with an average yield of 4.25 t/ha. [2].

In spite of the productive results of this crop, pests are considered to be among the most important limiting factors. Whether they are insects, pathogens or weeds, these organisms are responsible for 37% to 50% of the losses reported in world agriculture [2]. He further states that, throughout history, in order to eliminate or counteract these losses, humans have developed various technologies and implemented countless control programs around the world.

FAO estimates that losses in world agricultural production due to pests fluctuate between 20 and 40%, and that at least 10% of crops are destroyed by rodents and insects in storage areas.

The magnitude of damage varies according to region, season, crop, and pest causal factor, resulting in economic losses of billions of dollars per year [3].

A series of problems caused by fungi and insects have occurred in rice cultivation, one of the main ones being the "Rice Bride" (*Rupela albinella*), which affects yields and causes losses in the production of this crop in some regions, especially when field evaluations show 50% of the stalk has been drilled, which reduces yields by approximately 10-20%.

A large number of insects have been observed in the crop apparently without causing any damage, but in reality they are depositing eggs to reproduce, the state that produces the damage is in larva, directly attacking the stem, it is known that attacks the rice crop in its different stages; however, the greatest attack is reflected in the 30 or 45 days of the age of the plant [4]. In other countries it is considered a pest and occurs more frequently in flood irrigated crops.

Pesticides are promoted as the most effective solution for crop pest insect control. The result of an increase in the excessive use of pesticides is due to the development of resistant pests in crops. [5]

Taking into account the above, it was decided to carry out this work, which has the following objective: to investigate theoretically the alternatives for the control of Rupella albinella with biopesticides in rice cultivars.

2. Materials and methods.

In this work a qualitative research was used, through a documentary research, where information was collected about the alternatives for the control of *Rupella albinella* in rice cultivars. The information was obtained from various sources, such as publications of scientific articles in indexed journals, books, and Google Scholar [6].

For the elaboration of the documentary research, the study was divided into four stages, which are described below:

a) Justification.
The first stage consisted of arguing the reason for the documentary research, for which the problem of the researched topic was exposed. Next, the aspects investigated about the topic are shown:

- Fungi affecting rice cultivation,
- Viruses affecting the rice crop,
- Stem borer Rupella albinella Cramer,
- Most damaging rice stem borers,
- Characteristics of the pest,
- Control of Rupella albinella,
- Alternatives to pesticide use,
- Effect of indiscriminate use of insecticides,
- Research on the effect of insecticides.

b) Compilation of bibliography.
An online search for information was conducted in Spanish and English.

c) Evaluation and selection of bibliography.
The literature search included all types of documents found in Google Scholar and elsewhere on the Internet.

The inclusion criteria used was that the documents consulted were related to the following topics: Fungi affecting rice cultivation, Viruses affecting rice cultivation, Stem borer Rupella albinella Cramer, Most damaging rice stem borers, Characteristics of the pest, Ways to control Rupella albinella, Alternatives to the use of pesticides, Effect of indiscriminate use of insecticides, and Research conducted on the effect of insecticides [7].

Another criterion for inclusion was that the papers consulted could be of any publication date, but the one that provided the most information on the subject studied would be chosen [8].

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The exclusion criterion used was: to exclude all papers that did not include information on the topics listed in the inclusion criteria [8].

d) Data analysis.
The information analyzed was structured according to the themes related to the subject studied [8]. A matrix was generated by topic, in which the information obtained in each work consulted was included. This information was analyzed and used according to the one that provided the most information.

e) Elaboration.
Once the documentation was identified, the information was processed.

3. Results

Fungi affecting the rice crop.
Entomopathogenic fungi are a group of widely studied microorganisms, with more than 700 species in 100 genera. They occur frequently in nature and often cause significant reductions in insect populations including pest species. About 100 species of fungi with insecticidal effects are known, however, only about 20 species have been studied as control agents and their commercial development has been slow. *Beauveria bassiana* infects a great diversity of insect families, but especially Coleoptera and Lepidoptera [9].

Viruses affecting the rice crop.
Entomopathogenic viruses are considered infectious entities whose genome consists of nucleic acid, either DNA or RNA. They are obligate pathogens since they need a living organism, the host, in order to multiply and spread in the agroecosystem. They occur naturally, causing disease in a small number of individuals in the susceptible insect population.

There are more than 700 viruses infecting various orders of insects, but only some viruses are promising candidates for use as biological insecticides in pest control programs. In cases such as Baculovirus, where persistence in free form in the field is low, the virus is applied by releasing infected insects into the natural population [9].

When a commercial biopesticide is not yet available, i.e. in the research phase, or when an entomopathogen is obtained in an artisanal way, it is necessary to establish a dosage criterion. Generally, the number of infective units (spores, polyhedrons, etc.) per milliliter of the suspension to be used is established; or per unit of surface to be treated, whichever is more convenient.

In the case of bacteria, we can speak of the number of cells or the number of spores, in fungi, the number of spores, and in viruses, the number of polyhedra. In general, a good effect is obtained with concentrations higher than 107 infective units.ml-1, or when levels of the order of 1012-1013 i.u. ha^{-1} are achieved.[10]. When working with a virus, a criterion for dosage that is usually used is the number of hosts killed by the virus in each volume of water.

Recent research indicates that synthetic pesticides not only generate resistance in pests, but that plants in contact with them change their metabolism and become more vulnerable to pests. But despite all these developments, the prevailing method today is chemical control. According to [11] worldwide, more than 800 active ingredients are sold in tens of thousands of pesticide formulations.

Stem borer Rupella albinella Cramer.
The adults of Rupella albinella are bright white butterflies, with rather elongated scales on the thorax that resemble hairs. They are between 30 and 40 mm long. The larvae are yellowish white and bore into the rice stalk, causing weakness, yellowing, and wilting of the plant. The pupa is found inside the drilled stalk and is whitish in color. Among the control measures against this pest, it is recommended to eliminate the soca and use light traps inside the crop.

Most damaging rice stem sweepers.
According to the [1], Rice stem borers belong to the order Lepidoptera, in particular to the families Pyralidae and Noctuidae, and are of economic importance in Asia. The most damaging borers and their region are shown below.

In Asia:
- Yellow borer,
- Striped borer,
- White-headed borer,
- Black-headed borer,
- Pink borer.

In the case of the yellow borer, it is distributed mainly in tropical areas, but it also appears in temperate areas where the temperature remains above 10°C and rainfall exceeds 1000 mm/year.

In the Americas:
The South American white borer Rupella albinella is the most damaging species.

In Venezuela:
According to [12], field evaluations in Venezuela show that 50% of the stems are bored by Rupella albinella, which reduces yields by approximately 15%. Its control is difficult because its larvae or juvenile form hides and feeds in the rice stalk, so it is recommended to control weeds, eliminate socas and use light traps.

Characteristics of the pest.
This pest belongs to the order Lepidoptera and the family Pyralidae. The adult is a bright white butterfly, the female is 4 centimeters long and has an orange spot on the last abdominal segment, the average length of the male is 3.2 centimeters, the larva is 3-3.5 centimeters long when it reaches its maximum development, it is smooth and yellowish white.

The pupa is found inside the perforated stem and is whitish in color. The eggs are yellowish-green when freshly laid, turning almost black before hatching because the larva has already formed, are smooth and oval and are protected by a kind of cottony fiber.

According to [10] the adult Rupella is a bright white butterfly. The wing spread is 3.5 to 4 cm. The thorax has a tuft of silky hairs that stand out sharply from the surface. The head is often hidden by this tuft of hairs, but the black eyes are distinct. The maxillary palps are not prolonged as in Diatraea. There is in itself delicacy in the wings, but it is enough to touch them to break them easily. In this it has similarity with the Family Geometridae.

On the other hand, [10] mentioned that the rice bride Rupella albinella (Lepidoptera: Pyralidae) has acquired importance as a rice pest in the Portuguese state during the last years. On this insect in irrigated and rainfed rice crops in the "San Marino" Payara farm, in the Portuguese state, a percentage of parasitized egg masses was found ranging from 0% to 50% in irrigated rice, and from 82.3% to 35% in rainfed rice; the percentage of parasitized eggs ranged from 35% to 80.7% in irrigated rice, and from 57.3% to 71.0% in rainfed rice.

According to [10] the adult is a bright white fry or moth, an appearance that gives it the name rice bride. The female body is about 4 cm long and has an orange stripe on the last abdominal segment. The male is 3.2 cm long. When the adult emerges from the stem, it bores a hole in the stem near the line defined by the contact between the plant and the sheet of water. In the early stages of plant development, the larva bores into the stem and penetrates it.

It also indicates that this action interferes with the translocation of food to the panicle and causes the damage called white panicle. If the insect attack occurs after panicle initiation, nutrient translocation is not affected, and the white panicle is not observed.

This butterfly according to [13] belongs to:
Order: Lepidoptera
Family: Pyralidae
Genus: Rupella
Species: R. albinella
Common name: Bride of rice
Scientific name: Rupella albinella

According to [10] this borer is of the order Lepidoptera and family Pyralidae, it was classified by Cramer as Rupella albinella. In some texts it is also known as Scirpophaga. The eggs are laid on young leaves and the females lay 2 to 3 ovipositions, each of 80 to 120 yellowish-green eggs, covered by a white cottony mass. They are smooth and oval, 0.75 mm long and 0.5 mm wide. The incubation period is 7 days.

The larvae are white or cream-colored and are easily recognized by their small, reddish head. The abdomen, which ends in a point, has a brown longitudinal dorsal line. The larval period consists of 6 instars and lasts 35 to 50 days; at the end this larva is 25 to 30 mm long. The fully developed pupa then averages 20 mm in length, has a creamy white coloration and its incubation period of 7 to 12 days is spent inside the host's stem in a white silk cocoon.

According to [10] the larva is dark in its first instar and in the next instar is uniform creamy-white, except for a pale dorsal line. Head and anal shield with small undulations. Prothoracic coxa with a membranous sac.

The adult is silvery white with an abdominal tuft of orange or brownish hairs in the female and white in the male. In the early stages of plant development, the larva bores into the stem and penetrates it. This action interferes with the translocation of food to the panicle and causes damage called white panicle. If the insect attack occurs after panicle initiation, nutrient translocation is not affected, and the white panicle is not observed.

According to [14], in a study of the biology and entomology of the rice bride, Rupella albinella, in Daule and Samborondón cantons, it was established that the eggs were smooth and oval, diameter 0.75 mm, length 0.5 mm, had a yellowish green color at the time of oviposition and then acquired a blackish brown tone.

Control of Rupella albinella.
Agrotechnics.
Like D. *saccharalis*, removal of crop residues and weeds in rice fields helps destroy R. *albinella* larvae and pupae in postharvest stems. Field flooding destroys pupae remaining in stems and soil [10].

Biological or natural.
Rice fields usually have excellent natural controls, mainly due to egg parasites, predatory larvae and other factors that commonly reduce R. albinella populations, of which only 8.5% survive.

Colombia feeds Telenomus rowani, an important egg parasite that can infest up to 96% of eggs. These are recognizable by dark spots and decay of the cottony mass covering the eggs. Another important egg parasite is Trichogramma sp. Larvae of R. albinella can be infested by Polybia occidentalis and Strabotesababenes and Trathala sp. Parasitize. Adults are occasionally preyed upon by certain types of spiders [10].

Chemicals.
Due to the high incidence of parasitism of R. albinella eggs, the application of chemical insecticides is generally not recommended because, among other reasons, this insect causes little damage to the rice crop [10].

The use of pesticides has caused ecological imbalance; environmental contamination; harmful effects on natural enemies and non-target organisms; resistance, resurgence, and outbreaks of secondary pests; trophobiosis; and alterations in the soil microbial population [15].

Alternatives to the use of pesticides.
Ecological pest management.

Chemical insecticides have been used for many years as the only alternative for controlling insect pests of agricultural importance. These have generated numerous problems of environmental contamination, intoxication of animals and man himself. Biological pest control is an alternative to reduce their use.

This is based on the use of microorganisms such as viruses, bacteria, fungi, nematodes, and protozoa. In this work we describe entomopathogenic viruses and bacteria, to understand their biology, their infection mechanisms, field application, etc., as well as the reasons why they can be successful as biological pest control agents and can contribute to less environmental contamination and better pest control management, and to understand why they are friendlier to the environment and to society itself.[16].

Ecological Pest Management (EPM) responds to an agroecological approach, bearing in mind that in an agroecosystem there are complex dynamic interrelationships between plants, herbivores, predators, microorganisms, etc. These organisms are constantly evolving, so the farmer must take advantage of this and create diverse, complex environments to minimize the effect of pests, since the appearance of pests in a crop is not an isolated event and, as such, action must be taken. [17].

The EPM goes beyond the recipes that characterize the IPM, and what stands out are principles that can be disseminated, but that take specific technological forms according to the agro-ecological and socio-economic conditions of each region, respecting the heterogeneity of each place and the needs and desires of farmers, so the participation of farmers in the process of research and implementation of the EPM is essential [18].

These authors consider as important elements: understanding why pests reach epidemic proportions in certain agroecosystems and why agroecosystems become susceptible to pest invasions. For them, according to these elements, the focus is no longer so much on the biology and ethology of the insect, but rather on how to improve the immunity of the agroecosystem and how to promote and use the elements of functional biodiversity (predators, parasitoids, entomopathogens, antagonists, etc.) to prevent and regulate the populations of harmful organisms.

Asserts [19] that agrobiodiversity is an indicator of well-functioning agroecosystems. On the other hand, [20] and

[21], emphasize that diversified agricultural systems develop ecological properties that increase their capacity for self-regulation and the possibilities of maintaining equilibrium due to the multiple relationships between their biotic and abiotic components through energy and nutrient flows and biological synergies.

Biodiversity interacts in the agroecosystem. For example, plant residues increase the organic matter content of the soil and provide the substrate for the increase of micro, meso and macro fauna, also increasing the antagonists that suppress phytopathogens and the slow mineralization of carbon and nitrogen, activate genes that promote plant tolerance to diseases and certain invertebrates (collembolans and detritivores) serve as alternative food for natural enemies in times of lower incidence of pests [10].

Alternatives to pesticide use are implemented within IPM and EPM programs. There are two key components in the implementation of EPM programs: biological control and cultural control. Biological control has been developed in the country like no other component of EPM, so the level of understanding and adoption by the farmer is wide, which has allowed moving to another stage, in which the management and conservation of pest bioregulators is developed [22].

In essence, EPM is the use of biodiversity to prevent, limit, or regulate harmful organisms to crops, it means taking advantage of all the resources and ecological services that nature provides, it is the management of pests with a holistic approach, with a system approach [10].

Farmers need to be taught the ecological basis for understanding pest problems and their relationship to crop management. This is a great challenge for the technicians who work directly with farmers since the latter are the main actors [23].

Conservation and increase of natural enemies are two moments of the same continuum. The first consists of the elimination of measures that destroy them, while the second refers to the use of measures that favor the presence and action of such organisms in the agroecosystem [10].

The development achieved in the breeding and release of entomophages and in the mass production of entomopathogens has made biological means available every year for their application in more than 60% of the cultivated area [10].

Cultural control as a method of regulating harmful organisms is the implementation of practices that produce changes in the environment that make it less favorable for the development of these organisms and at the same time directly or indirectly benefit their natural enemies [10].

It classifies plant extracts as biochemical pesticides and proposes the use of these as an option for pest management that the farmer can carry out on his farm; it refers to the fact that these plants can exist naturally on the farm or be cultivated in certain sites for these purposes. Applications with botanical extracts at the right time, with adequate preparation and the required dosage exert a satisfactory control over pests [10].

This researcher [10] mentioned that Lepidoptera larvae that are infected by baculoviruses show visible signs of infection within 2-5 days after ingestion of the virus. These signs manifest as color change, reduced appetite, and cessation of feeding. Prior to death, the larvae of many Lepidoptera sometimes move to the aerial part of the plants where they die hanging from their anal propata. At the moment of death, the integument is degraded, and millions of new OBs are released to give rise to a new cycle of infection.

Field experiments in Mexico and Honduras showed that the application of baculoviruses (MNPVs) at a concentration of 6x1012 OBs ha-1 of maize caused approximately 40% mortality of S. frugiperda when applied in an aqueous formulation [24].

Effect of the indiscriminate use of insecticides.

[12] He mentions that in the state of Portuguesa, the indiscriminate use of chemical insecticides and increases in crop area have led to the advance of an insect that rarely caused problems: the rice bride (Rupella albinella). Field evaluations in areas of Payara show about 50% of stems bored by the insect, which reduces yields by about 15%. Control is difficult because its larvae or juvenile form hides and feeds in the rice stalk, so it is recommended to control weeds, eliminate socas and use light traps. Currently, the prospect of biological control by means of a parasite found in different Portuguese rice-growing areas is being evaluated.

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The following author [10] mentioned that in order to lay the foundations of knowledge of the morphology and biology of Rupella albinella, the larvae are reared inside the rice stalk, evaluating each of the larval stages of the insect pest until reaching the pupal stage. The maximum average duration of the biological cycle was 81 days and the minimum 72.6 days. The development of eggs, larvae and pupae had an average duration of 9.58 and 12.26 days, and a minimum of 7.49 and 11.9 days. The maximum average number of eggs per female was 155.4 and the lowest 133.6 with a fertility percentage that fluctuated between 88% and 76%.

Research on the effect of insecticides.

Profenofos shows an excellent translaminar action, developing a strong insecticidal action by ingestion, as well as a good initial contact and later residual effect. The rapid uptake or fixation of the active ingredient by the foliar parenchyma of the plant may be the reason for the efficacy observed when this insecticide is applied before a rain. It is a broad-spectrum translaminar insecticide-acaricide. It acts as a contact and stomach poison, being effective on a wide range of sucking, leafmining and chewing insects.

With a Colombian isolate of Spodptera frugiperda Sf NPV003 nucleopolyhedrovirus, a powder formulation was developed using a micro-encapsulation process with a methacrylic acid polymer, which increased the photostability of the virus. In order to generate recommendations for the use of this biopesticide, the objective of this research was to establish in vitro compatibility with the most commonly used chemicals (insecticides and fungicides). The virus was compatible with eight agrochemicals evaluated and presented an insecticidal activity higher than 80%. Based on the results obtained, it was recommended that the biopesticide based on Sf NPV003 be stored at temperatures below 28°C, which guarantees the quality of the product for at least 17 months, an adequate time for its distribution and use [2].

A study conducted on hybrid corn, measuring the response of Spodoptera frugiperda and Elasmopalpus lignosellus insect larvae to the application of biological and organic insecticides, showed that applying Neem (Azadirachtin indica) at a dose of 1.0 L ha-1, reduces the populations of S. frugiperda and E. lignosellus in relation to the other active substances applied in the trial. Higher doses cause migration of the pests to nearby hosts. The highest yield per hectare was found in the Neem 1.0 L ha-1 treatment with 8,940 kg ha-1 [25].

The toxicity of azadirachtin and methoxyphenocide, alone and in interaction with Spodoptera frugiperda nucleopolyhedrovirus (SfMNPV) was evaluated. Bioassays were conducted where third instar larvae with seven doses of azadirachtin: between 0.316 and 316 mg a.i./kg diet and five of methoxyphenocide: between 0.0316 and 3.16 mg a.i./kg and for combinations of the virus with the compounds three concentrations were used: 5.4 × 102, 4.62 × 104 and 8.81 × 105 occlusion bodies (c.o./ml). The interaction of the highest concentration of SfMNPV with two concentrations of azadirachtin resulted in increased larval mortality. When SfMNPV was tested with methoxyphenocide, a decrease in mortality was observed compared to the virus only at the two lowest concentrations of this insecticide [24].

Reported [26] who in their study evaluated the lethal effect of NPV applications on S. frugiperda larvae, with the determination of the most suitable NPV concentration for insect control. As a result of the applications made, it was found that the final larvae populations were lower in relation to the control, and the virus strain VPNSE-SP2 (SPOD-X®) at a dose of 0,25 L ha^{-1} presented the lowest number of attacked plants and a decrease in larvae, with the best control after 5 days after application.

A high incidence of the pest was observed in the control. The highest grain weight yield was found in the SPOD-X® 0,25 L ha^{-1}, treatment, with 7958 kg ha^{-1}, which was higher than the control (4128 kg ha^{-1}).

The purpose of this research was to determine the effectiveness of the nucleopolyhedrovirus of S. frugiperda in mixture with adjuvant substances under field conditions, using a randomized block experimental design covering an estimated experimental area of 17 x 47 m (799 m2). Sampling was carried out according to the methodology described by the National Center for Plant Health and efficacy was determined by the Henderson-Tifton formula. Treatment with the virus mixed with boric acid and OleoNim decreased larval infestation per plant with doses below 1012 CI ha^{-1} increased larval mortality by 2.5 and 2.16 times, respectively. The mixture of boric acid and OleoNim with the virus significantly improves its efficacy in population control of the pest [27].

4. Conclusions

The rice bridle (Rupella albinella Cramer) is the most important drilling pest in rice cultivation and can cause significant losses and greatly reduce crop yields.

The indiscriminate use of chemical pesticides was an alternative used to control important pests in rice cultivation, but they caused environmental pollution, animal poisoning and many problems for humans.

Biological pest control in rice cultivation is an excellent alternative to reduce the use of chemical pesticides.

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