CRIN Caribbean Rice Improvement Network
Red de Mejoramiento de Arroz para el Caribe
ación: CIAT - CIDA - IRRI - IICA - SEA - UNDP

Round Table on Plant Protection

Cooperation:

- Ministerio de Agricultura (**MINAG**), Cuba
- Ministerio de Educacion Superior (**MES**), Cuba
- Universidad Central de Las Villas (**UCLV**), Cuba
- Unión de Complejos Agroindustriales (**UCAI**), Cuba
- Instituto de Investigaciones del Arroz (**IIA**), Cuba
- o Internacional de Agricultura Tropical (**CIAT**).

CLARA, CUBA, 1990

PROCEEDINGS OF THE ROUND TABLE ON PLANT PROTECTION

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FOREWORD

The Round Table on Plant Protection has just begun to alleviate the lack of information that exists in the Caribbean on Integrated Pest Management (IPM) in rice. The primary objective of this event was to exchange information on the advances achieved in IPM both in theory and practice applied to rice production in Cuba and other countries in Latin America and the Caribbean, as well as to discuss the methodological advances for control of red rice.

This time, topics on Integrated Pest Management were dealt with, analizing the influence excerted by certain agricultural practices (nitrogen fertilization, seeding rate, water layer, etc.) on the level of incidence of certain weeds and their association with the presence of pests and diseases.

This kind of research with an associative or integrated approach deserves more attention, since it constitutes a strategic way of facing present and future agronomical problems with the idea of minimizing cost, taking best advantage of the genetic potential of the available germplasm, promoting the action of beneficial insects to achieve an equilibrium between them and insect pests, keeping the environment cleaner by reducing the application of pesticides harmful for human health, and in general, to reach a sustainable growth of national rice programs (research, extension and development of production) in the future, for the benefit of consumers, growers and millers.

We consider that the efforts of CIAT/CRIN and national systems of research and development of the Caribbean and Latin América are well advanced. With the support of its Member Countries, CRIN will continue to develop collaborative research actions through distributing more and better germplasm, supporting the development and fabrication of small farm machinery and implements, insisting in actions of training and technology transfer, and organizing regional workshops and conferences until the project's maturity enables its Member Countries to know how to take advantage of the fruits of this collaborative coexistence.

The participation of outstanding Cuban rice scientists as speakers, as well as the research staff of CIAT Rice Program is relevant, since the only way to know the problems and to design strategies for their solution is through communication and exchange of experiences in the field of Agricultural Sciences.

CRIN Coordination appreciates the interest and support given by the Ministry of Agriculture of Cuba, through the Unión de Complejos Agro-Industriales de Arroz, Instituto de Investigaciones del Arroz and the Universidad Central de Las Villas. Without this support it would no have been possible to carry out this event succesfully.

Jorge L. Armenta Soto
CRIN-Coordinador

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INTEGRATED WEED MANAGEMENT: ENVIRONMENTAL IMPLICATIONS, LOSS FORECAST, AGRONOMY AND PESTS

ALBERT FISHER[1]

INTRODUCTION

Weed management should be based on an the early estimate of the economic losses that they may cause. This way, the alternatives to control weed incidence may be evaluated in function of costs and benefits. Weed management must be compatible with the environment, and it will be closely linked to the different cultural practices. Crop practices affect both weeds and pests in general. This is the reason why the concept of Integrated Pest Management (IPM) is considered as a component of Integrated Crop Management (ICM). Within this context, aspects related to weed management, crop practices and relationships with other pests are discussed ahead.

2. RESISTANCE

This aspect refers to the development of biotypes resistant to

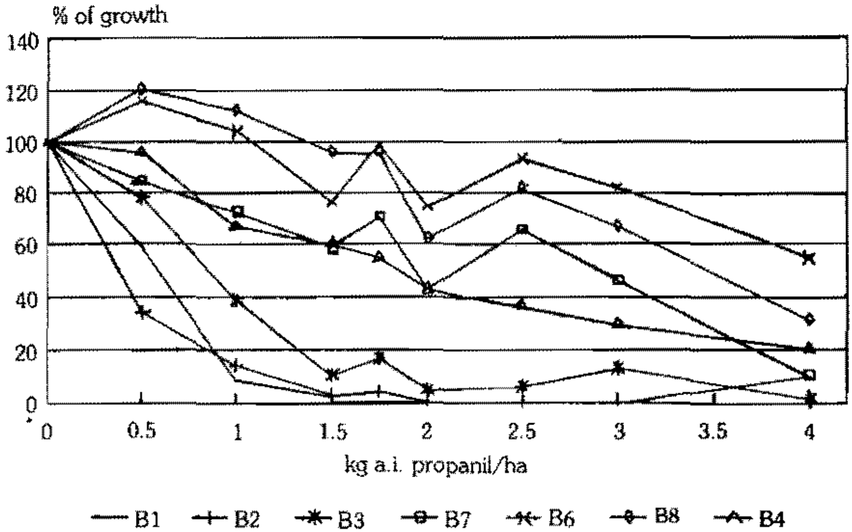
1. Agronomist at CIAT Rice Program, Colombia

certain herbicides in populations of certain species that originally behaved as susceptible to a specific herbicide. This is an aspect that results from the indiscriminated use of chemical control of weeds. The appearance of resistance occurs with the repeated use of the same herbicide on the same field. The repeated use of Propanil in certain rice areas in Colombia has resulted in the development of biotypes of *Echinochloa colona*, resistant to that herbicide. This has forced farmers to make a greater number of applications at higher dosages each time, which increases costs and accelerates even more the process that increases the resistance to the herbicide in populations of *E. colona*.

Figure 1 shows the response of seven biotypes of *E. colona* to the application of different amounts of Propanil. Biotypes 1, 2, and 3 appear to be susceptible, whereas the remaining, coming from areas continuously treated with Propanil showed considerable tolerance to the herbicide.

In other cases it has been found that the growth of biotypes resistant to a certain herbicide (Atrazine, for example) is smaller than that of the susceptible ones, as well as their capacity to compete with them. In studying resistant and susceptible biotypes of *E. colona*, no differences in growth or competitiveness associated with the resistance to Propanil were observed (Figure 2). In the replacement series of Figure 2b, no biotype appears to be the most successful competitor reducing growth of the associated biotype (straight diagonals show equivalent competitiveness). However, it was possible to observe that the greater the resistance to Propanil quantified by DL60[2], the less was the total weight of grains produced by studied biotypes of *E. colona*. This may imply an ecological disadvantage for the resistant biotypes to Propanil, as compared to the most prolific susceptible biotypes. Fortunately those characteristics result useful in managing the resistance to Propanil. If the use of herbicide is suspended, the pressure of selection toward resistant biotypes of Propanil is increased.

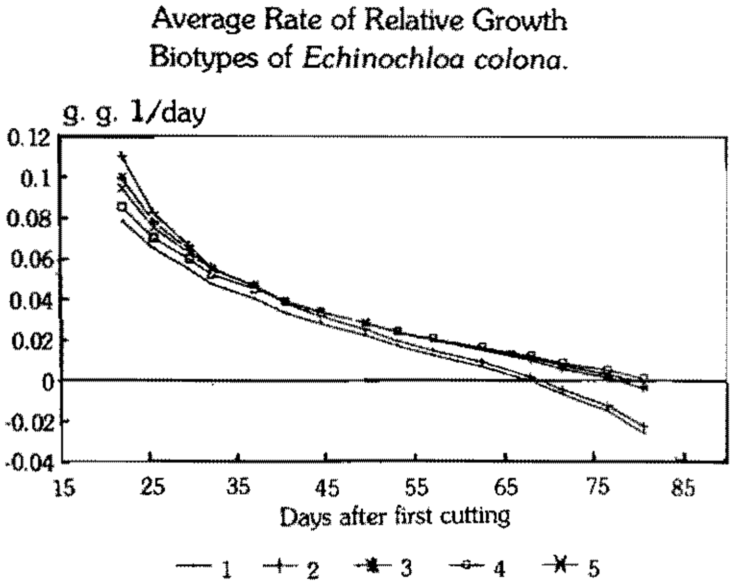
2. Dosage of Propanil needed to reduce growth in 60%.



The lowest reproductive efficiency of resistant biotypes will cause that once the use of herbicide is suspended, populations of *E. colona* return gradually to the original status where susceptible biotypes, readily controlled by Propanil, used to predominate. Thus the rotation of herbicides of different chemical families is a primary measure to avoid the development of resistance to herbicides in weed populations. No evidences of crossed resistance with other herbicides of common use in rice have been obtained in preliminary studies.

3. LOSS FORECAST

Studies like the one of Figure 3 allow to forecast the damage to rice crop based on the population density of a weed such as red rice. Weed population should be estimated early (30 days in this case) in crop growth to decide best which method is most suitable, in economic terms, to control red rice.



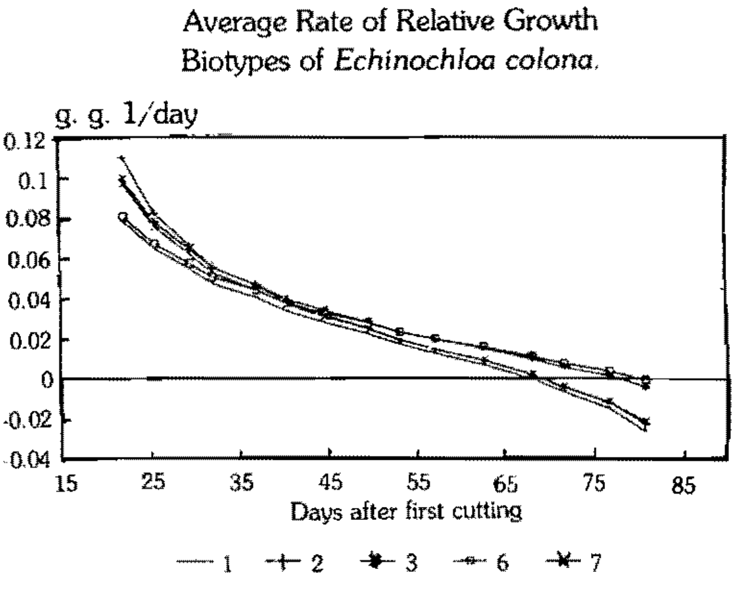


Figure 2a. Growth and competitivenes of biotypes of
Echinochloa colona

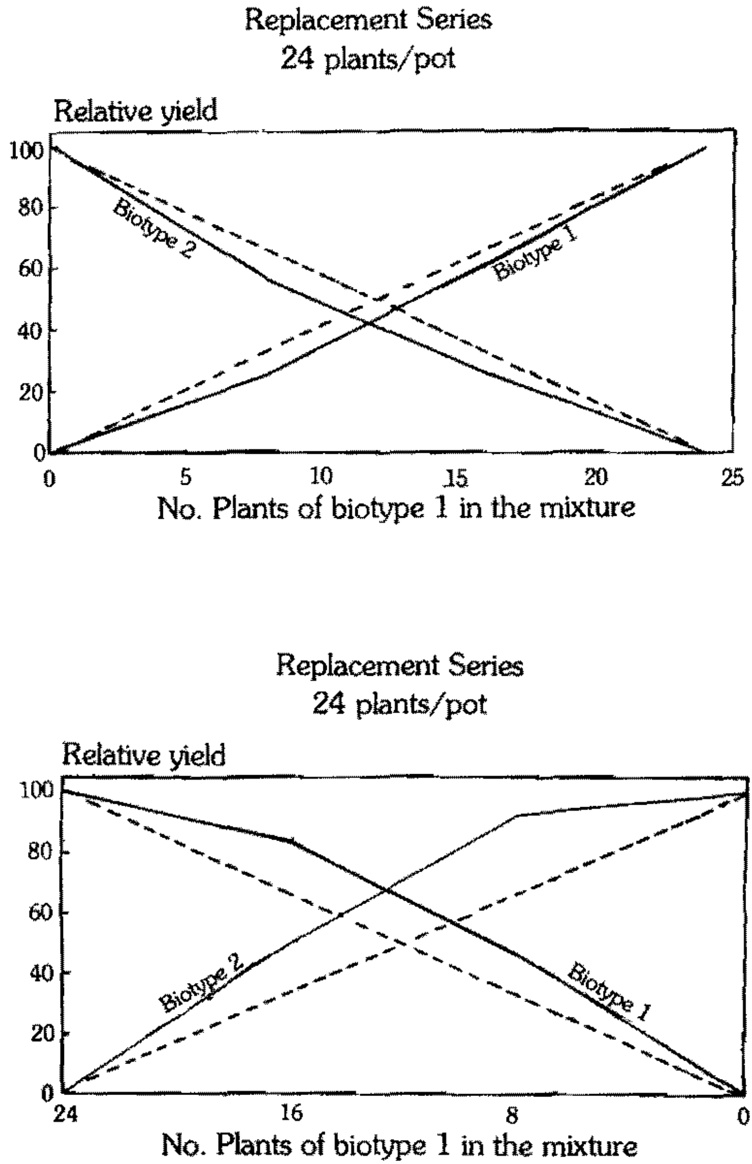


Figure 2b. Growth and competitiveness of biotypes of Echinochloa colona.

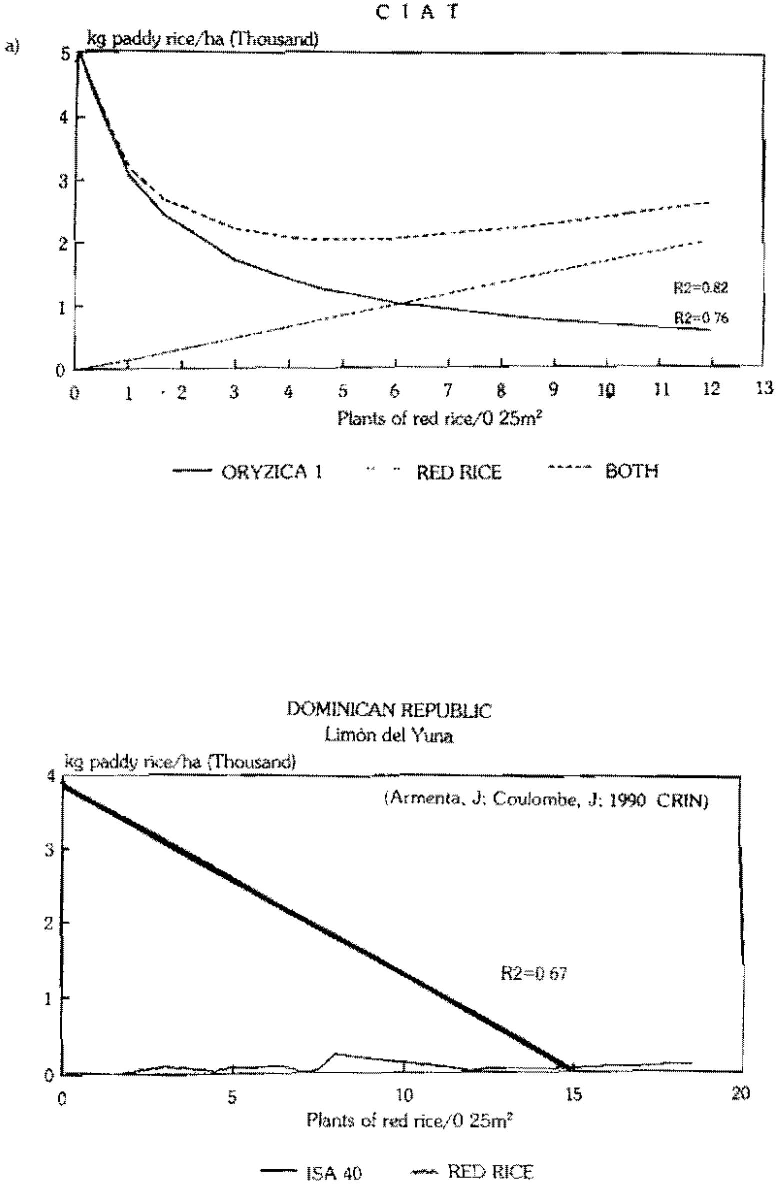


Figure 3. Levels of infestation of red rice

The combined yields of red rice and the commercial rice does not compensate for the decrease in rice yield (Figure 3). Results of this kind of studies present variations when carried out in different growing conditions (geography, varieties, densities, etc.) (Figure 4). When factors modifying the responses to competition are known, it is possible, within certain limits, to make predictions or think of management alternatives for different situations or environments. So it is possible to adjust predictions on yield decrease because of red rice competition, if planting density of rice is known (Fig. 4b). Similarly, alternatives could be planned to manage the competition of weeds for different levels of fertility, if the variations of the interference within determined ranges of fertility are known. The usefulness of critical periods of competition (Figure 5) increase when the behavior of the factors modifying them are known. In this example, the critical period at which the crop must be free from weeds goes from emergence until approximately 70 days after. Crop yield is stabilized through weeding until approximately 70 days after emergence ("without weed" curve). This coincides with the time of maximum leaf development and maximum suppression of weed growth (Figure 5). Knowing the behaviour of the parameters weed growth, and crop affected by the competition (Figure 5), may result useful to design strategies for weed management, and to forecast results under different conditions.

In conclusion, competition studies should not be limited to measuring yield decrease only under specific growing conditions, but in addition it is necessary to know the variations in competitive effects for a known range of situations (fertility levels, sowing rate, rainfall levels, etc.). Only so estimations may be made for more than one growing condition. Otherwise, the validity of experiments on competition is confined to very specific growing conditions and its usefulness is limited.

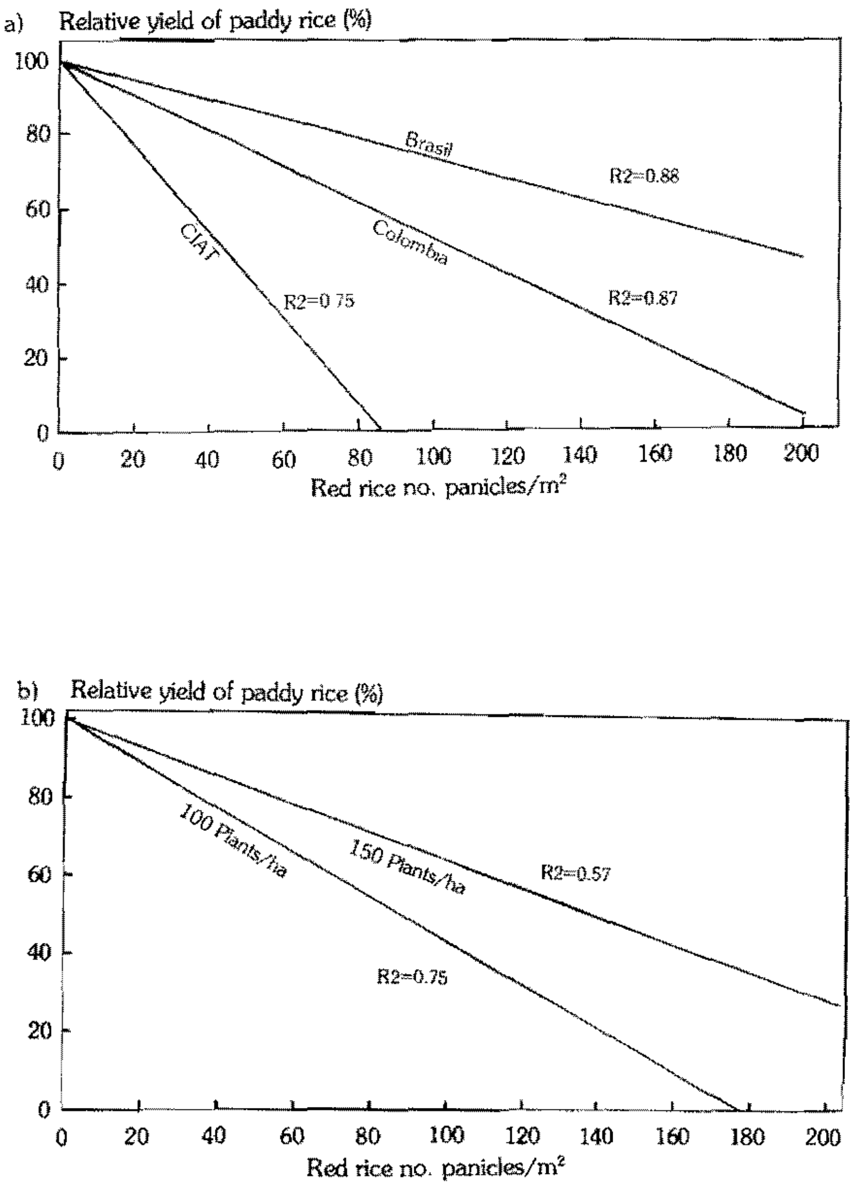


Figure 4. Effect of sowing rate populations of red rice and growing conditions on yield of comercial rice (Pulver, 1988 and Fischer, 1990.)

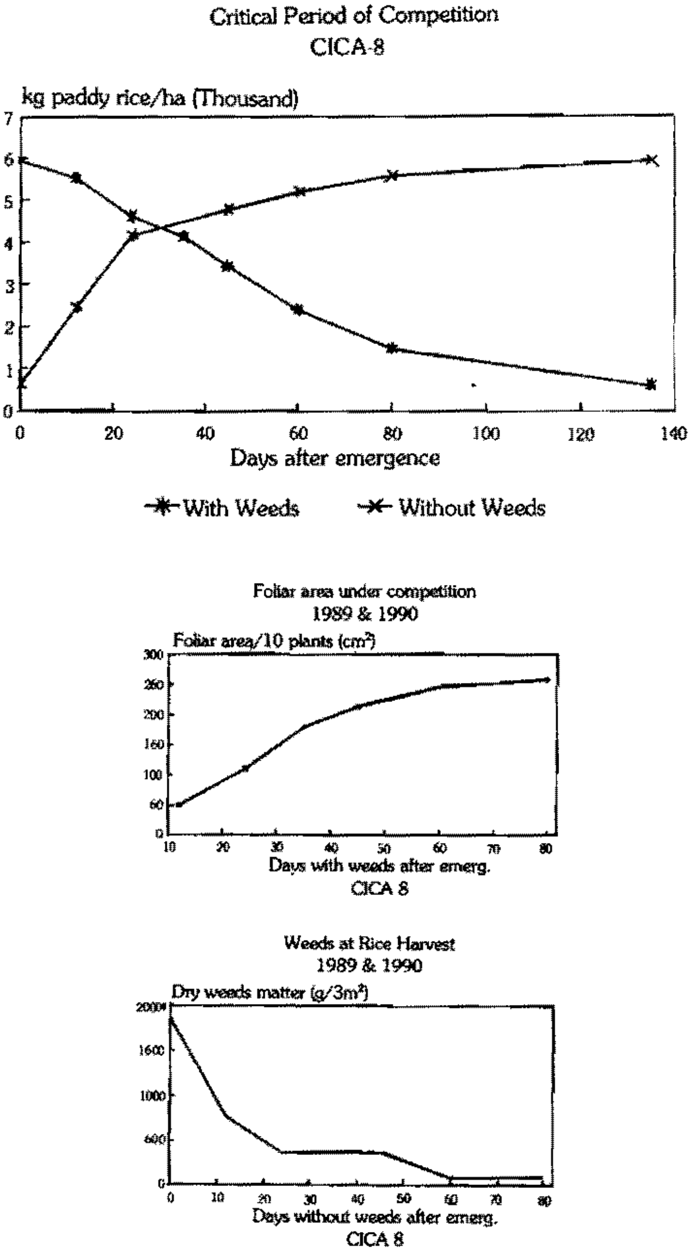


Figure 5. Critical period of competition and its relationship with the crop's foliar area and growth of weeds.

4. AGRONOMY

4.1 Response to Nutrients

Competition with weeds generally involves, to a greater or lesser degree, competition for light, water, and nutrients. These aspects are closely related. Thus, the competition for light, by reducing the leaf and root growth, interferes with the absorption of water and nutrients. This makes it difficult, in field conditions, to identify and isolate the different forms of competition, which in general superimpose one another. Therefore, by adding more fertilizer to a weed infested land to supposedly relieve the competition for nutrients, weed growth will be increased and so will the competition for light and water. Thus, if it is true that the availability of nutrients has been increased, it is also true that crop yield was reduced as compared to the one obtained with no weeds (Figure 6). Figure 7 shows how the presence of grasses, legumes, and other species of a pasture associated to rice interferred with the crop's capacity to use major nutrients, Nitrogen in this case. In Figure 7a yields of the clean and weedy crop draw near as more Nitrogen is added. Then, it is possible that in this case the competition was mainly for Nitrogen, since the negative effects disappear as the nutrient availability is increased. When responses differ (Figure 7b), competition for light and/or water would be predominant and it would be intensified at higher levels of fertility, which stimulates the growth of weeds and the competition they excert. Based on these responses, agronomical options of management may be derived to regulate weed competition.

4.2. Nutrients and Pests

Increases in Nitrogen fertilization increased the vegetative development of rice and the succulence of plants (Figure 8). This was associated with a greater incidence of certain insects and diseases (blast and others) (Figure 9). Knowing this type of interactions is fundamental in implementing sound programs of integrated crop management. Such integration implies the coordinated work of more than one field.

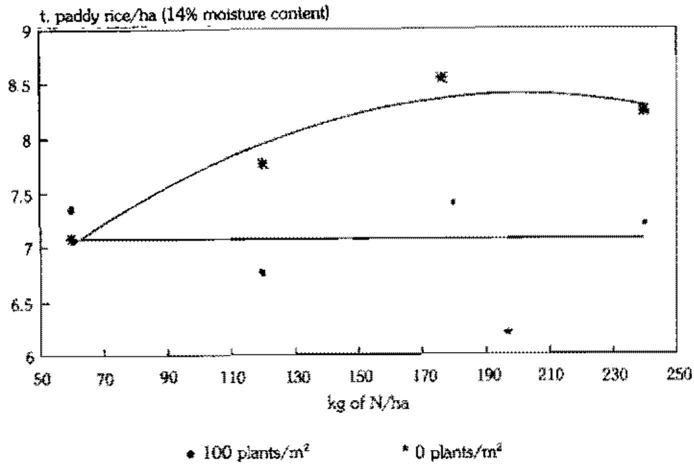


Figure 6. Weedy and response to Nitrogen.

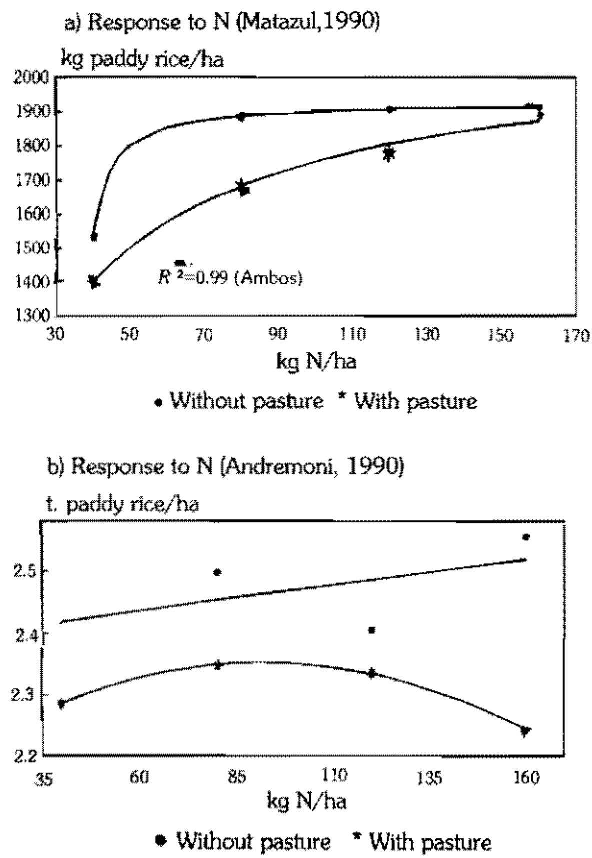
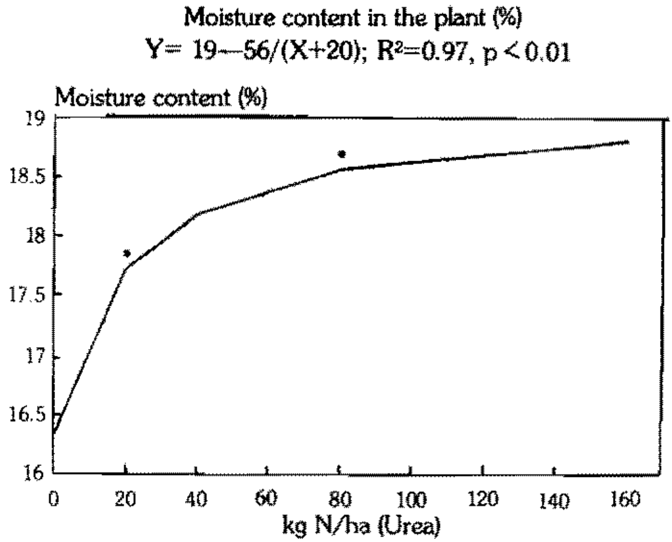


Figure 7. Rice-Pasture competition.



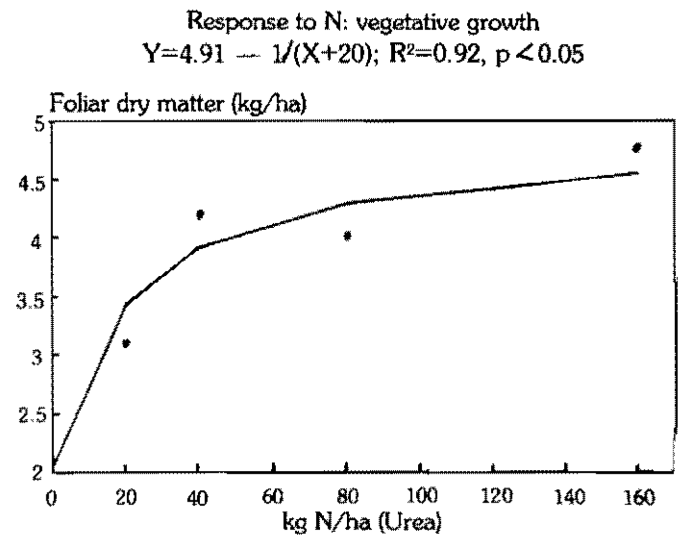
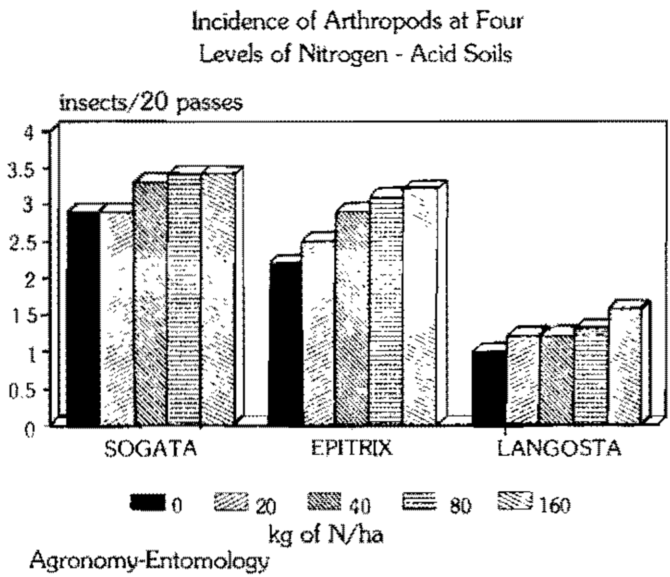


Figure 8. Effect of nitrogen fertilization on the vegetative development and moisture of the rice plant.



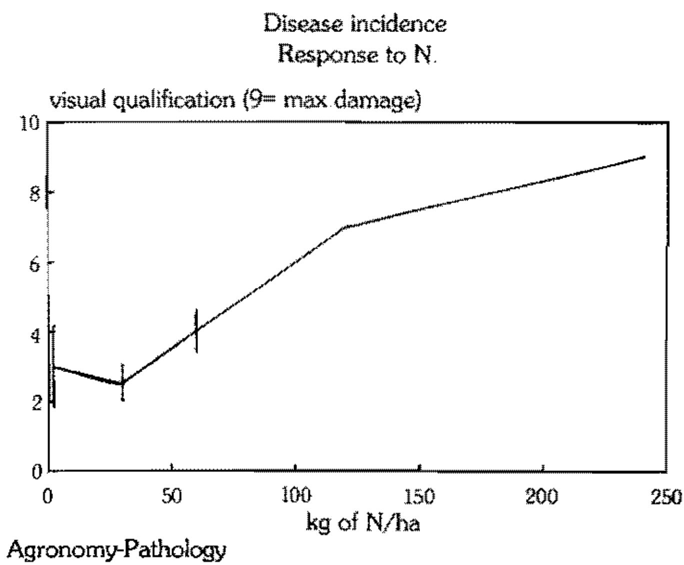


Figure 9. Effect of nitrogen fertilization on the health of rice crop.

5. CONCLUSIONS

The information presented may help interpret the ICM/IPM concept. This concept includes the ideas of ecological compatibility and sustainibility of agricultural practices. The rational implementation of a weed management program is supported by an adequate definition of potential yield losses that may be caused. This way, the most economically adventageous methods of pest management can be identified. Potential yield losses should be determined within variable ranges of management conditions. By doing this, the forecasts may be extended beyond local, specific growing conditions. Finally, the interaction among agricultural factors and their effect on pests shows, once again, the complexity of Integrated Crop Management. Integrating fields (entomology, pathology, weeds, etc.) is not only a juxtaposition, but, also involves considering the multiple interactions occurring among them.

VARIETY MIXTURES. THEIR NEGATIVE INFLUENCE IN OBTAINING HIGH YIELDS. RESEARCH BEING CARRIED OUT. CONTROL MEASURES USED. RECOMMENDATIONS FOR THEIR CONTROL.

GUILLERMO ANTIGUA PEREIRO[1]

INTRODUCTION

Oryza sativa L. is the most cultivated rice species. Variety mixtures are also commonly called red rice, although not all of them show the red color of the caryopsis. The red color of grain is determined by a recessive gene present in the genetic constitution of the rice plant. The origin of red rice in our country does not seem to be only the result of the recombination of this recessive gene in the species Oryza *sativa* L., since research carried out by Pérez, Martín and Herrera, at the Universidad Central de Las Villas, through a cross made between species *Oryza sativa* L. and *Oryza perennis* L. (native of our country), showed different forms of variety mixtures, including

1. Researcher at the Rice Research Institute, Cuba.

long-awned rice with black glumes, typical of our rice-growing areas. This long-awned rice presented the red color of caryopsis.

2. DAMAGES

The undesirable features of red rice lies in that it reduces both agricultural and milling yield of the cultivated variety, reducing cooking quality through the presence of red grains.

Variety mixtures become a weed to the cultivated variety because they compete for the utilization of nutrients, light, vital space and water. In general, they are earlier than the cultivated variety and, to a great extent, they scatter their grains before harvest, but unlike other weeds, they provide an usable production, although undesirable for human consumption. This contribution of grains of different length, thickness and color, affects both the milling and cooking quality of the cultivated variety.

In research carried out by Diarra, Smith and Talbert (1985) on the interference of red rice with the cultivated variety, they determined that rates of 5, 108, and 215 plants of red rice per m^2 reduced the agricultural yields of the commercial variety in 22, 77 and 82%, respectively. When they used a rate of 195 plants per m^2 of the commercial variety, the yield component grains per panicle was greatly affected. They found that variety Mars, of 138 days of growth duration, was more competitive against red rice than Lebonnet, a 126-day-growth-duration variety, since red rice yield was from 24 to 33% lower against variety Mars than against Lebonnet.

A research carried out by García at Sur del Jíbaro Rice CAI under field conditions (Table 1) enables us to know to what extent rice yield is reduced in relation to mixture density. This table shows that a possible yield of 7.81 t/ha in the variant without variety mixtures, is reduced to 0.79 t/ha with an average of 286 panicles of variety mixtures per m^2.

Table 1. Effect of variety mixtures on rice yield.

Range of No. panicles of mixtures per m^2	Average No. panicles of mixtures per m^2	Average No. of rice panicle per m^2	Average Yield t/ha	Yield Loss (%)
Checks	0	439	7.81	0.0
1-20	12	378	7.31	6.4
21-40	32	347	7.43	4.9
41-60	52	387	6.82	12.7
61-80	72	343	6.60	15.5
81-100	91	367	6.37	18.4
101-120	115	322	4.67	40.2
121-140	131	244	3.33	54.3
141-160	154	290	3.62	53.6
161-180	171	251	2.91	62.7
181-200	188	251	3.33	57.4
201-220	211	228	2.97	62.0
221-240	229	244	2.86	63.4
241-260	249	211	2.03	75.0
261-280	276	139	0.86	89.0
281-300	286	124	0.79	89.0

3. CONTROL MEASURES OF HARMFUL VARIETY MIXTURES USED IN MAJOR COUNTRIES.

Several cultural methods or practices have been designed in the world for controlling red rice. The following methods are used in the USSR in their struggle against red rice:

3.1. Sowing of certified seed free from red rice.
3.2. Rotation of rice with perennial and intercalated crops during

several years to eliminate the reserve of red rice grains present in the soil.

3.3. Cleaning of certified seed from red rice mixtures using sieves, based on the difference between red rice grain structure (length and thickness) and cultivated varieties.

3.4. Use of agrotechnical methods. Fallow rice fields are irrigated after harvest to stimulate germination of rice and weeds, which are then eliminated through harrowing. During this season of the year it is necessary to irrigate at least twice to stimulate germination, and plow 3-4 times with harrow.

In highly infested fields it is necessary to burn the stubble after threshing. Such fields should not be plowed afterwards in the fall, since the influence of high variations of moisture and temperature kill most of the red rice dropped on the soil's surface, which would not happen if the land was plowed, because they would be buried in the ground. Besides, much of the red rice on the soil's surface would be eaten by birds and rats.

The following seasons rice is planted using minimum soil tilling. Fields infested with red rice should not be plowed with implements reaching a depth of 10-12cm to prevent turning up the seeds again to the superficial layers of soil from where they germinate easily. In this case land preparation should be limited to a depth of 6 - 8 cm, in order to eliminate the seeds that could have started to germinate.

3.5. Keeping seed-growing fields at a distance not shorter than 200 meters from commercial fields.

3.6. Descriptive methods for red rice control in many countries.

3.6.1. United States of America.

In the USA, in addition to using the above measures, they also use water-seeding. This sowing method enables the cultivated variety to avoid red rice infestation. Other effective modifications of this method consists of constant flooding with a close watch of the irrigation regime.

If permanent flooding is to be used, a careful land preparation must be achieved, with the objective of eliminating all the existing plants. For so doing, a dry land preparation is necessary to pulverize the soil. Afterwards, the land is flooded and plowed with a light harrow or a similar implement. Sowing is then accomplished with dry or pregerminated seed and the field is not drained until harvest. This method is seldom used, since it causes a sensible decrease in rice plant population.

When control is based on flooding time, the land is dry-prepared until it is pulverized, eliminating the plants on the surface. Particular attention should be paid to the establishment of an optimum bed to receive the rice seed that will be sown. Next, the field is flooded and, if necessary, a land preparation in water can be carried out with a leveling implement. Such an implement compacts the soil, which avoids the germination of red rice seeds.

Afterwards, sowing takes place. If pregerminated seeds are used, the field is drained rapidly; if dry seeds are used, drainage should be slow to keep soil moisture longer. In both cases it is pursued that roots of germinated rice seeds reach a length of about 2.5 cm. Next, the field is flooded gradually as rice plants grow.

Although the constant flooding method guarantees the elimination of red rice, most farmers use this last variant which, in addition to providing an acceptable plant density, guarantees a considerable elimination of red rice.

In the USA, they also use herbicide Molinate (Ordram) to control red rice, at a rate of 4.7 kg of a.i./ha incorporated to the soil with two passes of a light harrow.

The use of Molinate, together with the water management enables farmers to effectively avoid the establishment of red rice. Rice is sown after the incorporation of Molinate in the soil and the establishment of the water layer. If the water layer is removed to accelerate growth of the rice plant, the growth of weeds is stopped thanks to the presence of Molinate. The soil must be constantly oversaturated to prevent germination of red rice plants. The use of Molinate, water-seeding of rice, and the management of water enables farmers to eliminate red rice in 80-90%.

3.6.2. Mexico.

In Mexico, at the Centro de Investigaciones Agrícolas de Sinaloa, they describe three control methods:

3.6.2.1. Sowing pure seeds
3.6.2.2. Hand weeding
3.6.2.3. Cultural methods

When it comes to lands with high infestation levels, the measures to be followed are:

a) With crops in furrows such as maize and sorghum, red rice can be eliminated through the use of a cultivator and roguing the plants that grow on the furrows.
b) With winter crops such as wheat, harvest is accomplished in spring and the land is allowed to rest during the summer, with periodical harrowings to eliminate "red rice" plants. Harrowings help to unearth a great number of seeds in dormant stage, preventing them from establishing in the soil. Later they germinate and are destroyed through successive harrowings. They suggest that crop rotation should be very strict at least during 3 or 4 seasons.
c) Another very practical combat system in other rice regions of Mexico consists of establishing forage crops for cutting or grazing in rotation with another regional crop. In Sinaloa, crop rotations can be established with alfalfa or forage sorghum, alternated with sugarcane. This way red rice propagation is prevented by mass cutting of forage and the remaining plants are destroyed with the sugarcane crop.
d) A system described by Mexicans that is used in southern USA where there are heavy infestations of red rice, and that can be adapted to the rice valleys of Sinaloa when they have enough water is the following:

d.1. Dry preparation of land.
d.2. Proper leveling and lay out of contour curves.
d.3. Establishment of a water layer of 10-12 cm during one week.
d.4 At the seventh day seeds are put to pregerminate by submerging them in big containers with water during 12 hours. After this time, sacks are exposed to the wind for draining for other 12 hours.
d.5. The same seventh day, if the water layer has not lowered because of infiltration or evaporation, then it must be reduced to a maximum height of 3-4 cm.
d.6. At the eight day sowing performed with an aircraft. Since seeds swell out because of water absorption, if "ventury" is used, it should be made sure that it be well open so that the seed comes out easily and that it does not obstruct the gate.
d.7 From 4 to 5 days after sowing, seeds which will be in full germination will be flushed, consisting of a light irrigation to prevent the soil from drying out and to make it easier for the seedling's roots to penetrate the soil.
d.8 After the above, two flushings similar to the first one should be given with the same interval of 4-5 days to avoid the germination of other weeds and to hasten the rice plant development.
d.9 After the third flushing, seedlings will be slightly over 15 cm high and then if there is enough water available, it will be possible to flood the crop, making sure that no small rice plants remain below the water level.

Through this system, two objectives are achieved:

— Red rice is controlled due to asphyxiation of the seeds established on the soil, and, at the same time, weed population, proper of rice fields, is considerably reduced.

3.6.3. Cuba.

In Cuba, in the early 70s, our fields started to be highly infested with red rice.

In some places, especially in Los Palacios, Pinar del Río, the mixture level was so high that it impeded the planting of large areas and the average yield during the years 1972-75 was only 1.9 t/ ha.Based on world experience, we designed a red rice control method that has proven to be effective, consisting of a modification of one of the methods used in the USA and described by Mexican researchers which consists of:

a) Dry land preparation until soil is it well pulverized and leveled.
b) Makig levees or contour curves.
c) Performing one or two flushings to stimulate germination of variety mixtures, rice of the cultivated variety in the previous crop, and weeds.
d) Elimination of such germinations through the application of total herbicides (Gramoxone, Surcopur + Carbaryl or Dalapon).
e) Flooding afterwards with a $\pm$ 15 cm high water layer during 5-7 days.
f) Reducing the water layer to 5 cm.
g) Sowing with pregerminated seed.
h) Flushing with short intervals of time to prevent the soil from drying out and splitting, and germination of red rice.

The fundamental conditions for establishing this method are the followings:

i. Establishment of a planting program based on the growth duration of the varieties to be used, especially by taking into consideration the fields near the area to be disinfested, to avoid damages with subsequent applications of total herbicides.

ii. Prevailing winds. This is the main factor to be considered. Sowing must be carried out in the same direction as the prevailing winds. This avoids damages caused by the applications of total herbicides in previously sown fields that have already germinated where this control method is being used, or in neighboring fields towards which the wind is headed.

iii. Doble-cropping areas must not be located in the disinfestation areas, since these can only be planted once a year. Besides, they must be located in fields opposite to the wind's direction, in respect to the fields to be disinfested.

iv. The areas to be disinfested must have water and herbicide, since this method does not give satisfactory results without the establishment of a water layer after the total herbicides are applied (2-3 applications).

Other necessary or possible practices to be used for controlling red rice are:

a. Cleaning agricultural equipment (combine, implements, etc.) before passing from a field infested with variety mixtures to a mixture-free one.
b. Avoid using drainage water from fields infested with variety mixtures in non-infested fields.
c. Use of cattle after harvest. This practice has been used in our country with good results.
d. Elimination of variety mixtures by hand (negative selection) in fields with low infestation levels. This prevents the reinfestation of fields.
e. Using no tilling and application of total herbicides after cold-season harvest. This practice is possible by itself or with some variations, as will be described in research completed or in study phase.

Other rice-growing countries presenting high infestations of red rice like Brazil, Colombia and Nicaragua, use control methods similar to the ones described here.

4. MAJOR RESEARCH CARRIED OUT OR IN STUDY PHASE

In field experiments carried out by Diarra et al (1985) searching for red rice control methods, they used the commercial rice variety Mars, either mixed or not with Calcium Peroxide 40% and a protectant R-33865 (0,0-diethyl -0- phenyl-phosphorothiate) at 0.5 and 1.0%. After pre-sowing incorporation of 6.7 kg/ha of Molinate, plots were flooded at a depth of 2.5-5.0 cm, and sown with 100 kg/ha of seed of variety Mars, at 2.5 cm deep.

With or without Calcium Peroxide, Molinate increased rice yield in 50% and increased the population density five times. Pre-sowing incorporation of Molinate controlled 96% of red rice. Rice seed treated with Calcium Peroxide or with Calcium Peroxide + 0.5% of R-33865, combined with Molinate incorporated prior to sowing, yielded 5.7 and 6.0 t/ha respectively. The highest yields associated with red rice control were attributed to Molinate and a good plant population as a result of the oxigen provided by Calcium Peroxide. R-33865 applied at 1% reduced plant density in 41%.

The use of seed protectants through Oximes was researched on sorghum against Metalachlor. Fhurazole - (2-chlo-4-tri-fluoromethyl) - 5 thiazolecarboxilic acid (phenilmethyl ester) was the most effective, showing also a protective effect to rice crop.

In field research in Crowley (USA) carried out by Baker et al (1984) on red rice control, variety Mars was sown in plots with a water layer previously treated with 4.5 kg a. i./ha of Thiobencarb. Next, flooding was continued in one treatment and the other was drained at 3-13 days. The plant population of variety Mars and red rice was increased from 2 to 20 times as drainage was increased from 0 to 13 days. Thiobencarb increased the number of panicles per square foot and the number of grain per panicle and, subsequently, the yield of variety Mars was increased from 3.3 to 4.9 t/ha and red rice yield was reduced from 4.5 to 2.6 t/ha.

Under heavy infestation of red rice in variety Leach, one application of 6.7 - 9.0 kg a.i./ha of Thiobencarb, 4.5 kg a.i./ha of Molinate, alone or mixed with 0.75 kg/ha of R-33865, caused a significant decrease in red rice population.

In field research against red rice, Griffin et al (1984), state that applications of 4.5 kg a.i./ha of active ingredient of Molinate in irrigation water did not cause any yield increases of the cultivated variety, but increased grain quality and reduced red rice infestation. In continuous rice planting, when the land was not plowed after the previous harvest and the fields were drained during the winter, the number of seeds of red rice was reduced both in the soil and at harvest time.

Baker et al (1986) state that through the incorporation of 5.05 kg a.i./ha of Molinate before flooding, and draining the field 5 days later, a better control of red rice was achieved in water-seeding without a significant decrease in rice populations. Continuos flooding reduced red rice population but it also reduced significantly the population of cultivated rice.

In a experiment on red rice control through the use of soybean as an intercalated crop carried out by Griffin and Harger (1984), they found that all of the herbicides used reduced red rice biomass and seed production. Herbicide Quizalofop allowed the lowest production of red rice seeds per square meter: 140, as compared to 3757 seeds per m^2 of the check with no control.

In experimental plots Barrentine et al (1984) evaluated 5 variants with herbicides for red rice control in soybean. The mixture of Mefluidide with Bentazone, 0.14 + 0.84 kg a.i./ha respectively, was the most effective for red rice control in one-to-two-leaf stage. Also double applications of Haloxyfop-methyl or Quizalofop were effective. Fluazifop-buthyl was the least effective. At 5-to-6-leaf stage of rice, Quizalofop at 0.56 kg a.i./ha was the most effective treatment.

At present, an experiment under field conditions is being carried out in our country with good perspectives at Sur del Jibaro, consisting

Scheme 1. Traditional method of red rice control.

1989 Jan-Feb	Jun-Jul	Jun-Dec	1989-1990 Dec-Apr	May-Jun	May-Jul	1990 Oct-Dec
Sowing	Harvest of fields with red rice.	Fallow with cattle, harrowings or puddling	Dry tilling with harrow	Chemical desinfestation	Water-seeding	Harvest

1990-1991 Dec-Apr	May-Jun	May-Jul	1991 Oct-Dec
Cattle or harrowings, dry tilling with harrow	Chemical desinfestation	Water-seeding	Harvest

Summary of the above:

2.5 years: 2 chemical desinfestations
2 desinfestations with harrow, cattle, or puddling
2 harvests

Scheme 2. New method of red rice control, under study

1990 Jan-Feb	Jun-Jul	Jun-Aug	1990-1991 Nov-Jan	1991 Nov-Apr	May-Jun
Dry-seeding	Harvest of fields with red rice.	Chopping, burning, irrigation, total herbicide, flooding and water-seeding.	Harvest	Cattle or harrowings, dry tilling with harrows	Chemical desinfestation
May-Jul Water-seeding	1991 Oct-Dec Harvest				

Summary of the above:

1.5 years: 2 chemical desinfestations
2 mechanical desinfestation
2 harvests

of: After cold-season harvest (months from June-July), the stubbles are cut, the harvest residues remaining uniformly distributed on the soil surface are burned (destroying thus most of the grains of variety mixtures, cultivated rice and weeds that are found on the soil surface), the field is flushed and then ($\pm$ 10-15 days after) a total herbicide having no residual effect is applied. A water layer is established, sowing is done with pregerminated seed and high sowing rate (200 kg/ha). Next, flushings are carried out with intervals of time as short as possible (4-5 days) until the permanent water layer is established.

5. RECOMMENDATIONS FOR RED RICE CONTROL

5.1. To continue the use of our traditional disinfestation method (Scheme 1), with the possibility of incorporating the new method that is being researched at Sur del Jíbaro (Scheme 2).

5.2. To intensify preventive methods for red rice control: use of red-rice-free certified seed, cleaning of equipment and implements when passing from infested to red-rice-free fields, and avoiding the use of water coming from infested fields in those free from red rice.

5.3. To implement negative selection (roguing red rice plants) as a method to prevent reinfestation of fields with red rice in areas with low levels of infestation.

5.4. Use of cattle after harvest, preventing that panicle ratoon yield grains.

5.5. Use of crop rotation or intercalated crops.

5.6. To undertake a research plan on red rice control based on the most advanced research that is being carried out in the USA, Brazil and Mexico.

BIBLIOGRAFIA

Abud, J. K. 1984. Effect of Molinate-based herbicides on control of red rice *(Oryza sativa)* In Anais da 13a Reuniáo de cultura de Arroz Irrigado. Florianapolis, Brasil, Empresa Catarinense de Pesquisa Agropecuaria, pp. 332-338 (Pt, 4 ref.) Estacao Experimental do Arroz, Cachoerrinha, R. S. Brasil.

Anónimo. 1980. Combata el arroz rojo. Agricultura de las Américas. Agosto, pp. 30-37.

Aprod, A. I.; Bieloglasov, D. F. 1971. Recomendaciones para la lucha contra las diferentes formas de arroz rojo. Krasnodar INIA, NTI, 14 p.

Aprod, A. I.; Zinnik, A. M. 1980. Medidas para evitar la invasión del arroz rojo en los campos arroceros. INIA, Krasnodar, 10 p.

Baker, J. B.; Dunand, R. T.; Shrefler, J. W. 1984. Chemical control of red rice in rice. In 76th Annual Progress Report, Rice Research Station, Crowley Louisiana, (Undated) 172-185 (En) Rice Res. Sta., Crowley, LA 705 26, USA.

Baker, J. B.; Sonnier, E. A.; Shrefler, J. W. 1986. Integration of Molinate use with water management for red rice *(Oryza sativa)* Control in water-seeded rice *(Oryza sativa)* Weed Science 34 (6): 916-922.

Barrentine, W. L.; Street, J. E.; Kurtz, M. E. 1984. Postemergence control of red rice *(Oryza sativa)* Weed Science 32 (6): 832-834 (En. 8 ref.) Mississippi Agric. and Forest Exp. Sta. Stoneville, MS 38776, USA.

Chang, T. S. 1984. Structure-Activity relationships of oximes and related components as seed safeners. Disertation Abstracts International, B. (Sciences and Engineering) 45 (1): 20 (En Order No. Da 8408412) Texas A. M. Univ. Lubbock. TX 77843. USA.

Diarra, A.; Smith, R. J. Jr; Talbert, R. E. 1985. Interference of red rice *(Oryza sativa)* With Rice *(O. sativa)*. Weed Science 33 (5): 644-649 (En 25 ref.) Dep. of Agron., Arkansas Univ. Fayeteville, AR 72701, USA.

Diarra, A.; Smith, R. J. Jr.; Talbert, R. E. 1985. Red rice *(Oryza sativa)* control in drill-seeded rice *(O. sativa)* Weed Science 33 (5): 703-707 (En. 20 ref.) Dep. of Agron., Arkansas Univ., Fayeteville. AR 72701, USA.

García, J. Influencia de las mezclas varietales en el rendimiento del arroz y en sus componentes fundamentales. (No publicado).

González, F. J. 1987. Red rice and its control - Rice Abstracts, February, 10 (1): 185.

Griffin, J. L.; Harger, T. R. 1984. Herbicidal effects on red rice competition in soybeans (Abstract). In proceedings, Southern Weed Science Society, 37th Annual Meeting. Champaign, Illinois, USA 93 (En) Lousiana Agric. Exp. Sta., Louisiana State Univ. Agric. Cent. Crowley, L. A. 70526, USA.

Griffin, J. L.; Regan, R. P.; Dunand, R. T.; Baker, J. B.; Cohn, M. A. 1984. An integrated approach to red rice control (A. preliminary report) In 76th Annual Progress Report, Rice Research Station, Crowley, Louisiana, (Undated) 312-316 (En) Rice Res. Sta, Crowley, LA 70526, USA.

Gutiérrez, A.; Antigua, G. y Perdomo, R. 1981. Recomendaciones Técnicas para el cultivo del arroz, Managua, Nicaragua. 100p.

Instituto Nacional de Investigaciones Agrícolas SAG Centro de Investigaciones Agrícolas de Sinaloa (CIAS) 1971. Circular CIAS No. 11, 2da. Edición. México, junio.

Normas Técnicas. 1975. Frío 1974-1975 y Primavera 1975. La Habana, INRA, 142 p.

Pérez Ponce, J.; Martín, R.; Herrera, I. Variación en *Oryza sativa*. Grupo nacional de arroz MN/84/36.

Siqueira, E. H. 1986. Control of red rice in small farms (Por) Lav. Arroz. 39 (365): 32 may/june.

221262

INFLUENCE OF CULTURAL PRACTICES ON THE INCIDENCE AND MANAGEMENT OF INSECTS

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SUMMARY

Examples of the effect of cultural practices in the management of insect pest of rice are presented. The examples shown in this paper are not applied to all situations and are presented as illustrations of the pest management concept, not as recommendations. It is important to consider and combine the effect of factors such as water management, fertilizer, land preparation, plant age, and other cultural practices in the development of programs on Integrated Pest Management and Integrated Crop Management

INTRODUCCION

Integrated pest management pretends to minimize pest damage

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to the crop, but, at the same time to provide sustainable alternatives with long-term effect with the least alteration of the environment. In this work we present examples of crop management practices that affect the incidence or damage to the crop by insects. It is important to point out that the examples presented here should be integrated with agronomical and phytosanitary concepts in the development of Integrated Crop Management programs, but not as individual and/ or specific recommendations. This information was extracted from works developed at CIAT, therefore no reference are given. For more information we suggest that you consult the authors.

2. EFFECTS OF PLANTING SEASON AND PLANT AGE.

The physical and chemical characteristics of plants affect the selection of the insects to use them as food, shelter or as a place for oviposition. Other important factors affecting the selection of hosts by the insect are the availability of water in the soil, temperature, solar radiation and others. Knowing the effect of these factors in the incidence of insects, we can manage some pests that respond to cultural or crop management practices.

Trials carried out in Colombia have shown that through transplanting, oviposition of *Hydrellia sp.* can be reduced in 70%, and 51% for pupae, as compared to broadcast (Figure 1). Transplant is not feasible in great extensions of land, but it's an acceptable alternative for small farmers and in areas where labor is cheap. Besides, the management of *Hydrellia* can be combined with other strategies, such as water management. Figure 2 shows the effect of weekly irrigations and permanent water layer on oviposition of *Hydrellia* and the survival of larvae and pupae. Fifty-nine per cent (59%) less eggs are seen on plants subjected to weekly irrigations as compared to plants with constant water layer. Likewise, fields with weekly irrigations have 38% less larvae and 66% less pupae than flooded fields.

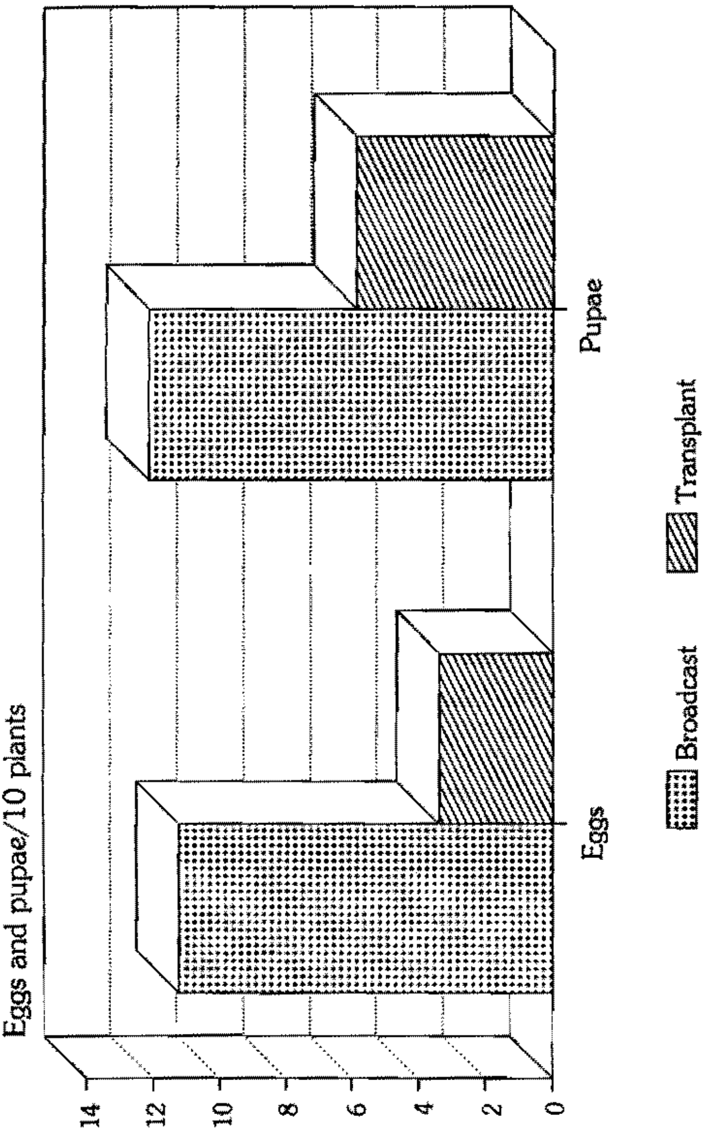

Figure 1. Oviposition of Hydrellia *sp. in broadcast and transplant, 1990.*

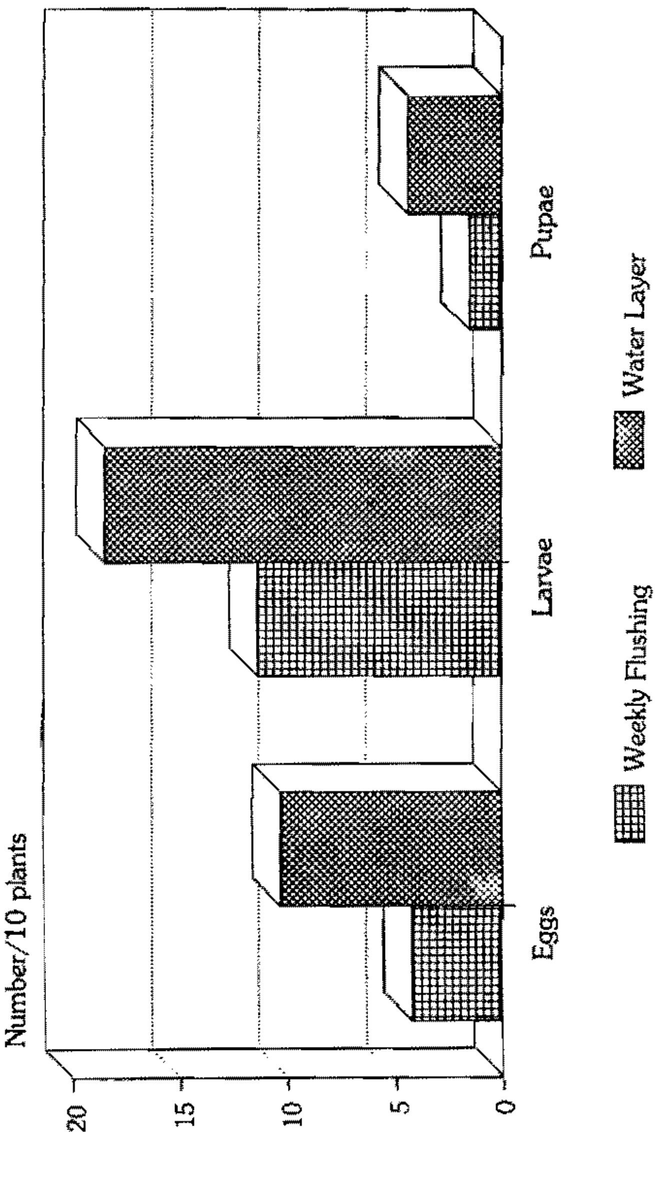

Figure 2. Effect of water layer on Hydrellia sp.

In another research (Figure 3) it was proved that populations of *Hydrellia* can be reduced through increasing sowing rate. If sowing rate is increased from 100 to 300 kg/ha, the number of pupae per plant is drastically reduced.

These cultural practices offer non-chemical alternatives for the management of *Hydrellia* in rice. However, it is convenient to mention some important factors that could affect other crop management practices. For example, increasing sowing rate reduces the incidence of insects on the crop, and can help in the competition against weeds. On the other hand, in areas where rice blast is a problem, increases in sowing rate could trigger epidemics of the disease. The practice of flushing every week, in spite of being effective in the management of *Hydrellia,* accelerates the loss of Nitrogen on the soil, and affects the effect of pre-emergent herbicides. This effect on herbicides could result in a weed problem.

Then, an adequate balance is necessary to apply the most effective control strategy without interfering with other management practices. Understanding the interaction among cultural practices makes it necessary to develop multidisciplinary groups that see the phytosanitary problem as a set of practices and not as individual fields.

Another example of cultural practices that could affect pest incidence is the effect of land preparation on the ant *Acromyrmex landolti*. Through an early land preparation it is possible to destroy 90% of the anthills of *A. landolti* (Figure 4). In this specific case it is important not only the mechanical effect of the preparation, but the time of preparing the land. If land preparation is done prior to nuptial flights, the probabilities of the establishment of new anthills are reduced. This effect of mechanical control of pest can be observed in other soil insects.

On the other hand, it is convenient to point out that land preparation (with its secondary effects of better weed control, incorporation of organic matter, etc.) can, in addition, affect other pests occurring later during the crop. For example, *Sogatodes oryzicola* is more abundant in upland rice in early land preparation (Figure 5). On the other hand, insects such as *Mocis* sp. and *Epitrix* sp. are more abundant in rice planted in land with late preparation (Figure 5).

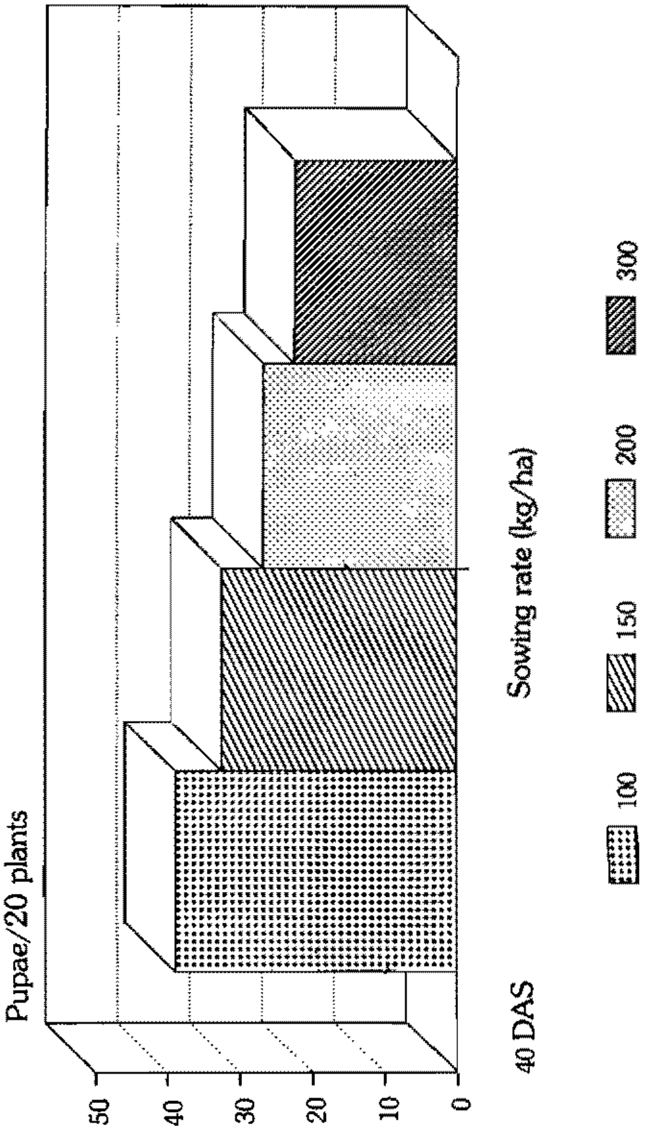

Figure 3. Effect of sowing rate on Hydrellia *sp.*

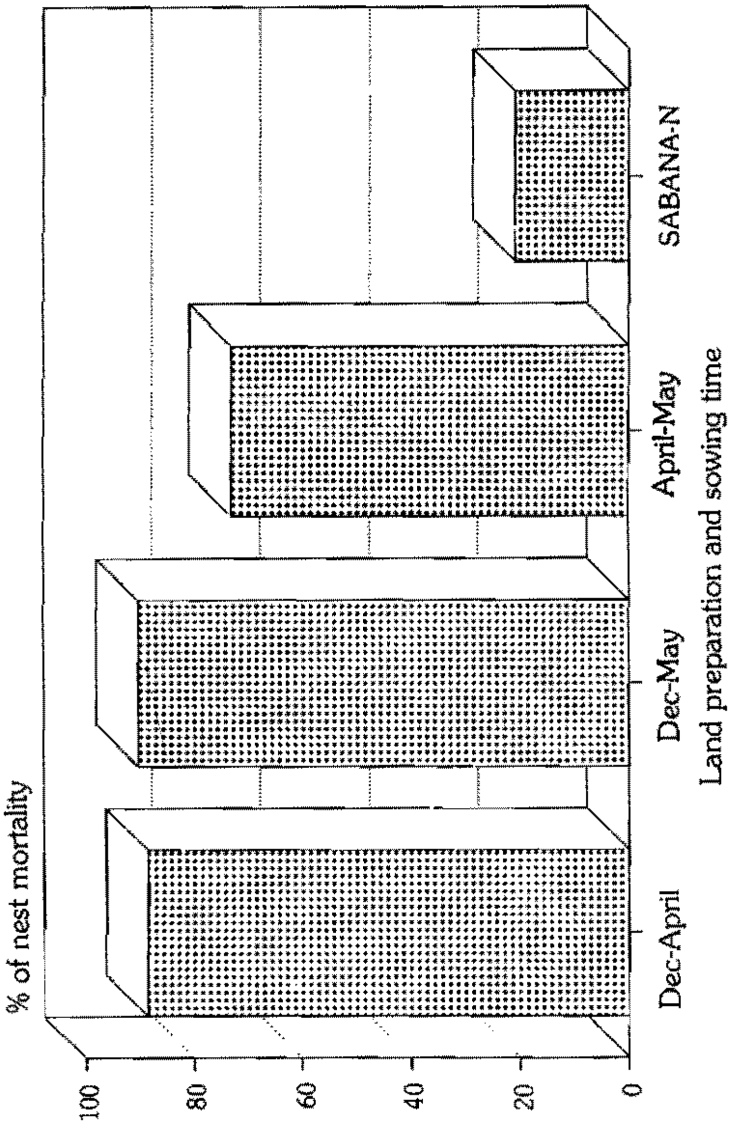

Figure 4. Effect of land preparation on Agromyrmex landolti.

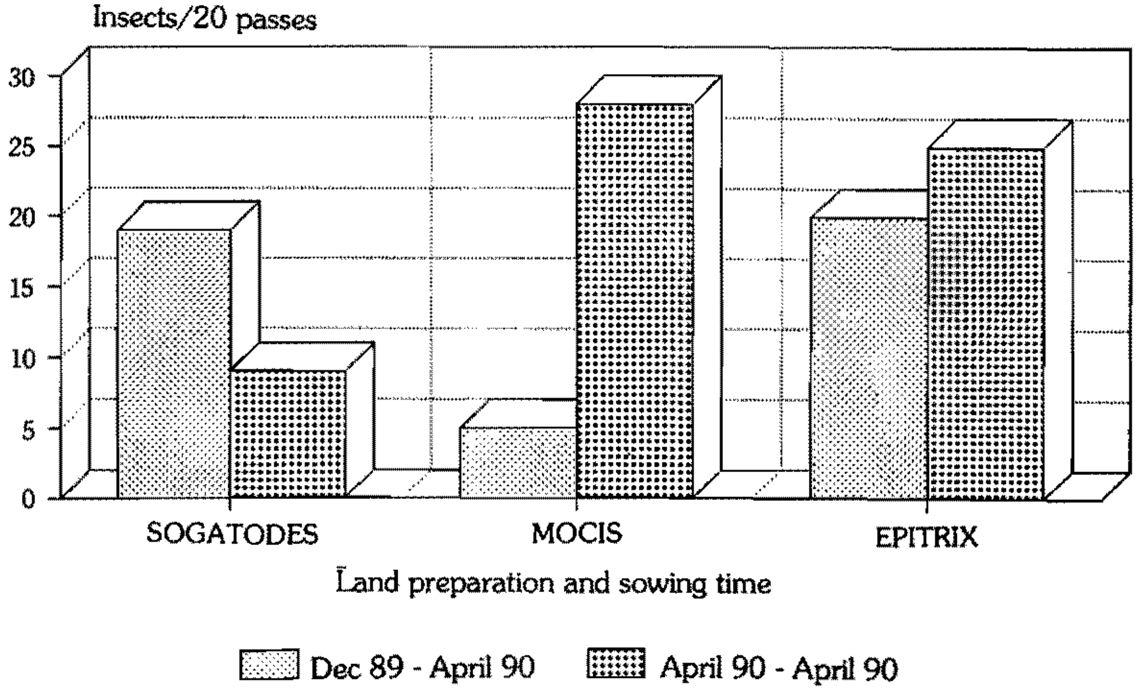

Figure 5. Effect of land preparation time on arthropods.

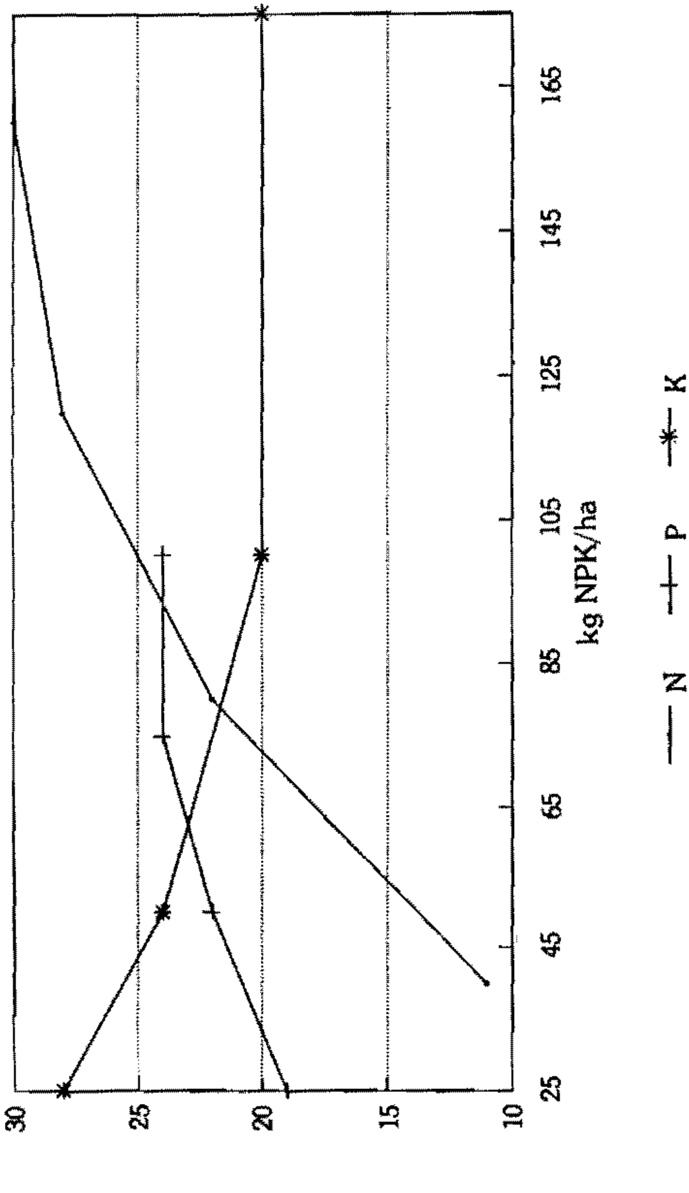

Figure 6. Influence of N, P, K, on the incidence of Spodoptera frugiperda.

Fertilization is another important factor of pest incidence on plants. Figure 6 shows the effect of fertilization (NPK) on *Spodoptera frugiperda* in upland rice. Increases in the rate of Nitrogen and Phosphorus per hectare cause increases in the incidence of *S. frugiperda*. On the other hand, increases in the rate of Potasium cause a tendency to reduce the incidence of *S. frugiperda*. It is known that Nitrogen and Phosphorus increase plant succulence, whereas Potassium stimulates plant suberization and hardening, making it less palatable for the insect.

221263

STUDIES ON BIOLOGY, DAMAGE AND VARIETY RESISTANCE TO Spodoptera frugiperda *IN RICE.*

ALBERTO PANTOJA[1]

SUMMARY

There are few works related to the management of *S. frugiperda* affecting rice crop. There are informations available on biology (Pantoja et al 1987), oviposition (Pantoja et al 1986 C), natural enemies (Pantoja et al 1985; Pantoja and Fuxa 1990; Simmons et al 1990), damdge (Navas 1967, 1974; Pantoja et al 1986A; Rice et al 1982) and variety resistance (Pantoja et al 1986B) that can be used in developing management programs of this rice pest. Additional research is necessary to determine the effect of natural enemies that are also affected by edaphic factors, as well as incorporating the resistance to improved varieties and validate currently available information in the different regions where the pest occurs.

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INTRODUCTION

Rice is attacked by about 100 insect species. Among the insects of economic importance, the fall armyworm, *Spodoptera frugiperda* (J. E. Smith), is considered as a sporadic pest of rice, but highly damaging. *S. frugiperda* is considered as the lepidopteran of major economic importance of rice in the world. Besides, this insect is a pest of economic importance for many other crops, especially those belonging to the Gramineae family.

Little is known on the damage of *S. frugiperda* and its effect on rice yield. Most of the works reported are based on the effects of simulated damage on rice yield or refer to other different genera of *Spodoptera*. Likely, there is few information on the natural enemies of *S. frugiperda* attacking rice plants, variety response to the damage and the development of the pest on rice plants.

This work discusses important aspects on biology, variety resistance and natural enemies of *S. frugiperda* affecting rice plants.

2. DAMAGE - YIELD RELATIONSHIP

The effect of *S. frugiperda* was studied under field conditions. Increases in larval density resulted in an increase in defoliation and decreases in plant population and yield (Table 1). Studies of yield components show that yield decrease is the effect of the decrease in plant population and therefore, a minor number of panicles per square meter (Table 2). The weight of 500 grains and the percentage of filled grains were not affected by defoliation caused by *S. frugiperda* in early stages of crop. The relationship of the damage or defoliation is linearly related to larval density (Pantoja el al 1986 A).

The results show that populations of 215 larvae per square meter are required to cause significant losses in rice yield. However, 26.9 larvae per square meter are capable of affecting yield. The population of 215 larvae/m2 is lower than natural populations reported for upland rice in Panamá (Navas 1974). Another genus, *Pseudaletia*

Table 1. Defoliation and yield of rice affected by larvae of Spodoptera frugiperda

Larvae/m^2	Biomass Index (mg/m)*	Yield (kg/ha)**
0	996.6 a***	10,267 a***
26.9	417.6 b	9,922 a
53.8	556.6 b	10,003 a
80.7	454.3 b	9,551 ab
107.6	621.1 b	9,885 a
215.1	329.7 b	8,511 b

* Biomass index = Weight in gram of plants on the ground/area.

** Yield adjusted at 12% of moisture content.

*** Averages with the same letter do not differ significantly at 5% probability according to Duncan's test.

Table 2. Effects of the damage of Spodoptera frugiperda *on some components of rice yield.*

Larvae/m^2	% density decrease		500 grain weight (g)
	Plants/m^2	Panicles/m^2	
0	0 a	0 a	10.6 a
17.5	39 b	16 a	12.0 a
35.1	58 b	30 a	11.9 a
52.6	85 c	76 b	10.8 a
70.2	100 c	100 b	*
87.7	100 c	100 b	*

* All plants were dead; no rice was collected

unipuncta (Haworth), causes up to 50% decrease in yield with a defoliation range of 25-30% (Rice et al 1982).

It is convenient to point out that the seriousness of damage is a function of plant age, the development stage of the larva, the variety, and environmental factors that could affect the insect's feeding activity, as well as plant recovery. That's why precaution is recommended in applying these results to conditions different from the ones reported here. The thresholds presented here can sure be used as a guide in the taking of decisions.

3. VARIETY RESISTANCE

Variety resistance is an important component in the development of packages on integrated pest management. Variety resistance is used for the management of *S. frugiperda* in various crops such as corn, sorghum, and pastures, but not in rice (Pantoja et al 1986B).

In studies carried out during 1983-1985 by Pantoja et al (1986B) a methodology was reported to identify sources of resistance against *S. frugiperda* in rice. The technique consists of submitting seedlings to the attack of newly born larvae of *S. frugiperda* under greenhouse conditions, which proved to be efficient. Various levels of resistance or susceptibility to the insect attack were detected.

Five thousand (5,000) genotypes were evaluated. It was found that several genotypes showed low preference and possibly antibiosis in other genotypes, with a high number of larvae in the preferencial test, but with low defoliation index in forced feeding tests (Table 3). Additional works are required to study the mechanisms of resistance in detail as well as to incorporate such resistance to improved varieties.

4. NATURAL ENEMIES

There are several revisions on natural enemies of *S. frugiperda*; however, there are very few reports on natural enemies of *S. frugiperda* attacking rice. In 1985 Pantoja et al reported, for the first time, parasitoids and entomopathogens identified and/or recovered of larvae of *S. frugiperda* collected in commercial rice fields in Puerto Rico. Later, Pantoja and Fuxa (1990) and Simmons et al (1990) reported additional studies on natural enemies of this pest.

Table 3. Defoliation and preference of larvae of Spodoptera frugiperda *on several rice genotypes.*

Genotype	Origin	Defoliation	Preference
2869	China	4.3 a	22.9 ab
H-62-15-1	Argentina	4.3 a	63.6 c
H-74-14-1	Argentina	5.0 ab	65.0 c
H-65-22-2	Argentina	5.8 ab	10.0 a
H-61-10-1	Argentina	5.8 ab	37.4 abc
H-64-11-1	Argentina	6.7 abc	36.0 abc
Chien	China	6.8 abc	24.1 ab
Saturno	USA	6.8 abc	26.0 ab
H-75-5-1	Argentina	7.0 abc	14.7 a
La Plata	Argentina	7.3 bc	12.4 a
Mars	USA	7.8 c	—
Yu-hsuan	China	9.0 c	54.6 bc

Among the parasitoids, seven genera belonging to two order and three families have been reported (Table 4). However, combined parasitism of all genera affect only 14.7% of the larval population of *S. frugiperda*. Parasitoids of major incidence are, in descending order: *Chelonus insularis*, *Euplectrus furnius* and *Cotesia marginiventris* (Pantoja and Fuxa, 1990).

Another natural enemy of *S. frugiperda* is the nematode *Noctuidonema* sp. that affects male adults (Simmons et al 1990). Studies in many countries show a large geographical distribution of the nematode, as well as a high incidence or percentage of parasitism. However, since adults are collected with pheromone traps, the place of origin of adults, or the crop on which they fed at larval stage are unknown. Additional research is required for studying the incidence of this nematode in rice fields.

Due to the condition of high moisture and/or flooding in which rice is grown, entomopathogens related to larvae of *S. frugiperda* in upland and flooded rice may be different. The virus *Nomuraea rileyi*, polyhedrosis virus and a microsporidian (Pantoja and Fuxa 1990) have been identified in irrigated rice in Puerto Rico. *N. rileyi* is the entomopathogen of major incidence,affecting 10% of specimens, followed by an unidentified microsporidian, and polyhedrosis virus. The total larvae affected by those three pathogens reach only 17.6%, and varies according to the sampling date.

Table 4. Parasitoids of larvae of Spodoptera frugiperda collected in rice fields in Puerto Rico.

Order/Family/Genus	% of Paratitism (N)
Diptera	
Tachinidae	
Archytas marmoratus (Towsend)	0.1 (2)
Lespesia sp.	1.2 (23)
Hyminoptera	
Braconidae	
Chelonus insularis (Cresson)	5.5 (106)
Cotesia marginiventris (Cresson)	3.1 (59)
Rogas laphygmae (Viereck)	0.1 (2)
Eulopidae	
Euplectrus furnius (Walker)	3.6 (69)
Euplectrus platyphypenae (Howard)	1.2 (23)
TOTAL	14.7 (284)

REFERENCES

Navas, D. 1967. Efectos de la destrucción del follaje en los rendimientos del arroz. In: Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios, XIII: 85-87.

Navas, D. 1974. Fall armyworm in rice. In: Proceedings tall timbe conference on Ecological Animal Control by Habitat Management. pp.99-106.

Pantoja, A.; C. M. Smith. and F. J. Robinson, 1985. Natural control agents affecting *Spodoptera frugiperda* (Lepidoptera: Noctuidae) infesting rice in Puerto Rico. Fla. Entomol. 68: 488-490.

Pantoja, A.; C. M. Smith. and J. F. Robinson, 1986 A. Effects of the fall armyworm (Lepidoptera: Noctuidae) on rice yields. J. Econ. Entomol. 79: 1324-1329.

Pantoja, A.; C. M. Smith. and J. F. Robinson, 1986 B. Evaluation of rice germplasm for resistance to the fall armyworm (Lepidoptera: Noctuidae). J. Econ. Entomol. 79:1319-1323.

Pantoja, A.; C. M. Smith. and J. F. Robinson, 1986 C. Fall armyworm oviposition and egg distribution on rice. J. Agric. Entomol. 3: 114-119.

Pantoja, A.; C. M. Smith. and J. F. Robinson, 1987. Development of fall armyworm, *Spodoptera frugiperda* (J. E. Smith), strains from Louisiana and Puerto Rico. Environ. 16: 116-119.

Pantoja, A.; and J. R. Fuxa, 1990. Prevalence of biotic agents in fall armyworm infesting rice in Puerto Rico. Folia Entomol. Mexicana. (Sub.).

Rice, S. E.; A. A. Girgorick. and M. O. Way, 1982. Effects of leaf and panicle feeding by armyworm (Lepidoptera: Noctuidae) larvae on rice yield. J. Econ. Entomol. 75: 593-595.

Simmons, A. M.; C. E. Rogers; K. U. Buekmire; B. Gray; K. D. Monkman, A. Pantoja, J. R. Raulston. and U. H. Waddill, 1990. Seasonal Chronology of *Noctunidonema,* an ectoparasitic nematode of adult maths, in Tropical and subtropical America. Flo. Entomol. (Sub.).

RESULTS OF STUDIES CARRIED OUT IN CUBA FOR THE MANAGEMENT OF Sogatodes oryzicola (Muir), Oebalus insularis (Stal), Lissorhoptrus brevirostris (Sulf) AND Hydrellia sp. *IN RICE CROP*

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I. SOGATA: Sogatodes oryzicola (Muir)

INTRODUCTION

S. oryzicola, is the major vector of the causal agent of Hoja Blanca disease in rice, occupies a relevant position among insect pests causing damages to rice crop in Cuba.

In the 1950's rice areas were increased considerably in almost all

1. Researchers at the Rice Research Institute, Cuba.

of the rice-growing countries in Latin-América, establishing the year-round cropping system in significant magnitude. This, together with varietal characteristics, favored the conditions for the development of *S. oryzicola*, and also increased the dissemination of Hoja Blanca disease, which caused severe losses in yields of cultivated rice.

With the objective of obtaining an optimum pest management, in early 1970 several bio-ecological studies of this insect were started in Cuba, in order to use these knowledges to control this serious rice pest which, together with the different control methods applied, has given as a result a considerable decrease in the damages caused to rice by *S. oryzicola* in our country.

2. BIOLOGY OF S. orizicola.

Males of *S. oryzicola* have an approximate length of 2.0 mm, they are smaller than females and from dark-brown to black in color. Females measure from 3.33 to 3.35 mm, amber-colored and lighter in color than males. The torax's back is pale up to the side keel, and this color extends up to the tip of the head.

Although females are generally amber-colored, they can show male-like darker forms. On the other hand, females can be winged or brachipterous even in the same generation.

Females lay their eggs in the midrib of leaves, inside a hole they make with their ovipositor. They show remarkable preference to lay their eggs in the middle section of leaves of the rice plant, in relation to apical and basal sections. Besides, 95% of the eggs have been found in the upper face of the leaf blade.

The number of eggs per cluster is variable; the eggs are curved with one of the extremes pointed and the other rounded. Its average size is of 0.679 mm long and 0.196 mm wide.

The incubation period of eggs of *S. oryzicola* varies in the different months of the years, influenced by the temperature of these seasons, varying between 7 and 10 days in the summer and up to 20 days in the winter.

The nymph of *S. oryzicola* passes through five instars to reach adulthood. In the first instar it has a whitish color and small size (0.65 to 0.90 mm long and 0.2 to 0.3 mm wide), but as it grows, the clearness of the brown parallel streaks on its back increases. The size of the last instar is from 2.8 to 3.0 mm long, and 1.2 mm wide.

The life cycle of *S. oryzicola* has been studied by different researchers, with some differences being obtained among them (Table 1).

3. ECOLOGY OF S. oryzicola.

3.1. Plant-insect relationship

Even though this pest may be found on the rice plant in different growing stages, specifically during the stages in which major population levels are recorded, they have also been found frequently feeding on young rice plants (from germination to active tillering) possibly, among other reasons, because their tissues are younger and therefore suitable for their fedding.

In this development stage of rice plant, an average of 104 eggs, 80 nymphs, and 280 adults were collected during three years through counting in such phenological stage. When plants were in panicle initiation stage, the average per collection was of 80 eggs, 12 nymphs, and 28 adults, which shows the high degree of preference of *S. oryzicola* for young rice plants.

This specie has sedentary habits, accentuated during the dry season with fresh temperature.

4. MAJOR HOST WEEDS

In addition to rice, which is its main host, *S. oryzicola* has other weeds on which it can feed during certain seasons of the year, among them: *Echinochloa colona,* to which it has been possible to transmit **Hoja Blanca** virus; *Panicum muticum (:: Brachiaria mutica); E.*

Table 1. Biology of Sogatodes oryzicola.

Researcher	Year	Stage of the insect	Duration (days)
Acuña et al	1959	Females-Males	30-15
Reinteria	1960	Females-Males	43.9-13.8
Rey and Garcia	1980	Females-Males	27.8-24.1
Gómez and Kamara	1980	Females-Males	31.1-14.6
Acuña et al	1959	Incubation of eggs	7.4-(27.6 °C)
			19.2-(16.9 °C)
Rey and Garcia	1980	Incubation of eggs	10.5-(21.6 °C)
			7.2-(25.8 °C)
Acuña et al	1959	Larval instars	14.0-(26.3 °C)
			21.3-(20.6 °C)
Rey and García	1980	Life cycle	
		Males	25.8-(21.5 °C)
		Females	23.3-(21.5 °C)
		Males	20.7-(25.5 °C)
		Females	22.1-(25.5 °C)

crus-galli. Also *Rottboellia exaltata*, *Paspalum plicatulum* and *Leersia hexandra* are mentioned as possible hosts.

5. POPULATION DYNAMIC OF S. oryzicola.

The most favorable conditions for increasing population density of *S. oryzicola* are an average temperature between 25 and 27°C, whereas it shows susceptibility to a temperature of 35°C or higher.

Temperatures below 25°C, as well as great thermic variations, have a negative influence on the growth and development of this insect.

Peaks in the population density of *S. oryzicola* are found within the months from April to November. This period covers the months of hottest temperature in Cuba. From December to March the population of this delphacid decreases under the influence of fresh temperature (average temperature below 25°C) and scarce rainfalls.

A remarkable drop in the population of *S. oryzicola* is observed within the months from June to September, when higher temperatures prevail, as well as rainfalls above 100 mm. During this period, natural enemies show a remarkable activity.

Other factors which, together with temperature, influence the population dynamic of *S. oryzicola* are natural enemies, both parasites and predators. Among these, the most important ones are: *Paranagrus perforator*, and *Tytthus parviceps* , parasite and predator of the insect's eggs, respectively.

In respect to flying activity of *S. oryzicola* measured through a modified Minnesota-type light trap, as well as with the sweep net, a considerable decrease was observed in the pest's activity during winter or drought periods, in which average temperatures reached lower values than between April and November. This activity increases to a maximum when temperature reaches the optimum range, between 25 and 27°C.

When the range correlation analysis between the population rate and temperature was computed, the coefficient obtained was $r=0.884$, highly significant.

In relation to the sex of *S. oryzicola*, a larger amount of males than that of females are caught through light traps. The opposite occurs with the net method.

For scouting the increase in population levels of *S. oryzicola* in Cuba, the month of March is essential, especially during the second half, when temperatures begin to rise.

6. *ECONOMIC IMPORTANCE OF* S. oryzicola *IN CUBA*

The insect begins to attack rice plants a few days after germination. Severe attacks produce a well defined yellowing on leaves, which progressively becomes light-brown in color. Another symptom of the attack is the development of fumagina on the leaves.

The attacks are observed in the field as spots which spread progressively throughout the field, if the insect is not controlled.

Rice plants subject to individual action of virus-free *S. oryzicola* during three days suffered a remarkable delay in growth and elongation of leaf sheath (Acuña et al 1959).

During 1960, 300 or more rice planthoppers were collected in the rice zone of Sancti Spiritus in 10 single passes of net, which represents a high population of the insect. In the years from 1971 to 1973, a population increase of the insect was observed in the same zone, standing out the first six months of 1972, when 23,652 insects were collected in population dynamic plots, between nymphs and adults, with weekly samples in an area of 75 m^2.

Concerning rice Hoja blanca disease in both decades (1960 and 1970), heavy infestations were detected in the former decade on varieties Century Patna, and Blue Bonnet 50; and IR-8 and IR-160 in the latter (70s).

In the years 1972 and 1973, 10.3 and 6.53 insecticide applications per area were made against *S. oryzicola* in Sur del Jíbaro, with an area planted of approximately 30 thousand hectares. But beginning in 1975, with the introduction of resistant varieties, planting seasons, and better cultural practices, this number was reduced to less than 0.5 applications, in 1987, and ever since no applications have been made to control this insect.

7. MANAGEMENT

7.1. Sampling method and action thresholds for S. oryzicola.

The sampling method recommended for scouting the pest is done through the sweep net, although the light trap can be used as a complementary method for determining the beginning of population increases of this pest in its invasion activity to young rice fields.

Samplings are carried out according to the established schedule, beginning 5 days after rice germination and with weekly intervals until the plants have reached panicle initiation stage. Besides, if an insecticide application is made, the technical effectiveness of such product should be evaluated afterwards.

In sampling using the sweep net, the first point should be taken at a distance of 20 m from the irrigation canal, making 10 sweeps at this point. Ten net sweeps should also be made at the remaining 9 points following the field's diagonals and trying to cover the whole length of such field.

In addition to this sampling, leaves are taken from 100 rice plants spread randomly in the field, with the objective of determining oviposition of *S. oryzicola* and *T. parviceps*, and parasitism caused by *P. perforator*, in order to take the necessary measures from the first moment of pest incidence.

Also a high number of *S. oryzicola* (+ 100) is collected on representative fields of the sampled area with the presence of this insect. They are put in a cage with rice plants from the same field, to evaluate vectoring capacity of such insects through the method of sampling on small plants (2-3 leaves). The ELISA test method can also be used.

This evaluation will enable us to detect any focus of appearance of Hoja Blanca disease and to be able to take the necessary measures in that respect.

As pointed out in the chapter on population dynamic of the insect, in Cuba it is extremely important to take special care in sampling and scouting *S. oryzicola* beginning in March, season in which temperature normally begins to rise, reaching the optimum ecological temperature of the insect. These previsions must be taken with great care in those fields having plants of only a few days after germination, which is their most susceptible stage.

Since all commercial rice varieties in Cuba are resistant to *S. oryzicola*, it is recommended to apply chemical control when the total of insects has surpassed the action threshold (Table 2).

Table 2. Recommendations for the Control of Sogatodes oryzicola.

Crop stage	Number of insects per planta
A. 10-25 days after germination	0.95
B. 25-40 days after germination	2.99
C. 55-70 days after germination	3.83
D. 75-90 days after germination	6.88

When more than 3% of virulence is found in the insect sampling, decision-making for controlling the insect is reduced to 20% with the objective of rapidly controlling any small focus of the vector insect.

7.2. Sampling of Rice Hoja Blanca disease.

a) If an infestation below 5% of plants is visually observed with Hoja Blanca symptoms, five field samples should be taken.
b) With higher percentages, an area of 0.5m x 0. 5 m (0.25 m^2) distributed at random in the field (10 sites), should be used for each sample to count the affected plants.

c) When the above evaluation is carried out in fields in stage A from germination to active tillering), total plants affected by the disease and the healthy ones are counted. In stages B and C, damage is quantified by counting the healthy stems and those affected by the virus.
d) The percentage of field damage is calculated to determine the level of action to be followed.

8. CONTROL METHODS OF S. oryzicola *AND HOJA BLANCA DISEASE (H.B.V.)*

8.1. Control of H.B.V.

In addition to the control executed against its vector insect, the most recommended method for controlling the disease is the use of resistant varieties.

From the information obtained through field sampling, decision will then be made in relation to the control of the disease. If they are found before panicle initiation in 20% or more of the evaluated plants with symptomatology of H.B.V., it is necessary to analyze the following aspects:

— Population of *S. oryzicola*.
— Rate of virulence of the insect.
— Location of the affected areas, in relation to unaffected young rice fields.
— Fields yield estimate.
— Actual possibilities to reduce the population of *S. oryzicola* to established levels.

If after analyzing these aspects a decision is made to eliminate the infested fields, the following methodology should be used:

Puddling to eliminate rice plants and weeds.

In some fields, particularly depending on the age and soil moisture, a total herbicide can be applied to accelerate plant elimination.

Furthermore, if the incidence of H.B.V. is found very rapidly and located in small areas of the field with a high yield estimate, such area can be eliminated through a confined puddling with a tractor provided with cage wheels and rotary tiller.

In this particular case it is necessary to increase samplings of *S. oryzicola* and Rice Hoja Blanca.

It is important to critically accomplish this decision-making process with the objective of eliminating possible focuses of H.B.V. that may endanger the rest of the rice fields.

8.2. Control of S. oryzicola.

8.2.1. Cultural measures

The use of cultural measures is exceedingly important to achieve the best control of *S. oryzicola*, aimed at reducing damages and production costs, and increasing crop yields.

Among those measures the use of resistant varieties should be included (Table 3).

Obtaining resistant varieties constitutes an effective combat method against this rice pest, since it plays an important role as primary factor in reducing the population of *S. oryzicola*, because insects have less possibilities to feed on the resistant varieties, which gives as a result individuals with less vigor and shorter lifetime.

Another measure of cultural control is the use of well defined planting seasons, so that the most susceptible stages of plant (from germination to active tillering) do not coincide with the seasons of greater pest incidence.

In studies carried out during three years in Sur del Jibaro rice zone, beginning in 1974, total application of insecticides against *S. oryzicola* were reduced in approximately 78% when variety CICA-4 was planted and two well-defined planting seasons were established: cold

Table 3. Characteristics of commercial rice varieties planted in Cuba.

Variety	Resistance to *S. oryzicola*	Yield (t/ha) Cold Season	Yield (t/ha) Spring	Growth duration (days) Cold Season	Growth duration (days) Spring
J-104	I	8.6	5.6	146	121
(4024) IIAC 14	R	8.7	5.7	142	118
(4024) IIAC 15	R	8.7	6.1	143	119
Perla	R	6.9	5.3	127	112
Amistad 82	R	6.7	5.2	127	112
ECIA-24	R	6.6	5.3	127	112

and spring. The former goes from December to February, and the latter from April to July. A similar performance was observed in Granma rice areas, very affected by H.B.V. in 1973.

In addition to the above, the following measures play an important role in reducing the insect's population:

— Control of weeds on levees and canals.
— Destroying stubble and weeds in harvested fields.
— Crop rotation.

8.3. Biological control

Within the complex of ecological factors acting on *S. oryzicola* in rice agroecosystems and causing remarkable depressions in their population levels in certain seasons of the year, there are different species of parasites and predators that act as natural enemies of such pest (Table 4).

Considering how difficult it is to achieve a good control of *S. oryzicola*, and that the use of chemical insecticides against such insect as the only control measure is practically ineffective, requiring the interaction of other methods to improve the results, natural enemies play a fundamental role in pest management.

Table 4. Major parasites and predators of Sogatodes oryzicola *(Muir)*[1]

Order	Family	Species	Parasite	Predator	Susceptible stage of S. oryzicola: Egg	Nymph	Adult
Hymenoptera	Mymaridae	*Paranegrus perforator* (Perkins)	X		X		
Hemiptera	Miridae	*Tytthus parviceps* (Reuter)		X	X	X	
Strepsiptera	Elenchidae	*Elenchus* sp.	X			X	X
Hymenoptera	Dryinidae	*Gonatopus* sp.	X			X	X
Coleoptera	Coccinellidae	*Coleomegilla cubensis* (Csy.)		X	X	X	
Arachnida	Tetragnathidae	*Tetragnatha pallescens* (kenn.)		X		X	X

1. Gómez J., R. Meneses and H. Grillo, 1979. Principales enemigos naturales de Sogatodes oryzicola (Muir) (Homoptera: Delphacidae) en la zona arrocera de Sancti Spiritus, Cuba. Revista Centro Agricola 6 (3): 3-13, 1979.

Among natural enemies, the ones of major importance are egg parasite *P. perforator* and predator *T. parviceps*. Up to 34.6% of total parasitism has been recorded from the former in field observation, being higher in rice fields between germination and active tillering.

Both natural enemies remain active during all the favorable time for the development of *S. oryzicola* (April - November), but the population of *T. parviceps* is higher during the first increase of the pest's population (May-June), whereas the percentage of parasitism of *P. perforator* is more intense during the second population increase of the vector in the months from October to November.

The increase of parasitism by *P. perforator* at the end of the year, and the drop of temperatures beginning in December, cause a considerable decrease in the population levels of *S. oryzicola*.

Other natural enemies favor and help to keep the level of *S. oryzicola* relatively low in certain seasons of the year, standing out among them *T. pallescens*, since there is a relationship between this insect's levels and the pest.

Such action of bioregulators of *S. oryzicola* was proved in a 3-year-study carried out in Granma rice zone, where the performance of resistant varieties was evaluated under field conditions (Hernández et al 1989), being observed how variety resistance, together with the action of natural enemies, made possible a reduction in applications of insecticides without affecting yields, with subsequent savings in production costs.

8.3.1. Interrelation insect - resistant varieties

Reports of García et al (1973) in Cuba show that losses were reduced considerably beginning in that year with the introduction of resistant varieties. However, isolated reports of research workers have shown that the insect *S. oryzicola* can again reach a pest status in the crop, since some contradictions have been observed in the resistance of commercial varieties to the insect where colonies from different rice zones have shown different behavior. This suggests the possibility of a physiological specialization of this pest.

In studies started by Orellana et al (1982) on insect colonies from different rice zones, they found variability in pathogenicity among such colonies. This served as the beginning for later studies in which the feeding activity and aggressiveness were evaluated, fundamentally on insect colonies coming from Los Palacios, Pinar del Río, and Sur del Yara, Granma, on varieties with different degrees of resistance. In both, the colony coming from Sur del Yara presented a higher feeding activity on all varieties, and surpassed that of Los Palacios in aggressiveness as well (Arias et al 1990 a, b) (Table 5, Figure 1).

Later on, in coordination with IRRI, morphometrical and cytogenetical studies were carried out in both colonies, showing variations in the insect's morphology. From a total of 101 morphological variables studied, 28 were different in the case of females, and 19 for males. In cytogenetical studies, when evaluating the dimensions of primary spermatocytes during meiosis, a variation was found in lenght and width of the cellular division in leptotene, pachytene, diplotene and diakinesis stages, as well as different variations for the meiotic index in both colonies (Arias et al 1990 c).

The differences in morphology, cytogenesis and feeding behavior in the colony of *S. oryzicola* coming from Sur del Yara allow us to affirm that a new biotype of this insect has developed in that zone, capable of developing in the future on varieties with some resistance to such pest. It is recommended, therefore, the establishment of trials on resistance to mechanical damage of *Sogatodes oryzicola* with colonies from such zone until this study is applied to the rest of the rice zones, with the objective of delimitating the zones where the insect might have variations in its behavior. Although, apparently, the conditions of the zone of Granma, where rice fields have been exploited for about 50 years with two harvests per year, have provided optimum conditions for such changes in the insect.

8.4. Chemical control

It has been established to apply chemical insecticides only when the number of *S. oryzicola* collected in field samplings reach or surpass the action threshold established for such purpose (Table 2), since the indiscriminated use of chemical insecticides can cause negative effects such as the destruction of beneficial parasites and predators, with the subsequent resurgence of the pest; possible appearance of resistance that would cause an increase in dose or a shift to a stronger insecticide that, in general, is more expensive. All these together give as a result an increase in production costs, besides causing pollution to the environment.

The insecticides fundamentally recommended are organophosphorates and carbamates. Among them:

- Methyl Parathion at 1.00 kg a.i./ha.
- Methamidophos at 0.60 kg a.i./ha.
- Carbaryl at 2.21 kg a.i./ha.

When applying these insecticides, their incompatibility with Propanil should be taken into consideration.

Table 5. Feeding behavior of two colonies of S. oryzicola *on a resistant and susceptible variety.*

Colony	Spotted area (mm^2)	
	Variety Blue Bonnet	Variety J-104
Los Palacios	192.4 a	37.0 a
Yara	301.6 a	145.2 b

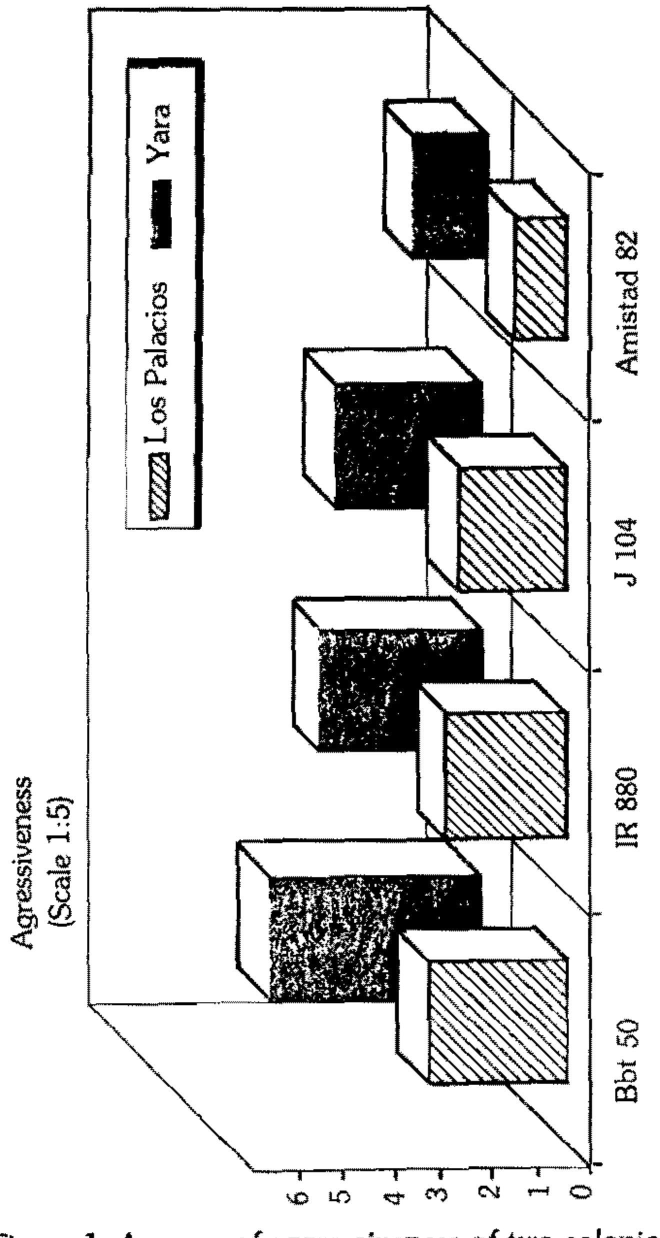

Figure 1. Average of aggressiveness of two colonies of S. oryzicola on different rice varieties (1986-1988).

BIBLIOGRAPHY

Acuña, J.; L. Ramos Ledon y T. López. 1959. Biología de *Sogata orizicola* (Muir) vector de la enfermedad virosa Hoja Blanca del arroz en Cuba. Centro de Experimentación agropecuaria. Cuba. Boletín Técnico No. 73, 42 pp.

Arias, E.; A. García y P. Almarales. 1990 a. Agresividad de dos colonias del delfácido del arroz *S. orizicola* (Muir)(Homoptera: Delphacidae) sobre variedades con diferentes grados de resistencia. Agrotecnia de Cuba 22 (2).

Arias, E.; y P. Almarales. 1990 b. Actividad alimentaria del insecto *Sogatodes orizicola* (Muir) sobre variedades resitentes y susceptibles. Ciencia y Técnica Agrícola, Serie Arroz 13 (1).

Arias, E.; R. C. Saxena and A. A. Barrion. 1990 c. Morphometric and Cytogenetic of the Rice Delphacid *Sogatodes orizicola* (Muir) sampled from Cuba. Informe final de entrenamiento IRRI. Los Baños, Filipinas.

Galvez, G. 1968. Transmission studies of the Hoja Blanca virus with highly active virus-free colonies of *Sogatodes orizicola*. Phytopathology 58 (6): 818-821.

Gómez, J. y R. Meneses, 1982. Dinámica de población de *Sogatodes orizicola* (Muir) en la región arrocera de Sancti Spiritus Revista Centro Agrícola 9 (1).

Gómez, J. y R. Meneses, 1976. Empleo de la fecha de siembra como medida de control cultural de *Sogatodes orizicola* (Muir) en el cultivo del arroz en la Agrupación Arrocera del Jíbaro, Las Villas. Centro Agrícola 3 (3): 1-8.

Gómez, J. y R. Meneses. 1978. Algunas observaciones sobre los hábitos y biología de *P. perforator* Perkins. Centro Agrícola 5 (1): 27-32.

Gómez, J.; R. Meneses y M. Grillo. 1979. Principales enemigos naturales de *S. orizicola* (Muir) (Homoptera: Delphacidae) en la zona arrocera de Sancti Spiritus. Cuba. Centro Agrícola 6 (3): 3-13.

Gómez, J. y R. Meneses. 1980. Evaluación de hembras y machos de

S. orizicola (Muir) mediante trampas de luz y jamo. Centro Agrícola 12 (2): 3-7.

Goméz, J. y F. Kamara. 1980. Determinación de algunos parámetros en la biología de *S. orizicola* (Muir). Centro Agrícola 7 (3): 13-21.

Hernández, A.; N. Zamora y E. Arias. 1989. Comportamiento de las variedades resistentes al insecto *Sogatodes orizicola* en condiciones de producción. Agrotecnia de Cuba 21 (1): 37-48.

Meneses, R. y J. Gómez. 1982. Algunos parámetros biológicos de *T. parviceps* (Hemiptera: Miridae) enemigo natural de *S. orizicola*.Revista Ciencia y Técnica Agrícola. Serie Arroz. 5 (2).

Reinteria, O. 1960. Biología de *Sogata orizicola* (Muir), vector de la Hoja Blanca del Arroz. Acta Agronómica (1): 71-100.

Rey, Xiomara y A. Garcia. 1980. Estudio de algunos aspectos del ciclo biológico del *Sogatodes orizicola*. Ciencia y Técnica Agrícola. Serie Arroz 3 (1): 31-65.

Segunda Missión Técnica Cubano-Japonesa, 1960. Inf. No. 7.

II. RICE BUG: Oebalus insularis (Stal)

INTRODUCTION

The "Rice Bug", *O. insularis* Stal, is considered as one of the three major pests of rice crop in Cuba. This specie also affects rice in other countries like Mexico, Colombia, Brazil, Nicaragua, El Salvador, etc. The damage is caused by the insect by feeding on the developing grain. A description of the same symptoms was made by Frohlich and Rodewald (1970). In such a description it is pointed that empty panicles and hulls can be seen in rice fields in milk or mature grain stage, where a more detailed observation will reveal a number of sucking places on the damaged plants. When "bugs" feed on grains, they can cause partial or total loss of grain weight. Partially affected grains cause serious decreases in rice milling quality, since grains break easily during the milling process, therewith modifying unfavorably the rate of head rice and broken grains. In this booklet, the results of studies carried out in Cuba on this insect are presented in a concise form, which makes possible a greater efficiency in the management of this pest.

2. SYSTEMATIC CLASSIFICATION, LIFE CYCLE AND MORPHOLOGICAL DESCRIPTION.

2.1. Systematic classification (Stys and Kershner, 1975)

Order: Heteroptera.
Intra-order: Pentatomorpha
Super-family: Pentatomoidea
Family: Pentatomidae
Genus: Oebalus
Species: Oebalus insularis (Stal)

2.2. Life Cycle and Description

Biological studies of species *O. insularis* on rice plant as well as on plants of *Echinochloa colona* have been carried out in Cuba. The eggs are greenish in color, with a jelly-like aspect and barrel-shaped during the first days. As time passes, they turn into a reddish color.

These eggs are located on both surfaces of the leaf blade, panicles and stems, but seldom on spikelets. The number of eggs per cluster is variable, sometimes reaching 50. Eggs are laid following a double-rowed straight line. Eggs hatch 4 to 5 days with temperatures between 23.6 and 26°C (Gómez and Meneses 1985). Eggs reach a diameter of 0.625 mm and a length of 0.750 mm.

Before becoming adults, the nymphs pass through five instars or changes which take place every 2-3 days.

Newly- hatched nymphs have a light-green color on their heads, red eyes, and light-purple legs and antennae, the same as the abdomen, which has dark-purple spots on the center and sides. In the last instar, the head, antennae and legs are dark-purple or black (Meneses et al 1982). The nymphal stage varies from 18 to 19 days with temperatures between 25 and 26°C.

Alayo (1967) makes a description of the adults and points out that they are straw-colored, usually light, with a total length of 7-9. 5mm and a shoulder width of 3-4.5 mm, showing yellowish callous spots on the scutellum. Females are slightly bigger than males and brighter in color (Portal et al 1978).

Adults start to copulate around one week after reaching adulthood and females can lay an average of 150 eggs during its lifetime. The adults cycle varies between 63 and 79 days.

3. MAJOR HOST WEEDS

Various studies carried out in Cuba show that in addition to rice, there are many weeds that serve as hosts to the insect. The main ones are: *Echinochloa colona*, *Echinochloa crus-galli*, *Leptochloa fascicularis*, *Ischaemun rugosum*, *Cyperus rotundus* and *Cyperus iria*. *E. colona* is the most preferred weed, on which the insect lays its eggs and nymphs develop until reaching their last stages.

4. POPULATION DYNAMIC OF O. insularis

Studies carried out in Cuba on population dynamic of the insect show that there is incidence of this species from April to December, with the higher population densities occurring from May to November when the mean temperatures vary between 25.2 and 27.7°C.

Relative humidity above 80% favors the development of the insect.

Regression analyses show a significant correlation between population density of the insect and mean and minimum temperatures, and relative humidity.

Our results indicate that the insect's multiplication is hindered during the dry period when mean temperatures below 26°C and relative humidity below 75% are recorded. Pathsk (1977) referring to rice bugs states that these insects are very sensible to changes in humidity and temperature.

Studies on dynamics also showed that the prevailing species among Pentatomidae collected in rice crop corresponded to *O. insularis* in more than 92%, which coincides with that stated by Cabello (1966); Bruner et al (1975), and Gómez (1982), who pointed at *O. insularis* as the most abundant species of insects affecting grain in rice fields in Cuba.

On the other hand, only 4.6% of the insects collected corresponded to the nymphal stage, which means that the damage caused by this pest to rice crop in our conditions occur mainly in the adult stage, when the plant is in flowering and grain filling stages.

These results confirm that population densities of *O. insularis* depend on environmental factors, at least temperature and relative humidity, as well as the development stage of rice fields. Knowing these aspects is very important, among many others, for the integrated management of pests. Reyes (1985) states that the integrated management consists of a combination or integration of all the available techniques, so that applied harmoniously reduce the insect pests to such levels that they do not cause damages of economic importance to the crop.

5. ECONOMIC IMPORTANCE OF O. insularis *IN RICE CROP IN CUBA.*

The statistical compilation of the National Board for Plant Health of the Ministry of Agriculture reports that 89% of the area infested by the pest throughout the country is found from May to October, which requires a close watch and adequate control.

Studies carried out in this country have allowed us to know the

Table 1. Paddy rice yield (t/ha) obtained in five trials carried out during 1982-1985 with different populations of O. insularis *in milk grain stage of rice.*

Treatment	1982	1983	1984	1984	1985
Check (without insects)	7.92 a	4.51 a	6.33 a	4.79 a	5.99 a
0.05 insects/panicle	—	—	6.20 a	—	—
0.1 insects/panicle	—	4.10 ab	6.17 a	4.57 ab	4.92 bc
0.2 insects/panicle	—	3.71 ab	5.96 a	4.38 ab	—
0.3 insects/panicle	5.80 b	3.37 b	—	3.53 c	4.12 c
0.7 insects/panicle	5.09 b	—	—	—	—
1.1 insects/panicle	2.71 c	—	—	—	—

Note: Equal letters mean that there are no significant differences, and different letters are different at 1%.

Table 2. Effect of different population levels of O. insularis *on some quantitative and qualitative parameters of rice grain.*

Treatment	Filled grains weight (g/m²)	Unfilled grains weight (g/m²)	Alkali	1000-grain weight (g/m²)
Check	792.76 a	125.66 a	3.27 a	28.25 a
0.3 insects/panicle	580.82 b	170.16 a	2.46 a	28.50 a
0.7 insects/panicle	509.16 b	150.09 a	2.26 a	26.97 b
1.1 insects/panicle	271.86 c	183.66 a	2.28 a	26.75 b

Note: Equal letters mean that there are no significant differences, and different letters are different at 1%.

Table 3. Milling yied performance of rice with different populations of O. insularis.

Treatment	Milled rice (%)	Head rice (%)
Check	67.65	48.40
0.1 insects/panicle	65.90	42.76
0.2 insects/panicle	66.95	43.91
0.3 insects/panicle	66.32	45.76

magnitude of both field and milling losses, depending on the insect's population density and its relationship with the phenological stage of the panicle. The results of such studies show a high correlation between yields and the insect's population level. In this respect, population densities from 0.3 to 1.1 insects per panicle during milk grain stage affected rice yields in 27 and 65%, respectively. These results are similar to those obtained by Swanson and Newson (1962), who observed that levels of 230 bugs per 1000 panicles caused severe losses to rice crop. Table 1 shows the decline of farm yields and Table 2 shows the decrease in weight of filled grains.

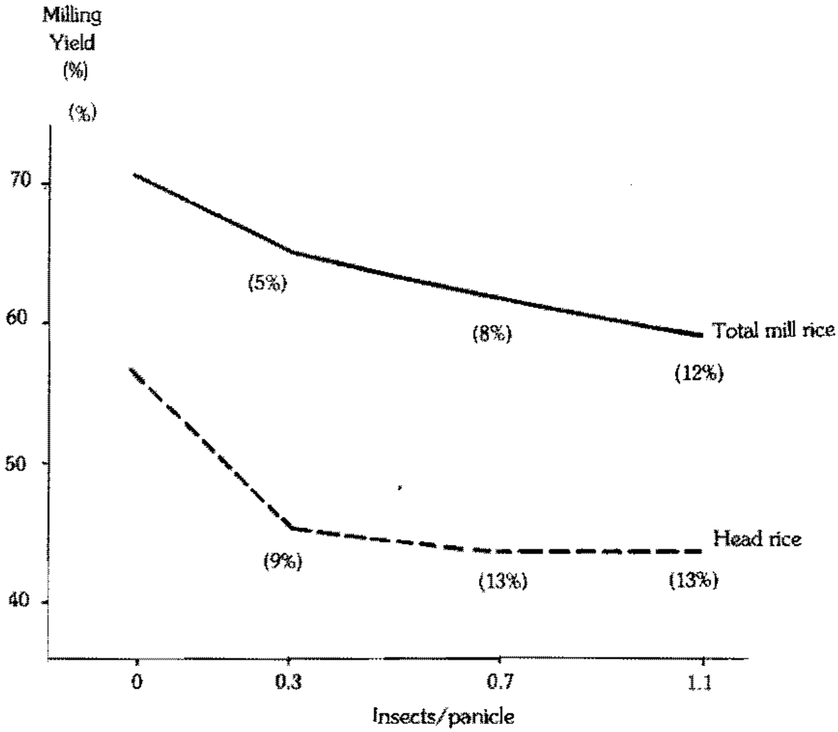

Figure 1. Influence of different treatments on milling yield

Note: Figures in parentheses correspond to the decrease in percentage as compared to the check.

The effect on milling yields can be seen in Table 3 and Figure 1, with a sensible decrease both in milled rice and the percentage of head rice as population density increased.

Similar studies in flowering and dough grain stages (Tables 4 and 5) also show damages on yields, but with the difference that such stages are more tolerant to certain population levels of the insect than the milk grain stage.

The effect on grain germination when rice is used for seed production was also studied, being observed that population levels of 0.3 and 1.0 insect per panicle in milk grain stage caused seed germination losses 6 and 14%, respectively.

5.1. Economic threshold

Considering the above results and compiling the corresponding statistical information influencing the phytosanitary control (Table 6), the economic threshold of noxiousness can be calculated, which is equivalent to 0.045 insects per panicle in milk grain stage. This calculation can be made in a much simpler way if we apply the formula of Deriabin et al (1979):

$$ET = \frac{X.P}{20C}$$

Where:

ET = Economic Threshold

X = Yield of check

P = Population of controlled insect

C = Difference in yields between the check and the experimental plot.

20 = Constant for low-yield crops

Bearing in mind the results obtained in milk and dough grain

Table 4. Effect of different populations of O. insularis *in flowering stage on various technical parameters of rice crop.*

Treatment	Total grain weight (g)	Filled grain weight (g)	Unfilled grain weight (g)	1000-grain weight (g)
Check (without insects)	8.11 a	6.96 a	1.02 ab	27.49 a
0.2 insects/panicle	8.06 a	7.93 a	0.90 b	27.95 a
0.6 insects/panicle	6.13 b	5.20 b	1.13 ab	27.90 a
1.0 insects/panicle	4.60 c	3.31 c	1.23 a	27.65 a

Note: Equal letters do not differ significantly, and different letters differ at 1%.

Table 5. Effect of different populations of O. insularis *on various parameters at dough grain stage.*

Treatment	Filled grains weight (g/m^2)	Unfilled grains weight (g/m^2)	1000-grain weight (g)	Milled rice (%)	Head rice (%)
Check (without insects)	505.4 a	25.2 a	28.4 a	67.80	58.12
0.1 insects/panicle	462.3 a	39.4 a	28.1 a	66.65	53.82
0.3 insects/panicle	455.9 a	32.11 a	27.6 a	66.00	52.35

Note: Equal letters have no significant differences.

stages of the rice plant, the economic thresholds were 0.12 and 0.221 insects per panicle, respectively.

According to the correlation studies carried out between insects per panicle and insects per net pass, and thereby applying the following equation:

$$Y = 0.01 + 0.05\,X$$

Where:
Y = Insects per panicle
X = Insects per net pass

Table 6. Economic effectiveness of control of O. insularis *in rice crop.*

Indicators	Measure unit	Plots with insects (0.3 per panicle)	Plots without insects
Dry paddy yield.	t/ha	4.48	6.23
Milled rice yield.	%	64.95	68.37
Head rice yield.	%	47.99	53.40
Protected milled rice yield.	t/ha	—	1.35
Protected head rice yield.	t/ha	—	1.18
Costs of protected yield considering increase in quality.	pesos/ha	—	624.01
Expenses in control, harvest and processing of the protected crop.	pesos/ha	—	97.05
Conventional net income due to control measures.	pesos/ha	—	526.96
Profitability of those measures.	%	—	542.90

allows us to express the economic threshold of noxiousness the following way:

For flowering stage = 2.2 insects/net pass
For milk grain stage = 0.67 insect/net pass
For dough grain stage = 4.34 insects/net pass

6. PEST'S MANAGEMENT

The phenological stage of rice fields and population levels of *O. insularis* are considered as fundamental in the pest's management, as well as an adequate sampling, season of the year, the phytosanitary condition of irrigation and drainage networks and nearby areas which, together with the characteristics of the cultivated varieties and the selection of proper insecticides, will remarkably help the efficiency of control. The management of each of the above aspects will be covered as follows:

6.1 Sampling method

Studies carried out on space distribution of *O. insularis* in 20 rice fields which size varied between 12 an 72 hectares, indicate, in the variance/mean relationship analysis, that the insects were in 100% of the fields, distributed in an aggregate form.

Figure 2 shows the regression equation between log (S^2) and log ($\overline{X}$), which indicates that the variance was positively related to the population mean of insects per sample. A Chi-square analysis (X^2) showed that in 80% of the fields the space distribution corresponded with the negative binomial form, as it frequently happens in many insect species.

Sampling was calculated considering the aggregate distribution of *O. insularis*, performing a comparative analysis between the mean of field populations and the corresponding sides and semi-diagonals (Table 7). T-Test results indicated that population means in 80 to 93%

of the fields did not differ negatively from the means of the sides, standing out the sides corresponding to the front and bottom of fields with 93% of coincidence.

The recommendations of Postón (1983) were followed to determine the number of samples. This requires the calculation of the conglomerate means (X) and its correlation with the means ($\overline{X}$), which results are used in the formula of Iwao and Kuno (1968) that finally determines the number of samples to be taken:

$$Q = \frac{T^2}{D^2} \left(\frac{(X + 1}{X} + B\text{-}1 \right)$$

Where:

Q = Number of samples

T = Table's T when N = X

D = Precision level desired

X = Population density

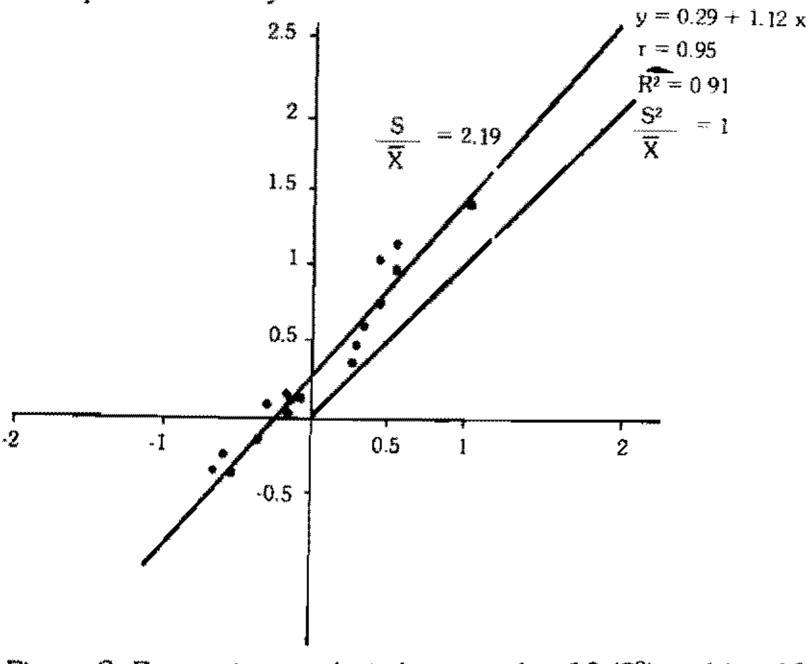

Figure 2. Regression analysis between log 10 (S^2) and log 10 ($\overline{X}$) in all 20 sampled fields.

Table 7. Percentage of fields showing no significant difference between total population means and that of transepts, and among transepts means in 15 fields.

	X1	X2	X3	X4	X5	X6	X7	X8
X0	86	80	93	86	93	80	80	86
X1		80	93	86	86	73	73	86
X2			86	86	80	66	73	73
X3				86	93	80	93	86
X4					66	86	73	80
X5						86	80	93
X6							73	86
X7								100

The required operation carried out on the sides of greater representativity (front and back of fields) of population means indicate that the number of samples varies from 1 to 8 depending on the magnitude of the insects population. This means that for populations of more than 4 insects per 10 net passes, only 1-2 samples are necessary, whereas for populations between 1 and 4 insects, 3-5 samples are required. If populations are below one insect per 10 net passes, the number of samples will be from 6-8.

6.2. Control method

6.2.1. Cultural control

Considering the high number of weeds that serve as hosts to *O. insularis*, control programs should include systematic cleaning of levees, canals and roads, as well as the rapid destruction and incorporation to the soil of harvest residues, since a number of egg clusters of this insect is frequently observed on ratoons.

A close watch should be kept on this pest during the period from May to November, especially on rice fields where the development stage of the insect coincides with flowering and filling of grains.

Regarding rice varieties resistance to this pest, studies carried out in Cuba in that respect, indicate that until now no significant differences have been found between a great number of varieties studied. For this reason, all cultivated varieties should be given equal protection measures against the damages of this insect.

6.2.2. Biological control

Although many parasites and predators are known to affect different Pentatomidae species, only *Telenomus* sp. has been observed in Cuba as egg parasite of *O. insularis*. *Telenomus* sp.

belongs to the Scelionidae family. They are tiny insects capable of remaining inside a single little egg of another species during feeding, especially in Lepidoptera, Heteroptera, Orthoptera and Diptera.

In research carried out from 1975 to 1977 in the state of Campeche, Mexico, Ruelas and Carrillo (1978) found parasitism in eggs of *O. insularis by Telenomus* sp. which varied between 85 and 100%.

Recent studies at the Rice Research Institute in Cuba have shown that clone Niña Bonita of fungus *Metarrhizium anisopliae* achieves good control on *O. insularis* both in laboratory and field conditions, but this technique requires complementary research which has not been concluded yet.

6.2.3. Chemical control

Chemical control will only be used when pest population reaches or surpasses the economic threshold of action established for different panicle phenostages.

Trials on chemical control on this insect indicate that the following insecticides achieve good control:

Product	Rate
Methyl Parathion CE 50%	1.0 lt/ha
Malathion CE 57%	1.5 lt/ha
Carbaryl PH 85%	2.5 kg/ha
Methamidophos CE 60%	0.5 lt/ha

Chemical control should be accomplished early in the morning or late in the afternoon when these insects are found on panicles. This facilitates the effectiveness of action of the product, whereas when there is hot sun, generally the pest prefers to hide in the lower part of plants.

BIBLIOGRAPHY

Alayo, D. P. Los hemípteros en Cuba, adiciones y enmiendas. Trabajos de Divulgación No. 43 Capitolio Nacional, La Habana, Cuba, 1967, pp. 1-10.

Cabello, A. Plagas de Arroz. Enfermedades y plagas. Editora Pedagógica, La Habana, 1966 pp. 336-350.

Deriabin, V.; R. Labrada y Magaly Barba. Metodología unificada para elaborar los umbrales económicos de nocividad de los insectos. Tomo II Instituto de investigaciones de Sanidad Vegetal.Ministerio de la Agricultura de Cuba, 1979, pp. 1-17.

Frohlich, G.; E. Rodewald. Enfermedades y plagas de las plantas tropicales Descripción y lucha. Edit. Leipzig, 1970, pp. 150-151.

Gómez, J.; R. Meneses. Biología de *Oebalus insularis* (Stal) (Heteroptera: Pentatomidae) sobre *Echinochloa colona* (L), 1985.

Portal, M. del Carmen; D. Castillo e Hilda Pampin. Algunas observaciones sobre *Solubea insularis* (chinche) y sus efectos sobre el grano de arroz. Ciencia y Técnica de la Agricultura 1 (2): 75-76, 1978.

Pastón, F.; R. J. Whitworth; S. M. Welch and J. Loera. Sampling south western corn borer population in post harvest Corn. Environmental Entomology 12 (1): 33-36, 1983.

Reyes, J. A. Manejo de Plagas en Arroz. Investigación y Producción. CIAT, 1985, pp 525-526.

Ruelas, H. J.; L. Carrillo. Parasitismo natural causado por *Telenomus* sp. sobre la chinche café del arroz *Oebalus insularis* (stal) en Campeche. Agricultura Técnica en México 4 (2): 137-142, 1978.

Stys, P. and I. Kerzhner. The Rand and Nomenclature of higher taxa in recent Heteroptera. Acta ant Bohemoslov 72 (2): 65-79, 1975.

III RICE WATER WEEVIL: *Lissorhoptrus brevirostris (Sulf)*

INTRODUCCION

L. brevirostris (rice water weevil) stands out within the insects affecting rice crop in Cuba.

Other species of the genus *Lissorhoptrus* are reported as major pests of rice crops in many countries in North, Central and South America.

Since 1976 *L. oryzophilus* has spread to 180,140 hectares of rice fields in Japan. It is assumed that this insect was introduced to this country in rice stubble from California.

Uhm et al (1989) carried out dissemination studies of rice water weevil *(L. oryzophilus)* in Korea.

L. brevirostris has only been reported in Cuba. It is considered as the second pest of economic importance of rice crop, and the most difficult to control.

2. MORPHOLOGY AND BIOLOGY OF *L. brevirostris*

The eggs are pearly-white in color, cylindrical, slightly curved in the middle and rounded in the extremes, with an average length of 0.865 mm and width of 0.285 mm.

The adults of both sexes have dark-grayish color with a darker tint marking the center of the back. They have elytra strongly joined to the zone of the central suture by (1 + 1) small layers that superimpose themselves when the elytra get in contact when closed. On the side edges they have a little curtain of fine and small hairs that assure a sealing of the elytra with the ventral part of the abdomen. When separating the elytra of living insects previously submerged in water, air bubbles are found trapped between the folds of the rear wings and underneath them. It was proved also that the abdominal spiracles are located in the side-dorsal zone of the abdomen, so that the insect can take advantage of the air held and remain several hours under the water layer in rice fields.

Sexual differences of the adults are extremely useful, being the most valuable that of the metastern and the first and last abdominal sternites.

The average body length of the male of *L. brevirostris* is of 2.91 mm and the female of 3.28 mm.

The larvae are yellowish-white in color, apodous, purple-colored head, small, as compared to its body. This characteristic becomes more accentuated in the last instars. The dorsal part from the second to the seventh segment shows a pair of abdominal spiracles on each segment. Those spiracles have the shape of a sharp hook directed towards the front end of the larvae. With these spiracles the larvae extract the necessary oxygen to respire from lagoonal canals of the host plants' roots.

The larval stage has four instars, differentiated by the diameter of the cephalic capsule and total body length (Table 1).

Table 1. Average body length and diameter of the cephalic capsule of larvae of L. brevirostris.

Instar	Length (mm)	Cephalic capsule (mm)
I	2.300	0.175
II	3.341	0.250
III	5.826	0.357
IV	8.366	0.507

Using logarithm of the width of the cephalic capsule (Y) and the number of instars (X) the following regression equation was obtained:

$$\text{Ln } Y = -2.0964 + 0.3547\,X$$

We consider that both measurements (diameter of the cephalic capsule and total body length) serve to accurately separate the different larval instars of *L. brevirostris*, since no superposition of values was found in consecutive instars.

The newly developed pupa is white, similar to the adult in shape and size, with the head directed towards the hole connecting with the root of the host plant.

The average duration from oviposition until the emergence of the adult was of 50 days, with a lifetime of 714 days (Table 2).

Table 2. Duration of different stages of Lissorhoptrus brevirostris.

Stage	Average duration (days)
From oviposition until leaving the leaf sheath	7.32
First instar	5.69
Second instar	6.96
Third instar	7.48
Fourth instar	9.36
Pupa	13.14
Adult	714.50

3. *MAIN ASPECTS OF THE HABITS OF* L. brevirostris *THAT SHOULD BE CONSIDERED IN INTEGRATED MANAGEMENT (IM) OF THAT PEST.*

3.1. Adults

a) They can remain up to 52 hours submerged in water without dying, due possibly to the fact that they can take advantage of the air held between the folds of the rear wings and by the position of the abdominal spiracles, located in the side-dorsal zone of the abdomen.

b) They have sedentary habits, leaving the plants only when disturbed, because of food shortage, or night flights toward young rice fields.
c) When weather conditions become unfavorable (mean temperature below 25°C) they remain immobile in the lower places of rice fields, remaining up to 205 days in average without ingesting food.
d) Adults live an average of 714.50 days, feeding only in 8 to 10% of them, and in 97% of the time they do it at night.

3.2. Larvae

a) Shortly after hatching, the larva moves through the lagoonal parenchyma of the leaf sheath of the plant where they begin to eat the transversal wall. They come out the leaf sheath through one of the holes where the egg was inserted or newly bored ones, moving by gravity in the water toward the soil and roots in approximately one or two minutes.
b) The larvae extract the necessary oxygen for respiration through its abdominal spiracles from the roots of the host plants.
c) They generally live at a depth of 5 to 7 cm in flooded soils, preferring roots of 0.600 to 1.375 mm thick as food.
d) They are capable of moving horizontally up to a distance of 20 cm in flooded soils.
e) They can stay alive in a rootless flooded soil between 24 to 52 hours, depending on the larval instar.

4. ECOLOGY OF L. brevirostris

4.1. Plant-insect relationship

There is a close relationship between the establishment of the water layer in rice fields and the beginning of the cycle of the insect. Eggs, larvae and pupae of *L. brevirostris* are not collected in fields kept at field capacity, without a water layer.

Two or three weeks after adults have been established in one field and females have accomplished oviposition, they move again to other young rice fields with water layer, where they start the cycle again.

An increase in population of *L. brevirostris* was observed with the increase of the rate of Nitrogen fertilizer (from 0 to 240 kg of N/ha).

The smallest quantities of adults, larvae and pupae were collected in plots with the highest levels of fertilization with Potassium (60 kg of K/ha).

4.2. Major host weeds

Poaceae grasses are the major hosts for the different development stages of *L. brevirostris*, standing out for their abundance: *Panicum muticum, Paspalum distichum, Echinochloa colona* and *E. crus-galli*.

In addition to the above weeds, 25 Poaceae species, 6 Cyperaceae, 2 Onagraceae, 2 Commelinaceae, 2 Puntederaceae, 1 Typhaceae and 1 Alismanaceae, are also hosts to the insect.

When weather conditions are unfavorable to adults of *L. brevirostris*, they remain in a state of total immobility, being mainly collected on weeds, especially on *P. muticum (=Brachiaria mutica)*.

5. POPULATION DYNAMIC OF L. brevirostris

Major populations densities of *L. brevirostris* in all its development stages occur in the season of the year when average temperatures between 25.0 and 27.5°C are combined with rainfalls near or above 100 mm.

The first adults begin to appear in rice fields with the first rainfalls beginning on the second half of March. Also in this season temperature begins to rise, especially in fields with young rice plants (with a water layer) where the first copulations occur, giving as a result a new generation.

The first larvae are seen approximately between 8 and 10 days after the adults have been established in rice fields. Their number increases considerably during the first weeks, with maximum values in June and September.

Because of the above, the months of March and April are critical for scouting *L. brevirostris* with the objective of reducing the possibility of a population increase of the pest.

6. ECONOMIC IMPORTANCE OF L. brevirostris IN CUBA

Rice water weevil is a pest that has been heavily infesting flooded rice fields in Cuba.

The adult feeds on rice plants and other species serving as alternate host, leaving a horizontal scar where the leaf surface has been cut off.

This scar has an average length of 6.0 mm and 4.0 mm in field and laboratory conditions, respectively, and an average width of 0.45 mm in both cases. They are found on the upper surface of the leaf blade in 96.7% of times.

Although feeding of adults causes the above damage, this is not serious, since in June when it reaches the highest values, it is not higher than 1.43% of the leaf area destroyed in field conditions, and of 56 mm^2 in laboratory conditions. Therefore, the damage caused by adults lacks economic importance.

The main damage is caused by larvae feeding on roots, which they trim intensively, destroying 83% of the rice plant root system (when not controlled) with a decrease in yield of 37.3 to 61.1%.

The regression equation existing between root volume (X) and yield (Y) was calculated:

$$Y = -0.46 + 0.19\,X$$

With this formula, yield losses caused by the larvae of this pest can be approximately calculated.

The average area affected by *L. brevirostris* throughout the nation varies from 20 to 45%, reaching its higher values from April to October.

7. PEST'S MANAGEMENT

7.1. Sampling method for L. brevirostris

Because of the insect's habits, sampling for scouting becomes difficult, and after trying various methods, it was proved that the direct method (manual) reflects more exactly the levels of adult population density of *L. brevirostris* than sampling through the sweeping net. Besides, larvae and pupae are also counted in the former method, which will allow to take the established measures for the integrated management of that pest.

7.1.1. Description of sampling method

For scouting *L. brevirostris*, it is recommended to carry out from 6-8 samplings beginning with plantings from April to July on plants 15 to 17 days of age, to determine the presence of adults in this phenological stage of rice before permanent flooding.

Ten (10) sites are selected in the field and 20 plants are chosen from each site. Sites will be chosen at approximately 20 m from the field's border, near the irrigation canal and at a distance between sites of 80 to 100 meters, although it must be proportional to the field's length. Three out of the total sites will be evaluated in the lower parts of the field.

All adults will be evaluated in all 20 plants in each of the sites of the field and on leaves with symptoms of the damage caused by the adults (3 last leaves of the culm).

If the average throughout the field is of 3-4 adults per 20 plants and/or if 50% of total plants evaluated have scars on young leaves, the field should be treated with insecticide (chemical or biological). If the percentage is lower than 50% and higher than 30%, two new sites will be selected, the same as if the population of adults is smaller than 3 and larger than 1.

This Control method of *L. brevirostris* based on the foliage damage reduces the reliability after 15 days of constant flooding. Therefore, this method should be used for the last time when the rice plant has 32-35 days of age when evaluation of the larvae incidence will be started. For this purpose, 2 plants are selected from each of the 10 sites described above.

If the average number of larvae per plant is 4 or 5, the field should be treated chemically. If it is 2 to 3 larvae per plant, two new sites should be taken.

In germinations from December to January it is not necessary to take samples, because in this season of the year the conditions are the most unfavorable for the activity and development of *L. brevirostris*. Samplings will take place beginning on February 15, although it is extremely important to watch very closely the weather parameters, fundamentally temperature.

Germinations of February will be evaluated beginning in March.

8. CONTROL METHODS OF *L. brevirostris*

8.1. Cultural control

Among the control measures traditionally used there is draining of rice fields for larvae control. Although larvae appear initially in fields with higher water layer, they can resist long draining periods. An average of 2.5 larvae per plant have been collected when the soil has 39.7% of moisture content, which shows the great resistance capacity of the larvae of *L. brevirostris* to draining of rice fields.

Besides, major infestations of the insect occur from April to November, which is the rainy season of the year, and because of the type of soil used in rice crop, the water provided by rainfalls is enough to keep it humid. It may also occur that the major infestation stage coincides with major demand of water by the crop, and a drainage at this stage can cause similar damages to those of the pest. It has been proved that if the field is drained, there is a major incidence of weeds that compete with rice crop.

Because of the above, it is not advisable to drain rice fields to control the larvae of *L. brevirostris*.

Rice planted in the cold season, mainly from December to mid-January, is less affected by *L. brevirostris* because when the pest begins to invade rice fields (late in March to April), the plants have reached a deep root development which enables them to be more tolerant to the attack of rice water weevil.

In addition to the above cultural measures, it is very important to eliminate the residues of harvest and weeds, and to carry out land preparation and planting in puddled soil with a water layer, since due to the characteristics of the soil, adults may lay their eggs on these plants, and even on small plants, the larvae that rapidly attacked young seedlings may be collected.

Another valuable aspect in controlling *L. brevirostris* is dry-seeding, in addition to its benefits from the technical point of view over sowing in puddled soil with water layer.

When dry-seeding is used the soil is only flushed during the first stages of the crop and therefore, females of *L. brevirostris* can not lay their eggs. This is done later when plants have a more profuse root system and are more tolerant to the pest, regardless of the variety.

In the aspect related to the interaction between weeds and the population of *L. brevirostris*, it was pointed out that adults can remain hidden during several months on *P. muticum*. That's why it is extremely important to keep levees and canals free from this weed in rice fields. This control is essential during the months of November to March, season in which the adults of *L. brevirostris* remain in those places, and with the increase in temperature beginning in March, they begin to invade rice fields.

8.2. Biological control

Until now no actions of natural enemies have been observed on any of the development stages of *L. brevirostris* in rice fields in Cuba.

All of the clones of *Beauveria bassiana* and *Metarrhizium anisopliae* have achieved a good depressing action on the adult population of *L. brevirostris*, standing out the clone *B. bassiana* 32 that achieved a 65.6% of insect mortality 4 days after the treatment and 95% at 20 days (Table 3)

In respect to viability, the spores of *B. bassiana* remained viable with a normal development until 44 days after water submergence simulating irrigation conditions in rice fields. During this stage and getting in contact with adults of *L. brevirostris* moistened by the water, the control by *B. bassiana* 32 was of 100%, which was achieved between 8 and 10 days after treatment.

B. bassiana was applied in rice field conditions to control adults of *L. brevirostris*, achieving an average control of 83% during the years 1981 and 1982.

In addition to the high control of adults of *L. brevirostris*, *B. bassiana* 32 is less toxical than chemical insecticides used to control

Table 3. Final evaluation of mortality of Lissorhoptrus brevirostris *caused by different clones of entomopathogen fungi (Est. Exp. del Arroz "Sur del Jibaro", 1978-1979).*

Treatment	Adults of *L. brevirostris*				% Control
	Inoculated	Dead	Females	Males	
B. b. 24	150	126	69	57	84
B. b. 32	150	143	74	69	95
M. a. 72	150	120	61	59	80
M. a. 4	150	84	46	38	56

B. b = *Beauveria bassiana*, and M. a. = *Metarrhizium anisopliae* this insect. Besides, it can be produced in small bio-factories near the rice areas and as applications increase, epizootics could be created, which will result in a gradual reduction of populations of *L. brevirostris.*

Because of all those advantages the control of adults by the fungus *B. bassiana* should occupy a place of major importance in the management of this pest.

Recent studies show that clone Niña Bonita of fungus *Metarrhizium anisopliae* is very aggressive in causing mortality to the adult of *L. brevirostris* in a shorter time than that needed by clone 32 of *B. bassiana.*

In laboratory conditions the nematode *Heterorhabditis* controlled 82% of adults and larvae of *L. brevirostris.*

No dose of the biopreparations of *Bacillus thuringiensis* (Bitoxibacilin, Insectin, Dendrobacilin and Dipel) killed the adults of *L.* brevirostris.

When the insects feed on the plants, they ingest the spores and the endotoxins produced by the bacillus. The protein crystals cause the death of the insects within one to three days after ingestion.

The leaf area affected by *L. brevirostris* did not reach higher values than 0.51 mm^2/day and they only fed between 7 and 8% of their lifetime. That is why it is difficult to control the insect with *B. thuringiensis.*

8.3. Chemical control

Among the factors that have increased losses caused by this pest in our country is the defficient chemical control applied against such pest, motivated by the habits of *L. brevirostris* and its resistance to some chlorinate pesticides. This has resulted in an increase in production costs of rice.

When insecticides were put in contact with the body of the insect in laboratory conditions, they caused a high percentage of death on them, except for Camphechlor (1.56 kg a.i./ha) which only con-

Table 4. Mortality caused by different insecticides to adults of Lissorhoptrus brevirostris.

Insecticide	Dosage (kg a. i./ha)	Control (%)	
		4 days	15 days
Methyl Paration	0.46	100	100
Demeton-S-Methyl	0.30	85	100
Carbaryl	2.21	90	100
Methamidophos	0.72	90	100
Camphechlor	1.56	10	45

trolled from 10 to 45%, confirming the resistance of the rice water weevil to chlorate insecticides. (Table 4).

Based on those results, Carbaryl (2.21 kg a.i./ha) and Methyl Parathion (0.46 kg a.i./ha) have been applied in some cases with acceptable control during the first invasion of adults in late March and early April.

This is feasible because in this season adults have just undergone the quiescence and they begin to feed and copulate as soon as they invade the fields, being most exposed to chemical products early in the morning.

The chemical insecticide that has kept the best control on the pest is Carbofuran at a rate between 0.55 to 0.75 kg a.i./ha with a percentage of control between 96 and 100%.

Due to the characteristic of being an organophosphorate insecticide, the use of Ethoprophos at a dose of 3.5 to 4.0 kg a.i./ha (90 to 95% of control), is a good alternative with Carbofuran. The major disadvantages are the high rates used and the low concentration (5 and 10%) of the commercial product, which implies the use of large amounts of insecticide with the subsequent raise in application costs for the control of *L. brevirostris*.

8.4. Some considerations for the integrated management (I.M.) of *L. brevirostris*.

As a result of the research work accomplished, it is extremely important to observe the following aspects in the integrated management of this major pest.

8.4.1. Practical recommendations for I.M.

a) In areas selected for cold-season planting systematically presenting a heavy infestation of *L. brevirostris*, it is convenient to plant from December to January. With this measure, when adults begin to invade the fields late in March and early in April, rice plants will be more than 70 days old, which contributes to a greater tolerance to an attack of the insect because of a more profuse root system.
b) Incorporation through land preparation, especially by puddling,of all residues of harvest and weeds, since they become important hosts to the pest.
c) Keeping levees and canals clean, mainly where *P. muticum* grows, since the insect protects itself under these plants beginning in September until late in March, from where it flies to rice fields.
d) Increasing sampling in all the fields with permanent flooding beginning in March, since this is the critical month for scouting *L. brevirostris*, and continued until September, since this is the period of greatest activity of the pest.

8.4.2. Control of *L. brevirostris*

For control of the insect the following should be considered:

a) Application of fungus *B. bassiana* 32 at a rate of 2 kg/ha to control adults.

b) In those areas where it is not feasible to apply *B. bassiana* 32, and coinciding with the months of March and April, it is advisable to use insecticides Carbaryl and Methyl Parathion at a rate of 2.21 kg a.i./ha and 0.46 kg a.i./ha, respectively.
c) The control of larvae or a high incidence of adults should be achieved through the application of Carbofuran at a rate of 0.55 to 0.75 kg a.i./ha.
d) Due to the insect's habits, all insecticide applications with aircraft should be carried out early in the morning.
e) Do not drain the fields to control larvae, since this practice is more dangerous for the crop than the damage that may be caused by the insect.
f) It is recommended to count on good rice populations (above 175 plants/m^2), as well as leveling of terraces, since the insect generally begins its attacks in lower and unpopulated places.

IV. RICE LEAF MINER: Hydrellia sp.

INTRODUCTION

Among sporadical pests that have increased their damages to rice crop in the last years are *Spodoptera frugiperda* (J. E. Smith) and *Hydrellia* sp.

The first observations of *Hydrellia* were carried out in rice fields in Sur del Jíbaro during 1981 and the year after on the farms of the Experimental Station in the same area. Meneses (1986) reported *Hydrellia* sp. as a new insect pest in the rice zone of Sur del Jíbaro, Sancti Spiritus.

2. BIOLOGY OF Hydrellia sp.

The eggs are pearly white, ovoid-shaped with an average length of 0.705 mm and a width of 0.270 mm. These eggs are layed generally in the upper part of the leaf blade. The female does not show any preference for any leaf section (basal, middle and apical).

Up to 115 eggs have been found on one plant of *Brachiaria mutica* with 38 eggs on one leaf of such plant. The time from oviposition to emergence of the larva was of 5.5 days in average.

The larvae are from pale to beige in color, with a black mouth piece, typical of miners. Larvae have been observed starting to make mines that sometimes measure from 0.5 to 10.0 cm long, during all its cycle.

Developed larvae measure an average of 2.76 mm long and 0.30 mm wide. The larval stage lasts 9.5 days in average.

The pupal stage generally occurs in the same mine occupied by the larva. The pupa is from light to dark-purple in color when reaching adulthood. The pupa is ovoid-shaped with an average of 3.43 mm long an 1.01 mm wide. The average time of this development stage lasts 6.0 days.

Adults measure around 2.5 mm with shining black color and translucent wings.

Amaya (1976) stated that the adult of *H. griseola* measures approximately 3 to 4 mm with its wings spread; dark-gray in color with iridescent reflections and a golden frontal spot. Females are generally larger than males.

Adults start to copulate beginning on the third day after reaching adulthood and start laying eggs the day after, with an average duration of 7 days.

The flies show greater activity in those areas with higher water layer during the first and last hours of the day, feeding on decaying organic matters.

3. ECOLOGY OF Hydrellia sp.

3.1. Major host weeds

In addition to the relationship of the insects with the rice plant, the presence of weeds serving as alternate hosts to these insects in a certain season plays and important role within the rice agroecosystem.

The Poaceae (=grasses) became the major hosts to Hydrellia, standing out B. mutica for its abundance and the high number of plants with eggs, larvae and pupae of the insect.

The presence of adults on this plant was not observed due to its characteristics of feeding on nectarous or decaying substances.

Leaves of T. domingensis have been found with 44 eggs and, as pointed above, up to 115 eggs on the plant of B. mutica, 38 out of which were on one leaf.

In cage-raising conditions, eggs of Hydrellia have only been collected on plants of B. mutica, but not on E. colona, C. iria and L. fascicularis.

4. POPULATION DYNAMIC OF Hydrellia sp.

The population of *Hydrellia* begins to increase since March and stays high until June depending on weather conditions, with the most favorable mean temperature being from 24°C to 27°C.

A correlation analysis between the population of *Hydrellia* and temperature showed a highly significant association ($r = 0.98$ **).

Similar results to the above were obtained with yellow traps. The highest values of collected adults were recorded between March and May, with decreasing values beginning in July.

4.1. Sampling method for Hydrellia

The sampling method used until now is the sweeping net using a methodology similar to the one used for scouting *S. oryzicola*.

In other countries sampling is carried out on the plant's leaves, evaluating the three younger leaves of the 10 neighboring stems in 5 randomized sites.

Table 1. Major hosts of Hydrellia *sp. in the rice zone of Sur del Jibaro (Sancti Spiritus, 1986-1987).*

Family	Scientific Name	Common name
Poaceae	*Echinochloa crus-galli* (L) Beauv.	Arrocillo
Poaceae	*E. colona* (L.) Link	Metebravo
Poaceae	*Brachiaria mutica* (Forsk.) Stapf	Paraná
Poaceae	*Leptochloa fascicularis* (Lam.) A. Gray	Plumilla
Poaceae	*Leptochloa panicea* (Retz.) Ohwi	Plumilla
Poaceae	*Leptochloa virgata* (L.) Beauv.	Plumilla
Poaceae	*Rottboellia exaltata* L. F.	Sancaraña
Poaceae	*Brachiaria fasciculata*	Súrbana
Poaceae	*Brachiara* sp.	
Poaceae	*Eleusine indica* (L.) Gaertn.	Pata de Gallina
Poaceae	*Andropogon* sp.	
Poaceae	*Sorghum halepense* (L.) Pers	Hierba de Don Carlos
Poaceae	*Hymenachne donacifalia* (Raddi) Chase	Camalote
Poaceae	*Cynodon dactylon* (L.) Pers	Hierba Fina
Poaceae	*Paspalum distichum* Borg	Hierba de cepa
Poaceae	*Leersia hexandra* Sw.	Leersin
Cyperaceae	*Cyperus iria* L.	Ciperáceas
Cyperaceae	*Cyperus ochraceus* Vahl	Ciperáceas
Cyperaceae	*Cyperus* sp.	
Cyperaceae	*Cyperus esculentus* L.	Ciperáceas
Cyperaceae	*Scleria setuloso* Ciliata Bocki	Cortadora
Typhaceae	*Typha domingensis* (Pers.) Kuth	Macio
Sphenocleaceae	*Sphenoclea zeylanica*	

5. METHODS OF CONTROL OF *Hydrellia* sp.

5.1. Cultural control

Fields planted between December and January, regardless of the variety used, are more tolerant to the attack of the pest because when the insect feeds on such fields, the rice plants present a profuse leaf development, which enables them to compete with *Hydrellia*.

The insect shows preference for the lower parts of the field. That's why a good land leveling and the use of a shallow water layer are also very helpful in reducing the pest's damages.

A constant search for varieties resistant to *Hydrellia* has been implemented by several researchers. In Cuba, it was found that several lines having varieties J-104 and CP1C8 among their parents, showed a high degree of intermediate resistance to *Hydrellia*.

In addition to the above factors, measures aimed at controlling *L. brevirostris* also play an important role in the cultural control of this pest.

5.2. Chemical control

Since this pest appears sporadically in some rice zones, until now the same insecticides recommended to control *S. oryzicola* have been applied on *Hydrellia* with good control.