CONTROL OF MAJOR DISEASES OF RICE IN LATIN AMERICA

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Although rice diseases have been recorded for several centuries, epidemics were unusual until the extensive cultivation of high-yielding varieties started 20 years ago. Parallel to the use of high yielding varieties was the use of high nitrogen inputs, more intensive management practices and the extensive monoculture. As a result, all these practices have brought higher yields in many countries. However, the use of high-yielding varieties in monoculture, associated with intensive cultivation practices such as high nitrogen fertilization increased the severity of some diseases, provoking large epidemics such as that occurred in Korea where in 1978 rice blast caused by *Pyricularia oryzae* provoked heavy losses.

The impact of new improved rice varieties in Latin America has been significant. In Latin America the area of irrigated rice for 1980-81 was 2.1 million hectares and, the additional production in the area planted with the new improved varieties was near to 2 million tons (8). The average yield of 4.0 tons/ha for Latin America is only exceeded by Western Europe and the United States. In some cases yields have been twice than those that will be expected in the absence of those new improved varieties, in other cases both yields, actual and expected, are equal. on the average yields,

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in the irrigated rice sector of Latin America have increased 1.2 tons/ha, that is a 43 percent increase over the 2.8 tons/ha average estimated in the absence of new improved varieties (8). Areas with mean yields of 4.0 tons/ha or higher tend to have high per hectare investments in fertilizers,pesticides, irrigation and other costs associated with mangement. Hence, pest control practices constitute a form of insurance so that return on these investments is assumed.

LIMITANT DISEASES OF RICE IN LATIN AMERICA

Although more than 70 rice diseases caused by both biotic and abiotic agents have been reported (Appendix 1), about a dozen of those diseases are considered as limiting factors of the rice production in Latin America (Table 1). Most of them are comprised by fungal diseases. Blast (*Pyricularia oryzae*), brown spot (*Cochliobolus miyabeanus*, conidial stage *Helminthosporium oryzae*) and leaf scald (*Metasphaeria albescens*, conidial stage *Rhynchosporium oryzae*) are the most widely distributed through the Latin American countries. All are seed-born pathogens.

FUNGAL DISEASES

Rice blast (*Pyricularia oryzae*). This disease is and will be for much time the most complex problem of the rice crop,especially in the tropical areas. More than 70 countries across 5 continents have registered the presence of this disease. Rice crop losses caused by the disease can sometimes at some locations be complete. There are many examples of varieties with resistance that have been overcome due to the appearance of new physiological races of the pathogen. More than 260 races have been reported (13). Although the

TABLA 1. PROBLEMAS LIMITANTES DE ARROZ EN AMERICA LATINA

PAIS	AGENTE CAUSAL														
	P. oryzae	*C. miyabeanus*	*M. albescens*	*A. oryzae*	*S. oryzae*	*M. salvinii*	*D. gigantea*	*Th. cucumeris*	*U. virens*	*Hoja blanca*	*X. oryzae*	*M. de grano*	*Espiga erecta*	*S. oryzicola*	*Nematodos*
Argentina	XXXX					XXX							XXXXX		XXX
Belice	XXXXX	XXXX												XXXX	
Bolivia	XXXX	XXXXX	XXX												
Brasil	XXXXX	XXX		XXXX											
Colombia	XXXX			XXX						XX	X	XXXXX		XXXXX	
Costa Rica	XXXXX	XXXX	XXX						XX					XXXX	
Ecuador	XXXXX					XXXX				XXXXX				XXXX	
El Salvador	XXXXX	XXX	XXXX									XX		XXXX	
Guatemala	XXXXX	XXXX	XXX												
Haití		XXXXX			XXXX										
Honduras	XXXXX	XXX	XX		XXXX										
México	XXXXX	XXX	XXX									XXX			
Panamá	XXXXX	X	XXXX				XX	XXX						XXXX	XXX
Perú	XXXXX			XXXXX		XXXXX	XXX			XXXXX		XXX		XXX	
Surinam	XXX	XXXXX			XXXX										
Venezuela	XXXXX		XXXX											XXXXX	

* Fuente : Informe de la Cuarta Conferencia del IRTP para América Latina, Agosto 10 - 14, 1981

P = Pyricularia, C = Cochliobolus, M = Metasphaeria, A = Alternaria, S = Sphaerulina, M = Magnaporthe, D = Drechslera, Th= Thanatephorus, U = Ustilaginoidea, X = Xanthomonas, M = Manchado, S = Sogatodes.

fungus can attack both seedling and panicle stages, the most important economical damage is caused at panicle stage. The humidity of both soil and environment is in close association with the development of the disease. Plants growing under dry soil conditions become more susceptible to the fungus. High relative humidity favors the development of the disease. The degree of resistance seems to increase in proportion to the application of silicates and to the amount of silice accumulated into the plant tissue. High nitrogen fertilization predisposes the rice plant to the attack of *P. oryzae*. There exists a close relationship between soluble nitrogen and susceptibility. The intensity of the influence of nitrogen supply on the disease varies with soil and climatic conditions and also with fertilizer application methods (16). The disease generally is found to be more drastic when quick-acting nitrogenous fertilizers, such as ammonium sulphate, are applied excessively at one time or when the retarded effects of fertilization occur either by too late or too heavy application or by low temperatures in the earlier stages of plant growth (16). The fungus can survive as conidia or myceliam in seed, plant debris in the soil and on many gramineas. Increase awarness of the short nature of most commercial varieties has led investigators to search for alternatives. Disease resistance, cultural practices and chemical control have been used to control the disease. When young plants are attacked, development of the disease can be slowed by flooding or risen the flood. Early planting can reduces significantly the incidence of the disease.

Brown spot (*Cochliobolus miyabeanus*, conidial stage *Helminthosporium oryzae*). This fungus can attack both seedlings and adult plants being more common on the lasts. The disease is associated with abnormal soils deficients in nutrients or reduced soils where many toxic substances are accumulated. The disease is more severe in plants growing in soils deficients in silice, potassium, magnessium, iron and zinc (1, 21). The sulphuric acid, ferric compounds and some organic acids found in the soil spoilage the rice roots reducing the rate of mineral absorpcion, hence, increasing the severity of the disease. It seems that production is more affected by the root rotting than by the disease properly. The most efficient measure of control of this pathogen is by using resistant varieties, where it is available in commercial varieties. Cultural practices such as good soil preparation, land leveling, balanced fertilization and good water management are efficient measures to reduce the incidence of the disease. In areas where seed infection is common, chemical seed treatment is likely to be useful in reducing the damage on seedlings. Field spraying with fungicides to prevent secondary air-borne infection has also been tried. However, the practical usefulness of such spraying is doubtful.

Leaf scald (*Metasphaeria albescens*, conidial stage *Rhynchosporium oryaze*). The disease is more common affecting adult plants after heading stage, being more severe in upland rice and under conditions of high relative humidity. Increase of nitrogen in the soil favors the development of the disease. Resistance is the cheapest way to control the fungus. Cultural practices such as to avoid heavy application of nitrogenous fertilizers and to avoid planting susceptible varieties on upland fields are recommended measures. Chemical control can be useful.

Narrow brown leaf spot (*Sphaeralina oryzina*, conidial stage *Cercospora oryzae*). The disease is more common observed attacking adults plants. Under unfavorable soil conditions such as phosphorous and potassium deficiencies, this pathogen may causes severe damages. It is common to find this disease associated with Helminthosporium oryzae. The most efficient measure to control the fungus is by the use of resistant varieties. Cultural practices such as planting early maturing cultivars and to avoid heavy application of potassium fertilizers aim to reduce the possible losses caused by this disease. The use of chemicals can be useful.

Stem rot (*Magnaporthe salvinii*, conidial stage *Sclerotium oryzae*). This disease when is present produce severe damage. The application of heavy nitrogen fertilization favors the disease development. On the contrary, potassium fertilization increase plant resistance to the fungus attack. Hence, the ratio K/N and C/K in the plant tissue are very important in determining resistance or susceptibility to stem rot disease. Application of sodium silicate reduces the incidence of this disease. The effect of phosphorus is similar to that of nitrogen but in a lower degree. The irrigation water constitute an important agent of dissemination of the disease since it transports the sclerotia from one field to another. Hence, proper management plays an important role in controlling stem rot infections. This disease can often be controlled by varying the water level during the vegetative stages of growth. When lesions on the outer sheath are covered by water they quickly rot and the fungus does not penetrate to the inner sheaths. When the water level is reduced, so that most of the lower leaf sheaths are exposed, the sheaths dry up and fall away from the culm, preventing penetration of the culm by the pathogen.

Sheath blight (*Thanatephorus cucumeris*, imperfect stage *Rhizoctonia solani*). The disease received little attention until very recently when it became a major problem of high-yielding varieties. Plant age influences greatly the incidence of this disease. Plants of 2-3 weeks old are more resistant to infection than older plants. At heading stage the plants become very susceptible to the fungus. Tall varieties with little tillering are more resistant to the disease than dwarf varieties with much tillering. High density of plants favors the development of the fungus due to the microenvironment and better attachment of sclerotia to the stem surface favoring the dissemination of the disease through the mycelium. Nitrogen and phosphorus fertilization or potassium deficiency predispose the rice plants to sheath blight disease. The fungus survives as sclerotia, as mycelium in plant debris in soil, and on weeds and other crop plants. Since resistance is very sensitive to environmental influences, the disease is primarily controlled by the use of cultural practices that do not favor disease development. The use of lower levels of nitrogen fertilizers, lower seeding rates in drilled rice, and wider spacing in transplanted rice reduce significantly the incidence of the disease. Since the fungus has a wide range of hosts is very important to control grasses. Chemical control has its limitations.

Other fungal diseases such as sheath rot, caused by *Acrocylindrium oryzae*. Eye spot, caused by *Drechslera gigantea*; and false smut caused by *Ustilaginoidea virens* are until now occassionally epidemic or locally serious. These diseases are usually controlled by the use of resistance when it is available in commercial varieties; cultural practices and fungicides.

BACTERIAL DISEASES

Bacterial leaf blight (*Xanthomonas oryzae*). The bacterium causes "Kresek" on seedlings and leaf blighting on the foliage. The disease has recently been reported in Mexico, Central and South America. However, the severity of the disease in Latin America has been from light to moderate. Rainy Weather, potassium deficiency and nitrogen excess are factors that predisposes greatly the rice plants to the attack of *X. oryzae*. The disease is controlled mainly by the use of resistance and certain cultural practices that reduce the amount of inoculum surviving between crops. The bacterium has rapidly become resistant to several antibiotics. No single effective control measure is available for the control of the disease and integrated measures are therefore, recommended.

VIRUS DISEASES

Hoja blanca virus (vector : *Sogatodes oryzicola*). Although fifteen virus and virus like diseases have been recorded since rice dwarf was registered in Japan in 1883 (18), only Hoja blanca is unique to the Americans. The disease is primarily contolled by the use of varieties resistant to the vector, virus, or both. The use of insecticides are useful to limit vector populations.

NEMATODE DISEASES

Eventhough little attention has been placed on nematodes, several diseases caused by nematodes are significant. The white tip nematode (*Aphelenchoides besseyi*) is the most frequent. Other nematodes, such as, the stem nematode (*Ditylenchus angustus*), the root nematode (*Hirschmanniella oryzae*), the root knot nematode (*Meloidogyne graminicola*), the ring nematode (*Criconemoides onoensis*), and the migratory nematodes (*Xiphinema parasetarie* and *X. orbum*) constitute a group of economical importance. The *Xiphinema* group is very important since several species are known to transmit some virus diseases. when damage is severe, it is suggested to search for resistant varieties. Since the white tip nematode is seed-borne, seed treatment with hot water and chemicals give significant reduction in the severity of the damage caused by the nematode.

NON - PARASITIC DISEASES

Straight head. The disease is generally common in new soils with poor drainage capacity or with high content of organic matter. The best control measure of this disease is by the use of resistant varieties. Cultural practices, such as to avoid planting in sandy loam soils which are not drained completely, draining just prior to the stem elongation and, to avoid repeated applications of arsenic-containing insecticides reduce significantly the incidence of this physiological disease.

GENERALIZED CONTROL MEASURES

Host Resistance. The use of resistance is one of the most cheapest and safest methods in controlling plant diseases. To reduce damage by diseases, most farmers apply chemicals. Although effective chemical control is available for temperate areas, its use in the tropics is questionable due to frequent and heavy rains. Thus, the development of resistant rice varieties is essential. There are now over 150 varieties of approximately 25 crops resistant to nematodes, over 100 varieties resistant to 25 types of insect pests, and more than 150 varieties resistant to a great diversity of plant diseases (5). However, many varieties of important crops lack broad pest-resistant bases and are vulnerable to serious disease organisms now present at low intensities or to potentially adaptable foreign pests. Unexpected disease problems can explode at any time, with disastrous effects on these crops.

Methods have been developed for screening and testing varietal resistance to major rice diseases by natural infection in the field or by artificial inoculation both in the greenhouse and in the field. The International Rice Testing Program (IRTP) has organized nurseries for testing resistance to several major diseases. The objective of these nurseries is to identify varieties with resistance to the various diseases and to determine the variation of the pathogen on the selected varieties. As a result of this intensive screening program, several sources of resistance to rice diseases have been identified. Although breeders are actively incorporating resistance into commercial varieties, good sources of stable resistance have not been found for several important diseases. It is common to observe that rice varieties having resistance to one important disease are susceptible to one or more other major diseases (Table 2). Hence, breeding for disease resistance must increasingly emphasize diverse varieties that resist a much wider complex of diseases. The incorporation of multiple resistance into commercial varieties has been a complex, long term undertaking and the so called "pyramiding of resistance genes" has been successful only to a limited extend. The most important disadvantage has been the breakdown of resistance due to the development of new physiological races of the pathogens. This is particularly true for *Pyricularia oryzae*. This fungus is highly variable and vertical resistance is overcome very soon in the tropics. A few commercial varieties have been highly resistant to the pathogen but only for a short period of time (Table 3). Hopefully, however, this drawback is expected to be overcome by the use of other breeding strategies such as the use of multilines, gene deployment, varietal diversification or concentration of slow blasting components. Nevertheless, breeding for resistance to a limited number of rice diseases is obviously a holding action where environment is favorable for disease development.

TABLE 2. DEGREE OF RESISTANCE OF SIX RICE VARIETIES TO THREE LIMITING DISEASES OF THE RICE CROP PRODUCTION IN COLOMBIA.

Variety	Degree of Resistance to :		
	Pyricularia oryzae	Hoja blanca virus	Manchado de grano
Colombia 1	R	R	R
Metica 1	R	R	S
Azucena	MR	S	S
CICA 4	S	MR	R
IR 22	S	S	MR
CICA 8	S	S	S

TABLE 3. CHANGES IN BLAST REACTION OF COMMERICAL RICE VARIETIES IN COLOMBIA*.

Variety	Time of: Released	Time of: Breakdown	Field performance (years)
IR 8	1968	1970	2
CICA 4	1971	1972	1
IR 22	1971	1972	1
CICA 6	1974	1975	1
CICA 9	1976	1977	1
CICA 8	1978	1981	3

* Observed in Commercial fields

Source : Ahn, S.W. 1981. The Slow Blasting Resistance. In Proceedings of the Symposium on Rice Resistance to Blast. Montpellier, France. pp. 343-370.

Cultural Practices. Cultural practices for disease control have been often integrated with other practices. Even though the farmer operates in a simple ecosystem, he still has a good deal of control. He can decide when to start succession and when to terminate it, and this must be decided in terms of damage by weather and diseases. In their natural environment, the rate of disease build-up depends primarily on the availability of susceptible tissue and any action which directly or indirectly influences the food supply will cause a corresponding change in disease numbers. Consequently, some of the improved rice cultivation techniques are indirectly responsible for increasing disease populations. Rice is unique among the field crops in that it is commonly grown under flooded conditions. The use of controlled irrigation water means better growth conditions not only for the plants but also for weeds, many of which are alternate hosts of insect pests. However, this water may be used to control weeds in the rice fields. Timing of planting and harvesting, seed storage, fertilizer rates, rotation crops, and weed control measures often have an effect on disease control. These and other cultural practices such as physical and regulatory control measures can be manipulated to minimize inoculum production, survival, and dissemination; as well as infection, and disease development. Unfortunately this area of rice disease control receives the least organized research of any of the major control measures and yet, it has one of the highest potentials for reducing yield losses due to diseases.

Chemical Control. The discovery of Bordeaux mixture a century ago may be considered as the first important landmark in the history of chemical control of plant diseases. Commercial production of many crops including rice, would be difficult or impossible without the use of chemicals to control major diseases. Nevertheless, the actitude of the public today is negative on the use of all pesticides, including those used to control plant diseases. The discovery of the dithiocarbamate fungicides fifty years ago and the introduction of several systemic fungicides in the late 1960's are considered to be the two most important events in the 100-year history of chemical disease control (4). Chemical pesticides are of considerable importance in food and fiber production, forest management, public health and urban pest control programs. However, in addition to continuing concern about their environmental and health effects, other disadvantages of heavy dependence on chemical pesticides have become increasingly apparent. First, the price of synthetic organic pesticides and the cost of their application have risen significantly in recent years, placing a financial burden on those farmers and others who use large quantities of these materials to control serious pests. Potentially or even more concern, significant groups of pests have developed strains that are genetically resistant to pesticides. Worldwide, over 300 species of insects, mites and ticks are known to possess strains resistant to one or more chemical pesticides and an additional 50 species are suspected of possessing resistant strains (5). In the population of a plant pathogenic species, which as a whole is sensitive to a disease control chemical, strains may exist or arise, that are significantly less sensitive to the compound. As the frequency of these strains increases under the selection pressure of the chemical agent, the effectiveness of the compound gradually decreases. This problem of resistance was practically unknown to plant pathology, as long as only inorganic chemicals were used for plant disease control. Resistance was observed in isolated instances, with a few of the organic protectans but became a major problem after the introduction of the specifically-acting systemic fungicides and antibiotics (4). Resistance was responsible for complete failure of the benzimidazole fungicides (benomyl, thiabendazole, carbendazim, thiophanate methyl) against diseases incited by a number of pathogenic fungi; blasticidin-s and Kasugamycin against Pyricularia oryzae, and polyoxin against Thanatephorus cucumeris of rice (4, 6, 9). It now appears likely that resistance will be a major factor in plant disease control in this decade. Whether resistance problems will arise in practice, depends further on the fitness and virulence of the resistant mutants, the type of disease, environmental conditions and the presistance and method of use of the fungicide. A continuous selection pressure by one type of fungicide may favor the build up of a resistant population and should, therefore, be avoided (9). The possibility of minimizing the importance of resistance by using mixtures of diseases control chemicals or by alternating the application of such chemicals to the crop deserves consideration.

The use of fungicides for disease control has been increasing and, there is in the market different fungicides which are useful to reduce the damage cause by some rice disease (Table 4) Fungicides may be specific for a single fungus species, for instance, tricyclazole and *Pyricularia oryzae* (22), or they may have a broad spectrum and give control of several diseases. Benomyl, for instance, controls *P. oryzae*, *Sphaerulina oryzina*, *Thanatephorus cucumeris* and *Metasphaeria albescens* (7, 12, 14, 23). Field tests with foliar fungicides to control *P. oryzae* produce yield increases from 1-2 tons/ha (7), which suggest that fungal diseases such as blast can destroy up to 25 per cent of the potential crop. This means that the development and use of fungicides for disease control in rice must be an essential element of any disease control or management program. Integrated programs including sanitation, good cultural practices and resistant

TABLA 4. LISTA PARCIAL DE PRODUCTOS QUIMICOS REPORTADOS EFICIENTES PARA EL CONTROL DE ALGUNOS DE LOS PATOGENOS MAS IMPORTANTES DEL CULTIVO DEL ARROZ

NOMBRE COMERCIAL	INGREDIENTE ACTIVO: NOMBRE COMUN OFICIAL	INGREDIENTE ACTIVO: FORMULA QUIMICA	COMPUESTOS	ACTIVIDAD	PATOGENOS CONTROLADOS O PREVENIDOS	REFERENCIAS
Kasumin	Kasugamicina		Antibiotico	Sistemica	Pyricularia oryzae	7,11,17,22,23
Hinosan	Edifenfos	O, etil - s.s. difenil-fosforoditioato	Organico	Preventiva, eradicante	P. oryzae, Thanatephorus cucumeris, Magnaporthe salvinii, Sphaerulina oryzae, Metasphaeria albescens	7,12,14,17,22,23
Benlate	Benomil	1 (butilcarbamoil) 2 benzimidazolcarbamato de metilo	Carbamato	Sistemica	Pyricularia oryzae, Magnaporthe salvinii, Metasphaeria albescens, Sphaerulina oryzae, Thanatephorus cucumeris.	7,14,22,23
Bla-S	Blasticidina	Sulfonato de bencilaminobenceno	Antibiotico	Preventiva	Pyricularia oryzae	11,17,22
Kitazin		S-bencil-O,O-diisopropil-fosforotioato	Organico	Sistemica	P. oryzae, Thanatephorus cucumeris, Magnaporthe salvinii	7,11,22
Beam	Triciclazole	5-metil-1,2,4-triazol (3,4,6) benzotiazol	Benzotiazol	Sistemica	P. oryzae	22,23
Topsin-M	Tiofanato metil	Dimetil-4,4' -O-(fenilene) bis-3 tioalofanato	Organico	Sistemica	P. oryzae, Sphaerulina oryzae, Thanatephorus cucumeris	14,22
Bayleton	Triadimefon	1(4-clorofenoxi)-3,3- dimetil-1(1 H-1,2,4-triazol-1-il)-2-butanona	Organico	Sistemica	Sphaerulina oryzae, Metasphaeria albescens	23
Bavistin	Carbendazim	Metil-1H - bencemedazol - 2-ilcarbamato	Benzimidazol	Sistemica	P. oryzae, Thanatephorus cucumeris, Sphaerulina oryzae, Metasphaeria albescens	22,23
Antracol	Propineb	Propilenobisditiocarbamato de zinc	Carbamato	Protectora	Sphaerulina oryzae, M. albescens, Helminthosporium oryzae	23
Dithane M-45	Mancozeb	Etilenobisditiocarbamato de manganeso mas zinc ionico	Carbamato	Protectora	S. oryzae, Helminthosporium oryzae	23
Difolatan	Captafol	Cis-N- (1,1,2,2, tetracloroetil) tio 4-ciclohexeno-1,2 dicarboximida	Organico	Protectora	Metasphaeria albescens	23
Validacin	Validamicina		Antibiotico	Sistemica	Thanatephorus cucumeris	22,23
Polyoxin			Antibiotico	Sistemica	T. cucumeris, Xanthomonas oryzae	11,22
Duter	Fentin hidroxido	Hidroxido trifenil de estaño	Organico	Protectora, curativa	Pyricularia oryzae, Helminthosporium oryzae	7,22,23
Neo-Asozin		Metanoarsonato ferrico	Organico	Preventiva	Thanatephorus cucumeris.	22
Rabcide	Tetracloroftalida	4,5,6,7 tetracloroftalida	Ftalido	Protectora	Pyricularia oryzae	22
Celdion	Fentiazon	3, bencilidenoamino-4-feniltiazolina-2-tiona	Organico	Preventiva	Xanthomonas oryzae	22
Ganocide	Drazoxolon	4 (2-clorofenilhidrazono)-3-metil-5-isoxazolona	Organico	Protectora, eradicante	Pyricularia oryzae	22
MC 25	Guazatina	sal de 9, aza-1,17-diguanidino heptadecano	Guanadina	Eradicante	Pyricularia oryzae	22
Fenazin		Fenazin-5-oxido	Organico	Preventiva	Thanatephorus cucumeris	22
Fuji-one	Isoprotiolano	Diisopropil 1,3-ditiolan-2-ilidan malatona	Organico	Sistemica	Pyricularia oryzae, Magnaporthe salvinii	22
MK 23	Fluoroimida	N-(p-fluorofenil)-2-3-dicloromaleimida	Organico	Preventiva	Pyricularia oryzae	22

Nota. El principal objetivo de esta lista es proporcionar una guía para la identificación apropiada de los compuestos químicos y en ningún momento se debe considerar como una recomendación de ellos por parte del CIAT varieties must go hand-in-hand with judicious application of chemicals (Appendix 2). There is a need for better chemicals, better application methods, better sanitation practices, and consistency in control programs. Chemicals are meant to be used in conjunction with good grower practices, and not as alternatives (20). Finally, integrated control by means of more stable resistance combined with chemical treatment becomes a fascinating alternative. Horizontal resistance is often incomplete, partial and in seasons exceptionally conductive to disease, it may not adequately protect the crop. There is evidence that this deficiency of horizontal resistance can be solved by the use of fungicides that are not sufficiently effective on susceptible varieties (24).

TIME OF APPLICATION IN RELATION TO FUNGICIDAL PROPERTIES OF CHEMICALS

Let us consider the most important disease of rice, that is, blast caused by *Pyricularia oryzae*. There are several excellent fungicides for the control of this disease but they are somewhat different from each other is mode of action. From Table 5, for instance, it can be observed that Kasugamycin, an antibiotic, does not have any protective activity against the penetration of the fungus but it has marked preventive effect on mycelial growth after penetration, with rather shorter residual activity, while blastin , an organochlorine compound, has strong protective effect on penetration with a long residual action, but not on mycelial growth after penetration, showing a striking contrast to those characteristics of Kasugamycin (17). On the other hand, benomyl, a carbamate compound, has both preventive and erradicant properties. The chemical is systemic in activity. As

TABLA 5. PROPIEDAD PROTECTORA-ERRADICANTE Y SISTEMICA DE ALGUNOS QUIMOTERAPEUTICOS CONTRA EL AÑUBLO DEL ARROZ

PRODUCTO	INGREDIENTE ACTIVO	Actividad protectora contra		Actividad erradicante contra			Actividad sistémica a través	
		Penetración	Acción residual	Desarrollo de lesión	Esporulación	Acción residual	Follaje	Raíces
BLA-S a/*	bencilaminobenzol-sulfanato	+++	++	++++	+++	++	-	-
BLASTIN*	pentachlorobenzyl alcohol	+++++	+++++	±	++++	+++	+++	-
HINOSAN*	(o-ethyl s,s-diphenyl phosphoroditioate).	+++	+++	+++	+++	+++	±	+
KASUMIN b/ *	kasugamycina	+	±	+++++	++++	+++	±	+++
KITAZIN P*	(s-benzyl o,o-diiso-propyl thiophosphate	+++	++	+++	+++	++	±	++++
BENLATE **	methyl 1-(butyl carba-moyl)-2-benzimidazole carbamate.	+++++	+++++	+++++	++++	+++	+++	+++++
BRESTAN **	trifenil acetato de estaño	+++	++					++++

a/ y b/ Antibióticos extraídos de *Streptomyces griseochromogenes* y *S. Kasugaensis*, respectivamente.

* Kozaka, T. 1969. Chemical Control of Rice Blast in Japan. Rev. Pl. Protect. Res. 2: 53-63

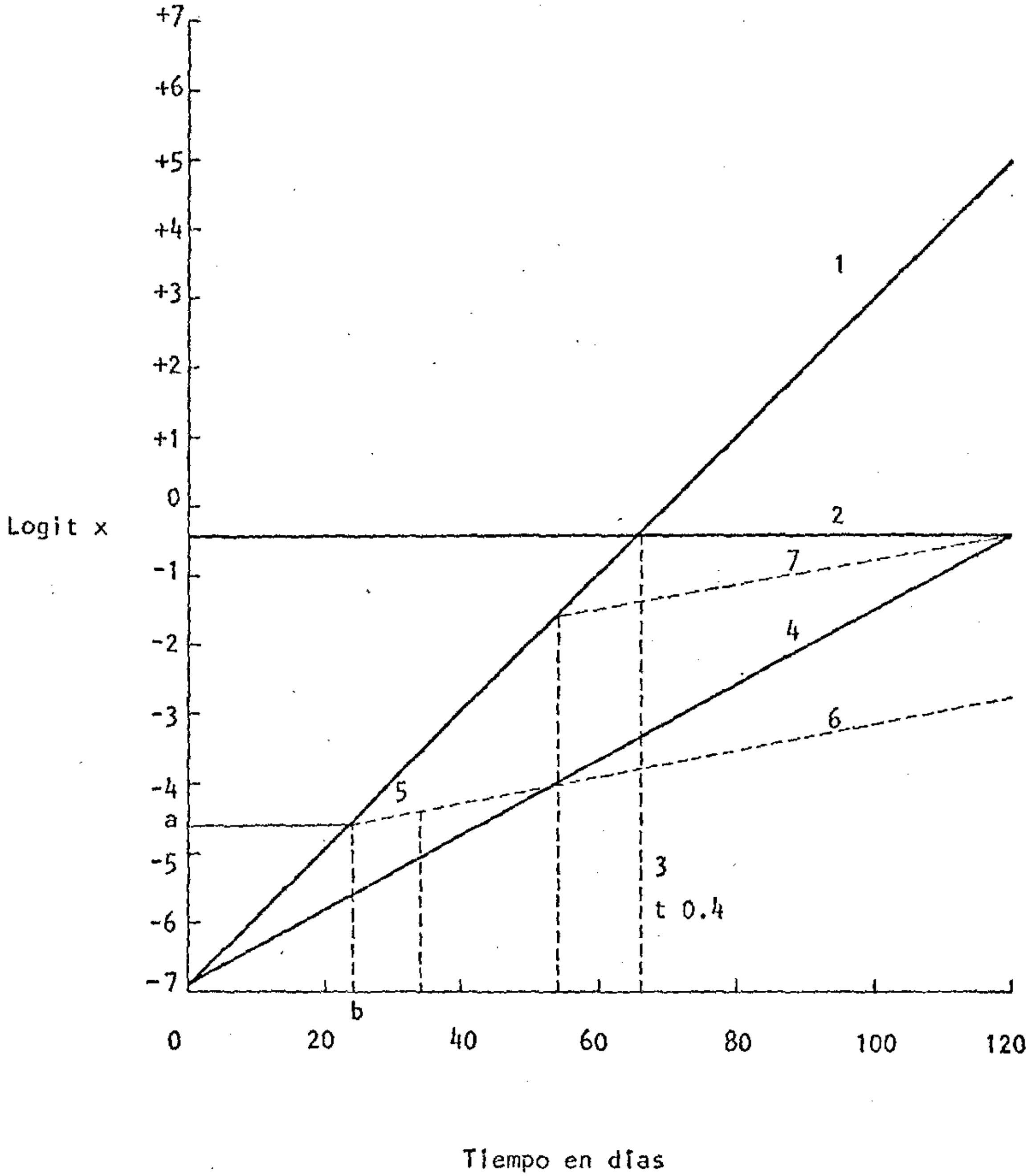
** Galvez, G y J. Castaño 1974. Aplicación de Productos Quimoterapeúticos al suelo para el control de *Pyricularia oryzae* en arroz. Fitopatología 9 (1): 18-23.

an effective soil fungicide roots must be contained within the treated areas having a long residual activity (10). If Kasugamycin, blastin and benomyl are applied several days before the primary infection, Kasugamycin would give unsatisfactory control, but blastin and benomyl would give an excellent control. On the contrary, if the three fungicides are applied several days after primary infection, blastin would give unsatisfactory control, but Kasugamycin and benomyl would give good control. Generally speaking, chemicals having a higher protective effect with a longer residual action give superior control when they are applied just before or immediately after the primary disease occurrence, against leaf blast, and at the time of uniform emergence of most panicles, against neck rot. In the case of leaf blast, protective control with any kind of chemicals in current use causes a delaying of primary disease occurrence for some time which depends on the chemical, but does not give any effect on the rate of disease development after occurrence. The duration period of chemical effect expressed by the delayed period of disease occurrence does not usually exceed one week even when the chemicals remain active for more than one week at high initial level on the plant surfaces, because leaves newly emerges at a rate of one leaf per week per plant after chemical control, on which new infection can not be presented. This sugggests that the best interval for successive control is one week, The conditions differ somewhat with the fungicides having a highly systemic effect through foliage application in addition to their high protective effect. These chemicals can prevent to some extent further infection on new leaves emerged following application. The erradicative effect reduces the rate of disease development. The duration period of the erradicative control is influence by several factors beside the valid period of chemical action on and into the plant tissues, but it is assumed to be determined mostly by the intensity of depressing the rate of disease development. The best control is achieved by frequent applications at early stage of disease development, i.e. two or three applications with an interval of 3 to 4 days. However, the number of applications depends on the environmental conditions of the area, disease severity, type of chemical and variety grown.

EPIDEMIOLOGICAL IMPLICATIONS OF CHEMICAL CONTROL

Disease increase is slowed by the application of efficient fungicides. Suppose that the rice variety "miracle" is being grown. It suffers from a compound interest, non-systemic foliar disease originated from infested seed. This variety has a growing period of 120 days. In its area of planting, "miracle" allows an apparent infection rate of $r = 0.10$ per day. The causal agent is carried on infested seed. An uncertified seed source was used that had one seed infested in every 10 seeds. This will result in a single lesion per plant. A plant can sustain 100 lesions. From Graphic 1, it can be observed that in the absence of chemical control the final disease severity (X_h) will be 0.993 (line 1). The damage threshold is estimated to be 0.40 (line 2) and it is obtained after 66 days (line 3). The interception of line 4 with line 2 shows the maximum disease progress allowable economically. Now we can see graphically the management problem facing the farmers.

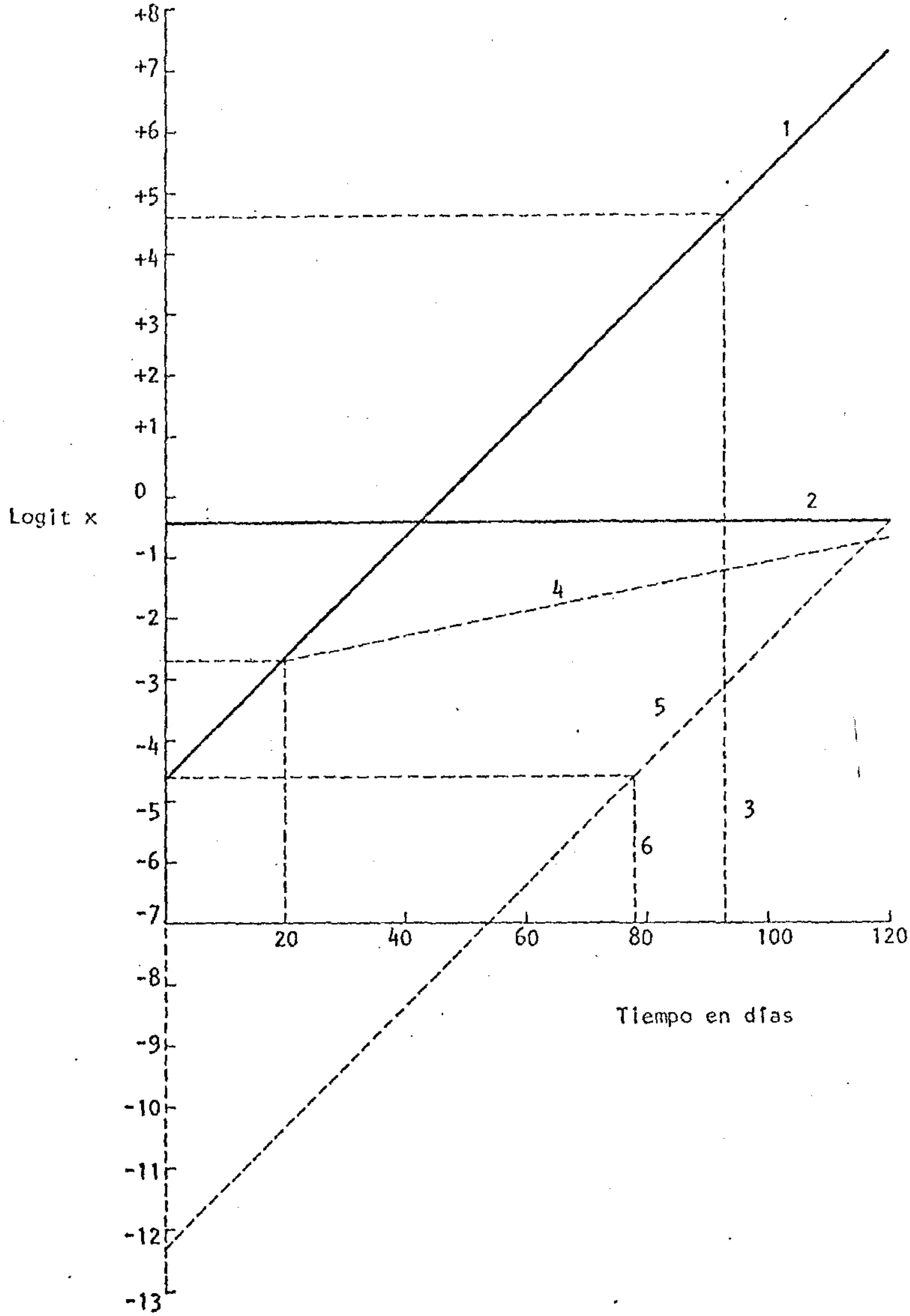
A fungicide is available which reduces the rate of disease development (r) to 0.02 per day for a 10-day period. Assume that the farmers would not act until they saw disease severity (x) at 0.01. Both the action threshold



Gráfica 1. Efectos del Control Químico mediante Aspersión foliar sobre el Desarrollo de la Enfermedad.

(a) and the action time (b) are represented on the graphic. Hence, starting at ta the final disease severity for one application will be 0.012 (Line 5). Extrapolating line 5 we get line 6. Now we can see that they will overcontrol, that is, they are doing a higher number of sprays than the required to get the maximum disease allowable economically. Thus, the farmers are applying an excess of unneccessary sprays and consequently they are losing money. Without further calculations, we can now use those two slops (line 5 and line 6) to make a guess as to how many sprays would be neccessary and when they should be applied in order to achieve just adequate control. This is represented by line 7 and from here we can deduce that it is required 7 applications and they should be applied beginning at 54th day at intervals of 10 days. However, many farmers might not be able to afford this number of sprays. Certainly, their profit would be greater if they could spray less. But, this case is based on the assumption that weather is continually favorable which really is not expected. Hence, the farmers can extent the interval of applications, that is, they can do applications at intervals of 14 days instead of 10 days. So, they are reducing the number of sprays from 7 to 5.

Disease has continuity in space and in time. One aspect of time is the polyetic effect, one year of disease affecting next year crop. Assume the farmers have controlled disease this year to the damage threshold and now they decide to use their own seed next year. The seed they harvested, let us assume, is 100 per cent infested. When planted, all infested seeds will produce infected plants; i.e., each infested seed would produce one lesion on a plant capable of sustaining 100 lesions. Assuming the same rate of disease development ($r = 0.10$), we observe from Graphic 2, that on the second



Gráfica 2. Efectos del Control Químico mediante Aspersión Foliar y Tratamiento de la Semilla sobre el Desarrollo de la Enfermedad.

year the final disease severity at time of harvesting will be 0.9993 (line 1). The damage threshold is the same as above (line 2). The question is: What do the farmers see happening, as, for instance, when disease severity (x) is 0.99?. A disease severity of 0.99 is reached at a very early time of the season (line 3) which implies tremendous potential losses in yield. Suppose the farmers use the fungicide beginning at day 20, could disease be managed within the damage threshold?. The answer is YES, it is possible (line 4). Ten sprays will be necessary to maintain disease severity below damage threshold. Imagine that a seed treatment is available to reduce the initial amount of inoculum (Xo). To what level would the initial amount of inoculum has to be reduced to allow growing of the crop unsprayed?. The calculations shows that Xo should be reduced to 0.0000045 (line 5). However, it is impossible to get a control by seed treatment of this magnitude. Suppose, for instance, we have an excellent fungicide which allows to get 0.999 of control by seed treatment. This means that we will get 0.001 of disease which is much higher than 0.0000045 required to reduce Xc to allow growing "miracle" unsprayed.

From the above theoretical analises it is clear that more than one measure is required to control most diseases. The control measures are often chosen to reduce both the amount of inital inoculum (Xo) and the rate of disease increase (r). An effective disease control implies a combination of cultural practices, regulatory actions, resistance breeding, biological and chemical control. The demand for new innovative fungicides is very strong, but fungicides alone are not the answer to reduce disease losses.

APENDICE 1

LISTA PARCIAL DE ENFERMEDADES DEL ARROZ

NOMBRE COMUN	AGENTE CAUSAL O VECTOR
I. Enfermedades fungosas	
A. Enfermedades del follaje	
Añublo - Bruzone (Blast)	*Pyricularia oryzae* Cav.
Helminthosporiasis (Brown leaf spot)	*Cochliobolus miyabaenus* (Ito et Kuribayashi) Drechsler et Dastur (*Helmintosporium oryzae* Breda de Haan)
Enfermedad del Bakana (Bakanae disease)	*Gibberella fujikuroi* (Saw) Wr. (*Fusarium moniliforme* Sheld)
Mildeo polvoso (Downy mildew)	*Sclerophthora macrospora* (Sacc.) Thirum, Shaw et Naras
Cercosporiasis (Narrow brown leaf Spot)	*Sphaerulina oryzina* Hara (*Cercospora oryzae* Miyake)
Carbón de la hoja (Leaf smut)	*Entyloma oryzae* Sydow
Quemazón (stack burn disease)	*Trichoconis padwickii* Ganguly
Escaldado de la hoja (Rhynchosporium leaf scald)	*Metasphaeria albescens* (Von thuemen) Wei (*Rhynchosporium oryzae*) Hashioka et Yokogi
Mancha del Homodendrum (Homodendrum spot)	*Homodendrum* sp.
Pudrición del cuello (collar rot)	*Ascochyta oryzae* Cattaneo
Branquisporios (Brachysporium blight)	*Brachysporium oryzae* Ito et Ishiyama
Rayado blanco de la hoja (White leaf streak)	*Ramularia oryzae*
Roya (Rust)	*Puccinia graminis* f. sp. *oryzae* Frag and *Uromyces coronatus* Miyabe et Nishid ex Deitel
Falso añublo (False blast)	*Alternaria oryzae* Hara, *Epicoccum neglectum* Desm., *Cladosporium herbarum* (persoon) Link, *Curvularia lunata* (Walker) Boedijn, etc.
Mancha ojival (Eyespot)	*Drechslera gigantea* syn. *Helminthosporium giganteum*
B. Enfermedades del tallo, de la vaina y de la raíz	
Pudrición del tallo (Stem rot)	*Leptosphaeria salvinni* Catt. (*Helminthosporium sigmoideum* Cav.) and *Helminthosporium sigmoideum* Cav. var. *irregulare* Cralley et Tullis

NOMBRE COMUN	AGENTE CAUSAL O VECTOR
Marchitamiento de la vaina (Sheath blight)	*Thanatephorus cucumeris* (Frank) Dork (*Rhizoctonia solania* Kuhn)
Mancha de la vaina (Sheath spot)	*Rhizoctonia* spp.
Marchitamiento de la vaina (Sheath net-blotch)	*Cylindrocladum spp*
Pudrición de la vaina (Sheath rot)	*Acrocylindrium oryzae* Sawada
Pudrición café de la vaina (Brown sheath rot)	*Ophiobolus oryzinus* Sacc. and *O. oryzae* Miyake
Manchas negras (black dots)	*Pyrenochaeta oryzae* Shirii ex Miyake
Hierba de bruja (Witch weed)	*Striga lutes* (Lour) and *S. hermothica*
C. Enfermedades de la plántulas	
Damping-off (Seedling dampling off)	*Fusarium* spp., *Pythium* spp., *Achlya* spp., *Pythiomorpha* sp. etc.
Marchitamiento (Seedling blight)	*Corticium rolfsii* Curzi (*Sclerotium rolfsii* Sacc.)
D.. Enfermedades del grano y la inflorescencia	
Falso carbón (False smut) (green smut)	*Ustilaginoidea virens* (Cke.) Tak.
Carbón del grano (Kernel smut)	*Neovossia horrida* (Tak.) Padwick et. Azmat. Khan
"Ubdatta ("Ubdatta" disease)	*Ephellis oryzae* Syd
Pudrición del grano (Scab)	*Gibberella zeae* (Schw) Petch.
Grano rosado (Pink colorig of rice grain)	*Epicoccum neglectum* Desmagier
Marchitamiento del grano (Kernel blight)	*Phyllosticta* (*Phoma*) *glumarum* (Ellis et Tracy) Miyake
Grano negro (black kernel)	*Curvularia* spp.
Manchado de grano (Grain discoloration)	Varios hongos
II. Enfermedades Bacteriales	
Marchitamiento bacterial de la hoja (Bacterial leaf blight)	*Xanthomonas oryzae* (Uyeda et Ishiyama) Dowson
Rayado bacterial de la hoja (Bacterial leaf streack)	*Xanthomonas translucens* f. sp. *oryza* Pordesimo (*X. oryzicola* Fang et al.)
Pudrición bacterial de la vaina (Bacterial sheath (brown) rot	*Pseudomonas oryzicola* Klement, *Erwinia carotovora* (L.R. Jones) Holland

NOMBRE COMUN	AGENTE CAUSAL O VECTOR
Ojo Negro del grano (Black eyespot of grain)	*Bacterium atroviridigenum* Miyake et Tsunoda
Pudrición negra del grano (Black rot of rice grain)	*Xanthomonas itoama* (Tochinai) Dowson
Mancha canela del grano(Cinnamon speck of rice grain)	*Xanthomonas cinnamona* (Miyake et Tsunoda) Muko
Rayado bacterial de la vaina (Bacterial sheath (brown) stripe)	*Pseudemonas panici* (Elliot) Goto
III. Enfermedades Virosas	
Enanismo (dwarf)	*Nephotettix cincticeps* (Uhler), *N. apicalis* (Motsch) and Recilia (*Inazuma*) *dorsalis* (Motsch)
Rayado (stripe)	*Laodelphax* (*Delphacodes*) *Striatellus* (Fallen), Unkanodes sapporonus, Ribautodelphax albifascia.
Hoja blanca (White-leaf)	*Sogatodes* (*Sogata*) *oryzicola* (Muir), and *S. cubanus* (Craxf.)
Enanismo del rayado negro (Black-streaked dwarf)	*Laodelphax* (*Deiphacodes*) *Striatellus* (Fallen)and *Unkanodes sapporonus* (Mats), *Ribautodelphax albifascia*
Tungro	*Nephotettix impicticeps* Ishihara, N. apicalis, Recilia (Inazuma) dorsalis.
Penjakit merah (Tungro)	*Nephotettix impicticeps* Ishihara
Mentek	*Nephotettix impicticeps* Ishihara
Amarillamiento de la hoja (tungro, leaf yellowing)	*Nephotettix impicticeps* Ishihara
Amarillamiento transitorio (transitory yellowing)	*Nephotettix apicalis* (Motsch.), and *N. cincticeps* (Uhler), *N. impicticeps*
Hoja amarillo-naranjada (tungro, yellow-orange leaf)	*Nephotettix impicticeps* Ishihara, *N. apicalis* Motsch. *Recilia* (*Inazuma*) *dorsalis* (Motsch)
Enanismo de graminea (grassy stunt)	*Nilaparvata lugens* (Stal)
Mosaico amarillo (yellow mottle)	*Sesselia pusilla* Gerstacker y transmisi mecánica
Mosaico (mosaic)	Transmisión mecánica
Mosaico Necroso (Necrosis Mosaic)	Transmisión a través del suelo
IV. Enfermedades causada por organismos similares a Mycoplasmas	
Enanismo amarillo (yellow dwarf)	*Nephotettix impicticeps* Ishihara, *N. cincticeps* (Uhler) and *N. apicalis* (Motsch)

NOMBRE COMUN	AGENTE CAUSAL O VECTOR
V. Enfermedades causadas por Nemátodos	
Nemátodo de la hoja o punta blanca (leaf or white tip)	*Aphelenchoides besseyi* Christie
Nemátodo del tallo (Stem nematode) (Ufra or Dak Pora)	*Ditylenchus angustus* (Butler) Filipjev
Nemátodos de la raíz (Root Knob nematodes)	*Meloidogyne incognita* var. *acrita* Chitwook and *M. graminicola* Golden and Birchfield
Nemátodo enquistado (Cyst nematode)	*Heterodera oryzae* Luc. et Briz
Nemátodo del enanismo (Stunt nematode)	*Tylenchorhynchus martini* Fielding, *T. elegans*, Siddiqi, *T. brevilineatus*
Nemátodo de raíz (Root nematode)	*Hishmanniella oryzae* Luc et Goodey *H. spiniecaudata* (sch. stek) Luc and goodey, *H. thornei* Thornei, *H. imamuri* Sher, *H. caudacrena* Sher, *H. mucronatus* (Das) Luc and Goodey
Nemátodo de la lesión de la raíz (Root lesion nematode)	*Pratulenchus brachyurus*, (Godfrey) Goodey, *P. pratensis*, (de Mar) Filipjev *P. zeae* Graham
Nemátodo espiral (Spiral nematode)	*Helicotylenchus multicinetus*, *H. erythrinae* (Zimmerman) Golden
Nemátodo anillado (Ring nematode)	*Criconemoides Komabensis*, *C. onoensis*, Hollis et al, *C. rusticus*, (Micolcetzky Taylor (Imamura) Taylor
Nemátodo espiral (Spiral nematode)	*Rotylenchus* spp.
Nemátodo migratorio (Migratory nematode)	*Xiphinema orbum*, Siddiqi, *X. parasetari* Luc.
Nemátodo de lanza (Lance nematode)	*Hoplolaimus galeatus*, (Cobb) Sher *H. indicus*
VI. Enfermedades no Parasíticas	
Akiochi (Akiochi)	
Akagare (Akagare)	
Aogare (Aogare)	
Espiga erecta (Straight head)	
Sofocación(Suffocation)	
Sofocación (Suffocation)	

Appendix 2

GENERALIZED CONTROL MEASURES OF MAJOR DISEASES OF RICE

DISEASE	PATHOGEN	GENERALIZED CONTROL MEASURES
Blast, Rottenneck	*Pyricularia oryzae* Cav.	A. VARIETAL RESISTANCE: 1. Tetep 2. Carreon 3. Milagrosa 4. Mamoriaka 5. Periyavellai 6. Chennellu 1388 7. C 46-15 8. Tadukan 9. Colombia 1 10. Dissi Hatif B. CULTURAL PRACTICES: 1. When young plants are attacked, development of the disease can be slowed by flooding or raising flood. 2. Early planting 3. Avoid heavy application of nitrogenous fertilizers. 4. Avoid closed spacing among plants. C. CHEMICAL CONTROL : 1. Kasugamicina 2. EdifenfOS 3. Benomyl 4. Tiofanato metil 5. Triciclazole 6. Blasticidin-S 7. Kitazin 8. Carbendazim
Brown spot	*Cochliobulus miyabeanus* Drechsler et Dastun *Helminthosporium oryzae* Breda de Haan	A. VARIETAL RESISTANCE: 1. Kameji 2. Norin 17 3. Taichung (N) 1 B. CULTURAL PRACTICES: 1. Balanced fertilizing 2. Crop rotation 3. Land leveling 4. Soil preparation 5. Good water management

DISEASE	PATHOGEN	GENERALIZED CONTROL MEASURES
		C. CHEMICAL CONTROL: In areas where seed infection is common, chemical seed treatment is likely to be useful in reducing the damage on seedlings, and many fungicides developed for seed treatment should be effective. Field spraying with fungicides to prevent secondary air-borne infection has also been tried. However, the practical usefulness of such spraying is doubtful.
Narrow brown leaf spot	*Sphaerulina oryzae* Hara *Cercospora oryzae* Miyake	A. VARIETAL RESISTANCE: 1. Bluebonnet 50 2. Fortuna 3. Nira 4. Rexoro 5. Nato 6. Century Patna 231 7. Asahi 8. Kamrose 9. Bonnet 73 10. Brazos 11. Caloro 12. Colusa 13. Mars 14. Melrose 15. Nortai B. CULTURAL PRACTICES: 1. Early maturing cultivars 2. Avoid heavy application of potassium fertilizers C. CHEMICAL CONTROL: 1. Benomyl 2. Tiofanato metil 3. Triadimefon 4. Edifenfos 5. Carbendazim 6. Propineb 7. Mancozeb
Leaf scald	Metasphaeria albescens (Von Themen) Wei *Rhynchosporium oryzae* Hashioka et yokogi	A. VARIETAL RESISTANCE: 1. Asahi 2. Pandhori

DISEASE	PATHOGEN	GENERALIZED CONTROL MEASURES
		B. CULTURAL PRACTICES: 1. Avoid heavy application of nitrogenous fertilizers 2. Avoid to plant on upland fields C. CHEMICAL CONTROL: 1. Fertin hidroxido 2. Captafol 3. Propineb 4. Benomil 5. Edifenfos 6. Triadimefon 7. Carbendazim
Stem rot	<u>Magnoporthe</u> <u>(Leptosheria)</u> <u>Salvini</u> <u>(Catt.)</u> Kranse & Webster <u>Sclerotium</u> <u>oryzae</u> catt. <u>Helminthosporium</u> <u>sigmoideum</u> Cav.	A. VARIETAL RESISTANCE: 1. Raminad Str. 3 2. Bozu 3. Gimbozu 4. Dudshar 5. Colusa 6. Shinriki 7. Asahi Mochi B. CULTURAL PRACTICES: 1. Burning of the rice stubble after harvest 2. Draining of the water and allowing the soil to crack before irrigating 3. Proper use of fertilizers help in reducing the damage. For example, excess of nitrogen tends to increase disease incidence and potassium tends to reduce the damage C. CHEMICAL CONTROL: Generally not recommended

DISEASE	PATHOGEN	GENERALIZED CONTROL MEASURES
Sheath blight	Thanatephorus cucumeris (Frank) Dork Corticium sasakii (Shirai) Rhizoctonia solani Kuhn Pellicullaria sasakii (Shirai) A. Ito.	A. VARIETAL RESISTANCE: 1. Ta-poo-cho-z 2. Kataktara DA-2 3. Colombia 1 4. Carreon 5. Sinaloa A-68 6. Begahia 7. Mehran 69 B. CULTURAL PRACTICES: 1. Proper use of fertili- zers help in reducing the damage. For exampl the disease is more se vere on plants grown i soil with high nitroge and phosphate. Potassi tends to reduce the da ge. 2. Avoid high density of plants per unit of ar 3. Because the fungus ha wide range of hosts (species in 32 familie Is very important to trol grasses. 4. Crop rotation C. CHEMICAL CONTROL: 1. Edifenfos 2. Polyoxin 3. Pentachlorophenol.Thi chemical used for wee control in rice field has also been found u ful in controlling sh blight as a side effe 4. Tiofanato metil 5. Benomyl 6. Kitazin 7. Carbendazim 8. Validamicina 9. Neo-Azozin 10. Phenzaim

DISEASE	PATHOGEN	GENERALIZED CONTROL MEASURES
Seedling blight	_Sclerotium rolfsii_ Sacc.	A. VARIETAL RESISTANCE: 1. Taiching (N) 1 2. Milfer No. 2 B. CULTURAL PRACTICES: 1. Avoid high soil moisture content 2. Avoid high content of soil organic matter 3. Deep ploughing to cover crop debris, which remov from surface soil the sub trate of the fungus, tend to reduce disease incide C. CHEMICAL CONTROL: Seed treatment with chemical should be tried

DISEASE	PATHOGEN	GENERALIZED CONTROL MEASURES
False smut	*Ustilaginoidea virens* (Cke.) Tak.	A. VARIETAL CONTROL: Little information is available on varietal resistance, but certain varieties have been observed to be more frequently attacked than others. B. CULTURAL PRACTICES: Since plants grown under conditions of high fertility favoralbe for the vegetative growth of rice, are more susceptible to the disease, proper manage of soil help in reducing the damage. C. CHEMICAL CONTROL: The disease does not warrant special control measures. With the better understanding of the disease cycle it is possible to combat false smut by spraying or dusting with a fungicide a few days before heading.
Kernel smut	*Tilletia barclayana* (Bref.) Sacc. & Syd.	A. VARIETAL CONTROL: 1. Arkrose 2. Saturn 3. Zenith 4. Elon-elon B. CULTURAL PRACTICES: 1. Avoid heavy application of nitrogenous fertilizers. 2. Planting of early heading varieties C. CHEMICAL CONTROL: The disease is not economically important and special control measures are normally unnecessary. Since the disease is not seed-borne and infection does not take place through germinating seed in a bunt disease of cereals, the seed treatment would have no value.

DISEASE	PATHOGEN	GENERALIZED CONTROL MEASURES
Bacterial leaf blight	*Xanthomonas oryzae* (Uyeda E. Ishiyama) Dowson	A. VARIETAL RESISTANCE: 1. BJ 1 2. DZ 192 3. Hahikalmi 4. TKM 6 5. Sigadis 6. Malagkit Sungsong 7. Zenith 8. Wase aikoko 3 B. CULTURAL PRACTICES: 1. Avoidance of flooding or deep water in the nursery and in the field because the bacteria is carry from field to field by irrigation water. 2. Removal of primary source of inoculum 3. Avoidance of the use of netrogenous fertilizers. C. CHEMICAL CONTROL: 1. Copper compounds 2. Chloramphenicol 3. Cellocidin 4. TF-130 5. Polvoxin 6. Fentiazon No single effective control measure is available for the control of the disease, and integrated measures are therefore, suggested. The practical usefulness of above measures in the tropics is rather doubtful.
White tip nematode	*Aphelenchoides besseyi* Christie	A. VARIETAL RESISTANCE: 1. Bluebonnet 50 2. Asahi 3. Fortuna 4. Nira 5. Rexoro 6. Century Patna 231 7. Bluebelle 8. Bonnet 73 9. Dawn 10. Della

DISEASE	PATHOGEN	GENERALIZED CONTROL MEASURES
		B. CULTURAL PRACTICES: 1. Disease-free seed 2. Early planting 3. Seeding directly into water C. CHEMICAL CONTROL: Since the nematode is seed-borne, seed treatment with hot water and chemicals such as Benomyl, Ethyl thio cyanoacetate (REE, also called Sassen) or Buthyl thio cyanoacetate (REB give significant reduction in the severity of the disease
Straight head	Physiological disease	A. VARIETAL RESISTANCE: 1. Bluebelle 2. Labelle 3. Lebonnet 4. Nortai B. CULTURAL PRACTICES: 1. Avoid to plant in sandy loam soil which are not drained completely 2. Draining just prior to the stem elongation 3. Avoid repeated applications of arsenic-containing insecticides C. CHEMICAL CONTROL: None
Hoja blanca	Vector: Sogatodes oryzicola (Muir) S. Cubanus (Craxf.)	A. VARIETAL RESISTANCE: 1. Colombia 1 2. Napal 3. ICA 10 4. Mudgo B. CULTURAL PRACTICES: Management of vectors 1. Azodrin/Nuvacron

DISEASE	PATHOGEN	GENERALIZED CONTROL MEASURES
		2. Metil paration 3. Dipterex 80 4. Furadan 5. Basudin 6. Dimecron-100 7. Sevin 80 C. CHEMICAL CONTROL OF THE VIRUS: None

NOTA: El principal objetivo de la lista de productos químicos acá citados es el de proporcionar una guía para su identificación apropiada y en ningún momento se deben considerar como una recomendación de ellos por parte del CIAT.

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