propagate any highly promising lines as fast as possible for their prompt use.[1) 2) 3) 5)] The methods of progressive improvement by T.P. Palmer (1953) and cumulative selection by T.R. Richmond (1949) could be effectively carried out by means of the shortening techniques of the breeding cycle.[5)]

However, the utility of the technique ought not to be confined to "acceleration" only. Development of an artificially controlled environmental condition would make it possible for breeders to distinguish precisely the minute differences of lines on various sorts of agronomic quantitative characters and to select superior lines accordingly. Some of the specific environments might reveal characteristics of breeding materials which might have been concealed under an ordinary environmental condition. It would be expected that a fully artificially controlled procedure of crop breeding could be developed in the future. Further innovation of the method of rapid turnover might lead breeders to establish "crop breeding without field."[5)]

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Fungicides for Rice Blast Disease

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Fungicides for Rice Blast Disease

Rice is the principal axis of agriculture in Japan. The greatest precautions have been taken for controlling pests of rice plants. Rice blast disease caused by *Piricuraria oryzae* is the most noxious of all rice-damages, including damages by diseases, insects, typhoon, drought, cold-weather etc. It is said that the damage by rice blast is about one third of all damages to rice plants. Since organo mercuric compounds were induced as a seed treatment for preventing rice blast in 1915, and especially since they were applied to rice plants in fields for controlling this fungi in 1955, rice blast has been controlled mostly by organo mercuric compounds, and it is well known that this practice be contributed greatly to increased production of rice.

In recent years, however, the residual toxicity of organo mercuric compounds to human or animals have come to be a serious problem. The reason for fear of mercuric poisoning was shown by "Minamata Disease" in Kumamoto Prefecture and a disease on the Agano River in Niigata Prefecture. However, these mercuric diseases were cleared from the charge of having been caused by agricultural mercuric chemicals. On the other hand, it was found that mercury has been accumulated in the Japanese body because of rice from plants treated with organo mercuric chemicals. Thus, the development of non-mercuric chemicals for controlling blast disease has come to be an essential emergency. As the result of earnest research, many excellent blast controllers of non-mercuric compounds have been developed in the past few years, and are appearing at present.

Although organo mercuric chemicals are still being used in large part for agricultural purpose at present, this chemical will by law be prohibited for use in agriculture by 1968. Therefore, in this paper, only non-mercuric chemicals that may be of practical age for controlling blast disease will be discussed.

Non-mercuric chemicals for controlling rice blast, both already registered and on application for registration, can be separated into 3 types as follows: (1) antibiotics, (2) organo chlorine compounds and (3) organo phosphorous compounds.

Their application concentration on rice for blast control are shown in Table 1. The concentration of antibiotics is about 20 ppm, approximately same as organo mercuric chemicals. Other chemicals are 300~500 ppm. The toxicity to mammals and fish are generally low as shown in Table 2.

1. Antibiotics

(1) Blasticidin S

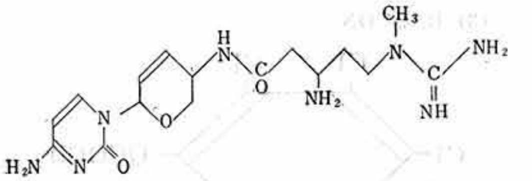
Blasticidin S was discovered in 1959 as an antibiotic produced by Streptomyces griseochromogenes which was isolated from soil at Saigasaki in Wakayama Prefecture. This is the first agricultural antibiotic developed in Japan. This antibiotic gives an excellent control of rice blast disease by spraying a solution of a low concentration (10 to 20 ppm). The mode of action of blasticidin S on rice blast, *Piricularia oryzae,* was found to be the inhibition of protein synthesis in this fungi, causing death.

Table 1. Non-mercuric fungicide for rice blast and their application concentration.

Chemicals	Dust	Solution
Antibiotics		
Blasticidin S	0.2%	10–20 ppm
Kasugamycin	0.2	20–40
Organo-chlorine compounds		
PCP-Ba	2.5	—
Blastin	4	300–500
Rabcon	3	300–500
Oryzon	3	300–500
Organophosphorous Compounds		
Kitazin	1.5	400–600

Table 2. Toxicity to mammals and fish of non-mercuric controlers for blast disease

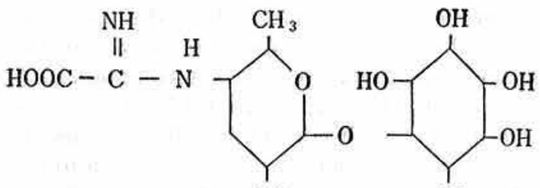
	Oral toxicity (LD_{50} in mouse)	Toxicity to fish (TLM)	
Blasticidin S	39.0 mg/kg	carp	8.7 ppm
Kasugamycin	>2,000	gold fish	>1,000
PCP-Ba	847	gold fish	30
Blastin	>3,600	carp	>10
Rabcon	5,000	carp	8.6
Oryzon	3,000	carp	48
Kitazin	3,000	carp	5



As the inhibitory action of blasticidin S on the mycelial growth of rice blast is 10 to 100 times more powerful than the action of organo-mercuric fungicides, it gives excellent control, especially against neck blast disease. Too high a concentration or too much treatment, however, causes necrotic spots on leaves. And also it occasionally causes necrosis on tomatoes, tobacco, egg-plant mulberries and beans. Therefore, care should be taken in treatment to avoid contact of this chemical with these low resistance crops. Further, the application by dusting occasionally causes conjuctivitis if it accidentally contacts the duster's eyes, so goggles and a respirator are necessary for protection. But, no accident has been reported in cases where application was as a spray of wettable powder solution or emulsion. Recently, as improved dusts which do not cause eye trouble developed, it is becoming practical to apply by plane.

Blasticidin S has been produced on a large scale by Kaken Chemical Co. and sold by Nihon Nohyaku Co. and Toa Noyaku Co. and it will be sold by Yashima Chemical Co., Ihara Agricultural Chemicals Co. and Takeda Chemical Industries.

(2) Kasugamycin

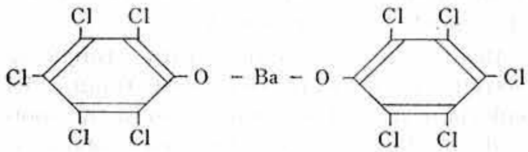


Kasugamycin, a water soluble and basic antibiotic, was isolated from the culture broth of *Streptomyces kasugaensis* which was isolated from the soil in the ground of Kasuga Shrine in Nara City. It gives excellent control against rice blast disease at a low concentration, such as about 20 ppm. It can be safely used because it has no toxicity to rice and other crops, and little toxicity to man, livestock and fish. It was reported that rice blast in field bed seedlings was prevented for about 30 days by coating seed with 2% wettable powder of Kasumin (a commercial name of kasugamycin). However, a weekness may be that blast fungi easily acquires resistance to kasugamycin. It was reported that resistant fungi were easily obtained on a culture medium containing 100 ppm of kasugamycin.

The chemical has been produced by Kaken Chemical Co., Banyu Seiyaku Co., Sanraku Shuzo Co. and Nippon Kayaku Co., and formulated and sold by Hokko Chemical Industry Co. since 1965.

2. Organo-chlorine Compounds

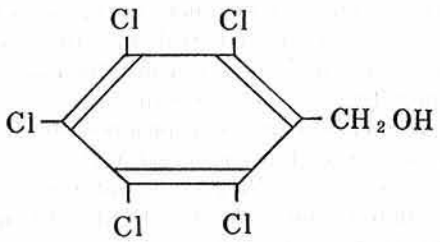
(1) PCP-Ba



PCP-Ba, balium di-pentachlorphenolate, developed by Tohoku Kyodo Chemical Co. and Mitsui Chemical Industries, was the first practical organo-chlorine fungiside for rice blast, and it has been on the market for the last few years. Originally, PCP (pentachlorphenol) itself had a fungicidal action, and it has been used as a wood preservative in long time. Also, PCP sodium salt with lime sulfer added has been used to protect fruit trees from disease in dormancy. Balium salt of PCP results in more fungicidal action and less phytotoxicity than the sodium salt, by decreasing the sublimility and the solubility. But, the balium salt still remained a fault of phytotoxicity under certain conditions. This chemical has an advantage of having the lowest marketing cost of non-mercuric fungisides used at present.

A dust containing 2.5% of PCP-Ba salt and a mixture dust with an organo-mercuric agent have been sold. The effect is mainly preventive. Mitsui Chemical Industries has produced the raw chemical, Tohoku Kyodo Chemical Co. has formulated, and Nissan Chemical Industries, Chugai Pharmaceutical Co. and Tohoku Kyodo Chemical Co. have sold.

(2) Blastin (PCBA)



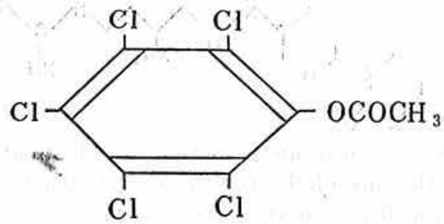
Blastin, pentachlorbenzylalcohol, was developed as a fungicide in 1964 by a cooperative project of Sankyo Co. and Dainihon Ink Co. It has been said that Blastin was developed during a trial to find PCP-derivatives with less fish-toxicity.

Blastin itself exhibits little fungicidal activity *in vitro* to rice blast fungi, Piricularia oryzae. The germination of the spore and the formation of the appressorium of this fungus can be seen even on the leaves treated with Blastin. But in field trials, Blastin has a peculiar activity to prevent the invasion and the penetration of hypha into the epidermis of the leaves treated previously with Blastin. Blastin also maintains this preventive activity even on new leaves which come out after treatment. Studies of this unique fungicidal action are in progress.

The application at a 500 ppm concentration shows an excellent and long lasting protecting effect in fields. The long-lasting effect gives a good result especially for the protection of neck blast. Blastin can be used safely because of the extremely low toxicity to man, livestock and fish and has little toxicity to crops.

The raw chemical is produced by Dainihon Ink Co. and the formulation of dust and wettable powder is produced and sold by Sankyo Co.

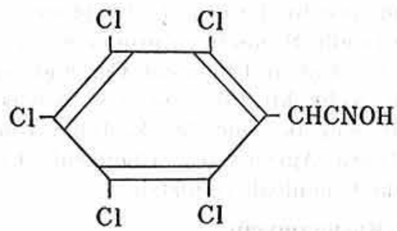
(3) RABCON



This chemical, pentachlorphenyl acetate, was found to be effective for controling rice blast disease by Kureha Chemical Industries. The application at 500 ppm concentration on leaves shows excellent effect. Rabcon is low-toxic to mammals and fish, but it is liable to cause necrosis on plants. If the fault can be removed, this compound shows promise because of the low cost, similar to PCP-Ba.

Rabcon is now on application for registration. The raw chemical will be produced by Kureha Chemical Industries, and the formulation will be sold by Toa Noyaku Chemical Co., Nihon Nohyaku Co., Yashima Chemical Co., Mikasa Chemical Co. and Takeda Chemical Industries.

(4) Oryzon

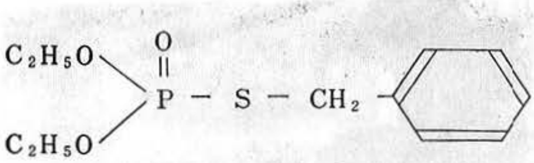


Since Blastin was found as an excellent protecter against rice blast disease, each agricultural chemical company started studies on the series of this compound. As the result, Oryzon was found by Nihon Nohyaku Co. It exhibits the excellent protecting effect to rice blast with an application at 500 ppm concentration. Oryzon, as Blastin, is low-toxic to mammals and fish, and causes no injury on crops. It is now on application for resistration.

3. Organo-phosphorous compounds

(1) Kitazin

Kitazin, 0, 0-diethyl-S-benzylthiophosphate,



was developed as a fungicide by Ihara Agricultural Chemicals Co. It is an interest discovery because many compounds of this type are well known as insecticides.

Kitazin shows excellent curative effects on the rice plant which has suffered from blast disease. A spray at 500 ppm concentration shows the same effect as organomercuric fungicide. Kitazin has a low toxicity to humans and animals and also to fish and shellfish. The phytotoxicity on rice plant is also low, but rarely a problem appears under some conditions, causing brown spots. Kitazin has a certain insecticidal activity, it is supposed from the chemical structure.

The raw chemical is produced by Ihara Chemical Co. and the dust and the emulsion are sold by Ihara Agricultural Chemicals Co., Toa Noyaku Co., Yashima Chemical Co. and Mikasa Chemical Co.

The non-mercuric chemicals described above generally exhibit the same or more effectiveness for rice blast control than mercuric chemicals. Although they are effective enough when they are looked at only for their effectiveness, many problems are still left. For example, blasticidin S causes eye trouble, kasugamycin is liable to cause formation of resistant fungi, PCP-Ba and Rabcon occasionally cause necrosis on leaves, and so on. Because each of the non-mercuric blast controllers used at present has merits and demerits, application of proper mixtures may be preferable for becoming the problems rather than using only one chemical to substitute for mercuric chemicals. The cost of non-mercuric chemicals being used at present is still 20~30% higher than mercuric chemicals. But, the cost will be reduced by large scale production in the future.

On Breeding Tomatoes for Disease Resistance

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In Japan since 1951, the study on breeding tomatoes for disease resistance has been carried out mainly at Okitsu Branch, Horticultural Research Station, Ministry of Agriculture and Forestry. The steps in progress of the actual breeding work are differentiated by the sorts of diseases. However, the screening methods, which are fundamental to the breeding of varieties with resistance to diseases, has arrived at a certain conclusion, satisfactory, to some extent, to the practice of breeding, and after several revisions, it has brought about some breeding-systems, both reasonable and practical, through experiments, owing to which several strains resistant to Fusarium wilt or leaf-mold have been found; besides, several new strains with their two complex resistances are expected to be produced in the near future.

An outline of the research conducted up to the present is as follows:

A. Screening method for resistance

1) For the screening method for Fusarium wilt resistance in tomatoes, the seedling-test method standardized by F. L. Wellman in 1939, has been adopted after some experimental modification suitable to the conditions for investigations in Japan. In this method, young plants are to be set on incubation-beds under glass after inoculation by dipping