Control of Rice Diseases by Fungicides Applied to Submerged Water in Japan

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Forword

Submerged application of chemicals for control of pests has some merits. They are: (1) systemic distribution of chemicals in the plants, (2) prevention of drift which contaminates environment, (3) fewer chemical applications than ordinary spraying and (4) disuse of spraying machines.

Submerged application of insecticides has been already put into practice after 1963 but in fungicides Kitazin (organophosphorous compound) and Kasugamycin (antibiotic) were discovered about 1965 to have high systemic action to prevent infection of rice blast fungus by submerged application[3),10)]. This systemic action of two fungicides in rice plants through the roots may be the first discovery in the world.

Nationwide examinations of submerged application of Kitazin P were carried out in 1966–1968, and these results showed excellent control effect on rice blast.

Kitazin P 17% granule was registered as a fungicide for submerged application for the first time. Thiadiazole compounds and antibiotic were confirmed after that to have practicable effect on bacterial leaf blight, Xanthomonas oryzae, by submerged application.

Submerged application for control of blast

The necessary dosage of Kasugamycin in the soil that gives the effect equivalent to that of spraying was found to be 20 holds as much as spraying. This dosage was too expensive to use practically at present so further investigation about submerged application of Kasugamycin was not carried out.

1) Kitazin P granule 17% (0,0-diisopropyl S-benzylthiophosphate, IBP)

Kitazin was the first organophosphorous fungicide developed by Ihara Chemical Company to control rice blast, and thereafter Kitazin P was developed as the fungicide having more effectiveness and less toxicity. IBP is effective on control of rice blast at 400 to 500 ppm by spraying.

This fungicide has inhibitory action on germination of spores, formation of appressoria, penetration into the epidermal cells, mycelial growth in the invaded tissues, and sporulation on the lesions. The oral LD_{50} dosage to the mouse 662 mg/kg, and TLM of 48 hours to carp is above 10 ppm[4)].

(1) Concentration of IBP in rice plants by submerged application

Umehara and Inoue[6)] applied ^{32}P-labelled IBP into the soil in which the rice plants were grown for tracing the absorbed chemical. Radiation of ^{32}P from the foliage was counted at different times after application by survey meter. (Fig. 1)

One-tenth of the total quantity of IBP in the rice plants translocated to the foliage 24 hours after application, then concentration of IBM accumulated in the foliage becomes

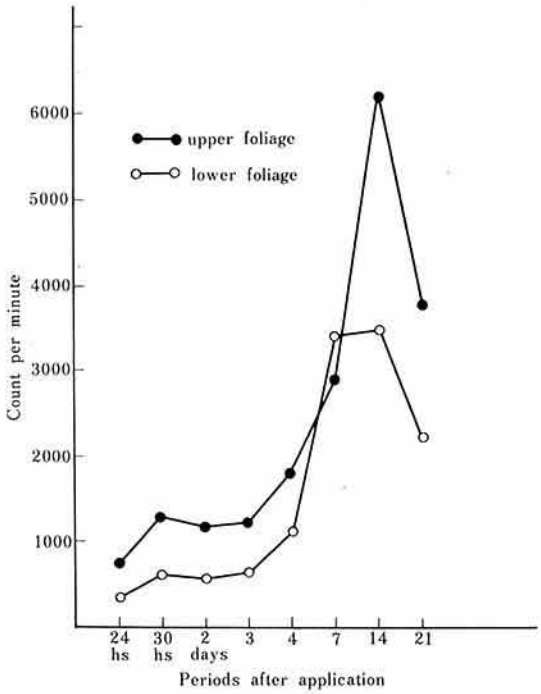

Fig. 1. Radiation counts of ^{32}P-labelled IBP from the foliage at different times after submerged application
(UMEHARA and INOUE 1970)

higher, and reaches maximum 1–2 weeks after application.

IBP accumulation is more in the leaves of lower parts than in upper ones, and more in the sheaths than in the blades. IBP translocates to the panicles through the nodes after heading stage and its concentration in the panicles is lower than in the nodes. IBP concentration in the nodes becomes highest among all parts of the rice plants after heading.

(2) Application method of granular IBP

The field tests concerning control methods of rice blast using granular IBP were carried out jointly at several prefectural agricultural experiment stations in 1968–69[1]. The most effective time of application for control of leaf blast is about 7 days before or immediately after the leaf blast but when it is applied more than 10 days before or after appearance of lesions, its effect reduces.

When granular IBP is applied too early before lesion appearance, its residual action becomes weak, and when it is applied too late after lesion appearance, its concentration in the leaves does not become high enough to prevent blast fungus development for delayed absorption.

The effective time for control of panicle blast is 7–14 days before heading period but its application after heading period shows no effect. (Fig. 2)

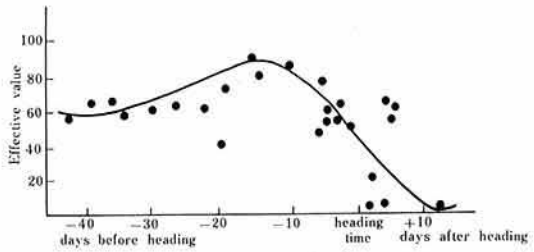

Fig. 2. Relation between effective values on neck rot and the time of application before or after heading
(Prefectural joint work in 1968)

In the case of application before the heading period, the chemical translocated to the panicle is protective to the blast fungus, and the chemical accumulated in the foliage inhibits formation of new blast lesins, and sporulation on lesions being the infection sources to the panicle blast.

When granular IBP was applied more than 14 days before the heading period, its concentration in the panicles reduces at the milky ripening stage so that panicle branch blast infecting at late periods after heading cannot be prevented. Submerged application of 500 g–1000 g IBP ingredient at effective times showed equal effect on rice blast with effect of ordinary 2-3 times spraying.

(3) Effect on growth and component of rice plants

The culm length of the rice plants becomes short about 10 cm as compared with the check by submerged application of IBP from tillering to young panicle formation stage, and the lodging resistance of the rice plants becomes higher as the result of culm shortening.

The number and the length of panicles are not influenced but the number of grains per

panicle increases by IBP application. The rice plants applied with IBP retain their green color in the leaves at the ripening stage and take upright form which may accept more sunlight.

The total nitrogenous content does not change but silica content, and silicated cells in flag leaf increase by IBP application. The yield of rice increased about 5% even in slightly infested fields and 30–50% in severely infested ones by blast disease compared with no applied field.

Oryzaemate granule 8% (allyloxibenzisothiazol dioxide)

Oryzaemate is a derivative from sacchrine, and it has almost no mammalian toxicity. This fungicide inhibits fungus penetration into epidermal cells and spore formation on the blast lesion, but it has a weak inhibitory action to spore germination, appressorium formation, and mycelial growth of Pyricularia oryzae[8].

1) Concentration of Oryzaemate in rice plants by submerged application

Study on the mode of absorption of Oryzaemate into rice plants was carried out using ^{3}H and ^{35}S isotope tracers[1]. The greater part of Oryzaemate is absorbed from the root and the small part from the sheath after application to irrigation water. The accumulation of it in the rice plants is largest in the foliage and smaller in the sheaths, panicles and nodes successively. The concentration in the panicles is very low and only one-fortieth of that in the foliage.

The total accumulation in the rice plants increases until 21 days after application and afterwards decreases gradually though the concentration remains moderately high until 42 days after application. Oryzaemate was highly effective on leaf blast in field tests but not so effective on panicle blast. The cause of this result may lie in the different accumulation of Oryzaemate in the leaves and panicles.

2) Application method of granular Oryzaemate

The effect of granular Oryzaemate on blast by submerged application at the dosage of 30–50 kg/ha is equal to ordinary dusting of reference fungicides. The most effective time of application on leaf blast is considered to be about 2 weeks before first disease occurrence, and its time on panicle blast will be about 2–3 weeks before heading. Oryzaemate granule is applied earlier than Kitazin P granule because Oryzaemate is absorbed by rice plants more slowly than IBP.

The effect of Oryzaemate granule on leaf blast may be superior to IBP granule because of the higher Oryzaemate accumulation in the leaves. However its effect on panicle and node blast may be inferior to IBP granule due to lower Oryzaemate accumulation in the panicles and nodes. The growth and yield of rice plants are not influenced by submerged Oryzaemate application.

Fujione granule 12% (diisopropyl 1.3-dithiolane-2-ylidenemalonate)

1) Concentration of Fujione in rice plants by submerged application

The mode of absorption of Fujione into rice plants was traced using ^{14}C. The greater part of Fujione is absorbed from the root after application to soil and gradually decomposed into three groups of substances.

The effective substance is the same with Fujione, containing in benzen layer by extraction from the rice plants, and substances contained in the water and the residual layers are almost not effective on blast.

The total accumulation of Fujione in the rice plants reaches maximum 28 days after application. The accumulation of it is largest in the leaves one-half in the sheaths, one-fourth in the panicles and one-eighth in the nodes compared with that in the leaves.

Fujione absorbed into rice plants decomposes, and the total effective part becomes 60% after 3 days, and 2–20% after 50 days

from application. The speed of this decomposition is slow in the nodes and the panicle branches but rapid in the husks, and medium in the leaves. Fujione decomposes also in the paddy soil or irrigation water, therefore, it will be free from care about accumulation of the chemical in the soil.

2) Application method of granular Fujione

The effect of granular Fujione on blast by submerged application at the dosage of 30–40 kg/ha is superior to IBP or Oryzaemate. The most effective time of application on leaf blast is considered to be about 2 weeks before first disease appearance, and its time on panicle blast will be about 2–3 weeks before heading. Many field tests about this granule have been conducted in recent 2–3 years and superior control effect has been confirmed out it is not yet registered due to unfinished chronic toxicity tests.

Submerged application for control of bacterial leaf blight

Organonickel compounds, Phenazine and Fenthiazon have been applied as a spray fungicide to control bacterial leaf blight. The effective value of these fungicides are usually below 60, and they cannot protect development of bacterial leaf blight under severe outbreak.

The pathogenic bacteria enter from water pores or wounded epidermis of leaves, and grow only in vessels. It is difficult therefore to control this disease adequately when the applied chemical cannot permeate into the vessels. Submerged application is an effective method because the chemical translocates through the vessels and distributes systemically.

Thiadiazole compounds and antibiotic Ohyamycin have meritarious effects on bacterial leaf blight by submerged application. These chemicals are supposed to have a long residual effective power as the disease severity in the plots applied 23 days before inoculation is mild compared with no application[2),9)].

They have been expected to be practicable not only in Japan but also in Southeast Asia. There were, however, some doubts concerning the carcinogenicity of the residue of thiadiazole compounds and practical use ceased. Ohyamycin is also difficult to use practically because its chronic toxicity may be over the permissible level.

There are now no candidate preparations to control bacterial leaf blight by submerged application. Intensive investigations are being conducted in the hope of developing new fungicides which have high control effect and no mammalian toxicity.

Discussion

Submarged application has some merits mentioned in the foreword, but it has also some demerits. They are: (1) It needs 3–5 times dosages of ingredient compared with ordinary spraying for getting same control effect; therefore, phytotoxicity, toxicity to fish and accumulation in the soil must be taken care.

(2) The applied chemical is soluble in irrigation water and is kept in the soil. After that rice plants absorb the chemicals. Therefore, control effect fluctuates sometimes according to irrigation practices and soil types. It is desirable to develop excellent chemicals having stable effect under unsuitable condition.

(3) The effective time of submerged application is about 1–3 weeks before the outbreak of the diseases. Whether application of chemicals is useful or not must be determined before the disease outbreak so chemicals may be applied wastefully when the diseases break out slightly. Submerged application must be carried out basing on information of forecasting of disease outbreak.

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