PLANT PROTECTION TECHNOLOGY FOR SUSTAINABLE AGRICULTURE IN JAPAN

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ABSTRACT

This paper discusses non-chemical methods of controlling pests and diseases in Japan. Plant seedlings are protected from virus by attenuated virus strains. Plastic rain shelter reduce the incidence of fungal and bacterial diseases. Solar sterilization raises the soil temperature in unused vinyl houses, killing pathogenic organisms. Protection of rice crops against rice blast is aided by computer simulation models which record favorable conditions and predict outbreaks.

CROP LOSSES FROM DISEASES AND INSECT PESTS

Every year, world agricultural production is reduced by diseases, insect pests, and weeds. According to Walker (1975), crop losses in 1967 due to diseases, insect pests and weeds amounted to about 207 million mt of rice, 312 million mt of wheat, maize and other cereals, 129 million mt of potatoes, and 80 million mt of vegetables. Therefore it was estimated that potential world crop production would be as high as 2,192 million mt if diseases, insect pests and weeds did not occur or could be completely controlled. This simple calculation exemplifies the great importance of the control of diseases and insect pests in securing world crop yields and providing food for the world.

METHODS OF CONTROLLING DISEASES AND INSECT PESTS

There are three major methods.

Breeding and Cultivation of Resistant Varieties

This method is economically the most efficient. However, resistant varieties soon become susceptible with the appearance of new strains and races of pathogenic microorganisms or new biotypes of insects.

Biological Control

This method is ecologically based, and aims at reducing crop damage by attempting to reduce the density of pathogens and insects.

Application of Pesticides

Currently, the effective use of pesticides plays an important role in reducing crop damage. Some experimental results indicate excellent efficacies. These experiments were carried out at 69 Prefectural Agricultural Experiment Stations in 22 Prefectures in Japan for two years, from 1991 to 1992. The average reduction in yield of crops when no pesticides were applied ranged from 27.7 to 97.0%.

In 1990, Knutson of Texas University and his colleagues assessed the economic impact of reducing chemical use in the United States. The yields of crops grown without pesticides was reduced by 32% in the case of corn, 37% for soybean, 24% for wheat, 39% for cotton, 57% for rice, and 78% for peanut without pesticides.

Keywords: attenuated virus, biological pest control, fusarium wilt, Japan, solar of vinyl houses sterilization

SYSTEMS FOR SAFE USE OF PESTICIDES IN JAPAN

In Japan, more than 400 active pesticide ingredients are used, and the total number of registered formulated products is about 6,000. The amount of pesticides sold on the domestic market is around 70,000 mt (on an active ingredient basis) every year. It is the responsibility of the Japanese government to ensure the safe use of pesticides in order to protect farmers' health, assure the safety of agricultural products, and preserve the environment. There are two main approaches to these targets. One is legislation, under the Agricultural Chemicals Regulation Law, and the other is education and guidance for farmers and dealers to encourage safe and proper handling and use.

In Japan, consumers demand safe food, and coexistence of human beings and the natural environment. We can expect this situation to continue in future. Therefore, the development of new plant protection technology which does not depend on chemical pesticides is essential for sustainable agriculture.

I should like to introduce the non-chemical techniques to control plant disease developed in Japan. Some of these are already in practical use in the field, while others are still at the development stage in research laboratories.

NON-CHEMICAL CONTROL OF CROP DISEASES

Control of Plant Virus Diseases by Attenuated Virus

Plant seedlings artificially inoculated with attenuated virus strains are subsequently protected from naturally-occurring virulent viruses. As protective viruses, either naturally occurring mild strains or an attenuated strain (an artificially-induced mild mutant) have been used. In Japan, much work has been done in order to select or to produce safe and efficient attenuated viruses since L11a, an attenuated TMV virus, was first produced. Several attenuated viruses are currently used on a large scale every year. A well-characterized attenuated virus does not have any harmful effect on the ecosystem or cause environmental pollution. It is believed to be a safe and effective tool for environmentally sustainable agriculture.

The first Japanese attenuated virus was L11, isolated from a virulent L strain of TMV after heat treatment of infected tomato stems. L11 protected tomato plants from the infection with the virulent L strain, but caused mosaic symptoms in the later growth stages in tomato plants in the field. The symptomless mutant L11a was then selected from L11, by repeated local lesion isolation and selection of milder isolates. Since 1972, L11a has been widely used for tomato production in both the open field and in greenhouses all over Japan, particularly in Shizuoka prefecture. In 1991, L11a was applied to 116 ha of tomato plants in 13 prefectures.

Crop Cultivation under Plastic Rain Shelters

The natural occurrence of many fungal and bacterial diseases is affected by high humidity and rain. For this reason, cultivation of vegetables, flowers and fruit trees under plastic rain shelters is now in use during summer and autumn throughout Japan. A steel framework of a suitable height is constructed over the cultivated plants, covered with plastic film to protect crops from the rain. In 1991, the area of cultivation under plastic rain shelters was 6,570 ha of vegetables (spinach, tomato, strawberry, melon, cucumber, pepper, watermelon, Welsh onion), 840 ha of flowers (chrysanthemum and carnation), and 4,020 ha of grapes, cherries and Navel orange.

Solar Sterilization of Greenhouse Soil to Control Soil-borne Diseases

Sterilization of soil by solar heating in a closed vinyl house is widely used during summer in the south-western part of Japan. This technique is used to reduce the incidence of soil-borne plant pathogens. In Japan, many vegetables are cultivated in vinyl houses from September until June the following year. At the end of July, after the crop is harvested, chopped rice straw (10-20 mt/ha) and other rough organic materials are ploughed into the soil, together with calcium cyanamide. The soil is then piled into ridges about 20-30 cm high. The soil surface is mulched with transparent polyethylene or vinyl film, and a sufficient volume of irrigation water is used to maintain a high soil moisture content. The vinyl house is kept closed without any planting until the end of August or early September, thereby raising the soil temperature to a level sufficient to kill pathogenic organisms.

Biological Control of Fusarium Wilt of Sweet Potato

Fusarium wilt of sweet potato can be controlled by prior inoculation with nonpathogenic *Fusarium oxysporum*. Many *F. oxysporum* isolates have been obtained from healthy sweet potato plants, most of which were not pathogenic. Some of these nonpathogenic isolates gave cross-protection against Fusarium wilt of sweet potato when sweet potato plants were inoculated with them before planting.

In naturally infested commercial fields, cross-protection by prior inoculation with nonpathogenic isolates of *F. oxysporum* always brings about a marked decrease in wilt incidence and a marked increase in the yield of sweet potato. The effect was equivalent to those obtained from a chemical treatment, in which cut ends of the sprouts were dipped into a benomyl suspension for 30 min. In inoculation with *F. oxysporum*, cut ends of sprouts are smeared with a condensed bud cell suspension of the fungus, or dipped in a diluted bud cell suspension. Higher yields and lower wilt incidence were evident when sprouts were planted as soon as possible after inoculation.

Forecasting Rice Blast Epidemics by Computer

Rice blast is one of the most destructive diseases in rice production. Therefore, it is important to control blast disease efficiently. Progression of the disease varies in different locations and years, depending mainly on weather conditions. Forecasting of disease epidemics is necessary if growers are to prevent severe yield losses caused by the disease. Growers many want to know when the disease will start, how severe the epidemic will be, whether fungicides should be applied, and if so, when.

BLASTAM is a system of predicting favorable conditions for infection, using only weather data from AMeDAS. AMeDAS is a Automated Meteorological Data Acquisition System which was completed by the Meteorological Agency of Japan. The system automatically acquires each factor related to precipitation, temperature, duration of sunshine, wind force and wind direction every hour at 840 points all over Japan. BLASTAM predicts favorable conditions for rice blast and likely outbreaks. Leaf blast starts one week after favorable conditions appear. Two weeks after favorable conditions, the severity of leaf blast is likely to increase rapidly. BLASTAM has been recently used in several prefectures in Japan, and its efficacy has been recognized.

Another system is BLASTL, a simulation model of leaf blast epidemics. The factors used include temperature, precipitation, duration of sunshine and wind force derived from AMeDAS every hour, and duration of the wet period estimated by the dew balance. The model calculates the development of leaf blast, the susceptibility of the host, the probability of spore penetration, etc. BLASTL has been used in several prefectures in Japan.

REFERENCES

Knutson. R.D., C.R. Taylor, J.B. Penson and E.G. Smith. 1990. *Economic impacts of reduced chemical use*. 72p, Knutson & Associates, College Station, Texas, U.S.A.

Walker, P.T. 1975. Pest control problems (pre-harvest) causing major losses in world food supplies. *FAO Plant Protection Bulletin*. 23(3/4): 70-77.

DISCUSSION

Dr. Hamblin was interested in inoculation with mild strains, and asked how long the inoculation persists, whether it needs to be repeated for each crop, and whether there is any system which can be applied direct to the soil. Dr. Inaba replied that the inoculum is not generally applied to the field, but is used to treat plants or seeds. In the case of *Fusarium oxysporum*, for example, the young sweet potato sprouts used as planting material are dipped in the inoculum.

Dr. Saleem Ahmed commented that during a survey of Japan's organic farms in 1993, he had found many farmers who used no chemicals, relying instead on biodiversity, and achieving excellent yields. These organic farmers had complained that the scientific community does not spend much time in studying their practices. Dr. Inaba replied that organic farming methods are now expanding in Japan, in spite of the limitations imposed by the climate. Many prefectural experiment stations are carrying out research on sustainable agriculture, and the Japanese government is planning a large national project on the same topic.