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Rice Insect Control by Granular Insecticide

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When granular insecticide is applied over the rice plant, little is deposited on the plant surface and most reaches the surface of the paddy soil after falling into the irrigation water. Therefore, granular application to rice field means the application of insecticide into irrigation water or paddy soil.

In recent years, the possibility of applying insecticide into soil or irrigation water of rice fields instead of spraying or dusting it over the rice plant, has been studied. Some of these studies have revealed information now being used in the field.

It was firstly shown by Koshihara and Okamoto (1957), that the treatment of paddy soil with γ-BHC at the time of puddling before the trans-plantation of rice seedling was effective for control of the rice stem borer, *Chilo suppressalis* Walker, one of the most important pests of rice, in the first generation. They observed that BHC 3 percent dust or lindane 3 percent dust applied in paddy soil at the rate of 90 to 180 kilograms per hectare was strong enough to control the insect damage to the rice crop in the first generation.

On the other hand, Okazaki, Kikuchi and Funabasama (1957) applied BHC emulsions carefully to the surface of the irrigation water in paddy field avoiding direct splashing off rice plants with insecticides, and concluded that number of the stems damaged by the rice stem borer in the first generation decreased significantly in the treated plots.

Concerning these effects in such treatments, special attention has been paid so far in Japan to the behavior of this insecticide in and on the rice plant. Okamoto and Koshihara (1959) inferred that the effect of γ-BHC treated in paddy soil had resulted from the absorption and translocation of the toxicant through the root. Horiguchi (1960, 1964) observed similar effects of γ-BHC, but he attributed the effect mainly to the insecticide in the paddy water, which had crept up along the leaf sheath by capillary action and was concentrated due to the evaporation of water. Ishii, Enjoji and Sekiguchi (1959) studied systemic action of γ-BHC in plants using radioactive γ-BHC as the emulsion, and concluded that γ-BHC was not easily translocated into other parts of the rice plant. But they also pointed out that the systemic action of this compound in the rice plant might be proved if a radioactive compound with a stronger specific activity were used.

Besides these studies, a number of workers attentively observed the effects of such treatments. Nevertheless, it was not clear whether the γ-BHC was absorbed from the root and translocated into the stem and the leaf sheath or reached the borer zone of the stem by capillary action.

In order to make clear this point, Ishii and Hirano (1962) carried out a study on the translocation of γ-BHC in the rice plant. In this experiment an aqueous solution of radioactive γ-BHC was used. As a result, they pointed out that γ-BHC dissolved in water was absorbed by the root and then translocated to the stem and leaf of the rice plant, but it also crept up along the leaf sheath by capillary action.

The following routes taken by the insecticide, when applied in paddy soil or irrigation water, may result in appearance of the insecticide in the aerial part of the plant:

After dissolving in paddy water, (a) the insecticide evaporates from the water surface then it is adsorped by the plant surface ; (b) it is absorbed into tissues through root or the lower part of leaf sheath and translocates upwards to the aerial parts ; and (c) it creeps up along the leaf sheath by capillary action.

Possibilities of these routes are all affirmed, but undoubtedly the route (a) is extremely small as compared with (b) or (c).

It is very difficult to examine the effects of results from each of the routes distinguishing one another. Therefore, it may be also difficult to conclude which is the major route causing death of the borers living in the rice stem. In the control effect against the rice stem borer, it seems that the route via roots is most important when the insecticide is applied into soil and the route via leaf sheath surfaces becomes important when application is in irrigation water.

Quantitative studies were carried out by Tsukano and Suzuki (1962), and Masuda and Fukuda (1962). The former workers determined chemically the amount of γ-BHC in the rice plant grown in a nutrient solution containing the insecticide. In this experiment, precaution was taken to keep the sheath above the water surface, so that only the root was immersed in the solution. They concluded that the rice plant can absorb γ-BHC through the root system and translocate it to the other parts of the plant. The latter workers attempted to determine the amount of γ-BHC translocated from treated soil to the rice plant by means of bioassay using the azuki bean weevil. A considerable amount of insecticidal toxicant, almost as much as that in the leaf sheath or root, was detected even in the leaf blade. And the detected amounts were nearly proportional to each of the treated dosages. Koshihara (1965) reported similar results in the study on absorption and translocation of γ-BHC in rice plants through the root system, using macropterous adult of the brown planthopper, *Nilaparvata lugens* Stål.

Miyahara and Fukuda (1964) studied on the relations of the γ-BHC content in the rice plant and that in the paddy water to the mortality of the rice stem borer larvae. They estimated the concentration of γ-BHC which caused nearly 100 percent death of the larvae hatched between 5 to 15 days after the treatment to be 2 ppm in the water and 0.2 ppm in the leaf sheath, respectively. Horiguchi (1964) reported that the mortality of the newly hatched larvae was 95 percent for 0.25 ppm of γ-BHC in the water and 100 percent for 0.5 ppm of γ-BHC, respectively.

It seems to be difficult to clarify the close relation between γ-BHC content which is determined at a certain time in the plant or in the water and mortality of the borer, because γ-BHC dissolved in the water is gradually transferred to the plant. Then the amount of insecticide which reaches the insect increases sufficiently to kill the insect.

The method of applying γ-BHC to irrigation water of paddy fields is easy and has a long residual effect. Thus, the method has been developed in Japan and γ-BHC is now generally applied at the rates of 1.2 to 1.8 and 2.4 kilograms per hectare in the irrigation water of rice fields at the periods of the insect occurrence to control the rice stem borer in the first and second generations, respectively. In this method, no difference in effect has been recorded when the insecticide was applied as granule, dust or emulsion (Horiguchi, 1965). Granular application in this method is welcomed by the farmers because of its labor-saving device and is being used in large areas.

In the last ten years, the occurrence of the virus diseases of rice plants has been increasingly severe in Japan. Therefore, it is particularly important to control the rice leafhoppers as virus vectors.

BHC is not effective to the green rice leafhopper, *Nephotettix cincticeps* Uhler, and carbaryl (Sevin) has been applied as extensively as malathion for the control of the leafhopper. The effect of this insecticide for the control of the insect has been shown in

Japan not only by foliar application but also by the same application method mentioned above in the case of BHC. Many workers in south-western Japan applied carbaryl in the soil or irrigation water of paddy field and obtained promising results in the leafhopper control.

Systemic insecticidal properties of this compound in the rice plant were investigated by Masuda and Fukuda (1961) by chemical analyses. In their laboratory experiments, it was noticed that this compound showed systemic action, transferring from treated soil to the plant. According to the further tests (Fukuda and Masuda, 1965), it was found that this compound was accumulated much more in the leaf blade than in the leaf sheath or root.

Masuda et al. (1963) studied the absorption and translocation of this compound in the rice plant using the radioactive tracer technique. In their experiment, the same dosage of naphthol-1-^{14}C-labeled carbaryl was applied to different layers of each pot containing dry soil. As a result, the amount of uptake of radioactive materials by the rice plant was associated with the radioactivity present in the surface water. And this trend was particularly evident in the leaf blade.

The behavior of carbaryl in the rice plant was quite different from that of γ-BHC in that carbaryl was taken up better than γ-BHC by roots or the lower part of leaf sheath and accumulated in leaf blade of the plant.

It has been considered that water-solubility of insecticides and their stability in plant may be related to the systemic properties of them. However, there has been no data to elucidate the difference in systemic action between γ-BHC and carbaryl, with exception of the fact that water-solubility of γ-BHC is considerably less than that of carbaryl.

Spraying or dusting in the leafhopper control are laborious and expensive because of the short insecticidal residual periods. Application of carbaryl granule in paddy water has longer residual effect and is a more efficient application method as compared with repeated foliar applications. This application method of carbaryl has been developed mainly in south-western Japan for the control of the green rice leafhopper and the other rice planthoppers. When applied into irrigation water at the rate of 2.4 kilograms per hectare, residual effect of carbaryl remains for about three or four weeks. Recently, it was found that another carbamate insecticide named arprocarb (Unden) also showed similar effects in such treatment, and many works on the other carbamate insecticides are now being carried out successively in Japan.

In addition to BHC granule, carbaryl granule and arprocarb granule, a granular formulation containing both γ-BHC and carbaryl or arprocarb is also now on the market in Japan with the intention of controlling both the rice stem borer and the rice leafhoppers simultaneously.

From the consideration on the problem of insecticide resistance, other effective insecticides will be required with such easy application methods. Moreover, from the point of residue toxicity in rice grain, any chlorinated hydrocarbon is potentially dangerous when accumulated in the human body. The organophosphorus insecticides are safer in this respect.

In rice insect control, application of organophosphorus insecticides in paddy soil or irrigation water was examined more than ten years ago in Japan. Suenaga and Yamamoto (1955) obtained good results on the control of the brown planthopper, black rice bug, *Scotinophara lurida* Burmeister, and the rice stem borer by treating the soil with parathion dust in pot tests. Applying phosphorus insecticides in irrigation water of the rice field has been also studied. Recently, many observations have been made on the effects of phosphorus insecticides in such treatment. For instance, Tamura (1963) reported that fenthion (Lebaycid) and fenitrothion (Sumithion) were effective in the rice stem borer control when they were applied as emulsions into irrigation water of rice field. Okamoto, Koshihara and Abe (1963) observed similar effect by granular application of fenthion or diazinon. Fukuda and Masuda (unpublished) studied the behavior of diazinon applied on the surface of soil by radioactive tracer techniques.

In their experiment, diazinon showed remarkable systemic action, transferring from the treated soil to leaf blade of the rice plant. The application of diazinon granule in irrigation water of rice fields is now being developed in Japan at the rates of 0.9 to 1.2 kilograms per hectare, because it was found to be effective not only in the rice stem borer control, but also in the rice leafhoppers control.

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Manufacturing Digestible Proteinous Foods from Oilseeds and Pulses by Enzymic Treatment

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Improvement of Miso manufacturing

Miso and shoyu made from soybeans by fermentation have been important food in Japan from ancient times. Although highly nutritious, soybeans consiting of 40% of protein, 20% of fat and oil, and 25% of carbohydrate are so hard in consistency that they are rather difficult to be digested sufficiently for nutrition, even after cooking by usual methods. In addition, they have an unfavourable beany flavour as a food. In order to improve these defects as food, a mechanical grinding method and fermentation processing have been devised a long time ago in Japan. Miso and shoyu are from same origin, the prototype of which is considered to have been introduced from the Chinese continent about 1,200 years or more ago. At present, shoyu is different from miso in method of manufacturing, consistency, and the way of usuage. Shoyu is considered as a salty seasoning for kitchen and table use.

Although there are many variety differences in the raw materials from which miso is made, recipes of raw materials including soybeans, rice, barley and salt, flavour as well as color, the principle of manufacturing can be outlined as follows:

Milled rice is cleaned and soaked in water over-night at 15°C or more, and then cooked in steam for 40 minutes. The cooked rice is then cooled to 30°C to be inoculated with tane-koji (spores of *Aspergillus oryzae* purely cultured) for fermentation in a koji-chamber or koji-fermenter, of which the temperature can be controlled at 30°C. Fermentation takes about 40 hours, or until all the rice is covered by the mycelium of the mold and develops into a mat of molded rice. Soybeans are cleaned and soaked in water under the same conditions as rice, and then cooked in steam or water at 115°C for 30 min. After cooling, cooked soybeans are mixed well with koji and salt. The mixed materials are passed through a big meat chopper, then packed into a vat or tank for fermentation. Weights equivalent to 20% of the total green miso are placed on the surface, which is covered with a plastic film sheet. During fermentation of miso, it is transferred from the first vat to another with a purpose to stir and mix homogeniously. At atmospheric temperature, it takes six months or more for green miso to be ripened well. The period for ripening is considered too long for modern industry, and an important problem to be solved as soon as possible is how to shorten the length of the ripening period. As a result of investigations on the mechanism of ripening, at least following steps have been revealed as necessary for ripening. First, the enzymes of koji act to hydrolyze the constituents of soybeans and rice or barley, resulting in the production of water-soluble protein up to 60% of the total protein, amino acids up to 30%, reducing sugar up to 75% of the total sugar (including starch and other polysaccharides). These products are important