Absorption and Translocation of γ-BHC in Rice Plants through the Root Systems

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Application of γ-BHC into a paddy field soil, at rates of 27 to 36 g per are, right before the transplanting of rice seedlings was found to reduce largely injuries caused by the first generation larvae of the rice stem borer, Chilo suppressalis Walker (KOSHIHARA & OKAMOTO, 1957). In regard to the mode of effectiveness of this soil application of γ-BHC against the rice stem borer, much attention has been paid to the absorption and translocation of γ-BHC in rice plants particularly through the root systems during past several years. Recently, γ-BHC was demonstrated to be absorbed through the root systems, and translocated to the leaf sheaths and leaf blades of rice plants by chemical analyses (TSUKANO & SUZUKI, 1962; ISHII & HIRANO, 1962). The toxic action of the translocated γ-BHC to the rice stem borer and other insect pests of rice plants, however, has never been studied.

The present experiments have been undertaken since 1960 to examine qualitatively whether or not γ-BHC is absorbed and translocated in rice plants through the root systems from the treated paddy field soil, and then kills newly hatched larvae of the rice stem borer feeding in the rice plants. In addition, some aspects of the absorption and translocation of γ-BHC in rice plants through the root systems were examined using macropterous adults of the brown planthopper, Nilaparvata lugens Stål.

MATERIALS AND METHODS

Experiments with the rice stem borer

Experiments were carried out using lindane dust, containing 3% of γ-BHC, specially prepared for the present experiments. The soil used was clay loam collected from the paddy field of the Chūgoku National Agricultural Experiment Station in Fukuyama and air-dried. Each of glass pots, 8 cm in diameter and 10 cm in depth, was filled with 500 g of the soil. The soil in each pot was completely mixed with 60 and 90 mg of lindane dust. The amounts of γ-BHC in the treated pots were equivalent to approximately 36 and 54 g in the top soil, 8 cm in depth, per are. The treated pots were immersed into the water regulated to flow over gently always in a cistern, 180 cm in length, 50 cm in width, and 12 cm in depth, with the untreated check pots. There was flowing water, about 3 to 4 cm in depth, on the soil surface of the immersed pots. In the cistern, about 31 of water was flowing in and out every minute. Rice seedlings, variety Norin No. 37, each consisting of one stem with about seven to eight leaves, about 35 cm in height, were used for the experiments. One hill consisting of three rice seedlings was transplanted in each pot. The basal parts of the leaf sheaths of the rice seedlings transplanted were soaked in the flowing water. Thus, the potted rice seedlings grew under conditions which eliminated any possible contamination of the aerial parts of the rice seedlings by the movement of γ-BHC through the agency of water on the treated soil. At the transplanting time, careful attention was paid to avoid the contamination of the aerial parts of the rice seedlings by contact with the γ-BHC treated soil. Nine days after the transplanting, approximately fifty newly hatched larvae of the rice stem borer were induced to invade the leaf sheaths of each hill of the growing rice.
rice seedlings. Egg masses were obtained from moths which emerged in the laboratory, and set on the leaf sheaths just before the hatching. Counts were made of the larvae which survived in the rice seedlings 5 days after the larval invasion. Moribund larvae were discriminated as dead ones. In July, the experiments were carried out with four hills every treatment in the laboratory. Throughout the experimental period, the potted rice seedlings were grown continuously in the flowing water.

Experiments with the brown planthopper

Experiments were carried out with the brown planthopper in a similar way to experiments with the rice stem borer. Each of glass pots, 8 cm in diameter and 10 cm in depth, was filled with 500 g of the soil. The soil in each pot was completely mixed with 45, 90, 180, and 270 mg of lindane dust containing 3% of γ-BHC. In the treated pots, the amounts of γ-BHC were equivalent to approximately 27, 54, 108, and 162 g in the top soil, 8 cm in depth, per are respectively. The treated pots were immersed into the water flowing in the cistern. Two hills of the rice seedlings were transplanted in each pot. Each hill consisted of three seedlings. After the rice seedlings were grown for 2, 5, 9, 14, and 21 days, the aerial parts of the rice seedlings were cut off above the surface of the flowing water. The aerial parts of three rice seedlings, about two-thirds of the leaf blades of which were cut out, were placed in each test tube, 3 cm in diameter and 20 cm in length. Besides, the aerial parts of three rice seedlings were separated into the leaf sheaths and the leaf blades, and then the two separate parts were placed in each test tube individually. Then, approximately ten macropterous male adults of the brown planthopper were transferred into each of the test tubes. Test insects were obtained from the mass rearing in the laboratory. The adults were used within 5 days after the emergence. The test tubes were covered with cotton plug or gauze, and placed in an incubator kept at 28°C under natural daylight conditions. Counts were made of the adults that survived in the test tubes at intervals of 4, 8, 24, 48, and 72 hours after the transfer. Moribund adults were discriminated as dead ones. All the experiments were carried out with five test tubes at every treatment during September to October.

RESULTS AND DISCUSSION

The results obtained from the experiments with the rice stem borer are shown in Table 1. Significant large reductions were observed in the number of the larvae which invaded on the 9th day after the transplanting into the rice seedlings growing in the soil treated with γ-BHC at rates of 36 and 54 g per are, as compared with those in the untreated check soil.

Table 1. Mortality of the rice stem borer larvae which invaded on the 9th day after the transplanting into rice seedlings growing in paddy field soil treated with lindane 3% dust.

<table>
<thead>
<tr>
<th>Active ingredient per are (grams)</th>
<th>Number of larvae</th>
<th>Per cent mortality 5 days after larval invasion</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>162</td>
<td>78.4</td>
</tr>
<tr>
<td>0</td>
<td>125</td>
<td>13.6</td>
</tr>
<tr>
<td>54</td>
<td>237</td>
<td>98.7</td>
</tr>
<tr>
<td>0</td>
<td>175</td>
<td>10.9</td>
</tr>
</tbody>
</table>

In the experiments with the brown planthopper, as shown in Fig. 1, similar large reductions were observed in the number of the adults transferred onto the rice seedlings grown for 14 and 21 days after the transplanting in the soil treated with γ-BHC at rates of 54 and 108 g per are. On the other hand, no reductions were observed in the number of the adults transferred onto the rice seedlings grown for less than 9 days. The adults transferred onto the rice seedlings grown for 21 days in the treated soil became almost dead within 24 to 48 hours (Fig. 2). As shown in Table 2, reductions were also observed in the number of the adults transferred onto the rice seedlings grown...
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for 21 days after the transplanting in the soil treated with \( \gamma \)-BHC at a rate of 27 g per are. However, occurrences of the reductions in this case began slowly. Reductions were observed in the number of the adults transferred onto both leaf sheaths and leaf blades. The reductions were larger in the former case than in the latter case (Table 3).

Table 2. Mortality of the brown planthopper adults transferred onto rice seedlings grown for 21 days in paddy field soil treated with lindane 3% dust.

<table>
<thead>
<tr>
<th>Active ingredient per are (grams)</th>
<th>Number of adults</th>
<th>Per cent mortality* after 24 hours</th>
<th>Per cent mortality* after 48 hours</th>
<th>Per cent mortality* after 72 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>51</td>
<td>41.2</td>
<td>76.5</td>
<td>84.3</td>
</tr>
<tr>
<td>54</td>
<td>51</td>
<td>64.7</td>
<td>98.0</td>
<td>100.0</td>
</tr>
<tr>
<td>108</td>
<td>53</td>
<td>60.4</td>
<td>92.5</td>
<td>94.3</td>
</tr>
<tr>
<td>162</td>
<td>51</td>
<td>88.2</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>0</td>
<td>50</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

* Mortality was determined in test tubes covered with gauze.

In the present experiments, most of the rice stem borer larvae and the brown planthopper adults survived in the untreated check rice seedlings. Most of the brown planthopper adults also survived in the rice seedlings grown in the treated soil for only a few days. If \( \gamma \)-BHC moved...
significantly to the aerial parts of the rice seedlings from the treated soil through the agency of the flowing water, high mortality of the test insects could be expected both in treated and untreated rice seedlings. It is reasonable to assume, therefore, that all the experiments were carried out under conditions which prevented completely the contamination of the aerial parts of the rice seedlings by the movement of \( \gamma \)-BHC from the treated paddy field soil through the agency of the flowing water. Likewise, it is also reasonable to assume that the aerial parts of the rice seedlings were not contaminated by the contact with the treated paddy field soil at the transplanting time. It is suggested that the significantly high mortality of the test insects observed in the treated rice seedlings might be due to the \( \gamma \)-BHC translocated to the aerial parts through the root systems.

It may be concluded from the results of the present experiments that \( \gamma \)-BHC is absorbed through the roots, and translocated to the leaf sheaths and leaf blades from the paddy field soil treated with a considerably large amount of this compound, and then \( \gamma \)-BHC kills newly hatched larvae of the rice stem borer feeding in the rice seedlings. It is reasonable to assume that the effectiveness of the application of \( \gamma \)-BHC into the paddy field soil against the first generation larvae of the rice stem borer is mainly due to the absorption and translocation of \( \gamma \)-BHC in rice seedlings through the root systems. It seems that the \( \gamma \)-BHC also kills macropterous adults of the brown planthopper feeding on rice seedlings. It may be reliable that the absorption and translocation of \( \gamma \)-BHC in rice seedlings through the root systems occur slowly and faintly. It may be also reliable that the translocation of \( \gamma \)-BHC is correlated with the amount treated into the paddy field soil, and the amount of \( \gamma \)-BHC translocated is larger in the leaf sheaths than in the leaf blades.

It is well known that there are a number of organic insecticides having systemic properties (METCALF, 1955; BENNETT, 1957; RIPPER, 1957; REYNOLDS, 1958; MITCHELL et al., 1960). Among these insecticides, as pointed out by REYNOLDS (1958), \( \gamma \)-BHC shows a somewhat different picture. In fact, it has been found that this compound has an ability to penetrate into and translocate within crop plants. Moreover, the toxic action of the translocated \( \gamma \)-BHC to pest insects of crop plants has been observed. However, it has been shown that considerably high rates of applications are necessary for this compound to penetrate and translocate in significantly detectable amounts.

The absorption and translocation of \( \gamma \)-BHC have been observed in various crops. Absorption and translocation of \( \gamma \)-BHC through root system have been confirmed in various crops such as potato (STARNES, 1950), tomato (EHRENHARDT, 1956), wheat (EHRENHARDT, 1956; BRADBURY & WHITAKER, 1956), corn (HAINES, 1956; LILLY & FAHEY, 1956), sorghum, soybean, lima bean (LILLY & FAHEY, 1956), alfalfa (KOELER & GYRISCO, 1957), red clover (BRASS & WARE, 1960), and pea (LICHTENSTEIN & SCHULZ, 1960) by chemical analysis and bioassay. In rice plants, TSUKANO & SUZUKI (1962) and ISHII & HIRANO (1962) demonstrated that \( \gamma \)-BHC is absorbed, and translocated to the leaf sheaths and leaf blades from the aqueous solution through the root systems. Furthermore, KOELER & GYRISCO (1957) demonstrated the systemic insecticidal action of \( \gamma \)-BHC through the root systems in alfalfa plants, following soil application, upon the meadow spittlebug, Philaenus leucophtalmus L., nymphs. Besides, similar phenomena which seemed to be due to the systemic insecticidal action of \( \gamma \)-BHC were reported (STARNES, 1950; HOWE, 1950; KOZLOVA & DVORTSOVA, 1952).

The results of the present experiments demonstrate that the absorption and translocation of \( \gamma \)-BHC in rice seedlings through the root systems may conceivably take place to some extent when a considerably large amount of \( \gamma \)-BHC was applied into the paddy field soil. Further-
more, the systemic insecticidal action of the \( \gamma \)-BHC upon some insect pests of rice seedlings may also conceivably occur.

**SUMMARY**

The absorption and translocation of \( \gamma \)-BHC in rice plants particularly through the root systems were qualitatively examined. Experiments were conducted on rice seedlings grown in the paddy field soil treated with \( \gamma \)-BHC under conditions which eliminated possibility of the contamination of the aerial parts by the movement of this compound through the agency of the irrigation water on the treated soil.

It was found from the results of the experiments that \( \gamma \)-BHC was absorbed and translocated to the aerial plant tissues of the rice seedlings from the paddy field soil treated with a considerably large amount of this compound, and then killed newly hatched larvae of the rice stem borer feeding in the rice seedlings. It is reasonable to assume that the effectiveness of the application of \( \gamma \)-BHC into the paddy field soil right before the transplanting against the first generation larvae of the rice stem borer is mainly due to the absorption and translocation of \( \gamma \)-BHC in rice seedlings through the root systems.

It seemed that the \( \gamma \)-BHC also killed macropterous male adults of the brown planthopper feeding on the rice seedlings.

The absorption and translocation of \( \gamma \)-BHC in the rice seedlings through the root systems were found to occur slowly and faintly. The translocation of \( \gamma \)-BHC was correlated with the amount applied into the paddy field soil. The amount of \( \gamma \)-BHC translocated was larger in the leaf sheaths than in the leaf blades.

**ACKNOWLEDGEMENTS**

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**REFERENCES**


* Cited from Rev. Appl. Ent.
水稲における根系からのγ-BHCの吸収移行について

挙 要

水稲における根系からのγ-BHCの吸収移行について

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BHC剤を土壤に混入した場合の、水稲苗における根系からのγ-BHCの吸収移行について実験した。
実験の結果、相当量のBHC剤を水田土壤に混入すると、γ-BHCが混入土壤から吸収されて水稲苗の地上部の植物体組織へ移行し、水稲苗に食入するニカメイチューの孵化直後の幼虫に対して殺虫作用を現わすことが認められた。田植え直前のしぼろかきの際のBHC剤の土壌混入によるニカメイチューの第1世代の駆除効果の発現には、水稲苗における根系からのγ-BHCの吸収移行が重要な役割を果たしていることは確実である。
また、γ-BHCは水稲苗に寄生するトピロウォンカの長翅成虫に対しても同様に殺虫作用を現わすようにうかがわれた。
水稲苗における根系からのγ-BHCの吸収移行はゆるやかに、しかも微弱に起こることが示された。その移行量は土壌混入の葉数に比例し、また葉数が多く、葉身では少ないと認められた。

抄 録

アワフキムシ1種による導管液液の吸収


アワフキムシの1種 Philaenus spumariusが栄養をどこからとらかをしらべた。吸汁性昆虫には細胞液液吸収者・ふるい導管液液吸収者・導管液液吸収者の3型がある。本種が摂食中に単一の浸込み口から多数の余剰汁液を分泌することと、吸汁口が長時間同一で壊死が少く少ないことは第1型の仮定に合わせない。分泌液のなかに糖がぜんぜんみられないことは、第2型の仮定（アブラムシ類はこれに属する）に合わない。さらに、多数個体が寄生すると寄主の上部がしおれてしまうが、そのすぐ下部の個体は吸汁と分泌をつづける事実や、吸汁部の上を切っても吸汁・分泌がつづく事実は、本種が導管液液吸収者であることを思わせる。

導管液液の連続切片の顕微観察の結果、上記の考えは裏づけられた。さらに導管汁とアワの分析の結果は、両者に含まれる有機物がほとんどすべて（98％）アミノ酸であり、その基本的構成も同一である（ただし寄主の条件によってはアワのなかではいくつかのアミノ酸が消化吸収の結果減少している）ことを示した。この事実は、導管汁液が単に無機物の水溶液であるという古い考え方とちがって、アミノ酸のかたちで根内でつくられた有機物を含んでいるという最近の知見を再確認する。
なお、アワをつくるのに必要な表面活性物質の代謝過程についてはふれていない。

（農技研 伊藤喜昭）