Deposit Distribution of BPMC and Its Control Effect on the Brown Rice Planthopper*

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When regular dust (RD) and less-drifting dust (DL) of BPMC were applied to paddy fields by four kinds of boom-type blow heads, a large amount of the dusts discharged from a DL30A blow head deposited at the base zone of the pipe and a small amount at the end zone, a large amount of deposits from DMH30A and DLH30A remained at the end zone and a small amount at the base, and a large amount of deposit from Blow-in Green at the middle zone. The deposit distributions on the vertical surface showed a similar tendency to that on the horizontal surface, whereas coefficients of variation (CVs) were smaller. The horizontal deposit and vertical deposit were correlated and the slope of the regression line of RD was steeper than that of DL. Mortality of the brown rice planthopper was related with BPMC deposits. Higher correlation coefficients were observed in the relationship between the vertical deposit of BPMC and the insect mortality. The slope of dosage-response curves was steeper in RD than in DL. The average insect mortality was 81.6–84.3% for RD and 71.7–73.1% for DL. The amount of the insecticide floating in the air was two to three times larger by RD application than by DL application. The insecticide characteristics mentioned above suggest that RD is more effective than DL for control of the brown rice planthopper which lives at the foot of rice plants.

INTRODUCTION

For pest control of rice plants, many kinds of insecticides and fungicides have been applied to paddy fields. Since the late 1960's, the knapsack-type power duster with a boom-type blow head has been used for pesticide application and has become predominant as a labor-saving method. It has been reported, however, that at the late stage of rice cropping, the application using a boom-type blow head was not effective enough for pest control as compared with the blow-in application or the swing application. Especially in some cases the 3rd generation nymphs and adults, and the 4th generation nymphs of the brown rice planthopper (Nilaparvata lugens Stål), which emerged around early August to late September, were not always controlled by application using a boom-type blow head. Moreover, as the resistance to insecticides develops, the use of a boom-type blow head has been discussed in relation to the improvement of effectiveness of insecticides. It is considered that less effectiveness by application using a boom-type blow head is due to ununiform distribution of insecticide deposit and a smaller amount of deposit at the foot of rice plants. However, there is no evidence to explain why the efficacy decreases when insecticide is applied by this method.

The purpose of this study is to elucidate the deposit distributions of BPMC when boom-type blow heads are used for application in paddy fields, and to determine the relationship

* Studies on the Pest Control Method Utilizing Boom-type Blow Heads in Paddy Fields (Part 1). A part of this paper was presented at the 11th Meeting of the Pesticide Science Society of Japan in March, 1986.
between the insecticide deposit and the control effect on the insect.

MATERIALS AND METHODS

1. Insecticide

Regular dust (RD) and less-drifting dust (DL) of BPMC (o-sec-butylyphenyl methyl-carbamate, a.i. 2%, Nihon Nohyaku Co., Ltd.) were subjected and applied at 40 kg/ha throughout this experiment. The physical properties of the dusts are shown in Table 1.

2. Power Duster and Boom-type Blow Heads

The knapsack-type power duster, DMD-350AE (Kyoritsu Co., Ltd.) was used and operated at a 7/10 position of engine lever and at a 6/10 position of shutter lever.

Four kinds of boom-type blow heads were used: DL30A (Maruyama Mfg. Co., Ltd.) and Blow-in Green (Hatsuta Ind. Co., Ltd.) are common types for RD and DL, DMH30A (Kyoritsu Co., Ltd.) a special type for RD, and DLH30A (Kyoritsu Co., Ltd.) for DL. All blow heads are 30 m long.

3. Examination of Insecticide Deposit Distribution

Paddy fields (30 m x 30 m) with rice plants (Oryza sativa cultivar Nakate shinsenbon) at the yellow-ripe stage were employed in this experiment.

For the determination of the horizontal deposit distribution of the insecticide in paddy fields, glass slides (76 mm x 26 mm) coated with silicone grease were set horizontally among rice plants at crossing points of 5, 10, 15, 20 and 25 m from the blow head base to the end, and 5, 10, 15 and 20 m longitudinally 3 cm above the ground. For the determination of the vertical deposit of the insecticide, glass slides were hung vertically 15 cm above the ground at the points of 5, 10, 15, 20 and 25 m from the blow head base to the end, and 5, 10, 15 and 20 m longitudinally. After application of the insecticide, the glass slides were carefully removed to the laboratory, deposited BPMC was eluted with acetone and subjected to quantitative analysis. The examinations were done at less than 3 m/sec of the velocity of wind.

Table 1 Physical properties of dust formulations used.

<table>
<thead>
<tr>
<th>Physical property</th>
<th>RD</th>
<th>DL</th>
</tr>
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<tbody>
<tr>
<td>Fineness (&gt;300 mesh)</td>
<td>1.5%</td>
<td>4.0%</td>
</tr>
<tr>
<td>Bulk density</td>
<td>0.71</td>
<td>0.85</td>
</tr>
<tr>
<td>Drift index</td>
<td>---</td>
<td>7.5</td>
</tr>
<tr>
<td>Dispersibility index</td>
<td>71</td>
<td>75</td>
</tr>
<tr>
<td>Moisture content</td>
<td>0.11%</td>
<td>0.11%</td>
</tr>
</tbody>
</table>

4. Measurement of Velocity of the Air Flow

Velocity of the air flow penetrating in the blow heads and discharging at the blow holes was measured by a micro manometer equipped with a pito tube of 3 mm diameter (DP-1000A, Okano Works Co., Ltd.). The power duster was operated at a 7/10 position of engine lever and at a 6/10 position of shutter lever, and the flow rate of the air was measured at 5, 10, 15, 20 and 25 m of the pipe.

5. Insecticidal Effect of BPMC on the Brown Rice Planthopper

For the determination of the insecticidal effect of RD and DL, the number of brown rice planthoppers was counted before and after application of the insecticide, and their mortality 24 hr after application was calculated. The observations were done with five hills of rice plants at each examination point of BPMC deposits, and the relationship between the deposited amount of BPMC and the mortality of the insects was determined.

6. Determination of Concentration of BPMC Floating in the Air

The amount of the insecticide floating in the air was determined by a model experiment as follows: RD and DL were scattered from above into a wooden box (90 cm x 90 cm x 90 cm) by blowing compressed air. One minute after application, the inside air was sucked up at the rate of 2 l/min in series at 3-minute intervals through SEP-PAK® Florisil® cartridges set at the center bottom of the box. BPMC trapped in the cartridge was eluted with acetone and subjected to quantitative analysis.
The experiments were done at 10, 20 and 30 cm above the bottom.

7. **Gas Liquid Chromatography**

For quantitative analysis of BPMC, gas liquid chromatograph (Shimadzu GC-5A, Shimadzu Co., Ltd.) equipped with an FTD-8 detector (Shimadzu Co., Ltd.) was employed. A 3 mm x 1.5 m glass column packed with 1.5% silicone OV-17 plus 1.95% silicone DC QF-1 on Chromosorb W(HP) (80-100 mesh) was used at 170°C. Gas flow rates of carrier (helium), air and hydrogen were 50 ml/min, 200 ml/min and 3 ml/min, respectively. The injection volume was fixed at 2 μl.

**RESULTS**

1. **Deposit Distribution of BPMC in Paddy Fields**

The deposit distributions of BPMC on the horizontal and vertical surfaces when it was applied by a power duster with DL30A are shown in Fig. 1-A and -B, and Fig. 2-A and -B. A large amount of the applied RD was horizontally deposited at the base zone of the blow head and a small amount at the end zone (Fig. 1-A). The average deposit was 105 g/ha, and the coefficient of variation (CV) 48.6%. In case of DL (Fig. 1-B), the amount of BPMC deposited at points of 5 m and 10 m of the blow head was large (200–500 g/ha), but the amount was small from the middle to the end zone of the pipe (less than 100 g/ha). The average was 206 g/ha, and the CV 72.6%. The deposit distribution of BPMC was less uniform when it was applied in DL than in RD. The vertical deposit of BPMC was similar to the case of horizontal deposit both in RD and DL, that is, a large amount at the base zone but a small amount at the end zone (Fig. 2-A and -B), with the average 120.6 ng/cm² for RD and 144.6 ng/cm² for DL, and the CV 53.8% for RD and 55.1% for DL.

The results obtained with special blow heads, DMH30A for RD and DLH30A for DL, are shown in Fig. 1-C and -D, and Fig. 2-C and -D. In case of RD, the horizontal deposit of BPMC was less than the average (102 g/ha) at the base zone, and increased gradually toward the end zone of the pipe, that is, a large amount than the average (Fig. 1-C). The CV was 78.6%. On the other hand, when DL was applied, the horizontal deposit of BPMC was almost close to the average from the base to the middle zone.

![Graphs showing deposit distribution](image-url)
of the pipe, and a large amount at the end zone of the pipe (Fig. 1-D). The average was 66 g/ha, and the CV 60.3%. The deposit tended to increase toward the end zone when RD was applied. In addition, in both dusts, the deposit gradually increased toward the forward direction. Variation of vertical deposit of BPMC was small in contrast with the horizontal deposit distributions (Fig. 2-C and -D). The average deposit and CV were 82.8 ng/cm² and 21.3% for RD, and 87.4 ng/cm² and 15.9% for DL, respectively.

The deposit distribution patterns when Blow-in Green was used for application are shown in Fig. 1-E and -F, and Fig. 2-E and -F. The horizontal deposit of the applied RD was less than the average (152 g/ha) at the base zone, but from the middle to the end zone, the deposit increased to a larger amount than the average (Fig. 1-E). In case of DL, the horizontal deposit was less than the average (125 g/ha) at the base and end zones, but larger at the middle zone (Fig. 1-F). The CV was 59.6% for RD and 55.8% for DL. Variation of vertical deposit of BPMC was small for both dusts (Fig. 2-E and -F), the average being 141.1 ng/cm² for RD and 127.7 ng/cm² for DL, and the CV 37.3% for RD and 33.7% for DL.

2. The Relationship between Horizontal and Vertical Deposits of BPMC

The horizontal deposit and vertical deposit of BPMC were correlated (Fig. 3), and the

![Fig. 2 Deposit distribution of BPMC of the vertical surface applied by a power dust-er with four kinds of boom-type blow heads. Abbreviations are the same as in Fig. 1.](image)

![Fig. 3 Relationship between horizontal deposit (X) and vertical deposit (Y) of BPMC. —: RD, ---: DL.](image)
regression equations are: \( Y = 21.86 + 0.86X \) \((n=50, r=0.678**)\) for RD and \( Y = 47.86 + 0.40X \) \((n=62, r=0.623**)\) for DL. The slope of RD was steeper than that of DL.

3. **Measurements of Velocity of the Air Flow Penetrating in the Blow Heads and Discharging at the Blow Holes**

Velocity of the penetrating air flow in the pipe decreased gradually toward the pipe end in all blow heads examined. The velocity at the 25 m point of the pipe was almost 50% of that at the 5 m point (Fig. 4-A). And in case of DL30A, the velocity was about 4 m/sec slower than that of other pipes at all points measured. On the other hand, the velocity of the discharging air at the blow holes did not decrease significantly from the base to the end in any blow heads (Fig. 4-B). However, the velocity of DMH30A and DLH30A was about 20 m/sec slower than that of DL30A and Blow-in Green.

4. **Amount of BPMC Floating in the Air**

The amount of BPMC floating in the air is shown in Fig. 5. The BPMC concentration of the applied RD floating 1 to 19 min after application was 4.4 to 1.3 \( \mu g/l \) at 10 cm, 4.7 to 1.3 \( \mu g/l \) at 20 cm, and 3.3 to 0.88 \( \mu g/l \) at 30 cm, respectively. The BPMC concentration was higher at 20 cm than at 10 cm until 13 min. In case of DL, the concentration was 2.4 to 0.36 \( \mu g/l \) at 10 cm, 1.8 to 0.46 \( \mu g/l \) at 20 cm, and 1.3 to 0.41 \( \mu g/l \) at 30 cm, respectively. The concentration of the applied DL was one-half to one-third lower in comparison with that of RD at any heights and times.

5. **Insecticidal Effects of RD and DL on the Brown Rice Planthopper**

Mortality of the brown rice planthopper when DL30A was used for RD application is shown in Table 2. The mortality was more than 95% at the base zone, but decreased toward the end zone, and was less than 50% at the 25 m point of the pipe. Such a tendency appeared to parallel to the insecticide deposit distribution (Fig. 1-A). A similar tendency was also observed when DL30A was used for DL application (Table 2). The mortality was high at the base zone where a large amount of BPMC deposit was observed, while the mortality was low at the end zone with a small amount of insecticide deposit. However, the average mortality for RD (84.3%) was higher than that for DL (73.1%). The mortality when DMH30A was used for RD increased gradually as BPMC deposit increased toward the end zone (Table 3). The mortality, when DLH30A was used for DL, varied from 60 to 90% depending on the deposit distribution of
BPMC (Table 3). The average mortality rate for RD (81.6%) was also higher than that for DL (71.7%). The dosage-response curve between the horizontal deposit of BPMC and the mortality of the insect is shown in Fig. 6-A. The regression equations are: \( Y = 3.70 + 0.22X \) \((n = 15, r = 0.740**)\) for RD and \( Y = 4.31 + 0.13X \) \((n = 18, r = 0.773**)\) for DL. LD\(_{50}\) values of the horizontal BPMC deposit are 39.8 g/ha for RD and 34.3 g/ha for DL. The slope of the equation for RD was steeper than that for DL. The relationship between the vertical BPMC deposit and the insect mortality is shown in Fig. 6-B. The regression equations are: \( Y = 1.71 + 4.03X \) \((n = 14, r = 0.868**)\) for RD and \( Y = 1.60 + 2.14X \) \((n = 15, r = 0.863**)\) for DL. LD\(_{50}\) values are 46.24 ng/cm\(^2\) for RD and 39.26 ng/cm\(^2\) for DL. The slope of the equation for RD was also steeper than that of for DL.

Table 2 Mortality (%) of the brown rice planthopper in paddy fields when DL30A boom-type blow head was used for application of BPMC dusts.\(^a\)

<table>
<thead>
<tr>
<th>Dust form</th>
<th>Distance from starting point</th>
<th>Distance from blow head base</th>
<th>Average value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 m</td>
<td>10 m</td>
<td>15 m</td>
</tr>
<tr>
<td>RD</td>
<td>10 m</td>
<td>100</td>
<td>95.7</td>
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<td>98.9</td>
</tr>
<tr>
<td></td>
<td>20 m</td>
<td>94.1</td>
<td>71.3</td>
</tr>
</tbody>
</table>

\(^a\) The paddy fields employed were 30 m x 30 m. The number of the brown rice planthopper before application of BPMC was 200-300 at each position.

Table 3 Mortality (%) of the brown rice planthopper when DMH30A and DLH30A boom-type blow heads were used for application of BPMC dusts in paddy fields.\(^a\)

<table>
<thead>
<tr>
<th>Dust form</th>
<th>Distance from starting point</th>
<th>Distance from blow head base</th>
<th>Average value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 m</td>
<td>14 m</td>
<td>23 m</td>
</tr>
<tr>
<td>RD</td>
<td>3.8 m</td>
<td>46.3</td>
<td>76.7</td>
</tr>
<tr>
<td></td>
<td>7.5 m</td>
<td>83.9</td>
<td>88.3</td>
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<tr>
<td></td>
<td>11.2 m</td>
<td>88.1</td>
<td>83.9</td>
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<tr>
<td>DL</td>
<td>3.8 m</td>
<td>91.9</td>
<td>71.6</td>
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<tr>
<td></td>
<td>7.5 m</td>
<td>67.0</td>
<td>61.3</td>
</tr>
<tr>
<td></td>
<td>11.2 m</td>
<td>75.0</td>
<td>71.1</td>
</tr>
</tbody>
</table>

\(^a\) The paddy fields employed were 15 m x 28 m. DMH30A was used for RD application and DLH30A was used for DL application. The number of the brown rice planthopper before application of BPMC was 200-300 at each position.
DISCUSSION

From the late 1960's to the early 1970's, the application of pesticides by a power duster with a boom-type blow head was introduced for pest control over a rice crop. And until now, the ununiformity of pest control effect was discussed in terms of the relation with the deposit distribution of pesticide.1-10)

In this experiment, the deposit distribution of BPMC in paddy fields is shown in three dimensions. The deposit distribution was different according to dust forms (RD and DL) and boom-type blow heads, under the same operation conditions of the power duster. The insecticide discharged from DL30A deposited in large amounts at the blow head base, and such a tendency was stronger in DL than in RD (Fig. 1-A and -B). The blow head was equipped with wall inserts at the blow holes until 12 m point from the blow head base, and its velocity of the air flow in the pipe was inferior to that of other blow heads (Fig. 4-A). Therefore, it is considered that the dust is forced to deposit at the base zone by collision with the wall inserts before it is carried to the pipe end. Moreover, the difference in deposit at the base zone between RD and DL can be ascribed in part to physical properties of dust such as fineness and bulk density. On the contrary, the velocity of the penetrating air flow in DMH30A and DLH30A was fast (Fig. 4-A), so that the dust can be carried to the pipe end (Fig. 1-C and -D). The dust discharged from Blow-in Green deposited in large amounts at the middle of the pipe, and the velocity of the penetrating air in this pipe was intermediate among all blow heads tested (Fig. 4-A). The amount of BPMC deposit discharged from DMH30A and DLH30A was generally smaller than the amount discharged from DL30A and Blow-in Green (Fig. 1). The velocity of the air blown off from the blow holes of DMH30A and DLH30A was about 20 m/sec lower than that of other blow heads (Fig. 4-B). Therefore, the dusts blown off deposited at the canopy of the rice plant and could not reach the plant foot. The blow holes of Blow-in Green were modified with attachments, so that the flow rate at the air outlet was the fastest of all blow heads examined, although the velocity of the air flow in the pipe was medium (Fig. 4). And the deposit distribution of BPMC was almost uniform (Fig. 1-E and -F). The results suggest that a fast flow rate of air in the pipe and at the blow holes is necessary for even deposit distribution of the dusts.

The deposit distribution of BPMC on the vertical surface was generally uniform as compared with the horizontal deposit distribution in all blow heads, and the coefficients of variation were smaller than those of the horizontal deposit distribution (Figs. 1 and 2). The relationship between the horizontal and vertical deposits of BPMC (Fig. 3) indicates that the ratio of the vertical deposit to the horizontal deposit for RD is high as compared with that for DL. It is considered that deposit on the vertical surface is influenced by high concentration of floating BPMC applied in RD (Fig. 5).

The horizontal deposit of insecticides has been studied to evaluate control effects on rice insect pests.2-5,7,8) However, in case of the brown rice planthopper, our data indicate that the vertical deposit of BPMC is closely associated with insect mortality (Fig. 6). The average mortality rate by application of RD was higher than that by application of DL (Tables 2 and 3). Yokoo et al.7) and Nonaka et al.8) reported that DL was effective for control of the green rice leafhopper (Nephotettix cincticeps Uhler) which lives around the canopy of rice plants. However, for control of the brown rice planthopper which lives on the rice plant foot, RD which floats in high concentration for a long time may be more effective than DL. Nonaka et al.8) implied the importance of concentration of pesticide floating in the air to explain the result that RD was more effective on the brown rice planthopper than DL although the amount of horizontal deposit of RD was small. Our data (Fig. 5) clearly demonstrated a typical difference in amounts of insecticide in the air when applied in dust form. Moreover, as the brown rice planthopper has developed resistance to carbamate or organophosphorus insecticide,11-13) for control of the brown rice planthopper, large amounts of insecticide deposit are required onto the insect. For the reasons mentioned above, in case of contact insecticides, concentration of an agro-chemical floating in the air is con-
considered an important factor for insecticidal activity, and RD having many chances to contact the insect can be of advantage to control the brown rice planthopper.

Because of the large deposit at the rice plant foot, Hiramatsu et al. suggested that the blow-in application was a better method than the application utilizing a boom-type blow head or the swing application for control of the brown rice planthopper. However, the use of a boom-type blow head for application could never be eliminated for the purpose of labor-saving in paddy culture. Therefore it becomes important to improve the application method using a boom-type blow head. From the viewpoint of prevention of environmental pollution, DL is more advantageous than RD, so it is also necessary to develop a new type insecticide which has enough insecticidal activity and merits of RD.

ACKNOWLEDGMENTS

The authors wish to express their thanks to Mr. K. Naba, entomologist, for his valuable suggestions and help during the observation of control effect on the insects, and to other members of the section for their advice during the course of study.

REFERENCES


要 約

BPMC の付着分布とトピボロウンカ防除効果* 1)

半川流行, 香口哲行

BPMC の普通粉剤 (RD) および DL 粉剤 (DL) を, 市販の 30 m ひろばの噴霧を用いて散布したところ, DL30A 噴霧では基部で多く先端部で少ない平面落下量分布を示し, DMH 30A (RD 専用) および DLH 30A (DL 専用) 噴霧では逆に先端部ほど多くなる落下分布を, また吹込ターリイ噴霧では中央部で多い山型の落下量分布を示した。垂直面付着量分布は, 平面落下量分布とほぼ同様の傾向を示したが, 変動係数は小さかった。単位平面面積当たりの垂直面付着量は, DL に比べ RD のほうが多く付着する傾向が見られた。BPMC の落下量（平面および垂直面）とトピボロウンカ死虫数の間には相関が見られたが, 垂直面付着量と死虫数の間でより高い相関が得られた。また薬量反応線の勾配は RD のほうが DL より急であった。平均死虫率は, RD が 81.6〜84.3%, DL が 71.7〜73.1% であった。両粉剤の気中浮遊濃度は, DL に比べ RD のほうが 2 〜 3 倍高い濃度で, しかも長時間浮遊しており, 薬剤の垂直面付着性や株向に棲息するトピボロウンカ防除において RD が有利であると思われた。

* バイブダスタによる水稲病害虫防除法に関する研究（第 1 報）