Development of the novel formulation “MAMETSUBU”
for the paddy rice

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We tried to develop a novel easy-to-use labor-saving formulation. And we have developed the "MAMETSUBU" formulation for paddy fields. This formulation has 3 to 8 mm diameters and disperses on the surface of water. This is a highly labor-saving formulation that can be applied from the levees by various methods without the necessity of stepping into the paddy fields. The conditions that disturb diffusion of an active ingredient in the "MAMETSUBU" formulation often changes. Therefore, spreading property of an active ingredient in the formulations was evaluated not only in small experimental fields but also in the actual paddy fields. In all of the experiments, the spreading property of the active ingredient was found sufficient enough for the formulations to be practically used. The conditions of paddy fields are usually not the same, but the "MAMETSUBU" formulation is a new formulation that can be reasonably applied. © Pesticide Science Society of Japan

Keywords: agricultural formulation, “MAMETSUBU” formulation, labor-saving, paddy field, application.

Introduction

In the current agriculture in Japan, rapidly advancing aging of farmers and the resulting generation changes in the farming population are particularly remarkable. It is also the fact that some of the conventional farmers’ organizations have been reorganized to companies that hold large-scale agricultural lands. Under such circumstances, it has been realized that overall efficiency of the farming works has become essentially important. In respect to the paddy fields, farming works including planting and harvesting of rice has been drastically reduced by the introduction of agricultural machinery. Likewise, time required for pest control by pesticides application has been significantly reduced thanks to the advent of highly effective active ingredients of pesticides. However, there still existed market demands for more labor-saving formulations of pesticide that allow efficient application to reduce application time and labor. For example, in order to apply herbicides in paddy fields, farmers had to step into the fields holding several kg of granular herbicides and had to apply them to the fields uniformly. This work required long time of work causing physically as well as mentally heavy burdens to farmers. Although limited to the paddy fields alone, various labor-saving formulations which could be applied from the levees without stepping into the fields were developed. In 1991, directly applicable "Flowable Formulation" that can be applied from the levees was developed and was widely used. However, since this formulation was of a liquid type, it had problems such as adhesion to clothes and drifts to outside of the fields, particularly when applied against the wind. In 1994, Jumbo formulation that can be applied by throwing as few as 10 granules per 10a from the levees was developed and was widely used. This formulation was highly labor-saving without exposure to humans. However, since this formulation spreads the paddy fields by the water current, spreading of the active ingredient was sometimes inhibited where there were obstacles such as algae growing in the water surface. With such backgrounds, we tried to develop a novel easy-to-use labor-saving formulation by overcoming all problems of conventional formulations. 1–3

1. Design of the “MAMETSUBU” formulation

Pesticide formulations are largely classified into solid and liquid types. We selected the solid type for development of a novel formulation by the following three reasons; (1) to avoid pesticide exposures to the body of applicators at application, (2) to avoid adhesion of the pesticide to rice plants, and (3) to avoid a large accumulation of used plastic containers. Next, we considered that a floating type granular formulation that dispersed in a short period of time on the water was most preferable in order to spread active ingredients. On the other hand, the spreading ability of an active ingredient in the labor-saving formulation is affected not only by the spreadable property of the prepara-
tion itself but also by field circumstances that influence the water convection caused by changes of wind and temperature as well as by existence of obstacles etc. Consequently, therefore, there are some cases where the spread of an active ingredient in the conventional labor-saving formulation was significantly inhibited (Fig. 1). Then we had an idea that in order to secure satisfactory diffusion of an active ingredient free from circumstantial changes in the field, a formulation that could be applied by various methods as needed by the users was most needed. We also thought that a formulation applied with various different types of instruments would give users more satisfaction (Fig. 2). In planning formulations, 5mm particle was considered to be well balanced in application easiness, application distance and suitability to spreading apparatuses. Meanwhile, the application rate was determined to be 250g per 10a in order to reduce weights of formulation. We have thus succeeded in developing various methods as needed by the users was most needed. We also thought that a formulation applied with various different types of instruments would give users more satisfaction (Fig. 2). In planning formulations, 5mm particle was considered to be well balanced in application easiness, application distance and suitability to spreading apparatuses. Meanwhile, the application rate was determined to be 250g per 10a in order to reduce weights of formulation. We have thus succeeded in developing

Fig. 1. Spreadable lack of active ingredient. (A) Peeling of the paddy field surface and (B) Insufficient effect of herbicide.

Fig. 2. State immediately after application. (A) Jumbo formulation and (B) “MAMETSUBU” formulation.

Fig. 3. Plan of the “MAMETSUBU” formulation.
2. Preparation of the “MAMETSUBU” formulation

An active ingredient, a surfactant, a binder, a floating carrier and a solid carrier are essential components of the “MAMETSUBU” formulation. Containing the floating carrier is a notable characteristic of the “MAMETSUBU” formulation. We use microspheres as the floating carrier, which is a co-polymer of an acrylonitrile monomer. Microspheres have spherical particles having a diameter of several 10 to several 100 μm. Microspheres have high buoyancy with light weight. Sufficient buoyancy can be obtained with a small quantity of the microsphere in the formulation. This made it possible to mix enough amounts of other ingredients in the formulation. The “MAMETSUBU” formulation is prepared by extrusion granulation. The bulk density is 0.4 and the particle size is 3–8 mm. This formulation floats on water and is dispersed in a short period of time at the surface of paddy water. It shows representative values of the physical properties of the “MAMETSUBU” formulation (Table 1).

3. Application of the “MAMETSUBU” formulation

We have developed the following versatile application methods for the “MAMETSUBU” formulation.6,7 (1) Hand application: This is the simplest application method without using application tools or machines. The formulation is applied from the levees by hand throwing. Throwing distances are approximately 3
(2) Dipper application: This is an application method using a dipper. The formation is applied from the levees by throwing with a dipper. Throwing distance is approximately 15 m (Fig. 6B). (3) Package application: This is an application method using a package. The formulation is applied from the levees by shaking the package (Fig. 6C). (4) Engine duster application: This is an application method using an engine duster. The formulation is applied from the levees by intermittent shooting with an engine duster. Flying distance is approximately 25 m (Fig. 6D). (5) Unmanned helicopter application: This is an application method using a radio controlled helicopter. The formulation is applied from the sky with a helicopter (Fig. 6E). (6) Water inlet application: This is an application method by diffusing the formulation by water flow. The formulation is applied in the field through the water inlet (Fig. 6F). (7) Jumbo formulation application: This is an application method using Jumbo formulation. Jumbo formulation wrapped with a water-soluble film is applied by hand throwing.

4. Spreading of the “MAMETSUBU” formulation

To evaluate the spreading property of the “MAMETSUBU” formulation, experiments in the actual paddy fields are very important. However, small field experiments are also useful for understanding the spreading properties of formulation. We there-

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Table 1. Physical properties of the “MAMETSUBU” formulation

<table>
<thead>
<tr>
<th>Item</th>
<th>Physical property</th>
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<tbody>
<tr>
<td>Bulk density</td>
<td>0.4</td>
</tr>
<tr>
<td>Granule size (3–8 mm)</td>
<td>99%</td>
</tr>
<tr>
<td>Moisture content</td>
<td>1.2%</td>
</tr>
<tr>
<td>Floating ratio on the water</td>
<td>100%</td>
</tr>
<tr>
<td>Dispersion time</td>
<td>6–9 min.</td>
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Fig. 7. Field trial.

Fig. 8. Hand application. (A) Outline of the paddy field, and (B) spreadability of the ingredient.
fore conducted the small field experiments. We prepared the “MAMETSUBU” formulation containing 1.8% of pyriminobac-methyl, 36.0% of bromobutide, 12.0% of bensulfuron methyl and 8.0% of pentoxazone. This formulation was applied to the end of the shorter side of a paddy field of $2\times20$ m. Herbicidal activity and phytotoxicity were evaluated 30 days after application. As a result, high herbicidal activities and a minimal phytotoxicity to rice plants were found. Thus, it was confirmed that the spreading ability of the “MAMETSUBU” formulation was very high (Fig. 7). Then, we conducted the actual field experiments. The same preparation as above was applied from all sides of the levees of a paddy field of $18\times56$ m. As a result, high herbicidal activities and a minimal phytotoxicity to rice plants were found 13 days and 38 days after application, indicating that the spreading property of the formulation was also good in the actual paddy fields. We also evaluated the spreading property of the “MAMETSUBU” formulation in each application method described above by analysis of an active ingredient in the water of paddy fields. We prepared the “MAMETSUBU” formulation containing 2.7% of pyrimisulfan in this experiment. The formulation prepared was applied to paddy fields by hand application (applied to the paddy field with 20 a from one side of the levees from windward), by dipper application (applied to the paddy field with 1 ha from all sides of the levees), by package application (applied to the paddy field with 20 a from all sides of the levees), by engine duster application (applied to the paddy field with 85 a from the sky at eight points), by the water inlet application (applied to the paddy field with 20 a from the water inlet) and Jumbo formulation application (applied to the paddy field with 20 a from all sides of the levees). The results were that the variation coefficient of the analyzed data in either method was low (hand application; 3.7% (Fig. 8), dipper application; 15.1%, package application; 4.5%, engine duster application; 7.8%, unmanned helicopter application; 24.7%, the water inlet application; 6.0%, Jumbo formulation application; 7.5%), suggesting that the spreading ability of the formulation was sufficient for the practical use (Table 2).

<table>
<thead>
<tr>
<th>Application method</th>
<th>Paddy field scale</th>
<th>Application time</th>
<th>Coefficient of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand application</td>
<td>One side of windward</td>
<td>20 a</td>
<td>2 min</td>
</tr>
<tr>
<td>Package application</td>
<td>All sides</td>
<td>20 a</td>
<td>5 min</td>
</tr>
<tr>
<td>Dipper application</td>
<td>All sides</td>
<td>1 ha</td>
<td>10 min</td>
</tr>
<tr>
<td>Engine duster application</td>
<td>All sides</td>
<td>50 a</td>
<td>7 min</td>
</tr>
<tr>
<td>Unmanned helicopter application</td>
<td>Eight points</td>
<td>85 a</td>
<td>3 min</td>
</tr>
<tr>
<td>Application to the water inlet</td>
<td>One point</td>
<td>20 a</td>
<td>Few sec</td>
</tr>
<tr>
<td>Jumbo formulation</td>
<td>20 bags</td>
<td>20 a</td>
<td>5 min</td>
</tr>
</tbody>
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Conclusion

We have developed the “MAMETSUBU” formulation for paddy fields. This formulation has 3 to 8 mm diameters and disperses on the surface of water. This is a highly labor-saving formulation that can be applied from the levees by various methods without the necessity of stepping into the paddy fields. The conditions of paddy fields are usually not the same. The conditions that disturb diffusion of an active ingredient in the “MAMETSUBU” formulation often changes. Therefore, spreading property of an active ingredient in the formulations was evaluated not only in small experimental fields but also in the actual paddy fields. In all of the experiments, the spreading property of the active ingredient was found sufficient enough for the formulations to be practically used. Twenty the “MAMETSUBU” formulation products have been registered in Japan by 2013 and those products now cover approximately 136,000 ha of paddy fields in Japan. Also, five products of the “MAMETSUBU” formulation cover 17,000 ha of paddy fields in South Korea. We wish that the “MAMETSUBU” formulation will greatly serve for the benefits of many rice growers of the world.

References