Original Article

Effect of Physicochemical Properties in Water on Release Profile of Metominostrobin from Time-Controlled Release Granule¹

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The effect of pH, water hardness and temperature in water on release profile of time-controlled release granule (TCRG) was investigated. The release profile of metominostrobin from TCRG did not change regardless of changing pH from 4 to 10 and water hardness from 3 to 100. However, as the temperature increased, the lag time was shortened and the release rate became faster. When the logarithmic cumulative temperature was plotted as abscissa and release percentage as ordinate, the release profiles measured at fixed temperatures (15, 20, 25, 30°C) and changing temperatures from 15 to 30°C periodically were superposed. Therefore, the released percentage could be predicted from cumulative temperature. Thus, it was thought that the difference in water permeation through PVC membrane by temperature caused different release profiles.

Key words: metominostrobin, controlled release granule, lag time, time-controlled release granule (TCRG), temperature.

INTRODUCTION

To keep a preventive effect and decrease the damage of seedling in a rice seedling box application, time-controlled release granule (TCRG) characterized by release after a lag time has been developed.¹⁾ Metominostrobin was optionally initiated to be released choosing the amount of talc contained in the granule pre-coated with an amount of white carbon in water-insoluble polymer membrane.^{2,3)} In application of TCRG containing metominostrobin, the concentration in rice plants varied according to the release profile from TCRG.⁴⁾

The release test into water has been conducted in the conditions of 3° water hardness, pH 6 and 20°C. However, as the water hardness, pH and temperature of paddy water vary under natural conditions, the release profile of agrochemicals from granules can be altered by those conditions. The release profile of metominostrobin from the granule would have much effect on its preventive value against rice blast disease and accordingly the damage to rice plants. But, in an agrochemical applica-

tion research field, the release test has rarely been conducted in varied release conditions.

Therefore, the effect of water hardness, pH and temperature in water on release profile of TCRG containing metominostrobin^{5,6)} was investigated.

MATERIALS AND METHODS

1. Chemicals

The chemical structure of metominostrobin is shown in Fig. 1. It was synthesized at Aburahi Laboratories, Shionogi & Co., Ltd. (Shiga, Japan). The compound dissolves at 128 mg/l in water at 20°C and easily dissolves in various organic solvents. The melting point is 87.0–89.0°C. Calcium carbonate (12–24 mesh; Kansui # 1224) as a core particle, low-substituted hydroxypropyl cellulose (Nisso, HPC-SL[®], HPC) as a binding agent and hydrophilic white carbon (CARPLEX[®] # 80) as an antiblocking agent among granules were supplied by Nitto Funka Co., Ltd. (Tokyo, Japan), Nisso & Co., Ltd. (Tokyo, Japan) and Shionogi & Co., Ltd. (Osaka, Japan), respectively. Acrylate starch (Sunfresh ST 100-MPS[®]) used as a swelling agent was supplied by Sanyo Kasei Co., Ltd. (Kyoto, Japan). As a water insoluble membrane-forming agent, aqueous dispersion of polyvinylidene chloride [PVC] (polymer content 50%;

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¹ Development of Time-Controlled Release Granule Containing Metominostrobin (Part 5): For Part 4, see Ref. 4.

Fig. 1 Structure of metominostrobin.

Table 1 Formula of time-controlled release granule (TCRG).

Function	Component	%
Active ingredient	Metominostrobin	3.0
Binding agent	SL-Hydroxypropylcellulose (HPC)	0.8
Swelling agent	Acrylate starch	8.0
Filler	Talc	8.0
Water insoluble polymer	Polyvinylidene chloride (PVC)	10.0
Anti-blocking agent	White carbon	0.75
Core particle	Calcium carbonate	69.45

Kurehalon® DO-821·S) was supplied by Kureha Co., Ltd. (Tokyo, Japan). As filler, talc was purchased from Wako pure chemicals Co., Ltd. (Osaka, Japan). All the other chemicals were of analytical grade and used without further purification.

2. Preparation of Granules

Table 1 showed the composition of TCRG. TCRG was prepared by coating water-insoluble polymer on the pre-coated granule containing metominostrobin, acrylate starch and talc. The pre-coated granule was prepared as described previously.¹⁾ Thereafter polymer coating was carried out by a fluidized bed process and the sieve fraction from 12 to 24 mesh was collected. White carbon of 0.75% was involved in water-insoluble polymer membrane.

3. Determination of Release Rate

The release profiles of metominostrobin from TCRG were studied as previously described²⁾ using water with various hardness (3, 10, 100°), pH (3.5, 6, 10) and temperature (15, 20, 25, 30°C). The cumulative temperature was followed by (1) equation.

$$\begin{aligned} &\text{Cumulative temperature (days} \cdot \text{degree)} \\ &= \text{temperature (15, 20, 25, 30}^\circ\text{C) in water per days} \\ &\times \text{measured terms (days)} \end{aligned} \quad (1)$$

4. Preparation of Film

The film was prepared as described previously.³⁾ In brief, PVC solution was diluted to one-half the content with distilled water followed by adding 0.75% white

Fig. 2 Measurement of water permeability through film.

carbon. The PVC solution was cast on glass share at 40°C for 1 hr to make a film. The film thickness was determined at five different positions on a specimen with the dimension of 4.5×4.5 cm using a micrometer dial gauge (Ozeki Seisakusho Co., Ltd., Japan).

5. Measurement of Water Permeation through Film

Water permeation through film was measured as described previously.³⁾ In brief, the prepared film was placed on a upper portion of a glass container (diameter: 4.0 cm, height: 2.8 cm) containing calcium chloride. This container was placed in a desiccator with saturated KNO₃ solution (relative humidity 92% at 20°C) (Fig. 2). The desiccator was put in a thermostat at constant temperature (15, 20, 25, 30°C). The container was weighed periodically and the increase of weight was defined as the amount of permeated water through film.

RESULTS AND DISCUSSION

1. Effect of Water Hardness and pH in Water on Release Profile

Release measurement was performed from TCRG into water having different hardness (Fig. 3). When the release test was conducted with water at different hardness, the release profiles were almost the same at all hardnesses. In the case of varied pH, there was also no

Fig. 3 Effect of water hardness on release profile.

Fig. 4 Effect of pH in water on release profile.

difference in metominostrobin release profile (Fig. 4). The water hardness may change by application of fertilizer. There may be differences in pH according to soil properties. Under those conditions, it was suggested that there were no differences in the release profile of TCRG.

2. Effect of Temperature on Release Profile

Release measurement was performed under the constant temperatures of 15, 20, 25 and 30°C (Fig. 5). As the temperature increased, the lag time was shortened and release rate became faster. As a result, there was a negative relationship between temperature and lag time (Fig. 6).

The temperature in water and the soil of paddy field is considered to be changing. Therefore, the release test was performed at various temperatures as follows.

15°C (for 3.5 hr) → 20°C (for 3.5 hr) → 25°C (for 3.5 hr) → 30°C (for 3 hr) → 25°C (for 3.5 hr) → 20°C (for 3.5 hr) → 15°C (for 3.5 hr)

When the logarithmic cumulative temperature was plotted as abscissa and the release percent as ordinate, the release profiles measured at the constant temperatures (15, 20, 25, 30°C) and changing temperature from 15 to 30°C periodically were superposed (Fig. 7). The release rate after a lag time was represented by the square-least method, $Y = 0.187X - 47.08$ (correlation coefficient; 0.975, X: logarithm of cumulative temperature [day · degree], Y: cumulative metominostrobin released percent [%]). From this result, it appeared that the released percentage could be predicted by its cumulative temperature. Therefore, even if the temperature varies, the released percent can be predicted.

3. Water Permeation through Film

In the previous study,³⁾ it was reported that the water permeation through membrane of TCRG had effects on the release profile of TCRG. Consequently, to examine

Fig. 5 Effect of temperature in water on release profile.

Fig. 6 Effect of temperature in water on lag time.

Fig. 7 Superposition analysis between release profile and temperature.

the reason why the release profile changed by temperature, the effect of temperature on water permeation through film was investigated at the constant temperatures [15, 20, 25, 30°C] (Fig. 8). As the temperature

Fig. 8 Effect of temperature on water permeation through film.

Fig. 9 Arrheniuth plot between water permeation and absolute temperature.

became higher, the rate of water permeation through film increased. Relationship between the rate of water permeation through film and temperature was investigated. There was a relationship between the reciprocal of the absolute temperature and the rate of water permeation (Fig. 9). Therefore, it appeared that the water permeation through film increased with higher temperature, and the water-absorption rate of swelling agent in TCRG can increase.²⁾ These findings suggested the shorter lag time and faster release rate with higher temperature.

In a paddy rice field, temperature in water would change and consequently the release profile of agrochemicals would vary. On the other hand, TCRG having various release profiles can be made by changing the amount of white carbon contained in water-insoluble

membrane.³⁾ Therefore, the optimized TCRG needs to be chosen to get the higher preventive value against rice blast disease.

In conclusion, the release profile of metominostrobin from TCRG was influenced by temperature. The released amount could be predicted by the cumulative temperature. Thus, it was suggested that alteration in the release profile by temperature was due to the change in water permeation through PVC film.

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要 約

時間制御型溶出性粒剤からのメトミノストロビンの溶出挙動に及ぼす水の物理化学的性質の影響*

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メトミノストロビンを含む時間制御型溶出性粒剤 (TCRG) からの溶出挙動に及ぼす水の物理化学的性質の影響を調べた。メトミノストロビンの溶出挙動は、水の pH や硬度に影響を受けないが、温度が高くなるに応じて、ラグタイムが短くなり、溶出速度が速くなった。累積温度 [溶出温度×時間(日)] を X 軸に、累積溶出率を Y 軸にとると、15~30°C までの溶出挙動において、グラフ上の溶出曲線が重なり、累積温度から溶出率を推算できることが明らかとなった。温度によって溶出挙動が変化したのは、PVC 皮膜の水透過性が変化したためと考えられた。

* メトミノストロビン含有時間制御型溶出性粒剤の開発 (第 5 報)