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EFFECT OF REDUCED RATE OF APPLICATION OF A HERBICIDE, PROMETRYN+THIOBENCARB DURING DRAINAGE PERIOD ON IMPROVEMENT OF WEED MANAGEMENT IN DIRECT SEEDED RICE IN AKITA, NORTHERN JAPAN

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ABSTRACT

A combination product of a granule herbicide of prometryn 0.80% and thiobencarb 8.0% (hereafter PT) which is not a one-shot herbicide, has been recommended in direct seeded rice fields in order to suppress Echinochloa spp. from seeding to emergence stage during the drained period just after seeding rice . The herbicides have a recommended application rate range of 0.32 kg + 3.2 kg to 0.48 kg + 4.8 kg a.i. ha^{-1}. Changes in efficacy and crop injury on direct seeded rice in a wet condition with reduced application rate of PT were evaluated under field and greenhouse conditions in Akita Prefecture, northern Japan. The aim of the study was to identify the herbicide rates required to avoid herbicidal injury to rice seedlings caused by unexpected rain, and to assess the sequential herbicidal efficacy of one-shot herbicides, which are major tools for weed management in direct seeded rice, applied under re-flooded condition after establishment of rice seedlings. With application of PT reduced to 0.16 kg + 1.6 kg a.i.ha^{-1}, sufficient herbicidal efficacy was obtained without injury to rice seedlings during the drained period after seeding. Effective control of weeds during the drained period using reduced rate of PT will ensure a sequential treatment of one-shot herbicide which can be applied after reflooding to provide good control of a range of weed species.

Keywords: Direct seeded rice, drainage period, granule of prometryn 0.80% and thiobencarb 8.0%, one-shot herbicide.

INTRODUCTION

In Akita prefecture located in northern Japan, rice farmers who need labor saving and wish to increase scale of farming, are trying to adopt direct seeding cultivation in wet condition. However, with this method of planting, rice yields are five to ten percent lower than in mechanical transplanting, the main method used in rice production. Therefore, these farmers need improvements for stable and high yields in direct seeded rice.

Difficulties in direct seeding in northern Japan are reliable establishment of rice seedlings and control of weeds. To prevent bird

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damage, seeds are buried by mechanical seeder and in order to accelerate emergence of rice seedlings under oxidized soil condition, drainage is strongly recommended. The drainage duration is determined according to the degree of paddy soil reduction. When weed management during the drainage period was unsuitable, emergences of weeds would be accelerated and that of rice would be suppressed, resulting in inadequate herbicidal efficacy in one-shot herbicide applied after re-flooding, because of missing appropriate application time.

A granule herbicide combination product of prometryn 0.80% and thiobencarb 8.0% (PT) has been registered for direct seeded rice fields as pre- and post-emergence treatment during the drainage period just after seeding, with the recommended application rate ranging from 0.32 kg + 3.2 kg to 0.48 kg + 4.8 kg a.i.ha^{-1}. However, PT can cause accidental herbicidal injury to rice seedlings when surface water remains (Yamamoto and Kikuchi, 2006) through unexpected rain and inadequate drainage after seeding. It is necessary to prevent herbicidal injury without reducing herbicidal efficacy in PT for securing available time of one-shot herbicide application at the re-flooded time after drainage. Therefore, changes in herbicidal efficacy and injury with reduced application rate of PT were evaluated under field and greenhouse conditions in Akita prefecture, northern Japan.

MATERIALS AND METHODS

Influences of drainage of surface water on establishment of direct seeded rice applied with reduced rate of PT herbicide; Greenhouse examination

Thirty-four seeds of rice, *Oryza sativa* cv. Akitakomachi, coated with calcium peroxide were seeded to a depth of 5 mm in a plastic container (width: 30 cm, length: 40 cm, depth: 5 cm), and filled with puddled soil, on 13th May 2006. After seeding in a wet condition, PT was applied at a reduced rate of 0.16 kg + 1.6 kg a.i.ha^{-1} and a recommended rate with 0.32 kg + 3.2 kg a.i.ha^{-1}, respectively. An untreated control was included. Treatments were applied under drained or saturated with 2-3 mm of water conditions, with three replications. Number of emergence and leaf number of rice plants were measured at 5 (18th May) and 21 (3rd June) days after seeding (DAS), respectively.

Influences of reduced application rate of PT herbicide on herbicidal efficacy to major weed species under sequential application with one-shot herbicide; Field examination

Seeds of rice cv. Akitakomachi, coated with calcium peroxide were seeded in paddy fields of Gray Lowland soils on 15th May 2006, at a rate of 40 kg ha^{-1} in Nikaho city, Akita prefecture. Surface water was

drained after seeding for 15 days in order to accelerate emergence of rice and was irrigated again on 30th May. Two reduced rates of PT were applied, 0.16 kg + 1.6 kg and 0.24 kg + 2.4 kg, and the recommended rate of 0.32 kg + 3.2 kg a.i.ha^{-1}, including an untreated control on 17th May, at the beginning of the drainage period. One-shot herbicide, a granule of cyhalofop-butyl, pyrazosulfuron-ethyl, buromobutide and mefenacet, was applied sequentially on 10th June. Leaf number of weeds, injury to rice seedlings by visual examination and herbicidal efficacy for major species including barnyard grass (*Echinochola* spp.), needle spikerush (*Eleocharis acicularis*), false pimpernel (*Lindernia* spp.), bulrush *(Scirpus juncoides* var. *ohwianus*), *Monochoria vaginalis* var. *plantaginea* (hereafter *Monochoria*) and *Cyperus* spp. were evaluated 15 days after application of PT (2nd June) and 30 days after treatment of one-shot herbicide (10th July). There was no replication in this examination.

RESULTS

Greenhouse examination

Influence of reduced PT on rice establishment

Reduction in number of established rice plants by existence of surface water was not recognized for plots with reduced rate of PT at 5 DAS and 21 DAS as shown in Figures 1 and 2, respectively, though it was observed in the plot of recommended rate under saturated condition at 21 DAS (Fig. 2).

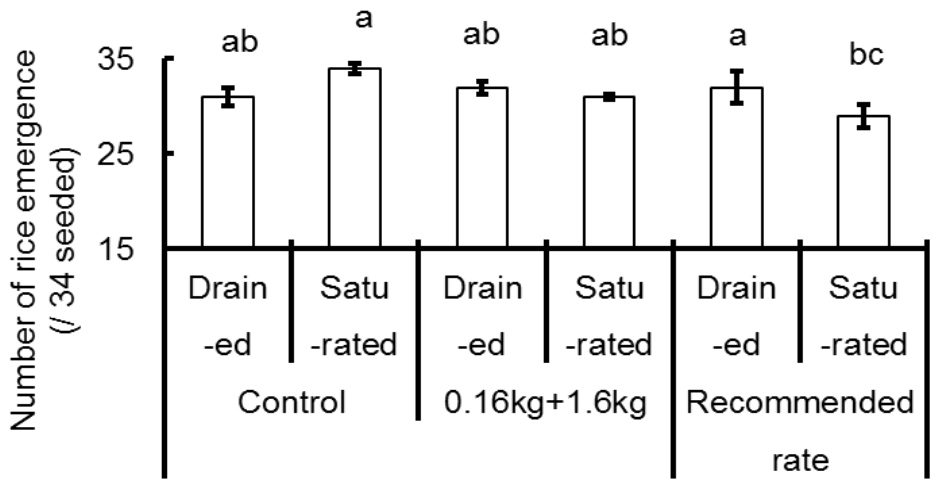

Figure 1. Influence of surface water and reduced application rate of PT to rice establishment at 5DAS. Bar indicates SE. Different letter indicate $p<0.05$, by Tukey's HSD test.

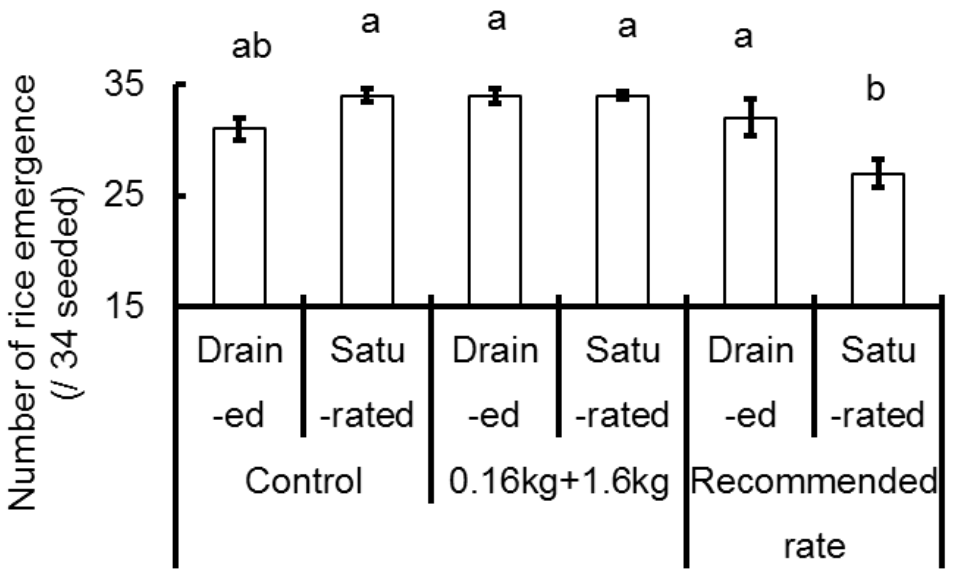

Figure 2. Influence of surface water and reduced application rate of PT to rice establishment at 21DAS. Bar indicates SE. Different letter indicate $p<0.05$, by Tukey's HSD test.

Influence of reduced PT on leaf number of rice seedlings

Leaf number of rice under reduced rate of PT was not influenced by existence of surface water at 5 DAS and 21 DAS as shown in Figures 3 and 4, whereas in the plots at the recommended rate at 5 DAS leaf number under saturated condition was suppressed compared to that under drainage condition (Figure 3).

Field examination

Growth stages of weeds at herbicide application

Weeds had not emerged at the time of PT application. At the application time of one-shot herbicide, leaf number of barnyard grass and bulrush were 2 and 1.5 for the plots of reduced rate of 0.16 kg + 1.6 kg a.i.ha^{-1} and control plots, respectively, and these weeds were not observed in the plots of reduced rate of 0.24kg + 2.4kg a.i.ha^{-1} and recommended rate (Table-1).

Efficacy of reduced application rate of PT

In the plot of 0.16 kg + 1.6 kg a.i.ha^{-1}, barnyard grass dry weight was suppressed by 92.3%, but bulrush was not suppressed, compared with the control. All weeds were controlled in the plots of 0.24 kg + 2.4 kg a.i.ha^{-1} and recommended rate (Table-2). Efficacy of reduced application of PT was considered as adequate to suppress weeds during the drained period except for bulrush in the plot of 0.16

kg + 1.6 kg a.i.ha^{-1}. At application time of one-shot herbicide, existence of barnyard grass, bulrush and *Monochoria* were observed in control plots (Table-2).

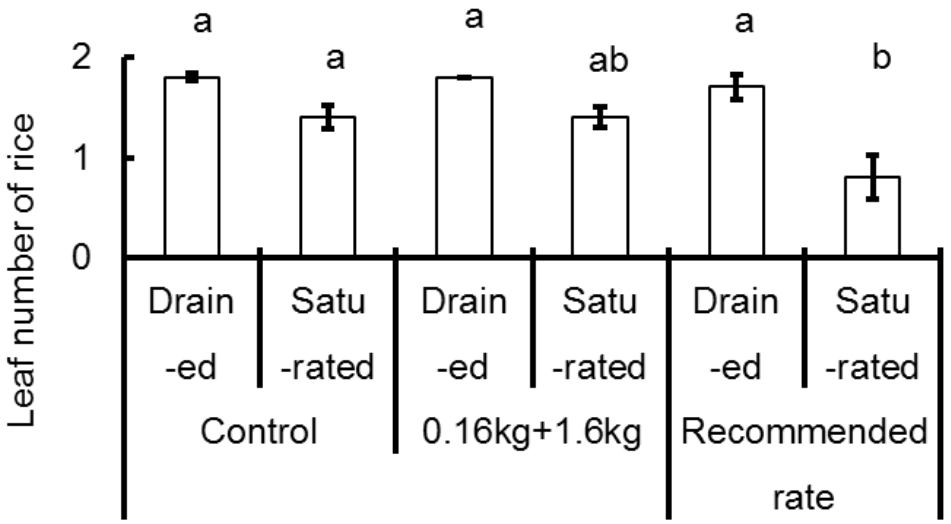

Figure 3. Influence of surface water and reduced application rate of PT on leaf number at 5DAS. Bar indicates SE. Different letter indicate p<0.05, by Tukey's HSD test.

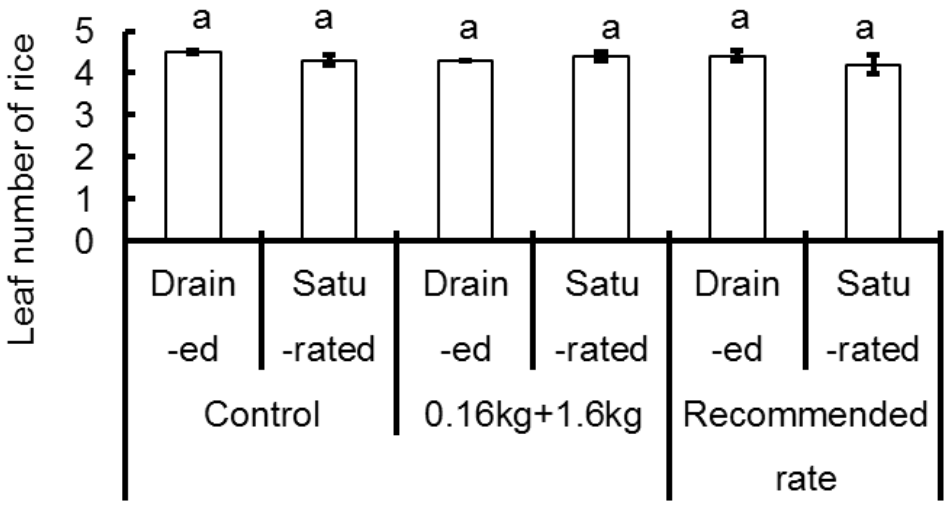

Figure 4. Influence of surface water and reduced application rate of PT on leaf number at 21DAS. Bar indicates SE. Different letter indicate p<0.05, by Tukey's HSD test.

Table-1. Leaf stages of weed at application time of one-shot herbicide

Application rate of PT* (kg + kg ha^{-1})	One-shot herbicide*	
	Barnyard grass	Bulrush
0.16 kg + 1.6 kg	2.0	1.5
0.24 kg + 2.4 kg	-	-
Recommended rate	-	-
Control	2.0	1.5

-: not found. *: see text

Table-2. Effect of reduced application rates of PT at 15 days after treatment before sequential application of one-shot herbicide*

Application rate of PT* (kg + kg ha-1)		Weed species				
		Barnyard grass	False Pimpernel	Bulrush	*Monochoria*	*Cyperus* spp.
0.16 kg + 1.6 kg	No.	62	0	6	0	0
	D.W.	0.1	0	0.02	0	0
0.24 kg + 2.4 kg	No.	0	0	0	0	0
	D.W.	0	0	0	0	0
Recommended Rate	No.	0	0	0	0	0
	D.W.	0	0	0	0	0
Control	No.	446	0	6	4	0
	D.W.	1.3	0	0.02	-	0

No. : Number of plant m^{-2} D.W. : Dry weight(gm^{-2}) - : below 0.01g * : see text

Efficacy of sequential application of one-shot herbicide

All weeds that survived PT applications of 0.16 kg + 1.6 kg and 0.24 kg + 2.4 kg a.i.ha^{-1} were suppressed by the sequential application of one-shot herbicide, as well as weeds in recommended rate. In the control plot, False pimpernel remained but total of weeds was suppressed by the one-shot herbicide to 2.8% in dry weight compared with the un-weeded plot (Table-3).

Injury to rice seedlings

In the plot of 0.16 kg + 1.6 kg a.i.ha^{-1}, injury in rice seedlings caused by PT was not observed, while it was observed slightly at 0.24 kg + 2.4 kg a.i.ha^{-1} and recommended rate (Table-4). Precipitation (50 mm) was recorded during the drainage period. However, aggravation caused by the rain was not observed.

Table-3. Efficacy of one-shot herbicide* with reduced application rates of PT at 30 days after treatment.

Application rate of PT* (kg + kg ha-1)		Weed species					
		Barnyard grass	Needle Spikerush	False pimpernel	Bulrush	*Monochoria*	*Cyperus* spp.
Un-weeded	No.	490	204	186	8	102	64
	D.W.	90.5	3.4	4.6	0.8	16	4.9
0.16 kg + 1.6 kg	No.	0	0	0	0	0	0
	D.W.	0	0	0	0	0	0
0.24 kg + 2.4 kg	No.	0	0	0	0	0	0
	D.W.	0	0	0	0	0	0
Recommended Rate	No.	0	0	0	0	0	0
	D.W.	0	0	0	0	0	0
Control	No.	0	0	220	0	0	0
	D.W.	0	0	3.4	0	0	0

No. : Number of plant m^{-2} D.W. : Dry weight(gm^{-2}) - : below 0.01g * : see text
Un-weeded was not applied herbicide at all.

Table-4. Visual evaluation of herbicidal injury of rice.

Application rate of PT* (kg + kg ha^{-1})	PT	One-shot herbicide*
0.16 kg + 1.6 kg	none	none
0.24 kg + 2.4 kg	slight	none
Recommended rate	slight	none
Control	none	none

*: see text

DISCUSSION

With reduced application of PT at 0.16 kg + 1.6 kg a.i.ha^{-1}, sufficient herbicidal efficacy was obtained with sequential application of one-shot herbicide. Injury to rice seedlings was also not observed regardless of drained or saturated soil surface at PT application time. In the plot of 0.16 kg + 1.6 kg a.i.ha^{-1}, bulrush survived until the application time of the one-shot herbicide, but it was controlled by successive application of the one-shot herbicide. As for false pimpernel, sequential application with reduced application of PT had equivalent efficacy to the sequential application with recommended rate of PT (Table-3).

Consequently, herbicidal efficacy of PT reduced from the rate of registered recommendation, preventing herbicidal injury to rice seedlings could be confirmed both in greenhouse and actual farmers'

fields of direct seeded rice in a wet condition. This method would contribute to labor saving and cost reducing in the direct seeded rice cultivation in Akita Prefecture. Further investigations on combination of sequential application of herbicide and methods to accelerate emergence of rice, are necessary to improve weed management procedures in direct seeded rice fields in northern Japan.

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