Estimation of both rice pollination rates under normal conditions at Tsukuba Japan and mixture rates between simulated GM rice and non-GM rice by co-use of harvester machine

Seiichiro Yonemura
National Institute for Agro-Environmental Sciences
yone@affrc.go.jp

Shigeto Kawashima
Kyoto University
sig@kais.kyoto-u.ac.jp

Hitoshi Ogiwara
National Agriculture and Food Research Organization/National Institute for Crop Sciences
ogi@affrc.go.jp

Hiroyuki Shibaike
National Institute for Agro-Environmental Sciences
shibaike@affrc.go.jp

Abstract

Intensive studies supported by MAFF Japan are now under way to model co-existence of GM crops under actual field conditions. In this project, the Kawashima-Shibaike model, whose basic structure consists of a plume diffusion model developed to simulate rice pollination processes for 4 years of intensive field investigations. Application of the model to normal conditions at Tsukuba showed that threshold pollination level 0.1% can be achieved under normal conditions without any measures to be taken, when areas of GM rice and non-GM rice are between 0.1ha and 1ha. At the same time, this paper reports mixture between simulated GM rice and non-GM rice during harvesting processes with co-usage of harvesters.

Introduction

Rice is a major crop in Asia and supports more than a billion people. Because international trade of rice is not large compared with other commercial crops such as wheat, rice was not the first GM crop to be commercialized. However, now GM rice is about to become a commercial target. Although rice is principally autogamous, a certain level of pollination exists between GM and non-GM rice.

Different from the EU regulation of 0.9% threshold (an example is maize whose pollen pollinate in farther fields), it may be expected that a lower threshold can be regulated for rice. To reveal the environmental impacts of GM rice, it is necessary to understand pollination processes through modeling. Intensive studies supported by Ministry of Agriculture, Forestry, and Fisheries (MAFF Japan) are now under way to model (using the Kawashima-Shibaike model, whose basic structure consists of a plume diffusion model developed to simulate pollination processes) 4 years of intensive field investigations, using data of cross-pollination of two varieties of non-GM rice.

Currently, in this study, we have set the threshold of pollination rates to be 0.9%-0.1% and calculated necessary isolation distances to be less than the threshold.

Furthermore, pollination processes in the field are not the result of a unique source of mixture between donor and recipient. Mixture between donor rice and recipient rice during harvesting processes with co-usage of a harvester is probably of secondary importance in the process of admixture. So, this paper reports mixture between simulated GM rice and non-GM rice during harvesting processes with co-usage of harvesters.

Kawashima-Shibaike (KS) Model and calculation conditions

KS model (Kawashima, 2006) is a relatively simple model to simulate pollination processes and then the cross-pollination rates of rice plants in fields. The basic structure of the model is the plume model that has been applied to the diffusion of atmospheric pollutants. Time in the model is measured in 1-hour increments and detailed flowing processes can be put into the model, which markedly differs from models developed in other countries such as MAPOD, that has daily time increments. The model assumes that the pollen emission is proportional to increasing air temperature. This assumption is well supported by the common knowledge that rice flowers around noon.

Meteorological and biological data, including density or number of flowers, as well as physical data including wind direction and speed, temperature, humidity, and precipitation were all put into the model.

We calculated the cross-pollination in the model under two types of conditions namely, normal cross-pollination and potential cross-pollination. The basic meteorological and biological parameters were taken from a 2005 experiment that showed the highest cross-pollination rates throughout 4 years of experiments conducted for the National Institute for Agro-Environmental Sciences. Varieties of the

donor and recipient in the experiments were Nipponbare and Heiseimochi, respectively.

The simulation of the normal cross-pollination was conducted under representative conditions with changes in magnitude of donor and recipient fields and the difference of flowering period of the donor and the recipient. The potential cross-pollination assumes optimistic conditions for the cross-pollination besides those of the normal cross-pollination. Continuous winds of 2ms^{-1}, were modeled from the donor to recipient field. The potential cross-pollination under this situation can be used as the most dangerous level of cross-pollination.

Under the two conditions, we calculated the isolation distance necessary for each condition and prepared a table.

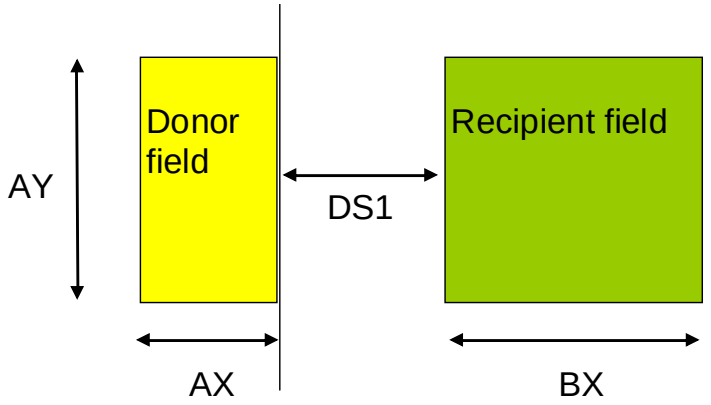

Fig.1 Spatial diagram of the calculation

We show a spatial diagram of the calculation in Fig.1. Three types (10a, 50a, 1ha) of the magnitude of the field were set by 10a (AX=30m, AY=40m), 50a (AX=50m, AY=100m), and 1ha (AX=70m, AY=140m).

Results and Discussion

Pollination

It was found that a threshold pollination level of 0.1% can be achieved for all situations under normal conditions without any measures being taken, when areas of donor rice and recipient rice are between 0.1ha and 1ha--all thresholds pollination rates were 0m. However, it should be noted that some measures are necessary to control thresholds under 0.1-0.01%.

Table 1 Determination table of isolation distance under set threshold of pollination rate

Area of donor	Area of recipient	Difference of flowing period	Threshold of pollination rate 5%	3%	0.9%	0.5%	0.1%
10a	10a	0-2	0 m	0 m	0 m	14m	51m
		4-6	0 m	0 m	0 m	0 m	22m
		8-	0 m	0 m	0 m	0 m	0 m
	50a	0-2	0 m	0 m	0 m	8m	45m
		4-6	0 m	0 m	0 m	0 m	17m
		8-	0 m	0 m	0 m	0 m	0 m
	1ha	0-2	0 m	0 m	0 m	5m	39m
		4-6	0 m	0 m	0 m	0 m	11m
		8-	0 m	0 m	0 m	0 m	0 m
50a	10a	0-2	0 m	0 m	7m	18m	57m
		4-6	0 m	0 m	0 m	0 m	27m
		8-	0 m	0 m	0 m	0 m	0 m
	50a	0-2	0 m	0 m	2m	12m	51m
		4-6	0 m	0 m	0 m	0 m	21m
		8-	0 m	0 m	0 m	0 m	0 m
	1ha	0-2	0 m	0 m	0 m	7m	44m
		4-6	0 m	0 m	0 m	0 m	14m
		8-	0 m	0 m	0 m	0 m	0 m
1ha	10a	0-2	0 m	0 m	8m	20m	60m
		4-6	0 m	0 m	0 m	0 m	29m
		8-	0 m	0 m	0 m	0 m	0 m
	50a	0-2	0 m	0 m	3m	14m	52m
		4-6	0 m	0 m	0 m	0 m	23m
		8-	0 m	0 m	0 m	0 m	0 m
	1ha	0-2	0 m	0 m	0 m	9m	47m
		4-6	0 m	0 m	0 m	0 m	17m
		8-	0 m	0 m	0 m	0 m	0 m

Even in the potential pollination scenario, no measure was necessary to control pollination rates at the threshold of 3% (Table 1). Among the measures considered, the most effective was to stagger the flowering period. This can be achieved by staggering transplantation or using different varieties. When the flowering period was 8 days apart, other measures were not necessary. The values (isolation distance) were not sensitive to the area of the donor. Of course, the spatial diagram is very important, it can be said that a donor far from the recipient rice is not as effective at cross-pollinating.

Mixture by the co-use of harvester

Three years of investigations show that the mixture rates in regard to harvested rice differ exponentially. The mixture rates after cleaning harvesters was one tenth of that without cleaning.

Table 2 Determination table for co-use of harvester

Cleaning	Running distance	Threshold of mixture rate 5%	3%	0.9%	0.5%	0.1%
No cleaning	100m	0m	0m	0m	0m	10m
	200m	0m	0m	0m	0m	10m
	500m	0m	0m	0m	0m	0m
	1000m	0m	0m	0m	0m	0m
Cleaning	100m	0m	0m	0m	0m	0m
	200m	0m	0m	0m	0m	0m
	500m	0m	0m	0m	0m	0m
	1000m	0m	0m	0m	0m	0m

We calculated how long the harvester should be run, discarding the harvested rice over the distance- the 'discard distance' is necessary to control mixture levels below the threshold of 0.1% (Table 2). This is an analogy to the pollination process (Table 1). Under cleaning conditions, no discard distance is necessary. Even 0.01% mixture levels can be achieved with cleaning. If there was no cleaning of harvesters, discard distances of more than 500m was necessary.
When farmers planted two different rice varieties, it is improbable that harvesting is done without cleaning. So, it can be said that with normal use of harvesters cause high contamination (mixture) of harvested rice seeds does not occur.

References

Kawashima, S, 2006, Modeling and Simulation of Pollen Dispersal and Hybridization processes, *Proceedings of the NIAES International Symposium 2006*, Dec. 12-14, 2006, Tsukuba, Japan, pp. 190-200.