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Effect of Deep-Flood Irrigation on Grain Quality, Yield and Root Activity in Rice

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To minimize the deterioration of grain quality caused by the high temperature stress in ripening stage is an important agronomical issue in rice cultivation. Field trial was conducted to investigate effects of deep-flood irrigation on growth and quality of rice under high and normal ripening temperature. The experiment was carried out at the paddy field in Niigata, Japan, using three rice cultivars (Hatsuboshi, Sasanishiki and Koshihikari). Two water management regimes were prepared (Figure1): DFI (deep-flood irrigation; water level was kept in 18 cm from active tillering to maximum tiller stage) and CWI (conventional water irrigation). DFI decreased inferior tillers (Figure2), resulting in higher percentage of tillers that produce mature grains (Figure3). Although DFI decreased the number of panicles, it increased the number of grains per panicle and thousand grain weight of brown rice, hence yielded equal to the CWI plot (Table1). In addition, DFI decreased occurrence of chalky grains (Figure4) due to suppression of milky white grains rather than white belly or basal white (data not shown). This effect was observed both under high temperature treatment (open top chamber) and normal temperature conditions, suggesting to be an effective method to overcome deterioration effect of high ripening temperature. The more sensitive the cultivar is to high temperature, the higher the DFI effect is to reduce grain deterioration. However, it should be noted that DFI start after production of enough number of tillers. Otherwise, yield will be decreased for a shortage of tillers. On the basis of the results of four years, three hundred and thirty tillers m^{-2} may need to get equal level of yield to the conventional cultivation while reducing deteriorated grains. The effect of DFI on the root activity will be also discussed in the present study.

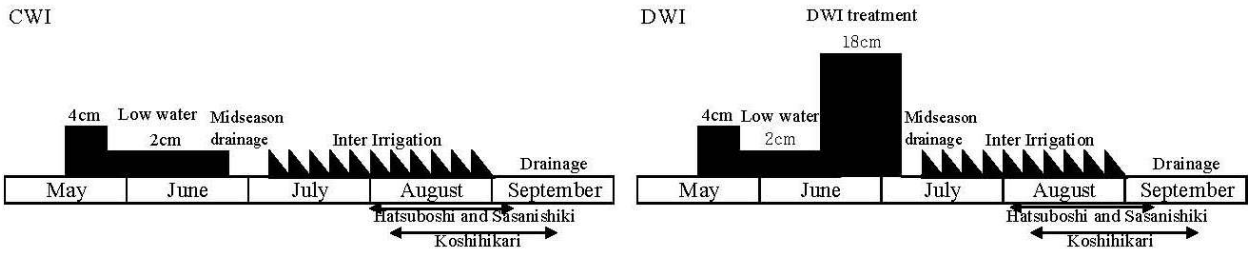

Figure 1. Water management of CWI and DWI.

⟷ indicates ripening perid.

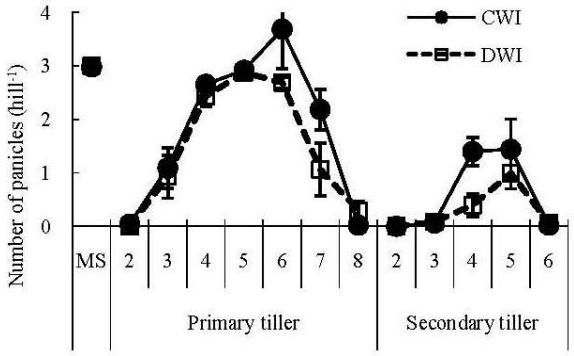

Figure 2. Number of panicles derived from different positions of tillers (Hatsuboshi).

Three plants were grown in a hill. MS indicates main stem.

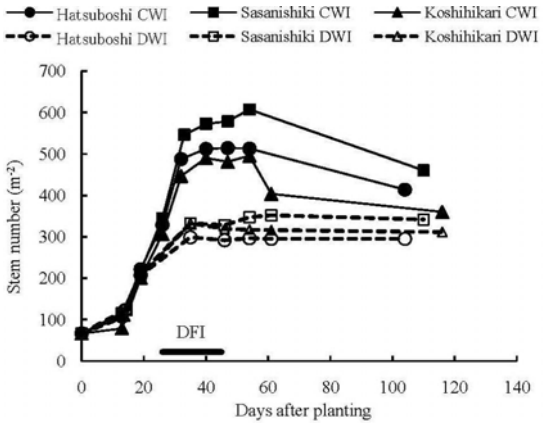

Figure 3. Time course of stem number differences in three cultivars grown under different water management (2004).

Table 3. Effect of water management on the grain yield (brown rice) and its determining components in three cultivars (average of four years).

Cultivar	Water management	Grain yeild	Number of panicles	Number of grains per panicle	1000-grain weight	Ripening percentage	Number of grains per area
		(kg m^{-2})	(m^{-2})		(g)	(%)	(100 m^{-2})
Hatsuboshi	CWI	0.485	381	68.8	23.0	89.4	248
	DWI	0.463	307	74.3	23.8	91.9	214
	DWI/CWI (%)	95.4	80.6	108.1	103.5	102.8	86.2
Sasanishiki	CWI	0.504	414	83.4	21.1	82.4	322
	DWI	0.524	348	97.1	22.1	87.3	313
	DWI/CWI (%)	103.9	84.0	116.4	104.7	106.0	97.2
Koshihikari	CWI	0.497	346	86.1	20.8	90.6	282
	DWI	0.504	308	96.5	21.3	89.3	282
	DWI/CWI (%)	101.4	89.1	112.0	102.4	98.5	99.9
Average	CWI	0.496	380	79.4	21.7	87.5	284
	DWI	0.497	321	89.3	22.4	89.5	269
	DWI/CWI (%)	100.3	84.4	112.4	103.5	102.3	94.9
Water management		ns	*	**	*	ns	ns
Cultivar		ns	***	***	***	ns	***
Water management×Cultivar		ns	ns	ns	ns	ns	ns

*, ** and *** indicate significance at P<0.05, 0.01 and 0.001, respectively. ns indicates not significant.

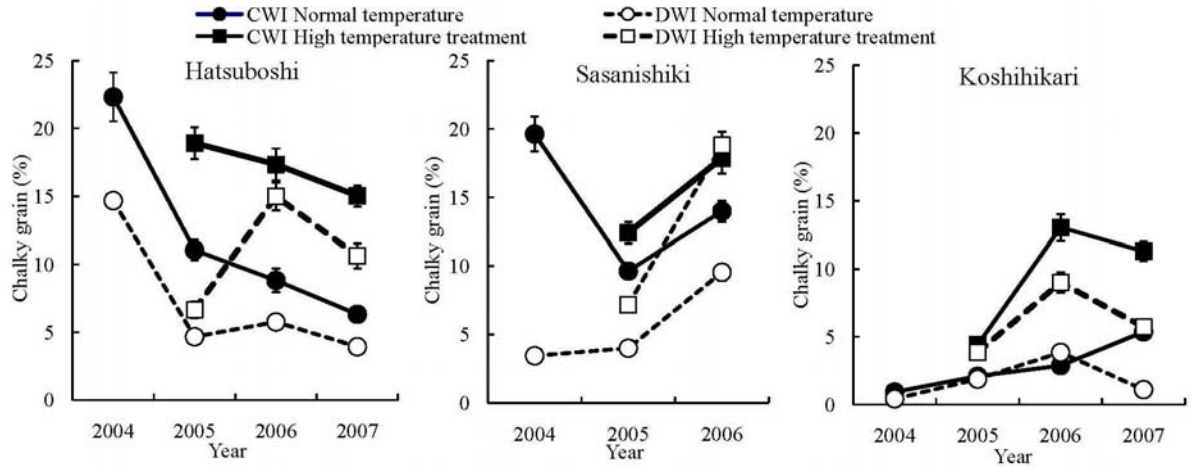

Figure4. Effect of water management and high temperature treatment on the occurrence of chalky grain in three cultivars for four years.