Agronomic Traits Associated with Rapid Canopy Establishment in Transplanted Rice

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ABSTRACT

Five popular improved varieties, 17 introgression lines and a donor parent, *Oryza glaberrima,* and 5 weedy-rice derived lines were evaluated for canopy establishment at the experimental field of the KU-Honda Project, Kasetsart University, Kamphaengsaen, Nakhon Pathom province during 2008 dry season. In addition, the possible contribution of plant height, tiller number, number of leaves and leaf area to rapid canopy establishment (RCE) was analyzed and determined. A wide variability in rate of canopy establishment among the 28 test varieties and lines was shown by significant differences in percent reduction of photosynthetically active radiation (PAR) within the canopy at 30 and 35 days after transplanting (DAT). Four weedy-rice derived lines, WR1-38, WR1-55, WR1-61 and WR4-14, and 2 improved varieties, IR 64 and Suphan Buri 1, showed rapid canopy establishment with more than 50% PAR reduction starting at 30 days after transplanting. The improved variety Phitsanulok 2 and four introgression lines (SV2F7-06, SV2F7-07, SV2F7-12 and SV3F6-01) also showed rapid canopy establishment but only at 35 DAT. Tiller number, number of leaves and leaf area were positively correlated to light reduction within the canopy at 35 days after transplanting with r=0.62**, r=0.37** and r= 0.51**, respectively. Plant height, on the other hand, did not contribute to light reduction within the canopy. Grain yield appeared to be independently inherited of RCE and can be combined in any variety. All these results indicate that rapid canopy establishment can be used as a selection index in the breeding of improved rice varieties for weed competitiveness.

Key words: plant canopy, canopy establishment, light reduction, weed competition

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Introduction

Weeds are a major constraint to rice production. Yield loss of up to 35% due to weed infestation has been reported in the tropics (Oerke and Dehne, 2004). In Thailand, yield loss due to weeds in transplanted rice amounts to 9.83 % (Chinawomg and Suwanketnikom, 2001). Weeding in rice is labour intensive and requires 2-3 repeated hand weeding per cropping season.

The use of herbicide has dramatically increased during the last 20 years in most of the major rice producing countries of Asia including China, India, Indonesia, Philippines, Thailand and Vietnam due to rising labour cost and the increasing efficacy and availability of herbicides. For instance, the cost of herbicide imported to Thailand in 1996 and 2003 was 2,444.00 and 6,101.00 million baht, respectively (Anon, 2004). However, while chemical control of weeds has been proven effective in most cases, there is a need to reduce herbicide application to reduce cost of production; protect the environment, and minimize the development of herbicide resistance in weeds (Heap, 2006).

A promising approach to weed control in rice is the use of improved varieties with enhanced weed competitive ability. The approach not only promotes sustainable agriculture but is environmentally friendly, cost effective and can readily be integrated into the farmers proven cultural practices (Gibson and Fischer, 2001). Some of the agronomic traits that have been suggested to increase weed competitive ability in transplanted rice include early germination, seedling vigour and early seedling recovery associated with rapid growth after transplanting.

The weed competitiveness of a variety depends primarily on its ability to compete with the weeds for growing space, light, water and nutrients. In this paper, the importance of rapid canopy establishment (RCE) as an agronomic trait that gives rice an edge over weeds in competing for space and light is explored. The study aims to develop a method by which RCE can be correctly measured and establish the relationships of plant height, tiller number, number of leaves and leaf area with rapid canopy establishment.

Materials and Methods

The study was conducted at the experimental field of the KU-Honda Project, Kasetsart University, Kamphaengsaen, Nakhon Pathom province from December, 2007 to March 2008 (dry season cropping).

Test varieties and lines

Improved varieties

Suphan Buri 1, Phitsanulok 2, IR 24, IR 64 and Koshihikari were used. These varieties are not only high yielding but also very popular with farmers. Suphan Buri 1 and Phitsanulok 2 were developed in Thailand while IR 24 and IR 64 were released from IRRI (International Rice Research Institute) Philippines. Koshihikari is a japonica variety, very popular in Japan. None of these varieties were previously evaluated for RCE.

Introgression lines and its donor parent

The African cultivated rice, *Oryza glaberrima*, and 17 of its advanced (BC_nF_5-BC_nF_7) introgression lines are included in the group. *O. glaberrima* has long been known for its extra ordinary vigour and rapid growth and a good donor parent for weed competitiveness. The 17 introgression lines, on the other hand, were selected from a total of 69 lines on the basis of their observed early recovery and fast growth after transplanting.

Weedy-rice derived lines

This included 5 advanced weedy-rice derived lines developed from a weedy rice plant collected from Kanchanaburi province, The lines have not only the good agronomic traits of improved varieties and but also high yielding potential (5-7 t/ha). In addition, these lines exhibited traits (grain aroma and brown planthopper resistance) suspected to have been inherited from the wild rice parent. Like the introgression lines from *O. glaberrima*, the weedy-rice derived lines showed early recovery and fast growth after transplanting.

Evaluation for rapid canopy establishment

In this study, the percent reduction of photosynthetically active radiation (PAR) passing through the plant canopy was used as an indicator of the plant's rate of canopy establishment. A variety or line effecting >50 % PAR reduction within a specific period (days after transplanting), can be scored as exhibiting relatively rapid canopy establishment compared with varieties and lines showing <50 % PAR.

Percent PAR reduction was computed using the formulae (1-BC/AC) x 100 where: BC is the total photosynthetic photon flux density (PPFD) expressed as $\mu mol/m^2/s^1$ at the ground level while AC is the total incident PPFD above the rice canopy. PPFD was measured from 3 pre-determined locations in the experimental plots using a line quantum sensor (Apogee Instruments Model LQS-QM) starting at 10 days after transplanting and repeated at 5 days interval.

Measurements for morphological traits

Data for plant height, tiller number and the number of leaves, leaf length and width (primary tiller) were taken from 4 pre-selected plants in each experimental plot. Measurement for the traits was initiated 10 days after transplanting (DAT) and repeated at 5 day intervals until maximum tillering stage. Grain yield was obtained from 20 plants within a square meter sampling area per plot.

Experimental design and data analysis

A randomized complete block design (RCBD) with 3 replications was used in the experiment. Plot dimensions were 2.0 x 2.4 m. Each plot consisted of 8 rows, 0.25 m apart, with 12 hills per, row spaced at 0.20 m. Rice seedlings were grown in raised wet beds and transplanted into the plots at 21 days after sowing.

Analysis of variance (ANOVA) was used to determine the differences among entries used in the experiment. Differences among means were compared by Duncan's Multiple Range Test (DMRT) at 5 % level when ANOVA revealed significant differences among treatments. Pearson correlation coefficients were calculated for the agronomic traits and percent PAR reduction to draw inferences on the relationship between the measured agronomic traits and light interception. All the statistical analysis was performed using the SAS statistical package (Anon, 1987).

Results and Discussion

Rate of canopy establishment

Canopy establishment refers to the growth stage of the crop when plant canopy starts to develop until it becomes fully closed. In transplanted rice, canopy establishment starts from transplanting and is generally completed at maximum tillering stage. Though canopy establishment (number of days) of any rice variety can be determined, it maybe very difficult to measure directly the rate in which plant canopy is established per unit time. In this study, the percent PAR reduction below the plant canopy was used to estimate the rate of canopy establishment of the test varieties and lines. Those which gave more than 50 % PAR reduction at the shortest time from transplanting were classified as having rapid canopy establishment while varieties and lines showing less than 50 % PAR reduction were designated to have slow canopy establishment (SCE).

The mean percent PAR reduction of the 28 test varieties and lines at 30 and 35 days after transplanting (DAT) is shown in Table 1. Though there were significant differences for percent PAR reduction among the varieties and lines at 30 DAT, only 2 varieties (IR 64 and Suphan Buri 1) and four weedy-rice derived lines (WR1-38, WR1-55, WR1-61 and WR4-14) showed more than 50 % PAR reduction and can be classified as having RCE. However, the weedy-rice derived lines showed significantly faster rate of canopy establishment compared to the improved varieties, IR 64 and Suphan Buri 1 (Table 1).

At 35 DAT, all the 28 varieties and lines showed an increase in canopy establishment. At this stage, 1 additional variety (Phitsanulok 2) and 4 introgression lines (SV2F7-06, SV2F7-07, SV2F7-12 and SV3F6-01) registered a PAR reduction of more than 50 % and classified to have RCE. Among the 11 varieties and lines positively scored for rapid canopy establishment at 35 DAT, the 4 weedy-rice derived lines still showed significantly faster canopy establishment than the 3 improved varieties and 4 introgression lines.

Weed competition and cultivar differences for weed competitiveness have been extensively studied in wheat (Challaiah *et al.*, 1986; Blackshaw, 1994; Lemerle *et al.*, 2001), barley (Christensen, 1995), soybean (Jannink *et al.*, 2000), and rice (Garrity *et al.*, 1992; Ni *et al.*, 2000; Fischer *et al.*, 2001; Haefele *et al.*, 2004). Unfortunately, no investigation has so far been done in rice dealing with canopy structure. Increasing interest on RCE as a trait for increasing weed competitiveness in rice has been observed in recent years. This is premised on the hypothesis that a variety that can close its canopy at the shortest time after transplanting has greater chance of out-growing weeds.

The results clearly showed variability for rapid canopy establishment in the varieties and lines used. It also proved that by inference, % PAR reduction taken below the plant canopy can successfully identify rice germplasm with slow or rapid canopy establishment at any growth stage from transplanting. This technique can be used in future breeding program aimed at incorporating RCE in improved varieties.

Morphological traits and RCE

Plant height and tiller number

Clear significant differences for height were observed at both growth stages. Plant height of the test materials ranged from 41.93 to 63.31 cm and 41.45.77 to 70.95 cm at 30 and 35 DAT, respectively, with all the varieties and lines showing an increase in height from 30 to 35 DAT (Table 2). There was no clear relationship between RCE and plant height. At 35 DAT, most of the significantly tall and short test entries had slower canopy establishment while those with RCE had intermediate plant height.

Significant differences in tiller number were also observed among the 28 varieties and lines at 30 and 35 DAT (Table 2). As in plant height, all the test entries showed an increase in tiller number from 30 to 35 DAT. Tiller number ranged from 6.25 to 16.58 and 6.50 to 19.92 at 30 and 35 DAT, respectively. In general, test entries with significantly high tiller number have RCE. Except for WR4-14, there was no significant difference in the tiller number among the weedy-rice derived lines and the improved varieties (IR 64, Suphan Buri 1 and Phitsanulok 2) identified to have RCE. Similarly, the 4 introgression (SV2F7-06, SV2F7-07, SV2F7-12 and SV3F6-01) lines showing RCE showed no significant difference in tiller number but significantly lower than the weedy-rice derived lines and improved varieties showing RCE.

Leaf number and leaf area

The mean leaf number of the 28 varieties and lines at 30 and 35 DAT is presented in Table 3. Except for two test entries (*O. glaberrima* and SV2F7-03) which did not show any increase in leaf number during the 5-day period, all the other test materials registered a positive growth for the trait at 35 DAT. Leaf number of the varieties and lines ranged from 2.08 to 3.5 at 30 DAT and 2.08 to 4.08 at 35 DAT. Significant differences for leaf number were small among the test entries both at 30 and 35 DAT. However, the 11 varieties and lines showing RCE have generally more leaves than the varieties and lines with SCE.

The twenty eight varieties and lines vary significantly for leaf area at 35 DAT with leaf area ranging from 26.71 to 747.20 cm (Table 3). As in leaf number, two entries registered an almost zero increase in leaf area while the rest showed either a moderate or very significant increase during a 5-day

Table 1. Mean percent PAR (photosynthetically active radiation) reduction in the test varieties and lines at 30 and 35 DAT *

Varieties/lines	Mean PAR Reduction (%)			
	30 DAT		35 DAT	
IR 24	36.66	fghi	39.79	ghi
IR 64	55.25	bc	61.50	abcde
Suphan Buri 1	53.62	bcd	60.10	abcdef
Phitsanulok 2	38.55	efghi	52.11	cdefgh
Koshihikari	23.60	j	31.17	i
O. glaberrima	23.84	j	32.14	i
WR1-38	67.86	a	73.43	a
WR1-55	69.09	a	72.01	ab
WR1-61	61.07	ab	63.61	abcd
WR4-14	54.64	bcd	66.84	abc
WR4-16	45.26	cdefg	48.24	defghi
SV1F8-01	36.66	fghi	45.71	efghi
SV2F7-01	37.69	fghi	45.30	efghi
SV2F7-02	39.49	efghi	45.11	efghi
SV2F7-03	37.89	fghi	44.80	efghi
SV2F7-04	36.19	fghi	37.42	hi
SV2F7-05	27.82	ij	40.00	ghi
SV2F7-06	46.60	cdef	50.62	cdefgh
SV2F7-07	43.43	defgh	50.95	cdefgh
SV2F7-08	38.94	efgh	43.48	fghi
SV2F7-09	42.09	efgh	48.24	defghi
SV2F7-10	34.47	ghij	40.89	ghi
SV2F7-11	29.11	ij	48.38	defghi
SV2F7-12	50.00	cde	56.14	bcedfg
SV3F6-01	45.39	cdefg	52.20	cdefgh
SV3F6-02	37.05	fghi	39.75	ghi
SV3F6-03	37.09	fghi	37.66	hi
SV3F6-04	32.40	hij	37.74	hi

Means in the same column followed by a common letter are not significantly different at the 5 % level by DMRT.

DAT = days after transplaning

Table 2. Mean plant height and tiller number of the test varieties and lines at 30 and 35 DAT

Varieties/lines	Plant height (cm)				Tiller number			
	30 DAT		35 DAT		30 DAT		35 DAT	
IR 24	42.08	j	46.27	j	10.75	cdefg	13.17	cd
IR 64	46.77	ij	51.80	i	15.83	ab	18.50	a
Suphan Buri 1	53.38	defg	59.90	fgh	14.75	abc	17.75	ab
Phitsanulok 2	41.93	j	46.95	j	16.58	a	19.92	a
Koshihikari	53.03	defgh	53.03	i	9.17	defg	11.08	cdef
O. glaberrima	45.77	ij	45.77	j	6.50	g	6.50	g
WR1-38	50.85	fghi	56.24	hi	16.50	a	18.08	a
WR1-55	51.58	efghi	56.40	hi	14.83	abc	17.50	ab
WR1-61	51.31	fghi	55.82	hi	12.92	abcde	12.92	cd
WR4-14	55.02	cdefg	62.51	cdef	15.00	abc	18.25	a
WR4-16	46.14	ij	53.25	i	10.50	cdefg	13.17	cd
SV1F8-01	59.00	abcd	68.49	ad	6.25	g	8.50	efg
SV2F7-01	57.14	bcdef	67.49	abc	10.00	defg	11.92	cde
SV2F7-02	54.97	cdefg	64.91	bcdef	8.83	defg	10.42	cdef
SV2F7-03	57.74	abcde	67.12	abc	8.50	efg	10.92	cdef
SV2F7-04	61.13	abc	68.48	ab	6.67	g	7.33	fg
SV2F7-05	48.95	ghi	56.78	ghi	8.83	defg	11.00	cdef
SV2F7-06	60.76	abc	68.53	ab	13.42	abcd	13.08	cd
SV2F7-07	54.37	defg	61.70	defg	13.42	abcd	14.33	bc
SV2F7-08	55.54	cdef	64.28	bcdef	10.00	defg	12.00	cde
SV2F7-09	62.53	ab	70.95	a	8.50	efg	11.08	cdef
SV2F7-10	55.98	cdef	64.62	bcdef	11.67	bcdef	13.25	cd
SV2F7-11	47.06	hij	54.14	i	11.67	bcdef	12.42	cde
SV2F7-12	54.84	cdefg	61.54	efg	10.50	cdefg	11.83	cde
SV3F6-01	55.11	cdefg	67.00	abcd	8.67	efg	11.08	cdef
SV3F6-02	56.58	cdefg	66.04	abcde	9.92	defg	11.17	cdef
SV3F6-03	59.32	abcd	67.49	abc	7.75	fg	9.25	cdef
SV3F6-04	63.31	a	69.63	ab	10.25	defg	11.00	cdef

Means in the same column followed by a common letter are not significantly different at the 5 % level by DMRT.

DAT = days after transplaning

growth period from 30 to 35 DAT. There was also no clear relationship between leaf area and RCE. Though the 11 varieties and lines have significantly high leaf area, they vary significantly for the trait. Interestingly, one introgression line (SV2F7-10) showing SCE gave the highest leaf area (747.20) putting one of the fastest canopy establishing weedy-rice derived lines only as second. It is suspected that at this growth stage (30 and 35 DAT), leaf position (droopiness or erectness) has more influence on canopy establishment than leaf area.

Correlation analysis with percent PAR reduction

Pearson correlation coefficients were calculated for all the morphological traits and % PAR reduction to clearly establish the relationships between the morphological traits and RCE. Tiller number, leaf number and leaf area was found to be positively correlated with percent of PAR reduction within the canopy with r = 0.62**, r = 0.37** and r = 0.51**, respectively. On the other hand, no association between plant height and percent PAR reduction was established (Table 4).

Khush (1996) stated that the competitive ability in rice is often associated with traits related to light capture. Jennings and Aquino (1968) reported plant height and tiller number can be highly correlated with competitive ability. Fischer *et al.* (1995, 1997), on the other hand, associated leaf area index (LAI) and tiller production, but not height, with competitive ability in irrigated rice cultivars. Similarly, Johnson *et al.* (1998) reported that instead of taller plants, most competitive cultivars have larger leaf weight, greater specific leaf area, and earlier production of tillers compared with the less-competitive ones. Though most researchers agreed that tiller number contribute to weed competitiveness, Garrity *et al.* (1992) and Kawano *et al.* (1974) argued that the trait is not associated with weed competitive ability of rice varieties.

The results of the present study not only confirmed the contributions of tiller number, leaf number and leaf area to the weed competing ability of rice varieties but most importantly provided insights on how early and rapid development of these morphological parts of the rice plant can be detected and used to increase weed competitiveness (Kropff *et al.*, 1993; Rajan *et al.*, 1995; Ni *et al.*, 2000). Using percent PAR reduction below the plant canopy to estimate rate of canopy estab-

Table 3. Mean leaf number and leaf area of the test varieties and lines at 30 and 35 DAT

Varieties/lines	Leaf number				Leaf area (cm)			
	30 DAT		35 DAT		30 DAT		35 DAT	
IR 24	3.08	abc	3.33	cdef	236.30	a	367.90	cdefg
IR 64	3.50	a	3.92	abc	228.10	a	310.18	fghi
Suphan Buri 1	3.33	ab	3.42	bcdef	284.70	a	326.80	fghi
Phitsanulok 2	3.00	abc	3.75	abcd	307.00	a	348.60	efgh
Koshihikari	2.75	c	3.00	f	90.50	a	90.54	jk
O. glaberrima	2.08	d	2.08	g	26.70	a	26.71	k
WR1-38	3.42	a	4.00	ab	270.50	a	500.54	bcde
WR1-55	3.33	ab	4.00	ab	433.69	a	625.50	ab
WR1-61	3.42	a	4.08	a	308.80	a	441.94	defg
WR4-14	3.17	abc	3.92	abc	244.40	a	333.06	fghi
WR4-16	3.00	abc	3.75	abcd	223.90	a	352.58	efg
SV1F8-01	3.00	abc	3.50	abcdef	232.00	a	321.67	fghi
SV2F7-01	3.00	abc	3.75	abcd	180.90	a	261.30	ghi
SV2F7-02	3.00	abc	3.58	abcdef	197.30	a	237.93	hi
SV2F7-03	3.25	abc	3.25	ef	308.59	a	454.10	bcdef
SV2F7-04	2.83	bc	3.92	abc	252.30	a	395.15	defg
SV2F7-05	3.00	abc	3.42	abcdef	282.29	a	482.00	bcdef
SV2F7-06	3.17	abc	3.83	abcd	229.70	a	333.94	efgh
SV2F7-07	3.00	abc	3.75	abcd	182.70	a	323.99	fghi
SV2F7-08	3.00	abc	3.42	abcdef	280.05	a	413.30	defg
SV2F7-09	3.00	abc	3.25	def	274.40	a	365.41	egf
SV2F7-10	3.00	abc	3.83	abcd	457.78	a	747.20	a
SV2F7-11	3.08	abc	3.75	abcd	216.00	a	339.16	efgh
SV2F7-12	3.08	abc	3.75	abcd	338.06	a	610.80	abc
SV3F6-01	3.00	abc	3.33	cdef	267.48	a	390.00	cdefg
SV3F6-02	3.08	abc	3.67	abcde	203.90	a	255.37	ghi
SV3F6-03	3.00	abc	3.25	def	156.60	a	179.76	ij
SV3F6-04	3.08	abc	3.33	cdef	200.15	a	542.00	abcd

Means in the same column followed by a comon letter are not significantly different at the 5 % level by DMRT.

DAT = days after transplaning

Table 4. Pearson correlation coefficient between PAR reduction and morphological traits at 30 DAT (above diagonal) and 35 DAT (below diagonal)

	PAR		PH		TN		LN		LA	
PAR			0.01	NS	0.58	**	0.52	**	0.12	NS
PH	-0.06	NS			-0.24	*	0.02	NS	-0.01	NS
TN	0.62	**	-0.28	**			0.49	**	0.19	NS
LN	0.37	**	0.13	NS	0.43	**			0.29	**
LA	0.51	**	0.16	NS	0.43	**	0.70	**		

PAR= % par reduction, PH=plant height, TN=tiller number, LN= leaf number, LA= leaf area

NS = non significant, * = significant ** = highly significant

lishment, a weedy-rice derived line effecting almost 70 % light reduction within the canopy at 30 DAT was identified. It is possible that other cultivars exhibiting much faster RCE than this weedy-rice derived line can be identified through proper screening of rice germplasm in the future.

Grain yield and RCE

The 28 varieties and lines showed significant differences in grain yield (Table 5). Grain yield of the test materials ranged from 2.72 to 7.35 t/ha. There was no direct relationship between RCE and yield. For instance, the 4 weedy-rice derived lines exhibiting the fastest canopy establishment both at 30 and 35 DAT have a yield range of 3.19-6.67 t/ha. The yield of WRI-38 and WR1-55 (6.67 and 5.86 t/ha) was not significantly different but significantly higher than the yield of WR1-61 (5.29 t/ha). All the three lines, however, gave significantly higher yield than WR4-14 (3.19 t/ha).

A similar situation was observed among the improved varieties. IR 64 and Suphan Buri 1 were identified to have RCE both at 30 and 35 DAT and yet the yield of Suphan Buri 1 (7.35 t/ha) was significantly higher than IR 64 (4.88 t/ha). Similarly, Phitsanulok 2 which was classified to have RCE starting only at 35 DAT had a yield which was not significantly different from Suphan Buri 1 but significantly higher than IR 64. On the other hand, IR 24 showing SCE at 30 and 35 DAT gave a very high yield but not significantly different from Suphan Buri 1 and Phitsanulok 2. (Table 5). All these results indicate that RCE and high yield are independently inherited and

Table 5. Yield and canopy establishment (CE) of the test varieties and lines

Varieties/lines	CE at 35 DAT	Yield (t/ha)
IR 24	Slow canopy establishment	6.51 abc
IR 64	Rapid canopy establishment	4.88 efghi
Suphan Buri 1	Rapid canopy establishment	7.35 a
Phitsanulok 2	Rapid canopy establishment	6.96 ab
Koshihikari	Slow canopy establishment	3.03 l
O. glaberrima	Slow canopy establishment	2.72 l
WR1-38	Rapid canopy establishment	6.67 abc
WR1-55	Rapid canopy establishment	5.86 cde
WR1-61	Rapid canopy establishment	5.29 defg
WR4-14	Rapid canopy establishment	3.19 kl
WR4-16	Slow canopy establishment	4.87 efghi
SV1F8-01	Slow canopy establishment	5.40 def
SV2F7-01	Slow canopy establishment	5.04 efghi
SV2F7-02	Slow canopy establishment	5.49 def
SV2F7-03	Slow canopy establishment	4.04 ijk
SV2F7-04	Slow canopy establishment	4.72 fghi
SV2F7-05	Slow canopy establishment	6.08 bcd
SV2F7-06	Rapid canopy establishment	4.29 ghij
SV2F7-07	Rapid canopy establishment	5.33 def
SV2F7-08	Slow canopy establishment	5.00 efghi
SV2F7-09	Slow canopy establishment	5.50 def
SV2F7-10	Slow canopy establishment	5.34 def
SV2F7-11	Slow canopy establishment	5.12 defgh
SV2F7-12	Rapid canopy establishment	4.26 hij
SV3F6-01	Rapid canopy establishment	4.82 fghi
SV3F6-02	Slow canopy establishment	4.72 fghi
SV3F6-03	Slow canopy establishment	3.40 jkl
SV3F6-04	Slow canopy establishment	3.37 jkl

Means in the same column followed by a common letter are not significantly different at the 5 % level by DMRT.

can be combined in improved variety.

When the idea of weed competitive ability in rice was raised in the mid-1960s, the general picture of the cultivar that can compete against weeds is one that is tall, exhibiting rapid growth in early vegetative stage and having leaves which are droopy and high leaf area. Through decades of research, these traits have been linked to low yield potential in some studies (Jennings and Aquino, 1968; Kawano *et al.*, 1974), but not in others (Garrity *et al.*, 1992; Ni *et al.*, 2000; Fischer *et al.*, 2001). Similarly, some researchers argued that competitive ability in rice is inversely correlated with yielding potential but more recent investigations in tropical rice have suggested that competitive cultivars could be developed without substantially lowering yields (Fofana and Rauber, 2000; Ni *et al.*, 2000). Fischer *et al.* (1997, 2001) reported no correlation between the competitive ability of rice and rice yields in field studies with junglerice, (*Echinochloa colona* (L.) Link) and two *Brachiaria* species. The results of this experiment clearly support these later findings. Improved high yielding varieties with enhanced weed-competing ability through RCE can be developed in the near future.

Conclusions

This study was a preliminary investigation on rapid canopy establishment (RCE) as a useful trait for weed competitiveness in transplanted rice. The results showed that the percent reduction in photosynthetically active radiation taken below the plant canopy at different periods after transplanting can be used to estimate the rate of canopy establishment in rice varieties and breeding lines. It was also established that tiller number, number of leaves and leaf area are positively correlated with RCE. On the other hand, plant height has no correlation at all with rapid canopy establishment. Similarly, high grain yield appeared also to be independently inherited of RCE indicating that both RCE and high yield can be successfully combined in improved rice varieties.

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