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Tillering Behavior of Low and High Tillering Rices

Je Kyu Kim* and B.S. Vergara**

水稻 小蘖性과 多蘖性 品種의 分蘖 習性

金帝圭*・비 에스 벨가라**

ABSTRACT : This experiment was conducted to evaluate the tillering behavior of low- and high-tillering rice plants. IR58, a high-tillering cultivar with small panicles showed not only higher tiller number but also earlier tillering, faster tillering rate and longer tillering duration than IR25588, a low-tillering cultivar with large panicles. Tillering ability of IR25588 was only 59% that of IR58. Percent effective tillers was higher in IR25588 (85%) than in IR58 (67%). Tillering response to wider spacing was higher in a high-tillering cultivar than in a low-tillering cultivar. Grain yield response to closer spacing (close spacing adaptability) was higher in a low-tillering cultivar than in a high-tillering cultivar.

Rice plants produce tillers mainly during the vegetative growth phase. Tillers are branches that develop from the leaf axil at each node of the main culm or other tillers. The primary tillers originate from the lowermost nodes of the main culm and give rise to the secondary tillers. The latter give rise to the tertiary tillers (Chang and Bardenas, 1976). Emergence of tillers is closely linked to leaf development. Thus all tillers emerge synchronously with the development of leaves on the main culm (Katayama, 1951).

Tillering ability differs with variety and environment. The emergence and development of tillers are greatly influenced by plant density, nitrogen (N) level, planting method, temperature and solar radiation among other factors. Panicle-weight type and panicle-number type are synonymous to low-tillering and high-tillering, respectively (Baba, 1956). High-tillering cultivars are widely used where transplanting is common, while low-tillering cultivars are used where direct seeding is practiced.

This study was conducted at the International Rice Research Institute (IRRI) in 1987 dry season to evaluate the tillering behavior of low- and high-tillering rice plants and investigate the grain yield respons to spacing (close spacing adaptability).

MATERIALS AND METHODS

Experiment I. Tillering behavior of low- and high-tillering rices

IR25588, a low-tillering advanced breeding line with large panicles and IR58, a high-tillering cultivar with small panicles were used (Table 1). Both cultivars have similar plant height and growth duration but differ in tillering ability and panicle size.

Pregerminated seeds were sown in trays containing Maahas clay soil (*Andaqueptic Haplaquoll*). One 10-day-old seedling was transplanted per 1/5000a Wagner pot containing 3.5 kg soil, puddled and mixed with 0.9 g N, 0.4 g phosphorus and 0.5 g potassium. Nitrogen was splitted : 50, 20, 20, and 10% at pretransplanting, 2 weeks after transplanting (WAT), panicle initiation stage and heading, respectively. Water depth was maintained at 2 to 3 cm.

The experiment was laid out in a completely randomized design with 22 replications per cultivar. Emergence of primary, secondary and tertiary tillers were recorded by marking tillers with plastic labels and colored threads every two days. Labeling continued until new tillers ceased to appear.

* 作物試驗場 Rice Production Division, Crop Experiment Station, RDA, Suweon 441-100, Korea)
** 國際米作硏究所 International Rice Research Institute, P.O. Box 933, Manila, Philippines) <'90. 9. 1 接受>

Table 1. General characteristics of rice entries used (averaged over 1987 wet and dry seasons).

Entry	Tillering ability[1] (max. tiller no./hill)	Panicle type[2] (spikelet no. /panicle)	Plant height[2] (cm)	Growth duration[2] (days)
UPLR-19-1	Low(36)	Panicle wt.(104)	Medium(98)	Medium(113)
IR25588-7-3-1	Low(37)	Panicle wt.(91)	Short(88)	Short(104)
IR58	High(62)	Panicle no.(71)	Short(87)	Short(103)
IR37025-R-R-R-29-3	High(65)	Panicle wt.(131)	Tall(106)	Long(131)

[1] Maximum tiller number at 50 × 50 cm spacing with 100 kg N/ha
[2] Data from 20 × 20 cm spacing with 100 kg N/ha

Experiment II. Tillering and yield responses to spacing and nitrogen

Two low-tillering, UPLR and IR25588, and two high-tillering types, IR58 and IR37025, were used in the field experiment (Table 1). The experimental design was a split-plot design combining two plant spacings (20 × 20 and 50 × 50 cm) and two N levels (0 and 100 kg N/ha) as the mainplot and four rice cultivars as the subplots with three replications. One 10-day-old seedling was transplanted per hill. Nitrogen, phosphorus and potassium were applied to the main plots at the rate of 0-40-40 and 100-40-40 kg/ha. Split application of N was the same as that in Experiment I.

RESULTS AND DISCUSSION

Experiment I. Tillering behabior of low- and high-tillering rices

1. Tiller number

The tiller number of IR25588 and IR58 were 19.1 and 32.5 per hill, respectively (Table 2). The tillering ability of IR25588, a low-tillering type was only 58.8% of IR58, a high-tillering type. The main contributor to total tiller number in both cultivars were the secondary tillers which contributed 50.3 and 54.5 % to the total tiller number of IR25588 and IR58, respectively (Table 2).

2. Tillering time, rate and duration

High-tillering cultivar, IR58 had earlier tillering, faster tillering rate and longer tillering duration as compared with low-tillering type, IR25588 (Fig. 1)

The tillering times of the first tiller in IR58 and IR25588 were 11 and 13 days after transplanting (DAT), respectively (Fig.1). The tillering rates of IR25588 and IR58 were 0.71 and 0.90 tiller per day, respectively. The tillering duration of IR25588 and IR58 were 27 and 36 days, respectively. The longer tillering period of IR 58 is disadvantageous as late tillers generally are small, mature late or become nonberaing.

Different tiller orders also had different tillering durations. Tillering durations of the primary, secondary and tertiary tillers in IR25588 were 26, 17 and 5 days, respectively, while those of IR58 were 30, 28 and 8 days, respectively (Fig. 1). Tertiary tillers started appearing at about 32 to 35 DAT and stopped

Table 2. Contribution of different tiller orders to total tiller number in a hill.

Cultivar	Tiller no. per hill				
	Tiller order				
	Main culm	Primary	Secondary	Tertiary	Total
IR25588	1.0±0[1]	5.6±0.2	9.6±0.3	2.9±0.4	19.1
	(5.2)[2]	(29.3)	(50.3)	(15.2)	(100)
IR58	1.0±0	7.5±0.1	17.7±0.4	6.3±0.7	32.5
	(3.1)	(23.0)	(54.5)	(19.4)	(100)

[1] Mean±standard error
[2] Figures in parentheses are the percent values as compared with the total.

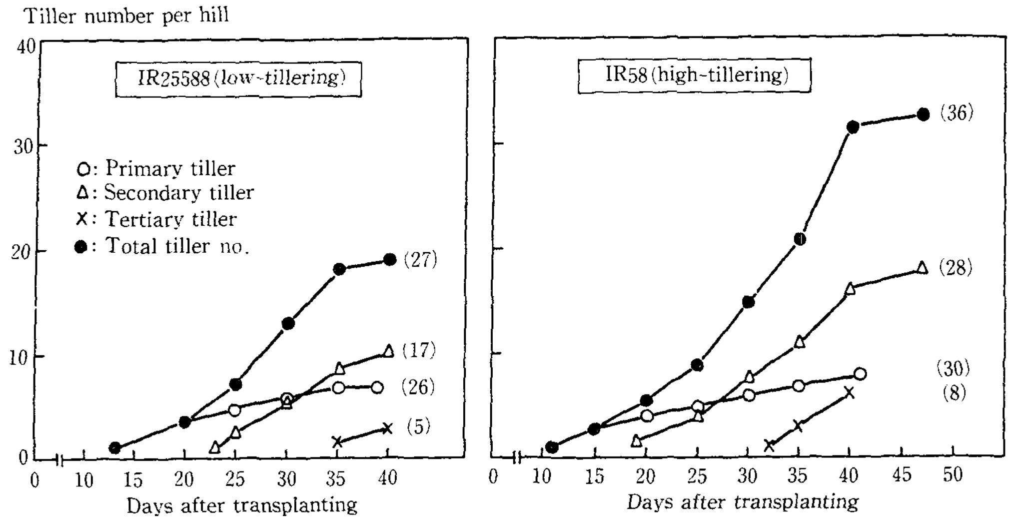

Fig. 1. Tillering changes of different tiller orders in a low-tillering (IR25588) and in a high-tillering (IR58) cultivars in 22 replications. Figures in parenthesis are the duration of tillering in days.

around 40 DAT.

3. *Effective tiller*

The percent effective tillers in a low-tillering, IR25588 (85.3%) was hihger than in a high-tillering cultivar, IR58 (67.4%) (Table 3). The percent effective tiller of the primary tillers did not differ between IR25588 and IR58, whereas the percent effective tiller of the secondary and tertiary tillers in IR25588 was markedly higher than that in IR58. The lower values in IR58 may be related to its faster tillering rate and longer tillering duration. The bearing tillers depended greatly on how soon they emerged after transplanting. Early tillers produced panicles, while late tillers remain mostly nonbearing.

Experiment II. Tillering and yield responses to spacing and nitrogen

1. *Tillering*

Tillering abilities of two low- and two high-tillering rice cultivars as affected by spacing and N level are shown in Fig. 2. IR58 showed the highest tiller number per m^2, particularly at 20 × 20 cm spacing with 100 kg N/ha, while UPLR and IR25588 showed low-tillering abilities. High-tillering, IR58 and IR37025, showed faster tillering rate than low-tillering cultivars, UPLR and IR25588, especially at 50 × 50 cm spacing. This indicates that high tillering cultivars have better adaptablilty to wide spacing than low-tillering cultivars. Tillering capacity of rice is better evaluated at wide spacing and high N level (Yoshida and Parao, 1972).

Closely spaced plants reached the maximum tillering stage earlier than widely spaced plants (Fig. 2). At 20 × 20 cm spacing the maximum tiller number was observed at 5 WAT, while at 50 ×50 cm spacing the tiller numbers increased up to 8 WAT in all cultivars.

Table 3. Percent effective tillers of different tiller orders in a hill.

Cultivar	Effective tillers (%)[1]				
	Main culm	Primary	Secondayry	Tertiary	Total
IR25588	100.0	92.9	86.5	62.1	85.3
IR58	100.0	89.3	69.5	30.2	67.4

[1] $\frac{\text{Panicle number}}{\text{Max. tiller number}} \times 100$

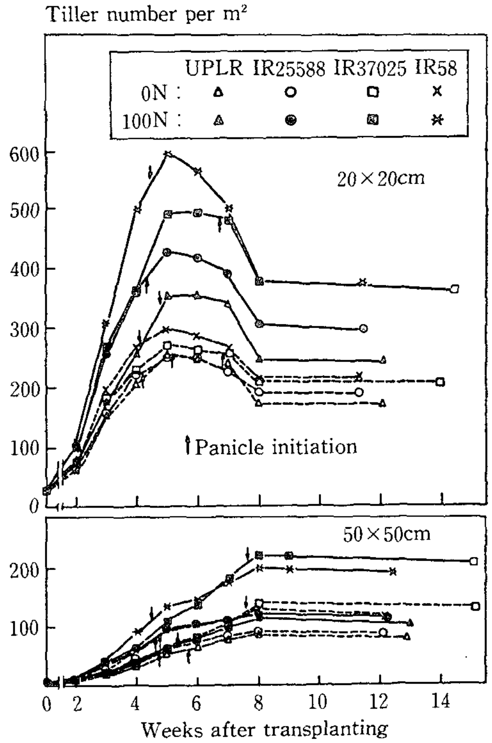

Fig. 2. Tillering pattern of four rice cultivars at different plant spacing and nitrogen levels.

2. Maximum tiller number

The average maximum tiller number across spacings and N levels of UPLR, IR25588, IR58 and IR37025 were 18.3, 19.6, 29.3 and 30.4 tillers per hill, respectively (Table 4). Low-tillering IR25588 produced 66.9% of the tiller number of high-tillering cultivar, IR58. IR25588 and IR58 showed significantly different tiller number under all spacings and N levels except one treatment. They have similar plant type, plant height and growth duration except for tillering ability and panicle size (Table 1). Therefore, the two cultivars would be good materials for comparing the performance of low- and high-tillering rices for grain yield potential.

Differences in tiller number per hill between low- and high-tillering cultivars were more distinct at wide spacing and high N level (Table 4). The lower tiller number per m² at 50 × 50 cm spacing than at 20 × 20 cm spacing implies that low-tillering cultivars cannot compensate for the reduction in plant population by producing more tillers at wide spacing. This also indicates that low-tillering cultivars need relatively higher planting density than high-tillering ones for increasing grain yield.

3. Percent effective tillers

Percent effective tillers at 0 to 100 N level increased with increase in plant spacing (Table 5). At 50 × 50 cm spacing the percent effective tillers was higher than 90% in all cultivars, and 62 to 76% at 20 × 20 cm spacing. High-tillering IR58 showed only 61.8 % effective tillers which was significantly lower than that of low-tillering IR25588 at 20 × 20 cm spacing with 100 N level. The low values of percent effective tillers at close spacing indicates inter-plant competition for light and nutreints among others. Low-tillering cultivars may be better suited for close spacing or dense population than high-tillering cultivars because of higher percent effective tiller in close spacing.

4. Tillering response to spacing and nitrogen

Tillering response to wider spacing based on the maximum tiller number per hill was higher than that to N (Fig. 3). Tillering response to spacing was

Table 4. Maximum tiller number as affected by spacing and nitrogen level.

Cultivar	Maximum tiller (no./hill)				
	20×20cm		50×50cm		Mean
	0 N	100 N	0 N	100 N	
UPLR	10.2	14.4	21.0	27.7	18.3
IR25588	10.1	17.1	22.1	29.0	19.6
IR58	11.9	23.5	32.0	49.8	29.3
IR37025	10.8	19.8	34.7	56.2	30.4

LSD .05=3.6 in a column
LSD .05=4.3 in a row

Table 5. Percent effective tillers as affected by spacing and nitrogen level.

Cultivar	Effective tiller (%)				
	20×20cm		50×50cm		Mean
	0 N	100 N	0 N	100 N	
UPLR	66.4	68.5	95.9	93.1	81.0
IR25588	75.1	68.6	91.7	94.1	82.4
IR58	73.5	61.8	91.4	94.0	80.2
IR37025	76.3	72.8	93.8	93.7	84.2

LSD .05=7.0 in a column
LSD .05=7.1 in a row

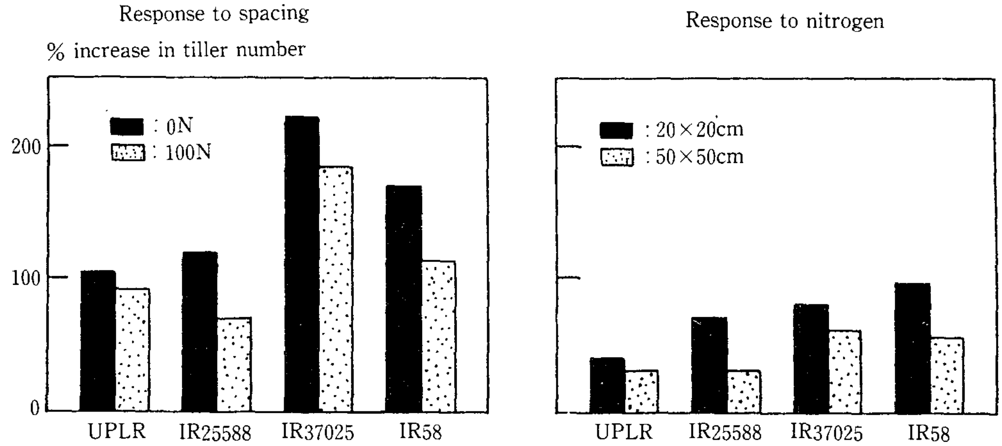

Fig. 3. Tillering response of low- and high-tillering cultivars in different plant spacings(from 20 x 20 to 50 x 50 cm) and nitrogen levels (from 0 to 100 kg/ha) based on the maximum tiller number per hill.

higher in the high-tillering cultivars, IR37025 and IR58, than in the low-tillering, UPLR and IR25588. This implies that high-tillering cultivars are better suited for widely spaced plants because of high-tillering ability. Tillering response to N showed a similar tendency as that to spacing. Yoshida and Hayakaya (1970) reported that tillering stops when N content in the leaf blade becomes 2.0 % ; phosphorus 0.03 % and potassium 0.5 %.

5. Grain yield and close spacing adaptability

Low-tillering cultivar, IR25588 gave higher grain yield than high-tillering IR58 at close spacing, while at wide spacing it was *vice versa* (Table 6). Grain yield response to closer spacing (close spacing adaptability) was higher in low-tillering, UPLR and IR25588, than in high-tillering cultivars, IR37025 and IR58 (Fig. 4). This result implies that low-tillering cultivars with large panicles have better grain yield

Table 6. Grain yield of four rice cultivars as affected by apacing and nitrogen level.

Cultivar	Grain yield (t/ha)				
	20×20cm		50×50cm		Mean
	0 N	100 N	0 N	100 N	
UPLR	2.79	4.60	1.77	2.78	2.99
IR25588	3.40	5.66	1.62	3.10	3.45
IR58	3.02	4.91	1.89	3.49	3.33
IR37025	3.90	7.01	3.64	5.31	4.97

LSD .05=0.63 in a column
LSD .05=0.70 in a row

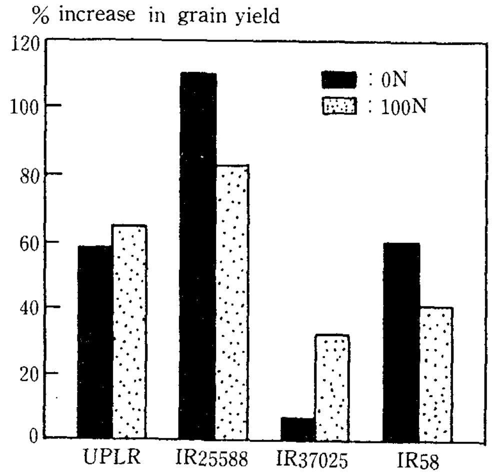

Fig. 4. Grin yield response to closer spacing (close spacing adaptability) of low- and high-tillering cultivars in different plant spacings (from 50×50 to 20×20cm).

performance than high-tillering ones at close spaced plant and / or direct seeded rice. Kim and Vergara (1989) suggested that a low-tillering plant type with large panicles would be ideal to increase the grain yield potential of rice in direct seeded rice (IRRI, 1988 a and 1988b).

摘　　要

本 試驗은 水稻 小蘗性과 多蘗性 品種의 分蘗 習性의 差異를 究明하고, 栽植密度에 對한 小·多蘗性 品種의 收量 反應 및 密植 適應性을 조사하기 위하여 國

際米作硏究所(IRRI)에서 實施하였다. 供試品種은 多蘖·穗數型인 IR58과 小蘖·穗重型인 IR25588을 比較하였던 바 이들은 分蘖能力과 이삭의 크기는 현저히 달랐으나 다른 特性은 비슷하였다.

1. 小蘖性인 IR25588(19.1 個/株)은 多蘖性인 IR58(32.5 個/株)에 比하여 約 60%의 分蘖能力을 지니고 있었으며, 總 分蘖數에 對한 主稈與分蘖은 두 品種 모두 2次 分蘖로서 50~55%를 차지하였다.

2. 多蘖性(IR58)은 小蘖性(IR25588)에 比하여 첫 分蘖이 일찍 發生되었고, 分蘖速度가 빨랐으며, 分蘖發生期間이 길었다.

3. 分蘖 種類에 따라서 分蘖發生期間이 달랐는데 1次, 2次, 3次分蘖의 發生期間이 IR25588은 26, 17, 5日이고 IR58은 30, 28, 8日로서 多蘖性의 分蘖發生期間이 小蘖性보다 길었다.

4. 有效莖比率은 IR25588(85.3%)이 IR58(67.4%)보다 높았다. 1次分蘖의 有效莖比率은 두 品種이 비슷하였으나 2·3次分蘖의 有效莖比比率은 小蘖性이 多蘖性보다 현저히 높았다.

5. 收量에 對한 密植適應性은 小蘖性品種이 多性品種보다 컸는데, 이는 密植栽培 또는 直播栽培時에 小蘖性品種이 多蘖性品種보다 收量面에서 有利할 수 있다는 것을 나타내고 있다.

REFERENCES CITED

1. Baba, I. 1956. Lectures on Rice Cultivation. Vol. 1. Asakura Co., Ltd., Tokyo.
2. Chang, T.T. and E.A. Bardenas. 1976. The morphology and varietal characteristics of the rice plant. IRRI, Los Baños, Laguna, Philippines. Tech. Bull. 4. 40p.
3. IRRI(International Rice Research Institute). 1988a Annual Report for 1988. Los Banos, Laguna, Philippines. 26-31.
4. IRRI(International Rice Research Institute). 1988b IRRI Research Highlights 1988. Los Baños, Laguna, Philippines. 16.
5. Katayama, T. 1951. Studies on the tillering of rice, wheat and barley. Yokendo Publ. Co., Tokyo, Japan. 117p.
6. Kim, J.K. and B.S. Vergara. 1989. Contribution of different tillers within a hill to grain yield of rice. IRRI Saturday Seminar (March 18, 1989). 26p.
7. Yoshida, S. and Y. Hayakawa. 1970. Effects of mineral nutrition on tillering of rice. Soil Sci. Plant Nutr. 16 : 186-191.
8. Yoshida, S. and F. T. Parao. 1972. Performance of improved rice varieties in the tropics with special reference to tillering capacity. Exp. Agric. 8 : 203-212.