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A Low Tillering Ideotype of Rice Plant for Increasing Grain Yield Potential

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벼 收量性 增加를 위한 理想的인 小蘖性 草型

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ABSTRACT : Since IR8, the first high-yielding rice cultivar characterised by semidwarf and high-tillering, was released in 1966, rice yields during the last two decades have apparently reached a plateau and subsequent efforts to further improve yielding ability have not resulted in visible gains. At this point of time, a new ideotype of rice plant would be necessary to increase grain yield potential. This experiment was conducted to investigate the yield contribution of different tillers within a plant in relation to an ideotype of rice plant.

A low-tillering, large panicled IR25588 was compared with a high-tillering, small panicled IR58. Based on spikelet number and grain weight per panicle, the top six panicles in both low- and high-tillering cultivars were significantly bigger than those in the other panicles. The top six panicles were M, P1, P2, P3, P4 and S1P2 in both cultivars. Their tillers had 100% probability of occurring. The top six tillers were characterised by earlier initiation and heading, longer growth duration, greater leaf area, and heavier culm and total dry weight per tiller. The top six panicles, based on grain weight was mainly due to higher spikelet number per panicle with little differences in 1,000 grain weight and percent fertility. They had also a greater number of high-density grains.

The top six panicles were significantly bigger than the rest of the panicles in both low- and high-tilliering types suggesting that a new rice ideotype having six or fewer potential tillers or panicles per palnt with 200 to 250 spikelets per panicle (a low-tillering, paicle weight type) may help increase grain yield potential since they have been shown to be superior physio-morphologically to the rest of the tillers.

Rice yields have greatly increased in the last 25 years mainly through varietal improvement and the accompanying cultural practices. IR8, the first high-yielding rice cultivar adapted to tropical climantes, was released in 1966 by the International Rice Research Institute(IRRI). It started the "green revolution" in rice mainly through its ideotype : semidwarf, high-tillering, stiff culm, erect leaves, photoperiod insensitive and higher response to fertilizer nitogen(N) compared with traditional cultivars. However, rice yields during the last two decades have apparently reached a plateau(Flinn et al., 1982) and subsequent effforts to further improve yielding ability have not resulted in visible gains.

Several scientists have proposed the different types of rice plant(Donald, 1968 ; Beachell and Jennings, 1965 ; Chandler, 1969 ; Yoshida, 1972 ; Kim and Vergara, 1989). An ideal crop should make a minmum demand on resources per unit of dry matter produced(Donald, 1968,). Morphological characteristics of rice plant ideotype are generally short and stiff culm, and erect leaves(Yoshida, 1972). Yoshida(1972) and Bhattacharya and Chatterjee(1973) emphasized that high-tillering rice cultivars can give high yields at close spacing as well as wide spacing. Chandler(1969) claimed that low- to medium-tillering cultivars, if short and stiff strawed, yield best at close spacing. Recently, Kim and Vergara(1989)

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suggested a low - tillering plant type with large panicles. Low-tillering and high-tillering are synonymous to panicle weight type and panicle number type, respectively.

This study was conducted at the IRRI in 1987 to investigate the relationship beween panicle location and panicle size within a plant of a low- and a high-tillering rice cultivars, and to assess the yield contribution of different tillers within a plant in relation to an ideotype of rice plant.

MATERIALS AND METHODS

IR25588-7-3-1, a low-tillering advanced breeding line with large panicles and IR58, a high-tillering cultivar with small panicles were used. Both genotypes have similar plant height (about 88cm) and growth duration (about 103 days) but differ in tillering ability and panicle size. Tillering ability of IR25588 was only 60% of IR58.

Pregerminated seeds were sown in trays containing Maahas clay soil (*Abdaqueptic Haplaquoll*). One 10-day-old seeding in December 20, 1987 was transplanted per 1/5,000a Wagner pot containing 3.5kg soil, puddled and mixed with 0.9g N, 0.4g P_2O_5 and 0.5g K_2O. Nitrogen was splitted : 50, 20, 20 and 10% at pretransplanting as basal, 2 weeks after transplanting (WAT) for tillering, panicle initiation stage and heading time, respectively. Water depth was maintained at 2 to 3cm.

The experiment was laid out in a completely randomized design with 22 replications per cultivar. Emergence of primary (P), secondary (S) and tertiary (T) tillers were recorded by marking tillers with plastic labels and colored threads every two days. The tillers were labelled M (main culm) ; P1, P2, P3 (1st, 2nd, 3rd primary tillers) ; S1P1, S2P1, S3P1 (1st, 2nd, 3rd secondary tillers originating from P1 and so on) ; and T1, T2, T3 (1st, 2nd, 3rd tertiary tillers developing from the secondary tillers). The secondary tillers originating from the prophyll of P1 and P2 were labelled S0P1 and S0P2. Labelling continued until new tillers ceased to appear.

At heading, leaf area, culm weight and total dry weight per tiller were measured using 15 replications per cultivar. Rice plants were harvested using 22 replications per cultivar at 30 days after heading and dried at 75℃ for 3 days. Panicles from different tiller orders were separated, and grain yield and yield components were determined. Distribution of grain density was determined using salt solutios of different specific gravities (Venkateswarlu et el., 1986).

RESULTS AND DISCUSSION

1. Yield contribution of different tiller orders

The contribution of different tiller orders to grain yield per plant in IR25588 were 9, 40, 46 and 5% for the main culm, primary, secondary and tertiary tillers, respectively (Table 1). IR58 showed a similar trend, indicating no varietal difference in that character between low- and high-tillering cultivars. The differences in grain yield among the different tiller orders may be due to the fact that the tillers formed

Table 1. Contribution of different tiller orders to grain yield, panicles and tiller numbers in a plant in IR25588 and IR58.

Cultivar	Tiller order				
	Main culm	Primary	Secondary	Tertiary	Total
		Grain yield (g/plant)			
IR25588	4.5±0.1[1]	18.8±0.5	21.9±0.6	2.4±0.4	47.6
IR58	3.2±0.1	16.1±0.4	21.7±0.7	1.9±0.4	42.9
		Panicles (no./plant)			
IR25588	1.0±0	5.2±0.2	8.3±0.3	1.8±0.3	16.3
IR58	1.0±0	6.7±0.2	12.3±0.4	1.9±0.4	21.9
		Tillers (no./plant)			
IR25588	1.0±0	5.6±0.2	9.6±0.3	2.9±0.4	19.1
IR58	1.0±0	7.5±0.1	17.7±0.4	6.3±0.7	32.5

[1] Mean±standard error

earlier had a longer duration of growth than the tiller formed later (Kim and Vergara, 1990). Thus the tiller formed earlier would be received more light intensity and accumulated more photosynthates to growth.

Both low- and high-tillering cultivars had more primary and secondary panicles than tertiary panicles (Table 1). The grain yield from primary and secondary tillers were the main contributor of the grain yield : 86% of the total yield in IR25588 and 88% in IR58. The tertiary panicles contributed only 5% in both cultivars. Thus, the contribution of tertiary panicles to grain yield was low compared with the number of tertiary tillers, giving 15 to 20% in both cultivars.

2. Location of large panicles

Grain yield contribution of different tillers within a plant varied not only among the tiller orders but also within a tiller order. Generally, panicles from primary tillers were larger (heavier and more spikelets) than those from secondary and tertiary tillers up to 5th primary (P5) tiller in both cultivars (Figs. 1 & 2). The panicles from tertiary tillers weighed

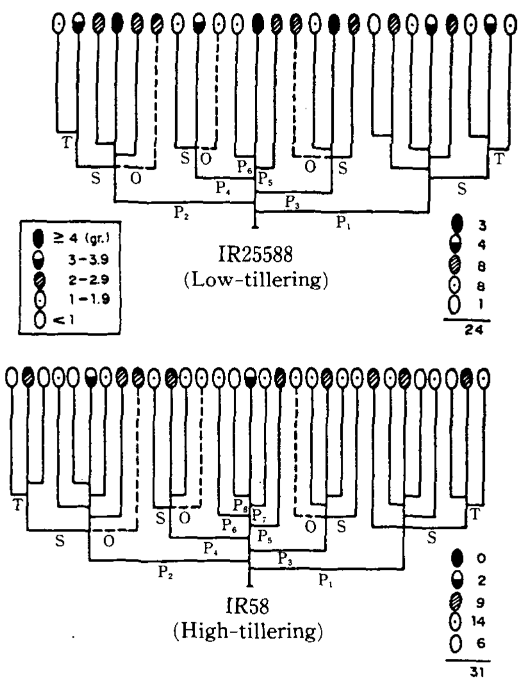

Fig. 1. Location of different grades of panicles in a plant based on grain weight per panicle.

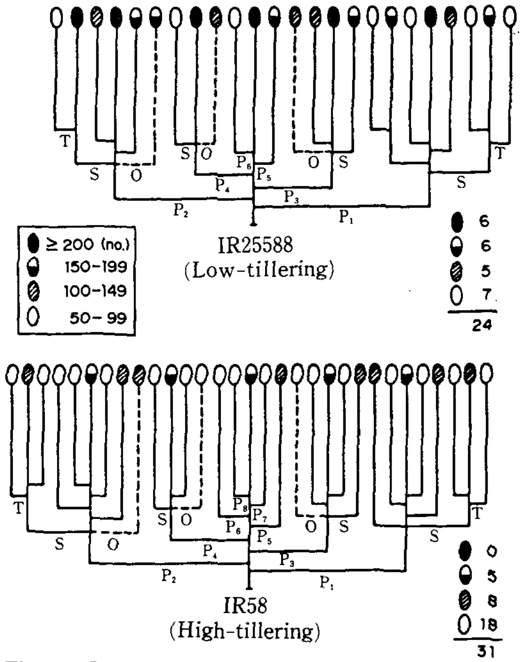

Fig. 2. Location of different grades of panicles in a plant based on spikelet number per panicle.

less and had fewer spilelets per panicle.

IR25588 had 71% of bigger panicles (more than 100 spikelets per panicle), while IR58 had 42% (Fig. 2). This indicates that low-tillering cultivars had higher proportion of large panicles than high-tillering cultivars.

Kim and Vergara (1990) reported that the percent effective tiller of a low-tillering cultivar (85.3%) was higher than that of a high-tillering cultivar (67.4%). They also claimed that low-tillering cultivars would better suited for close spacing or dense population than hight-tillering cultivars because of higher percent effective tiller at close spacing. It is necessary to suppress the growth of non-bearing and weak tillers in order to obtain larger and stronger panicles.

3. Critical panicle number for an ideotype

The six tillers with the bigger panicle in terms of panicle weight and spikelets per panicle are shown in Figure 3. The 6th heavier panicle (S1P2) of IR25588 and IR58 had 200 and 144 spikelets per panicle, respectively, while the 7th panicle (S1P1) in both cultivars had 172 and 125 spikelets per panicle,

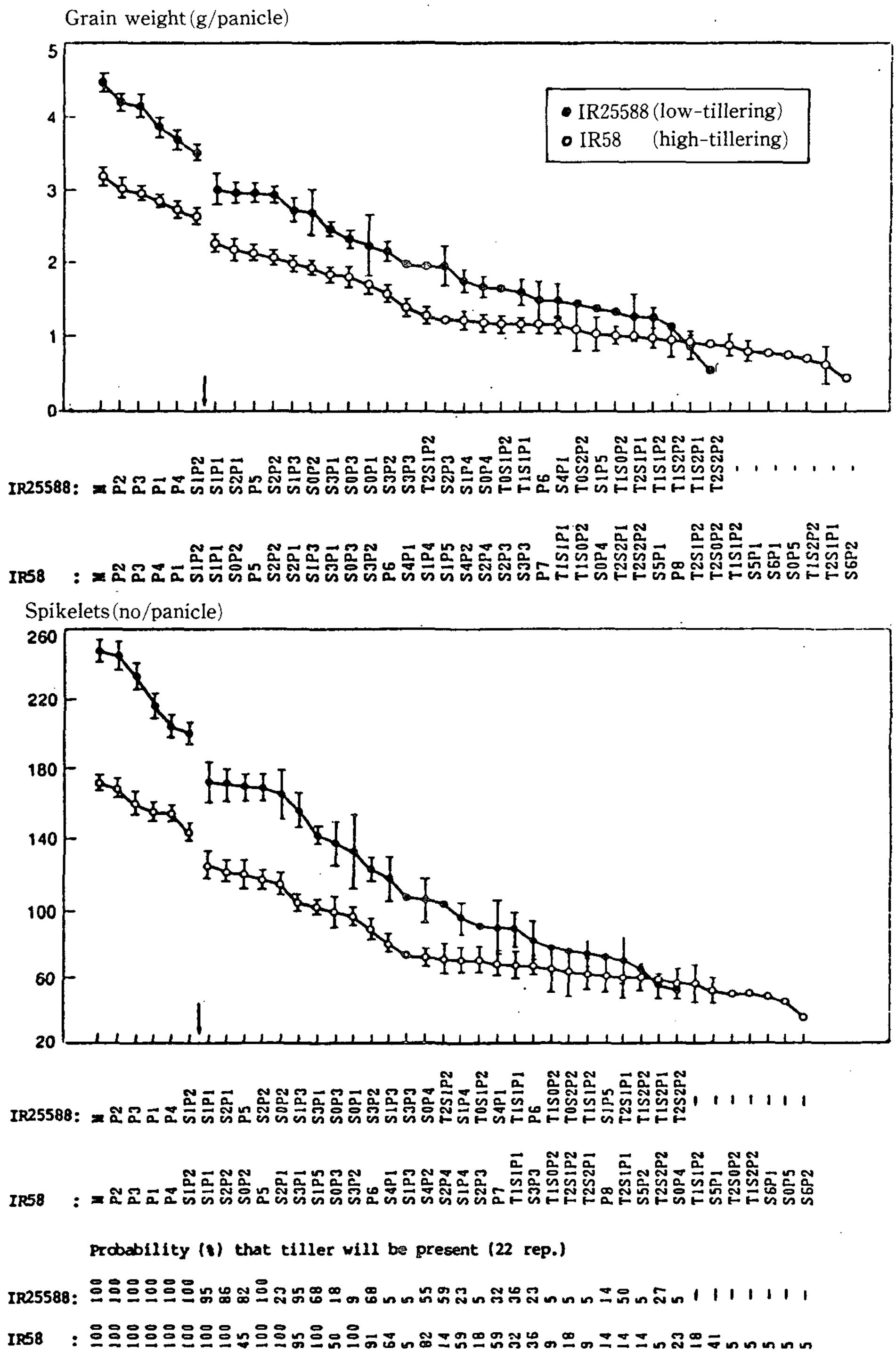

Fig. 3. Grain weight and number of spikelets on panicles on different tillers in a plant in IR25588 and IR58. (Vertical bar at each point refers to standard error of the mean. Left of arrow shows the top six tiller. The top six tillers are significant at P<0.01 to S1P1).

respectively. The differences in the 6th and 7th panicles were 28 and 19 spikelets per panicle in IR25588 and IR58, respectively(Fig. 3 & Tabel 4). And, the panicle weight and spikelet number per panicle of the top six panicles in both cultivars were significantly($P<0.01$) more than in the other panicles.

The top six panicles were the main culm, the 1st, 2nd, 3rd and 4th primary tillers, and the 1st secondary tiller from the 2nd primary tiller(M, P1, P2, P3, P4, & S1P2) in both cultivars. The top six tillers had 100% probability of occurring, while other tillers varied greatly in their chances of being initiated or producing a panicle. The top six panicles were significantly bigger than the other panicles in both low- and high-tillering types suggesting that a new rice ideotype having six or fewer potential tillers or panicles per plant may help increase grain yield potential.

Donald(1968) proposed a uniculm plant as an ideotype of cereal crops due to the nonplasticity of the culm number resulting in a large panicle.

However, Yoshida and Parao(1972) criticized this and emphasized the high-tillering type. They reported that panicle size was mainly affeted by the total number of panicles per unit area and did not appear to be affected by whether the panicle was produced by the main shoot or by the other tillers. However, the results of the present experiment indicate the lowtillering type having six or fewer panicles is more favorable.

This result may also imply that yield potential of low-tillering cultivars would be higher than that of high-tillering cultivars under proper cultural practices, especically in dense planting or direct seeded rice. Kim and Vergara(1990) reported that the close spacing adaptability based on grain yield in low-tillering cultivars was higher than that in high-tillering cultivars. Therefore, a low-tillering cultivar with large and fewer panicles could be apply to direct seeded rice as an ideotype of rice plant.

The top six panicles in IR25588 had 200 to 250 spikelets per panicle suggesting that low-tillering cultivars with large panicles may need around 200 to 250 spikelets per panicle to compensate for low-tillering (Fig. 3 & Table 4). Large culms and leaves of low-tillering plant type can be accumulate more carbohydrates before heading which can be supplied to large sinks(spikelets) for better grain filling after heading.

4. Heading time of different tillers

Heading of the different tillers in a hill occurred in 11 to 12 days(Table 2). No varietal difference was observed, although IR58 had more tillers than IR25588. Heading of 2nd(P2) and 3rd(P3) primary tillers in IR25588 was earlier than that of the main culm(M). Hoshikawa (1989) reported that main culm headed the 3rd among tillers in a japonica rice plant. The date of heading differed not only within a hill but also among plants in the same field(Yoshida, 1981). It takes about 7 to 10 days for all spikelets within the same panicle to complete heading while within the same field, it takes 10 to 14 days.

Generally, the top six tillers flowered earlier than the others(Table 2). Those that emerged earlier also flowered earlier execept the 1st primary(P1) tiller,

Table 2. Number of days to the heading after transplanting and emergence of different tillers in a plant(sowing date : 10 Dec., 1978).

Tiller	Heading		Tiller emergence	
	IR25588	IR58	IR25588	IR58
M *	58	58	0	0
P1*	58	58	13	11
P2*	56	58	15	13
P3*	57	57	20	17
P4*	58	58	25	21
P5*	60	59	32	26
P6*	67	67	40	33
S1P1	59	59	26	21
S2P1	59	58	30	24
S3P1	58	58	32	28
S4P1	63	59	39	34
S1P2*	57	57	25	21
S2P2	59	58	30	26
S3P2	60	60	38	31
S1P3	59	59	31	27
S2P3	62	62	35	35
S1P2	61	61	36	33
T1S1P1	61	61	35	35
T2S1P1	61	63	39	36
T1S1P2	63	63	37	34

* The top six tillers.

which was relatively late, and S1P2 which was relatively early. The top six tillers all headed in 3 days, while the interval within a hill was 11 to 12 days. Synchronous flowering and maturity of the crop are more likely to expect if only the top six tillers are considered in cultural management. Thus, synchronous flowering in low-tillering cultivars could be improved grain quality of rice. Also, the top six tillers, which are initiated earlier, can probably accumunlate more photosynthates than the tillers formed later because of their longer growth duration.

5. Leaf area and dry matter of different tillers

IR25588 had generally larger leaf area, and heavier culm and total dry weight per tiller than IR58 at heading (Table 3). The top six tillers had larger culms and leaves per tiller than the rest of the tillers in both cultivars. The large leaves and culms as the sources of photosynthesis could support the formation of many spikelets during spikelet differentiation stage and permit better grain filling after heading. Bigger culms would also be necessary to support heavy panicles.

The bigger culms of the top six tillers would more vascular bundles indicating a better translocation system which is an important factor in dry matter accumulation. Kim and Vergara (1989) showed that a low-tillering cultivar had more inner and outer vascular bundles than a high-tillering cultivar just below the panicle neck node.

Yoshida and Cock (1971) reported that 74% of grain carbohydrates was derived from photosynthesis after flowering and 26% of the carbohydrates was translocated from accumulated carbohydrates in the plant body. The proportion of the latter may be increased by the larger and earlier tillers produced thereby increasing the degee of grain filling.

Table 3. Leaf area, culm weight and total dry weight per tiller of different tillers in IR25588 and IR58 at heading.

Tiller	IR25588			IR25		
	Leaf area (cm^2)	Culm weight (g)	Total dry weight (g)	Leaf area (cm)	Culm weight (g)	Total dry weight (g)
M*	302±10[1]	1.87±0.1	3.89±0.1	250±11	1.61±0.1	3.15±0.1
P1*	352± 6	1.71±0.1	3.54±0.1	259± 8	1.40±0.1	2.81±0.1
P2*	301±10	1.83±0.1	3.83±0.1	248±10	1.47±0.1	2.86±0.2
P3*	301± 7	1.63±0.1	3.44±0.1	230± 9	1.36±0.1	2.74±0.1
P4*	278± 6	1.46±0.1	3.11±0.1	232± 7	1.39±0.1	2.82±0.1
P5	209±19	0.99±0.1	2.06±0.2	225± 7	1.09±0.1	2.25±0.1
P6	147±21	0.71±0.1	1.36±0.2	167± 6	0.70±0.1	1.55±0.1
S1P1	235±17	1.10±0.1	2.36±0.2	228±10	1.05±0.1	2.16±0.2
S2P1	242±12	1.11±0.1	2.36±0.2	209±10	0.96±0.1	1.98±0.1
S3P1	218± 6	0.94±0.1	1.97±0.1	190±11	0.83±0.1	1.67±0.1
S4P1	142±25	0.64±0.1	1.30±0.3	154±10	0.57±0.1	1.18±0.1
S1P2*	258± 7	1.41±0.1	3.02±0.1	231± 7	1.24±0.1	2.52±0.1
S2P2	225± 6	1.17±0.1	2.46±0.1	213± 8	0.95±0.1	2.04±0.1
S3P2	185±12	0.82±0.1	1.88±0.2	187± 7	0.79±0.1	1.71±0.1
S1P3	213± 6	1.02±0.1	2.08±0.1	167±17	0.85±0.1	1.77±0.1
S2P3	179±19	0.71±0.1	1.44±0.2	154± 8	0.53±0.1	1.11±0.1
S1P4	160±15	0.62±0.1	1.27±0.2	123±14	0.53±0.1	1.11±0.2
T1S1P1	123±28	0.42±0.1	0.83±0.2	121±25	0.34±0.1	0.78±0.2
T2S1P1	191±19	0.74±0.2	1.42±0.2	71±15	0.23±0.1	0.50±0.1
T1S1P2	127±18	0.43±0.1	0.86±0.2	69±12	0.20±0.1	0.44±0.1

*The top six tillers. [1] Mean±standard error.

6. Yield components of the top six tillers

IR25588 had more spikelets per panicle than IR58(Table 4&5). The top six tillers had more spikelets per panicle than the rest of the tillers in both cultivars.

Spikelet number on primary rachis-branches of IR25588 and IR58 were similar within the same tiller or tiller order, whereas spikelet number on secondary rachis-branches in IR25588 were always higher than that in IR58(Table 5). Grains on the secondary branches in IR25588 were the main contributor to the grain yield. The low-tillering cultivar has many secondary branches to compensate for its low panicle number per plant compared with the high-tillering cultivar.

The higher grain weight of the top six tillers was the result mainly of more spikelets per panicle(Table 4). Among tillers within a plant, differences in 1,000 grain weight of primary rachis-branches in both cultivars tended to be higher than those of secondary rachis-branches.

The top six tillers have significantly more high-density grains than the rest of the tillers (Table 6). High-density grains have higher milling and head rice yield(Venkateswarlu et al., 1986). Increasing the proportion of high-density grains would enhance the grain yield potential of rice.

Production of tertiary tillers and even of late primary and seconday tillers(P6, S4P1 and S1P4) should be prevented as they contribute little to grain yield and may actually have a negative effect. Their total spikelets were low and they initiated and flowered late. Selection of breeding lines without late tillers would be useful in increasing yield potential of rice.

The findings in the study strongly show the advantage of a low-tillering plant type in increasing the grain yield potential of rice. In breeding for low-tillering plant type, six or fewer tillers per plant would be ideal since the top six tillers have been shown to be superior morpho-anatomically and physiologically to the rest of the tillers.

Table 4. Yield and yield components of different tillers in IR25588 and IR58.

Tiller	IR25588				IR58			
	Grain wt. (g/panicle)	Spikelts /panicle	Filled spikelets (%)	1,000-grain wt. (g)	Grain wt. (g/panicle)	Spikelets /panicle	Filled spikelets (%)	1,000-grain wt. (g)
M*	4.5±0.1[1]	247± 7	82±1	22±0.2	3.2±0.1[1]	172± 4	84±2	22±0.2
P1*	3.8±0.1	216± 8	82±2	22±0.2	2.7±0.1	155± 4	80± 2	22±0.2
P2*	4.2±0.1	245± 7	81±1	22±0.2	3.0±0.1	169± 5	84± 2	22±0.2
P3*	4.2±0.1	233± 7	81±1	22±0.2	3.0±0.1	160± 5	85± 2	22±0.2
P4*	3.7±0.1	204± 6	82±2	22±0.2	2.9±0.1	155± 4	85± 2	22±0.2
P5	3.0±0.1	169± 8	80±2	22±0.2	2.2±0.1	117± 4	85± 2	22±0.2
P6	2.0±0.3	82±13	82±4	21±0.5	1.6±0.1	89± 5	84± 2	22±0.3
S1P1	3.0±0.2	172±11	82±2	22±0.2	2.3±0.1	125± 5	84± 2	22±0.3
S2P1	3.0±0.1	171± 9	81±2	22±0.3	2.0±0.1	115± 5	83± 2	22±0.2
S3P1	2.5±0.1	142± 5	81±2	22±0.3	1.9±0.1	104± 4	83± 2	22±0.3
S4P1	2.0±0.3	90±18	78±4	22±0.4	1.4±0.1	81± 4	81± 3	21±0.3
S1P2*	4.0±0.1	200± 5	81±1	22±0.3	2.7±0.1	144± 5	86± 2	22±0.2
S2P2	3.0±0.1	169± 6	80±1	22±0.2	2.1±0.1	121± 5	82± 2	21±0.2
S3P2	2.2±0.1	123± 6	80±2	22±0.3	1.7±0.1	97± 4	86± 2	21±0.6
S1P3	2.7±0.2	157± 9	80±2	22±0.2	1.9±0.1	102± 4	88± 1	22±0.3
S2P3	2.0±0.2	118±13	76±3	22±0.3	1.2±0.1	72± 6	85± 2	21±0.3
S1P4	1.8±0.2	97± 8	84±3	22±0.2	1.3±0.1	72± 6	87± 2	21±0.3
T1S1P1	1.6±0.2	90±11	86±2	22±5.5	1.2±0.1	68± 7	83± 4	21±0.2
T2S1P1	1.3±0.3	70±16	83±7	22±0.6	0.7±0.2	61±11	61±10	17±2.5
T1S1P2	1.3±0.1	75± 7	81±4	21±0.3	1.9±0.1	56± 9	85± 2	20±1.1

* The top six tillers. [1] Mean±standard error.

Table 5. Number of spikelets on the primary and secondary rachis-branches of different tillers in IR25588 and IR58.

Tiller	IR25588		IR58	
	Primary branch	Secondary branch	Primary branch	Secondary branch
M*	67±1[1]	180± 7	62±2[1]	110±4
P1*	59±3	157± 7	57±2	98±4
P2*	60±2	185± 7	58±4	111±4
P3*	63±2	170± 7	54±2	106±5
P4*	58±2	146± 6	53±2	101±4
P5	55±1	114± 8	51±2	66±4
P6	46±4	36±10	50±1	39±4
S1P1	58±1	114±11	52±2	73±5
S2P1	57±1	115± 9	52±2	63±4
S3P1	54±1	89± 5	50±2	54±4
S4P1	49±6	41±13	49±2	32±3
S1P2*	55±2	145± 6	51±2	93±5
S2P2	56±1	113± 7	49±2	72±4
S3P2	53±2	71± 6	49±2	47±4
S1P3	53±2	104±8	48±1	54±4
S2P3	48±2	70±12	45±2	26±5
S1P4	49±2	48±6	45±2	26±5
T1S1P1	45±5	45± 9	45±3	23±5
T2S1P1	43±8	27± 8	43±5	17±6
T1S1P2	45±3	30±4	40±6	16±5

* The top six tillers. [1] Mean±standard error.

摘 要

本 試驗은 벼의 潛在收量을 增加시킬 수있는 새로운 理想型 草型을 提示할 目的으로 벼 小蘖性과 多蘖性 品種을 利用하여 分蘖의 位置와 이삭의 크기 사이의 關係를 究明하고 收量을 增加시킬수 있는 草型으로서 알맞은 分蘖의 數를 決定하기 위하여 國際米作硏究所(IRRI)에서 1987年에 實施하였다. 供試品種은 小蘖·穗重型인 IR25588과 多蘖·穗數型인 IR58을 利用하였는데 이들은 分蘖能力과 이삭의 크기는 현저히 差異가 있었으나 다른 特性들은 비슷하였다.

1. 穗當穎花數와 收量을 基準으로 볼때, 小蘖性인 IR25588과 多蘖性인 IR58 모두 "上位6個의 分蘖"은 다른 分蘖에 비하여 有意的으로 이삭이 무겁고 穎花數가 많았다. 이러한 結果로 미루어 벼의 潛在收量을 現在보다 높일 수 있는 새로운 草型으로서 "分蘖이 6個 또는 그 보다 적은 小蘖性이고 穗當穎花數가 200~250個인 草型"을 提示한다. 이러한 小蘖·穗重型品種은 密植適應性이 높기 때문에 直播栽培에서도 收量을 높일 수있을 것으로 思料된다.

2. "上位 6 個의 分蘖"이 다른 分蘖들에 비하여 높은 收量을 나타낸 것은 主로 穗當穎花數가 越等히 많았기 때문이며 千粒重과 稔實比率은 寄與度가 적었다. 또한, "上位6個의 이삭"은 다른 이삭에 비하여 高密度粒(high-density grains)이 많았다.

3. "上位6個의 分蘖"은 主稈(M), 첫번째, 두번째, 세번째, 네번째 1次分蘖(P1, P2, 93, P4)과 두번째 1次分蘖에서 나온 첫번째 2次分蘖(S1P2)이었다.

4. 小蘖·多蘖性 모두 "上位6個의 分蘖"은 다른 分蘖에 비하여 葉面積이 크고, 稈重과 總分蘖重이 무거웠는데, 이는 많은 sink(穗當穎花數)를 채울 수있는 source로서 光合成 作用과 同化物質의 蓄積에 크게 寄與할 것이다.

Table 6. Number of high-density grains per panicle with specific gravity in IR25588 and IR58.

Tiller	High-density grains	
	IR25588 (> 1.18)	IR58 (> 1.12)
M*	135± 7[1]	129± 4[1]
P1*	119±10	106± 5
P2*	124± 9	128± 4
P3*	121± 9	122± 4
P4*	111± 8	119± 4
P5	87± 8	90± 4
P6	42±12	63± 3
S1P1	95± 8	89± 5
S2P1	95± 8	85± 4
S3P1	85± 5	77± 4
S4P1	49± 8	57± 4
S1P2*	110± 7	108± 4
S2P2	89± 6	86± 6
S3P2	72± 5	73± 3
S1P3	86± 6	77± 4
S2P3	65±11	56± 4
S1P4	56± 7	53± 5
T1S1P1	57± 7	45± 4
T2S1P1	43±16	29±13
T1S1P2	36± 4	36± 3

* The top six tillers.
[1] Mean±standard error

5. "上位6個의 分蘖"은 다른 分蘖보다 일찍 發生되어 生育期間이 길며, 分蘖 發生頻度가 100%로서 모두 有効分蘖이 되었다. 또한, 벼 1포기가 모두 出穗하는데 11~12日이 所要되었으나, 小蘖·多蘖性 모두 "上位6個의 分蘖"은 出穗期가 빨랐으며, 이들은 3日內에 모두 出穗되어 짧은 期間 內에 均一한 出穗와 登熟이 이루어 짐으로서 米質 向上에 有利할 것으로 해석된다.

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