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Morpho-anatomical Characteristics on Spikelet Filling of Different Tiller Orders in Rcie

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벼 分蘖莖의 解剖 形態學的 特性과 登熟性 比較

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ABSTRACT : Greenhouse experiments were conducted at the International Rice Research Institute during the 1989 dry season to investigate varietal differences in morpho-anatomical characters affecting spikelet filling in different tiller orders. There were varietal differences in tiller initiation and heading dates, and tiller duration. The main culm had competitive advantage over the other tillers. The maximum contribution to filled spikelet weight was made by primary tillers in low tillering cultivars and by secondary tillers in high tillering cultivars. The reduction in inner vascular bundle (IVB) by tiller orders and the number of IVB and outer vascular bundles (OVB) varied among cultivars. The number of IVB in the peduncle of IR30, Rewa and Hybrid was more than OVB but in IR47705, Silewah, Unbongbyeo and SR14453, OVB was more than IVB. Early formed tillers produced more IVB than the late formed tillers. The number of IVB was positively correlated with number of spikelet and filled spikelet weight, however percent of filled spikelet did not show significant differences as well as 1000 spikelet weight in all types of cultivars.

Grain yield of rice is determined by panicle number per unit area, spikelet number per panicle, percent ripened grain and weight of single grain[12]. The number of spikelets per unit area is the most important component limiting yield[14,15]. These factors, however, are affected by the size and status of the tillers.

In transplanted rice culture, the panicle number per unit area largely depends on tillering ability. Generally, the main culm within a plant is the heaviest and has the largest panicle followed by the primary, secondary, and tertiary tillers[9,10]. Although environment and cultural management greatly influence the number of tillers, differences in tillering capacity is inherent in rice. Since tiller size and hence panicle size within a plant vary greatly, the number of top or high yielding tillers per plant probably differ among rice cultivars.

Large tillers generally result in higher sink : source ratio, spikelet number, percent filled spikelets, leaf area per tiller and sink capacity[3]. The tillers formed earlier were productive tillers, while tillers formed later, especially the tertiary tillers were non-bearing tillers[11]. Carbohydrates produced by photosynthesis and other substances are transported to sink through phloem tissue. The capacity of the vascular system to transport nutrients is defined as the mass transfer rate and has the dimension of mass per time[1]. Although capacity of the vascular system may not be the major yield-limiting factor in

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cereals, it is important in dry matter accumulation[5,13].

There was high and positive correlation between the number of inner vascular bundles and number of spikelets and weight of a panicle[6,7].

This study was conducted to investigate the morpho-anatomical differences of different tiller orders on grain yield and yield components in various cultivars.

MATERIALS AND METHODS

The experiment was conducted in the greenhouse of the International rice Research Institute, Los Baños, Laguna, Philippines, during the 1989 dry season,

Rice cultivars IR30, a high-tillering indica : Rewa 353(Rewa) and IR47705-AC5(IR47705), low-tillering indica ; Silewah, a low tillering ; avanica ; Milyang 83(M83), an intermediate tillering Indica/Japonica hybrid ; IR30/IR47705, an intermediate tillering hybrid rice, Unbongbyeo(unbong), an intermediate-tillering japonica ; and SR14453-TCP1767-2D(SR14453), a low-tillering Japonica were used in the experiment.

One 10 day-old seedling was transplanted per 4-liter plastic pot(1/5, 000a) containing 4kg of puddled Maahas clay soil(*Andaqueptic Haplaquoll*) mixed with 4g ammonium sulfate(21% N) and 2g each of solophos(18% P_2O_5) and muriate of potash (60% K_2O).

The experimental design was randomized complete block with 18 replications for yield contribution of different tiller orders and 8 replications for assessment of anatomical differences. Date of emergence of primary, secondary and tertiary tillers were noted using plastic labels with colored threads every day. Each panicle which was 1/3 exserted from the flag leaf sheath, was tagged daily, indicating the heading date. At 5 days after heading, about 2 to 3cm internode just below the peduncle was sampled and free-hand transverse sections were made just below the peduncle, The sections were observed under a light microscope at 40× magnification to determine the number and size of vascular bundles(VB). The diameter and thickness of the peduncle were also measured.

RESULTS AND DISCUSSION

1. Tillering and heading patterns

The cultivars used had different tillering and heading patterns(Table 1, and 2). High tillering type IR30 had 37 tillers while moderates such as M83 and Hybrid had 18 and 20, and low-tillering like IR47705, Silewah, Rewa, and SR14453 had 12, 12, 11 and 8 tillers, respectively. (Table 1)

The first primary tiller emerged 8 days after transplanting(DAT) in Silewah and 14 DAT in Unbong. The duration of the initiation of the primary tiller ranged from 14 days in Hybrid to 32 days in IR30. Hybrid rice produced the first secondary tillers 7

Table 1. Varietal differences in tiller emergence of different tiller orders in eight rice cultivars. (1989. DS)

Cultivar	Tiller no.	Total duration	Tillering date					
			Primary		Secondary		Tertiary	
			ID[1]	DUR[2]	ID[3]	DUR	ID	DUR
IR30	37	65	9	32	9	26	28	19
M83	20	30	11	17	11	11	-	-
Hybrid	18	28	10	14	7	14	-	-
Unbong	11	26	14	22	11	14	-	-
Rewa	11	28	11	16	9	14	-	-
IR47705	12	21	11	18	11	9	-	-
Silewah	12	31	8	17	10	12	-	-
SR14453	8	28	12	16	14	9	-	-

1) Days from transplanting to tiller initation
2) Days from first to last tiller initiation
3) Days after initiation of first primary tiller
-No tertiary tillers

Table 2. Varietal differences in days to heading of different tiller orders in eight rice cultivars.(1989 DS)

Cultivar	Panicle no.	Total* duration	Tiller order		
			Main	Primary	Secondary
IR30	24	16	67	66	65
M83	17	7	59	60	61
Hybrid	15	3	71	69	69
Unbongbyeo	11	14	41	47	52
Rewa	10	4	61	59	60
IR47705	11	8	85	83	78
Silewah	8	4	71	69	68
SR14453	8	9	49	48	51

* From first heading date to last heading date

days after initiation of the first primary tiller but much later in SR14453. The duration of secondary tillers ranged from 9 days in IR47705 and SR14453 to 26 days in IR30.

Generally, the tillering and heading orders were the same. However, the earlier tillers took more days to flower than the ones formed later, Thus the primary tillers generally had longer growing periods than the others. However, the main panicle was usually not the first one to exsert(Table 2). Except in M83 and Unbong, all main panicle exserted the one to six days after the first exsertion. Thus, although the tillering occurred over a longer period, heading was more synchronous and occurred within a shorter duration. Not all tillers produced panicles (Table 3). Late formed tillers, mostly tertiary tillers, were nonbearing. On the average 96% of primary tillers, 76% of secondary tillers, and only 32% of tertiary tillers produced panicles. Since most tertiary tillers were nonbearing, it might be best to prevent the initiation of tertiary tillers or develop a variety without tertiary tillers.

Late tillers, mostly tertiary and some secondary tillers, particularly in high tillering cultivars like IR30, continued to emerge until heading or even after heading. Thus. IR30 had the lowest percent effective tillers while Rewa, SR14453 and IR47705, all low tillering cultivars, had a higher percentage of effective tillers(Table 3)

The secondary tillers comprised the bulk of the effective tillers in the high tillering cultivars IR30(54%) and M83(53%). In low tillering cultivars, the relative contribution of the secondary tillers to the total number of effective tillers was less than the primary tillers(Fig. 1). In IR30, tertiary tillers consisted 15% of the total number of effective tillers, the highest among the cultivars studied. When the morphological differences related traits of the different tiller orders were compared, the main culm and primary tillers which emerged earlier than the others had greater plant height, panicle length, leaf area, and more primary branches as well as secondary branches per panicle(Table 4). However there were varietal difference among the cultivars. Primary tiller in Hybrid rice and Silewah had longer plant height than the main culm.

Table 3. Percent effective tillers on different tiller orders in eight rice cultivars. (1989 DS)

Cultivar	Total/plant			Primary			Secondary			Tertiary		
	Tiller (no.)	Panicle (no.)	Effect (%)	Tiller (no.)	Panicle (no.)	Effect (%)	Tiller (no.)	Panicle (no.)	Effect (%)	Tiller (no.)	Panicle (no.)	Effect (%)
IR30	37.4	27.4	73.2	7.6	7.3	96.3	20.3	14.9	73.7	8.6	4.2	48.8
M83	20.4	15.9	77.9	6.1	5.9	96.7	10.8	8.4	87.5	2.6	0.7	26.9
Hybrid	17.6	13.3	75.6	5.7	5.4	94.7	9.6	6.7	68.8	1.2	0.1	9.2
Unbong	12.5	11.9	95.2	4.5	4.4	97.8	6.2	6.0	96.8	1.2	0.5	41.7
Rewa	11.2	10.1	90.2	5.4	5.2	96.3	4.5	3.9	86.7	0.3	-	·
IR47705	11.4	9.3	81.6	5.7	5.2	96.5	4.7	2.8	59.6	-	-	-
Silewah	11.6	8.9	76.7	5.2	4.9	94.2	5.1	2.9	56.7	0.3	0.1	-
SR14453	7.7	6.8	88.3	3.7	3.4	91.9	2.7	2.1	77.8	0.2	-	-
Mean			82.2			95.5			76.1	·	·	31.7

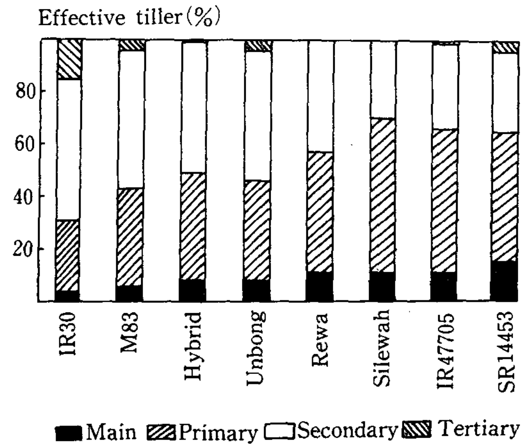

Fig. 2. Contribution of tiller orders to effective tiller number in a plant 1989 DS.

2. Varietal differences in anatomical characters

The size of the peduncle of the main culm and the number of VB varied greatly (Plate 1). The number of inner vascular bundles (IVB) and outer vascular bundles (OVB) in the peduncle varied with different tiller orders among the cultivars (Table 5 and 6). Generally, the main culm of all cultivars had the highest number of VB, followed by primary and secondary tillers. The primary tillers emerged early and had more VB than secondary tillers. However, variations occurred within the tiller orders. Some secondary tillers that emerged earlier than the late

Table 4. Plant height, panicle length, leaf area, and number of panicle branch for different tiller orders in eight rice cultivars. (1989 DS)

Cultivar	Tiller order	Plant height (cm)	Panicle length (cm)	Leaf area (cm²)	Panicle branch primary	Panicle branch secondary
IR30	M	83±1.5*	22.3±0.5	143± 9.7	10.6±0.3	22.6±1.6
	P	80±0.6	21.1±0.2	137± 3.6	10.3±0.1	17.1±0.7
	S	70±0.7	18.8±0.7	129± 2.2	8.5±0.2	10.6±0.5
M83	M	84±2.9	20.3±0.5	224± 3.2	12.1±0.6	31.1±5.1
	P	80±1.0	18.3±0.3	216± 8.9	11.1±0.3	25.7±2.0
	S	70±1.4	16.2±0.3	173± 7.0	10.2±0.2	20.5±1.5
Hybrid	M	170±3.7	32.6±0.7	229±17.0	17.9±0.5	51.6±2.3
	P	172±2.1	31.9±0.4	201± 6.7	14.7±0.3	42.8±1.6
	S	157±2.1	29.1±0.4	165± 6.2	13.2±0.3	28.4±1.7
Unbong	M	79±1.0	20.5±0.5	97± 6.2	10.0±0.4	16.6±1.8
	P	72±1.2	19.8±0.3	72± 3.0	8.3±0.2	14.4±0.7
	S	63±0.9	17.8±0.2	43± 1.8	7.1±0.1	11.0±0.5
Rewa	M	175±3.8	36.1±0.5	446±28.7	13.4±0.4	54.9±3.8
	P	169±1.8	33.9±0.4	356±11.4	12.3±0.2	50.0±1.4
	S	156±4.0	31.5±0.7	295±16.8	11.2±0.3	35.0±2.3
IR47705	M	152±3.5	30.5±0.7	310±21.4	13.5±0.7	14.9±1.4
	P	148±1.4	30.4±0.4	280± 8.2	13.0±0.3	13.1±0.6
	S	138±2.0	27.9±0.5	227±11.2	10.8±0.4	9.8±0.5
Silewah	M	189±6.3	28.8±1.2	229±28.0	14.1±0.6	25.8±3.9
	P	196±2.4	30.8±0.8	276±11.0	13.3±0.3	21.8±1.1
	S	189±5.5	28.9±1.0	222±13.1	11.8±0.4	16.8±1.5
SR14453	M	85±3.8	23.3±0.8	160±11.0	8.4±0.5	13.0±1.0
	P	79±1.6	20.0±1.6	116± 3.3	7.2±0.3	8.7±0.5
	S	72±3.2	19.6±0.5	78± 4.6	6.4±0.3	6.2±0.6

* Mean ± standard error
M : main culm, P : primary tillers, S : secondary tillers

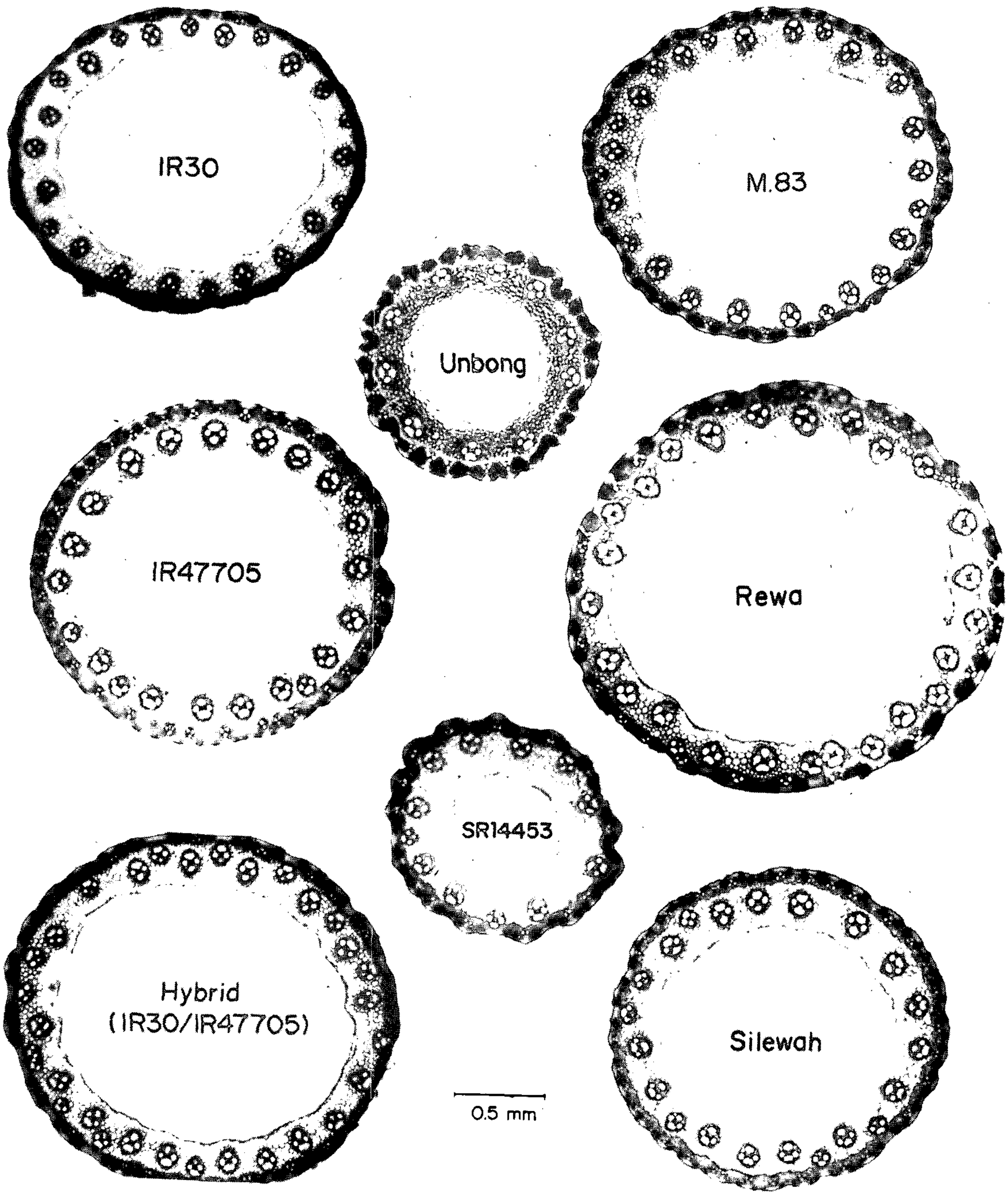

Fig. 1. Cross section of main culm peduncle showing vascular bundles of eight rice cultivars. IRRI, 1989 DS.

primary tillers had more number of VB than primary tillers. For example, in IR30, P2S1 had more IVB than P6 and P7, and P1S1 of Unbong had more IVB than P2, P3 and P4 (Table 5).

In previous studies, Hayashi[7], and Kim[8] observed that the number of IVB decreased at the rate of one and two each tiller order, respectively. The present study showed varietal differences in the number of IVB among the cultivars tested (Table 5).

The number of IVB in the Indicas, IR30 and IR47705, and M83 (indica/japonica) reduced at the rare of two for each tiller order. In SR14453, a

Table 5. Comparison of number of inner vascular bundle on tiller orders in eight rice cultivars. (1989 DS)

Tillers	IR30	M83	Hybrid	Unbongbyeo	Rewa	IR47705	Silewah	SR14453
M	24.0 a	23.3 a	30.3 a	8.9 a	28.1 ab	23.4 a	18.3 a	9.8 a
P1	22.1 a-e	21.9 a-c	27.9 a-c	10.1 a	25.3 a-d	21.6 ab	17.5 a	9.5 ab
P2	21.1 a-e	22.1 ab	29.1 ab	8.8 ab	26.9 a-c	22.6 a	16.2 ab	9.3 ab
P3	21.8 a-e	20.8 a-d	28.6 a-c	8.8 ab	26.9 a-c	22.4 ab	17.3 a	9.3 ab
P4	23.4 ab	22.1 ab	27.6 a-d	8.3 ab	26.1 a-c	22.4 ab	15.7 ab	8.2 ab
P5	22.9 a-c	21.6 a-c	27.3 a-e	-	29.0 a	20.9 ab	14.3 b	-
P6	21.6 a-e	18.1 b-f	22.3 g		-	21.3 ab	-	
P7	20.7 a-f	-	-			-		
*	21.9	21.1	27.1	9.0	26.8	21.1	16.2	9.1
P1S1	20.9 a-f	20.3 a-e	25.4 c-g	9.0 ab	22.3 c-e	20.8 ab	16.7 ab	8.1 ab
P1S2	20.4 a-f	22.0 ab	23.3 f-g	7.8 b	24.0 b-d	20.3 ab		8.0 b
P1S3	19.7 b-g	20.1 a-e	24.0 e-g	8.1 ab	20.5 de	-	-	-
P1S4	19.8 b-g	-	-	-	-			
P2S1	22.5 a-d	18.3 b-f	26.0 b-f	8.1 ab	19.0 e	19.0 b	15.6 ab	8.3 ab
P2S2	20.6 a-f	17.4 c-g	25.8 c-f	8.3 ab	-	-	-	-
P2S3	20.0 a-g	-	23.3 fg	-				
P2S4	18.9 c-g		-					
P3S1	19.0 c-g	21.0 a-d	24.4 d-g	8.0 b	21.4 d-g	21.0 de	19.0 b	
P3S2	19.7 b-g	-	-	-	-	-	-	-
P3S3	19.4 b-g							
P4S1	18.4 d-g	17.0 d-g						
P4S2	18.8 d-g	-						
P5S1	20.5 a-f							
**	20.0	19.4	21.6	8.2	21.4	20.3	17.1	8.1

M : main culm P : Primary tiller S : secondary tiller
Means with a same letter are not significantly different by DMRT, 5% level.
* Mean of primary tillers ** Mean of secondary tillers

Japonica, the IVB reduced at the rate of one for each tiller order. For Unbong, a Japonica, the main culm and primary tillers had similar number of VB while in Hybrid and Rewa, there was a big difference in the number of IVB between primary and secondary tillers. There was no consistent trend in OVB number varying with tillers order (Table 6). Apparently, the relationship between tiller orders and OVB number depends on the cultivar.

Hybrid rice had the highest number of IVB while IR47705 had the highest number of OVB. The number of IVB was higher than OVB in IR30, Rewa and Hydrid. However, IR47705, Silewah and two Japonica cultivars had more OVB than IVB (Table 7). The significance of this difference should be analyzed and the proper development or selection criteria for better total VB determined. Hayashi[6] showed that Indica rice had more VB than Japonica, while Lee at al[9]. reported that the Tongil types (indica × japonica) had more IVB than Japonica rice. This was confirmed in the present experiment.

Varietal differences in peduncle diameter and thickness than the other cultivars. However, peduncle thickness was similar in most cultivars except IR30 and Unbong which had thinner peduncles. The number of VB was negatively correlated with date to tillering (DT) except in Rewa and IR47705 (Table 8). i.e., the earlier tillering, the longer the growing period and the more VB are formed. On the other hand, the peduncle diameter had highly significant negative correlation with DT in all cultivars except IR47705 and SR14453. This indicates dependence of tiller growth on the date of initiation.

The peduncle diameter, peduncle thickness and VB number had a significant negative correlation with date to heading (DH) in IR30, M83, and Unbong whereas tiller duration had positive correlation with those characters (Table 8). The earlier tiller had thicker peduncles than those formed later. Hence early initiation or formation of tillers is important for better panicle development. Kim[8] reported that the top six tillers showed bigger weight

Table 6. Comparison of number of outer vascular bundle on tiller orders in eight rice cultivars. (1989 DS)

Tillers	IR30	M83	Hybrid	Unbongbyeo	Rewa	IR47705	Silewah	SR14453
M	19.9 a	22.1 a	24.9 a-d	17.1 ab	25.5 a	31.5 a	29.4 a	13.5 b
P1	19.6 ab	21.5 ab	27.7 a	17.6 ab	21.3 b-d	29.9 ab	28.1 a	14.7 ab
P2	20.1 a	20.9 ab	26.8 ab	18.1 a	22.9 ab	30.5 ab	25.8 ab	15.5 ab
P3	19.9 a	19.8 a-e	24.8 a-d	18.1 a	22.4 a-c	31.4 a	27.5 ab	15.3 ab
P4	19.9 a	20.7 a-c	25.6 a-c	16.0 ab	21.4 bc	29.1 ab	25.4 ab	16.6 a
P5	18.5 ab	20.1 a-d	24.5 b-d	-	23.0 ab	29.3 ab	25.3 ab	-
P6	19.3 ab	19.1 a-e	19.0 f		-	30.0 ab	-	
P7	18.6 ab	-	-			-		
*	19.4	20.4	24.7	17.5	22.5	30.0	26.4	15.5
P1S1	18.0 ab	19.6 a-e	23.4 cd	15.0 ab	18.8 cd	28.2 ab	25.7 ab	13.9 b
P1S2	18.0 ab	20.6 a-c	21.9 c-e	16.1 ab	18.7 cd	27.5 ab	-	13.3 b
P1S3	16.9 ab	18.3 b-f	21.7 d-e	13.0 b	17.5 d	-		-
P1S4	17.9 ab	-	-	-	-			
P2S1	18.5 ab	18.0 b-f	24.4 c-f	15.0 ab	17.5 d	25.7 b	23.0 b	14.7 ab
P2S2	17.4 ab	17.9 c-f	22.5 c-e	15.3 ab	-	-	-	-
P2S3	17.8 ab	-	23.0 cd	-				
P2S4	16.4 ab	-						
P3S1	16.3 ab	17.0 d-f	19.8 ef	14.5 ab	19.4 b-d	26.5 ab	22.9 b	
P3S2	18.5 ab	-	-	-	-	-	-	
P3S3	17.0 ab							
P4S1	17.4 ab	17.6 e-f						
P4S1	17.1 ab	-						
P5S1	16.5 ab							
**	17.4	18.4	22.4	14.8	18.4	27.0	23.9	14.0

M : Main culm P : Primary tiller S : Secondary tiller
Treatment means having a same letter are not significantly different by DMRT, 5% level.
* Mean of primary tillers ** Mean of secondary tillers

Table 7. Varietal differences of number and size of vascular bundle in the peduncle in eight rice cultivars. (1989 DS)

Cultivar	Inner vascular bundle (no.)	Outer vascular bundle (no.)	Peduncle thickness (mm)	Peduncle diameter (mm)
IR30	20.73±0.35*	18.14±0.27	1.64±.02	0.25±.002
M.83	19.92±0.68	19.41±0.40	1.90±.03	0.30±.003
Hybrid	26.22±0.69	23.86±0.64	2.10±.03	0.33±.005
Unbong	8.55±0.13	15.90±0.24	1.22±.02	0.27±.008
Rewa	24.40±0.85	20.64±0.71	2.37±.05	0.34±.007
IR47705	21.24±0.43	29.04±0.57	2.13±.03	0.39±.005
Silewah	16.44±0.44	26.28±0.70	1.90±.03	0.36±.005
SR14453	8.81±0.25	14.67±0.39	1.23±.02	0.33±.007

* Mean±standard error.

culm diameter than the rest of the tillers. The correlation of filled spikelet weight (FSW) with the number of IVB and OVB in all cultivars was highly significant (Table 9). There were highly significant positive correlations between the number of IVB and OVB with the number of panicle branches (PB and SB), number of spikelet, number and weight of filled spikelet in all cultivars. While 1000-grain weight was not correlated with IVB and OVB in all cultivars and fertility generally showed negative correlation except M83 (Table 9). These relationships indicate that the number of IVB is an important determinant of FSW per panicle which is apparently promoted by adequate flow of carbohydrates from the source to the sink. These results also indicate that the number of IVB and OVB could be

Table 8. Correlation of vascular bundle of the peduncle with tillering and heading dates. (1989 DS)

Cultivar	Dates to tillering				Dates to heading			
	IVB	OVB	PDM	PTM	IVB	OVB	PDM	PTK
IR30	-**	-*	-**	-**	-**	-**	-**	-*
M.83	-**	-**	-**	-NS	-*	-**	-**	-**
Hybrid	-**	-*	-**	-*	-NS	-NS	-NS	-NS
Unbong	-**	-**	-**	-**	-**	-**	-**	-**
Rewa	-NS	-NS	-*	-**	-NS	-NS	-NS	-*
IR47705	-NS	-NS	-NS	-*	-NS	-NS	-NS	-NS
Silewah	-*	-NS	-*	-NS	*	**	*	NS
SR14453	-**	NS	-NS	-NS	-NS	-NS	-NS	-NS

IVB : Inner vascular bundle   * Significant at the 5% level
OVB : Outer vascular bundle   ** Significant at the 1% level
PDM : Peduncle diameter
PTK : Peduncle thickness

Table 9. Correlation analysis between nmber of vascular bundle in peduncle and panicle characters in seven rice cultivars. (1989 DS)

Cultivar	Vascular bundle	Branches Primary	Branches Secondary	No. of spikelet	No. of filled spikelet	Wt. of filled spikelet	Fertility	1000 grain weight
IR30	IVB	**	**	**	**	**	-NS	NS
	OVB	**	**	**	**	**	NS	NS
M.83	IVB	**	**	**	**	**	**	NS
	OVB	**	**	**	**	**	NS	NS
Hybrid	IVB	**	**	**	**	**	-**	NS
	OVB	**	**	**	**	**	-**	NS
Unbong	IVB	**	**	**	**	**	-NS	NS
	OVB	**	**	**	**	**	-NS	NS
Rewa	IVB	**	**	**	**	**	-NS	NS
	OVB	**	**	**	**	**	NS	NS
IR47705	IVB	**	**	**	**	**	-NS	NS
	OVB	**	**	**	**	**	-NS	NS
Silewah	IVB	*	*	*	*	*	-NS	-NS
	OVB	**	**	**	**	**	-*	-NS

IVB : Inner vascular bundle   * Significant at 5% level
OVB : Outer vascular bundle   ** Significant at 1% level

assessed more easily by measuring peduncle diameter.

IVB are important because of their much larger size relative to OVB. Actually, OVB are so small that precise estimates of their size could not be obtained (Plate 1) and probably have little significance in transport of carbohydrates to the sink. Chaudhry and Nagato[2] suggested that IVB play a major role in translocating plant nutrients to the spikelets and influence the ripening whereas OVB entered and terminated in the rudimentary glumes of the spikelets.

3. Grain Yield and Yield Components

The highest grain weight per panicle was produced by Rewa and the lowest by IR30 for all tiller orders (Table 10). In all cultivars main panicle produced the maximun grain weight followed by the primary and the secondary panicles. In the hybrid rice, the mean primary panicle weight was only 6% less than that of the main panicle, it was 29% less in the case of SR14453. Small reduction in panicle weight between main culm and the primary tillers might be an important trait for direct seeded rice.

On the other hand, the high panicle weight of the main culm of Rewa can be exploited for the development of a uniculm plant type.

The reduction in panicle weight of the secondary tillers was highest in SR14453(53%) and was the lowest for Hydrid. In general, low and intermediate tillering cultivars had higher grain weight per panicle, than high tillering cultivars.

The number of spikelets per panicle varied greatly among tiller order. The main tiller had more spikelets/panicle than the primary tiller while the secondary tillers had the least. The fertility percentage had no trend with tiller order while 1000 grain weight generally decreased from the main tiller to the secondary tillers. Spikelet number per panicle could be considered as the most important determinant of FSW (Table 10). This was confirmed by the highly significant correlation between FSW and the number of spikelets per panicle(Table 11). For instance, Rewa had the highest whereas SR14453 had the lowest spikelet number/panicle and, consequently panicle grain weight for all tiller orders. Since 1000-grain weight was not correlated with spikelet number, it is possible to increase individual grain weight regardless of spikelet number. Although the panicles from the main tillers were the heaviest, they

Table 10. Filled spikelet weight and its components for different tiller orders in eight rice cultivars. (1989 DS)

Cultivar	Tiller order	Spikelet (no./panicle)	Fertility (%)	1000-grain wt. (g)	Filled spikelet wt. (g/panicle)
IR30	M	98± 5.6	89.1±1.5	19.60± .17	1.71±.07
	P	86± 2.1	88.0±0.8	19.11± .42	1.43±.03
	S	67± 1.4	87.3±0.6	18.40± .10	1.07±.02
M.83	M	178±10.8	84.7±1.9	17.32± .36	2.58±.13
	P	156± 5.5	85.6±2.2	16.06± .22	2.06±.06
	S	113± 4.7	80.0±1.2	16.02± .20	1.44±.06
Hybrid	M	232± 6.9	79.9±1.6	24.81± .29	4.57±.14
	P	215± 5.1	82.6±0.7	24.22± .13	4.32±.09
	S	171± 3.9	84.4±0.6	23.96± .15	3.45±.08
Unbong	M	108± 3.8	93.0±1.4	24.54± .57	2.34±.15
	P	88± 2.8	91.5±0.9	24.82± .43	1.90±.07
	S	69± 1.9	87.5±2.0	24.62± .43	1.47±.00
Rewa	M	327± 7.8	84.1±1.5	23.66± .30	6.50±.22
	P	264± 6.1	81.3±1.2	23.25± .37	4.93±.12
	S	193± 9.3	81.2±1.6	22.95± .58	3.59±.19
IR47705	M	140± 7.6	88.7±1.4	30.11± .14	3.71±.18
	P	123± 2.7	89.3±0.8	29.06± .17	3.18±.07
	S	102± 2.8	89.7±1.2	29.24± .15	2.66±.07
Silewah	M	169± 8.5	53.3±4.0	27.78± .29	2.52±.23
	P	128± 3.1	57.3±1.7	28.89± .14	2.12±.08
	S	110± 5.0	58.7±2.6	28.25± .20	1.84±.12
SR14453	M	83± 4.0	93.7±1.6	25.55± .33	2.00±.10
	P	61± 1.7	89.7±1.4	25.72± .28	1.43±.04
	S	43± 2.1	76.0±6.6	22.19±1.74	0.95±.10

* Mean±standard error. M : main culm, P : primary, S : secondary.

Table 11. Correlation between the number of spikelets per panicle and spikelet filling in eight rice cultivars. (1989 DS)

Cultivar	Tillering dates	Heading dates	Fertility	1000-grain weight	Filled spikelet no.	Filled spikelet wt.
IR30	-0.79**	-0.64**	0.10ns	0.53*	0.99**	0.98**
M.83	-0.84**	-0.88**	0.61*	0.22ns	0.99**	0.99**
Hybrid	-0.72**	-0.25ns	-0.77**	-0.40ns	0.99**	0.99**
Unbong	-0.83**	-0.90**	0.36ns	-0.22ns	0.99**	0.97**
Rewa	-0.86**	-0.70*	0.00ns	0.19ns	0.97**	0.98**
IR47705	-0.63*	-0.15ns	-0.42ns	0.00ns	0.98**	0.96**
Silewah	-0.85**	0.93**	-0.72ns	-0.66ns	0.98**	0.98**
SR14453	-0.94**	0.74*	0.84**	-0.52ns	0.98**	0.99**

* Significant at the 5% level
** Significant at the 1% level

contributed the least as there could be only one main tiller per plant.

Generally tillering date had the significant negative correlation with the number of spikelet per panicle while there was varietal difference between the number of spikelet and heading date. This result showed that early formed tillers produced more number of spikelet than late one. However heading date gave the more complication effect on number of spikelet in Hybrid, IR47705, Silewah and SR14453 cultivars.

摘　要

分蘗力이 서로 다른 日本型, 印度型, 統一型, Java型, Hybrid等 8個 品種 分蘗莖의 解剖生態學的 特性과 收量 및 收量構成要素를 比較檢討하기 爲해 國際米作硏究所에서 實驗을 實施하였다.

1. 1次 分蘗의 시작은 日本型 벼는 移秧後 12-14日, 印度型 벼는 9-11日, 其他品種은 8-10日頃에 시작 되었으며 2次分蘗은 1次 分蘗後 7日(Hybrid)-14日(SR14453)로 品種間 特性은 1次 分蘗과 비슷한 傾向이었다. 또한 分蘗莖數는 1次 分蘗莖은 4(SR14453)-8個(IR30), 2次는 3(SR14453)-20個(IR30)이었다.
2. 分蘗期間은 21日(IR14453)-65日(IR30)이 所要되었고 出穗는 短期間(6-32日)內에 끝나 生育期間이 多樣하였으며 主稈의 出穗는 密陽 83號와 雲峰벼에서만 가장 먼저 出穗하였다.
3. 이삭목의 大維管束數는 品種에 따라 多樣하였으며 IR30, 밀양 83號, Rewa, Hybrid 벼는 大維管束數가 小維管束數보다 많았으나 IR47705, Silewah, 雲峰벼, SR14453은 反對의 傾向이었다.
4. 이삭목의 大維管束數의 減少率은 主稈과 1次分蘗莖間에 0(SR14453)-3.0個(Hybrid)로 品種間 差異가 顯著하였으며 一般的으로 出現이 빠른 分蘗莖은 늦은 것보다 維管束數가 많았으나 品種에 따라 差異가 없는 것도 있었다.
5. 分蘗莖間 收量特性은 稔實率이나 千粒重은 分蘗順序와 큰 差가 없었으나 穗當粒數의 差가 크기 때문에 收量은 主稈에 가장 많았고 1次分蘗莖, 2次分蘗莖 順으로 減少하는 傾向이었으며 主稈과 1次 分蘗莖은 2次 分蘗莖에 比해 草長, 穗長, 葉面積이 크고 維管束의 數가 많았다.
6. 이삭목의 維管束數는 穗當粒數 및 收量과 高度의 正의 相關을 보였으나 稔實率과 千粒重과는 有意性이 없었으며 穗當粒數는 分蘗時期에 따라 負의 相關이 있었으나 出穗時期와는 品種간 差異가 認定되었다.

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