Botanical Studies in the Genus *Oryza*

VI. Panicle Structure and Flowering Behaviour

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Morphological characters of panicle or spike and flowering behaviour were reported in *Oryza sativa* (1), in the genus *Triticum* (2), in *Triticum aestivum* L., *Secale cereale* L., *Avena sativa* L., *Panicum miliaceum* L. (7) and others.

Informations of flowering behaviour are useful for botanical studies and plant breeding. Especially in the genus *Oryza*, a spikelet is available for fertilization centering around flowering day, and a pollen is available for fertilization only a few minutes. It is seriously requested to detect the flowering behaviour in the respective day for breeding and others. In the previous paper (5), seventy six strains belonging to 24 different species of the genus *Oryza* were used for investigations of flowering order in panicle. It became to clear that the flowering of spikelets in a panicle takes place in a regular sequence according to the respective species. In the other paper (6), seventy six strains belonging to 24 different species were also used for investigations of flowering time. It became to clear that the species can be roughly classified into four groups with respect to their responses to climatic conditions on the time of flowering start.

Then, using *Oryza* for this experiments, the writer studied the twenty characters upon the panicle structure and flowering behaviour and the correlations between them, in hope to obtain a useful informations on the taxonomical, morphological studies of the genus.

Materials and Method

Seventy six strains belonging to 26 species of the genus *Oryza*, including 2 cultivated and 24 wild species, were used in the present investigation.

Enumerations of the species, their distribution and chromosome numbers were given in Table 1 of the previous paper (4). ROSCHEVICZ's classification (9) seems to be the most natural and reasonable so that it is mainly adopted in this paper. The materials were grown in the greenhouse. One to six strains of each species, obtained from different localities, were used. The observations were made every day during September to December. As no obvious intraspecific variation has been found, except in *O. officinalis*, one strain was selected as the representative of the species and recorded in this experiment. Several strains of *O. officinalis* showed a great variation in flowering behaviour. Therefore, two strains were used in the present study. As *O. subulata*

showed peculiar flowering behaviour, two strains were shown. In this species, flowering occurred in the first panicle at first and followed by 1/P1 and 1/P2 (according to the standard formula showing plastochrone age), the flowering behaviour was very different from that of other species. In this paper, first panicle was called as *O. subulata*-II and all of panicle was called as *O. subulata*-I.

Results and Discussion

Twenty characters upon the panicle structure and flowering behaviour are shown in Tables 1 and 2. They are as follows ; number of flowered spikelets (Abbr. A in Table 1), number of unflowered spikelets (B), total number of spikelets (C), percentage of unflowered spikelets to the total number of spikelets (D), number of the first rachis (E), number of the second and third rachises (F), number of the second and third rachises per the first rachis (G), number of spikelets per the first rachis (H), number of spikelets per the second and the third rachises (I), panicle length (J), average internode length (K), length from neck-node to the lowest rachis (L), the first date of heading (Abbr. M in Table 2), the last date of heading (N), the first date of flowering (O), the last date of flowering (P), interval between the first date of heading and the first date of flowering (Q), heading duration (R), flowering duration (S) and number of flowered spikelets per day (T). Correlation between seven characters of panicle structure and flowering behaviour are shown in Table 3.

1) Number of flowered spikelets

Number of flowered spikelets in three subspecies of *O. meyeriana* was peculiarly small. The species belonging to section *Sativae* had more flowered spikelets than those in the other three sections of the genus *Oryza*. In *O. officinalis* intraspecific variation of numbers was very large. Number of spikelets in the first rachis and the second and the third rachises, and its mode or peak was different according to the species.

2) Number of unflowered spikelets

Ratios of unflowered spikelets to the total spikelets were very large in *O. ridleyi*, *O. longiglumis* and *O. coarctata*. The former two species are growing under heavily shaded and relatively humid environment at the natural habitats. But the latter one is found on saline soil of delta area in India and Burma. It is not clear that the relationship between number of unflowered spikelets and degeneration pattern. Unflowered spikelets were not always sterile but flowered spikelets were not necessarily fertile.

3) Number of the first rachises

O. sativa, *O. perennis*, *O. eichingeri* and *O. alta* had relatively large numbers of the first rachises. They have so-called "open type" panicle showing large angle of rachis to the main culm of the panicle. On the other hand, *O. meyeriana* subsp. *granulata*, *O. meyeriana* subsp. *meyeriana*, *O. meyeriana* subsp. *abromeitiana*, *O. coarctata*, *O. brachyantha*, *O. tisseranti*, *O. perrieri* and *O. subulata*-II had relatively small number of the

Table 1. Panicle structures in each species.

Species	Characters											
	A	B	C	D	E	F	G	H	I	J	K	L
O. sativa	187	9	196	4.6	16	51	3.2	12.2	3.8	31.0	2.0	5.6
O. sativa var. *spontanea*	83	0	83	0.0	11	18	1.6	7.5	4.6	21.6	1.9	6.4
O. perennis	97	10	107	9.3	13	24	1.7	8.2	4.5	17.8	1.4	0.5
O. glaberrima	113	8	121	6.6	15	15	1.0	8.1	8.1	18.2	1.2	0.3
O. stapfii	77	1	78	1.3	12	12	1.0	6.5	6.5	21.2	1.8	4.6
O. breviligulata	61	3	64	4.2	10	10	1.0	6.4	6.4	16.7	1.7	0.2
O. officinalis-I	118	0	118	0.0	10	29	2.9	11.8	4.1	24.1	2.4	22.5
O. officinalis-II	50	4	54	7.4	6	13	2.2	9.0	4.9	17.8	3.0	16.2
O. minuta	57	0	57	0.0	7	15	2.1	8.1	3.8	13.5	1.9	9.3
O. malabarensis	111	5	116	4.3	9	27	3.0	12.9	4.3	20.8	2.3	10.0
O. malampuzhaensis	102	3	105	2.8	8	25	3.1	13.1	4.2	19.8	2.5	11.3
O. eichingeri	245	16	261	6.1	15	56	3.7	17.3	4.7	31.2	2.1	10.5
O. punctata	139	9	148	6.1	12	33	2.8	12.3	4.5	24.4	2.0	9.9
O. latifolia	230	5	235	2.2	11	53	4.8	20.9	4.3	31.3	2.8	13.6
O. alta	312	8	320	2.5	23	75	3.3	13.9	4.3	42.3	1.8	37.7
O. grandiglumis	89	13	102	12.7	10	24	2.4	10.2	4.3	32.3	3.2	27.5
O. australiensis	69	16	85	18.8	10	24	2.4	8.5	3.5	20.0	2.0	26.8
O. meyeriana subsp. *granulata*	13	0	13	0.0	5	5	1.0	2.6	2.6	7.0	1.4	11.7
O. meyeriana subsp. *meyeriana*	13	0	13	0.0	5	5	1.0	2.6	2.6	6.0	1.2	8.2
O. meyeriana subsp. *abromeitiana*	15	0	15	0.0	5	5	1.0	3.0	3.0	6.4	1.3	7.7
O. ridleyi	35	11	46	23.9	10	10	1.0	4.6	4.6	23.0	2.3	0.9
O. longiglumis	41	16	57	28.1	11	14	1.3	5.2	4.1	24.3	2.2	6.2
O. coarctata	10	4	14	28.6	3	3	1.0	4.7	4.7	7.0	2.3	0.2
O. brachyantha	11	1	12	8.3	4	4	1.0	3.0	3.0	5.0	1.3	0.1
O. tisseranti	24	4	28	14.3	7	7	1.0	4.0	4.0	17.0	2.4	0.4
O. perrieri	23	5	28	17.8	6	6	1.0	4.7	4.7	16.4	2.7	0.3
O. subulata-I	125	1	126	0.8	10	22	2.2	12.6	5.7	45.2	4.5	0.2
O. subulata-II	33	1	34	2.9	6	6	1.0	5.7	5.7	23.0	3.4	-

A : Number of flowered spikelets; B : Number of unflowered spikelets; C : Total number of spikelets; D : Percentage of unflowered spikelets; E : Number of the first rachises; F : Number of the second and third rachises; G : Number of the second and the third rachises per the first rachis; H : Number of spikelets per the first rachis; I : Number of spikelets per the second and the third rachises; J : Panicle length (cm); K : Average internode length (cm); L : Length from neck-node to the lowest rachis (cm).

first rachises. They showed "close type" panicle. Excepting *O. alta*, the number of the first rachises were found as continuously between 3 and 16 in the whole species.

4) Number of the second and the third rachises

The third rachis was found only in *O. eichingeri* and was counted as three. The second rachis in one first rachis was counted as six in maximum. The present

materials are divided into two groups according to the total number of the second and the third rachises, the one having more than 50 and the other less than 50. *O. sativa*, *O. eichingeri*, *O. latifolia* and *O. alta* belong to the former group and remaining species belong to the latter group. Boundary between the two groups is very clear.

5) Number of the second and third rachises per the first rachis

As shown in Table 1, twelve strains, *i e.*, *O. glaberrima*, *O. stapfii*, *O. breviligulata*, *O. meyeriana* subsp. *granulata*, *O. meyeriana* subsp. *meyeriana*, *O. meyeriana* subsp. *abromeitiana*, *O. ridleyi*, *O. coarctata*, *O. brachyantha*, *O. tisseranti*, *O. perrieri* and *O. subulata*-II, had only first rachis but no second and third rachises. Fifteen strains, *i. e.*, *O. sativa*, *O. sativa* var. *spontanea*, *O. perennis*, *O. officinalis*-I and -II, *O. minuta*, *O. malabarensis*, *O. malampuzhaensis*, *O. eichingeri*, *O. punctata*, *O. latifolia*, *O. alta*, *O. grandiglumis*, *O. australiensis*, *O. longiglumis* and *O. subulata*-I, had the second and/or the third rachises.

It is very interesting that the Asian cultivated species, *O. sativa*, and its related species, *i. e.*, *O. sativa* var. *spontanea* and *O. perennis*, had many the second rachises in the first rachis, but the African cultivated species, *O. glaberrima*, and its closely related species, *i. e.*, *O. stapfii* and *O. breviligulata*, had no second rachis.

O. meyeriana subsp. *granulata*, *O. meyeriana* subsp. *meyeriana* and *O. meyeriana* subsp. *abromeitiana* are taxonomically closely related with each other and showed no variation in five characters mentioned above. *O. brachyantha*, *O. tisseranti* and *O. perrieri* are also closely related with each other and showed same tendency.

The first rachis having many the second and the third rachises is located at about middle position in a panicle. In the most species used, then, the number of the second and the third rachises gradually decreased upward and downward in a panicle.

6) Number of spikelets per each rachis

Number of spikelets per the first rachis and per the second and the third rachises were observed between 2.6 to 20.9 and 2.6 to 8.1, respectively. The smallest number of spikelets per the first rachis was obtained in Meyeriana Complex (10), *O. meyeriana* subsp. *granulata*, *O. meyeriana* subsp. *meyeriana*, *O. meyeriana* subsp. *abromeitiana*, showing 2.7 in average. Brachyantha Complex, *O. brachyantha*, *O. tisseranti*, *O. perrieri*, showed 3.9 in average. Ridleyi Complex, *O. ridleyi*, *O. longiglumis*, showed 4.9 in average. Glaberrima Complex, *O. glaberrima*, *O. stapfii*, *O. breviligulata* showed 7.0 in average. The largest value was found in Latifolia Complex, *O. latifolia*, *O. alta*, *O. grandiglumis*, showing 15.0 in average. It will be said that they are clearly divided into several groups according to taxa.

About four seventh of the species used showed 4.0 to 4.9 in the number of spikelets per the second and the third rachises. This character showed smaller variation in comparison with the former character. The number of spikelets per the second and the third rachises seems to be constant in the genus *Oryza*.

The values of the former character of Sativa Complex, *O. sativa*, *O. sativa* var. *spontanea*, *O. perennis*, are clearly larger than that of Glaberrima Complex, *O. glaberrima*, *O. stapfii*, *O. breviligulata*, showing 9.3 in average and 7.0 in average, respectively. On the

contrary, the values of the latter character of Sativa Complex are clearly smaller than that of Glaberrima Complex, showing 4.3 in average and 7.0 in average, respectively. It is assumed that the differences found in those two complexes would be caused by the evolutional passway, *i. e.*, natural and artificial selections.

7) Panicle length

Panicle length of Meyeriana Complex (= *O. meyeriana* subsp. *granulata*, *O. meyeriana* subsp. *meyeriana*, *O. meyeriana* subsp. *abromeitiana*), *O. coarctata and O. brachyantha* were conspicuously shorter than that of other 21 species. The longest panicle was observed in *O. alta* and *O. subulata*-I ; *O. sativa*, *O. eichingeri*, *O. latifolia* and *O. grandiglumis* had relatively long panicle. The remaining 20 species had short panicle in the continuous range.

Panicle length of *O. minuta* and *O. officinalis* was reported by TATEOKA *et al.* (11). They reported that *O. minuta* has small panicle (up to 17 cm long), and *O. officinalis* has large panicle (up to 40 cm long). The present observations supported TATEOKA's observations.

8) Average internode length

In the present study, an average internode length of panicle was calculated by panicle length/numder of the first rachises. Excepting *O. subulata*-I, whole species showed in average internode length of panicle with consecutive variations, varying between 1.2 and 3.4

9) Length from neck-node to the lowest first rachis

Length from neck-node to the lowest first rachis was less than 1 cm in 9 species, *i. e.*, *O. perennis*, *O. glaberrima*, *O. breviligulata*, *O. ridleyi*, *O. coarctata*, *O. brachyantha*, *O. tisseranti*, *O. perrieri* and *O. subulata*. Relatively large value in length, more than 20 cm, was found in 4 species, *i. e.*, *O. officinalis*-I, *O. alta*, *O. grandiglumis* and *O. australiensis*. In the preliminary experiments, it was observed that panicle length and length from neck-node to the lowest first rachis was determined by temperature, water content and light intensity. Because the plants used in the present experiment were growing in favourable condition, the length observed in this experiment will be considered as species specific character.

The point of insertion of the spikelets on the lower branches of the panicle was reported by TATEOKA *et al.* (11). In *O. minuta*, the lower one-third of the branches is naked, but in typical *O. officinalis* the lower half is naked. In the present observations, 48.3 %, 48.2 % and 40.8 % were obtained in *O. officinalis*-I, *O. officinalis*-II and *O. minuta*, respectively. These values supported TATEOKA's observations.

O. ridleyi and *O. longiglumis* are morphologically very similar but this specific character is conspicuously larger in *O. longiglumis*, showing 6.2 cm in average, than in *O. ridleyi*, showing 0.9 cm in average. This is due to the fact that the former is growing in heavily deep water, showing typical floating habit (3) adapted to the natural habitats. In *O. perennis* and *O. glaberrima*, strains showing also floating habit were found in

Africa, Philippines and others. If these strains are used, these specific character would be found.

10) Interval between the first date of heading and the first date of flowering

O. grandiglumis had no interval between the first date of heading and the first date of flowering. In other species, the first date of heading came earlier than the first date of flowering. One day interval was observed in 3 species, *i. e.*, *O. sativa* var. *spontanea*, *O. stapfii*, *O. alta* ; 2 days, in 3 species, *i. e.*, *O. breviligulata*, *O. malampuzhaensis*, *O. eichingeri* ; 3 days, in 6 species, *i. e.*, *O. sativa*, *O. glaberrima*, *O. officinalis*-II, *O. punctata*, *O. meyeriana* subsp. *granulata*, *O. coarctata* ; 4 days, in 4 species, *i. e.*, *O. perennis*,

Table 2. Flowering behaviour in each species.

Species	Characters							
	M	N	O	P	Q	R	S	T
O. sativa	Nov. 19	Nov. 23	Nov. 21	Nov. 27	3	5	7	26.7
O. sativa var. *spontanea*	Nov. 8	Nov. 10	Nov. 9	Nov. 16	1	3	8	10.8
O. perennis	Nov. 18	Nov. 23	Nov. 22	Nov. 29	4	6	9	10.8
O. glaberrima	Oct. 28	Nov. 2	Oct. 31	Nov. 8	3	6	9	12.6
O. stapfii	Nov. 6	Nov. 9	Nov. 7	Nov. 13	1	9	7	11.0
O. breviligulata	Nov. 3	Nov. 8	Nov. 5	Nov. 11	2	6	7	8.7
O. officinalis-I	Oct. 31	Nov. 9	Nov. 6	Nov. 15	6	10	10	11.8
O. officinalis-II	Nov. 6	Nov. 18	Nov. 9	Nov. 23	3	13	15	3.6
O. minuta	Nov. 2	Nov. 12	Nov. 8	Nov. 18	6	11	11	5.2
O. malabarensis	Nov. 13	Nov. 23	Nov. 18	Nov. 28	5	11	11	10.1
O. malampuzhaensis	Nov. 16	Nov. 23	Nov. 18	Nov. 29	2	8	12	8.5
O. eichingeri	Nov. 1	Nov. 9	Nov. 3	Nov. 16	2	9	14	17.5
O. punctata	Oct. 31	Nov. 7	Nov. 3	Nov. 15	3	8	13	10.7
O. latifolia	Oct. 29	Nov. 3	Nov. 3	Nov. 15	5	6	13	11.7
O. alta	Nov. 2	Nov. 9	Nov. 3	Nov. 21	1	8	19	16.4
O. grandiglumis	Nov. 3	Nov. 10	Nov. 3	Nov. 17	0	8	15	5.9
O. australiensis	Nov. 5	Nov. 13	Nov. 9	Nov. 17	4	9	9	7.7
O. meyeriana subsp. *granulata*	Nov. 1	Nov. 5	Nov. 4	Nov. 13	3	6	10	1.3
O. meyeriana subsp. *meyeriana*	Oct. 28	Nov. 4	Nov. 3	Nov. 12	6	8	10	1.3
O. meyeriana subsp. *abromeitiana*	Oct. 27	Nov. 5	Nov. 1	Nov. 12	5	10	12	1.3
O. ridleyi	Oct. 29	Nov. 20	Nov. 4	Nov. 27	6	23	16	2.3
O. longiglumis	Oct. 30	Nov. 19	Nov. 7	Nov. 27	8	21	17	2.4
O. coarctata	Oct. 31	Nov. 2	Nov. 3	Nov. 6	3	3	4	2.5
O. brachyantha	Nov. 9	Nov. 18	Nov. 13	Nov. 19	4	11	7	1.6
O. tisseranti	Nov. 4	Nov. 11	Nov. 8	Nov. 13	4	8	6	4.0
O. perrieri	Nov. 1	Nov. 10	Nov. 6	Nov. 12	5	10	7	3.3
O. subulata-I	Oct. 30	Dec. 1	Nov. 4	Dec. 9	5	33	36	3.5
O. subulata-II	Oct. 30	Nov. 8	Nov. 4	Nov. 10	5	10	7	4.7

M : The first date of heading ; N : The last date of heading ; O : The first date of flowering ; P : The last date of flowering ; Q : Interval between the first date of heading and the first date of flowering ; R : Heading duration ; S : Flowering duration ; T : Number of flowered spikelets per day.

O. australiensis, *O. brachyantha*, *O. tisseranti* ; 5 days, in 6 species, *i. e.*, *O. malabarensis*, *O. latifolia*, *O. meyeriana* subsp. *abromeitiana*, *O. perrieri*, *O. subulata*-I, *O. subulata*-II ; 6 days, in 4 species, *i. e.*, *O. officinalis*-I, *O. minuta*, *O. meyeriana* subsp. *meyeriana*, *O ridleyi* ; and 8 days, in 1 species, *i. e.*, *O. longiglumis*, respectively.

11) Heading duration

Heading duration was calculated by days between the first date of heading and the last date of heading in the present study. The individual tillers of a plant headed one by one within few days. Heading duration varied between 3 to 13 days with consecutive variations, excepting three species, *i. e.*, 23 days in *O. ridleyi*, 21 days in *O. longiglumis* and 33 days in *O. subulata*-I, respectively. They needed relatively many days from the first date of heading to the first date of flowering.

In general, all species belonging to Perennis group, *i. e.*, *O. sativa*, *O. sativa* var. *spontanea*, *O. perennis*, *O. glaberrima*, *O. stapfii* and *O. breviligulata*, which have A genome alone, showed relatively short heading duration. On the other hand, *O. ridleyi* and *O. longiglumis*, belonging to the same group, showed relatively long duration. These two phenomena indicate that heading duration is a property of the genome constitution.

12) Flowering duration

The individual tillers of a plant flowered one by one within few days. Flowering processes in each first, second and the third rachis of all species used were shown in the previous paper (5).

Flowering duration, which was expressed by days between the first date of flowering and the last date of flowering, varied between 4 and 19 days with consecutive variations, excepting *O. subulata*-I, which showed 36 days. Mode was found in 7 days. All species belonging to Perennis group, which have the A genome alone, and all species belonging to Meyeriana group, *i. e.*, *O. meyeriana* subsp. *granulata*, *O. meyeriana* subsp. *meyeriana*, *O. meyeriana* subsp. *abromeitiana*, and all species belonging to Brachyantha group, *i. e.*, *O. brachyantha*, *O. tisseranti*, *O. perrieri*, showed uniform pattern in the flowering duration in the respective group. This indicated that flowering duration is a property of the genome constitution.

Oka *et al.* (8) reported that estimated percentages of out-crossing was larger in wild species than in cultivated species. The phenomenon, in which long flowering duration was found in most of wild species, might be the proof of advantage to out-crossability.

According to several characters mentioned above and reported in the previous paper (5), it is concluded that *O. subulata*-II in this paper is considered a single panicle corresponding to other species, and rachises lower than this are considered to be belonging to other panicle.

13) Number of flowered spikelets per day

Number of flowered spikelets per day, which was expressed by ratio of whole of flowered spikelets to the flowering duration, varied between 1.3 to 26.7 in whole species used. Average number of flowered spikelets of the species belonging to *Granulatae*, *Coarctatae*

and *Rhynchoryza* sections were less than 4.7 ; namely, 1.3, 2.7 and 4.1, respectively. But *O. sativa* flowered 26.7 spikelets per day, which was significantly more than that of other 25 species. On the other hand, another cultivated species, *O. glaberrima*, flowered only 12.6 spikelets per day. Generally speaking, cultivated species had more flowered spikelets per day in comparison with wild species. The fact that the many spikelets per day flowered in *O. sativa* than in *O. glaberrima* seems to be mainly due to two causes. One is that the former has a longer history than the latter, as can be easily deduced from the fact that it has become increasing in number per panicle than the latter. Another cause of the difference might be sought in much less intensive artificial selection in the latter. We are supposed to look for the putative ancestors of *O. sativa* and *O. glaberrima* judging from the results of cytological, taxonomic and physiological investigations, *O. sativa* var. *spontanea* and *O. stapfii*, respectively. The latter two species showed relatively smaller values (10.8 and 11.0) than that of the former two species (26.7 and 12.6). These increment seems to be mainly due to the evolutional processes.

14) Correlation between seven characters

Four characters of panicle structure and three characters of flowering behaviour were selected and the correlation coefficients among them were calculated (Table 3).

Table 3. Correlation between seven characters of panicle structure and flowering behaviour.

	C	E	F	J	Q	R
E	0.870***					
F	0.928***	0.800***				
J	0.814***	0.759***	0.766***			
Q	-0.370	-0.372	-0.292	-0.223		
R	0.051	0.008	0.045	0.361	0.503**	
S	0.399*	0.309	0.367	0.764***	0.238	0.789***

***, **, * : Significant at 0.1%, 1%, 5%, respectively.
C : Total number of spikelets ; E : Number of the first rachis ; F : Number of the second and the third rachises ; J : Panicle length ; Q : Interval between the first date of heading and the first date of flowering ; R : Heading duration ; S : Flowering duration.

Number of spikelets in a panicle and panicle length were highly correlated to other characters. On the other hand, number of days from the first date of heading to the first date of flowering was only correlated to heading duration. It is interesting that the number of spikelets was not correlated to heading duration.

Summary

Twelve characters of panicle structure and eight characters of flowering behaviour of seventy six strains belonging to 26 species of the genus *Oryza* were observed. Moreover, four characters of panicle structure and three characters of flowering behaviour were selected from them and the correlation coefficients among them were calculated.

Several characteristics in each article were found in species level or group level. Number of spikelets in a panicle and panicle length were highly correlated to other characters. Some biological significance of flowering behaviour was discussed.

Literature Cited

1. AKEMINE, M. Über das Blühen des Reises und einige sich daran anknüpfende Erscheinungen. *Zeit. f. Pflanzenzücht.* **2**: 339-375, 1914.
2. HIRAYOSHI, I. Some observations on the blooming of *Triticum* and its allied genera in relation to systematics (in Jap. with Eng. Sum.). *Jap. Jour. Genet.* **17** : 265-294, 1941.
3. KATAYAMA, T. C. Scientific report on the rice-collection-trip to the Philippines, New Guinea, Borneo and Java. *Memoirs Fac. Agr. Kagoshima Univ.* **6** : 89-134, 1968.
4. —— Botanical studies in the genus *Oryza*. I. *Ibid.* **7** : 89-117, 1969.
5. —— Botanical studies in the genus *Oryza*. IV. *Ibid.* **7** : 219-241, 1970.
6. —— Botanical studies in the genus *Oryza*. V. *Ibid.* **7** : 243-256, 1970.
7. MINAMI, T. and G. MISONOO Observations of blooming in several cereal species (in Jap.). *Rep. Exper. Farm Fac. Agr. Hokkaido Univ.* **4** : 1-98, 1933.
8. OKA, H. I. and H. MORISHIMA Variations in the breeding systems of a wild rice, *Oryza perennis*. *Evolution* **21** : 249-258, 1967.
9. ROSCHEVICZ, R. J. A contributions to the knowledge of rice (in Russ. with Eng. Sum.). 1931.
10. TATEOKA, T. Taxonomic studies of *Oryza*. II. Several species complexes. *Bot. Mag., Tokyo* **75** : 455-461, 1962.
11. —— and J. V. PANCHO A cytotaxonomic study of *Oryza minuta* and *O. officinalis*. *Bot. Mag., Tokyo* **76** : 366-373, 1963.