On the Wild Rice, *Oryza officinalis* WALL., Collected at Tembilahan, Sumatra, Indonesia

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Abstract

One strain of wild rice was found and its seeds were collected at Sumatra, Indonesia, by Dr. K. TANAKA on October, 1984, and delivered to the present author. In this paper, the records on identification, habitat and morphological characters of those seeds were reported.

Based of the data obtained, the strain of wild rice was detected to be *Oryza officinalis* WALL.

Twenty-four characters of the unhusked and husked grains and 27 mutual relations between the respective 2 characters were calculated. In the unhusked grains, length, width and thickness of the unhusked grains were found to be 4.63 mm, 2.29 mm and 1.23 mm in average values, respectively. Those of the husked grains were found to be 3.24 mm, 1.79 mm and 0.98 mm in average values, respectively. In the latter, 1, 2, 2 and 22 character combinations showed significances at the 0.1 %, 1 % and 5 % levels and no significance even at the 5 % level, respectively.

In comparison with the data obtained in the present and the previous studies in view of strain differentiations, the following facts were ascertained. The present strain would be located in the position as relatively shorter length and moderate width and thickness of this species of wild rice, *Oryza officinalis* WALL., in Indonesia. Moreover, it was concluded that the present strain had a long history after migrating here from another site.

Key Words : Wild Rice, *O. officinalis*, Sumatra, Ecotypic Differentiation

Introduction

The seeds of one strain belonging to wild rice species was collected by Dr. Koji TANAKA, Kyoto University, and delivered to the present author.

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Due to the great importance of rice as food stuff, a large amount of work on rice from different viewpoints has been reported. However, on many points more extensive investigations are required in order to solve the interesting but highly complex problem of its origin and the history of transformation from a wild state into the cultivated crop plant of our time. The research done on this problem by a wide range of workers will contribute to the improvement of rice in the future.

Distribution and taxonomical reports on various *Oryza* species in Asian countries have been published by many workers (PRODOEHL, 1922 ; BACKER, 1946 ; JANSEN, 1953 ; TATEOKA, 1962 ; KATAYAMA, 1963a, 1963b, 1968 ; NAKAGAMA, 1976 ; KATAYAMA, 1984). Incidentally, one strain of wild rice was delivered to the present author. In the present paper, the records of identification, habitat and morphological characters are briefly reported. Some consideration on situation of this strain in the whole wild rice was also discussed. These data might be of assistance to researchers on the origin and genetic analyses of rice.

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Materials and Methods

Plants were found along the road from Tembilahan to Sungai Selak, Indragii River, Riouw State, Sumatra, Indonesia, on October 27, 1984. The seeds were sent to Kagoshima University, and used for morphological investigation.

Measurements for morphological studies of grains were done for length, width and thickness of unhusked and husked grains. Fifteen grains were used for the measurement. The measurements were done at the largest position of the respective characters. Calculations were done for determining the ratios of length to width, of length to thickness, and of width to thickness, for comparative values on morphological characters of unhusked and husked grains. Moreover, the following 6 characters of unhusked and husked grains were illustrated by the area (=length× width) and volume (=length×width×thickness) for both unhusked and husked grains, the area and volume quotients (=ratio of value of husked to value of unhusked grains).

The correlation between practical values of unhusked and husked grains and the linear regression between them were also calculated in the whole characters measured by comparing them.

To make clear the relations between the present material and other strains collected in Indonesia and other Asian countries, comparison was made using the data obtained in the present and previous papers (KATAYAMA, 1963a, 1968 ; NAKAGAMA,

1976) on the characters of the unhusked grains (partially on the husked grains also). The previous materials were included the following materials, *i. e.*, Philippines (8 strains) collected in 1961 ; North Borneo (16 strains), Brunei (11 strains), Sarawak (6 strains), Kalimantan (1 strain) and Java (1 strain) collected in 1963, which were directly collected by the present author ; Sumatra and Kalimantan (10 strains) collected by NAKAGAMA in 1974.

Results and Discussion

1. Grain morphology

Table 1. Morphological characters of the unhusked and husked grains of the present and previous materials

	Character		No.	Average and its standard deviations	
				Present material	Previous materials
Unhusked	Length		1	4.63±0.27 mm	4.51±0.14 mm
	Width		2	2.29±0.07 mm	2.30±0.10 mm
	Thickness		3	1.23±0.06 mm	1.24±0.05 mm
	Length/Width		4	2.02±0.14	1.98±0.11
	Length/Thickness		5	3.78±0.27	3.67±0.18
	Width/Thickness		6	1.88±0.13	1.87±0.04
Husked	Length		11	3.24±0.15 mm	3.27±0.11 mm
	Width		12	1.79±0.08 mm	1.83±0.08 mm
	Thickness		13	0.98±0.05 mm	1.01±0.07 mm
	Length/Width		14	1.82±0.09	1.80±0.09
	Length/Thickness		15	3.32±0.23	3.28±0.16
	Width/Thickness		16	1.83±0.13	1.83±0.07
Comparison	Length		21	0.70±0.04	0.72±0.01
	Width		22	0.78±0.03	0.80±0.01
	Thickness		23	0.80±0.07	0.81±0.03
	Length/Width		24	0.90±0.06	0.91±0.02
	Length/Thickness		25	0.88±0.07	0.90±0.03
	Width/Thickness		26	0.98±0.10	0.98±0.02
Area & Volume	Unhusked	Area	31	10.61±0.68 mm²	10.36±0.55 mm²
		Volume	32	13.02±1.12 mm³	12.81±1.12 mm³
	Husked	Area	33	5.79±0.43 mm²	5.97±0.36 mm²
		Volume	34	5.68±0.52 mm³	6.01±0.62 mm³
	Quotient	Area	35	0.55±0.04	0.58±0.01
		Volume	36	0.44±0.05	0.47±0.02

Quotient : Husked/Unhusked

Area : length×width ; Volume : length×width×thickness

1) Practical values

Unhusked grains (Character Nos. 1 to 6)

The results are given in Table 1. Grains showed the following characteristics; 4.20 mm to 5.10 mm long, 2.15 mm to 2.40 mm wide, 1.10 mm to 1.35 mm thick, 1.88 to 2.28 in ratio of length to width, 3.35 to 4.26 in ratio of length to thickness, and 1.65 to 2.18 in ratio of width to thickness. Fig. 1 shows the relationship between length and width of the unhusked grains in mm.

Husked grains (Character Nos. 11 to 16)

Grains showed the following characteristics; 2.90 mm to 3.55 mm long, 1.70 mm to 1.95 mm wide, 0.90 mm to 1.10 mm thick, 1.67 to 1.97 in ratio of length to width, 2.91 to 3.89 in ratio of length to thickness, and 1.55 to 2.06 in ratio of width to thickness. Fig. 2 shows the relationship between length and width of the husked grains in mm.

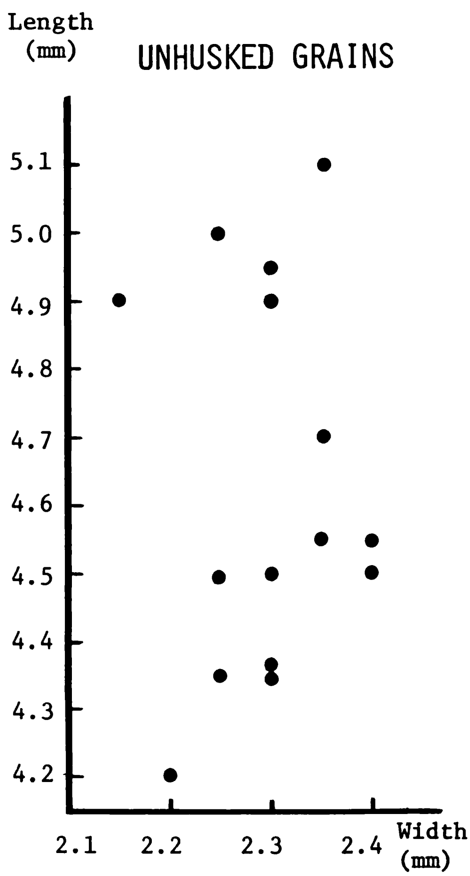


Fig. 1. Relation between length and width of unhusked grains in mm. Vertical axis; length of grain; abscissa; width of grain.

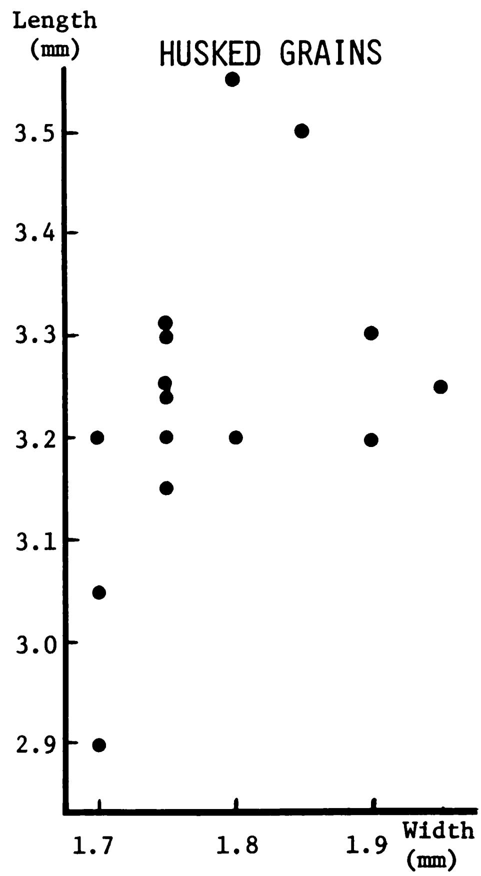


Fig. 2. Relation between length and width of husked grains in mm. Vertical axis; length of grain; abscissa; width of grain.

Comparison (Character Nos. 21 to 26)

Grains showed the following characteristics; 0.64 to 0.78 in length, 0.75 to 0.84 in width, 0.69 to 0.92 in thickness, 0.78 to 1.01 in ratio of length to width, 0.73 to 0.99 in ratio of length to thickness, and 0.82 to 1.21 in ratio of width to thickness.

Comparative studies of data obtained in the previous characters have been looked upon as one of the most important characters for ecotypic differentiations in view of evolution. This character means biologically or agronomically the "grain fullness" in its capacity (KATAYAMA and KURODA, 1974). In evolutional and agronomical viewpoints, it may be said that the larger is the ratio of husked to unhusked grains in the respective characters, the more advanced is the evolutional state of the respective strain. Values of length, width and thickness were clearly found to be smaller than those of cultivated strains (KATAYAMA, 1976, 1978).

Averages and ranges of variation became larger in order of length, width and thickness of grain. In other words, grain length showed the lowest value but was most stable in view of the grain fullness, and was not affected by any environmental conditions. On the contrary, grain thickness showed the highest value but was unstable in view of the grain fullness. And grain width showed intermediate value both in the practical values and its stability. Such tendencies were found to be the same in cultivated rice strains (KATAYAMA, 1976, 1978), and wild rice species in India (KATAYAMA and KURODA, 1974). Then, the order found in length, width and thickness in view of practical values and variation ranges are constant in the genus *Oryza*, regardless of the species status.

Area and volume (Character Nos. 31 to 36)

Grains showed the following characteristics; 9.24 mm^2 to 11.99 mm^2 in area of unhusked grain, 11.09 mm^3 to 16.18 mm^3 in volume of unhusked grain, 4.93 mm^2 to 6.48 mm^2 in area of husked grain, 4.68 mm^3 to 6.39 mm^3 in volume of husked grain, 0.48 to 0.61 in quotient of area and 0.34 to 0.51 in quotient of volume.

The ears of rice plants have an ability of net photosynthesis. The maximum rate of net photosynthesis per one exposed surface has been fixed as 1-2 mg CO_2/dm^2 (100 spikelets/h, TSUNO *et al.*, 1975). Grain volume has been looked upon as an end product. Then, studies on surface and volume of grains were regarded as important characters in view of strain differentiations. So, these characters were employed here as a new method. However, these could not be fully explained at the present, and further studies on this character should be soon performed.

2) Relations between the respective 2 characters

Unhusked grains (Character combinations 1 & 2 to 5 & 6)

To make clear the 3 relationships between length and width, length and thickness, width and thickness, as well as 3 components, *i. e.*, ratios of length to width (abbreviated as L/W in Table 2) and of length to thickness (L/T), of length to width (L/W) and of width to thickness (W/T), of length to thickness (L/T) and

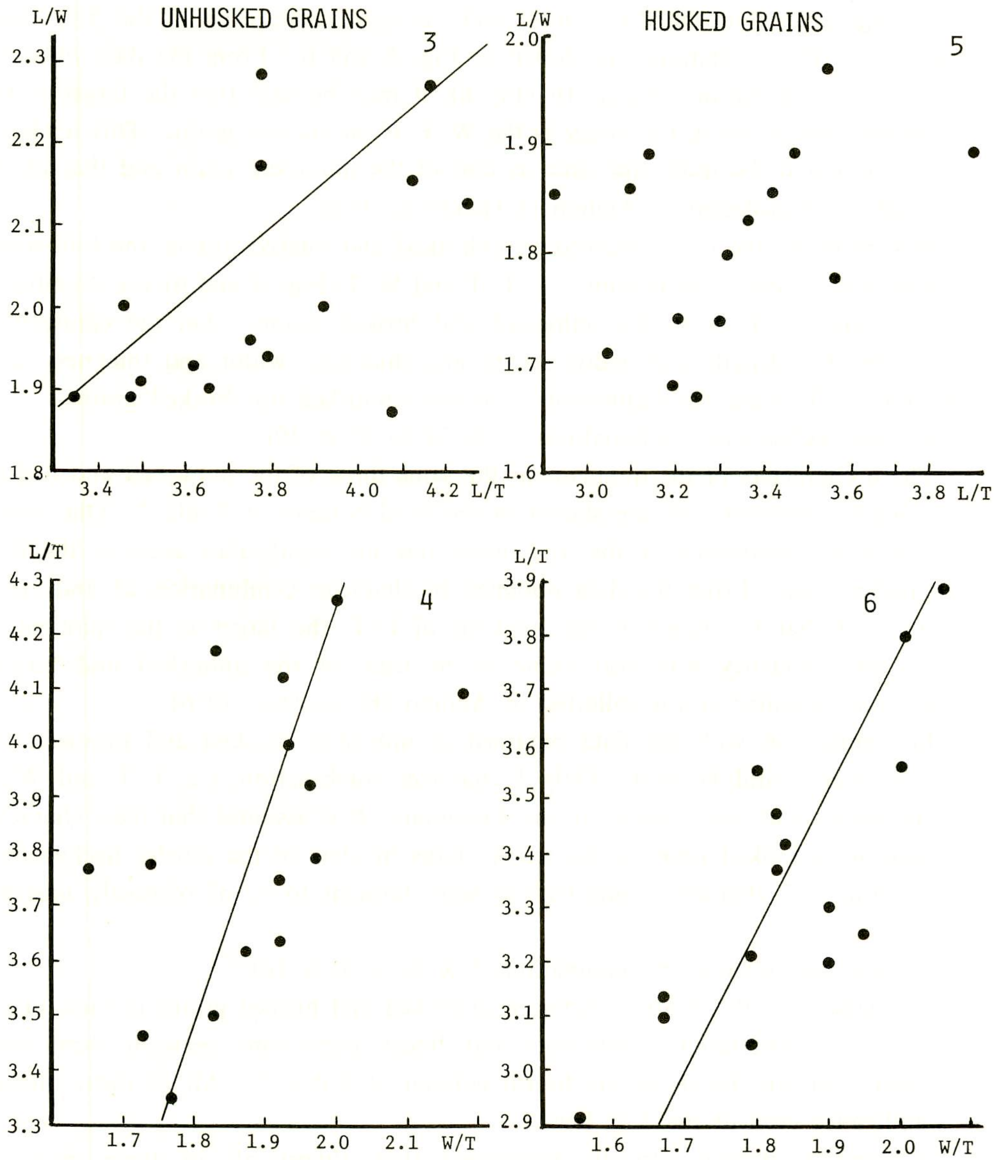
Table 2. Correlation coefficient and linear regression of the former character (Y) on the latter character (X) for 27 character-combinations

	Character	Nos.	Correlation coefficient	Linear regression
Unhusked	Length and Width	1 & 2	−0.0422	—
	Length and Thickness	1 & 3	0.1283	—
	Width and Thickness	2 & 3	−0.2234	—
	L/W and L/T	4 & 5	0.5495*	Y=2.172X−0.757
	L/W and W/T	4 & 6	−0.4112	—
	L/T and W/T	5 & 6	0.5368*	Y=0.247X+0.943
Husked	Length and Width	11 & 12	0.4230	—
	Length and Thickness	11 & 13	0.0572	—
	Width and Thickness	12 & 13	−0.0645	—
	L/W and L/T	14 & 15	0.3210	—
	L/W and W/T	14 & 16	−0.3515	—
	L/T and W/T	15 & 16	0.7730***	Y=0.417X+0.446
Quotient	Length and Width	21 & 22	0.3135	—
	Length and Thickness	21 & 23	0.2624	—
	Width and Thickness	22 & 23	−0.1414	—
	L/W and L/T	24 & 25	0.2322	—
	L/W and W/T	24 & 26	0.1628	—
	L/T and W/T	25 & 26	0.6812**	Y=0.931X+0.160
Comparison	Length	1 & 11	0.3258	—
	Width	2 & 12	0.4799	—
	Thickness	3 & 13	−0.2349	—
	L/W	4 & 14	0.3037	—
	L/T	5 & 15	0.3217	—
	W/T	6 & 16	0.0641	—
Ratio	Area	31 & 33	0.4082	—
	Volume	32 & 34	0.0097	—
	Quotient	35 & 36	0.7552**	Y=0.927X−0.070

L/W : ratio of length to width, L/T : ratio of length to thickness, W/T : ratio of width to thickness, Area : length×width, Volume : length×width×thickness, Quotient : Husked/Unhusked

***, **, * : significant at 0.1 %, 1 % and 5 % levels, respectively

of width to thickness (W/T), correlation coefficients and linear regressions between them were calculated, and are shown in the first column of Table 2. Two and 4 cases showed significances at the 5 % level and no significance even at the 5 % level, respectively. The 2 relations of the former are shown in Figs. 3 and 4. For example, from the data obtained in character combination 4 and 5 (Fig. 3), it may be said



Figs. 3 to 6. Relations between the 2 characters in the unhusked and the husked grains. Figs. 3 and 4 : unhusked grains ; Figs. 5 and 6 : husked grains ; Figs. 3 and 5 : L/W and L/T ; Figs. 4 and 6 : L/T and W/T.

that the larger is the L/W of the unhusked grain, the larger is the L/T of the unhusked grain. This tendency was also found to be true for cultivated strain collected in Ambon, Indonesia (KATAYAMA, 1976).

Husked grains (Character combinations 11 & 12 to 15 & 16)

The 6 characters of the husked grains as the same those of the unhusked grains were calculated, and are shown in the second column of Table 2. One and 5 cases showed significance at the 0.1 % level and no significance even at the 5 % level, respectively. The 2 relations are shown in Figs. 5 and 6. From the data obtained in character combination 15 and 16 (Fig. 6), it may be said that the larger is the L/T of the husked grain, the larger is the W/T of the husked grain. This tendency was also found to be quite the same as that of the unhusked grain and that of the cultivated strain collected in Ambon (KATAYAMA, 1976).

In comparing the data obtained in unhusked and husked grains, the followings could be said. Only 1 correlation, *i. e.*, L/T and W/T (Figs. 4 and 6) was significant and was constant both in the unhusked and husked grains. On the contrary, 4 correlations, *i. e.*, length and width, length and thickness, width and thickness, and L/W and W/T, were not significant in neither unhusked nor husked grains.

Quotient (Character combinations 21 & 22 to 25 & 26)

The 6 characters of the quotients as the same those of the unhusked and husked grains were calculated, and are shown in the third column of Table 2. One and 5 cases showed significance at the 1 % level and no significance even at the 5 % level, respectively. From the data obtained in character combination 25 and 26, it may be said that the larger is the quotient of L/T, the larger is the quotient of W/T. This tendency was also found to be true for the unhusked and husked grains, and cultivated strain collected in Ambon (KATAYAMA, 1976).

In comparison with the data obtained in unhusked, husked and quotient, the following facts could be said. Only 1 character combination, *i. e.*, L/T and W/T, was significant and was constant in the 3 columns. It is assumed that these character combination is looked upon as the stable status in view of the genetic background. The remaining 5 character combinations were thought to be of relatively unstable status.

Comparison (Character combinations 1 & 11 to 6 & 16)

To make clear the relations between unhusked and husked grains in view of the six characters, correlation coefficients and linear regressions between them were calculated, and are shown in the fourth column of Table 2. All of them showed no significance even at the 5 % level.

In general, it was already ascertained that almost all of these character combinations in these columns, and almost all of the materials belonging to the genus *Oryza*, including the cultivated rice (KATAYAMA, 1976, 1978 ; and others) and wild rice (KATAYAMA, 1984 and others), showed high significances. So, it might be said that the very low significance found in the present material was looked upon as peculiar tendency and as a clear ecotypic specificity of the material.

Ratio (Character combinations 31 & 33 to 35 & 36)

To make clear the relations between unhusked and husked grains with regard to area and volume, correlation coefficients and linear regressions between them were calculated, and are shown in the last column of Table 2. One and 2 cases showed significance at the 1 % level and no significance even at the 5 % level, respectively.

From the data obtained in character combination 35 and 36, it may be said that the larger is the ratio of area, the larger is the ratio of volume.

2. Comparison with the data obtained in the present and previous materials

To make clear the status of this material, and the relations between the present material and other strains previously collected in Indonesia and other Asian countries (KATAYAMA, 1963a, 1968 ; NAKAGAMA, 1976), comparison was made using the data obtained in the present and the previous papers on the characters of the unhusked grains (Tables 1 and 3).

Six characters of the unhusked grains of those materials were calculated in view of the respective average values, and are shown in Table 3. In this table, length, width, thickness, ratios of length to width, of length to thickness, and of width to thickness were adopted on only unhusked grains. In comparison with the present and the previous data in view of strain differentiations, the following facts were ascertained.

i) Values of length, L/W and L/T were remarkably smaller than those of other regions except Sumatra. ii) Value of width was smaller than that of other regions except the Philippines. iii) Values of thickness and W/T showed intermediate status. iv) In comparison with the results obtained here, the present strain would be located in the position of relatively shorter length but moderate width and thickness status of this species in Indonesia.

In standard deviations, *i. e.*, intra-population's variations, the following facts were ascertained. i) Value of width was remarkably smaller than that of other regions. ii) Values of thickness, L/W and L/T were smaller than that of other regions except Sumatra. iii) Value of L/W was smaller than that of other regions

Table 3. Comparison of six characters of the unhusked grains collected from eight regions in view of the respective average values

Region	No. of strains	Length (mm)	Width (mm)	Thickness (mm)	L/W	L/T	W/T
Philippines	8	5.02±0.17	2.27±0.11	1.20±0.10	2.22±0.13	4.23±0.36	1.91±0.18
North Borneo	16	5.25±0.42	2.33±0.17	1.10±0.13	2.26±0.16	4.85±0.73	2.17±0.29
Brunei	11	5.56±0.34	2.37±0.10	1.29±0.06	2.34±0.15	4.31±0.30	1.85±0.10
Sarawak	6	5.78±0.42	2.30±0.10	1.14±0.23	2.47±0.17	4.80±0.35	2.09±0.37
Kalimantan	1	5.64±0.24	2.30±0.11	1.36±0.07	2.45±0.13	4.15±0.36	1.69±0.25
Java	1	6.01±0.50	2.48±0.11	1.22±0.07	2.42±0.14	4.93±0.44	2.03±0.28
Present	1	4.63±0.27	2.29±0.07	1.23±0.06	2.02±0.14	3.78±0.27	1.88±0.13
Sumatra	10	4.51±0.18	2.27±0.11	1.21±0.04	2.00±0.12	3.73±0.30	1.88±0.15

L/W : ratio of length to width, L/T : ratio of length to thickness, W/T : ratio of width to thickness except Sumatra and Brunei. iv) Value of length showed the moderate one. v) In general, the strains having large standard deviations are said to be genetically unstable, while those with small standard deviations stable. So, the present strain is belonging to the latter one in comparison with the data mentioned above. It is thought that the present strain was looked upon having a long history after migrating here from another site.

Because the characters of the present material show nearly the same data obtained in Sumatra, the next comparison was made in these two strains. Values were ascertained to be 4.63 mm (present) and 4.51 mm (strain No. W5 of Sumatra) in length, 2.29 mm and 2.27 mm (in the same order) in width, 1.23 mm and 1.21 mm in thickness, 2.02 and 2.00 in L/W, 3.78 and 3.73 in L/T, 1.88 and 1.88 in W/T, respectively. Strain No. W5 of Sumatra was found at the side of a small river behind a residence in an area, shaded by trees near Betaung, about 65 km west from Palembang.

The present strain was found near Indragii River, about 0°10′S, 103°E. W5 of the previous data was found near Betaung, Palembang, 3°S, 104°E. The former is located about 350 km northwest of the latter. In spite of the long distance from one another, it is presumable that the present material has nearly the same characters as those of the strain mentioned above.

In the Sumatra group, W5 belonged to the middle and the relatively larger group in view of grain width and grain thickness, respectively.

3. Some consideration on status of *Oryza officinalis* WALL.

According to the previous research on *O. officinalis*, the following facts were ascertained (KATAYAMA, 1963b).

Strains of *O. officinalis* were found at different localities in North Borneo, Brunei, Sarawak and Kalimantan. These strains were conspicuously different from those collected in other tropical Asiatic regions in the following characteristics. i) Native localities of 46 strains of *O. officinalis* were widely scattered over the whole island of Borneo, whereas those of strains found in other regions were rather limited to narrow areas. Population size of each strain found in Borneo was much larger than that of the strains found in other regions of tropical Asia. ii) In Borneo, *O. officinalis* was found not only in shady places under the trees but also in open fields. Sometimes it was growing sympatrically with *O. sativa* in the paddy fields. On the contrary, the natural habitats of most strains of this species collected in other regions were shady spots in forests. iii) A high variation was found in size and shape of grains, leaf length and plant height of *O. officinalis* collected in Borneo. iv) The ratio of photoperiodically sensitive vs. insensitive plants among 46 strains of *O. officinalis* collected in Borneo was 7 to 5. The value indicates a considerable difference from the ratio 1 sensitive to 3 insensitive, obtained for the strains of this species found in other regions. It is noteworthy that many sensitive strains were detected even in Borneo, an equatorial island, situated between 7°N to 4°S latitude.

Judging from those characteristics of *O. officinalis* found in Borneo, it is assumed that *O. officinalis* might have originated in Borneo or its adjacent islands, and that photoperiodically sensitive strains of this species might be the original form from which insensitive strains would have derived.

From the previous (KATAYAMA, 1963a, 1968 ; NAKAGAMA, 1976) and the present researches, it might be concluded, in view of the situation of *O. officinalis* in the world and southeast Asian countries, that the present material played an important role for species evolution, strain differentiation and geographical specificity.

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