

Geographical Distribution and Grain-Type of Cultivated Rice, *Oryza sativa* L. and *Oryza glaberrima* STEUD., in Africa

Akinori NAKAGAMA and Tadao C. KATAYAMA
(Faculty of Agriculture, Kagoshima University, JAPAN)

Introduction

In classification of cultivated rice made according to morphological characters, grain-type has been used as a basic principle, and some reports^{2, 3)} on their geographical distribution have already been published. As regards to African cultivated rice species, especially indigenous one, *Oryza glaberrima* STEUD., however, it is considered that data of grain-type and its distribution in Africa have been insufficient. In the present paper, classification and some considerations on geographical distribution of the respective grain-types were described, using the materials collected in 1984 and 1985.

Materials and Methods

110 strains of *Oryza sativa* L. and 78 strains of *Oryza glaberrima* STEUD. collected in 5 African countries, *i.e.*, Madagascar, Kenya, Nigeria, Liberia and Senegal including Gambia, were used for morphological investigations of unhusked grain. Measurements were done for length, width and thickness, and calculations of 3 ratios, *i.e.*, of length to width, of length to thickness and of width to thickness, were made. The whole data referring to the respective characters were illustrated by the average values of 20 grains in the respective strains. The data of individual strains on these characters were mentioned in the previous papers⁴⁻⁸⁾.

In the present paper, "grain-type" was decided by combining the two components, *i.e.*, grain-shape and grain-size. Ratio of length to width was used as a component of "grain-shape". Furthermore, product of length and width was calculated and used as a component of "grain-size". On the respective components, interspecific difference between *O. sativa* and *O. glaberrima*, intraspecific variation in the respective species and distributions according to region and to habitat were investigated.

Results and Discussion

1. Interspecific difference, intraspecific variation and geographical distribution in components of grain-type

Classifications of the length and width of unhusked grain according to species and countries where their collection was made were shown in Tables 1 and 2, respectively. Grain-lengths were observed between 12.40 mm and 6.30 mm in *O. sativa* and between 9.84 mm and 7.47 mm in *O. glaberrima*, respectively. The proportion of longer grain-types in *O. sativa* was higher than that of *O. glaberrima*. It was noted to be less variable in grain-length of *O. glaberrima* than that of *O. sativa*. In *O. sativa*, longer grain-types were more frequent in Kenya and shorter grain-types were so in Senegal, respectively. Strains in Madagascar and Senegal were more diverse in grain-length than those in the other countries. In *O. glaberrima*, the proportion of long grain-types in Nigeria was higher than those in Liberia and Senegal.

Table 1. Classification of the grain-length according to species and their original countries

Up to (mm)	<i>Oryza sativa</i>						<i>Oryza glaberrima</i>			
	MD ¹⁾	KE	NI	LI	SE	Total	NI	LI	SE	Total
12.4	1					1				
12.0										
11.6	1					1				
11.2										
10.8		1				1				
10.4	2	4	1		2	9				
10.0	4	5				9				
9.6	6	7	1	4		18	4	1		5
9.2	11	3	6	5	1	26	11		2	13
8.8	4	2	7		1	14	8	5	6	19
8.4	2	5	4		1	12	2	2	16	20
8.0	3		1	2	2	8		3	12	15
7.6	2				3	5		1	4	5
7.2	4				1	5			1	1
6.8										
6.4										
6.0					1	1				
Total	40	27	20	11	12	110	25	12	41	78
Mean (mm)	9.3	9.7	9.1	9.3	8.5	10.2	9.3	8.8	8.8	8.8
CV (%) ²⁾	11.6	7.2	5.2	6.3	14.0	10.2	3.6	5.4	5.3	6.2

1) MD: Madagascar, KE: Kenya, NI: Nigeria, LI: Liberia, SE: Senegal.

2) Coefficient of variance.

Table 2. Classification of the grain-width according to species and the original countries

Up to (mm)	<i>Oryza sativa</i>						<i>Oryza glaberrima</i>			
	MD ¹⁾	KE	NI	LI	SE	Total	NI	LI	SE	Total
3.8	1	1				2	1			1
3.7			2	1		3	1		1	2
3.6	1	1	4			6	5			5
3.5	2	4	4	1	1	12	6		1	7
3.4			1	5	2	8	7	1	9	17
3.3	5	1		3		9	3		11	14
3.2	3		2		1	6	1	2	12	15
3.1	5	2		1	2	10	1	2	3	6
3.0	7	3	1			11		3	2	5
2.9	4	3	1			8		1	2	3
2.8	1	4	5		2	12		1	1	2
2.7	5	3			1	9		2	2	4
2.6	1	3				4				
2.5	3	2			1	6				
2.4	2				1	3				
2.3										
2.2					1	1				
Total	40	27	20	11	12	110	25	12	41	78
Mean (mm)	3.1	3.0	3.3	3.4	3.0	3.1	3.5	3.1	3.3	3.3
CV (%) ²⁾	10.6	11.7	10.3	3.9	13.8	11.7	4.5	6.4	4.9	5.5

1), 2) For explanation, refer to Table 1.

Grain-widths were observed from 3.89 mm to 2.21 mm in *O. sativa* and from 3.83 mm to 2.70 mm in *O. glaberrima*, respectively. The proportion of wider grain-types in *O. glaberrima* was relatively higher than that in *O. sativa*. It was noted that *O. glaberrima* was less variable in grain-width than that in *O. sativa* in the same manner as in case of grain-length. In *O. sativa*, wider grain-types were more frequent in Nigeria and Liberia. While, larger variations of grain-width were found in Madagascar, Kenya and Senegal. In *O. glaberrima*, the proportion of wider grain-types was the highest in Nigeria, followed by in Senegal. Grain-width was distinctly narrow in Liberia.

Classifications of ratio of length to width, and product of length and width according to species and the countries where their collection was made were shown in Tables 3 and 4, respectively. The former was used as one of the component of grain-type expressing grain-shape, and the latter as expressing grain-size, respectively. Values of ratios of length to width ranged from 4.08 to 2.02 in *O. sativa* and from 3.40 to 2.27 in *O. glaberrima*, respectively. Smaller values of ratio were more frequent in *O. glaberrima* than *O. sativa*. *O. sativa* showed larger variation than that of *O. glaberrima*. Namely,

Table 3. Classification of the ratio of length to width of grain expressed in grain-shape according to species and the original countries

Up to	<i>Oryza sativa</i>						<i>Oryza glaberrima</i>			
	MD ¹⁾	KE	NI	LI	SE	Total	NI	LI	SE	Total
4.0	2					2				
3.8	5	2				7				
3.6	1	6	1		1	9				
3.4	5	4	1			10		1		1
3.2	4	6	3			13				
3.0	5	2				7	1	2	1	4
2.8	8	1	3	2	2	16	3	5	7	15
2.6	2	1	3	8	3	17	12	2	10	24
2.4	4	3	7	1	1	16	9	2	22	33
2.2	1	1	2		3	7		1	1	2
2.0	3	1				4				
Total	40	27	20	11	12	110	25	12	41	78
Mean	3.1	3.3	2.8	2.7	2.9	3.0	2.7	2.9	2.6	2.6
CV (%) ²⁾	17.7	14.9	13.9	4.4	20.7	17.4	5.6	8.0	45.6	5.3

1), 2) For explanation, refer to Table 1.

O. sativa contained various grain-shapes varying from round to slender, while *O. glaberrima* had roundish grain-shape, in general. In *O. sativa*, larger values of ratio, *i.e.*, more slender types, were more frequent in Kenya and smaller values, *i.e.*, roundish types, in Liberia, Nigeria and Senegal, respectively. Grain-shape in Liberia were noted to be approximately homogenous. In *O. glaberrima*, generally, there were many round types in Nigeria and Senegal, but, the proportion of more slender types was higher in Liberia.

Products of length and width ranged from 38.32 to 15.37 in *O. sativa* and from 37.42 to 21.57 in *O. glaberrima*, respectively. No significant difference of values of product of length and width was found between *O. sativa* and *O. glaberrima*. In *O. sativa*, larger values of product (larger grain) were more frequent in Liberia and smaller values of products (smaller grain) in Senegal, respectively. Various grain-sizes were found in Senegal. In *O. glaberrima*, the proportion of larger grain was higher in Nigeria than those in Liberia and Senegal.

2. Distribution of grain-type according to the habitat

Habitats in collection sites of strains investigated were shown in Table 5. In classification of habitat, deep water conditions contained heavily submerged paddy field,

Table 4. Classification of the product of length and width of grain expressed in grain-size according to species and their original habitats

Up to	<i>Oryza sativa</i>						<i>Oryza glaberrima</i>			
	MD ¹⁾	KE	NI	LI	SE	Total	NI	LI	SE	Total
38.0	1					1				
36.0	1	1		1		3	1			1
34.0	1		2	1		4	5			5
32.0	2	3	5	4		14	9			9
30.0	7	8	4	3		22	8		6	14
28.0	6	7	3		3	19	1	5	16	22
26.0	10	3	3	2	4	22	1	4	11	16
24.0	7	4	3		1	15		1	6	7
22.0	5	1			1	7		1	2	3
20.0					1	1		1		1
18.0					1	1				
16.0										
14.0					1	1				
Total	40	27	20	11	12	110	25	12	41	78
Mean	28.2	29.4	30.2	32.0	25.1	28.9	32.5	26.7	27.7	29.2
CV (%) ²⁾	13.2	10.1	9.9	9.4	17.1	13.3	6.1	8.4	8.4	10.7

1), 2) For explanation, refer to Table 1.

pond, river and swamp in large scale. Depressions contained not only depression of various forms but also road-side ditches and swamps in small scales. Wild status contained the outskirts of cultivated field, and the fields seemed to be comparatively similar to the abandoned ones. Irrigated paddy field contained not only artificially irrigated paddy fields but also rain-fed paddy field obtaining abundant irrigation water in dry season.

In Madagascar and Kenya, almost all the cultivated rices had been harvested at the collection times, and the greater part of strains collected in these countries were mainly gathered from farmers' stores, and also from threshing floor and from unthreshed panicles piled to dry. Accordingly, their habitats were indistinctly fixed.

In west Africa, differences of habitat in collection sites by countries concerned were distinct. Namely, in Nigeria, many strains of *O. sativa* were collected in river-flooded plains found along the Sokoto river and its tributary, and rain-fed paddy fields distributed in the outskirts of Kano and Zaria follow here. Strains of *O. glaberrima* were mainly collected in river-flooded plain mentioned above and in depression scattered in the same region. In Liberia, many strains of both species were collected from upland condition in shifted field distributed on hill-slope and some ones of *O. glaberrima* were gathered from border of shifted field. In Senegal, strains of both species were mainly collected in the rain-fed paddy fields.

Table 5. Habitats of collection sites and percentage of number of strains collected there to that of the whole strains of the respective countries (%)

Habitat	<i>Oryza sativa</i>					<i>Oryza glaberrima</i>		
	MD ¹⁾	KE	NI	LI	SE	NI	LI	SE
Irrigated paddy field	15.0	14.8		18.2		8.0		4.9
Rain-fed paddy field			25.0		91.7	12.0		73.2
Deep water condition			20.0			12.0		7.3
River-flooded plain			35.0			32.0		
Upland field		3.7	5.0	72.7	8.3	4.0	50.0	7.3
Depression			15.0	9.1		32.0	25.0	
Wild condition							25.0	7.3
Unknown	85.0	81.5						

1) For explanation, refer to Table 1.

Classification of grain-type according to the collected habitat was shown in Table 6. The most part of the strains collected in East Africa were excepted from this classification, because their habitats were indistinct. In *O. sativa*, strains distributed in irrigated paddy field were larger in ratio of length to width and smaller in product of length and width. While, strains distributed in deep water condition were smaller in the ratio of length to width, and larger in product of length and width. These components of strains collected in the river-flooded plain, upland field and depression showed no difference between those in deep water condition. From these facts, it was assumed that many improved varieties belonging to *indica* (slender) type distributed in the irrigated paddy field, and many varieties belonging to *javanica* (large) type distributed in the traditional habitats excepting the rain-fed paddy field. Strains distributed in the rain-fed paddy field showed similar components to those in the irrigated paddy field. It was a noticeable fact that the strains collected in rain-fed paddy field contained a large amount of morphological variability of grain-type, as compared with the strains collected in deep water condition.

In *O. glaberrima*, the strains distributed in river-flooded plain looked obviously large in grain-size. While, the strains collected in upland field and wild status looked more slender in grain-shape and obviously small in grain-size. In general, variations of grain-shape were smaller than those of grain-size. However, in upland condition, morphological variability of grain-shape was noted to be large as in case of grain-size.

Table 6. Grain-type in the respective habitats

Habitat	<i>Oryza sativa</i>				<i>Oryza glaberrima</i>			
	L / W ¹⁾		L × W ²⁾		L / W		L × W	
	Average	CV(%)	Average	CV(%)	Average	CV(%)	Average	CV(%)
Irrigated paddy field	3.3 ^a	16.8	28.6 ^{bc}	9.2	2.6 ^b	3.4	28.8 ^{bc}	12.9
Rain-fed paddy field	3.1 ^{ab}	18.7	26.2 ^c	16.7	2.6 ^b	6.1	28.8 ^{bc}	7.4
Deep water condition	2.5 ^c	2.5	32.5 ^a	4.4	2.5 ^b	1.5	29.9 ^{bc}	11.7
River-flooded plain	2.6 ^{bc}	10.5	30.7 ^{ab}	8.7	2.6 ^b	2.5	32.6 ^a	7.7
Upland field	2.8 ^{bc}	9.7	31.5 ^{ab}	7.8	2.8 ^a	10.8	28.1 ^c	12.2
Depression	2.9 ^{abc}	10.8	31.1 ^{ab}	14.6	2.7 ^{ab}	6.7	31.1 ^{ab}	5.4
Wild status	-	-	-	-	2.8 ^a	4.6	25.1 ^d	8.4

1) Ratio of grain-length to grain-width expressed in grain-shape.

2) Product of grain-length and grain-width expressed in grain-size.

3) Average within each column followed by the same letter does not differ significantly at the 5% level according to Duncan's Multiple Range Test.

Compared with Tables 3 and 4, and Tables 5 and 6, in both species, it seemed that distributions of grain-type according to the collected countries (Tables 3 and 4) were intensively influenced by the respective main habitat (Tables 5 and 6). A large amount of variability of grain-type was obtained in the rain-fed paddy field in *O. sativa* and in upland field in *O. glaberrima*, respectively. While, stabilities of those were obtained in deep water condition in *O. sativa* and in river-flooded plain in *O. glaberrima*, respectively. These facts indicate that rice cultivations in Africa are decided by precipitation or inundation of rivers ¹⁾ on one hand.

Accordingly, after dividing into more detailed regions in the respective countries, relations between morphological characters based on grain-type and meteorological and topographical conditions shall be discussed in the following papers.

Summary

Using 110 strains of *Oryza sativa* L. and 78 strains of *Oryza glaberrima* STEUD. collected in 5 African countries, *i.e.*, Madagascar, Kenya, Nigeria, Liberia and Senegal including Gambia, in 1984 and 1985, interspecific difference, intraspecific variation, and

geographical distribution on grain-type of unhusked grain were investigated.

The results obtained were as follows.

1. *O. glaberrima* was shorter in grain-length, and wider in grain-width, than those of *O. sativa*, respectively. In both characters, *O. glaberrima* were less variable than those of *O. sativa*. In both species, regional differences on grain-length and grain-width were remarkably observed.
2. Though, no difference of product of grain-length and grain-width (grain-size) between *O. sativa* and *O. glaberrima* was found, ratio of grain-length to grain-width (grain-shape) in *O. glaberrima* was smaller than that of *O. sativa*. Grain-shape in *O. glaberrima* were less diverse than those in *O. sativa*. In both species, regional differences on these components were observed.
3. In *O. sativa*, strains collected in traditional habitats, *i.e.*, deep water condition, river-flooded plain, upland field and depression, looked more roundish in grain-shape and larger in grain-size, respectively. While, strains collected in irrigated paddy field and rain-fed paddy field looked more slender in grain-shape and smaller in grain-size, respectively. Variations of both components were obviously small in strains collected in the deep water condition and large in strains collected in the rain-fed paddy field, respectively. In *O. glaberrima*, grain-sizes were clearly large in strains collected in river-flooded plain and small in strains collected in the upland field and the wild status. The grain-shapes were generally roundish, but, the grain-shapes of strains collected in upland field and wild status were more slender.

References

- 1) OKA, H. I. and W. T. CHANG: Observation of wild and cultivated rice species in Africa (in mimeograph). pp. 73 (1964)
- 2) MATSUO, T.: Genecological studies on cultivated rice. Bull. Natl. Inst. Agr. Sci. Ser., **D3**: 1-111 (1952) (in Japanese with English Summary)
- 3) NAGAMATSU, T.: Studies of the geographical distribution of the cultivated rice (Third report). Proc. Crop Sci. Soc. Japan, **14** (2): 132-145 (1952) (in Japanese)
- 4) NAKAGAMA, A., X. R. RAKOTONJANAHARY, A. SUMI and T. C. KATAYAMA: On distribution and morphology of cultivated rice in Madagascar. Bull. Exp. Farm Fac. Agr. Kagoshima Univ., **13**: 11-19 (1988)
- 5) NAKAGAMA, A., A. SUMI and T. C. KATAYAMA: On distribution and morphology of cultivated rice in Kenya. Bull. Exp. Farm Fac. Agr. Kagoshima Univ., **13**: 21-28 (1988)
- 6) NAKAGAMA, A., A. SUMI and T. C. KATAYAMA: On distribution and morphology of cultivated rice in Nigeria. Bull. Exp. Farm Fac. Agr. Kagoshima Univ., **13** : 29-39 (1988)

- 7) NAKAGAMA, A., A. SUMI and T. C. KATAYAMA: On distribution and morphology of cultivated rice in Liberia. Bull. Exp. Farm Fac. Agr. Kagoshima Univ., **13**: 41-50 (1988)
- 8) NAKAGAMA, A., Massamba NGNING, A. SUMI and T. C. KATAYAMA: On distribution and morphology of cultivated rice in Senegal. Bull. Exp. Farm Fac. Agr. Kagoshima Univ., **13**: 51-64 (1988)