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Grain Weight Characters as Indices for Identification of Differentiation in Wild Rice Species

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Introduction

Recently, wild *Oryza* species have frequently been studied from several agronomic viewpoints[10], chiefly because the wild rice may be used in the wider ranges of practical usages, *i.e.*, growing period, resistance for some pests and insects, genetic research.

During the three scientific tours made from 1994 to 1988, the writer was sent to 8 countries of Africa. Morphological investigations of the materials of wild rice collected during the tours were already reported in the previous papers by the present author[1-6]. In the present paper, some records of the grain weight were reported.

Investigations on the grain weight, especially on the relationships between grain weight and other morphological characters of the grain, were not so frequently reported. Takeda reported about the statuses found between grain weight and morphological characters[11]. However, investigation was conducted only for the cultivated rice species. So, these items for the wild rice species were studied in the present paper.

The present investigation was constituted by two parts. In the PART I, 21 strains of wild rice species, *Oryza longistaminata* CHEV. et ROEHR., collected in 5 countries of Africa, were used for the preliminary study. As some interesting results were obtained in the PART I, the following experiment was conducted as PART II, using 109 strains distributed over the wider ranges of Africa and the supplied with the respective species statuses.

Materials and Methods

In PART I, 21 strains of wild rice belonging to *Oryza longistaminata* CHEV. et ROEHR. were used. They were collected in the 5 countires of Africa, *i.e.*, 3 strains collected in Madagascar in 1985 --- Accession Nos. 302-312 in Table 1 (abbreviated as MD), 4 strains collected in Kenya in 1985 --- Accession Nos. 315-319 (KE), 5 strains collected in Nigeria in 1984 --- Accession No. 325, and in 1985 --- Accession Nos. 346-371 (NI), 7 strains collected in Ivory Coast in 1984 --- Accession Nos. 384-390 (IV), 2 strains collected in Senegal in 1985 --- Accession Nos. 399-401 (SE).

In PART II, 109 strains of wild rice species were used, *i.e.*, 47 strains collected in Madagascar in 1988 --- Accession Nos. 2001-2047 (abbreviated as MDL), and 36 strains collected in Tanzania in 1988 --- Accession Nos. 2048-2083 (TAL) of *Oryza longistaminata* CHEV. et ROEHR., and 26 strains collected in Tanzania in 1988 --- Accession Nos. 2084-2109 (TAP) of *Oryza punctata* KOTSCHY.

Thirty matured grains were used for measurements of each strain. Measurements were

done at length (abbreviated as L), width (W) and thickness (T) of the respective grains, centering at the most eminent section of the respective characters, using a dial caliper (Kori Seiki). Calculations were done for the ratios of length to width (L/W), of length to thickness (L/T) and of width to thickness (W/T). Grain weights were also measured, using a balance (A & A, ER-182A) (GW characters). Comparative values (CV characters) were illustrated by the ratios of the values fixed in the husked grains to the values fixed in the unhusked grains concerning the respective characters. The following 6 characters of the unhusked and the husked grains were illustrated by the area (= length x width) and the volume (= length x width x thickness) for the unhusked and the husked grains, the area and volume quotients (= ratio of the value of husked to the value of unhusked grains, AV characters). The whole data referring to the 27 characters were applied to the unhusked (UHG characters) and the husked (HG characters) grains, and were illustrated by the average values in the whole grains.

Correlation coefficients (abbreviated as c.c.) between the respective two characters for 25 combinations were fixed, in which the weight character was used as one character in the whole combinations. Lastly, correlation coefficients were summed-up in grain and strain levels and were compared each other.

Results and Discussion

The data obtained for grain morphology excluding grain weight (GW) were cited from the previous papers of the present author, *i.e.*, unhusked grains (UHG)[1,2,3], husked grains (HG)[4], comparative characters (CV)[5] and area and volume characters (AV)[6], and they were not shown in the present paper as tables.

PART I

1. Three grain weight characters

The results obtained concerning the grain weight for PART I are given in Table 1. Practical values in UHG for the individual grain level ranged from 21.5 mg (Accession No.401) to 8.1mg (No.317). At the strain level, the heaviest (17.4mg) and the lightest (9.5mg) were obtained in No.390 and No.303, respectively. Average and its standard deviation (abbreviated as s.d.) in the whole strains were found to be 13.37 ± 1.98. Practical values in HG for the individual grain level ranged from 15.4mg (No.390) to 4.8mg (Nos.302 and 317). At the strain level, the heaviest (11.77mg) and the lightest (6.14mg) were obtained in No.390 and No.303, respectively, which were the same as in the case of UHG. Average and its s.d. in the whole strains were found to be 8.91 ± 1.53. Practical values in the quotient of weight for the individual grain level ranged from 0.95 (No.384) to 0.47 (No.302). At the strain level, the largest (0.75) and the smallest (0.61) were obtained in No.371, and Nos.302 and 317, respectively. Average and its s.d. in the whole strains were found to be 0.67 ± 0.03.

In view of the country averages, practical values in UHG showed the heaviest (15.15mg) and the lightest (11.06mg) in the strains collected in IV and MD, respectively. Practical values in HG showed the heaviest (10.17mg) and the lightest (7.12mg) in the strains collected in IV and MD, respectively, which were the same as in the case of UHG. Practical values in the quotient showed the largest (0.70) and the smallest (0.64) in the strains collected in SE, and MD and KE, respectively.

The standard deviations of each strain for the whole strains were noted as 1.61 ± 0.48, 1.21 ± 0.39 and 0.05 ± 0.02 in UHG, HG and quotient, respectively. In locality specificities, the

Table 1. Three grain characters in view of practical value and pure range, *i.e.*, unhusked (UHG), husked (HG) and ratio of value in husked to value in unhusked grains (HG/UHG) illustrated by 0.1 mg; Accession Nos.302-312 (Madagascar, MD), 315-319 (Kenya, KE), 325-371 (Nigeria, NI), 384-390 (Ivory Coast, IV) and 399-401 (Senegal, SE)

Accession No.	Practical value			Range		
	UHG	HG	HG/UHG	UHG	HG	HG/UHG
302	117.05±10.73	71.55±11.92	0.61±0.09	45	46	0.27
303	94.90±8.59	61.40±7.97	0.65±0.06	29	30	0.25
312	119.85±20.26	80.65±15.23	0.67±0.05	65	51	0.18
315	135.75±14.58	91.50±10.69	0.67±0.04	58	41	0.16
316	119.30±11.01	73.05±6.74	0.62±0.06	37	25	0.19
317	103.15±13.10	62.80±9.46	0.61±0.06	43	31	0.20
319	131.60±13.38	83.80±8.76	0.64±0.03	54	35	0.13
325	122.20±12.78	82.75±8.66	0.68±0.06	52	30	0.27
346	138.05±21.25	88.60±17.87	0.64±0.06	70	54	0.24
352	129.35±19.65	86.70±16.64	0.67±0.05	69	52	0.16
354	139.00±13.64	95.50±8.86	0.69±0.03	49	32	0.14
371	123.50±13.51	91.55±10.24	0.75±0.09	43	36	0.34
384	124.95±23.69	79.85±19.07	0.64±0.09	80	66	0.41
385	136.95±11.60	92.30±7.64	0.68±0.06	46	30	0.18
386	133.55±10.22	87.20±7.36	0.65±0.04	34	26	0.13
387	170.30±18.51	116.35±11.80	0.68±0.03	67	46	0.11
388	154.75±19.92	103.75±11.72	0.67±0.03	89	48	0.11
389	166.65±21.10	114.70±17.08	0.69±0.05	82	55	0.21
390	173.45±16.45	117.70±13.71	0.68±0.03	67	61	0.15
399	125.65±17.95	88.30±14.82	0.70±0.03	73	58	0.12
401	147.60±26.28	101.75±18.28	0.69±0.04	106	67	0.16

largests (2.21 in UHG and 1.66 in HG) and the smallests (1.30 in UHG and 0.89 in HG) were obtained in SE and KE, respectively, both in UHG and HG.

Pure ranges in UHG, HG and quotient for the whole strains were found as the largests (10.6mg in No.401, 6.7mg in No.401, and 0.41 in 384) and as the smallests (2.9mg in No.303, 2.5mg in No.316, and 0.11 in Nos.387 and 388) in UHG, HG and quotient, respectively. In locality specificities, the largests (8.95mg in UHG and 6.25mg in HG) were obtained in SE, but the smallests were obtained as 4.63mg and 3.30mg in MD and KE, respectively. In quotients, the largest (0.23) and the smallest (0.14) were obtained in MD and NI, and SE, respectively. Averages and their s.ds. through the whole strains were found to be 5.99±1.92, 4.38±1.31 and 0.20±0.08 in UHG, HG and quotient, respectively.

2. Relations between the respective two characters

1. As shown in Table 2, correlation coefficients (c.c.) of the respective character-combinations at the strain level were fixed to be significant in 132 cases out of 525 combinations of the whole cases (=21 strains x 25 character-combinations) (=25.1%). In detail, some characteristics were found. Significant correlations at the strain level were ascertained as follows in the order of the combination numbers 1-25; 20; 6, 3, 10; 1, 2, 0; 12, 3, 10; 0, 0, 3; 3, 2, 0; 4, 2, 1; 8, 14, 12, 14, 1 and 1 strains, respectively. It may be noticed that the values were particularly large in the combination numbers 1, 8, 21, 22 and 23. Average value and its s.d.

Table 2. Summed-up data showing correlation coefficients in the 25 character-combinations

Combination No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Character Nos.		7 · 17	7 · 1	7 · 2	7 · 3	7 · 4	7 · 5	7 · 6	17 · 11	17 · 12	17 · 13	17 · 14	17 · 15	17 · 16	27 · 21	27 · 22	27 · 23	27 · 24	27 · 25	27 · 26	7 · 31	7 · 32	17 · 33	17 · 34	27 · 35	27 · 36
Accession No.	302	*	*		**																**	**	**	*		
	303	***			**				*													*				
	312	***							*	***	**												***	***		
	315	*									*			*	*											
	316	*																								
	317	***	*		**				*												*	***	*	*		
	319	***		*												*					**	**				
	325	***					*		*					*		**		*		***				*		
	346	***			*						**				**			*	*					**		
	352	***		**	*	*			***		*				**				*		**	***	***	***	*	
	354	***							*														**	**		
	371		*											**				*			*	**				
	384	***		**	***				**	***	**										**	***	***	***		
	385	*			*				*													*				
	386	***																								
	387	***	*		**				***		**											*	**	***		
	388	***	*						***	**												*	***	***		
	389	***									*										*	*	*	**		
	390	***			*				*		**											*	**	***		*
	399	***			***		*				**							*				***	*	**		
	401	***	*						**		***										**	**	**	***		
Whole		***	***	***	***				***	***	***										***	***	***	***		

Character numbers; 1, 11, 21 length, 2, 12, 22 width, 3, 13, 23 thickness, 4, 14, 24 L/W, 5, 15, 25 L/T, 6, 16, 26 W/T, 7, 17, 27 weight, 1~7, 31, 32 unhusked grains, 11~17, 33, 34 husked grains, 21~27 comparative values (= husked/unhusked), 31, 33 area, 32, 34 volume, 35 quotient of area (= 33/31), 36 quotient of volume (= 34/32)

d.f.; 18 and 19 in strain level and the whole, respectively

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

through the whole combinations were found to be 5.28±5.48.

The whole combinations were divided into 3 groups, *i.e.*., group I (combination No.1, high), group II (Nos.2-4, 8-10, 20-21, 22-23, intermediate) and group III (Nos.5-7, 11-13, 14-19, 24-25, low). Significant correlations were accounted as 95.2% (=20/21), 43.8% (=92/210) and 6.8% (=20/294) in the groups of I, II and III, respectively. Those averages and their s.ds. through the whole combinations within the groups were found to be 20.00±0.00, 23.00±2.74 and 4.20±1.60 in the groups of I, II and III, respectively. Those differences found might be looked upon as specificities of the characters or character-combinations.

2. The respective strains showed significant correlations as follows in the order from strain No.302 to No.401; 7, 4, 6, 4, 1, 8, 5, 8, 7, 13, 4, 5, 10, 4, 1, 8, 7, 6, 8, 8 and 8, respectively. It was noticeable that strain No.352, and Nos.316 and 386 showed significances in 13/25 (=52.0% in the whole combinations) and 1/25 (=4.0%), respectively. One, 1, 6, 3, 2, 2, 4 and 2 strains showed significances in 13, 10, 8, 7, 6, 5, 4 and 1 character-combinations, respectively.

Table 3. Correlation coefficient of the former character (Y) on the latter character (X) for 25 character-combinations, practical value (left), s.d. (center) and range (right); and for 3 characters, practical value on its s.d. (left), practical value on its range (center) and s.d. on range (right)

Combination	Practical value	S.d.	Range
7 · 1	0.8025***	-0.0765	-0.3718
7 · 2	0.6789***	0.4676*	0.4036
7 · 3	0.8794***	0.4832*	0.5026*
7 · 4	0.2665	0.4160	0.3553
7 · 5	0.0658	0.0818	-0.1421
7 · 6	-0.2364	0.1717	0.1594
17 · 11	0.8214***	0.3887	0.3908
17 · 12	0.8295***	0.6777***	0.2679
17 · 13	0.9334***	0.1422	0.2237
17 · 14	0.0462	0.3755	0.2788
17 · 15	0.0146	0.0481	-0.0625
17 · 16	0.0006	0.0546	0.4286
27 · 21	0.1847	-0.0206	0.0541
27 · 22	0.4136	-0.2412	-0.1968
27 · 23	0.2087	-0.3176	-0.2185
27 · 24	-0.1032	0.0438	-0.0169
27 · 25	0.1381	0.1781	0.0353
27 · 26	0.4106	-0.3805	-0.5195*
7 · 31	0.8423***	0.3618	0.4437
7 · 32	0.8998***	0.5619**	0.6115**
17 · 33	0.9403***	0.4909*	0.6116**
17 · 34	0.9691***	0.3697	0.6400**
27 · 35	0.3525	-0.4084	-0.1501
27 · 36	0.3205	-0.6141*	0.1944
7 · 17	0.9732***	0.9074***	0.8634***

Character	Practical value on its s.d	Practical value on its range	S.d. on range
7	0.4717*	0.5833***	0.9421***
17	0.3270	0.4511*	0.9396***
27	-0.1869	-0.0581	0.9118***

Character numbers are the same as those mentioned in Table 2.
d.f.; 19
***, **, *; significant at 0.1%, 1% and 5% levels, respectively

Average value and its s.d. through the whole strains were found to be 6.29±2.75.

3. Significant correlations were analysed in the positive and the negative statuses as well as in the degrees of the respective statuses. Significant correlations were accounted as follows in the order of 0.1% (positive, negative and the whole), of 1% (positive, negative and the whole) and of 5% levels (positive, negative and the whole); 39 (29.6%), 1 (0.8%), 40 (30.3%); 35 (26.5%), 2 (1.5%), 37 (28.0%); 48 (36.4%), 7 (5.3%), 55 (41.7%).

The positive and the negative combinations in the total were accounted as 122 combinations (=92.4%) and 10 combinations (=7.6%), respectively. Those percentages were quite the same as in case of the wild rice collected in Bangladesh in 1994[9].

3. Relationships among practical value, standard deviation and variation range

The mutual relations in view of the three major components were accounted, and are given in the left and the upper parts of right columns of Table 3.

1. In practical-value-combinations (A), 11 and 14 character-combinations showed significances at 0.1% level and no significance even at 5% level, respectively. It showed "all or nothing" status in character-combination. In s.d.-value-combinations (B), 2, 1, 4 and 18 char -acter-combinations showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. In the range-value-combinations (C), 1, 3, 2 and 19 character-combinations showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. In the 3 character-combinations mentioned above (D), 14, 4, 6 and 51 character-combinations showed significances at 0.1%, 1% and 5% levels and no significance even

at 5% level, respectively. The total columns were regulated, under the condition that the calculation was to be made by means of the significances, in disregard of the significant levels. Significant combinations were accounted as 11/25 cases (=44.0%), 7/25 cases (=28.0%), 6/25 cases (=24.0%) and 24/75 cases (32.0%) in columns A, B, C and D, respectively. Moreover, 4, 3, 6 and 12 character-combinations showed significances at 3, 2, 1 and 0 columns, respectively. Average and its s.d. through the whole cases were found to be 0.96±1.11.

2. The other mutual relations in view of the respective three major components were calculated, and are shown in the right-lower column of Table 3.

In the relations between the practical values and their s.ds. (E), the practical values and their variation ranges (F) and s.ds. and their variation ranges (G), 0, 0, 1, 2; 1, 0, 1, 1; 3, 0, 0, 0 characters showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. Significant relations were accounted as 1/3 (=33.3%), 2/3 (=66.7%), 3/3 (=100.0%) and 6/9 (=66.7%) in E, F, G and H (the whole of 3 items), respectively. One, 1 and 1 characters showed significances at 3, 2 and 1 columns, respectively. Average and its s.d. through the whole columns were found to be 2.00±0.82. It was noticeable that character No.7 showed the highest freuqency. It was clearly ascertained that significant levels were fixed to be in the order of G, F and E, which was the same as in case of the wild rice collected in Bangladesh, 1994[9].

PART II

1. Three grain weight characters

The results obtained concerning grain weight for PART II are given in Table 4.

i] *O. longistaminata collected in Madagascar, 1988 (MDL)*:

Practical values in UHG for the individual grain level ranged from 23.4mg (Accession No.2044) to 4.9mg (No.2010). At the strain level, the heaviest (19.0mg) and the lightest (8.8mg) were obtained in No.2016 and No.2009, respectively. Average and its s.d. in the whole strains were found to be 12.81±2.70. Practical values in HG for the individual grain level ranged from 17.7mg (No.2043) to 2.2mg (No.2010), in which the latter was the same as in case of UHG. At the strain level, the heaviest (12.6mg) and the lightest (5.8mg) were obtained in No.2023 and No.2015, respectively. Average and its s.d. in the whole strains were found to be 8.54±1.96. Practical values in quotient of the weight for the individual grain level ranged from 0.93 (No.2027) to 0.33 (No.2035). In the strain level, the largest (0.82) and the smallest (0.57) were obtained in No.2027 and No.2015, respectively, in which the latter was the same as in case of HG. Average and its s.d. in the whole strains were found to be 0.67±0.05.

The standard deviations of each strain for the whole strains were noted as 1.73±0.54, 1.45±0.44 and 0.06±0.02 in UHG, HG and quotient, respectively.

Pure ranges in UHG, HG and quotient for the whole strains were found as the largests (11.5mg in No.2044, 11.1mg in No.2043 and 0.43 in No.2035) and as the smallests (3.2mg in No.2033, 2.3mg in No.2039 and 0.10 in No.2022) in UHG, HG and quotient, respectively.

ii] *O. longistaminata collected in Tanzania, 1988 (TAL)*:

Practical values in UHG for the individual grain level ranged from 33.7mg (No.2051) to 8.1mg (Nos.2073 and 2083). At the strain level, the heaviest (21.6mg) and the lightest (10.6mg) were obtained in No.2051 and No.2073, respectively. Average and its s.d. in the whole strains were found to be 15.58±2.35. Practical values in HG for the individual grain level ranged from 20.9mg (No.2051) to 4.5mg (No.2056), in which the former was the same as in

Table 4. Three grain characters in view of practical value and pure range, *i.e.*, unhusked (UHG), husked (HG) and ratio of value in husked to value in unhusked grains (HG/UHG) illustrated by 0.1 mg; Accession Nos.2001-2047 (Madagascar, MDL) and Nos.2048-2083 (Tanzania, TAL) of *O. longistaminata*, and Nos.2084-2109 (Tanzania, TAP) of *O. punctata*

Accession No.	Practical value			Range		
	UHG	HG	HG/UHG	UHG	HG	HG/UHG
2001	124.60±12.69	84.00±11.60	0.67±0.05	49	48	0.20
2002	113.95±13.94	79.60±13.14	0.70±0.06	59	52	0.22
2003	125.35±17.34	84.20±13.22	0.67±0.04	72	56	0.19
2004	106.50±18.40	65.50±17.14	0.61±0.09	70	68	0.33
2005	98.45±16.01	62.45±13.34	0.63±0.06	67	44	0.24
2006	98.20±20.06	63.60±17.98	0.64±0.08	85	70	0.29
2007	127.60±11.32	85.40±11.41	0.67±0.05	39	40	0.20
2008	97.20±10.38	64.45±7.88	0.66±0.04	50	35	0.18
2009	87.85±15.19	57.95±12.22	0.66±0.08	55	45	0.28
2010	90.65±15.92	59.50±14.16	0.65±0.07	59	54	0.30
2011	96.75±16.05	60.95±11.81	0.63±0.06	71	50	0.22
2012	122.55±18.39	75.50±13.76	0.62±0.05	81	56	0.20
2013	128.45±19.58	86.15±16.79	0.67±0.06	83	65	0.22
2014	127.95±24.10	86.40±20.26	0.67±0.06	95	79	0.21
2015	101.35±25.13	57.80±17.12	0.57±0.08	82	53	0.33
2016	189.75±20.84	120.90±15.59	0.64±0.05	85	56	0.19
2017	180.25±21.24	118.90±21.82	0.66±0.07	69	74	0.24
2018	157.65±13.82	104.55±10.85	0.66±0.06	54	43	0.25
2019	163.25±15.39	112.50±13.73	0.69±0.07	57	51	0.28
2020	111.25±21.57	70.20±14.72	0.63±0.08	79	49	0.30
2021	118.35±21.37	89.55±15.36	0.76±0.05	85	70	0.24
2022	167.30±19.46	126.00±15.45	0.75±0.03	69	57	0.10
2023	171.90±14.57	126.40±12.10	0.74±0.04	60	45	0.17
2024	102.85±12.90	78.95±11.29	0.77±0.05	54	40	0.25
2025	106.30±21.62	72.25±17.27	0.68±0.05	67	52	0.22
2026	103.15±12.08	79.60±9.22	0.77±0.04	47	35	0.18
2027	90.50±12.42	73.65±10.75	0.82±0.06	42	33	0.25
2028	110.50±18.70	77.50±12.70	0.70±0.06	76	51	0.28
2029	117.55±15.63	78.40±14.21	0.66±0.07	60	61	0.32
2030	129.35±18.32	84.60±10.32	0.66±0.05	77	39	0.19
2031	106.00±15.69	62.85±12.82	0.60±0.11	53	47	0.32
2032	113.90±10.77	70.45±12.28	0.62±0.10	40	52	0.37
2033	108.20±10.49	62.55±10.86	0.58±0.09	32	38	0.32
2034	136.80±17.48	80.90±16.80	0.59±0.09	77	62	0.31
2035	122.00±12.33	74.40±15.76	0.61±0.11	40	58	0.43
2036	136.70±15.50	86.05±12.87	0.63±0.05	66	57	0.21
2037	122.35±13.30	76.35±11.31	0.63±0.08	47	47	0.30
2038	130.40±20.86	91.20±17.12	0.70±0.04	75	68	0.18
2039	134.40±11.23	93.55±6.18	0.70±0.03	48	23	0.14
2040	161.90±19.90	110.35±15.86	0.68±0.04	74	60	0.15
2041	137.50±20.65	88.85±12.18	0.65±0.06	81	49	0.17

(Continued)

Table 4. (Continued)

Accession No.	Practical value			Range		
	UHG	HG	HG/UHG	UHG	HG	HG/UHG
2042	146.10±22.91	90.50±11.40	0.63±0.08	72	51	0.23
2043	148.80±32.84	106.15±29.59	0.71±0.08	111	111	0.27
2044	168.15±27.14	111.80±23.24	0.66±0.05	115	88	0.19
2045	187.90±19.96	125.20±16.89	0.66±0.04	71	60	0.17
2046	167.15±29.88	114.40±26.31	0.68±0.05	113	94	0.18
2047	122.65±14.77	80.45±12.04	0.66±0.07	57	43	0.23
Average	128.05±27.00	85.40±19.64	0.67±0.05	68	54	0.24
2048	178.15±21.26	118.50±14.90	0.67±0.06	79	60	0.16
2049	133.25±24.48	88.90±18.83	0.67±0.09	83	71	0.30
2050	165.60±24.88	108.10±18.34	0.65±0.06	117	83	0.19
2051	216.40±56.30	132.20±31.22	0.62±0.05	222	124	0.21
2052	196.85±31.04	122.25±13.89	0.63±0.08	104	70	0.24
2053	182.65±27.56	113.05±14.04	0.63±0.10	115	50	0.33
2054	158.55±22.06	96.10±11.33	0.61±0.08	86	36	0.27
2055	148.80±21.71	91.95±10.50	0.63±0.10	68	47	0.31
2056	133.40±29.05	77.35±21.54	0.59±0.12	104	70	0.40
2057	170.80±26.41	116.60±16.66	0.69±0.10	115	72	0.32
2058	138.20±32.85	89.65±26.30	0.64±0.07	105	85	0.27
2059	154.60±33.98	110.30±27.70	0.71±0.05	115	105	0.18
2060	145.75±18.57	103.50±14.27	0.71±0.03	75	53	0.10
2061	180.45±17.66	109.95±12.43	0.61±0.04	72	45	0.11
2062	158.95±21.86	101.50±14.33	0.64±0.03	77	57	0.12
2063	161.30±18.74	114.30±12.42	0.71±0.03	80	48	0.11
2064	147.40±14.71	100.35±12.22	0.68±0.03	58	47	0.12
2065	147.35±18.53	100.80±13.66	0.68±0.04	63	51	0.15
2066	125.65±17.80	85.45±13.13	0.67±0.06	67	49	0.23
2067	169.95±20.40	119.00±18.54	0.70±0.05	87	74	0.21
2068	131.35±17.50	96.25±11.96	0.74±0.05	58	44	0.20
2069	169.30±31.81	104.75±25.10	0.62±0.06	105	89	0.27
2070	155.05±20.94	115.45±15.10	0.75±0.05	86	62	0.18
2071	135.15±18.98	94.25±11.97	0.70±0.04	72	51	0.15
2072	166.65±18.17	111.80±13.49	0.67±0.03	75	49	0.13
2073	105.75±13.45	71.70±8.52	0.68±0.09	67	36	0.36
2074	156.25±19.42	101.40±12.24	0.65±0.04	74	51	0.16
2075	161.30±23.10	106.60±15.27	0.66±0.04	87	57	0.13
2076	159.25±21.29	103.80±14.21	0.65±0.04	78	48	0.13
2077	198.45±25.01	134.25±17.05	0.68±0.04	113	77	0.14
2078	165.25±20.68	118.00±16.48	0.71±0.03	80	63	0.13
2079	177.65±20.21	125.15±15.84	0.70±0.04	100	63	0.15
2080	140.15±15.81	98.35±13.97	0.70±0.04	60	51	0.16
2081	132.40±14.43	90.80±11.39	0.69±0.05	52	36	0.20
2082	127.05±17.09	83.95±15.39	0.66±0.08	55	51	0.38
2083	113.70±16.16	82.15±10.43	0.73±0.04	75	40	0.18
Average	155.80±23.53	103.85±14.70	0.67±0.04	87	60	0.21

(Continued)

Table 4. (Continued)

Accession No.	Practical value			Range		
	UHG	HG	HG/UHG	UHG	HG	HG/UHG
Average of both groups	140.09±29.01	93.40±19.90	0.67±0.05	76	57	0.22
2084	96.10±7.03	67.10±4.17	0.70±0.07	28	15	0.22
2085	120.10±12.69	88.40±9.38	0.74±0.08	59	30	0.36
2086	95.65±9.74	69.45±8.16	0.73±0.11	39	36	0.38
2087	111.05±19.82	88.00±9.59	0.81±0.12	74	32	0.48
2088	136.25±16.59	86.95±10.14	0.64±0.04	63	40	0.17
2089	98.80±11.84	57.35±7.15	0.58±0.05	37	24	0.20
2090	93.40±6.39	54.40±6.38	0.58±0.06	23	23	0.20
2091	118.30±9.11	67.90±8.28	0.57±0.05	36	31	0.20
2092	112.75±8.47	62.15±8.21	0.55±0.05	29	33	0.18
2093	114.10±12.70	63.35±9.57	0.55±0.04	56	35	0.16
2094	113.75±12.68	62.55±10.56	0.55±0.06	54	35	0.26
2095	124.40±9.50	76.90±8.04	0.62±0.05	38	30	0.21
2096	117.30±14.20	69.75±10.12	0.60±0.05	49	35	0.17
2097	105.70±11.69	63.80±9.95	0.60±0.06	39	28	0.21
2098	131.70±6.47	81.35±7.19	0.62±0.05	22	24	0.21
2099	105.05±12.68	66.55±7.21	0.64±0.04	49	25	0.15
2100	105.15±13.43	67.25±6.46	0.65±0.07	43	26	0.27
2101	117.30±9.19	72.20±6.16	0.62±0.03	34	18	0.09
2102	115.30±9.65	70.30±8.72	0.61±0.04	32	29	0.14
2103	113.65±10.54	75.45±6.00	0.67±0.03	43	24	0.13
2104	113.80±5.50	74.25±5.31	0.65±0.05	19	22	0.17
2105	96.60±10.13	65.85±7.42	0.68±0.04	38	27	0.15
2106	106.40±9.44	68.00±9.93	0.64±0.07	34	41	0.29
2107	115.90±10.48	76.45±8.66	0.66±0.05	36	32	0.17
2108	108.70±9.83	70.45±6.04	0.65±0.03	34	28	0.14
2109	109.75±8.75	69.20±7.23	0.63±0.05	29	27	0.22
Average	114.42±10.35	70.59±8.48	0.64±0.06	40	29	0.21

case of UHG. At the strain level, the heaviest (13.4mg) and the lightest (7.2mg) were obtained in No.2077 and No.2073, respectively, in which the latter was the same as in case of UHG. Average and its s.d. in the whole strains were found to be 10.39±1.47. Practical values in quotient of grain weight for the individual grain level ranged from 0.87 (No.2057) to 0.34 (No.2056), in which the latter was the same as in case of HG. At the strain level, the largest (0.75) and the smallest (0.59) were found in No.2070 and No.2056, respectively. Average and its s.d. in the whole strains were found to be 0.67±0.04.

The standard deviations of each strain for the whole strains were noted as 2.26±0.77, 1.57±0.50 and 0.06±0.02 in UHG, HG and quotient, respectively. They were clearly larger than those of MDL.

Pure ranges in UHG, HG and quotient for the whole strains were found as the largests (22.2mg and 12.4mg in No.2051, and 0.38 in No.2082) and as the smallests (5.2mg in No.2081, 3.6mg in Nos.2054, 2073 and 2081, and 0.10 in No.2060) in UHG, HG and quotient, respectively.

iii] *O. longistaminata collected in the both countries*:

In practical values, averages and their s.ds. in the whole strains were found to be 14.01±2.90, 9.34±1.99 and 0.67±0.05 in UHG, HG and quotient, respectively. The standard deviations of each strain for the whole strains were noted to be 1.96±0.70, 1.50±0.47 and 0.06±0.02 in UHG, HG and quotient, respectively.

iv] *O. punctata collected in Tanzania, 1988 (TAP)*:

Practical values in UHG for the individual grain level ranged from 15.9mg (No.2087) to 7.2mg (No.2105). At the strain level, the heaviest (13.6mg) and the lightest (9.3mg) were obtained in No.2088 and No.2090, respectively. Average and its s.d. in the whole strains were found to be 11.44±1.04. Practical values in HG for the individual grain level ranged from 10.4mg (No.2087) to 4.1mg (No.2090), in which the former was the same as in case of UHG. At the strain level, the heaviest (8.8mg) and the lightest (5.4mg) were obtained in No.2085 and No.2090, respectively, in which the latter was the same as in case of UHG. Average and its s.d. in the whole strains were found to be 7.06±0.85. Practical values in quotient of grain weight for the individual grain level ranged from 0.95 (No.2087) to 0.42 (No.2094), in which the former was the same as in cases of UHG and HG. At the strain level, the largest (0.81) and the smallest (0.55) were obtained in No.2087, and Nos.2092, 2093 and 2094, respectively. Average and its s.d. in the whole strains were found to be 0.64±0.06.

The standard deviations of each strain for the whole strains were noted as 1.03±0.34, 0.79 ±0.17 and 0.06±0.02 in UHG, HG and quotient, respectively.

Pure ranges in UHG, HG and quotient for the whole strains were found as the largests (7.4mg in No.2087, 4.0mg in No.2088 and 0.48 in No.2087) and as the smallests (1.9mg in No.2104, 1.5mg in No.2084 and 0.09 in No.2101) in UHG, HG and quotient, respectively.

2. Relations between the respective two characters

i] *MDL*:

1. As shown in Table 5, c.cs. of the respective character-combinations in the strain level were fixed to be significant in 326 cases out of 1,175 combinations of the whole cases (=47 strains x 25 character-combinations) (=27.8%). Significant correlations at the strain level were accounted as follows in the order of the combination numbers 1-25; 47; 17, 7, 19; 7, 7, 10; 17, 10, 27; 3, 10, 6; 5, 5, 5; 5, 4, 2; 15, 26, 22, 39, 6 and 5 strains, respectively. It may be noticed that the values were particularly large in the combination numbers 1, 10, 21 and 23. Average value and its s.d. through the whole combinations were found to be 13.04±11.32.

The whole combinations were divided into 3 groups, *i.e.*, group I (combination No.1, high), group II (Nos.2-4, 8-10, 20-21, 22-23, intermediate) and group III (Nos.5-7, 11-13, 14-19, 24-25, low). Significant correlations were accounted as 100.0% (=47/47), 42.3% (=199/470) and 12.2% (=80/658) in the groups of I, II and III, respectively. Those averages and their s.ds. through the whole combinations within the groups were found to be 47.00±0.00, 49.75±8.17 and 16.00±4.98 in the groups of I, II and III, respectively. Those differences found might be looked upon as specificities of the characters or character-combinations.

2. The respective strains showed significant correlations as follows in the order from strain No.2001 to No.2047; 5, 8, 9, 7, 10; 3, 10, 2, 5, 5; 3, 6, 7, 8, 6; 7, 7, 11, 7, 6; 7, 11, 7, 2, 10; 10, 5, 4, 2, 9; 7, 6, 5, 4, 11; 4, 4, 10, 4, 7; 9, 4, 16, 13, 5; 14 and 4, respectively. It was noted that strain No.2043, and Nos.2008, 2024 and 2029 showed significances in 16/25 (=64.0% in the whole combinations) and in 2/25 (=8.0%), respectively. One, 1, 1, 3, 5, 3, 2, 9, 4, 6, 7, 2 and 3 strains showed significances in 16, 14, 13, 11, 10, 9, 8, 7, 6, 5, 4, 3 and 2 character-combinations,

Table 5. Summed-up data showing correlation coefficients in the 25 character-combinations

Combination No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Character Nos.		7 · 17	7 · 1	7 · 2	7 · 3	7 · 4	7 · 5	7 · 6	17 · 11	17 · 12	17 · 13	17 · 14	17 · 15	17 · 16	27 · 21	27 · 22	27 · 23	27 · 24	27 · 25	27 · 26	7 · 31	7 · 32	17 · 33	17 · 34	27 · 35	27 · 36
Accession No.	2001	***							*												*	*		*		
	2002	***													*	**	*						*	***	***	***
	2003	***	**	***					***	*											***	***	***	***		
	2004	***		**		**					*						*					*		**		
	2005	***	**			*	*		**				*								**	*	**	**		
	2006	***									*													*		
	2007	***			***		**	**			**		**			*		**				**		*		
	2008	***																						*		
	2009	***									***		*										*	**		
	2010	***				*			**														*	**		
	2011	***									*		*													
	2012	***								*	**											*	*	**		
	2013	***			*				***		**	**		**										**		
	2014	***			**			*	***		*											*	*	*		
	2015	***	*		*						**											*		*		
	2016	***			*		*	*			*													*	*	
	2017	***	*		*						*								*			**		**		
	2018	*	**	**						*					**						***	***	**	**	*	*
	2019	**	*						*												*	*	**	***		
	2020	***								*	*						*						*	**		
	2021	***			*				*		*											*	*	*		
	2022	***	*		**			**	***		***			**				*				***	*	***		
	2023	***			*		*		*		*												**	**		
	2024	***									*															
	2025	***		*	**	*	*	***			***		*	**										**		
	2026	***	**	*	**					**		*									**	***	*	**		
	2027	***	*						*	*														**		
	2028	***			*			*														*				
	2029	***																						*		
	2030	***	**			**			**		*								*		*		*	**		
	2031	*	*	*												**					**	**				*
	2032	*		**												*		*			*	**				
	2033	*			**						*											**		*		
	2034	***									***		**	*												
	2035	*	**								***		***	***			*		*	*	*	*		***		
	2036	***			**																*	**				
	2037	**	*			**																		*		
	2038	***	**					*	**		**				**						**	***	**	***		
	2039	***	**																		**	*				
	2040	***							**		**										*	*	*	***		
	2041	***	***		*	**			*	*												**	**	**		
	2042	**							*														**	**		

(Continued)

Table 5. (Continued)

Combination No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Character Nos.		7 · 17	7 · 1	7 · 2	7 · 3	7 · 4	7 · 5	7 · 6	17 · 11	17 · 12	17 · 13	17 · 14	17 · 15	17 · 16	27 · 21	27 · 22	27 · 23	27 · 24	27 · 25	27 · 26	7 · 31	7 · 32	17 · 33	17 · 34	27 · 35	27 · 36
Accession No.	2043	***	**		*		*	**	**	***	***		*		**						**	***	***	***	*	*
	2044	***			***		***	*			***		*	**	**		*	*	*			*		**		
	2045	***			*					**													**	**		
	2046	***			**			*		***	***	**	*			***		**		*			***	***	***	***
	2047	***									**													*		*
	2048	***	**						**	**	*										*	*	***	***		*
	2049	***									*													*		
	2050	***									*					*								*	*	
	2051	***	**	**	***					**	**	*	*							*	**	***	**	**		
	2052	*							*													*	***	***		
	2053								*	*	**											*		***		
	2054				*	*								*							*	**				
	2055																*			*						
	2056	**		*	**		*			***	**	*										*	***	***		
	2057	**			*																					
	2058	***			**						*											***				
	2059	***			***		**				***			*	**							***		**	**	**
	2060	***								*	**												*	**		
	2061	***																								
	2062	***			*																	**				
	2063	***			***		**	***	***		**	**		**								**	*	***		
	2064	***			*				**			*												**		
	2065	***		*	**						**		*								*	***		*		
	2066	***				*					**													***		
	2067	***	*		*				*		**			*								*		**		
	2068	***	**						**		***			*							*		**	***		
	2069	***			**	*	**				***			**										***		*
	2070	***	**		**			*	***		*	*		*							**	***	*	*		
	2071	***	*					*	***		*				*				*			*	**	***		
	2072	***								***	**	**											***	***		
	2073	*													**			**	*							
	2074	***		**	**				*	*	***										**	***	**	***		
	2075	***		**	*					*	**										**	**	*	***		
	2076	***	**		**	*		**	**		***				*			***	*		**	***	**	***		
	2077	***	**	*					*		**										***	***	***	***		
	2078	***	*		***				*		***										*	***	***	***		
	2079	***			*			*			**				*								*	***		*
	2080	***			**			*	***			**										*				
	2081	***								*												**		*		
	2082	***																								
	2083	***			**																					*
	2084							**																		

(Continued)

Table 5. (Continued)

Combination No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Character Nos.		7 · 17	7 · 1	7 · 2	7 · 3	7 · 4	7 · 5	7 · 6	17 · 11	17 · 12	17 · 13	17 · 14	17 · 15	17 · 16	27 · 21	27 · 22	27 · 23	27 · 24	27 · 25	27 · 26	7 · 31	7 · 32	17 · 33	17 · 34	27 · 35	27 · 36
Accession No.	2085	**																					*	*		
	2086															*	*						*	*	*	**
	2087									**	*	*								*	*			*		
	2088	***		*							**										**	**	*	**		
	2089	***								*	**												*	**		
	2090	*		*							***						*			*	*	**		*		
	2091	**					**		*														*	**		
	2092	***		*		*																*	*	*		
	2093	***	*																			*		*		
	2094	***			**						*											**	*	**		
	2095	***	*								**													*		
	2096	***						*								*				*	*					
	2097	***		*					*												*	*				
	2098	*	**						**				*				*		*		*	*				
	2099	***					***											*	*							
	2100	**																				*				
	2101	***	**	*		**	**	*	*												***	*				
	2102	***		*		*					**		*				*									
	2103	***	*						*		*										*	*		*		
	2104																									*
	2105	***						*			*			**			***		*							
	2106	***	**	*							**										**	**		*		
	2107	***							*	*												*	**	**		
	2108	***	**																							
	2109	**	**		*					**				*			*				**	***	**			*
Group A		***	***	***	***	*			***	***	***	*					*				***	***	***	***		*
Group B		***	*	**	***		*		***	**	***										***	***	***	***		
Group C		***	***	***	***				***	***	***						*				***	***	***	***		*
Group D		***	***	**	***				*	***	***	*			*						***	***	***	***		*

Character numbers are the same as mentioned in Table 2.
Groups A, B, C and D; *O. longistaminata* of Madagascar (47 strains), of Tanzania (36 strains), of both countries (83 strains), and *O. punctata* of Tanzania (26 strains), respectively
d.f.; 18, 45, 34, 81 and 24 in strain level, A, B, C and D groups, respectively
***, **, *; significant at 0.1%, 1% and 5% levels, respectively

respectively. Average value and its s.d. through the whole combinations were found to be 6.94 ±3.17.

3. Significant correlations were analysed in the positive and the negative statuses as well as in the degrees of the respective statuses. Significant combinations were accounted as follows in the order of 0.1% (positive, negative and the whole), of 1% (positive, negative and the whole) and of 5% levels (positive, negative and the whole); 82 (25.2%), 4 (1.2%), 86 (26.4%); 83 (25.5%), 17 (5.2%), 100 (30.7%); 111 (34.1%), 29 (8.9%), 140 (43.0). These values were looked upon as nearly the same as those of PART I.

The positive and the negative combinations in the total were accounted as 276 combinations (=84.7%) and 50 combinations (=15.3%), respectively, in which the former value was slightly smaller than that of PART I.

ii] *TAL*:

1. As shown in Table 5, c.cs. of the respective character-combinations in the strain level were fixed to be significant in 240 cases out of 900 combinations of the whole cases (=36 strains x 25 character-combinations) (=26.7%). Significant combinations at the strain level were accounted as follows in the order of the combination numbers 1-25; 33; 9, 6, 20; 4, 4, 6; 14, 9, 24; 7, 2, 7; 5, 1, 1; 2, 3, 2; 11, 21, 16, 26, 2 and 5 strains, respectively. It may be noticed that the values were particularly large in the combination numbers 1, 10, 21 and 23, which were the same as in case of MDL. Average value and its s.d. through the whole combinations were found to be 9.60±8.70.

The whole combinations were divided into 3 groups as in case of MDL. Significant correlations were accounted as 91.7% (=33/36), 43.3% (=156/360) and 10.1% (=51/504) in the groups of I, II and III, respectively. Those averages and their s.ds. through the whole combinations within the groups were found to be 33.00±0.00, 39.00±5.87 and 10.20±3.97 in the groups of I, II and III, respectively. Those differences found might be looked upon as specificities of the characters or character-combinations.

2. The respective strains showed significant correlations as follows in the order from strain No.2048 to No.2083; 10, 3, 5; 13, 5, 5, 5, 2; 10, 2, 4, 10, 5; 1, 3, 11, 5, 8; 4, 8, 8, 8, 12; 10, 6, 4, 10, 9; 14, 9, 9, 8, 6; 4, 1 and 3, respectively. It was noted that strain No.2076, and Nos.2061 and 2082 showed significances in 14/25 (=56.0% in the whole combinations) and 1/25 (=4.0%), respectively. One, 1, 1, 1, 5, 3, 5, 2, 6, 4, 3, 2 and 2 strains showed significances in 14, 13, 12, 11, 10, 9, 8, 6, 5, 4, 3, 2 and 1 character-combinations, respectively. Average value and its s.d. through the whole combinations were found to be 6.67±3.40.

3. Significant correlations were analysed in the positive and the negative statuses as well as in the degrees of the respective statuses. Significant correlations were accounted as follows in the order of 0.1% (positive, negative and the whole), of 1% (positive, negative and the whole) and of 5% levels (positive, negative and the whole); 78 (32.5%), 1 (0.4%), 79 (32.9%); 63 (26.3%), 9 (3.7%), 72 (30.0%); 69 (28.8%), 20 (8.3%), 89 (37.1%). The value of 0.1% level was clearly larger than that of MDL.

The positive and the negative combinations in the total were accounted as 210 combinations (=87.5%) and 30 combinations (=12.5%), respectively. Those values were nearly the same as in case of MDL.

iii] *Both of MDL and TAL*:

1. In both of MDL and TAL (=83 strains), c.cs. of the respective character-combinations in the strain level were fixed to be significant in 566 cases out of 2,075 combinations of the whole cases (=83 strains x 25 character-combinations) (=27.3%). Significant correlations in the strain level were accounted as follows in the order of the combination numbers 1-25; 80; 26, 13, 39; 11, 11, 16; 31, 19, 51; 10, 12, 13; 10, 6, 6; 7, 7, 4; 26, 47, 38, 65, 8 and 10 strains, respectively. It may be noticeable that the values were particularly large in the combination numbers 1, 10, 21 and 23, which were the same as in cases of MDL and TAL. Average value and its s.d. through the whole combinations were found to be 22.64±19.79.

The whole combinations were divided into 3 groups as in the cases of MDL and TAL. Significant correlations were accounted as 96.4% (=80/83), 42.8% (=355/830) and 11.3%

(=131/1,162) in the groups of I, II and III, respectively. Those averages and their s.ds. through the whole combinations within the groups were found to be 80.00±0.00, 88.75±13.39 and 26.20 ±8.59 in the groups of I, II and III, respectively. Those differences found might be looked upon as specificities of the characters or character-combinations.

2. Significant correlations of the respective strains ranged from 16 (No.2043) to 1 (Nos.2061 and 2083), in which the former was remarkably of the large value of 64.0% (=16 /25). Average value and its s.d. through the whole combinations were found to be 6.82±3.27.

3. Significant correlations were analysed in the positive and the negative statuses as well as in the degrees of the respective statuses. Significant correlations were accounted as follows in the order of 0.1% (positive, negative and the whole), of 1% (positive, negative and the whole) and of 5% levels (positive, negative and the whole); 160 (28.3%), 5 (0.9%), 165 (29.2%); 146 (25.8%), 26 (4.6%), 172 (30.4%); 180 (31.8%), 49 (8.7%), 229 (40.5%). The positive and the negative combinations in the total were accounted as 486 combinations (=85.9%) and 80 combinations (=14.1%), respectively. Those values were found to be intermediate between MDL and TAL.

iv] *TAP*:

1. In TAP, c.cs. of the respective character-combinations at the strain level were fixed to be significant in 139 cases out of 650 combinations of the whole (=26 strains x 25 character-combinations) (=21.4%). Significant correlations in the strain level were accounted as follows in the order of the combination numbers 1-25; 22; 8, 7, 2; 3, 3, 4; 6, 4, 10; 1, 2, 2; 0, 2, 6; 1, 3, 3; 10, 13, 9, 14, 1 and 3, respecitvely. It may be noticeable that the values were particularly large in the combination numbers 1, 21 and 23; and combination No.10 showed intermediate value, and No.14 showed no significant strain at all. These tendencies were clearly different from the data of *O. longistaminata* (MDL and TAL). Average value and its s.d. through the whole combinations were found to be 5.56±5.05.

The whole combinations were divided into 3 groups as in the cases of *O. longistaminata*. Significant correlations were accounted as 84.6% (=22/26), 31.9% (=83/260) and 9.3% (=34 /364) in the groups of I, II and III, respectively. Those averages and their s.ds. through the whole combinations within the groups were found to be 22.00±0.00, 20.75±2.49 and 6.80±2.14 in the groups of I, II and III, respectively. Those differences found might be looked upon as specificities of characters or character-combinations.

2. The respective strains showed significant correlations as follows in the order from strain No.2084 to No.2109; 1, 3; 6, 6, 7, 5, 8; 5, 6, 4, 6, 4; 5, 5, 8, 4, 2; 9, 6, 7, 1, 6; 7, 6, 2 and 10, respectively. It was noticed that strain No.2109, and Nos.2084 and 2104 showed significances in 10/25 (=40.0% in the whole combinations) and 1/25 (=4.0%), respectively. One, 1, 2, 3, 7, 4, 3, 1, 2 and 2 strains showed significances in 10, 9, 8, 7, 6, 5, 4, 3, 2 and 1 character-combinations, respectively. Average value and its s.d. through the whole combinations were found to be 5.35±2.25.

3. Significant correlations were analysed in the positive and the negative statuses as well as in the degrees of the respective statuses. Significant correlations were accounted as follows in the order of 0.1% (positive, negative and the whole), of 1% (positive, negative and the whole) and of 5% levels (positive, negative and the whole); 19 (13.7%), 2 (1.4%), 21 (15.1%); 34 (24.5%), 4 (2.9%), 38 (27.3%); 67 (48.2%), 13 (9.4%), 80 (57.6%). It was noticeable that the values of 5% and of 0.1% levels were fixed to be remarkably larger and smaller than those of the whole groups of *O. longistaminata*, respectively, especially the positive value of 5%

level showed 48.2% of the whole, being about half of them.

The positive and the negative combinations in the total were accounted as 120 combinations (=86.3%) and 19 combinations (=13.7%), respectively. Those values were nearly the same as in cases of the whole of *O. longistaminata*.

3. Relationships among practical value, standard deviation and variation range

The mutual relations in view of the three major components were accounted, and are given in the upper (practical value on the other practicl value, s.d. on the other s.d., and range on the other range) and the lower (practical value on its s.d., practical value on its range, and s.d. on range) columns of Table 6.

i] *MDL*:

1. Eleven, 1, 3 and 10 combinations in practical value (I), 5, 2, 1, and 17 in s.ds.-value (II), 5, 1, 2 and 17 in range-value (III), and 21, 4, 6 and 44 combinations in the whole combinations (IV) showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. Significant combinations were accounted as 15/25 cases (=60.0%), 8/25 cases (32.0%), 8/25 cases (=32.0%) and 31/75 cases (=41.3%) in I, II, III and IV, respectively. Moreover, 6, 2, 9 and 8 character-combinations showed significances at 3, 2, 1 and 0 columns, respectively. Average and its s.d. through the whole cases were found to be 1.24 ± 1.14. It was ascertained that practical-value-combinations (I) showed remarkably high significances in comparison with the II, III and IV combinations.

2. In the relationships between the practical values and their s.ds. (V), between the practical values and their variation ranges (VI), and between s.ds. and their variation ranges (VII), 1, 1, 1, 0; 1, 1, 0, 1; 3, 0, 0, 0 characters showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. Significant relations were accounted as 3/3 (=100.0%), 2/3 (=66.7%), 3/3 (=100.0%) and 8/9 (=88.9%) in V, VI, VII and VIII (= the whole of V, VI and VII), respectively. Two and 1 characters showed significances at 3 and 2 columns, respectively. Average and its s.d. through the whole columns were found to be 2.67 ± 0.47. Significant levels were fixed to be in the order of VII, VI and V.

ii] *TAL*:

1. Nine, 2, 2 and 12 in I, 8, 2, 4 and 11 in II, 6, 3, 2 and 14 in III, and 23, 7, 8 and 37 combinations in IV columns showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. Significant combinations were accounted as 13/25 cases (=52.0%), 14/25 cases (=56.0%), 11/25 cases (=44.0%) and 38/75 cases (=50.7%) in I, II, III and IV, respectively. Moreover, their values were nearly the same in the whole columns, which were clearly different from those of MDL. Ten, 3, 2 and 10 combinations showed significances at 3, 2, 1 and 0 columns, respectively. Average value and its s.d. through the whole cases were found to be 1.52 ± 1.36, which were fixed to be larger than those of MDL.

2. In V, VI and VII columns, 1, 1, 0, 1; 1, 1, 1, 0; 3, 0, 0, 0 characters showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. Significant relations were accounted as 2/3 (=66.7%), 3/3 (= 100.0%), 3/3 (=100.0%) and 8/9 (=88.9%) in V, VI, VII and VIII, respectively. Two and 1 characters showed significances at 3 and 2 columns, respectively. Average value and its s.d. through the whole columns were found to be 2.67 ± 0.47, which were quite the same as in case of MDL.

iii] *Both of MDL and TAL*:

1. Eleven, 0, 1 and 13 in I, 9, 2, 1 and 13 in II, 9, 3, 0 and 13 in III, and 29, 5, 2 and 39 combinations in IV columns showed significances at 0.1%, 1% and 5% levels and no significance

Table 6. Correlation coefficient of the former character (Y) on the latter character (X) for 25 character-combinations, practical value (left), s.d. (center) and range (right); and for 3 characters, practical value on its s.d. (left), practical value on its range (center) and s.d. on range (right)

Combination	Practical value				S.d.				Range			
	A	B	C	D	A	B	C	D	A	B	C	D
7 · 1	***	***	***	***		***		*		**	**	*
7 · 2	***	**	***	**		***	***			***	***	
7 · 3	***	***	***	***	**	**	***			*	**	
7 · 4	*					**			*	**	***	
7 · 5		*										
7 · 6												
17 · 11	***	***	***	*	***	*	***		***		***	
17 · 12	***	**	***	***		*	**			*	**	
17 · 13	***	***	***	***	***	***	***	**	***	**	***	
17 · 14	*			*								
17 · 15												
17 · 16		*				*						
27 · 21				*	*		**					
27 · 22												
27 · 23	*		*									
27 · 24												
27 · 25									*			
27 · 26						*	*					
7 · 31	***	***	***	***		***	***	*		***	***	
7 · 32	***	***	***	***	**	***	***		**	***	***	
17 · 33	***	***	***	***	***	***	***		***	***	***	
17 · 34	***	***	***	***	***	***	***		***	***	***	
27 · 35												
27 · 36	**											
7 · 17	***	***	***	***	***	***	***	**	***	***	***	**

Character	Practical value on its s.d.				Practical value on its range				S.d. on range			
	A	B	C	D	A	B	C	D	A	B	C	D
7	**	***	***		**	***	***		***	***	***	***
17	*		**			**			***	***	***	***
27	***	**	***		***	*	***	***	***	***	***	

Character numbers, group marks, d.f. and significant levels are the same as shown in Table 5.

even at 5% level, respectively. Significant combinations were accounted as 12/25 cases (=48.0%), 12/25 cases (=48.0%), 12/25 (=48.0%) and 36/75 cases (=48.0%) in I, II, III and IV, respectively. Their values were quite the same in I, II, III and IV. Ten, 1, 4 and 10 combinations showed significances at 3, 2, 1 and 0 columns, respectively. Average value and its s.d. through the whole cases were found to be 1.44 ± 1.36.

2. In V, VI and VII columns, 2, 1, 0, 0; 2, 0, 0, 1; 3, 0, 0, 0 characters showed significances

at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. Significant relations were accounted as 3/3 (=100.0%), 2/3 (=66.7%), 3/3 (=100.0%) and 8/9 (=88.9%) in V, VI, VII and VIII, respectively, which were quite the same as in the cases of MDL and TAL. Two and 1 characters showed significances at 3 and 2 columns, respectively. Average value and its s.d. through the whole columns were found to be 2.67 ± 0.47, which were also quite the same as in the cases of MDL and TAL.

iv] *TAP*:

1. Nine, 1, 3 and 12 in I, 0, 2, 2 and 21 in II, 0, 1, 1 and 23 in III columns, and 9, 4, 6 and 56 combinations in IV column showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. Significant combinations were accounted as 13/25 cases (=52.0%), 4/25 cases (=16.0%), 2/25 cases (=8.0%) and 19/75 cases (=25.3%) in I, II, III and IV, respectively. The whole of those were ascertained to be lower than those of the former 3 groups, and the tendency was looked upon as species specificity of *O. punctata*. Two, 2, 9 and 12 combinations showed significances at 3, 2, 1 and 0 columns, respectively. Average value and its s.d. through the whole cases were found to be 0.76 ± 0.91, which were ascertained to be about half the value of those of the former 3 groups.

2. In V, VI and VII columns, 0, 0, 0, 3; 1, 0, 0, 2; 2, 0, 0, 1 characters showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. Significant relationships were accounted as 0/3 (=0.0%), 1/3 (=33.3%), 2/3 (= 66.7%) and 3/9 (=33.3%) in V, VI, VII and VIII, respectively, which were fixed as one third levels of those of the former 3 groups. Each one character showed significances at 1 column. Average value and its s.d. through the whole columns were found to be 1.00 ± 0.00, which were fixed as 38% of those of the former 3 groups.

v] *The whole groups*:

1. Forty, 4, 9 and 47 in the I, 22, 8, 8 and 62 in the II, 20, 8, 5, 67 in the III, and 82, 20, 22 and 176 combinations in the IV columns showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. Significant combinations were accounted as 53/100 cases (=53.0%), 38/100 (=38.0%), 33/100 cases (=33.0%) and 124/300 cases (=41.3%) in I, II, III and IV, respectively. One, 1, 3, 4, 2, 1, 1, 4, 3 and 5 combinations showed significances at 12, 11, 10, 9, 8, 5, 3, 2, 1 and 0 columns, respectively. They were divided into two groups, *i.e.*, the high and the low significant groups. Eleven combinations, *i.e.*, 7·1, 7·2, 7·3, 17·11, 17·12, 17·13, 7·31, 7·32, 17·33, 17·34 and 7·17 combinations, belonged to the high group. The remaining 14 combinations belonged to the low group. Averages and their s.ds. through the whole cases were found to be 9.55 ± 1.16, 1.36 ± 1.39 and 4.96 ± 4.27 in the high, low and total groups, respectively.

2. In the summed-up values of the V, VI and VII columns, average value and its s.d. through the whole cases were found to be 9.00 ± 1.41 (VIII).

PART III General discussion

As in the cases of as several morphological characters of grains, the items concerning grain weight were ascertained to be of universal validities for analyses of species and/or strain specificities of rice, regardless of the species statuses, wild or cultivated, though they have been made used of by few scientists.

Weights of UHG and HG showed large variation and locality specificities to some extent. It was fixed to be a very interesting fact that both of *O. longistaminata* and *O. punctata*

showed species specificities in UHG and HG, but they showed quite the same values in the quotient of HG/UHG.

In the correlation coefficient between the characters of grain weight and other items, *i.e.*, length, width, thickness, L/W, L/T and W/T, it was clearly ascertained that 11 out of 25 character-combinations, *i.e.*, both of the UHG and HG and 5 characters (length, width, thickness, area, volume), and of UHG and HG themselves, showed high significant frequencies, but the remaining 14 combinations showed low ones. In these sense, averages and their s.ds. through the whole combinations in the higher group were found to be 2.00 ± 0.85, 2.18 ± 0.94, 2.91 ± 0.29, 2.91 ± 0.29, 1.55 ± 0.78 and 9.55 ± 1.16 in the first experiment (PART I), MDL, TAL, MDL+TAL, TAP, MDL+TAL+TAP in the second experiment (PART II), respectively. Those in the lower group were 0.14 ± 0.40, 0.50 ± 0.63, 0.43 ± 0.73, 0.28 ± 0.45, 0.14 ± 0.35 and 1.36 ± 1.39 in the same order, respectively. In the whole groups, the values were fixed to be remarkably larger in the higher groups than those in the lower groups. The characters and character-combinations consisting in the higher group should be recommended as articles in an analysing method for species- and/or strain-differentiations.

Takeda reported that grain length is mainly related to grain weight, followed by grain width and thickness, in the strains showing large intra-strain's variations. On the other hand, grain length, width and thickness are equally related to grain weight in the strains with a few intra-strain's variations[11]. In the old carbonized rice grains belonging to *O. sativa* L., 5 significant correlations within 8 character-combinations concerning grain weight were ascertained[7]. These materials were assumed to be belonging to the latter case.

In the present materials, some results different from Takeda's and carbonized data were found. Grain thickness was mainly related to grain weight, followed by grain length and width. The results were looked upon as one of the species specificities.

In another experiment done by the present author using cultivated rice species, *O. sativa* L. and *O. glaberrima* STEUD., a close relationship between the single weight of well ripened grain and grain volume was fixed, which corresponded to the character-combination No.21 in the present experiment. These results also suggested that thickness as well as length and width might be regarded as important characteristics of the grain morphology[8].

Summary

In the genus *Oryza*, concerning the grain weight, to clarify some scientific meanings of characters for analysing species- and/or strain-differentiations, 21 strains of *Oryza longistaminata* collected in 1984 and 1985 in 5 countries of Africa (PART I), and 109 strains of *Oryza longistaminata* and *Oryza punctata* collected in 1988 in 2 countries of East Africa (PART II) were used in the first and the second experiments, respectively. The main results obtained were summarized as follows:

Averages of the whole strains within groups were found to be 13.4mg, 14.0mg, 11.4mg in *O. longistaminata* used in the first experiment, *O. longistaminata* and *O. punctata* used in the second experiment in view of the unhusked grains, respectively. Those were found to be 8.9mg, 9.3mg and 7.1mg in the same order in view of the husked grains, respectively.

In the relationships between the respective two characters, 132/525 character-combinations (=25.1%) and 30/84 (=35.7%) at grain and strain levels were ascertained as significant in the first experiment, respectively. In the second experiment, 705/2,725 (=25.9%) and 151/

336 (=44.9%) in grain and strain levels were fixed to be significant, respectively. Locality and species specificities were ascertained to some extent.

Eleven and 25 character-combinations, *i.e.*, those both of the unhusked and the husked grains and of the 5 characters (length, width, thickness, area and volume), and between the unhusked and husked grains themselves were recommended as having universal validities for analysing the species- and/or strain-differentiations in the genus *Oryza*.

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