

Morphological Characters of the Cultivated Rice Grains Delivered from Rice Research Station, Chinsurah, West Bengal, India (VII)

Tadao C. KATAYAMA
(*Experimental Farm*)

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Introduction

During the period from December in 1978 to January in 1979, the writer was sent to India for collection of the wild and cultivated rices under the project, designated "The Distribution of Wild Rice and the Ecotypic Differentiation of Cultivated Rice in Burma and Assam", supported by the Grant from the Ministry of Education, Science and Culture of the Japanese Government. At this opportunity, 100 strains of cultivated rice stocked in Rice Research Station, Chinsurah, West Bengal, India, were delivered to the present author through the kindness of Dr. S. Wiswas of the station. The grains of these strains were used for the morphological studies.

In the station, many strains of cultivated rice, *Oryza sativa* L., were collected and studied in view of the breeding program. While they were not used for morphological characters. For genetic and breeding purposes, however, varietal variations and methodology of these should be ascertained as promptly as possible.

Since 1969, high yielding varieties have been recommended by the governments of a lot of countries in south and southeast Asia. In India, breeding works have been being pushed forward in viewpoints of aromatic^{3,12)}, early maturity¹⁴⁾, medium-duration¹⁷⁾ and short-duration¹⁰⁾ varieties. Further, the following publications might be picked up as those showing an outline of breeding or selection varieties in recent times in India. Roy¹¹⁾ reported of rice germplasm in Orissa. In this report, farmers of the irrigated zones prefer to grow a few improved varieties only in "kharif" season, and they grow generally high yielding varieties in "rabi" season. Sharma *et al.*¹³⁾ reported a new, stable, high yielding rice for hilly areas of Himachal Pradesh. Sinha *et al.*¹⁵⁾ reported of performance of new 11 varieties of rices in Chinsurah. Sivasubramanian *et al.*¹⁷⁾ reported new varieties in Tamil Nadu. Sinha *et al.*¹⁶⁾ reported of screening rice varieties for cold tolerance at the seedling and the reproductive stages.

On the other hand, it is said that local and domestic varieties have been on the way of disappearance in these processes^{1,2)}. However, because of several problems in modern agronomical practices, using the high yielding varieties, local varieties has been consciously kept on in the respective localities. Recently, analyses of the primitive varieties have been being put into limelight in these fields.

Taking these factors into account, the author tried to accomplish the work, the aim of which was to make a classification of the varietal variation and to ascertain the phylogenetic relationships of cultivated-rice-strains (=cultivars), using the relatively primitive and un-advanced cultivars in India in the previous experimental series. The present experimental series was made to search the varietal variations, using the relatively advanced cultivars in India, taking these facts into

considerations.

In the previous papers, the records of morphological characters of the unhusked and husked grains⁴⁾, comparative values, area, volume columns and 6 characters of ranges⁵⁾, 18 characters of ranges and their summed-up data^{6,7)}, 27 mutual relations^{8,9)}, were reported.

In the present paper, mutual relations in views of practical values, standard deviations and variation ranges were mainly described as the final report of the present experimental series in order to confirm the morphological characters of grains as well as to make clear the geographical and ecotypic differentiations of those grains.

Materials and Methods

One hundred strains of rice cultivars were used in this experiment. They were listed up in Table 1 of the previous paper⁴⁾. In that table, collection number, original place were mentioned. Now, they have come to suggest different meanings in view of physiological characters, *i.e.*, *aman* and *aus*, and should also be considered separately in morphological studies. Accordingly, they are divided into two groups in the present experiment, *i.e.*, Group A --- *aman* varieties (=strain Nos.1~50), Group B --- *aus* varieties (=strain Nos.51~100).

To make clear the relationship between practical value, standard deviations and variation ranges in the strain level, 6 relations were calculated, *i.e.*, practical value and other practical values (Table 1), standard deviations and other standard deviations (Table 2), variation range and other variation ranges (Table 3), practical value and its standard deviations (Table 4), practical value and its variation range (Table 5), standard deviations and its variation range (Table 6). Finally, comparisons of 8 relation-groups were made, mainly using the data shown in Tables 1, 2, 3 (Table 7), and those in Tables 4, 5 and 6 (Table 8).

In the present paper, the following abbreviations were used, *i.e.*, L (length), W (width), T (thickness), L/W (ratio of length to width), L/T (ratio of length to thickness), W/T (ratio of width to thickness), c.c. (correlation coefficient), l.r. (linear regression), s.d. (standard deviations), d.f. (degree of freedom), UHG (unhusked grain), HG (husked grain).

Results

1. Relationships between the practical values of the two respective characters

Group A: Correlation coefficients (abbreviated as c.c.) and linear regression (abbreviated as l.r.) of the practical value on any other practical values among 27 character-combinations were calculated, and are shown in Table 1. Seventeen, 3 and 7 combinations showed significances at 0.1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of W (UHG) on T (UHG) through the whole strains (=50) was found to be +0.7490 to the degree of freedom of 48, which is significant at 0.1% level. Generally speaking, the wider is the W (UHG), the thicker is the T (UHG). L.r. of W (UHG) on T (UHG) was calculated as follows: $Y=0.245X+1.395$, where Y and X indicate the W (UHG) and T (UHG), respectively. This formula indicates that the W (UHG) becomes 0.245mm wider, when the T (UHG) becomes thicker by 1 degree.

Group B: Nineteen and 8 combinations showed significances at 0.1% level and no significance even at 5% level, respectively. For example, c.c. of W (UHG) on T (UHG) through the whole strains (=50) was +0.8947 to the degree of freedom of 48, which is significant at 0.1% level.

Table 1. Correlation coefficient and linear regression of the practical value (the former character, Y) on another practical value (the latter character, X) for 27 combinations

Combi- nation	Group A		Group B		Whole	
	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression
1·2	0.0154	—	0.0101	—	--0.1963	—
1·3	0.2416	—	0.1985	—	--0.0166	—
2·3	0.7490***	Y=0.245X+1.395	0.8947***	Y=0.378X+0.985	0.9005***	Y=0.299X+1.245
4·5	0.8407***	Y=0.753X+1.808	0.9273***	Y=0.901X+1.490	0.9144***	Y=0.727X+1.927
4·6	-0.7411***	Y=-0.162X+1.848	-0.8303***	Y=-0.199X+2.002	--0.8929***	Y=-0.205X+2.007
5·6	-0.2669	—	-0.5683***	Y=-0.140X+2.017	--0.6458***	Y=-0.186X+2.154
11·12	-0.0810	—	-0.1190	—	--0.3054**	Y=-0.186X+3.641
11·13	0.1725	—	0.0669	—	--0.1080	—
12·13	0.7277***	Y=0.310X+1.152	0.8945***	Y=0.424X+0.838	0.8876***	Y=0.339X+1.078
14·15	0.8971***	Y=0.817X+1.124	0.9441***	Y=0.901X+1.023	0.9375***	Y=0.763X+1.305
14·16	-0.7036***	Y=-0.145X+1.633	-0.8096***	Y=-0.193X+1.798	--0.8724***	Y=-0.199X+1.800
15·16	-0.3251*	Y=-0.073X+1.473	-0.5765***	Y=-0.144X+1.803	--0.6576***	Y=-0.184X+1.892
21·22	0.2337	—	0.0310	—	0.2316*	Y=0.415X+0.556
21·23	-0.0909	—	0.2569	—	0.1955	—
22·23	0.2810*	Y=1.343X+0.795	0.2614	—	0.3894***	Y=0.162X+0.769
24·25	0.5723***	Y=0.461X+0.403	0.5645***	Y=0.275X+0.551	0.5119***	Y=0.300X+0.533
24·26	-0.5515***	Y=0.567X+1.418	-0.8385***	Y=-0.726X+1.543	--0.6680***	Y=-0.700X+1.524
25·26	0.3139*	Y=0.401X+0.631	-0.0764	—	0.1244	—
1·11	0.9852***	Y=0.750X-0.333	0.9625***	Y=0.671X+0.280	0.9774***	Y=0.737X-0.256
2·12	0.9846***	Y=0.746X+0.291	0.9563***	Y=0.731X+0.343	0.9849***	Y=0.745X+0.297
3·13	0.9813***	Y=0.970X-0.126	0.9859***	Y=0.846X+0.123	0.9880***	Y=0.860X+0.096
4·14	0.9838***	Y=0.839X-0.033	0.9618***	Y=0.808X+0.088	0.9875***	Y=0.809X+0.078
5·15	0.9836***	Y=0.853X-0.297	0.9756***	Y=0.805X-0.090	0.9868***	Y=0.828X-0.183
6·16	0.9657***	Y=0.777X+0.217	0.8510***	Y=0.709X+0.324	0.9620***	Y=0.784X+0.211
31·33	0.9737***	Y=0.553X+1.364	0.9641***	Y=0.502X+2.431	0.9755***	Y=0.506X+2.375
32·34	0.9801***	Y=0.518X+1.722	0.9784***	Y=0.464X+4.047	0.9843***	Y=0.468X+4.009
35·36	0.9304***	Y=0.956X-0.029	0.9550***	Y=0.909X-0.004	0.9574***	Y=0.969X-0.038

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, 1~6-unhusked grains, 11~16-husked grains, 21~26-comparative values (=husked/unhusked), 31-area (UHG), 32-volume (UHG), 33-area (HG), 34-volume (HG), 35-quotient of areas (=33/31), 36-quotient of volumes (=34/32)

***, **, *; significant at 0.1%, 1% and 5% levels, respectively
d.f.; Group A-48, Group B-48, Whole-98, respectively

Generally speaking, the wider is the W (UHG), the thicker is the T (UHG). L.r. of W (UHG) on T (UHG) was calculated as follows; $Y=0.378X+0.985$, where Y and X indicate the W (UHG) and T (UHG), respectively. This formula indicates that the W (UHG) becomes 0.378mm wider, when the T (UHG) becomes thicker by 1 degree.

Whole: Twenty, 1, 1 and 5 combinations showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of W (UHG) on T (UHG) through

the whole strains of both of the groups (=100) was +0.9005 to the degree of freedom of 98, which is obviously significant at 0.1% level. Generally speaking, the wider is the W (UHG), the thicker is the T (UHG). L.r. of W (UHG) on T (UHG) was calculated as follows; $Y=0.299X+1.245$, where Y and X indicate the W (UHG) and T (UHG), respectively. This formula indicates that the W (UHG) becomes 0.299mm wider, when the T (UHG) becomes thicker by 1 degree.

2. Relationships between the s.d. of the two respective characters

Group A: C.c. and l.r. of s.d. on another s.d. among 27 character-combinations were calculated, and are shown in Table 2. Eleven, 3, 3 and 10 combinations showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of s.d. of L (UHG) on s.d. of L (HG) through the whole strains was +0.6098 to the degree of freedom of 48, which is significant at 0.1% level. Generally speaking, the larger is the s.d. of L (UHG), the larger is the s.d. of L (HG). L.r. of s.d. of L (UHG) on s.d. of L (HG) was calculated as follows; $Y=0.385X+0.075$, where Y and X indicate the s.d. of L (UHG) and the s.d. of L (HG), respectively. This formula indicates that the s.d. of L (UHG) becomes 0.385 larger, when the s.d. of L (HG) becomes larger by 1 degree.

Group B: Ten, 6, 1 and 10 combinations showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of s.d. of L (UHG) on s.d. of L (HG) through the whole strains was +0.6754 to the degree of freedom of 48, which is significant at 0.1% level. Generally speaking, the larger is the s.d. of L (UHG), the larger is the s.d. of L (HG). L.r. of s.d. of L (UHG) on s.d. of L (HG) was calculated as follows; $Y=0.420X+0.058$, where Y and X indicate the s.d. of L (UHG) and the s.d. of L (HG), respectively. This formula indicates that the s.d. of L (UHG) becomes 0.420 larger, when the s.d. of L (HG) becomes larger by 1 degree.

Whole: Fifteen, 2, 3 and 7 combinations showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of s.d. of L (UHG) on s.d. of L (HG) through the whole strains of both of the groups was +0.6333 to the degree of freedom of 98, which is significant at 0.1% level. Generally speaking, the larger is the s.d. of L (UHG), the larger is the s.d. of L (HG). L.r. of s.d. of L (UHG) on s.d. of L (HG) was calculated as follows; $Y=0.394X+0.068$, where Y and X indicate the s.d. of L (UHG) and the s.d. of L (HG), respectively. This formula indicates that the s.d. of L (UHG) becomes 0.394 larger, when the s.d. of L (HG) becomes larger by 1 degree.

3. Relationships between the variation ranges of the two respective characters

Group A: C.c. and l.r. of variation range on another variation range among 27 character-combinations were calculated, and are shown in Table 3. Eleven, 3, 1 and 12 combinations showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of variation range of L (UHG) on variation range of L (HG) through the whole strains was +0.5332 to the degree of freedom of 48, which is significant at 0.1% level. Generally speaking, the larger is the variation range of L (UHG), the larger is the variation range of L (HG). L.r. of variation range of L (UHG) on variation range of L (HG) was calculated as follows; $Y=0.386X+0.288$, where Y and X indicate variation range of L (UHG) and variation range of L (HG), respectively. This formula indicates that the variation range of L (UHG) becomes 0.386 larger, when the variation range of L (HG) becomes larger by 1 degree.

Group B: Seven, 4, 4 and 12 combinations showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of variation range of L (UHG) on

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

Combination	Group A		Group B		Whole	
	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression
1·2	0.1281	—	0.2293	—	0.2107*	Y=0.085X+0.082
1·3	0.0751	—	-0.0793	—	0.0152	—
2·3	0.2271	—	0.3835**	Y=0.314X+0.038	0.3569***	Y=0.276X+0.041
4·5	0.3773**	Y=0.396X+0.107	0.2576	—	0.3388***	Y=0.313X+0.124
4·6	0.4003**	Y=0.223X+0.035	0.1552	—	0.2443*	Y=0.114X+0.055
5·6	0.4896***	Y=0.260X+0.025	0.4095**	Y=0.185X+0.042	0.4551***	Y=0.230X+0.033
11·12	-0.0764	—	0.1346	—	0.0280	—
11·13	0.1360	—	0.1298	—	0.1317	—
12·13	0.3071*	Y=0.285X+0.046	0.3869**	Y=0.210X+0.047	0.3199**	Y=0.200X+0.050
14·15	0.2226	—	0.0687	—	0.2309*	Y=0.285X+0.100
14·16	0.2998*	Y=0.205X+0.041	0.3935**	Y=0.236X+0.047	0.2648**	Y=0.158X+0.051
15·16	0.7379***	Y=0.366X+0.016	0.4078**	Y=0.199X+0.046	0.5933***	Y=0.288X+0.031
21·22	-0.2292	—	0.2804*	Y=0.410X+0.019	0.0944	—
21·23	0.2827*	Y=0.322X+0.019	-0.1686	—	0.0643	—
22·23	0.0254	—	0.3958**	Y=0.332X+0.011	0.3437***	Y=0.266X+0.014
24·25	-0.0896	—	0.1320	—	0.0728	—
24·26	0.5375***	Y=0.576X+0.022	0.5467***	Y=0.542X+0.018	0.5648***	Y=0.631X+0.018
25·26	-0.0729	—	0.0313	—	0.0628	—
1·11	0.6098***	Y=0.385X+0.075	0.6754***	Y=0.420X+0.058	0.6333***	Y=0.394X+0.068
2·12	0.5835***	Y=0.601X+0.024	0.4675***	Y=0.648X+0.032	0.5825***	Y=0.728X+0.018
3·13	0.8866***	Y=1.025X-0.000	0.8022***	Y=0.736X+0.015	0.8283***	Y=0.840X+0.010
4·14	0.7351***	Y=0.557X+0.040	0.5198***	Y=0.545X+0.041	0.7276***	Y=0.556X+0.040
5·15	0.8558***	Y=0.854X-0.003	0.6600***	Y=0.677X+0.016	0.7907***	Y=0.809X-0.000
6·16	0.7708***	Y=0.719X+0.018	0.6338***	Y=0.702X+0.021	0.7296***	Y=0.717X+0.019
31·33	0.6515***	Y=0.415X+0.205	0.7460***	Y=0.439X+0.202	0.7704***	Y=0.451X+0.175
32·34	0.7092***	Y=0.530X+0.141	0.8159***	Y=0.399X+0.544	0.8200***	Y=0.422X+0.457
35·36	0.4048**	Y=0.407X+0.018	0.7675***	Y=0.804X+0.005	0.6481***	Y=0.717X+0.009

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, 1~6-unhusked grains, 11~16-husked grains, 21~26-comparative values (=husked/unhusked), 31-area (UHG), 32-volume (UHG), 33-area (HG), 34-volume (HG), 35-quotient of areas (=33/31), 36-quotient of volumes (=34/32)

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

d.f.; Group A-48, Group B-48, Whole-98, respectively

variation range of L (HG) through the whole strains was +0.6034 to the degree of freedom of 48, which is significant at 0.1% level. Generally speaking, the larger is the variation range of L (UHG), the larger is the variation range of L (HG). L.r. of variation range of L (UHG) on variation range of L (HG) was calculated as follows; $Y=0.343X+0.296$, where Y and X indicate variation range of L (UHG) and variation range of L (HG), respectively. This formula indicates that the variation range of L (UHG) becomes 0.343 larger, when the variation range of L (HG)

Table 3. Correlation coefficient and linear regression of the range (the former character, Y) on another range (the latter character, X) for 27 combinations

Combi- nation	Group A		Group B		Whole	
	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression
1·2	0.1585	—	0.0786	—	0.1262	—
1·3	0.1441	—	-0.1147	—	0.0239	—
2·3	0.0958	—	0.2308	—	0.1672	—
4·5	0.2509	—	0.1202	—	0.2593**	Y=0.279X+0.534
4·6	0.3953**	Y=0.221X+0.151	0.2210	—	0.2911**	Y=0.129X+0.218
5·6	0.5813***	Y=0.254X+0.105	0.3723**	Y=0.134X+0.202	0.5163***	Y=0.212X+0.143
11·12	-0.0653	—	-0.0254	—	-0.0689	—
11·13	0.0578	—	0.0272	—	0.0520	—
12·13	0.2102	—	0.3645**	Y=0.218X+0.175	0.2142*	Y=0.162X+0.215
14·15	0.1251	—	0.0995	—	0.2153*	Y=0.292X+0.418
14·16	0.3310*	Y=0.260X+0.155	0.3358*	Y=0.202X+0.210	0.3028**	Y=0.202X+0.198
15·16	0.6847***	Y=0.341X+0.083	0.3292*	Y=0.193X+0.198	0.4193***	Y=0.236X+0.164
21·22	0.1858	—	0.1651	—	0.1560	—
21·23	0.4098**	Y=0.678X+0.058	0.0577	—	0.2275*	Y=0.339X+0.069
22·23	0.0318	—	0.3277*	Y=0.235X+0.056	0.2965**	Y=0.240X+0.062
24·25	-0.0118	—	0.1209	—	0.0774	—
24·26	0.5066***	Y=0.427X+0.102	0.3887**	Y=0.352X+0.091	0.4495***	Y=0.416X+0.094
25·26	-0.1135	—	0.1368	—	0.0761	—
1·11	0.5332***	Y=0.386X+0.288	0.6034***	Y=0.343X+0.296	0.5570***	Y=0.358X+0.299
2·12	0.6275***	Y=0.578X+0.098	0.3105*	Y=0.326X+0.273	0.4990***	Y=0.517X+0.153
3·13	0.7964***	Y=0.885X+0.035	0.5996***	Y=0.591X+0.094	0.7146***	Y=0.762X+0.057
4·14	0.6672***	Y=0.535X+0.185	0.5739***	Y=0.567X+0.157	0.6990***	Y=0.559X+0.165
5·15	0.8077***	Y=0.841X+0.014	0.4163**	Y=0.331X+0.278	0.7094***	Y=0.715X+0.064
6·16	0.8106***	Y=0.956X+0.018	0.4618***	Y=0.599X+0.119	0.7252***	Y=0.875X+0.040
31·33	0.5862***	Y=0.414X+0.826	0.6948***	Y=0.410X+1.018	0.7137***	Y=0.441X+0.782
32·34	0.6940***	Y=0.617X-0.283	0.7302***	Y=0.383X+2.502	0.7419***	Y=0.412X+2.106
35·36	0.3697**	Y=0.380X+0.075	0.5820***	Y=0.556X+0.042	0.7144***	Y=0.831X+0.024

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, 1~6-unhusked grains, 11~16-husked grains, 21~26-comparative values (=husked/unhusked), 31-area (UHG), 32-volume (UHG), 33-area (HG), 34-volume (HG), 35-quotient of areas (=33/31), 36-quotient of volumes (=34/32)

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

d.f.; Group A-48, Group B-48, Whole-98, respectively

becomes larger by 1 degree.

Whole: Twelve, 4, 3 and 8 combinations showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of variation range of L (UHG) on variation range of L (HG) through the whole strains of both of the groups was +0.5570 to the degree of freedom of 98, which is significant at 0.1% level. Generally speaking, the larger is the variation range of L (UHG), the larger is the variation range of L (HG). L.r. of variation range of

L (UHG) on variation range of L (HG) was calculated as follows; $Y=0.358X+0.299$, where Y and X indicate variation range of L (UHG) and variation range of L (HG), respectively. This formula indicates that the variation range of L (UHG) becomes 0.358 larger, when the variation range of L (HG) becomes larger by 1 degree.

4. Relationships between the practical values and their s.d.

Group A: C.c. and l.r. of practical value on their s.d. among 24 characters were calculated, and are shown in Table 4. Eleven, 2, 1 and 10 characters showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of practical value of L (UHG) on s.d. of L (UHG) through the whole strains was +0.4191 to the degree of freedom of 48, which is significant at 1% level. Generally speaking, the larger is the practical value of L (UHG), the larger is the s.d. of L (UHG). L.r. of practical value of L (UHG) on s.d. of L (UHG) was calculated as follows; $Y=0.031X-0.029$, where Y and X indicate practical value of L (UHG) and s.d. of L (UHG), respectively. This formula indicates that the practical value of L (UHG) becomes 0.031mm longer, when the s.d. of L (UHG) becomes larger by 1 degree.

Group B: Five, 5, 5 and 9 characters showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of practical value of L (UHG) on s.d. of L (UHG) through the whole strains was +0.3414 to the degree of freedom of 48, which is significant at 5% level. Generally speaking, the larger is the practical value of L (UHG), the larger is the s.d. of L (UHG). L.r. of practical value of L (UHG) on s.d. of L (UHG) was calculated as follows; $Y=0.036X-0.044$, where Y and X indicate practical value of L (UHG) and s.d. of L (UHG), respectively. This formula indicates that the practical value of L (UHG) becomes 0.036mm longer, when the s.d. of L (UHG) becomes larger by 1 degree.

Whole: Fourteen, 2, 1 and 7 characters showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of practical value of L (UHG) on s.d. of L (UHG) through the whole strains of both of the groups was +0.3316 to the degree of freedom of 98, which is significant at 0.1% level. Generally speaking, the longer is the practical value of L (UHG), the larger is the s.d. of L (UHG). L.r. of practical value of L (UHG) on s.d. of L (UHG) was calculated as follows; $Y=0.028X+0.016$, where Y and X indicate practical value of L (UHG) and s.d. of L (UHG), respectively. This formula indicates that the practical value of L (UHG) becomes 0.028mm longer, when the s.d. of L (UHG) becomes larger by 1 degree.

5. Relationships between the practical values and their variation ranges

Group A: C.c. and l.r. of practical value on their variation ranges among 24 characters were calculated, and are shown in Table 5. Four, 8, 4 and 8 characters showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of practical value of L (UHG) on variation range of L (UHG) through the whole strains was +0.3331 to the degree of freedom of 48, which is significant at 5% level. Generally speaking, the longer is the practical value of L (UHG), the larger is the variation range of L (UHG). L.r. of practical value of L (UHG) on variation range of L (UHG) was calculated as follows: $Y=0.107X+0.063$, where Y and X indicate practical value of L (UHG) and variation range of L (UHG), respectively. This formula indicates that the practical value of L (UHG) becomes 0.107mm longer, when the variation range of L (UHG) becomes larger by 1 degree.

Group B: Four, 6, 4 and 10 characters showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of practical value of L (UHG) on the

Table 4. Correlation coefficient and linear regression of the practical value (Y) on its s.d. (X) for 24 characters

Char- acter	Group A		Group B		Whole	
	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression
1	0.4191**	Y=0.031X-0.029	0.3414*	Y=0.036X-0.044	0.3316***	Y=0.028X+0.016
2	0.3093*	Y=0.025X+0.029	0.4132**	Y=0.030X+0.017	0.5136***	Y=0.028X+0.021
3	-0.0518	—	0.4488**	Y=0.062X-0.065	0.3217**	Y=0.041X-0.018
4	0.5410***	Y=0.053X-0.028	0.5035***	Y=0.038X+0.006	0.7047***	Y=0.053X-0.032
5	0.5391***	Y=0.062X-0.103	0.2415	—	0.4054***	Y=0.036X+0.068
6	0.4758***	Y=0.119X-0.084	0.2837*	Y=0.051X-0.004	0.3249***	Y=0.050X+0.001
11	0.5438***	Y=0.034X-0.043	0.1615	—	0.3751***	Y=0.026X+0.010
12	0.5107***	Y=0.056X-0.045	0.4116**	Y=0.054X-0.041	0.5728***	Y=0.052X-0.037
13	-0.0557	—	0.1881	—	0.0751	—
14	0.4720***	Y=0.041X+0.008	0.1997	—	0.5289***	Y=0.037X+0.018
15	0.4389**	Y=0.058X-0.059	0.1772	—	0.3928***	Y=0.042X-0.004
16	0.5282***	Y=0.153X-0.119	0.3491*	Y=0.084X-0.044	0.3798***	Y=0.070X-0.022
21	-0.2668	—	-0.2797*	Y=-0.095X+0.080	-0.2535*	Y=-0.085X+0.073
22	-0.2577	—	-0.3365*	Y=-0.084X+0.095	-0.0221	—
23	-0.2425	—	-0.4417**	Y=-0.230X+0.227	-0.1617	—
24	0.2768	—	0.3750**	Y=0.101X-0.057	0.2776**	Y=0.083X-0.039
25	-0.0458	—	0.0481	—	0.0077	—
26	-0.0121	—	-0.0437	—	0.1058	—
31	0.5862***	Y=0.046X+0.047	0.5326***	Y=0.056X-0.117	0.6682***	Y=0.058X-0.212
32	0.6141***	Y=0.044X+0.784	0.6863***	Y=0.072X-0.528	0.7628***	Y=0.068X-0.289
33	0.5346***	Y=0.047X-0.003	0.4565***	Y=0.054X-0.052	0.5940***	Y=0.058X-0.144
34	0.5423***	Y=0.055X+0.212	0.5508***	Y=0.060X+0.158	0.6477***	Y=0.062X+0.056
35	-0.1724	—	-0.2718	—	-0.0257	—
36	-0.1544	—	-0.1106	—	0.1564	—

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, 1~6-unhusked grains, 11~16-husked grains, 21~26-comparative values (=husked/unhusked), 31-area (UHG), 32-volume (UHG), 33-area (HG), 34-volume (HG), 35-quotient of areas (=33/31), 36-quotient of volumes (=34/32)

***, **, *: significant at 0.1%, 1% and 5% levels, respectively
d.f.; Group A-48, Group B-48, Whole-98, respectively

variation range of L (UHG) through the whole strains was +0.3193 to the degree of freedom of 48, which is significant at 5% level. Generally speaking, the longer is the practical value of L (UHG), the larger is the variation range of L (UHG). L.r. of practical value of L (UHG) on variation range of L (UHG) was calculated as follows; $Y=0.161X-0.327$, where Y and X indicate practical value of L (UHG) and variation range of L (UHG), respectively. This formula indicates that the practical value of L (UHG) becomes 0.161mm longer, when the variation range of L (UHG) becomes larger by 1 degree.

Whole: Ten, 5, 1 and 8 characters showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. For example, c.c. of practical value of L (UHG) on the

Table 5. Correlation coefficient and linear regression of the practical value (Y) on its range (X) for 24 characters

Char- acter	Group A		Group B		Whole	
	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression
1	0.3331*	Y=0.107X+0.063	0.3193*	Y=0.161X-0.327	0.2887**	Y=0.109X+0.079
2	0.3654**	Y=0.159X-0.026	0.3779**	Y=0.150X-0.023	0.4554***	Y=0.133X+0.039
3	-0.0689	—	0.4037**	Y=0.241X-0.240	0.1819	—
4	0.4481**	Y=0.205X-0.059	0.4485**	Y=0.175X-0.016	0.6316***	Y=0.223X-0.134
5	0.4171**	Y=0.263X-0.442	0.2029	—	0.3538***	Y=0.169X-0.014
6	0.5118***	Y=0.580X-0.461	0.2071	—	0.2954**	Y=0.201X+0.011
11	0.3527*	Y=0.108X-0.005	0.1573	—	0.2858**	Y=0.092X+0.099
12	0.5665***	Y=0.300X-0.352	0.4586***	Y=0.249X-0.254	0.6000***	Y=0.239X-0.220
13	-0.1342	—	0.1901	—	-0.0302	—
14	0.3587*	Y=0.156X+0.084	0.1525	—	0.5003***	Y=0.174X+0.027
15	0.3845**	Y=0.289X-0.381	0.0622	—	0.3908***	Y=0.228X-0.186
16	0.4610***	Y=0.766X-0.642	0.3873**	Y=0.451X-0.323	0.2979**	Y=0.298X-0.096
21	-0.2221	—	-0.3176*	Y=-0.423X+0.352	-0.2473*	Y=0.292X+0.261
22	-0.1997	—	-0.4027**	Y=-0.461X+0.482	-0.1195	—
23	-0.3627**	Y=-1.000X+1.005	-0.2569	—	-0.1265	—
24	0.2940*	Y=0.553X-0.331	0.3495*	Y=0.430X-0.240	0.2911**	Y=0.415X-0.223
25	0.1452	—	0.0972	—	0.1262	—
26	-0.0277	—	-0.0884	—	0.0496	—
31	0.4894***	Y=0.165X+0.752	0.4204**	Y=0.193X+0.446	0.5718***	Y=0.211X-0.200
32	0.4512**	Y=0.135X+0.554	0.7301***	Y=0.322X-3.742	0.7557***	Y=0.278X-0.119
33	0.4050**	Y=0.170X+0.302	0.4772***	Y=0.248X-0.635	0.5554***	Y=0.244X-0.669
34	0.3901**	Y=0.195X+1.913	0.5852***	Y=0.268X+0.042	0.6033***	Y=0.260X+0.191
35	-0.1664	—	-0.2917*	Y=-0.335X+0.281	0.0031	—
36	-0.1695	—	-0.1014	—	0.1733	—

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, 1~6-unhusked grains, 11~16-husked grains, 21~26-comparative values (=husked/unhusked), 31-area (UHG), 32-volume (UHG), 33-area (HG), 34-volume (HG), 35-quotient of areas (=33/31), 36-quotient of volumes (=34/32)

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

d.f.; Group A-48, Group B-48, Whole-98, respectively

variation range of L (UHG) through the whole strains of both of the groups was +0.2887 to the degree of freedom of 98, which is significant at 1% level. Generally speaking, the longer is the practical value of L (UHG), the larger is the variation range of L (UHG). L.r. of practical value of L (UHG) on variation range of L (UHG) was calculated as follows; $Y=0.109X+0.079$, where Y and X indicate practical value of L (UHG) and variation range of L (UHG), respectively. This formula indicates that the practical value of L (UHG) becomes 0.109mm longer, when the variation range of L (UHG) becomes larger by 1 degree.

6. Relationships between the s.d. and their variation ranges

Group A: C.c. and l.r. of s.d. on their variation ranges among 24 characters were calculated, and are shown in Table 6. Twenty-three and 1 characters showed significances at 0.1% and 1% levels, respectively. In other words, the whole characters showed significant relations. For example, c.c. of s.d. of L (UHG) on variation range of L (UHG) through the whole strains was +0.9144 to the degree of freedom of 48, which is obviously significant at 0.1% level. Generally speaking, the larger is the s.d. of L (UHG), the larger is the variation range of L (UHG). L.r. of s.d. of L (UHG) on variation range of L (UHG) was calculated as follows; $Y=0.392X+0.032$, where Y and X indicate s.d. of L (UHG) and variation range of L (UHG), respectively. This

Table 6. Correlation coefficient and linear regression of the s.d. (Y) on its range (X) for 24 characters

Char- acter	Group A		Group B		Whole	
	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression
1	0.9144 ***	$Y=0.392X+0.032$	0.9076 ***	$Y=4.335X-0.098$	0.9088 ***	$Y=4.109X-0.027$
2	0.8223 ***	$Y=4.417X-0.028$	0.8526 ***	$Y=4.709X-0.068$	0.8531 ***	$Y=4.491X-0.039$
3	0.8369 ***	$Y=4.928X-0.045$	0.9065 ***	$Y=3.895X+0.007$	0.8530 ***	$Y=4.258X-0.010$
4	0.9159 ***	$Y=4.342X-0.022$	0.8981 ***	$Y=4.618X-0.048$	0.9345 ***	$Y=4.368X-0.023$
5	0.9029 ***	$Y=4.980X-0.122$	0.8499 ***	$Y=4.424X-0.052$	0.8868 ***	$Y=4.826X-0.106$
6	0.8746 ***	$Y=3.975X+0.013$	0.8317 ***	$Y=3.453X+0.044$	0.8629 ***	$Y=3.847X+0.020$
11	0.8663 ***	$Y=4.264X-0.051$	0.8935 ***	$Y=3.905X-0.002$	0.8775 ***	$Y=4.092X-0.027$
12	0.8251 ***	$Y=3.968X+0.001$	0.8914 ***	$Y=3.726X+0.033$	0.8880 ***	$Y=3.871X+0.013$
13	0.8691 ***	$Y=4.917X-0.049$	0.8641 ***	$Y=3.992X-0.007$	0.8574 ***	$Y=4.505X-0.032$
14	0.8834 ***	$Y=4.430X-0.027$	0.8930 ***	$Y=4.328X-0.020$	0.8908 ***	$Y=4.516X-0.041$
15	0.9265 ***	$Y=5.333X-0.132$	0.8374 ***	$Y=3.354X+0.079$	0.9027 ***	$Y=4.844X-0.086$
16	0.9034 ***	$Y=5.200X-0.057$	0.8682 ***	$Y=4.220X-0.005$	0.8875 ***	$Y=4.837X-0.041$
21	0.6223 ***	$Y=1.950X+0.030$	0.4017 **	$Y=1.544X+0.033$	0.5999 ***	$Y=2.120X+0.028$
22	0.6728 ***	$Y=2.727X+0.031$	0.8301 ***	$Y=3.789X+0.005$	0.7774 ***	$Y=3.133X+0.020$
23	0.5261 ***	$Y=2.392X+0.040$	0.5807 ***	$Y=2.264X+0.036$	0.6113 ***	$Y=2.586X+0.033$
24	0.8351 ***	$Y=4.347X-0.010$	0.8555 ***	$Y=3.919X+0.008$	0.8433 ***	$Y=4.035X+0.002$
25	0.5350 ***	$Y=2.124X+0.051$	0.7370 ***	$Y=3.491X+0.017$	0.6667 ***	$Y=2.935X+0.030$
26	0.6741 ***	$Y=2.758X+0.045$	0.7346 ***	$Y=3.049X+0.032$	0.7465 ***	$Y=2.961X+0.036$
31	0.8880 ***	$Y=3.842X+0.303$	0.8867 ***	$Y=3.885X+0.220$	0.9099 ***	$Y=3.855X+0.273$
32	0.8427 ***	$Y=3.475X+1.861$	0.9329 ***	$Y=3.903X+0.767$	0.9385 ***	$Y=3.888X+0.741$
33	0.8895 ***	$Y=4.238X-0.109$	0.8634 ***	$Y=3.786X+0.267$	0.8932 ***	$Y=3.993X+0.075$
34	0.8678 ***	$Y=4.252X-0.062$	0.9217 ***	$Y=4.131X-0.064$	0.9123 ***	$Y=4.081X+0.135$
35	0.5866 ***	$Y=2.124X+0.047$	0.6704 ***	$Y=2.904X+0.021$	0.6748 ***	$Y=2.777X-0.027$
36	0.3889 **	$Y=1.668X+0.065$	0.6561 ***	$Y=2.787X+0.026$	0.6329 ***	$Y=2.900X+0.026$

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, 1~6-unhusked grains, 11~16-husked grains, 21~26-comparative values (=husked/unhusked), 31-area (UHG), 32-volume (UHG), 33-area (HG), 34-volume (HG), 35-quotient of areas (=33/31), 36-quotient of volumes (=34/32)

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

d.f.; Group A-48, Group B-48, Whole-98, respectively

formula indicates that the s.d. of L (UHG) becomes 0.392 larger, when the variation range of L (UHG) becomes larger by 1 degree.

Group B: Twenty-three and 1 characters showed significances at 0.1% and 1% levels, respectively. In other words, the whole characters showed significant relations. This tendency was fixed to be quite the same with that of Group A. For example, c.c. of s.d. of L (UHG) on variation range of L (UHG) through the whole strains was +0.9076 to the degree of freedom of 48, which is obviously significant at 0.1% level. Generally speaking, the larger is the s.d. of L (UHG), the larger is the variation range of L (UHG). L.r. of s.d. of L (UHG) on variation range of L (UHG) was calculated as follows; $Y=4.335X-0.098$, where Y and X indicate s.d. of L (UHG) and variation range of L (UHG), respectively. This formula indicates that the s.d. of L (UHG) becomes 4.335 larger, when the variation range of L (UHG) becomes larger by 1 degree.

Whole: The whole characters (=24) showed significances at 0.1% level. For example, c.c. of s.d. of L (UHG) on variation range of L (UHG) through the whole strains of both of the groups was +0.9088 to the degree of freedom of 98, which is obviously significant at 0.1% level. Generally speaking, the larger is the s.d. of L (UHG), the larger is the variation range of L (UHG). L.r. of s.d. of L (UHG) on variation range of L (UHG) was calculated as follows; $Y=4.109X-0.027$, where Y and X indicate s.d. of L (UHG) and variation range of L (UHG), respectively. This formula indicates that the s.d. of L (UHG) becomes 4.109 larger, when the variation range of L (UHG) becomes larger by 1 degree.

7. The four relation-groups under comparison

From the data obtained in the Tables 1, 2 and 3 of the present experiment, relationships between the two respective characters were compared, and are shown in Table 7. In this table, 3 relation-groups, *i.e.*, relation between the two respective practical values (A column in Table 7), relation between the two respective s.d. (B column) and relation between the two respective variation ranges (C column), were analysed. In addition to these, summed-up data from columns A, B and C were regulated, and are shown in D column in the table, under the condition that the calculation was to be made by means of the significances in disregard of significant levels.

In Group A, significant combinations were counted as 20/27 cases (74.1%), 17/27 cases (63.0%), 15/27 cases (55.6%) and 52/81 cases (64.2%) in A, B, C and D columns, respectively. In Group B, those were counted as 19/27 cases (70.4%), 17/27 cases (63.0%), 15/27 cases (55.6%) and 51/81 cases (63.0%) in the same order, respectively. In the whole of both of the groups, those were counted as 22/27 cases (81.5%), 20/27 cases (74.1%), 19/27 cases (70.4%) and 61/81 cases (75.3%) in the same order, respectively.

In Group A, 13, 4, 5 and 5 character-combinations showed significances at 3, 2, 1 and 0 chances, respectively. Average and its s.d. through the whole combinations were found to be 1.93 ± 1.18 . In Group B, 14, 2, 5 and 6 combinations showed significances at 3, 2, 1 and 0 chances, respectively. Average and its s.d. through the whole combinations were found to be 1.89 ± 1.26 . In the whole, 18, 1, 5 and 3 combinations showed significances at 3, 2, 1 and 0 chances, respectively. Average and its s.d. through the whole combinations were found to be 2.26 ± 1.11 .

In the total of these three groups, significant combinations were counted as 61/81 cases (75.3%), 54/81 cases (66.7%), 49/81 cases (60.5%) and 164/243 cases (67.5%) in A, B, C and D columns, respectively. In column A, 18, 2, 3 and 4 combinations showed significances at 3, 2, 1 and 0 chances, respectively. Average and its s.d. through the whole combinations were found to be 2.26 ± 1.14 . In column B, 14, 4, 4 and 5 combinations showed significances at 3, 2, 1 and 0 chances,

Table 7. Comparisons of 4 relation-groups; relations between the respective character-combinations in view of practical values (A), standard deviations (B), variation ranges (C) and summing-up of A, B and C packs (D). Figures used in columns Total and D showed the number of significant relations in the respective combinations in disregard of the grade of significances.

Combi- nation	Group A				Group B				Whole				Total			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
1·2				0				0		*		1	0	1	0	1
1·3				0				0				0	0	0	0	0
2·3	***			1	***	**		2	***	***		2	3	2	0	5
4·5	***	**		2	***			1	***	***	**	3	3	2	1	6
4·6	***	**	**	3	***			1	***	*	**	3	3	2	2	7
5·6		***	***	2	***	**	**	3	***	***	***	3	2	3	3	8
11·12				0				0	**			1	1	0	0	1
11·13				0				0				0	0	0	0	0
12·13	***	*		2	***	**	**	3	***	**	*	3	3	3	2	8
14·15	***			1	***			1	***	*	*	3	3	1	1	5
14·16	***	*	*	3	***	**	*	3	***	**	**	3	3	3	3	9
15·16	*	***	***	3	***	**	*	3	***	***	***	3	3	3	3	9
21·22				0		*		1	*			1	1	1	0	2
21·23		*	**	2				0			*	1	0	1	2	3
22·23	*			1		**	*	2	***	***	**	3	2	2	2	6
24·25	***			1	***			1	***			1	3	0	0	3
24·26	***	***	***	3	***	***	**	3	***	***	***	3	3	3	3	9
25·26	*			1				0				0	1	0	0	1
1·11	***	***	***	3	***	***	***	3	***	***	***	3	3	3	3	9
2·12	***	***	***	3	***	***	*	3	***	***	***	3	3	3	3	9
3·13	***	***	***	3	***	***	***	3	***	***	***	3	3	3	3	9
4·14	***	***	***	3	***	***	***	3	***	***	***	3	3	3	3	9
5·15	***	***	***	3	***	***	***	3	***	***	***	3	3	3	3	9
6·16	***	***	***	3	***	***	***	3	***	***	***	3	3	3	3	9
31·33	***	***	***	3	***	***	***	3	***	***	***	3	3	3	3	9
32·34	***	***	***	3	***	***	***	3	***	***	***	3	3	3	3	9
35·36	***	**	**	3	***	***	***	3	***	***	***	3	3	3	3	9

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, 1~6-unhusked grains, 11~16-husked grains, 21~26-comparative values (=husked/unhusked), 31-area (UHG), 32-volume (UHG), 33-area (HG), 34-volume (HG), 35-quotient of areas (=33/31), 36-quotient of volumes (=34/32)

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

d.f.; Group A-48, Group B-48, Whole-98, respectively

respectively. Average and its s.d. through the whole combinations were found to be 2.00 ± 1.19 . In column C, 13, 4, 2 and 8 combinations showed significances at 3, 2, 1 and 0 chances, respectively. Average and its s.d. through the whole combinations were found to be 1.82 ± 1.31 . In column D, 12, 2, 1, 2, 2, 0, 2, 1, 3 and 2 combinations showed significances at 9, 8, 7, 6, 5, 4, 3, 2, 1 and 0 chances,

respectively. Average and its s.d. through the whole combinations were found to be 6.07 ± 3.33 .

Through the whole groups and columns, 27 character-combinations might be divided into 2 categories, *i.e.*, the one with higher frequency and the other with lower frequency. Nineteen character-combinations, *i.e.*, combination Nos. 2·3, 4·5, 4·6, 5·6, 12·13, 14·15, 14·16, 15·16, 22·23, 24·26, 1·11, 2·12, 3·13, 4·14, 5·15, 6·16, 31·33, 32·34, 35·36, belonged to the former one. The remaining 8 character-combinations, *i.e.*, 1·2, 1·3, 11·12, 11·13, 21·22, 21·23, 24·25, 25·26, belonged to the latter one.

8. The other four relation-groups under comparison

From the data obtained in Tables 4, 5, 6 of the present experiment, relations between the two respective characters were compared, and are shown in Table 8. In this table, 3 relation-groups, *i.e.*, relation between practical values and their s.d. (E column in Table 8), relation between practical values and their variation ranges (F column) and relation between s.d. and their variation ranges (G column), were analysed. In addition to these, summed-up data from columns E, F and G were regulated, and are shown in H column in the table, under the condition that the calculation was made by means of the significances in disregard of significant levels.

In Group A, significant characters were counted as 14/24 (=58.3%), 16/24 (=66.7%), 24/24 (=100.0%) and 54/72 (=75.0%) in E, F, G and H columns, respectively. In Group B, those were counted as 15/24 (=62.5%), 14/24 (=58.3%), 24/24 (=100.0%) and 53/72 (=73.6%) in the same order, respectively. In the whole, those were counted as 17/24 (=70.8%), 16/24 (=66.7%), 24/24 (=100.0%) and 57/72 (=79.2%) in the same order, respectively.

In Group A, 14, 2 and 8 characters showed significances at 3, 2 and 1 chances, respectively. In other words, the whole characters showed significant relations at least. Average and its s.d. through the whole characters were found to be 2.25 ± 0.92 . In Group B, 13, 3 and 8 characters showed significances at 3, 2 and 1 chances, respectively. In other words, the whole characters showed significant relations, too. Average and its s.d. through the whole characters were found to be 2.21 ± 0.91 . In the whole strains of both of the groups, 16, 1 and 7 characters showed significances at 3, 2 and 1 chances, respectively. In other words, the whole characters showed significant relations at least. Average and its s.d. through the whole characters were found to be 2.38 ± 0.90 .

In the total of these groups, significant characters were counted as 46/72 cases (63.9%), 46/72 cases (63.9%), 72/72 cases (100.0%) and 164/216 cases (75.9%) in E, F, G and H columns, respectively. In column E, 10, 7, 2 and 5 characters showed significances at 3, 2, 1 and 0 chances, respectively. Average and its s.d. through the whole characters were found to be 1.92 ± 1.15 . In column F, 10, 6, 4 and 4 characters showed significances at 3, 2, 1 and 0 chances, respectively. Average and its s.d. through the whole characters were found to be 1.92 ± 1.12 . In column G, the whole characters (=24) showed significances at 3 chances. So, average and its s.d. through the whole characters were found to be 3.00 ± 0.00 . In column H, 9, 2, 5, 1, 2, 1 and 4 characters showed significances at 9, 8, 7, 6, 5, 4 and 3 chances, respectively. Average and its s.d. through the whole characters were found to be 6.83 ± 2.23 .

Through the whole groups and columns, 24 characters might tentatively be divided into 2 categories, *i.e.*, the one with higher frequency and the other with lower frequency. Sixteen characters, *i.e.*, character Nos. 1, 2, 4, 5, 6, 11, 12, 14, 15, 16, 21, 24, 31, 32, 33 and 34, belonged to the former one. The remaining 8 characters, *i.e.*, character Nos. 3, 13, 22, 23, 25, 26, 35 and 36, belonged to the latter one.

Table 8. Comparisons of 4 relation-groups; relations between practical values and its standard deviations (E), practical values and its variation ranges (F), standard deviations and its variation ranges (G) and summing-up of E, F and G packs (H). Figures used in columns of Total and H showed the number of significant relations in the respective characters in disregard of the grade of significances.

Charac- ters	Group A				Group B				Whole				Total			
	E	F	G	H	E	F	G	H	E	F	G	H	E	F	G	H
1	**	*	***	3	*	*	***	3	***	**	***	3	3	3	3	9
2	*	**	***	3	**	**	***	3	***	***	***	3	3	3	3	9
3			***	1	**	**	***	3	**		***	2	2	1	3	6
4	***	**	***	3	***	**	***	3	***	***	***	3	3	3	3	9
5	***	**	***	3			***	1	***	***	***	3	2	2	3	7
6	***	***	***	3	*		***	2	***	**	***	3	3	2	3	8
11	***	*	***	3			***	1	***	**	***	3	2	2	3	7
12	***	***	***	3	**	***	***	3	***	***	***	3	3	3	3	9
13			***	1			***	1			***	1	0	0	3	3
14	***	*	***	3			***	1	***	***	***	3	2	2	3	7
15	**	**	***	3			***	1	***	***	***	3	2	2	3	7
16	***	***	***	3	*	**	***	3	***	**	***	3	3	3	3	9
21			***	1	*	*	**	3	*	*	***	3	2	2	3	7
22			***	1	*	**	***	3			***	1	1	1	3	5
23		**	***	2	**		***	2			***	1	1	1	3	5
24		*	***	2	**	*	***	3	**	**	***	3	2	3	3	8
25			***	1			***	1			***	1	0	0	3	3
26			***	1			***	1			***	1	0	0	3	3
31	***	***	***	3	***	**	***	3	***	***	***	3	3	3	3	9
32	***	**	***	3	***	***	***	3	***	***	***	3	3	3	3	9
33	***	**	***	3	***	***	***	3	***	***	***	3	3	3	3	9
34	***	**	***	3	***	***	***	3	***	***	***	3	3	3	3	9
35			***	1		*	***	2			***	1	0	1	3	4
36			**	1			***	1			***	1	0	0	3	3

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, 1~6-unhusked grains, 11~16-husked grains, 21~26-comparative values (=husked/unhusked), 31-area (UHG), 32-volume (UHG), 33-area (HG), 34-volume (HG), 35-quotient of areas (=33/31), 36-quotient of volumes (=34/32)

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

d.f.; Group A-48, Group G-48, Whole-98, respectively

Discussion

Basing on the results obtained in the previous and present experiments, the following problems are to be discussed here.

1. C.c. of the practical value on the other practical values (Table 1 and column A in Table 7) were decided to be positively and negatively significant in 20/27 cases (74.1%), 19/27 cases (70.4%) and 22/27 cases (81.5%) in Group A, Group B and the whole, respectively. Through the

3 groups mentioned just above, 18, 2, 3 and 4 character-combinations showed significant correlations in 3, 2, 1 and 0 chances, respectively. It was noticed that combination Nos.1·2 (L and W of UHG), 1·3 (L and T of UHG), 11·13 (L and T of HG), 21·23 (comparative values of L and T), showed no significant correlation at all. Combination Nos.11·12 (L and W of HG) and 21·22 (comparative values of L and W) showed no significant relation in Groups A and B, but showed significant relations in the whole strains of both of the groups. Average and its s.d. through the whole combinations and groups were found to be 2.26 ± 1.14 .

C.c. of the intra-strain's variations (=s.d.) on other s.d. (Table 2 and column B in Table 7) were decided to be positively significant in 17/27 cases (63.0%), 17/27 cases (63.0%) and 20/27 cases (74.1%) in Group A, Group B and the whole, respectively. Through the 3 groups, 18, 2, 3 and 4 character-combinations showed significant correlations at 3, 2, 1 and 0 chances, respectively. It was noticed that 7 combinations, *i.e.*, Nos.1·3 (L and T of UHG), 11·12 (L and W of HG), 11·13 (L and T of HG), 21·22, 21·23, 24·25, 25·26 (comparative values of L and W, L and T, L/W and L/T, and L/T and W/T), showed no significance at all. Combination Nos.1·2 (L and W of UHG) and 14·15 (L/W and L/T of HG) showed no significance in Group A and Group B, but showed significances in the whole strains of both of the groups. Average and its s.d. through the whole combinations and groups were found to be 2.00 ± 1.19 .

C.c. of the variation range on the other variation ranges (Table 3 and column C in Table 7) were decided to be positively significant in 15/27 cases (55.6%), 15/27 cases (55.6%) and 19/27 cases (70.4%) in Group A, Group B and the whole, respectively. Through the 3 groups, 13, 4, 2 and 8 character-combinations showed significant correlations in 3, 2, 1 and 0 chances, respectively. It was noticed that 8 combinations, *i.e.*, Nos.1·2 (L and W of UHG), 1·3 (L and T of UHG), 2·3 (W and T of UHG), 11·12 (L and W of HG), 11·13 (L and T of HG), 21·22 (comparative values of L and W), 24·25 (comparative values of L/W and L/T), 25·26 (comparative values of L/T and W/T), showed no significance in the 3 groups at all. Combination Nos.4·5 (L/W and L/T of UHG) and 14·15 (L/W and L/T of HG) showed no significance in Group A and Group B, but showed significances in the whole strains. Average and its s.d. through the whole combinations and groups were found to be 1.82 ± 1.31 .

C.c. of the three columns mentioned above (column D in Table 7) were decided to be significant in 52/81 cases (64.2%), 51/81 cases (63.0%) and 61/81 cases (75.3%) in Group A, Group B and the whole, respectively. Through the 3 groups, 12, 2, 1, 2, 2, 2, 1, 3 and 2 character-combinations showed significant correlations in 9, 8, 7, 6, 5, 3, 2, 1 and 0 chances, respectively. It was noticed that combination Nos.1·3 (L and T of UHG) and 11·13 (L and T of HG) showed no significance in the 3 groups at all. Twelve combinations, *i.e.*, Nos.14·16 (L/W and W/T of HG), 15·16 (L/T and W/T of HG), 24·26 (comparative values of L/W and W/T), 1·11 (L of UHG and HG), 2·12 (W of UHG and HG), 3·13 (T of UHG and HG), 4·14 (L/W of UHG and HG), 5·15 (L/T of UHG and HG), 6·16 (W/T of UHG and HG), 31·33 (areas of UHG and HG), 32·34 (volumes of UHG and HG), 35·36 (quotients of areas and volumes), showed significant correlations through the whole cases (=9).

2. C.c. of the practical value on their s.d. of the respective characters (Table 4 and column E in Table 8) were decided to be significant in 14/24 cases (58.3%), 15/24 cases (62.5%) and 17/24 cases (70.8%) in Group A, Group B and the whole, respectively. Through the 3 groups, 10, 7, 2 and 5 characters showed significant correlations in 3, 2, 1 and 0 chances, respectively. It was noticed that 5 characters, *i.e.*, Nos.13 (T of HG), 25 (comparative values of L/T), 26 (comparative values of W/T), 35 (quotients of areas), 36 (quotients of volumes), showed no significant relation

through the whole cases at all. Character Nos.22 (comparative values of W) and 23 (comparative values of T) showed no significance in Group A and the whole, but showed significances in Group B. Average and its s.d. through the whole characters were found to be 1.92 ± 1.15 .

C.c. of the practical value on their variation ranges of the respective characters (Table 5 and column F in Table 8) were decided to be significant in 16/24 cases (66.7%), 14/24 cases (58.3%) and 16/24 cases (66.7%) in Group A, Group B and the whole, respectively. Through the 3 groups, 10, 6, 4 and 4 characters showed significant correlations at 3, 2, 1 and 0 chances, respectively. It was noticed that 4 characters, *i.e.*, Nos.13 (T of HG), 25 (comparative values of L/T), 26 (comparative values of W/T), 36 (quotients of volumes), showed no significance through the whole groups at all. Character Nos.3 (T of UHG), 22 (comparative values of W) and 35 (quotients of areas) showed significances in Group B, but showed no significance in Group A and the whole. Character No.23 (comparative values of T) showed significances in Group A, but showed no significance in Group B and the whole. Average and its s.d. through the whole characters were found to be 1.92 ± 1.12 .

C.c. of s.d. on their variation ranges of the respective characters (Table 6 and column G in Table 8) were expectedly decided to be significant in 24/24 cases (100.0%) and being the same as in cases of Group A, Group B and the whole. Moreover, they were noted to have some high levelled relations, *i.e.*, 71/72 cases (98.6%) showed significances at 0.1% level, and only 1 case (1.4%) [=relation between s.d. and its variation range of quotient of volumes] showed significance at 1% level. Those phenomena meant that the character-s.d. were reasonably assumed to be connected with the character-variation-ranges. Generally speaking, the larger is the s.d., the larger is the variation range. Through the 3 groups, the whole characters (=24) showed significant correlations in 3 cases. Average and its s.d. through the whole characters were found to be 3.00 ± 0.00 .

C.c. of the 3 columns mentioned above (column H in Table 8) were decided to be significant in 54/72 cases (75.0%), 53/72 cases (73.6%) and 57/72 cases (79.2%) in Group A, Group B and the whole, respectively. Through the 3 groups, 9, 2, 5, 1, 2, 1 and 4 characters showed significant correlations in 9, 8, 7, 6, 5, 4 and 3 chances, respectively. Nine characters, *i.e.*, Nos.1 (L of UHG), 2 (W of UHG), 4 (L/W of UHG), 12 (W of HG), 16 (W/T of HG), 31 (areas of UHG), 32 (volumes of UHG), 33 (areas of HG), 34 (volumes of HG), showed significant correlations through the whole cases (=9).

3. Fifteen (=4 in Group A, 5 in Group B, 6 in the whole), 0 and 0 negative correlations at the significant levels were found in the relations of the practical value on another practical value (column A), of s.d. on another s.d. (column B), and of variation range on another variation range (column C), respectively. Moreover, character-combination Nos.4•6 (L/W and W/T of UHG), 5•6 (L/T and W/T of UHG), 11•12 (L and W of HG), 14•16 (L/W and W/T of HG), 15•16 (L/T and W/T of HG) and 24•26 (comparative values of L/W and comparative values of W/T), showed negative correlations at significant levels as in 3, 2, 1, 3, 3 and 3 cases, respectively. It was noticed that character-combinations of L/W and W/T showed many negative correlations.

Four (=0 in Group A, 3 in Group B, 1 in the whole), 5 (=1 in Group A, 3 in Group B, 1 in the whole) and 0 negative correlations at the significant levels were found in the relations between the practical value and its s.d. (column E), between the practical value and its variation range (column F), and between s.d. and its variation range (column G), respectively. Moreover, character Nos.21 (comparative values of L), 22 (comparative values of W), 23 (comparative values of T) and 35 (quotients of areas) showed negative correlations at significant levels as in 4, 2, 2 and 1 cases.

respectively.

Basing on the data obtained in the columns A to H, it was concluded that those phenomena meant the character-specificities in these characters. In other words, these characters might genetically be fixed as those in possession of a flexibility and affectability to any of the several environmental conditions.

4. In summing-up, significant relations were found as 61/81 cases (75.3%), 54/81 cases (66.7%), 49/81 cases (60.5%), 164/243 cases (67.5%), 46/72 cases (63.9%), 46/72 cases (63.9%), 72/72 cases (100.0%) and 164/216 cases (75.9%) in the order of columns A to H, respectively. Average and its s.d. through the whole columns were found to be 82.00 ± 48.03 . It might be concluded that column G (=s.d. and its variation range) was of the most stable character, and was intimately correlated with each other through the whole strains in disregard of the geographical conditions. However, some characters showed quite low correlations or no significant correlation at all even at 5% level.

Twenty-four characters and 27 mutual combinations were used for analysing the variety- and strain-differentiations in the present experimental series. Some of them are yet of developing status. However, it may be affirmed that those characters of character-combinations are to be used for analysing the grain morphological constitution in the future. Moreover, it might be confirmed that such indices of ideas may be used as a sort of handy indices in the experiments.

5. It might be noticeable that significant relations were found as 328/459 cases (71.5%) in summed-up data. Moreover, in view of significant level, 240/328 cases (73.2%), 53/326 cases (16.2%) and 35/328 cases (10.7%) showed significances at 0.1%, 1% and 5% levels, respectively. In addition to these facts, 240/459 cases (52.3%), 53/459 cases (11.6%), 35/459 cases (7.6%), 328/459 cases (71.5%) and 13/459 cases (28.5%) showed significances at 0.1%, 1% and 5% levels, respectively. It might have meant such biological actions, as was extremely called "all or nothing", *i.e.*, going from one extreme to another. In a stricter sense, those characters were looked upon as being in possession of a stable state, to be exhibited independently of the other characters.

6. Comparisons of morphological characters found in the materials, which had been nominated as *aman* varieties (Group A) and *aus* varieties (Group B), are looked upon as having quite important meanings in view of the origin and diversity of the wild and cultivated rice species. These considerations were carried out, aiming at getting better understanding of the phylogenetic status and of mutual relationships between them. Although several comparative data were mentioned in the present paper, an accumulation of complete data endorsed by proper discussions on these aspects have been far from being perfect, and further studies are to be performed sincerely. Universal theory on ancestral species and original place of the one of the cultivated rice species (*Oryza sativa* L.) may be accomplished only after consummation of these schemes.

Summary

Succeeding to the previous papers, some morphological studies on grain characters and considerations on ecotypic differentiations of 100 strains of cultivated rice species, *Oryza sativa* L., delivered from Rice Research Station, Chinsurah, West Bengal, India, were reported in the present paper. The results obtained here were summarized as follows:

1. In the data obtained from summing-up the informations from 3 relation-groups, *i.e.*, practical value on the other practical values, s.d. on the other s.d., and variation range on the other variation ranges, 52 (20 in Group A, 17 in Group B and 15 in the whole), 51 (19 in Group A, 17 in

Group B and 15 in the whole) and 61 (22 in Group A, 20 in Group B and 19 in the whole) character-combinations showed significances, respectively. Averages and their s.d. through the whole character-combinations were found to be in the same order as 2.26 ± 1.14 , 2.00 ± 1.19 and 1.82 ± 1.31 , respectively. In the total, 61, 54, 49 and 164 character-combinations showed significances in Group A, Group B, the whole and the grand total, respectively. Averages and their s.d. through the whole character-combinations were found to be 1.93 ± 1.18 , 1.89 ± 1.26 , 2.26 ± 1.11 and 6.07 ± 3.33 in the same order, respectively.

2. Concerning correlations among the 3 components in the same characters, *i.e.*, between practical value and its s.d., between practical value and its variation range, and between s.d. and its variation range, 54 (14 in Group A, 16 in Group B and 24 in the whole), 53 (15 in Group A, 14 in Group B and 24 in the whole) and 57 (17 in Group A, 16 in Group B and 24 in the whole) characters showed significances, respectively. Averages and their s.d. through the whole characters were found to be in the same order as 1.92 ± 1.15 , 1.92 ± 1.12 , 3.00 ± 0.00 and 6.83 ± 2.23 , respectively.

In the total, 46, 46, 72 and 164 characters showed significances in Group A, Group B, the whole and the grand total, respectively. Averages and their s.d. through the whole characters were found to be 2.25 ± 0.92 , 2.21 ± 0.91 , 2.38 ± 0.90 and 6.83 ± 2.23 in the same order, respectively.

3. Varietal and ecotypic differentiations were extensively discussed, basing on the data from the previous and the present experiments. Characters and character-combinations confirmed in the experiments were to be looked upon as something useful, having some universal validities as indices in the examinations of variety- and strain-differentiations. Moreover, comparisons of data obtained in research institutes, field surveys in neighbouring regions were carried out to some extents, and several interesting informations were obtained in view of the locality-specificities.

Owing to the fact that several problems were left unascertained, further experiments might be requested.

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