Mem. Fac. Agr. Kagoshima Univ., 28, 1-13, 1992

Morphological Characters of the Cultivated Rice Grains in Fiji (IV)

Tadao C. KATAYAMA
(*Experimental Farm*)
Received for Publication September 9, 1991

Introduction

Following the previous papers[4,8,9], morphological characters of the cultivated rice grains of Fiji were investigated.

Twenty strains of cultivated rice, *Oryza sativa* L., using in Fiji were collected. Most of those were delivered to him through the kindness of Dr. S. A. HAQUE, and some of them were directly collected in the fields by the present author. The main purpose is to clarify the varietal variations and the phylogenetic relationships of the cultivated-rice strains used in the south Pacific areas.

Cultivation areas in Fiji increased from year by year[2]. Many items were considered to be a counterplan for the advancement of rice production[3]. In Solomon Islands, experiments have also been carried out from the several aspects[12].

The present experimental series has been made to search the varietal variations, taking historical and racial improvements into considerations. In view of the grain type, Paramasivan *et al.* (1990)[11] reported the TM6012 variety in Tamil Nadu showed "long slender" as grain shape. Abassi *et al.* (1991)[1] reported of a stability for the yield of medium-long-grain rice varieties and the advanced lines in Pakistan.

In the previous papers, the records of morphological characters of the unhusked and the husked grains, varietal ranges in 12 characters[4], comparisons of the unhusked and the husked grains in 12 characters and the variation ranges in 12 characters[8], correlation coefficients between the practical values of the unhusked and the husked grains, and linear regressions between them[9], were reported, in order to confirm the morphological characters of grains which were indispensable to make the strain's specificities clear.

In the present paper, the remaining 15 mutual relations among 24 characters in view of practical values were mainly described.

Materials and Methods

Twenty strains of rice cultivars, *Oryza sativa* L., collected in Fiji, between 15°S and 22°S, between 174°E and 174°W, South Pacific, during the trip in 1982 were used in this experimental series.

They are listed up in Table 1 of the previous paper[8]. In this table, strain number, ordinary sowing and harvesting times in the respective sites and some remarks are mentioned.

Thirty grains were used for the measurement of the respective strains. To make clear the relations between the respective 2 characters of the unhusked and the husked grains in the grain level, correlation coefficient and linear regression between them were calculated through the whole characters, *i.e.*, comparative values (Tables 1 and 2), comparison of the unhusked with the husked grains (Tables 3 and 4), and area and volume columns (Table 5). Correlation coefficients in the whole character-combinations (=27) were summed-up (Table 6).

A few new techniques for picking-up and grouping the relatively larger or smaller strains were adopted for the comparative studies of the whole strains collected in Fiji.

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), s.d. (standard deviations), UHG (unhusked grain), HG (husked grain), c.c. (correlation coefficient), l.r. (linear regression), d.f. (degree of freedom).

Results

1. Comparative values of length and width

Correlation coefficient (abbreviated as c.c.) and linear regression (abbreviated as l.r.) of width (W) on length (L) in the same strains were calculated, and are shown in the left column of Table 1. One, 1, 1 and 17 strains showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. In the whole strains (=20), c.c. was −0.1002 to the degree of freedom of 18, showing no significance even at 5% level.

Table 1. Correlation coefficient and linear regression of the three components; comparative values of width (Y) on length (X), comparative values of thickness (Y) on length (X), and comparative values of thickness (Y) on width (X)

Strain No.	Length and Width		Length and Thickness		Width and Thickness	
	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression
1	0.1786	—	−0.0095	—	0.1268	—
2	0.0210	—	0.1967	—	−0.0520	—
3	−0.0622	—	−0.2139	—	0.0255	—
4	−0.0601	—	−0.0359	—	0.0280	—
5	0.1774	—	0.1189	—	0.5105**	Y=0.975X+0.099
6	0.6999***	Y=0.816X+0.174	0.5315**	Y=0.952X+0.177	0.8764***	Y=0.500X−0.280
7	0.5111**	Y=0.710X+1.312	0.2100	—	0.4444*	Y=0.293X−0.310
8	−0.1501	—	0.1283	—	−0.1209	—
9	0.1777	—	0.5089**	Y=0.384X+0.640	0.6100***	Y=0.258X+1.003
10	0.3710*	Y=0.333X+0.570	0.4111*	Y=0.227X+0.799	0.5511**	Y=0.975X+0.100
11	−0.0152	—	−0.1892	—	0.0406	—
12	−0.3484	—	0.0225	—	0.0504	—
13	0.0432	—	−0.0258	—	0.0000	—
14	0.2113	—	−0.1086	—	0.2622	—
15	0.0836	—	0.2100	—	−0.1656	—
16	−0.2792	—	0.0676	—	−0.2489	—
17	0.1905	—	0.2185	—	0.1416	—
18	0.0166	—	0.2011	—	0.4703**	Y=0.185X+0.750
19	−0.2407	—	0.0599	—	−0.0120	—
20	0.0321	—	0.0910	—	−0.0052	—

d. f.=28

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

2. Comparative values of length and thickness

C.c. and l.r. of T on L in the same strains were calculated, and are shown in the central column of Table 1. Two, 1 and 17 strains showed significances at 1% and 5% levels and no significance even at 5% level, respectively. In the whole strains, c.c. was −0.3895 to the degree of freedom of 18, showing no significance even at 5% level.

3. Comparative values of width and thickness

C.c. and l.r. of T on W in the same strains were calculated, and are shown in the right column of Table 1. Two, 3, 1 and 14 strains showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. In the whole strains, c.c. was +0.8061 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the larger is the comparative value of W, the larger is the comparative value of T. L.r. of W on T was calculated as follows; Y=0.510X+0.471, where Y and X indicate the comparative values of W and T, respectively. This formula indicates that the comparative value of W becomes 0.510 larger, when the comparative value of T becomes larger by 1 degree.

Table 2. Correlation coefficient and linear regression of the three components; comparative values of ratio of length to thickness (Y) on ratio of length to width (X), comparative values of ratio of width to thickness (Y) on ratio of length to width (X), and comparative values of ratio of width to thickness (Y) on ratio of length to thickness (X)

Strain No.	L/W and L/T		L/W and W/T		L/T and W/T	
	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression
1	0.4377*	Y=0.351X+0.500	−0.6118***	Y=−0.675X+1.513	0.4273*	Y=0.588X+0.470
2	0.1643	—	−0.8727***	Y=−0.998X+1.773	0.3082	—
3	0.2351	—	−0.7590***	Y=−0.978X+1.751	0.4186*	Y=0.732X+0.349
4	0.1569	—	−0.7753***	Y=−1.189X+1.943	0.0283	—
5	0.7475***	Y=0.859X+0.047	−0.0091	—	0.6422***	Y=0.486X+0.536
6	0.7993***	Y=0.826X−0.412	−0.7470***	Y=−0.413X+0.499	0.6578***	Y=0.315X+0.625
7	0.6811***	Y=0.747X+0.051	−0.7111***	Y=−0.840X+1.881	0.5702**	Y=0.953X+0.560
8	0.1132	—	−0.7351***	Y=−0.849X+1.673	0.3532	—
9	0.7000***	Y=0.247X+0.488	−0.6896***	Y=−0.942X+1.581	0.6888***	Y=0.665X+0.419
10	0.7710***	Y=0.855X+0.051	−0.7711***	Y=−0.943X+1.553	0.6135***	Y=0.954X+0.222
11	0.0354	—	−0.3992*	Y=−0.617X+1.458	0.3401	—
12	0.6856***	Y=0.473X+0.369	−0.6379***	Y=−0.544X+1.374	0.0126	—
13	0.4256*	Y=0.322X+0.520	−0.6047***	Y=−0.597X+1.442	0.2662	—
14	0.6406***	Y=0.769X+0.144	−0.2025	—	0.5723***	Y=0.484X+0.560
15	−0.1392	—	−0.7043***	Y=−0.843X+1.805	0.7988***	Y=0.904X−0.050
16	0.1899	—	−0.8248***	Y=−0.942X+1.758	0.3547	—
17	0.2979	—	−0.4556*	Y=−0.757X+1.553	0.6495***	Y=0.953X+0.202
18	0.4433*	Y=0.247X+0.559	−0.7668***	Y=−0.705X+1.510	0.7336***	Y=0.218X+0.761
19	0.5755***	Y=0.339X+0.497	−0.7893***	Y=−0.711X+1.528	0.0178	—
20	0.4153*	Y=0.261X+0.521	−0.7209***	Y=−0.740X+1.506	0.3077	—

d. f.=28

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

4. Comparative values of L/W and L/T

C.c. and l.r. of L/T on L/W in the same strains were calculated, and are shown in the left column of Table 2. Eight, 4 and 8 strains showed significances at 0.1% and 5% levels and no significance even at 5% level, respectively. In the whole strains, c.c. was +0.1114 to the degree of freedom of 18, showing no significance even at 5% level.

5. Comparative values of L/W and W/T

C.c. and l.r. of W/T on L/W in the same strains were calculated, and are shown in the central column of Table 2. Sixteen, 2 and 2 strains showed significances at 0.1% and 5% levels and no significance even at 5% level, respectively. In the whole strains, c.c. was −0.0698 to the degree of freedom of 18, showing no significance even at 5% level.

6. Comparative values of L/T and W/T

C.c. and l.r. of W/T on L/T in the same strains were calculated, and are shown in the right column of Table 2. Eight, 1, 2 and 9 strains showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. In the whole strains, c.c. was −0.0244 to the degree of freedom of 18, showing no significance even at 5% level.

Table 3. Correlation coefficient and linear regression of the three characters of unhusked (Y) on husked (X) grains; length, width and thickness

Strain No.	Length		Width		Thickness	
	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression
1	0.6122***	Y=0.654X+0.607	0.5942***	Y=0.571X+0.867	0.8463***	Y=0.833X+0.142
2	0.7833***	Y=0.554X+1.266	0.5267**	Y=0.358X+1.266	0.7697***	Y=0.707X+0.363
3	0.9103***	Y=0.673X+0.285	0.5898***	Y=0.430X+1.216	0.9213***	Y=0.917X−0.021
4	0.8952***	Y=0.542X+1.627	0.7760***	Y=0.557X+0.869	0.9401***	Y=0.879X+0.051
5	0.6331***	Y=0.343X+3.222	0.9598***	Y=0.621X+0.659	0.8023***	Y=0.824X+0.177
6	0.6296***	Y=0.611X+3.341	0.6625***	Y=1.182X+1.323	0.8013***	Y=0.880X+0.621
7	0.6135***	Y=0.337X+0.998	0.8129***	Y=0.563X+1.000	0.8721***	Y=0.781X+0.364
8	0.9060***	Y=0.646X+0.749	0.6304***	Y=0.347X+1.485	0.8950***	Y=0.754X+0.317
9	0.7692***	Y=0.660X+2.111	0.6031***	Y=0.798X+0.368	0.8026***	Y=0.953X+0.087
10	0.8004***	Y=0.308X+3.004	0.7595***	Y=0.667X+0.350	0.8111***	Y=1.002X−0.100
11	0.6792***	Y=0.633X+0.631	0.8528***	Y=0.740X+0.245	0.8556***	Y=0.810X+0.174
12	0.6692***	Y=0.406X+2.739	0.7957***	Y=0.730X+0.333	0.9170***	Y=1.025X−0.273
13	0.8921***	Y=0.655X+0.585	0.6827***	Y=0.630X+0.600	0.9041***	Y=0.876X+0.065
14	0.8915***	Y=0.749X−0.330	0.9150***	Y=0.646X+0.561	0.9062***	Y=0.873X+0.051
15	0.8092***	Y=0.455X+2.168	0.6003***	Y=0.565X+0.187	0.6137***	Y=0.418X+0.239
16	0.9570***	Y=0.660X+0.646	0.7962***	Y=0.521X+0.928	0.9448***	Y=0.978X−0.164
17	0.9030***	Y=0.652X+0.386	0.8859***	Y=0.795X+0.155	0.8762***	Y=1.000X−0.210
18	0.8922***	Y=0.542X+1.452	0.8163***	Y=1.028X−0.607	0.9665***	Y=0.968X−0.140
19	0.8416***	Y=0.555X+1.270	0.8559***	Y=0.756X+0.290	0.9863***	Y=0.953X−0.100
20	0.7699***	Y=0.403X+2.226	0.6405***	Y=1.184X−1.410	0.8515***	Y=0.609X+0.670

d. f.=28

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

7. Lengths of UHG and HG

C.c. and l.r. of L of HG on L of UHG in the same strains were calculated, and are shown in the left column of Table 3. The whole strains (=20) showed significances at 0.1% level. In the whole strains, c.c. was +0.9586 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the longer is the L of UHG, the longer is the L of HG. L.r. of L of UHG on L of HG was calculated as follows; Y=0.671X+0.315, where Y and X indicate L of UHG and L of HG, respectively. This formula indicates that the L of UHG becomes 0.671 mm longer, when the L of HG becomes longer by 1 degree.

8. Widths of UHG and HG

C.c. and l.r. of W of HG on W of UHG in the same strains were calculated, and are shown in the central column of Table 3. Nineteen and 1 strains showed significances at 0.1% and 1% levels, respectively. In the other words, the whole strains (=20) showed significances in high level. In the whole strains, c.c. was +0.8457 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the wider is the W of UHG, the wider is the W of HG. L.r. of W of UHG on W of HG was calculated as follows; Y=0.804X+0.064, where Y and X indicate W of UHG and W of HG, respectively. This formula indicates that the W of UHG becomes 0.804 mm wider, when the W of HG becomes wider by 1 degree.

9. Thicknesses of UHG and HG

C.c. and l.r. of T of HG on T of UHG in the same strains were calculated, and are shown in the right column of Table 3. The whole strains (=20) showed significances at 0.1% level. In the whole strains, c.c. was +0.9159 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the thicker is the T of UHG, the thicker is the T of HG. L.r. of T of UHG on T of HG was calculated as follows; Y=1.085X−0.399, where Y and X indicate T of UHG and T of HG, respectively. This formula indicates that the T of UHG becomes 1.085 mm thicker, when the T of HG becomes thicker by 1 degree.

10. L/W of UHG and HG

C.c. and l.r. of L/W of HG on L/W of UHG in the same strains were calculated, and are shown in the left column of Table 4. The whole strains (=20) showed significances at 0.1% level. In the whole strains, c.c. was +0.7365 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the larger is L/W of UHG, the larger is the L/W of HG. L.r. of L/W of UHG on L/W of HG was calculated as follows; Y=0.673X+0.549, where Y and X indicate L/W of UHG and L/W of HG, respectively. This formula indicates that the L/W of UHG becomes 0.673 larger, when the L/W of HG becomes larger by 1 degree.

11. L/T of UHG and HG

C.c. and l.r. of L/T of HG on L/T of UHG in the same strains were calculated, and are shown in the central column of Table 4. Eighteen and 2 strains showed significances at 0.1% and 1% levels, respectively. In the other words, the whole strains (=20) showed significances in high level. In the whole strains, c.c. was +0.8280 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the larger is the L/T of UHG, the larger is the L/T of HG. L.r. of L/T of UHG on L/T of HG was calculated as follows; Y=0.833X−0.176, where Y and X indicate L/T of UHG and L/T of HG, respectively. This formula indicates that the L/T

Table 4. Correlation coefficient and linear regression of the three characters of unhusked (Y) on husked (X) grains; ratio of length to width, ratio of length to thickness, and ratio of width to thickness

Strain No.	Length/Width		Length/Thickness		Width/Thickness	
	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression
1	0.6181***	Y=0.581X+0.792	0.7153***	Y=0.725X+0.332	0.7834***	Y=0.897X+0.065
2	0.6364***	Y=0.478X+1.158	0.8093***	Y=0.679X+0.468	0.6378***	Y=0.491X+0.607
3	0.7236***	Y=0.508X+0.933	0.8709***	Y=0.781X−0.003	0.8107***	Y=0.877X+0.062
4	0.7861***	Y=0.580X+0.811	0.7699***	Y=0.442X+1.540	0.6259***	Y=0.614X+0.450
5	0.7520***	Y=0.467X+1.071	0.6070***	Y=0.471X+1.247	0.9036***	Y=0.998X−0.125
6	0.7227***	Y=0.696X−1.003	0.9075***	Y=0.473X−1.145	0.9575***	Y=1.015X−0.973
7	0.7861***	Y=0.517X+0.843	0.7679***	Y=0.711X−0.469	0.8000***	Y=0.978X−0.724
8	0.7069***	Y=0.418X+1.326	0.8772***	Y=0.704X+0.434	0.7619***	Y=0.518X+0.596
9	0.7510***	Y=0.671X+0.481	0.8072***	Y=0.623X+0.275	0.7183***	Y=0.613X+0.222
10	0.7001***	Y=0.675X+0.830	0.8000***	Y=0.725X+0.440	0.8442***	Y=0.600X+0.324
11	0.8191***	Y=0.846X+0.025	0.5254**	Y=0.575X+0.878	0.7810***	Y=0.772X+0.216
12	0.6312***	Y=0.494X+1.014	0.7515***	Y=0.613X+0.629	0.8779***	Y=0.889X+0.053
13	0.7609***	Y=0.623X+0.780	0.8824***	Y=0.615X+0.827	0.8484***	Y=0.978X−0.057
14	0.8673***	Y=0.866X−0.083	0.7947***	Y=0.796X−0.032	0.9135***	Y=0.863X+0.110
15	0.7834***	Y=0.855X−1.745	0.4888**	Y=0.420X+0.370	0.4784**	Y=0.678X+0.528
16	0.8733***	Y=0.596X+0.873	0.9138***	Y=0.785X+0.124	0.8649***	Y=0.798X+0.215
17	0.9194***	Y=0.790X+0.092	0.8984***	Y=0.828X−0.275	0.8540***	Y=0.975X−0.061
18	0.8640***	Y=0.805X+0.060	0.9327***	Y=0.694X+0.297	0.9000***	Y=1.147X−0.313
19	0.6628***	Y=0.571X+0.676	0.9175***	Y=0.823X−0.155	0.9263***	Y=0.937X−0.009
20	0.5912***	Y=0.550X+0.605	0.8337***	Y=0.513X+0.826	0.2923	—

d. f.=28
***, **; significant at 0.1% and 1% levels, respectively

of UHG becomes 0.833 larger, when the L/T of HG becomes larger by 1 degree.

12. W/T of UHG and HG

C.c. and l.r. of W/T of HG on W/T of UHG in the same strains were calculated, and are shown in the right column of Table 4. Eighteen, 1 and 1 strains showed significances at 0.1% and 1% levels and no significance even at 5% level, respectively. In the whole strains, c.c. was + 0.8059 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the larger is the W/T of UHG, the larger is the W/T of HG. L.r. of W/T of UHG on W/T of HG was calculated as follows; Y=0.715X+0.292, where Y and X indicate W/T of UHG and W/T of HG, respectively. This formula indicates that the W/T of UHG becomes 0.715 larger, when the W/T of HG becomes larger by 1 degree.

13. Areas of UHG and HG

C.c. and l.r. of area of HG on area of UHG in the same strains were calculated, and are shown in the left column of Table 5. Nineteen and 1 strains showed significances at 0.1% and 1% levels, respectively. In the other words, the whole strains (=20) showed significances in high level. In the whole strains, c.c. was +0.9346 to the degree of freedom of 18, which is obviously

Table 5. Correlation coefficient and linear regression of the three components; area of husked grain (Y) on area of unhusked grain (X), volume of husked grain (Y) on volume of unhusked grain (X), and quotient of volume (Y) on quotient of area (X)

Strain No.	Area		Volume		Quotient	
	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression
1	0.5790***	Y=0.500X+3.203	0.7031***	Y=0.440X+6.588	0.8604***	Y=0.924X−0.013
2	0.5763***	Y=0.300X+6.467	0.5972***	Y=0.289X+10.274	0.9215***	Y=0.853X+0.024
3	0.6964***	Y=0.429X+3.986	0.8678***	Y=0.463X+3.723	0.3224	—
4	0.8271***	Y=0.424X+5.142	0.8768***	Y=0.423X+7.690	0.9212***	Y=0.925X−0.014
5	0.8567***	Y=0.404X+5.157	0.8360***	Y=0.375X+9.695	0.8158***	Y=1.107X−0.119
6	0.8750***	Y=0.518X+2.421	0.8644***	Y=0.665X+9.049	0.9606***	Y=1.345X−0.267
7	0.7743***	Y=0.409X+3.200	0.8111***	Y=0.519X+4.905	0.8658***	Y=0.921X−0.311
8	0.7343***	Y=0.366X+6.846	0.8136***	Y=0.413X+8.641	0.8865***	Y=0.947X−0.027
9	0.7700***	Y=0.411X+4.444	0.7002***	Y=0.389X+6.723	0.7066***	Y=0.684X−0.048
10	0.9001***	Y=0.338X+4.315	0.8033***	Y=0.359X+6.480	0.7111***	Y=0.800X−0.030
11	0.8388***	Y=0.481X+2.446	0.7969***	Y=0.397X+5.949	0.8114***	Y=0.849X+0.028
12	0.8419***	Y=0.515X+1.748	0.8633***	Y=0.532X−1.106	0.8495***	Y=0.889X−0.007
13	0.8669***	Y=0.591X+0.321	0.8922***	Y=0.549X−0.350	0.8536***	Y=0.929X−0.017
14	0.9052***	Y=0.499X+2.178	0.9254***	Y=0.470X+2.893	0.8060***	Y=0.916X−0.011
15	0.5459**	Y=0.355X+4.759	0.6785***	Y=0.400X+3.125	0.5922***	Y=0.670X+0.048
16	0.8994***	Y=0.520X+2.768	0.9328***	Y=0.516X+2.382	0.3731*	Y=0.242X+0.410
17	0.8565***	Y=0.535X+1.498	0.8127***	Y=0.490X+2.722	0.7733***	Y=1.014X−0.062
18	0.7170***	Y=0.488X+2.777	0.8365***	Y=0.488X+2.573	0.8705***	Y=0.853X+0.031
19	0.9142***	Y=0.546X+1.434	0.9469***	Y=0.495X+2.873	0.9556***	Y=0.821X+0.051
20	0.6585***	Y=0.486X+1.652	0.7827***	Y=0.447X+2.687	0.8819***	Y=0.944X−0.023

d. f.=28

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

significant at 0.1% level. Generally speaking, the wider is the area of UHG, the wider is the area of HG. L.r. of area of UHG on area of HG was calculated as follows; Y=0.542X+1.234, where Y and X indicate area of UHG and area of HG, respectively. This formula indicate that the area of UHG becomes 0.542 mm^2 wider, when the area of HG becomes wider by 1 degree.

14. Volumes of UHG and HG

C.c. and l.r. of volume of HG on volume of UHG in the same strains were calculated, and are shown in the central column of Table 5. The whole strains (=20) showed significances at 0.1% level. In the whole strains, c.c. was +0.9542 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the larger is the volume of UHG, the larger is the volume of HG. L.r. of volume of UHG on volume of HG was calculated as follows; Y=0.521X+0.451, where Y and X indicate volume of UHG and volume of HG, respectively. This formula indicates that the volume of UHG becomes 0.521 mm^3 larger, when the volume of HG becomes larger by 1 degree.

15. Quotients of area and volume

C.c. and l.r. of quotient of volume on quotient of area in the same strains were calculated, and are shown in the right column of Table 5. Eighteen, 1 and 1 strains showed significances at 0.1% and 5% levels and no significance even at 5% level, respectively. In the whole strains, c.c. was +0.9379 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the larger is the quotient of area, the larger is the quotient of volume. L.r. of quotient of area on quotient of volume was calculated as follows; $Y=1.082X-0.109$, where Y and X indicate quotient of area and quotient of volume, respectively. This formula indicates that the quotient of area becomes 1.082 larger, when the quotient of volume becomes larger by 1 degree.

Discussion

Basing on the results obtained in the previous[9] and the present experiments, the following problematic items are to be discussed here.

1. C.c. of the respective character-combinations in the strain level were fixed to be significant in 354 cases of 540 combinations of the whole cases (=20 strains×27 character-combinations) (Table 6). In detail, some characteristics were found. Significant correlations in the strain level were accounted as follows in the order of the combination numbers from 1 to 27; 7, 8, 5; 9, 17, 13; 4, 6, 5; 11, 20, 18; 3, 3, 6; 12, 18, 11; 20, 20, 20; 20, 20, 19; 20, 20, 19 strains, respectively. It may be noticed that the values were particularly larger in the combination numbers 5, 11, 12, 17 and Nos. 19~27. Average value and its s.d. through the whole combinations were found to be 39.33±18.29.

The whole combinations were divided into 2 groups, *i.e.*, group I (combination Nos. 1~18) and group II (Nos. 19~27). Significant correlations were accounted as 48.9% (=176/360) and 98.9% (=178/180) in groups I and II, respectively. Those averages and their s.ds. through the whole combinations within groups were found to be 29.33±14.20 and 59.33±0.47 in group I and group II, respectively. Moreover, group I was re-divided into 6 sub-groups as follows; sub-group-1 (combination Nos. 1~3), sub-2 (Nos. 4~6), sub-3 (Nos. 7~9), sub-4 (Nos. 10~12), sub-5 (Nos. 13~15) and sub-6 (Nos. 16~18). Significant correlations were accounted as follows in the order from sub-1 to sub-6; 33.3% (=20/60), 65.0% (39/60), 25.0% (15/60), 81.7% (49/60), 20.0% (12/60) and 68.3% (41/60), respectively. It was ascertained that subs-2, -4 and -6, *i.e.*, ratio-columns, showed the higher significances [71.7% (129/180)] in comparison with those of subs-1, -3 and -5 [26.1% (47/180)]. It might be attributed to gene actions. And those differences found might be seen as specificities of character or character-combination. Those averages and their s.ds. through the whole combinations within sub-groups were found to be 43.00±4.32 and 15.67±3.30 in the higher and in the lower sub-groups, respectively.

2. The respective strains showed significant correlations as follows in the order from strain No. 1 to No. 20; 17, 14, 14, 13, 18, 25, 23, 14, 23, 25, 14, 14, 16, 19, 21, 17, 17, 17, 17, 16, respectively. It was noticeable that the strain Nos. 6 and 10 showed significances in 25/27 combinations (=92.6% in the whole character-combinations), and Nos. 7 and 9 showed significances in 23/27 combinations (=85.2% in the whole). On the other hand, No. 4 showed significances only in 13/27 combinations (=48.2% in the whole), and Nos. 2, 3, 8, 11 and 12 showed significances only in 14/27 combinations (=51.9% in the whole). Two, 2, 1, 1, 1, 5, 2, 5 and 1 strains showed significances in 25, 23, 21, 19, 18, 17, 16, 14 and 13 character-combinations, respectively. Average value and its s.d. through the whole strains were found to be 17.70±3.70.

3. Significant correlations were analysed in the positive or the negative statuses as well as in

Table 6. Summed-up table showing correlation coefficients in the 27 character-combinations; data of Nos. 1～12 and Nos. 13～27 cited from the previous[9] and the present papers, respectively

	Combination Nos.	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	26	27
	Character Nos.	1·2	1·3	2·3	4·5	4·6	5·6	11·12	11·13	12·13	14·15	14·16	15·16	21·22	21·23	22·23	24·25	24·26	25·26	1·11	2·12	3·13	4·14	5·15	6·16	31·33	32·34	35·36
Strain No.	1		*			***	***					***	***				*	***	*	***	***	***	***	***	***	***	***	***
	2					***					*	***	*					***		***	**	***	***	***	***	***	***	***
	3					***	***					**	***					***	*	***	***	***	***	***	***	***	***	
	4					***						**	**					***		***	***	***	***	***	***	***	***	***
	5				*	**		*	*			***	***			**	***		***	***	***	***	***	***	***	***	***	***
	6	***	***	*	***	*		*		***	***	**	***	***	**	***	***	***	***	***	***	***	***	***	***	***	***	***
	7	*		**		***	***		*	***	*	**	***	**		*	***	***	**	***	***	***	***	***	***	***	***	***
	8					***	**					**	***					***		***	***	***	***	***	***	***	***	***
	9	**	*	*	*	***	***				*	**	***		**	***	***	***	***	***	***	***	***	***	***	***	***	***
	10		**	*	***	***	***		*	***	*	***	***	*	*	**	***	***	***	***	***	***	***	***	***	***	***	***
	11					***	***					***	*					*		***	***	***	***	**	***	***	***	***
	12						**					***	***				***	***		***	***	***	***	***	***	***	***	***
	13				***		**				*	**	***				*	***		***	***	***	***	***	***	***	***	***
	14	**	**			***	***		*		*	**	***				***		***	***	***	***	***	***	***	***	***	***
	15	***	**			***	***	*	***	***	***	***	***					***	***	***	***	***	***	***	**	**	***	***
	16	*	*		*	***			*			***	**					***		***	***	***	***	***	***	***	***	*
	17				**	**	**				*	*	***					*	***	***	***	***	***	***	***	***	***	***
	18				***	***					**	***				**	*	***	***	***	***	***	***	***	***	***	***	***
	19	**	*			***		**				***	***				***	***		***	***	***	***	***	***	***	***	***
	20			*	***		**			***	***	**					*	***		***	***	***	***	***		***	***	***
	Total		***	*	***	***				***	***	**				***				***	***	***	***	***	***	***	***	***
Whole	B type				**	*		**			***									**	***	***	***	***	***		**	***
	C type				***	*				***	***					***				***	*	***	*	***	*	***	***	***

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 area (=33/31), 36-quotient of volume (=34/32)

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

d. f.; 5 in type B, 11 in type C and 18 in the whole, respectively

the degree of the respective status. Significant correlations were accounted as follows in the order of 0.1% levels (positive, negative and the whole), 1% levels (positive, negative and the whole) and 5% levels (positive, negative and the whole); 231 (65.3%), 40 (11.3%), 271 (76.6%); 28 (7.9%), 11 (3.1%), 39 (11.0%); 38 (10.7%), 6 (1.7%), 44 (12.4%).

It might be a noticeable phenomenon that about three fourths (76.6%) of them showed significant combinations at 0.1% level. It might have meant those biological actions, which were 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, and they were exhibited independently on the other characters. The positive and the negative combinations in the total were accounted as 297 combinations (=83.9%) and 57 combinations (=16.1%), respectively. Nearly the same pattern was found in the case of the strains collected in Madura, Indonesia[7].

Negative correlations were found in the strain level in some combinations, though positive correlations were found in the most strains in the same character-combinations, *vice versa*. Two cases were found, *i.e.*, strain No. 15, combination 11·12; strain No. 16, combination 1·2. In the strains of Madura[7], 6 cases were found. Unfortunately, those unnatural facts and discrepancies are not to be fully explained at the present time. It was, however, an interesting phenomenon concerning strain differentiations. Those phenomena may be attributed to the actions of the respective genes concerned through the whole events.

4. According to the tripartite classification[10], correlation coefficients of the respective characters in the strain level were fixed to be significant in 122/189 cases (=64.4%) and 232/351 cases (=66.1%) in type B (=7 strains) and type C (=13 strains), respectively. There was no clear difference between the two types. Those averages and their s.ds. through the whole combinations within types were found to be 13.56±6.88 and 25.78±11.62, respectively.

In detail, significant correlations were accounted as 92 cases (=48.7%), 14 cases (=7.4%) and 16 cases (=8.5%) at 0.1%, 1% and 5% levels, respectively, in type B. Those were accounted as 179 cases (=51.0%), 25 cases (=7.1%) and 28 cases (=8.0%) at 0.1%, 1% and 5% levels, respectively, in type C. No clear difference was also ascertained between the two types.

In type B, significant correlations were composed by positive and negative statuses in 104 cases (=85.2%) and 18 cases (=14.8%), respectively. In type C, they consisted in 193 cases (=83.2%) and 39 cases (=16.8%), respectively. No clear difference was also found between two types.

In the whole strains within type, significant correlations were ascertained as follows in the order of 0.1% levels (positive, negative and the whole), 1% levels (positive, negative and the whole) and 5% levels (positive, negative and the whole); type B (7 strains, d. f.=5)···7 (=7/27 =25.9%), 0, 0; 3 (=11.1%), 1 (=3.7%), 0; 0, 1 (=3,7%), 0; type C (13 strains, d. f.=11)···10 (=37.0%), 0, 0; 0, 0, 0; 3 (=11.1%), 1 (=3.7%), 0; both of the types B and C (20 strains, d. f.= 18)···14 (=51.9%), 1 (=3.7%), 0; 0, 1 (=3.7%), 0; 1 (=3.7%), 0, 0.

5. As the whole strains, some detailed considerations were paid before making the tripartite classifications. In type B, significant correlations were accounted as 47.6% (=60/126) and 98.4% (=62/63) in group I (combination Nos. 1~18) and group II (combination Nos. 19~27), respectively. Those averages and their s.ds. through the whole combinations within groups were found to be 10.00±5.75 and 20.67±0.47 in group I and group II, respectively. Moreover, significant correlations were accounted as follows in the order from sub-1 to sub-6; 19.1% (4/21), 66.7% (14/21), 23.8% (5/21), 76.2% (16/21), 19.1% (4/21), 81.0% (17/21), respectively. It was ascertained that subs-2, -4 and -6, *i.e.*, ratio columns, showed higher significances [74.6% (47/63)] in comparison with those of subs-1, -3 and -5 [20.6% (13/63)]. It might be attributed to gene actions. These detected differences found might be looked upon as the specificity of character or character-combinations. Those averages and their s.ds. through the whole combinations within sub-groups were found to be 15.67±1.25 and 4.33±0.47 in the higher and the lower sub-groups, respectively.

In type C, significant correlations were accounted as 49.6% (=116/234) and 99.2% (=116/117) in group I and group II, respectively. Those averages and their s.ds. through the whole combinations within groups were found to be 19.33±8.83 and 38.67±0.47, respectively. Moreover, significant correlations were accounted as follows in the order from sub-1 to sub-6; 41.0%

(16/39), 64.1% (25/39), 25.6% (10/39), 84.6% (33/39), 20.5% (8/39) and 61.5% (24/39), respectively. It was also ascertained that subs-2, -4 and -6, *i.e.*, ratio columns, showed higher significances [70.1% (82/117)] in comparison with those of subs-1, -3 and -5 [29.1% (34/117)]. Those averages and their s.ds. through the whole combinations within sub-groups were found to be 27.33±4.03 and 11.33±3.40 in the higher and the lower sub-groups, respectively.

6. The three strains showing relatively larger values in correlation coefficient were picked-up in the whole character-combinations (=27), regardless of the positive or the negative and significant or non-significant statuses. The respective strains showed the following numbers of the larger values in the order from strain No. 1 to No. 20; 0, 2, 1, 0, 3, 12, 3, 1, 5, 11, 3, 1, 0, 7, 8, 6, 2, 3, 10, 3, respectively. The highest frequency (=12) was obtained in strain No. 6, followed by No. 10 (11) and No. 19 (10). The lowest frequency (=0) was noted in Nos. 1, 4 and 13. Average and its s.d. through the whole strains were found to be 4.05±3.65.

In the larger sets of values, the largest one (0.5315 in combination No. 14 and 0.8764 in combination No. 15) were obtained in strain No. 6, followed by No. 9 (0.5089 in combination No. 14 and 0.6100 in combination No. 15) and No. 10 (0.4111 in combination No. 14 and 0.5511 in combination No. 15). These orders of strains were fixed to be the same both in the character-combination No. 14 (=comparative values of length and thickness) and in character-combination No. 15 (=comparative values of width and thickness). This phenomenon was found only in one case.

On the other hand, some sets of strains did not show the same order, but showed the same combinations, which meant the same strain numbers regardless of orders. Two cases were ascertained as follows; ① 6·15·19 in the larger sets···combination No. 1 (L of UHG and W of UHG) [15>6>19] and combination No. 7 (L of HG and W of HG) [19>15>6]; ② 16·18·19 in the larger sets···combination No. 21 (T of UHG and T of HG) [19>18>16] and combination No. 23 (L/T of UHG and L/T of HG) [18>19>16].

7. The three strains showing relatively smaller values were picked-up in the whole combinations (=27), regardless of the positive or the negative and significant or non-significant statuses. The respective strains showed the following numbers of the smaller values in the order from strain No. 1 to No. 20; 6, 7, 4, 4, 3, 3, 1, 6, 1, 1, 5, 4, 5, 2, 7, 2, 3, 3, 7, 7, respectively. The highest frequency (=7) was obtained in strain Nos. 2, 15, 19 and 20. The lowest frequency (=1) was noted in strain Nos. 7, 9 and 10. Average and its s.d. through the whole strains were found to be 4.05±2.06. It was noticed that the value of s.d. (=2.06) was remarkably smaller than those of the larger case (=3.65).

The same order and the same combination were not found at all.

8. The strains showing the relatively larger and smaller values were summed-up in the respective combinations, regardless of the positive or the negative and significant or non-significant statuses. The respective strains showed the following numbers in the order from strain No. 1 to No. 20; 6, 9, 5, 4, 6, 15, 4, 7, 6, 12, 8, 5, 5, 9, 15, 8, 5, 6, 17, 10, respectively. The highest frequency (=17) was obtained in strain No. 19, followed by Nos. 6 and 15 (=15). The lowest frequency (=4) was noted in strain Nos. 4 and 7. Average and its s.d. through the whole strains were found to be 8.10±3.78. It was noticeable that the value of s.d. was very large.

9. From the data mentioned in the previous 3 chapters, c.c. and l.r. of the respective character-combinations were calculated and the following facts were found. C.c. of numbers of strains showing the larger and the smaller values were found to be −0.2195 to the degree of freedom 18, showing no significance even at 5% level.

C.c. of the numbers of strains showing the larger values and the total strains (=larger+smaller) was +0.8468 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the more is the number of strains showing the larger values, the more is the numbers of the total strains. L.r. of the numbers of strains showing the larger values on the numbers of the total strains was calculated as follows; $Y=0.876X+4.551$, where Y and X indicate the number of strains showing larger values and the total strains, respectively. This formula indicates that the number of strains showing the larger values becomes 0.876 more, when the number of total strains becomes more by 1 degree.

C.c. of the number of strains showing the smaller values and the total strains was +0.3331 to the degree of freedom of 18, showing no significance even at 5% level.

In the strains of India's cultivars[5], of Burma[6] and the present materials, non-significant, significant at 0.1% level and non-significant correlations were ascertained between larger and smaller, larger and total, and smaller and total, respectively. On the other hand, strains of Madura[7] showed non-significant, significant at 0.1% level and significant at 0.1% level correlations in the same order, respectively. These differences were explained as geographical and ecotypic differentiations. Moreover, it may be concluded as character specificity to show the non-significance between the larger and the smaller values through the whole materials used.

Summary

Succeeding to the previous papers, some morphological studies on grain characters and considerations on ecotypic differentiation of 20 strains of cultivated rice species, *Oryza sativa* L., collected in Fiji, South Pacific, in 1982, were reported in the present paper. The results obtained here were summarized as follows:

Concerning correlation coefficients among 15 character-combinations, 231/300 cases (=77.0%) showed significant relationships through the whole cases.

From the previous and the present experiments, concerning correlation coefficients among 27 character-combinations, 354/540 cases (=65.6%) showed significant relationships through the whole cases. The whole combinations were divided into 2 groups in view of the correlation-occurrence-frequencies, *i.e.*, group I (character-combination Nos. 1~18) and group II (Nos. 19~27). Significant correlationships were accounted as 48.9% (176/360 cases) and 98.9% (178/180 cases) in group I and group II, respectively. Those averages and their s.ds. through the whole combinations within the groups were found to be 29.33 ± 14.20 and 59.33 ± 0.47, respectively, and 39.33 ± 18.29 in the whole cases.

According to the tripartite classification, type B (=7 strains) and type C (=13 strains) showed significances in 122/189 cases (=64.6%) and 232/351 cases (=66.1%), respectively. No clear difference between them was found at all.

The three strains showing relatively larger and smaller values in the correlation coefficients were picked-up in the respective correlation-combinations (=27), regardless of the positive or the negative statuses. These characteristics and techniques confirmed in the experiments were to be looked upon as something useful, having some universal validities in the experiments of strain-differentiations.

Moreover, some new techniques, by which correlation coefficients and linear regressions based on the respective character-combinations were re-calculated in view of correlation between them, were adopted. Although some findings were ascertained, some problems were remained,

and further experiments might be requested.

References

1) Abassi, F. M., Sagar, M. A. and Rabbani, A.: Stability for yield of medium-long-grain varieties and advanced lines. *Intern. Rice Res. Newsletter,* **16**(1), 9 (1991)
2) Annual Report for the Year 1979, 1981: Parliamentary Report No. 14 of 1981. Ministry of Agriculture and Fisheries, Fiji (1981)
3) Annual Research Report 1981: Department of Agriculture, Fiji (1981)
4) Katayama, T. C.: Morphological characters of the cultivated rice grains of Fiji. *Kagoshima Univ. Res. Center South Pacific, Occasional Papers,* **5**, 117–134 (1985)
5) Katayama, T. C.: Some morphological characters of the cultivated rice grains collected in India (V). *Mem. Fac. Agr. Kagoshima Univ.,* **22**, 1–17 (1986)
6) Katayama, T. C.: Morphological characters of the cultivated rice grains of Burma (IV). *Mem. Fac. Agr. Kagoshima Univ.,* **24**, 21–36 (1988)
7) Katayama, T. C.: Morphological characters of the cultivated rice grains of Madura, Indonesia (IV). *Mem. Fac. Agr. Kagoshima Univ.,* **26**, 29–42 (1990)
8) Katayama, T. C.: Morphological characters of the cultivated rice grains of Fiji (II). *Mem. Fac. Agr. Kagoshima Univ.,* **26**, 43–63 (1990)
9) Katayama, T. C.: Morphological characters of the cultivated rice grains of Fiji (III). *Mem. Fac. Agr. Kagoshima Univ.,* **27**, 33–40 (1991)
10) Matsuo, T.: Genecological studies on the cultivated rice (in Japanese with English Summary). *Bull. Nat. Inst. Agr. Sci. Series D* **3**, 1–111 (1952)
11) Paramasivan, K. S., Thyagarajan, A., Nilakantapillai, K. and Ranganathan, T. B.: TM6012, a short-duration rainfed rice. *Intern. Rice Res. Newsletter,* **15**(2), 21 (1990)
12) Stapley, J. H.: The rice leaf roller in the Soloman Islands. *Intern. Rice Res. Newsletter,* **3**(1), 13 (1978)