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# Morphological Characters of the Cultivated Rice Grains of Fiji (Ⅲ)

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## Introduction

In the 1982 academic year, the Kagoshima University Research Center for the South Pacific carried out the second-year's research in Fiji and Solomon Islands. This project examined the ecological, ethnological and bio-productive features of the natural environment, as well as the resources in Fiji and Solomon Islands. The present author was joined in researching the agricultural sciences, *i.e.*, agricultural productivity, cultural pattern, pathological and physiological conditions, land-use practices in tropical areas.

As a part of the project, 20 strains of cultivated rice, *Oryza sativa* L., used in Fiji were collected. Most of them were delivered him through the kindness of Dr. S.A. HAQUE, and some of them were directly collected in the fields by the members of the party. The grains of these strains were used for the morphological studies. The main purposes are to clarify the varietal variations and the phylogenetic relationships of the cultivated-rice-grains (=cultivars), used in the South Pacific region.

Rice cultivation in Fiji had been started in Navua areas in the late 19th century[4]. Cultivation areas were increased from year by year by Indo-Fijians[1]. Many items were considered to be a counterplan for the advancement of rice production[2]. In other island of South Pacific region, Solomon Islands, extensive researches have also been carried out from the several aspects[11].

The present experimental series have been made to search the varietal variations, taking historical and racial improvements into considerations.

In the previous papers, the records of morphological characters of the unhusked and the husked grains, variation range in 12 characters[7], and comparisons of the unhusked and the husked grains in 12 characters and the variation ranges in 12 characters[10], were reported, in order to confirm the morphological characters of grains which were to make the strain's specificities clear.

In the present paper, correlation coefficients between the practical values of the unhusked and the husked grains and linear regressions between these were mainly described.

## Materials and Methods

Twenty strains of rice cultivars, *Oryza sativa* L., collected in Fiji, between 15°S to 22°S, and between 174°E to 174°W, in South Pacific, during the trip were used in this experimental series. They were listed up in Table 1 of the previous paper[10]. In that table, strain number, ordinary sowing and harvesting times in the respective sites and some remarks were 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 the two were calculated through the whole characters, *i.e.*, the unhusked grains (Tables 1 and 2) and the husked grains (Tables 3 and 4).

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

## Results

### 1. Length and width of UHG

Correlation coefficient (abbreviated as c.c.) and linear regression (abbreviated as l.r.) of width (as W) on length (as L) in the same strains were calculated, and are shown in the left column of Table 1. Two, 3, 2 and 13 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 +0.2254 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 of unhusked grains; width on length, thickness on length, and thickness of width

| Strain No. | Length and Width | | Length and Thickness | | Width and Thickness | |
|---|---|---|---|---|---|---|
| | Correlation coefficient | Linear regression | Correlation coefficient | Linear regression | Correlation coefficient | Linear regression |
| 1 | −0.0970 | − | 0.4214* | Y=0.175X+0.437 | 0.0941 | − |
| 2 | −0.0719 | − | 0.2134 | − | −0.1327 | − |
| 3 | −0.1632 | − | 0.3282 | − | 0.1697 | − |
| 4 | −0.2803 | − | 0.1947 | − | 0.1786 | − |
| 5 | 0.2962 | − | 0.3075 | − | 0.3111 | − |
| 6 | 0.5721*** | Y=0.100X+1.968 | 0.6708*** | Y=0.355X+1.280 | 0.4264* | Y=0.364X+1.055 |
| 7 | 0.3610* | Y=0.211X+0.996 | 0.0137 | − | 0.4800** | Y=0.353X+1.840 |
| 8 | −0.0530 | − | −0.0377 | − | −0.1183 | − |
| 9 | 0.4630** | Y=0.571X+0.299 | 0.4111* | Y=0.400X−1.000 | 0.4444* | Y=0.208X+1.393 |
| 10 | 0.2899 | − | 0.5555** | Y=0.877X+1.338 | 0.4311* | Y=0.333X+1.100 |
| 11 | 0.3211 | − | −0.2350 | − | −0.1563 | − |
| 12 | −0.0385 | − | 0.1834 | − | −0.2878 | − |
| 13 | 0.0125 | − | −0.0175 | − | 0.1283 | − |
| 14 | 0.4003** | Y=1.507X−2.864 | 0.5505** | Y=0.164X+0.683 | 0.3040 | − |
| 15 | 0.6836*** | Y=0.572X−1.411 | 0.5267** | Y=0.449X−1.553 | 0.1199 | − |
| 16 | −0.3871* | Y=−0.112X+3.837 | 0.4000* | Y=0.069X+1.364 | −0.2122 | − |
| 17 | −0.2480 | − | 0.0744 | − | −0.2686 | − |
| 18 | −0.2653 | − | 0.0995 | − | 0.2196 | − |
| 19 | 0.4965** | Y=0.236X+1.312 | 0.3751* | Y=0.134X+1.124 | 0.0281 | − |
| 20 | −0.1162 | − | 0.1275 | − | 0.4377* | Y=0.592X+0.065 |

d.f.=28

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

**2. Length and thickness of UHG**

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. One, 3, 4 and 12 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 +0.6533 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the longer is the L, the thicker is the T. L.r. of L on T was calculated as follows; $Y=0.341X+1.111$, where Y and X indicate L and T, respectively. This formula indicates that the L becomes 0.341mm longer, when the T becomes thicker by 1 degree.

**3. Width and thickness of UHG**

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. One, 4 and 15 strains showed significances at 1% and 5% levels and no significance even at 5% level, respectively. In the whole strains, c.c. was +0.4969 to the degree of freedom of 18, which is significant at 5% level. Generally speaking, the wider is the W, the thicker is the T. L.r. of W on T was calculated as follows; $Y=0.084X+1.386$, where Y and X indicate W and T, respectively. This formula indicates that the W becomes 0.084mm wider, when the T becomes thicker by 1 degree.

**4. L/W and L/T of UHG**

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. Five, 1, 3 and 11 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 +0.8697 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the larger is the L/W, the larger is the L/T. L.r. of L/W on L/T was calculated as follows; $Y=0.824X+1.715$, where Y and X indicate L/W and L/T, respectively. This formula indicates that the L/W becomes 0.824 larger, when the L/T becomes larger by 1 degree.

**5. L/W and W/T of UHG**

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. Fourteen, 2, 1 and 3 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 −0.7394 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the larger is the L/W, the smaller is the W/T. L.r. of L/W on W/T was calculated as follows; $Y=-0.202X+2.009$, where Y and X indicate L/W and W/T, respectively. This formula indicates that the L/W becomes 0.202 larger, when the W/T becomes smaller by 1 degree.

**6. L/T and W/T of UHG**

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, 5 and 7 strains showed significances at 0.1% and 1% levels and no significance even at 5% level, respectively. In the whole strains, c.c. was −0.3224 to the degree of freedom of 18, showing no significance even at 5% level.

**7. Length and width of HG**

C.c. and l.r. of W on L in the same strains were calculated, and are shown in the left column of Table 3. One, 3 and 16 strains showed significances at 1% and 5% levels and no significance even at 5% level, respectively. In the whole strains, c.c. was +0.2709 to the degree of freedom of 18, showing no significance even at 5% level.

**8. Length and thickness of HG**

C.c. and l.r. of T on L in the same strains were calculated, and are shown in the central column of Table 3. One, 5 and 14 strains showed significances at 0.1% and 5% levels and no significance

Table 2. Correlation coefficient and linear regression of the three components of unhusked grains; ratio of length to thickness (abbreviated as L/T) on L/W, W/T on L/W, and W/T on L/T

| 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 | 0.1874 | — | −0.6624*** | Y=−0.421X+2.770 | 0.6090*** | Y=0.287X+0.237 |
| 2 | 0.2785 | — | −0.7656*** | Y=−0.333X+2.438 | 0.3512 | — |
| 3 | 0.2909 | — | −0.6066*** | Y=−0.373X+2.465 | 0.5811*** | Y=0.255X+0.437 |
| 4 | 0.3415 | — | −0.6968*** | Y=−0.270X+2.216 | 0.3098 | — |
| 5 | 0.4423* | Y=0.619X+2.293 | −0.5604** | Y=−0.311X+2.308 | 0.3077 | — |
| 6 | 0.7498*** | Y=0.869X+1.312 | −0.4320* | Y=−0.138X+1.726 | 0.2728 | — |
| 7 | 0.1200 | — | −0.8649*** | Y=−0.581X+2.555 | 0.5802*** | Y=0.472X+0.482 |
| 8 | 0.1233 | — | −0.7658*** | Y=−0.382X+2.552 | 0.5402** | Y=0.274X+0.182 |
| 9 | 0.3911* | Y=0.946X+1.750 | −0.7100*** | Y=−0.491X+2.047 | 0.5900*** | Y=0.238X+0.766 |
| 10 | 0.7001*** | Y=0.300X−0.280 | −0.7777*** | Y=−0.625X−0.640 | 0.7133*** | Y=0.208X+0.460 |
| 11 | −0.0693 | — | −0.7863*** | Y=−0.481X+2.836 | 0.6675*** | Y=0.343X−0.071 |
| 12 | 0.2508 | — | −0.3141 | — | 0.5346** | Y=0.230X+0.397 |
| 13 | 0.6306*** | Y=0.923X+1.439 | −0.3290 | — | 0.5220** | Y=0.121X+0.767 |
| 14 | 0.0812 | — | −0.6948*** | Y=−0.481X+2.771 | 0.6571*** | Y=0.657X+0.124 |
| 15 | −0.2730 | — | −0.6815*** | Y=−0.889X+3.874 | 0.8900*** | Y=0.437X−0.196 |
| 16 | 0.4141* | Y=0.391X+3.347 | −0.7342*** | Y=−0.283X+2.341 | 0.3069 | — |
| 17 | 0.5130** | Y=0.700X+2.120 | −0.4868** | Y=−0.213X+2.046 | 0.4976** | Y=0.160X+0.712 |
| 18 | 0.6766*** | Y=0.846X+1.741 | −0.5311*** | Y=−0.191X+2.000 | 0.2614 | — |
| 19 | −0.0308 | — | −0.6618*** | Y=−0.611X+3.012 | −0.1471 | — |
| 20 | 0.7268*** | Y=1.443X+0.455 | −0.1757 | — | 0.5467** | Y=0.164X+1.030 |

d.f.=28

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

even at 5% level, respectively. In the whole strains, c.c. was +0.3241 to the degree of freedom of 18, showing no significance even at 5% level.

### 9. Width and thickness of HG

C.c. and l.r. of T on W in the same strains were calculated, and are shown in the right column of Table 3. Five and 15 strains showed significance at 0.1% level and no significance even at 5% level, respectively. In the whole strains, c.c. was +0.8685 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the wider is the W, the thicker is the T. L.r. of W on T was calculated as follows; Y=0.451X+0.781, where Y and X indicate W and T, respectively. This formula indicates that the W becomes 0.451mm wider, when T becomes thicker by 1 degree.

### 10. L/W and L/T of HG

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 4. Three, 1, 7 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 +0.8753 to the degree of freedom of 18, which is obviously significant at 0.1% level. Generally speaking, the larger is the L/W, the larger is the L/T. L.r. of L/W on L/T was calculated as follows; Y=0.931X+0.961, where Y and X indicate L/W and L/T, respectively. This formula indicates that the L/W becomes

Table 3. Correlation coefficient and linear regression of the three components of husked grains; width on length, thickness on length, and thickness on width

| Strain No. | Length and Width | | Length and Thickness | | Width and Thickness | |
|---|---|---|---|---|---|---|
| | Correlation coefficient | Linear regression | Correlation coefficient | Linear regression | Correlation coefficient | Linear regression |
| 1 | 0.1819 | — | 0.2870 | — | −0.1368 | — |
| 2 | −0.0649 | — | 0.1550 | — | −0.0832 | — |
| 3 | 0.0972 | — | 0.3027 | — | −0.0039 | — |
| 4 | −0.0635 | — | −0.0485 | — | 0.0974 | — |
| 5 | 0.3829* | Y=0.200X+1.420 | 0.3631* | Y=0.194X+0.792 | −0.0297 | — |
| 6 | 0.3918* | Y=0.199X+2.000 | −0.2830 | — | 0.8467*** | Y=0.871X−0.683 |
| 7 | 0.1278 | — | 0.3711* | Y=0.124X+1.320 | 0.7111*** | Y=0.714X−0.004 |
| 8 | 0.0478 | — | 0.2604 | — | 0.0313 | — |
| 9 | 0.2711 | — | 0.2100 | — | 0.1272 | — |
| 10 | 0.0499 | — | 0.3886* | Y=0.250X+0.488 | 0.8100*** | Y=0.500X+0.825 |
| 11 | −0.0259 | — | −0.0810 | — | −0.2634 | — |
| 12 | 0.0885 | — | 0.2478 | — | −0.1783 | — |
| 13 | 0.1845 | — | 0.2775 | — | −0.1569 | — |
| 14 | 0.3609 | — | 0.3983* | Y=0.136X+1.015 | 0.2309 | — |
| 15 | −0.4593* | Y=−0.644X+5.522 | 0.5888*** | Y=0.254X+0.023 | 0.8400*** | Y=0.259X+1.947 |
| 16 | 0.0496 | — | 0.3721* | Y=0.097X+1.145 | −0.2746 | — |
| 17 | −0.2128 | — | 0.0400 | — | −0.2720 | — |
| 18 | −0.2273 | — | 0.1863 | — | 0.1101 | — |
| 19 | 0.4861** | Y=0.310X+0.943 | 0.2291 | — | −0.0516 | — |
| 20 | 0.1273 | — | 0.0595 | — | 0.7387*** | Y=0.387X+0.887 |

d.f.=28

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

0.931 larger, when the L/T becomes larger by 1 degree.

### 11. L/W and W/T of HG

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 4. Ten, 9 and 1 strains showed significances at 0.1%, 1% and 5% levels, respectively. In other words, the whole strains (=20) showed significances. In the whole strains, c.c. was −0.6127 to the degree of freedom of 18, which is significant at 1% level. Generally speaking, the larger is the L/W, the smaller is the W/T. L.r. of L/W on W/T was calculated as follows; Y=−0.163X+1.715, where Y and X indicate L/W and W/T, respectively. This formula indicates that the L/W becomes 0.163 larger, when the W/T becomes smaller by 1 degree.

### 12. L/T and W/T of HG

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 4. Fourteen, 2, 2 and 2 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 −0.1606 to the degree of freedom of 18, showing no significance even at 5% level.

Table 4. Correlation coefficient and linear regression of the three components of husked grains; ratio of length to thickness (abbreviated as L/T) on L/W, W/T on L/W, and W/T on L/T

| Strain No. | L/W and L/T | | L/W and W/T | | L/W and W/T | |
|---|---|---|---|---|---|---|
| | Correlation coefficient | Linear regression | Correlation coefficient | Linear regression | Correlation coefficient | Linear regression |
| 1 | 0.0919 | — | −0.6525*** | Y=−0.506X+2.704 | 0.6934*** | Y=0.369X+0.109 |
| 2 | 0.4117* | Y=0.419X+2.320 | −0.6687*** | Y=−0.298X+2.081 | 0.3969* | Y=0.174X+0.680 |
| 3 | 0.0833 | — | −0.5411** | Y=−0.513X+2.519 | 0.7907*** | Y=0.419X+0.039 |
| 4 | 0.3235 | — | −0.5009** | Y=−0.263X+1.969 | 0.5006** | Y=0.237X+0.440 |
| 5 | −0.0602 | — | −0.6439*** | Y=−0.635X+2.822 | 0.8001*** | Y=0.451X−0.073 |
| 6 | 0.9177*** | Y=0.615X−1.126 | −0.4839** | Y=−0.145X+0.803 | 0.7918*** | Y=0.135X+0.763 |
| 7 | 0.4111* | Y=0.600X−0.002 | −0.4991** | Y=−0.245X+0.724 | 0.5811*** | Y=0.500X+0.611 |
| 8 | 0.3383 | — | −0.5568** | Y=−0.319X+2.138 | 0.5913*** | Y=0.254X+0.423 |
| 9 | 0.3702* | Y=0.539X+0.114 | −0.5555** | Y=−0.483X+0.611 | 0.7999*** | Y=0.211X+0.449 |
| 10 | 0.4344* | Y=0.555X−1.000 | −0.6865*** | Y=−0.300X+2.770 | 0.5999*** | Y=0.400X−0.840 |
| 11 | −0.1151 | — | −0.7585*** | Y=−0.444X+2.430 | 0.4202* | Y=0.195X+0.627 |
| 12 | 0.0549 | — | −0.7268*** | Y=−0.483X+2.534 | 0.6185*** | Y=0.331X+0.206 |
| 13 | 0.3704* | Y=0.462X+2.333 | −0.5060** | Y=−0.243X+1.967 | 0.5843*** | Y=0.225X+0.416 |
| 14 | 0.3865* | Y=0.538X+1.884 | −0.4973** | Y=−0.326X+2.104 | 0.6057*** | Y=0.285X+0.449 |
| 15 | 0.6024*** | Y=0.438X+4.596 | −0.9888*** | Y=−0.545X+2.940 | 0.7292*** | Y=0.847X−0.770 |
| 16 | 0.2744 | — | −0.6380*** | Y=−0.332X+2.278 | 0.5622** | Y=0.247X+0.352 |
| 17 | 0.4153* | Y=0.608X+1.729 | −0.3834* | Y=−0.223X+1.857 | 0.6724*** | Y=0.267X+0.426 |
| 18 | 0.4876** | Y=0.487X+2.072 | −0.6954*** | Y=−0.341X+2.173 | 0.2826 | — |
| 19 | −0.0604 | — | −0.6344*** | Y=−0.687X+2.824 | 0.8079*** | Y=0.487X−0.043 |
| 20 | 0.8214*** | Y=1.080X+0.741 | −0.4778** | Y=−0.215X+1.879 | 0.1662 | — |

d.f.=28

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

## Discussion

Basing on the results in the present experiment, the following problematic items are to be discussed here.

**1.** Correlation coefficients of the respective characters in the strain level were fixed to be significant in 123/240 cases =51.3% through the whole strains. In detail, these were ascertained in the respective combination groups as follows; group 1 (L and W, L and T, W and T in UHG)---20/60=33.3%, group 2 (L/W and L/T, L/W and W/T, L/T and W/T in UHG)---39/60=65.0%, group 3 (L and W, L and T, W and T in HG)---15/60=25.0%, group 4 (L/W and L/T, L/W and W/T, L/T and W/T in HG)---49/60=81.7%. From these data, it might be said that the combinations in groups 2 and 4 showed more significant strains than those in groups 1 and 3. Barring these points, there were not any noticeable differences between the present experiment and those in the northeastern India[5], India proper[8], Burma[6] and Madura[9].

Through the whole combinations (=12), 3, 2, 1, 1, 4, 2, 5 and 2 strains showed significant correlations in 10, 9, 8, 7, 6, 5, 4 and 3 character-combinations, respectively. Average value and

its s.d. through the whole strains were found to be 6.15±2.35. It was noticed that strain Nos.6, 10 and 15, and Nos.4 and 12 showed significant correlations in 10/12 cases, *i.e.*, 83.3%, and in only 3/12 cases, *i.e.*, 25.0%, respectively.

**2.** According to the tripartite classification, correlation coefficients in the respective character-combinations in strain level were fixed to be significant in 39/84 (=46.4%) and 84/156 (=53.9%) in type B and type C, respectively. In these viewpoints, no remarkable difference was noticed between these two types.

In detail, these were ascertained in the respective combination-groups as follows, in case of type B; group 1---4/21=19.1%, group 2---14/21=66.7%, group 3---5/21=23.8%, group 4---16/21=76.2%; in type C---group 1---16/39=41.0%, group 2---25/39=64.1%, group 3---10/39=25.6%, group 4---33/39=84.6%. From these data, it might be said that the combinations groups 2 and 4 showed more significant strains than those of the remaining combination-groups, even in type B and type C as likewise in case of the whole strains.

Through the whole combinations (=12), in type B, 1, 3, 1, 1 and 1 strains showed significant correlations in 9, 6, 5, 4 and 3 combinations, respectively. In type C, 3, 1, 1, 1, 1, 1, 4 and 1 strains showed significant correlations in 10, 9, 8, 7, 6, 5, 4 and 3 combiantions, respectively. Averages and their s.ds. through the whole strains were found to be 4.29±2.05 and 6.46±2.56 in type B and type C, respectively. It was clearly recognized that the values of practical values and s.d. of type C were larger than those of type B. It might be of some phenomenal interest for variety-differentiations.

## Summary

In order to confirm the varietal variations of the cultivated rice strains, *Oryza sativa* L., in Fiji, South Pacific, 12 mutual relations among 24 characters in view of the practical values were investigated in this report, following the previous papers. The main results obtained were summarized as follows:

Concerning correlation coefficients among 12 character-combinations, 39/84 cases (=46.4%), 84/156 cases (=53.9%) and 123/240 cases (=51.3%) in type B, type C and in the whole strains of both of the types, respectively, showed significant relations through the whole cases. In the whole combinations (=12), average values and those standard deviations through the whole strains were found to be 4.29±2.05, 6.46±2.56 and 6.15±2.35 in type B, type C and the whole strains of both of the types, respectively.

Strain differentiations and character specificities were extensively discussed.

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