

Some Morphological Characters of the Cultivated Rice Grains Collected in India (II)

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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 rice. In this opportunity, the cultivated rice distributed not only in Assam but also in West Bengal States were collected and studied in view of morphological characters.

East and northeastern parts of India have been considered to be one of the differentiation centers of rice in accordance with many investigations⁴⁾. However, an accumulation of complete data endorsed by discussions on these aspects has been unfortunately far from being perfect. Sharma *et al.*⁵⁾ carried out systematic collections of current and primitive cultivars of rice in the northeastern part of India from the viewpoint of breeding purposes. For genetic and breeding purposes, at first varietal variations and their methodologies should be ascertained as early as possible.

Taking these facts into account, the present series was made to accomplish the work, the aim of which are going to clarify the varietal variation and the phylogenetic relationships of cultivated rice in India. In the previous paper²⁾, the record of morphological characters of the unhusked and husked grains and some mutual relations were reported.

In the present paper, comparison of the unhusked and husked grains for 12 characters and variation ranges in 6 characters were mainly described, in order to confirm the morphological characters of grains which were to make the strain's specificities clear. Variation ranges were used in peanut³⁾ and wild species of *Vigna*¹⁾ and some useful informations were obtained. So, these characters were applied for the cultivated rice strains. The records on the relations between the respective two characters will be reported in the separate articles.

Materials and Methods

Twenty one strains of Indian rice strains collected in India were used in the experiment. They are listed up in Table 1 of the previous paper²⁾. In this table, collection number, collection date and place, and detailed informations are mentioned. States included in this paper are Meghalaya, Assam and West Bengal. The rice strains distributed in the respective localities have different meanings in view of the morphological and physiological characters, and should be separately considered in view of their respective phylogenetical status. Accordingly, they are divided into two groups in this investigation-series, *i.e.*, Group A...strains collected in Meghalaya State and

Assam State, Group B...strains collected in West Bengal State.

Thirty grains were used for the measurement of each strain. Comparative values for 6 characters (Table 1) were illustrated by the ratios of value in the husked to the value in the unhusked grains in the respective characters. The following 6 characters of unhusked and husked grains (Table 2) were illustrated by the area (= length \times width) and volume (= length \times width \times thickness) for unhusked and husked grains, the area and volume quotients (= ratio of value of husked to value of unhusked grains). The whole data referring to the 12 characters were illustrated by the average value through the whole grains.

The variation ranges in 6 characters (Table 3) were illustrated by the maximum, the minimum and the pure-range value in the whole grains.

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).

Results

PART I. The respective characters

1. Quotient in length

Group A: The results are given in Table 1. The values for the individual grain level ranged from 0.77 (strain No. 7) to 0.68 (No. 3). In the strain level, the largest (0.73) was obtained

Table 1. Comparative table on some morphological characters of unhusked and husked grains of the cultivated species; illustrating by the ratios of value in husked to the value in unhusked grains in the respective characters

Strain No.	Length	Width	Thickness	L/W	L/T	W/T
1	0.73 \pm 0.02	0.87 \pm 0.03	0.92 \pm 0.02	0.84 \pm 0.03	0.80 \pm 0.03	0.95 \pm 0.04
2	0.72 \pm 0.02	0.87 \pm 0.03	0.89 \pm 0.03	0.83 \pm 0.03	0.81 \pm 0.03	0.98 \pm 0.05
3	0.70 \pm 0.02	0.61 \pm 0.07	0.67 \pm 0.04	1.08 \pm 0.06	1.05 \pm 0.05	0.90 \pm 0.07
4	0.71 \pm 0.01	0.88 \pm 0.02	0.90 \pm 0.01	0.81 \pm 0.02	0.79 \pm 0.01	0.98 \pm 0.02
5	0.71 \pm 0.01	0.85 \pm 0.04	0.90 \pm 0.03	0.84 \pm 0.03	0.79 \pm 0.03	0.94 \pm 0.04
6	0.72 \pm 0.01	0.83 \pm 0.01	0.91 \pm 0.01	0.87 \pm 0.02	0.80 \pm 0.02	0.92 \pm 0.01
7	0.73 \pm 0.02	0.86 \pm 0.04	0.92 \pm 0.02	0.85 \pm 0.04	0.80 \pm 0.03	0.95 \pm 0.05
8	0.71 \pm 0.01	0.80 \pm 0.03	0.90 \pm 0.01	0.89 \pm 0.04	0.79 \pm 0.02	0.88 \pm 0.04
9	0.71 \pm 0.01	0.86 \pm 0.04	0.89 \pm 0.03	0.84 \pm 0.04	0.80 \pm 0.03	0.96 \pm 0.05
10	0.71 \pm 0.02	0.84 \pm 0.03	0.90 \pm 0.03	0.85 \pm 0.03	0.80 \pm 0.02	0.94 \pm 0.04
11	0.71 \pm 0.01	0.89 \pm 0.03	0.90 \pm 0.03	0.79 \pm 0.04	0.79 \pm 0.03	0.99 \pm 0.05
12	0.68 \pm 0.01	0.87 \pm 0.02	0.91 \pm 0.01	0.78 \pm 0.02	0.74 \pm 0.01	0.95 \pm 0.02
13	0.70 \pm 0.02	0.85 \pm 0.03	0.91 \pm 0.02	0.82 \pm 0.03	0.77 \pm 0.03	0.94 \pm 0.04
14	0.69 \pm 0.01	0.83 \pm 0.02	0.89 \pm 0.04	0.83 \pm 0.03	0.77 \pm 0.03	0.94 \pm 0.06
15	0.67 \pm 0.02	0.89 \pm 0.03	0.91 \pm 0.02	0.75 \pm 0.04	0.74 \pm 0.03	0.98 \pm 0.03
16	0.73 \pm 0.02	0.83 \pm 0.03	0.91 \pm 0.02	0.88 \pm 0.04	0.81 \pm 0.03	0.92 \pm 0.04
17	0.68 \pm 0.03	0.84 \pm 0.04	0.90 \pm 0.02	0.82 \pm 0.05	0.76 \pm 0.03	0.94 \pm 0.05
18	0.70 \pm 0.01	0.85 \pm 0.03	0.91 \pm 0.02	0.82 \pm 0.03	0.77 \pm 0.02	0.94 \pm 0.03
19	0.71 \pm 0.03	0.82 \pm 0.04	0.89 \pm 0.03	0.87 \pm 0.05	0.80 \pm 0.04	0.92 \pm 0.05
20	0.70 \pm 0.03	0.82 \pm 0.04	0.90 \pm 0.03	0.85 \pm 0.05	0.77 \pm 0.04	0.92 \pm 0.05
21	0.68 \pm 0.02	0.85 \pm 0.03	0.92 \pm 0.02	0.80 \pm 0.03	0.75 \pm 0.02	0.90 \pm 0.07

in Nos. 1 and 7. The smallest (0.70) was noted in No. 3. Average and its s.d. through the whole strains were found to be 0.72 ± 0.01 . The s.d. of each strain, *i.e.*, intra-population's variations, were found to be 0.01 ± 0.01 .

Group B: The values for the individual grain level ranged from 0.77 (Nos. 10, 16 and 19) to 0.62 (No. 17). In the strain level, the largest (0.73) was obtained in No. 16, followed by Nos. 10, 11 and 19 (0.71). The smallest (0.67) was noted in No. 15, followed by Nos. 12, 17 and 21 (0.68). Average and its s.d. through the whole strains were found to be 0.70 ± 0.02 . S.d. of each strain were found to be 0.02 ± 0.01 .

Whole: Average and its s.d. through the whole strains of both groups were found to be 0.71 ± 0.02 . S.d. of each strain were found to be 0.02 ± 0.01 .

2. Quotient in width

Group A: The values for the individual grain level ranged from 0.94 (No. 2) to 0.51 (No. 3). In the strain level, the largest (0.88) was obtained in No. 4, followed by Nos. 1 and 2 (0.87). The smallest (0.61) was noted in No. 3, which was the same as in case of length, followed by No. 8 (0.80) and No. 6 (0.83). It was noted that the value was peculiarly small in No. 3. Average and its s.d. through the whole strains were found to be 0.83 ± 0.08 . S.d. of each strain were found to be 0.03 ± 0.02 .

Group B: The values for the individual grain level ranged from 0.95 (Nos. 11 and 15) to 0.71 (No. 19). In the strain level, the largest (0.89) was obtained in Nos. 11 and 15, followed by No. 12 (0.87). The smallest (0.82) was noted in Nos. 19 and 20, followed by Nos. 14 and 16 (0.83). Average and its s.d. through the whole strains were found to be 0.85 ± 0.02 . S.d. of each strain were found to be 0.03 ± 0.01 .

Whole: Average and its s.d. through the whole strains of both groups were found to be 0.84 ± 0.06 . S.d. of each strain were found to be 0.03 ± 0.01 .

3. Quotient in thickness

Group A: The values for the individual grain level ranged from 0.96 (Nos. 1, 5 and 7) to 0.62 (No. 3). In the strain level, the largest (0.92) was obtained in Nos. 1 and 7, which were the same as in case of length, followed by No. 6 (0.91). These orders of strains were found to be the same as in case of length. The smallest (0.67) was noted in No. 3, which was the same as in cases of length and width, followed by Nos. 2 and 9 (0.89). It was noted that the value was peculiarly small in No. 3. Average and its s.d. through the whole strains were found to be 0.88 ± 0.08 . S.d. of each strain were found to be 0.02 ± 0.01 .

Group B: The values for the individual grain level ranged from 1.00 (Nos. 13 and 20) to 0.77 (No. 14). In the strain level, the largest (0.92) was obtained in No. 21. The smallest (0.89) was noted in Nos. 14 and 19. Average and its s.d. through the whole strains were found to be 0.90 ± 0.01 . S.d. of each strain were found to be 0.02 ± 0.01 .

Whole: Average and its s.d. through the whole strains of both groups were found to be 0.89 ± 0.05 . S.d. of each strain were found to be 0.02 ± 0.01 .

4. Quotient in L/W

Group A: The values for the individual grain level ranged from 1.12 (No. 3) to 0.76 (No. 9). In the strain level, the largest (1.08) was obtained in No. 3, followed by No. 8 (0.89) and No. 6 (0.87). It was noted that the value was peculiarly large in No. 3. The smallest (0.81)

was noted in No. 4, followed by No. 2 (0.83). Average and its s.d. through the whole strains were found to be 0.87 ± 0.08 . S.d. of each strain were found to be 0.03 ± 0.01 .

Group B: The values for the individual grain level ranged from 0.99 (No. 16) to 0.67 (No. 11). In the strain level, the largest (0.88) was obtained in No. 16, which was the same as in case of length, followed by No. 19 (0.87) and Nos. 10 and 20 (0.85). The smallest (0.75) was noted in No. 15, which was the same as in case of length, followed by No. 12 (0.78) and No. 11 (0.79). Average and its s.d. through the whole strains were found to be 0.82 ± 0.04 . S.d. of each strain were found to be 0.04 ± 0.01 .

Whole: Average and its s.d. through the whole strains of both groups were found to be 0.84 ± 0.06 . S.d. of each strain were found to be 0.04 ± 0.01 .

5. Quotient in L/T

Group A: The values for the individual grain level ranged from 1.14 (No. 3) to 0.73 (No. 1). In the strain level, the largest (1.05) was obtained in No. 3, which was the same as in case of L/W, followed by No. 2 (0.81). It was noted that the value was peculiarly large in No. 3. The smallest (0.79) was noted in Nos. 4, 5 and 8. Average and its s.d. through the whole strains were found to be 0.83 ± 0.08 . S.d. of each strain were found to be 0.03 ± 0.01 .

Group B: The values for the individual grain level ranged from 0.88 (No. 10) to 0.69 (Nos. 14 and 20). In the strain level, the largest (0.81) was obtained in No. 16, which was the same as in cases of length and L/W, followed by Nos. 10 and 19 (0.80). These combinations of strains were found to be the same as in case of L/W. The smallest (0.74) was noted in Nos. 12 and 15, followed by No. 21 (0.75). These combinations of strains were found to be the same as in case of length. Average and its s.d. through the whole strains were found to be 0.77 ± 0.02 . S.d. of each strain were found to be 0.03 ± 0.01 .

Whole: Average and its s.d. through the whole strains of both groups were found to be 0.80 ± 0.06 . S.d. of each strain were found to be 0.03 ± 0.01 .

6. Quotient in W/T

Group A: The values for the individual grain level ranged from 1.08 (No. 9) to 0.82 (Nos. 3 and 8). In the strain level, the largest (0.98) was obtained in Nos. 2 and 4, followed by No. 9 (0.96). The smallest (0.88) was noted in No. 8, followed by No. 3 (0.90) and No. 6 (0.92). These combinations of strains were found to be the same as in case of width. Average and its s.d. through the whole strains were found to be 0.94 ± 0.03 . S.d. of each strain were found to be 0.04 ± 0.02 .

Group B: The values for the individual grain level ranged from 1.12 (No. 14) to 0.76 (No. 21). In the strain level, the largest (0.99) was obtained in No. 11, followed by No. 15 (0.98) and No. 12 (0.95). These combinations of strains were found to be the same as in case of width. This phenomenon was ascertained to be the same pattern as in the combination with the smallest of Group A. The smallest (0.90) was noted in No. 21, followed by Nos. 16, 19 and 20 (0.92). Average and its s.d. through the whole strains were found to be 0.94 ± 0.03 . S.d. of each strain were found to be 0.04 ± 0.01 .

Whole: Average and its s.d. through the whole strains of both groups were found to be 0.94 ± 0.03 . S.d. of each strain were found to be 0.04 ± 0.02 .

7. Area in unhusked grains

Group A: The results are given in Table 2. The practical values for the individual grain level ranged from 31.76 mm² (No. 5) to 20.41 mm² (No. 6). In the strain level, the widest (28.89 mm²) was obtained in No. 5, followed by No. 2 (27.85 mm²) and No. 1 (26.52 mm²). It was noted that the value was peculiarly large in No. 5. The narrowest (22.56 mm²) was noted in No. 4, which was the same as in case of L/W, followed by No. 7 (23.25 mm²) and No. 3 (24.22 mm²). It was noted that the value was peculiarly small in No. 4. Average and its s.d. through the whole strains were found to be 25.50 ± 2.08.

The largest (1.96) of s.d. was obtained in No. 2, followed by No. 6 (1.83) and No. 8 (1.81). The smallest (1.21) was noted in No. 9, followed by No. 3 (1.26) and No. 7 (1.33). S.d. of each strain were found to be 1.54 ± 0.27.

Group B: The practical values for the individual grain level ranged from 32.48 mm² (No. 10) to 15.79 mm² (No. 11). In the strain level, the widest (29.83 mm²) was obtained in No. 18, followed by No. 19 (28.92 mm²) and No. 21 (28.57 mm²). The narrowest (17.61 mm²) was noted in No. 11, followed by No. 15 (17.71 mm²) and No. 13 (21.26 mm²). Average and its s.d. through the whole strains were found to be 24.86 ± 4.32.

The largest (3.16) of s.d. was obtained in No. 17, followed by No. 20 (2.50) and No. 16 (2.18). It was noted that the value was peculiarly large in No. 17. The smallest (0.68) was noted in No. 11, followed by Nos. 12 and 15 (1.19). It was noted that the value was peculiarly small in No. 11. S.d.

Table 2. Six characters of unhusked and husked grains; illustrating by the area (= length × width), the volume (= length × width × thickness), the area and volume quotients (= ratio of value of husked to value of unhusked grains)

Strain No.	Unhusked		Husked		Quotient	
	Area (mm ²)	Volume (mm ³)	Area (mm ²)	Volume (mm ³)	Area	Volume
1	26.52±1.54	62.57±4.74	16.77±1.01	36.35±3.03	0.63±0.03	0.58±0.02
2	27.85±1.96	65.65±5.88	17.11±1.25	36.39±4.36	0.62±0.03	0.56±0.06
3	24.22±1.26	39.24±5.38	10.26±1.12	11.30±3.75	0.42±0.07	0.28±0.06
4	22.56±1.41	43.89±3.33	13.94±0.72	24.34±1.71	0.62±0.01	0.56±0.02
5	28.89±1.51	67.08±5.22	17.36±0.93	36.09±3.63	0.60±0.03	0.54±0.03
6	24.63±1.83	51.05±3.85	14.78±1.16	27.67±2.31	0.60±0.01	0.54±0.01
7	23.25±1.33	50.37±3.72	14.60±0.85	28.94±2.42	0.63±0.03	0.58±0.04
8	26.14±1.81	57.27±3.69	14.79±1.08	29.30±2.27	0.56±0.03	0.51±0.02
9	25.44±1.21	53.81±3.64	15.54±0.78	29.29±2.19	0.61±0.03	0.55±0.03
10	28.08±1.96	60.32±4.90	16.70±1.20	32.32±3.11	0.60±0.03	0.54±0.04
11	17.61±0.68	33.57±1.98	11.04±0.46	18.93±1.34	0.63±0.02	0.57±0.03
12	23.50±1.19	53.60±3.07	13.76±0.96	28.64±2.05	0.58±0.02	0.53±0.02
13	21.26±2.15	43.03±6.69	12.66±1.44	23.24±3.87	0.60±0.03	0.54±0.03
14	25.14±1.56	52.41±5.39	14.43±0.74	26.83±3.44	0.58±0.02	0.51±0.03
15	17.71±1.19	31.72±2.95	10.51±0.41	17.06±1.17	0.60±0.03	0.54±0.03
16	28.16±2.18	61.41±5.72	16.91±1.38	33.37±3.54	0.60±0.03	0.54±0.03
17	22.49±3.16	45.81±8.66	12.87±1.77	23.57±4.59	0.57±0.04	0.52±0.04
18	29.83±1.37	69.60±5.33	17.85±0.90	38.23±2.93	0.60±0.03	0.55±0.04
19	28.92±1.86	74.21±7.87	16.62±1.46	37.64±4.48	0.58±0.04	0.51±0.04
20	27.08±2.50	59.20±7.76	15.86±1.61	31.21±4.00	0.59±0.06	0.53±0.06
21	28.57±1.85	64.21±5.13	16.59±0.87	33.69±2.54	0.58±0.03	0.53±0.03

of each strain were found to be 1.80 ± 0.67 .

Whole: Average and its s.d. through the whole strains of both groups were found to be 25.14 ± 3.48 . S.d. of each strain were found to be 1.69 ± 0.54 .

8. Volume in unhusked grains

Group A: The practical values for the individual grain level ranged from 76.10 mm^3 (No. 2) to 34.22 mm^3 (No. 3). In the strain level, the largest (67.08 mm^3) was obtained in No. 5, which was the same as in case of area of UHG, followed by No. 2 (65.65 mm^3) and No. 1 (62.57 mm^3). These orders of strains were found to be the same as in case of area of UHG. The smallest (39.24 mm^3) was noted in No. 3, which was the same as cases of length, width and thickness, followed by No. 4 (43.89 mm^3) and No. 7 (50.37 mm^3). It was noted that the value was peculiarly small in No. 3. These combinations of strains were found to be the same as in case of area of UHG. Average and its s.d. through the whole strains were found to be 54.55 ± 9.55 .

The largest (5.88) of s.d. was obtained in No. 2, which was the same as in case of area of UHG, followed by No. 3 (5.38) and No. 5 (5.22). The smallest (3.33) was noted in No. 4, followed by No. 9 (3.64) and No. 8 (3.69). S.d. of each strain were found to be 4.38 ± 0.93 .

Group B: The practical values for the individual grain level ranged from 93.35 mm^3 (No. 19) to 28.08 mm^3 (No. 15). In the strain level, the largest (74.21 mm^3) was obtained in No. 19, followed by No. 18 (69.60 mm^3) and No. 21 (64.21 mm^3). These combinations of strains were found to be the same as in case of area of UHG. The smallest (31.72 mm^3) was noted in No. 15, which was the same as in cases of length and L/W, followed by No. 11 (33.57 mm^3) and No. 13 (43.03 mm^3). These combinations of strains were also found to be the same as in case of area of UHG. Average and its s.d. through the whole strains were found to be 54.10 ± 13.42 .

The largest (8.66) of s.d. was obtained in No. 17, which was the same as in case of area of UHG, followed by No. 19 (7.87) and No. 20 (7.76). It was noted that the value was peculiarly large in No. 17. The smallest (1.98) was noted in No. 11, which was the same as in case of area of UHG, followed by No. 15 (2.95) and No. 12 (3.07). It was noted that the value was peculiarly small in No. 11. These combinations of strains were found to be the same as in case of area of UHG. S.d. of each strain were found to be 5.45 ± 2.08 .

Whole: Average and its s.d. through the whole strains of both groups were found to be 54.29 ± 11.65 . S.d. of each strain were found to be 5.00 ± 1.74 .

9. Area in husked grains

Group A: The practical values for the individual grain level ranged from 19.77 mm^2 (No. 1) to 8.48 mm^2 (No. 3). In the strain level, the widest (17.36 mm^2) was obtained in No. 5, which was the same as in cases of area and volume of UHG, followed by No. 2 (17.11 mm^2) and No. 1 (16.77 mm^2). These orders of strains were found to be the same as in cases of area and volume of UHG. The narrowest (10.26 mm^2) was noted in No. 3, which was the same as in cases of length, width, thickness and volume of UHG, followed by No. 4 (13.94 mm^2) and No. 7 (14.60 mm^2). It was noted that the value was peculiarly small in No. 3. These combinations of strains were found to be the same as in cases of area and volume of UHG. Moreover, the orders of strains were found to be the same as in case of volume of UHG. Average and its s.d. through the whole strains were found to be 15.02 ± 2.16 .

The largest (1.25) of s.d. was obtained in No. 2, which was the same as in cases of area and volume of UHG, followed by No. 6 (1.16) and No. 3 (1.12). The smallest (0.72) was noted in No. 4,

which was the same as in case of volume of UHG, followed by No. 9 (0.78) and No. 7 (0.85). S.d. of each strain were found to be 0.99 ± 0.18 .

Group B: The practical values for the individual grain level ranged from 19.68 mm² (No. 19) to 9.27 mm² (No. 11). In the strain level, the widest (17.85 mm²) was obtained in No. 18, which was the same as in case of area of UHG, followed by No. 16 (16.91 mm²) and No. 19 (16.62 mm²). The narrowest (10.51 mm²) was noted in No. 15, which was the same as in cases of length, L/W and volume of UHG, followed by No. 11 (11.04 mm²) and No. 13 (12.66 mm²). These combinations of strains were found to be the same as in cases of area and volume of UHG. Moreover, these orders of strains were found to be the same as in case of volume of UHG. Average and its s.d. through the whole strains were found to be 14.65 ± 2.46 .

The largest (1.77) of s.d. was obtained in No. 17, which was the same as in cases of area and volume of UHG, followed by No. 20 (1.61) and No. 19 (1.46). These combinations of strains were found to be the same as in case of volume of UHG. The smallest (0.41) was noted in No. 15, followed by No. 11 (0.46) and No. 14 (0.74). S.d. of each strain were found to be 1.10 ± 0.44 .

Whole: Average and its s.d. through the whole strains of both groups were found to be 14.81 ± 2.29 . S.d. of each strain were found to be 1.05 ± 0.35 .

10. Volume in husked grains

Group A: The practical values for the individual grain level ranged from 51.36 mm³ (No. 2) to 7.63 mm³ (No. 3). In the strain level, the largest (36.39 mm³) was obtained in No. 2, followed by No. 1 (36.35 mm³) and No. 5 (36.09 mm³). These combinations of strains were found to be the same as in cases of area and volume of UHG and area of HG. In other words, the strains (1·2·5) showed consistently large values in their characters. The smallest (11.30 mm³) was noted in No. 3, which was the same as in cases of length, width, thickness, volume of UHG, and area of HG, followed by No. 4 (24.34 mm³) and No. 6 (27.67 mm³). It was noted that the value was peculiarly small in No. 3. Average and its s.d. through the whole strains were found to be 28.85 ± 7.87 .

The largest (4.36) of s.d. was obtained in No. 2, which was the same as in cases of area and volume of UHG and area of HG, followed by No. 3 (3.75) and No. 5 (3.63). In other words, No. 2 showed consistently large s.d. values in their characters. It was noted that the value was peculiarly large in No. 2. These orders of strains were found to be the same as in case of volume of UHG. The smallest (1.71) was noted in No. 4, which was the same as in cases of volume of UHG and area of HG, followed by No. 9 (2.19) and No. 8 (2.27). It was noted that the value was peculiarly small in No. 4. These orders of strains were found to be the same as in case of volume of UHG. S.d. of each strain were found to be 2.85 ± 0.89 .

Group B: The practical values for the individual grain level ranged from 45.54 mm³ (No. 19) to 15.30 mm³ (No. 11). In the strain level, the largest (38.23 mm³) was obtained in No. 18, which was the same as in cases of areas of UHG and HG, followed by No. 19 (37.64 mm³) and No. 21 (33.69 mm³). These combinations of strains were found to be the same as in cases of area and volume of UHG. Moreover, these orders of strains were found to be the same as in case of area of UHG. The smallest (17.06 mm³) was noted in No. 15, which was the same as in cases of length, L/W, volume of UHG, and area of HG, followed by No. 11 (18.93 mm³) and No. 13 (23.24 mm³). These combinations of strains were found to be the same as in cases of area and volume of UHG and area of HG. Moreover, these orders of strains were found to be the same as in cases of volume of UHG and area of HG. In other words, these strains (11·13·15) showed consistently large values in

their characters. Average and its s.d. through the whole strains were found to be 28.73 ± 6.92 .

The largest (4.59) of s.d. was obtained in No. 17, which was the same as in cases of area and volume of UHG and area of HG, followed by No. 19 (4.48) and No. 20 (4.00). In other words, No. 17 showed consistently large s.d. values in their characters. These combinations of strains were found to be the same as in cases of volume of UHG and area of HG. Moreover, these orders of strains were found to be the same as in case of volume of UHG. The smallest (1.17) was noted in No. 15, which was the same as in case of area of HG, followed by No. 11 (1.34) and No. 12 (2.05). These combinations of strains were found to be the same as in cases of area and volume of UHG. S.d. of each strain were found to be 3.09 ± 1.13 .

Whole: Average and its s.d. through the whole strains of both groups were found to be 28.78 ± 7.15 . S.d. of each strain were found to be 2.99 ± 1.02 .

11. Quotient in areas

Group A: The values for the individual grain level ranged from 0.70 (Nos. 1 and 7) to 0.36 (No. 3). In the strain level, the largest (0.63) was obtained in Nos. 1 and 7, followed by Nos. 2 and 4 (0.62). These combinations of strains were found to be the same as in case of length. The smallest (0.42) was noted in No. 3, which was the same as in cases of length, width, thickness, volumes of UHG and HG, and area of HG, followed by No. 8 (0.56) and Nos. 5 and 6 (0.60). It was noted that the value was peculiarly small in No. 3. These combinations of strains were found to be the same as in case of width. Average and its s.d. through the whole strains were found to be 0.59 ± 0.07 . S.d. of each strain were found to be 0.03 ± 0.02 .

Group B: The values for the individual grain level ranged from 0.79 (No. 20) to 0.46 (No. 19). In the strain level, the largest (0.63) was obtained in No. 11, which was the same as in case of W/T. The smallest (0.57) was noted in No. 17. Average and its s.d. through the whole strains were found to be 0.59 ± 0.02 . S.d. of each strain were found to be 0.03 ± 0.01 .

Whole: Average and its s.d. through the whole strains of both groups were found to be 0.59 ± 0.04 . S.d. of each strain were found to be 0.03 ± 0.01 .

12. Quotient in volumes

Group A: The values for the individual grain level ranged from 0.81 (No. 2) to 0.22 (No. 3). In the strain level, the largest (0.58) was obtained in Nos. 1 and 7, followed by Nos. 2 and 4 (0.56). These orders of strains were found to be the same as in case of quotient of areas. The smallest (0.28) was noted in No. 3, which was the same as in cases of length, width, thickness, volume of UHG, area and volume of HG, and quotient of areas, followed by No. 8 (0.51) and Nos. 5 and 6 (0.54). It was noted that the value was peculiarly small in No. 3. These orders of strains were found to be the same as in case of quotient of areas. Average and its s.d. through the whole strains were found to be 0.52 ± 0.09 . S.d. of each strain were found to be 0.03 ± 0.02 .

Group B: The values for the individual grain level ranged from 0.71 (No. 20) to 0.40 (No. 10). In the strain level, the largest (0.57) was obtained in No. 11, which was the same as in cases of W/T and quotient of areas, followed by No. 18 (0.55). The smallest (0.51) was noted in Nos. 14 and 19, followed by No. 17 (0.52). Average and its s.d. through the whole strains were found to be 0.53 ± 0.02 . S.d. of each strain were found to be 0.04 ± 0.01 .

Whole: Average and its s.d. through the whole strains of both groups were found to be 0.53 ± 0.06 . S.d. of each strain were found to be 0.03 ± 0.01 .

PART II. Ranges among the respective characters

1. Length in unhusked grains

Maximum: 1) Group A: The results are given in Table 3. In this table, the maximum, the minimum and their range are shown. The longest (9.85 mm) was obtained in No. 9, followed by No. 4 (9.15 mm) and No. 6 (9.05 mm). It was noted that the value was peculiarly large in No. 9. The shortest (8.20 mm) was noted in No. 8, followed by No. 1 (8.25 mm) and No. 3 (8.70 mm). Average and its s.d. through the whole strains were found to be 8.85 ± 0.49 .

2) Group B: The longest (10.80 mm) was obtained in Nos. 16, 20 and 21. The shortest (7.60 mm) was noted in No. 12, followed by No. 11 (8.45 mm) and No. 19 (8.85 mm). It was noted that the value was peculiarly small in No. 12. Average and its s.d. through the whole strains were found to be 9.72 ± 1.06 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 9.35 ± 0.95 .

Minimum: 1) Group A: The longest (8.60 mm) was obtained in No. 9, which was the same as in case of the maximum, followed by Nos. 4 and 5 (8.05 mm). The shortest (7.00 mm) was noted in No. 7, followed by No. 8 (7.10 mm) and No. 1 (7.20 mm). Average and its s.d. through the whole strains were found to be 7.67 ± 0.54 .

2) Group B: The longest (9.45 mm) was obtained in No. 21, followed by No. 16 (9.00 mm) and No. 18 (8.55 mm). It was noted that the value was peculiarly large in No. 21. The shortest (6.95 mm) was noted in No. 12, which was the same as in case of the maximum, followed by Nos. 11 and 19 (7.65 mm). It was noted that the value was peculiarly small in No. 12. These combinations of strains were found to be the same as in case of the maximum. Average and its s.d. through the whole strains were found to be 8.29 ± 0.65 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 8.03 ± 0.67 .

Range: 1) Group A: The largest (1.80 mm) was obtained in No. 7, followed by No. 6 (1.40 mm) and No. 2 (1.35 mm). It was noted that the value was peculiarly large in No. 7. The smallest (0.70 mm) was noted in No. 3, followed by No. 5 (0.85 mm) and No. 1 (1.05 mm). Average and its s.d. through the whole strains were found to be 1.17 ± 0.32 .

2) Group B: The largest (2.30 mm) was obtained in No. 20, followed by No. 17 (2.10 mm) and No. 10 (2.05 mm). The smallest (0.65 mm) was noted in No. 12, which was the same as in cases of the maximum and the minimum, followed by No. 11 (0.80 mm) and No. 15 (0.90 mm). Average and its s.d. through the whole strains were found to be 1.42 ± 0.54 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 1.31 ± 0.46 .

2. Width in unhusked grains

Maximum: 1) Group A: The widest (3.95 mm) was obtained in No. 1, followed by No. 2 (3.75 mm) and No. 5 (3.70 mm). The narrowest (2.80 mm) was noted in No. 4, followed by Nos. 3 and 9 (2.95 mm). Average and its s.d. through the whole strains were found to be 3.37 ± 0.42 .

2) Group B: The widest (3.80 mm) was obtained in No. 19, followed by No. 12 (3.55 mm) and No. 10 (3.50 mm). The narrowest (2.20 mm) was noted in No. 15, followed by No. 11 (2.25 mm).

Table 3. Ranges of unhusked grains in the strain level; length (mm), width (mm), thickness (mm), ratio of length to width (%), ratio of length to thickness (%) and ratio of width to thickness (%)

Strain No.	Length			Width			Thickness			Length/Width			Length/Thickness			Width/Thickness		
	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range
1	8.25	7.20	1.05	3.95	2.90	1.05	2.55	2.10	0.45	2.85	1.91	0.94	3.81	2.80	1.01	1.76	1.26	0.50
2	8.75	7.40	1.35	3.75	3.20	0.55	2.55	2.15	0.40	2.61	2.14	0.47	3.82	2.96	0.86	1.57	1.31	0.26
3	8.70	8.00	0.70	2.95	2.80	0.15	1.75	1.45	0.30	2.98	2.71	0.27	5.52	4.96	0.55	2.04	1.69	0.35
4	9.15	8.05	1.10	2.80	2.50	0.30	2.10	1.80	0.30	3.44	3.02	0.42	4.69	4.00	0.69	1.47	1.22	0.25
5	8.90	8.05	0.85	3.70	3.00	0.70	2.50	2.00	0.50	2.90	2.28	0.62	4.35	3.37	0.98	1.59	1.33	0.26
6	9.05	7.65	1.40	3.20	2.70	0.50	2.20	1.90	0.30	3.02	2.55	0.47	4.50	3.55	0.95	1.66	1.27	0.39
7	8.80	7.00	1.80	3.35	2.90	0.45	2.40	2.00	0.40	2.93	2.12	0.81	3.83	3.13	0.70	1.60	1.21	0.39
8	8.20	7.10	1.10	3.65	3.00	0.65	2.35	2.00	0.35	2.61	2.08	0.53	3.93	3.02	0.91	1.75	1.28	0.47
9	9.85	8.60	1.15	2.95	2.65	0.30	2.20	2.00	0.20	3.48	3.02	0.46	4.59	4.00	0.59	1.44	1.25	0.19
10	10.65	8.50	2.05	3.50	2.75	0.75	2.35	1.85	0.50	3.50	2.53	0.97	5.33	3.96	1.37	1.89	1.28	0.61
11	8.45	7.65	0.80	2.25	2.05	0.20	2.00	1.55	0.45	4.02	3.47	0.55	5.23	3.88	1.35	1.45	1.07	0.38
12	7.60	6.95	0.65	3.55	2.95	0.60	2.55	2.10	0.45	2.48	2.07	0.41	3.45	2.78	0.67	1.57	1.18	0.39
13	9.55	8.15	1.40	3.00	2.15	0.85	2.35	1.70	0.65	4.08	3.03	1.05	5.21	3.87	1.34	1.35	1.07	0.28
14	9.70	8.40	1.30	3.10	2.50	0.60	2.30	1.70	0.60	3.67	2.84	0.83	5.15	4.09	1.06	1.62	1.15	0.47
15	9.15	8.25	0.90	2.20	1.90	0.30	1.90	1.65	0.25	4.61	3.84	0.77	5.38	4.34	1.04	1.24	1.06	0.18
16	10.80	9.00	1.80	3.00	2.40	0.60	2.35	2.05	0.30	4.08	3.00	1.08	5.14	4.23	0.91	1.46	1.14	0.32
17	10.55	8.45	2.10	3.00	2.10	0.90	2.25	1.85	0.40	4.38	3.19	1.19	4.97	4.14	0.83	1.40	1.09	0.31
18	9.75	8.55	1.20	3.40	2.90	0.50	2.45	2.00	0.45	3.15	2.52	0.63	4.73	3.60	1.13	1.60	1.21	0.39
19	8.85	7.65	1.20	3.80	3.25	0.55	2.90	2.20	0.70	2.53	2.10	0.43	3.71	2.76	0.95	1.55	1.24	0.31
20	10.80	8.50	2.30	3.15	2.40	0.75	2.35	1.80	0.55	4.29	2.70	1.59	5.38	3.87	1.51	1.62	1.09	0.53
21	10.80	9.45	1.35	3.00	2.60	0.40	2.40	2.05	0.35	3.98	3.22	0.76	5.15	4.11	1.04	1.42	1.15	0.27

Average and its s.d. through the whole strains were found to be 3.08 ± 0.48 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 3.20 ± 0.46 .

Minimum: 1) Group A: The widest (3.20 mm) was obtained in No. 2, followed by Nos. 5 and 8 (3.00 mm). The narrowest (2.50 mm) was noted in No. 4, which was the same as in case of the maximum, followed by No. 9 (2.65 mm) and No. 6 (2.70 mm). Average and its s.d. through the whole strains were found to be 2.85 ± 0.21 .

2) Group B: The widest (3.25 mm) was obtained in No. 19, which was the same as in case of the maximum, followed by No. 12 (2.95 mm) and No. 18 (2.90 mm). The narrowest (1.90 mm) was noted in No. 15, which was also the same as in case of the maximum, followed by No. 11 (2.05 mm) and No. 17 (2.10 mm). Average and its s.d. through the whole strains were found to be 2.50 ± 0.41 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 2.65 ± 0.38 .

Range: 1) Group A: The largest (1.05 mm) was obtained in No. 1, which was the same as in case of the maximum, followed by No. 5 (0.70 mm) and No. 8 (0.65 mm). It was noted that the value was peculiarly large in No. 1. The smallest (0.15 mm) was noted in No. 3, which was the same as in case of the range of length, followed by Nos. 4 and 9 (0.30 mm). It was noted that the value was peculiarly small in No. 3. These combinations of strains were found to be the same as in case of the maximum. Average and its s.d. through the whole strains were found to be 0.52 ± 0.27 .

2) Group B: The largest (0.90 mm) was obtained in No. 17, followed by No. 13 (0.85 mm) and Nos. 10 and 20 (0.75 mm). The smallest (0.20 mm) was noted in No. 11, followed by No. 15 (0.30 mm) and No. 21 (0.40 mm). Average and its s.d. through the whole strains were found to be 0.58 ± 0.21 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 0.56 ± 0.23 .

3. Thickness in unhusked grains

Maximum: 1) Group A: The thickest (2.55 mm) was obtained in Nos. 1 and 2, followed by No. 5 (2.50 mm). These combinations of strains were found to be the same as in case of the maximum of width. The thinnest (1.75 mm) was noted in No. 3, which was the same as in cases of the ranges of length and width, followed by No. 4 (2.10 mm) and Nos. 6 and 9 (2.20 mm). It was noted that the value was peculiarly small in No. 3. These combinations of strains were found to be the same as in cases of the maximum and the range of width. Average and its s.d. through the whole strains were found to be 2.29 ± 0.26 .

2) Group B: The thickest (2.90 mm) was obtained in No. 19, which was the same as in cases of the maximum and the minimum of width, followed by No. 12 (2.55 mm) and No. 18 (2.45 mm). It was noted that the value was peculiarly large in No. 19. These orders of strains were found to be the same as in case of the minimum of width. The thinnest (1.90 mm) was noted in No. 15, which was the same as in cases of the maximum and the minimum of width, followed by No. 11 (2.00 mm) and No. 17 (2.25 mm). These orders of strains were found to be the same as in case of the minimum of width. This phenomenon was ascertained to be the same as in case of the large values. Average and its s.d. through the whole strains were found to be 2.35 ± 0.25 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be

2.32 ± 0.25.

Minimum: 1) Group A: The thickest (2.15 mm) was obtained in No. 2, which was the same as in case of the minimum of width, followed by No. 1 (2.10 mm). The thinnest (1.45 mm) was noted in No. 3, which was the same as in cases of the ranges of length and width, and the maximum of thickness, followed by No. 4 (1.80 mm) and No. 6 (1.90 mm). Average and its s.d. through the whole strains were found to be 1.93 ± 0.21.

2) Group B: The thickest (2.20 mm) was obtained in No. 19, which was the same as in cases of the maximum and the minimum of width, and the maximum of thickness, followed by No. 12 (2.10 mm) and Nos. 16 and 21 (2.05 mm). The thinnest (1.55 mm) was noted in No. 11, which was the same as in case of the range of width, followed by No. 15 (1.65 mm) and Nos. 13 and 14 (1.70 mm). Average and its s.d. through the whole strains were found to be 1.88 ± 0.20.

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 1.90 ± 0.20.

Range: 1) Group A: The largest (0.50 mm) was obtained in No. 5, followed by No. 1 (0.45 mm). The smallest (0.20 mm) was noted in No. 9, followed by Nos. 3, 4 and 6 (0.30 mm). These combinations of strains were found to be the same as in cases of the maximum and the range of width. Average and its s.d. through the whole strains were found to be 0.36 ± 0.09.

2) Group B: The largest (0.70 mm) was obtained in No. 19, which was the same as in cases of the maxima and the minima of width and thickness, followed by No. 13 (0.65 mm) and No. 14 (0.60 mm). The smallest (0.25 mm) was noted in No. 15, which was the same as in cases of the maxima of width and thickness, and the minimum of width, followed by No. 16 (0.30 mm) and No. 21 (0.35 mm). Average and its s.d. through the whole strains were found to be 0.47 ± 0.14.

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 0.42 ± 0.13.

4. Ratio of length to width (L/W) in unhusked grains

Maximum: 1) Group A: The largest (3.48) was obtained in No. 9, which was the same as in cases of the maximum and the minimum of length, followed by No. 4 (3.44) and No. 6 (3.02). It was noted that the values were peculiarly large in Nos. 4 and 9. These orders of strains were found to be the same as in case of the maximum of length. The smallest (2.61) was noted in Nos. 2 and 8, followed by No. 1 (2.85). Average and its s.d. through the whole strains were found to be 2.98 ± 0.31.

2) Group B: The largest (4.61) was obtained in No. 15, followed by No. 17 (4.38) and No. 20 (4.29). The smallest (2.48) was noted in No. 12, which was the same as in cases of the maximum, the minimum and the range of length, followed by No. 19 (2.53) and No. 18 (3.15). Average and its s.d. through the whole strains were found to be 3.73 ± 0.69.

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 3.41 ± 0.67.

Minimum: 1) Group A: The largest (3.02) was obtained in Nos. 4 and 9, followed by No. 6 (2.55). These combinations of strains were found to be the same as in cases of the maxima of length and L/W. The smallest (1.91) was noted in No. 1, followed by No. 8 (2.08) and No. 7 (2.12). These combinations of strains were found to be the same as in case of the minimum of length. Average and its s.d. through the whole strains were found to be 2.43 ± 0.42.

2) Group B: The largest (3.84) was obtained in No. 15, which was the same as in case of the maximum of L/W, followed by No. 11 (3.47) and No. 21 (3.22). It was noted that the value

was peculiarly large in No. 15. The smallest (2.07) was noted in No. 12, which was the same as in cases of the maximum, the minimum and the range of length, and the maximum of L/W, followed by No. 19 (2.10) and No. 18 (2.52). These orders of strains were found to be the same as in case of the maximum of L/W. Average and its s.d. through the whole strains were found to be 2.88 ± 0.53 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 2.68 ± 0.52 .

Range: 1) Group A: The largest (0.94) was obtained in No. 1, which was the same as in cases of the maximum and the range of width, followed by No. 7 (0.81) and No. 5 (0.62). It was noted that the value was peculiarly large in No. 1. The smallest (0.27) was noted in No. 3, which was the same as in cases of the ranges of length and width, the maximum and the minimum of thickness, followed by No. 4 (0.42) and No. 9 (0.46). It was noted that the value was peculiarly small in No. 3. These combinations of strains were found to be the same as in cases of the maxima and ranges of width and thickness. Average and its s.d. through the whole strains were found to be 0.55 ± 0.21 .

2) Group B: The largest (1.59) was obtained in No. 20, which was the same as in case of the range of length, followed by No. 17 (1.19) and No. 16 (1.08). It was noted that the value was peculiarly large in No. 20. The smallest (0.41) was noted in No. 12, which was the same as in cases of the maxima and the minima of length and L/W, and the range of length, followed by No. 19 (0.43) and No. 11 (0.55). In other words, No. 12 showed consistently the smallest values through the 6 characters. These combinations of strains were found to be the same as in cases of the maximum and the minimum of length. Average and its s.d. through the whole strains were found to be 0.86 ± 0.34 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 0.73 ± 0.32 .

5. Ratio of length to thickness (L/T) in unhusked grains

Maximum: 1) Group A: The largest (5.52) was obtained in No. 3, followed by No. 4 (4.69) and No. 9 (4.59). It was noted that the value was peculiarly large in No. 3. The smallest (3.81) was noted in No. 1, which was the same as in case of the minimum of L/W, followed by No. 2 (3.82) and No. 7 (3.83). Average and its s.d. through the whole strains were found to be 4.34 ± 0.57 .

2) Group B: The largest (5.38) was obtained in Nos. 15 and 20, followed by No. 10 (5.33). The smallest (3.45) was noted in No. 12, which was the same as in cases of the maxima, the minima and the ranges of length and L/W, followed by No. 19 (3.71) and No. 18 (4.73). It was noted that the values were peculiarly small in Nos. 12 and 19. These orders of strains were found to be the same as in cases of the maximum and the minimum of L/W. Average and its s.d. through the whole strains were found to be 4.90 ± 0.65 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 4.66 ± 0.66 .

Minimum: 1) Group A: The largest (4.97) was obtained in No. 3, which was the same as in case of the maximum of L/T, followed by Nos. 4 and 9 (4.00). It was noted that the value was peculiarly large in No. 3. These combinations of strains were found to be the same as in case of the maximum of L/T. The smallest (2.80) was noted in No. 1, which was the same as in cases of the minimum of L/W and the maximum of L/T, followed by No. 2 (2.96) and No. 8 (3.02). These combinations of strains were found to be the same as in case of the maximum

of L/W. Average and its s.d. through the whole strains were found to be 3.53 ± 0.69 .

2) Group B: The largest (4.34) was obtained in No. 15, which was the same as in cases of the maximum and the minimum of L/W, followed by No. 16 (4.23) and No. 17 (4.14). The smallest (2.76) was noted in No. 19, followed by No. 12 (2.78) and No. 18 (3.60). These combinations of strains were found to be the same as in cases of the maxima of L/W and L/T, and the minimum of L/W. Average and its s.d. through the whole strains were found to be 3.80 ± 0.52 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 3.69 ± 0.60 .

Range: 1) Group A: The largest (1.01) was obtained in No. 1, which was the same as in cases of the maximum of width, and the ranges of width and L/W, followed by No. 5 (0.98) and No. 6 (0.95). The smallest (0.55) was noted in No. 3, which was the same as in cases of the maximum and the minimum of thickness, and the ranges of length, width and L/W, followed by No. 9 (0.59) and No. 4 (0.69). These combinations of strains were found to be the same as in cases of the maxima of width and thickness, and ranges of width, thickness and L/W. Average and its s.d. through the whole strains were found to be 0.80 ± 0.17 .

2) Group B: The largest (1.51) was obtained in No. 20, which was the same as in cases of the ranges of length and L/W, followed by No. 11 (1.37) and No. 12 (1.35). The smallest (0.67) was noted in No. 12, which was the same as in cases of the maxima, the minima and the ranges of length and L/W, and the maximum of L/T, followed by No. 17 (0.83) and No. 16 (0.91). It was noted that the value was peculiarly small in No. 12. Average and its s.d. through the whole strains were found to be 1.10 ± 0.25 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 0.97 ± 0.26 .

6. Ratio of width to thickness (W/T) in unhusked grains

Maximum: 1) Group A: The largest (2.04) was obtained in No. 3, which was the same as in cases of the maximum and the minimum of L/T, followed by No. 1 (1.76) and No. 8 (1.75). It was noted that the value was peculiarly large in No. 3. The smallest (1.44) was noted in No. 9, which was the same as in cases of the ranges of thickness and L/T, followed by No. 4 (1.47) and No. 2 (1.57). Average and its s.d. through the whole strains were found to be 1.65 ± 0.18 .

2) Group B: The largest (1.89) was obtained in No. 10, followed by Nos. 14 and 20 (1.62). It was noted that the value was peculiarly large in No. 10. The smallest (1.24) was noted in No. 15, which was the same as in cases of the maxima of width and thickness, the minimum of width, and the range of thickness, followed by No. 13 (1.35) and No. 17 (1.40). Average and its s.d. through the whole strains were found to be 1.51 ± 0.17 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 1.57 ± 0.18 .

Minimum: 1) Group A: The largest (1.69) was obtained in No. 3, which was the same as in cases of the maxima of L/T and W/T, and the minimum of L/T, followed by No. 5 (1.33) and No. 2 (1.31). It was noted that the value was peculiarly large in No. 3. The smallest (1.21) was noted in No. 7, which was the same as in case of the minimum of length, followed by No. 4 (1.22) and No. 9 (1.25). Average and its s.d. through the whole strains were found to be 1.31 ± 0.15 .

2) Group B: The largest (1.28) was obtained in No. 10, which was the same as in case of the

maximum of W/T, followed by No. 19 (1.24) and No. 18 (1.21). The smallest (1.06) was noted in No. 15, which was the same as in cases of the maxima of width, thickness and W/T, the minima of width and W/T, and the range of thickness, followed by Nos. 11 and 13 (1.07). These combinations of strains were found to be the same as in case of the minimum of thickness. Average and its s.d. through the whole strains were found to be 1.14 ± 0.07 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 1.22 ± 0.14 .

Range: 1) Group A: The largest (0.50) was obtained in No. 1, which was the same as in cases of the maximum of width, and the ranges of width, L/W and L/T, followed by No. 8 (0.47) and Nos. 6 and 7 (0.39). The smallest (0.19) was noted in No. 9, which was the same as in cases of the ranges of thickness and L/T, followed by No. 4 (0.25) and No. 5 (0.26). It was noted that the value was peculiarly small in No. 19. These orders of strains were found to be the same as in case of the maximum of W/T. Average and its s.d. through the whole strains were found to be 0.34 ± 0.11 .

2) Group B: The largest (0.61) was obtained in No. 10, which was the same as in cases of the maximum and the minimum of W/T, followed by No. 20 (0.53) and No. 14 (0.47). These combinations of strains were found to be the same as in case of the maximum of W/T. The smallest (0.18) was noted in No. 15, which was the same as in cases of the maxima of width, thickness and W/T, the minima of width and W/T, and the range of thickness, followed by No. 21 (0.27) and No. 13 (0.28). Average and its s.d. through the whole strains were found to be 0.37 ± 0.12 .

3) Whole: Average and its s.d. through the whole strains of both groups were found to be 0.36 ± 0.11 .

Discussion

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

Comparative values

1. In L/W, the largest (0.88) was obtained in No. 16. This value was attributable both to the largest value (0.73) in length and nearly the smallest value (0.83) in width. On the other hand, the smallest (0.75) was noted in No. 15. This value was attributable both to the smallest value (0.67) in length and the largest value (0.89) in width. In L/T, nearly the largest (0.80) was obtained in No. 19. This value was attributable both to nearly the largest value (0.71) in length and the smallest value (0.89) in thickness. On the other hand, nearly the smallest (0.75) was noted in No. 21. This value was attributable both to nearly the smallest value (0.68) in length and the largest value (0.92) in thickness. In W/T, the largest (0.98) was obtained in No. 2. This value was attributable both to nearly the largest value (0.87) in width and nearly the smallest value (0.89) in thickness. On the other hand, nearly the smallest (0.92) was noted in No. 6. This value was attributable both to nearly the smallest value (0.83) in width and nearly the largest value (0.91) in thickness.

In quotient of areas, nearly the largest (0.62) was obtained in No. 4. This value was attributable to the peculiarly smallest value (22.56 mm^2) in UHG. On the other hand, the smallest (0.42) was noted in No. 3. This value was attributable to the peculiarly small value (10.26 mm^2) in HG. In quotient of volumes, the largest (0.58) was obtained in No. 7. This value was attributable to nearly the smallest value (50.37 mm^3) in UHG. On the other hand, nearly the smallest (0.54) was

noted in No. 5. This value was attributable to the largest value (67.08 mm³) in UHG. In general, these analyses were fixed to be more difficult than that in case of the comparative columns.

2. Though the values were peculiarly large or small in some characters, the values were found to be the standard level in other characters in view of the same strains. For example, No. 11 showed the largest value (0.89) in width, but showed the middle value (0.90) in thickness. In other case, No. 21 showed nearly the smallest value (0.68) in length, but showed the middle value (0.85) in width.

Though the values were peculiarly large in some characters, the values were found to be very small in other characters in view of the same strains, and *vice versa*. For example, No. 15 showed the largest value (0.89) in width, but showed the smallest value (0.67) in length. These phenomena were found in the several combinations.

In view of area and volume characters, the following general aspects were found. The larger is the value of one character, the larger is the value of another character.

3. In view of s.d., the following facts were ascertained to some extent. As the values of s.d. of comparative columns were ascertained to be very small, the considerations were done only in area and volume columns. In general, the larger is s.d. in some character, the larger is s.d. in another character. For example, No. 2 showed the largest s.d. (1.96) in area (UHG), and showed also the largest s.d. (5.88) in volume (UHG). Some exceptions, however, were found. No. 3 showed nearly the smallest s.d. (1.26) in area (UHG), but showed nearly the largest s.d. (5.38) in volume (UHG).

In general, the larger is the practical value, the larger is its s.d. For example, No. 2 showed the largest practical value (36.39 mm³) and the largest s.d. (4.36) in volume (HG). Some exceptions, however, were found. No. 3 showed 39.24 mm³ and 5.38 mm³ in the practical value and its s.d., respectively, in volume (UHG). The former and the latter were looked upon as the smallest and nearly the largest portions, respectively. These discrepancies may be expected as evolutionary meanings. But it was left inexplicable in the present time. It was noticeable that Nos. 2 and 17, Nos. 11 and 15 showed always the largest s.d. and the smallest or nearly the smallest s.d. through the whole area and volume characters, respectively.

4. In comparison with type A, type B and type C according to the tripartite classification²⁾, the following facts were ascertained. Type A (strain No. 12) showed the general features as follows; the values in width, thickness and W/T were found to be larger than average of the whole materials; value of quotient of volumes was found to be the same as in it; and the values of other 8 characters were found to be smaller than it. S.d. in the 4 characters were clearly fixed to be smaller than average of the whole strains. In type B (strain Nos. 2, 5, 18, 19 and 21), the values were found to be very flexible in accordance with the respective characters. In view of the average values through the type B and in comparison with the average values through the whole strains, 8 characters, *i.e.*, width, thickness, areas (UHG and HG), volumes (UHG and HG), quotients of areas and volumes, showed the larger values. Three characters, *i.e.*, length, L/W and L/T, showed the smaller values. One character, *i.e.*, W/T, showed the same value. It was noticeable that the characters of area and volume showed consistently the larger values. S.d. in the 3 characters, *i.e.*, area (HG) and volumes (UHG and HG), showed the larger values. Type C (strain Nos. 1, 3, 4, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17 and 20) showed very variable values through the whole characters. In view of the average values through the whole type C and in comparison with the average values through the whole strains, only 1 character, *i.e.*, L/W, showed the larger value. The five characters, *i.e.*, width, areas (UHG and HG), volumes (UHG and HG), showed the smaller

values. The six characters, *i.e.*, length, thickness, L/T, W/T, quotients of areas and volumes, showed the same values. It was noticeable that the characters of area and volume showed consistently the smaller values, which was in form a striking contrast to type B. In the 4 values in s.d., any clear tendency was not found.

5. In comparison with Groups A and B in view of group-averages, the following facts were ascertained. In the practical values, 7 (length, L/W, L/T, areas of UHG and HG and volumes of UHG and HG), 3 (width, thickness and quotient of volumes) and 2 (W/T and quotient of areas) showed larger, smaller and the same values in Group A than those of Group B, respectively. In s.d., the values of Group A of the whole area and volume columns were clearly fixed to be smaller than those of Group B. From these viewpoints, it was assumed that characters ascertained might be used as useful indices in analysing the varietal variations and variation-groups.

Some locality specificities were ascertained. 1) Peculiarly large or small values in view of practical ones were found only in Group A, but not in Group B. 2) These values in view of s.d. were found in both groups. 3) These values in area and volume characters were found partially in materials collected in Calcutta Delta, Shillong and Nowgong. These findings proposed an interesting problem for locality-specificities and strain differentiations.

6. In the larger set of areas, the widest (28.89 mm² in UHG and 17.36 mm² in HG) were obtained in No. 5, followed by No. 2 (27.85 mm² and 17.11 mm² in the same order, and so forth) and No. 1 (26.52 mm² and 16.77 mm²). These orders of strains were finally illustrated as $5 > 2 > 1$. These orders of strains were fixed to be the same as both in UHG and HG. These phenomena were found in other 8 cases, *i.e.*, ① $1 = 7 > 2 = 4 \dots$ Nos. 1 and 7 (0.63 and 0.58) and Nos. 2 and 4 (0.62 and 0.56) in the larger sets of quotients of areas and volumes; ② $3 < 4 < 7 \dots$ No. 3 (39.24 mm³ and 10.26 mm²), No. 4 (43.89 mm³ and 13.94 mm²) and No. 7 (50.37 mm³ and 14.60 mm²) in the smaller sets of volume (UHG) and of area (HG); ③ $3 < 8 < 5 = 6 \dots$ No. 3 (0.42 and 0.28), No. 8 (0.56 and 0.51) and Nos. 5 and 6 (0.60 and 0.54) in the smaller sets of quotients of areas and volumes; ④ $18 > 19 > 21 \dots$ No. 18 (29.83 mm² and 38.23 mm³), No. 19 (28.92 mm² and 37.64 mm³) and No. 21 (28.57 mm² and 33.69 mm³) in the larger sets of area (UHG) and volume (HG); ⑤ $15 < 11 < 13 \dots$ No. 15 (31.72 mm³ and 17.06 mm³), No. 11 (33.57 mm³ and 18.93 mm³) and No. 13 (43.03 mm³ and 23.24 mm³) in the smaller sets of volumes (UHG and HG); ⑥ $2 > 3 > 5 \dots$ No. 2 (5.88 and 4.36), No. 3 (5.38 and 3.75) and No. 5 (5.22 and 3.63) in the larger sets of s.d. of volumes (UHG and HG); ⑦ $4 < 9 < 8 \dots$ No. 4 (3.33 and 1.71), No. 9 (3.64 and 2.19) and No. 8 (3.69 and 2.27) in the smaller sets of s.d. of volumes (UHG and HG); ⑧ $17 > 19 > 20 \dots$ No. 17 (8.66 and 4.59), No. 19 (7.87 and 4.48) and No. 20 (7.76 and 4.00) in the larger sets of s.d. of volumes (UHG and HG). It was noticeable that these synchronized orders of strains were not found in the comparative columns. It meant that gene actions of these characters were expressed independently of each other.

On the other hand, some sets of strains did not show the same orders, but showed the same combinations, which meant the same strain numbers regardless of orders. Twelve cases were ascertained, *i.e.*, ① $1 \cdot 2 \cdot 5$ in the larger sets \dots area in UHG ($5 > 2 > 1$), volume in UHG ($5 > 2 > 1$), area in HG ($5 > 2 > 1$) and volume in HG ($2 > 1 > 5$); ② $1 \cdot 2 \cdot 7$ in the larger sets \dots length ($1 = 7 > 2$), quotient of areas ($1 = 7 > 2$) and quotient of volumes ($1 = 7 > 2$); ③ $3 \cdot 6 \cdot 8$ in the smaller sets \dots width ($3 < 8 < 6$), W/T ($8 < 6 < 3$), quotient of areas ($3 < 8 < 6$) and quotient of volumes ($3 < 8 < 6$); ④ $3 \cdot 4 \cdot 7$ in the smaller sets \dots area in UHG ($4 < 7 < 3$), volume in UHG ($3 < 4 < 7$) and area in HG ($3 < 4 < 7$); ⑤ $11 \cdot 12 \cdot 15$ in the larger sets \dots width ($11 = 15 > 12$) and W/T ($11 > 15 > 12$); ⑥ $10 \cdot 16 \cdot 19$ in the larger sets \dots length ($16 >$

10 = 19), L/W ($16 > 19 > 10$) and L/T ($16 > 10 = 19$); ⑦ 18 · 19 · 21 in the larger sets ... area in UHG ($18 > 19 > 21$), volume in UHG ($19 > 18 > 21$) and volume in HG ($18 > 19 > 21$); ⑧ 12 · 15 · 21 in the smaller sets ... length ($15 < 12 = 21$) and L/T ($12 = 15 < 21$); ⑨ 11 · 13 · 15 in the smaller sets ... area in UHG ($11 < 15 < 13$), volume in UHG ($15 < 11 < 13$), area in HG ($15 < 11 < 13$) and volume of HG ($15 < 11 < 13$); ⑩ 14 · 17 · 19 in the smaller sets ... quotient of areas ($17 < 14 = 19$) and quotient of volumes ($14 = 19 < 17$); ⑪ 17 · 19 · 20 in the larger sets of s.d. ... volume in UHG ($17 > 19 > 20$), area in HG ($17 > 20 > 19$) and volume in HG ($17 > 19 > 20$); ⑫ 11 · 12 · 15 in the smaller sets of s.d. ... area in UHG ($11 < 12 = 15$), volume in UHG ($11 < 15 < 12$) and volume in HG ($15 < 11 < 12$).

It was noticeable that the orders of s.d. in volumes were quite the same as in cases of UHG and HG in view of the larger and the smaller sets found in both Groups A and B ($2 > 3 > 5$, $4 < 9 < 8$, $17 > 19 = 20$, $11 < 15 < 12$), and the combinations of the practical values in area and volume were also the same as in cases of UHG and HG.

Ranges in the unhusked grains

1. Though the values were peculiarly large or small in some characters, the values were found to be the standard level in other characters in view of the same strains. For example, No. 6 showed nearly the largest value (9.05 mm) in the maximum of length, but showed the middle value (3.20 mm) in the maximum of width. On other case, No. 7 showed the smallest value (7.00 mm) in the minimum of length, but showed the middle value (2.90 mm) in the minimum of width.

On the other hand, though the values were peculiarly large in some characters, the values were found to be peculiarly small in other characters in view of the same strains, and *vice versa*. For example, No. 9 showed peculiarly large value (9.85 mm) in the maximum of length, but showed nearly the smallest value (2.95 mm) in the maximum of width. In other case, No. 1 showed nearly the smallest value (8.25 mm) in the maximum of length, but showed the largest value (3.95 mm) in the maximum of width. These phenomena were found in several combinations. In quotients of areas and volumes, these facts were not ascertained in the present experiment.

2. In comparison with type A, type B and type C in accordance with the tripartite classification, the following facts were ascertained. Type A showed the general features as follows; 7 characters, *i.e.*, the maxima, the minima and the ranges of width and thickness, and the range of W/T, showed the larger values than that of the average of the whole strains; 1 character, *i.e.*, the maximum of W/T, showed the same value with the average of the whole strains; and the remaining 10 characters, *i.e.*, the maxima, the minima and the ranges of length, L/W and L/T, and the minimum of W/T, showed the smaller values than that of the average of the whole strains. It was a remarkable fact that the maxima, the minima and the ranges of the length and L/W showed the lowest values through the whole strains. It was explicable as strain-specificities. Moreover, it may be anticipated that the value of L/W was attributable to and was under the control of the value of length.

In type B, the values were found to be flexible in accordance with the respective characters. In view of the average values through the whole type B in comparison with the average values through the whole strains, 9 characters, *i.e.*, the maxima and the minima of length, width and thickness, the minimum of W/T, and the ranges of thickness and L/T, showed the larger values. Other 9 characters, *i.e.*, the maxima of L/W, L/T and W/T, the minima of L/W and L/T, the ranges of length, width, L/W and W/T, showed the smaller values.

In type C, the values were found to be very variable in accordance with the respective char-

acters and the respective strains. In view of the average values through type C in comparison with the average values through the whole strains, 10 characters, *i.e.*, the maxima, the minima and the ranges of L/W and L/T, the maxima and the ranges of length and W/T, showed the larger values. Six characters, *i.e.*, the maxima of width and thickness, the minima of width, thickness and W/T, the range of thickness, showed the smaller values. Two characters, *i.e.*, the minimum of length and the range of width, showed the same values.

3. In comparison with Groups A and B in view of group-averages, the following facts were ascertained. Five characters, *i.e.*, the maxima and the minima of width and W/T, and the minimum of thickness, showed the larger values in Group A than those of Group B. The remaining 13 characters showed the smaller values in Group A than those of the Group B. It is noticeable that the whole characters in length, L/W and L/T showed the smaller values in Group A than those of Group B. These phenomena may be looked upon as geographical specificities.

4. In the larger set of length, the longest (9.85 mm) was obtained in No. 9, followed by No. 4 (9.15 mm) and No. 6 (9.05 mm). In the larger set of L/W, the largest (3.48) was obtained in No. 9, followed by No. 4 (3.44) and No. 6 (3.02). These orders of strains were finally illustrated in both characters as $9 > 4 > 6$, and were fixed to be the same as in both characters. These phenomena were found in other 4 cases, *i.e.*, ① $9 < 4 < 2 \dots$ No. 9 (1.44 and 0.19), No. 4 (1.47 and 0.25) and No. 2 (1.57 and 0.26) in the smaller sets of the maximum and the range of W/T; ② $19 > 12 > 18 \dots$ No. 19 (3.25 mm and 2.90 mm), No. 12 (2.95 mm and 2.55 mm) and No. 18 (2.90 mm and 2.45 mm) in the larger sets of the minimum of width and the maximum of thickness; ③ $15 < 11 < 17 \dots$ No. 15 (1.90 mm and 1.90 mm), No. 11 (2.05 mm and 2.00 mm) and No. 17 (2.10 mm and 2.25 mm) in the smaller sets of the minimum of width and the maximum of thickness; ④ $12 < 19 < 18 \dots$ No. 12 (2.48, 2.07 and 3.45), No. 19 (2.53, 2.10 and 3.71) and No. 18 (3.15, 2.52 and 4.73) in the smaller sets of the maximum of L/W, the minimum of L/W and the maximum of L/T. It was noticeable that these synchronized orders of strains were not found in the pure-ranges.

The orders of $19 > 12 > 18$ and $15 < 11 < 17$ were similarly found in the minimum (width) and in the maximum (thickness), respectively. Though these 2 characters were looked upon as closely related items from each other, conclusions have left several points in questions.

On the other hand, some sets of strains did not show the same orders, but showed the same combinations, which meant the same strain numbers regardless of the orders. Ten cases were ascertained, *i.e.*, ① $4 \cdot 6 \cdot 9$ in the larger sets \dots the maximum of length ($9 > 4 > 6$), the maximum of L/W ($9 > 4 > 6$) and the minimum of L/W ($4 = 9 > 6$); ② $1 \cdot 2 \cdot 5$ in the larger sets \dots the maximum of width ($1 > 2 > 5$) and the maximum of thickness ($1 = 2 > 5$); ③ $3 \cdot 4 \cdot 9$ in the larger sets \dots the maximum of L/T ($3 > 4 > 9$) and the minimum of L/T ($3 > 4 = 9$); ④ $1 \cdot 7 \cdot 8$ in the smaller sets \dots the minimum of length ($7 < 8 < 1$) and the minimum of L/W ($1 < 8 < 7$); ⑤ $3 \cdot 4 \cdot 9$ in the smaller sets \dots the maximum of width ($4 < 3 = 9$), the range of width ($3 < 4 = 9$), the maximum of thickness ($3 < 4 < 9$), the range of thickness ($9 < 3 = 4$), the range of L/W ($3 < 4 < 9$) and the range of L/T ($3 < 9 < 4$); ⑥ $1 \cdot 2 \cdot 8$ in the smaller sets \dots the maximum of L/W ($2 = 8 < 1$) and the minimum of L/T ($1 < 2 < 8$); ⑦ $10 \cdot 14 \cdot 20$ in the larger sets \dots the maximum of W/T ($10 > 14 = 20$) and the range of W/T ($10 > 20 > 14$); ⑧ $11 \cdot 12 \cdot 19$ in the smaller sets \dots the maximum of length ($12 < 11 < 19$), the minimum of length ($12 < 11 = 19$) and the range of L/W ($12 < 19 < 11$); ⑨ $11 \cdot 13 \cdot 15$ in the smaller sets \dots the minimum of thickness ($11 < 15 < 13$) and the minimum of W/T ($15 < 11 = 13$); ⑩ $12 \cdot 18 \cdot 19$ in the smaller sets \dots the maximum of L/W ($12 < 19 < 18$), the minimum of L/W

(12 < 19 < 18), the maximum of L/T (12 < 19 < 18) and the minimum of L/T (19 < 12 < 18).

Summary

In order to confirm the varietal variations of the cultivated rice collected in India, comparisons of the unhusked and husked grains for 12 characters and variation ranges in 6 characters were carried out following the previous paper. Those were divided geographically into 2 groups, *i.e.*, Group A ... Northeastern India, Group B ... West Bengal State. The results obtained here were summarized as follows:

Comparative values of length, width, thickness, L/W, L/T, W/T, area (UHG), volume (UHG), area (HG), volume (HG), quotient of areas and quotient of volumes in Group A were measured as 0.72, 0.83, 0.88, 0.87, 0.83, 0.94, 25.50 mm², 54.55 mm³, 15.02 mm², 28.85 mm³, 0.59 and 0.52 in average values, respectively. Those in Group B were measured in the same order as 0.70, 0.85, 0.90, 0.82, 0.77, 0.94, 24.86 mm², 54.10 mm³, 14.65 mm², 28.73 mm³, 0.59 and 0.53 in average values, respectively. Those in the whole strains of both groups were measured in the same order as 0.71, 0.84, 0.89, 0.84, 0.80, 0.94, 25.14 mm², 54.29 mm³, 14.81 mm², 28.78 mm³, 0.59 and 0.53 in average values, respectively. Seven, 3 and 2 characters showed larger, smaller and the same values in Group A than those of Group B, respectively.

The maximum, the minimum and the pure-range of length, width, thickness, L/W, L/T and W/T in Group A were ascertained as 8.85 mm, 7.67 mm, 1.17 mm; 3.37 mm, 2.85 mm, 0.52 mm; 2.29 mm, 1.93 mm, 0.36 mm; 2.98, 2.43, 0.55; 4.34, 3.53, 0.80; 1.65, 1.31, 0.34 in average values, respectively. Those in Group B in the same order were ascertained as 9.72 mm, 8.29 mm, 1.42 mm; 3.08 mm, 2.50 mm, 0.58 mm; 2.35 mm, 1.88 mm, 0.47 mm; 3.73, 2.88, 0.86; 4.90, 3.80, 1.10; 1.51, 1.14, 0.37 in average values, respectively. Those in the whole strains of both groups in the same order were ascertained as 9.35 mm, 8.03 mm, 1.31 mm; 3.20 mm, 2.65 mm, 0.56 mm; 2.32 mm, 1.90 mm, 0.42 mm; 3.41, 2.68, 0.73; 4.66, 3.69, 0.97; 1.57, 1.22, 0.36 in average values, respectively. Five and 13 characters showed the larger and the smaller values in Group A than those of Group B, respectively.

Basing on the data obtained in these characters, several patterns were found to be strain specificities. Strains showing relatively large or small values in the respective characters were tentatively picked-up and grouped as "order" or "combination". These new techniques were fixed to be useful for testing the strain or geographical differentiations of rice varieties.

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