Mem. Fac. Agr. Kagoshima Univ., **18**, 29–44, 1982

Distribution and Some Morphological Characters of the Wild Rice in the Northeastern India (II)

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Received for Publication August 26, 1981

Introduction

During the period from December in 1978 to January in 1979, the winter was sent to India for collection of the wild and cultivated rice under the project, designated "The distribution of wild rice and the ecotypic differentiation of cultivated rice in Burma and Assam", supported by a Grant from the Ministry of Education, Japan.

Although Watabe[8] had confirmed the growing wild rice distributed in the northeastern India, Assam, no distinct record has been reported on the wild rice in these regions. According to the research trip made at this opportunity, the habitat and the record of some morphological characters of unhusked and husked grains of the wild rice collected in the northeastern India, which was denoted here Assam, Meghalaya and most northern part of West Bengal, were described[3]. Gustchin[1] reported that rice might have been originated on the slopes of the Himalaya, both on the India and Chinese sides. Morinaga[7] stated that Himalaya is an indigenous center of rice. Katayama[2] held that Sikkim might be one of the differentiation-centers of *O. sativa* into *japonica* and *indica*. Then, those areas have been considered to be one of the most important world centers for the origin and dispersal of cultivated rice, *Oryza sativa* L. It seems to be very important to keep in mind that natural habitat of wild rice made to be disappearing owing to man-made environments year by year, that the wild rices may serve as reservoires of germplasm for cultivated rices, and then collection scheme of these plant must be hurried up in its workings.

In the present paper, variation ranges in 12 characters and some mutual relations among them were mainly described, in order to confirm the morphological characters of grains as well as to make clear the species specificities and the ecotypic differentiations of those grains. The records on the comparison of the unhusked and the husked grains and some considerations of wild rice in the whole India and in the world will be reported in the separate articles.

Materials and Methods

The taxonomy of the genus *Oryza* shows a complicated state, because there are natural hybrids between the respective species. In the present paper, however, the following 2 species-names are adopted, *i.e.*, *O. sativa* var. *spontanea* and *O. perennis*.

Seventeen strains of wild rice were collected in this trip, and they were used for morphological investigations. Their collection number, collection date, district and habitat were mentioned in Table 1. Thirty grains were used for the measurement of each strain. The whole data referring to the 12 characters were illustrated by the maximum, the minimum and the pure-range-values in

Table 1. Distribution and habitat of wild rice collected in the Northeastern India

Collection No.	Species	Date	Place	Detailed locality, habitat and remarks
W1	p	Jan. 4	Jorabat	S 20 km northeast from Jorabat. Swamp, 50 m × 100 m. Large population. Growing only in edge.
W2	p	Jan. 4	Jaji Road	S 2 km west from Jaji Road. Swamp, 50 m × 50 m. Growing only about 30 plants.
W3	p	Jan. 4	Chapatmukh	N 16 km west from Chapatmukh. Pond, 50 m × 100 m. Growing sporadically only in the edge of pond.
W4	p	Jan. 5	Nowgong	N 6 km east from Nowgong. Swamp, 100 m × 200 m. Growing only in edge. Soaking jute here.
W5	p	Jan. 5	Nowgong	N 26 km northeast from Nowgong. Pond, dia. 100 m. Large population.
W6	p	Jan. 5	Nowgong	N, S 30 km north east from Nowgong. Swamp, 50 m × 200 m and 100 m × 100 m. Large population.
W7	s	Jan. 5	Nowgong	N, S Same locality and habitat as above. Growing sympatrically with the plant metioned above.
W8	p	Jan. 5	Kaziranga	N 5 km west from Kaziranga. Swamp, 100 m × 100 m. Large population.
W9	p	Jan. 5	Bakaknat	N, S 2 km west from Bakaknat. Swamp, 50 m × 200 m and 100 m × 100 m. Large population.
W10	s	Jan. 5	Bakaknat	N, S Same locality and habitat as above. Growing sympatrically with the plant mentioned above.
W11	p	Jan. 5	Jorhat	N 3 km west from Jorhat. Pond, 50 m × 30 m. Growing only in edge.
W12	p	Jan. 6	Jorhat	E In Kumarguan village. Swamp, 50 m × 200 m. Growing sporadically.
W13	p	Jan. 6	Jorhat	E In Neamati village. Swamp, 50 m × 200 m. Growing sporadically only in edge.
W14	p	Jan. 6	Jorhat	S 18 km west from Jorhat. Swamp, 30 m × 100 m. Growing sporadically in edge.
W15	p	Jan. 7	Jorhat	S Near Jorhat Airport. Swamp, 30 m × 50 m. Growing sporadically.
W16	p	Jan. 12	Bagdogra	W 8 km north from Bagdogra, W. B. Swamp, 50 m × 30 m. Growing only in edge of swamp.
W17	s	Jan. 12	Bagdogra	W Same locality as above. Swamp, 20 m × 10 m.

Abbreviations: s; *Oryza sativa* var. *spontanea* ROSCHEV., p; *Oryza perennis* MOENCH, m; meter or meters, km; kilometer or kilometers, N, E, S and W; north, east, south and west side of the main road, respectively

the whole grains. Inquiries were done to fix the variation-ranges for 12 characters, *i.e.*, 1 & 7 — length (mm), 2 & 8 — width (mm), 3 & 9 — thickness (mm), 4 & 10 — ratio of length to width (%), 5 & 11 — ratio of length to thickness, 6 & 12 — ratio of width to thickness (%). Characters from No. 1 to No. 6 and No. 7 to No. 12 were concerned to the unhusked and the husked grains, respectively. The whole data were cited from the previous paper[3].

To make clear the relations between the respective two characters of the unhusked and the husked grains, correlation coefficient and linear regression between them were calculated through

the whole characters.

In this paper, the following abbreviations were used; L (length), W (width), T (thickness), L/W (ratio of length to width), L/T (ratio of length to thickness), W/T (ratio of width to thickness), c.c. (correlation coefficient), l.r. (linear regression) and s.d. (standard deviations).

Results

Part I. Ranges among the respective characters

1. Length in unhusked grains

Maximum: The results are given in Table 2. In this table, the maximum, the minimum and their range are shown. The longest (9.55 mm) was obtained in No. 17, followed by No. 1 (8.85 mm) and No. 16 (8.80 mm). It may be noted that the value was peculiarly large in No. 17. The shortest (7.75 mm) was noted in No. 14, followed by Nos. 4 and 12 (7.80 mm). Average and its s.d. through the whole strains were found to be 8.18 ± 0.49.

Minimum: The longest (8.45 mm) was obtained in No. 17, followed by Nos. 2, 8 and 14 (7.20 mm). It may be noted that the value was peculiarly large in No. 17. The shortest (6.50 mm) was noted in No. 9, followed by No. 5 (6.65 mm). Average and its s.d. through the whole strains were found to be 7.08 ± 0.48.

Range: The largest (1.85 mm) was obtained in No. 1, followed by No. 10 (1.55 mm) and No. 5 (1.45 mm). The smallest (0.55 mm) was noted in No. 14, followed by No. 15 (0.65 mm). Average and its s.d. through the whole strains were found to be 1.09 ± 0.37.

2. Width in unhusked grains

Maximum: The widest (3.25 mm) was obtained in No. 10, followed by No. 7 (3.10 mm) and No. 17 (2.80 mm). The narrowest (2.15 mm) was noted in No. 14, which was the same as in case of the length, followed by Nos. 2 and 6 (2.20 mm). Average and its s.d. through the whole strains were found to be 2.45 ± 0.31.

Minimum: The widest (2.50 mm) was obtained in No. 7, followed by No. 17 (2.45 mm) and No. 10 (2.30 mm). The narrowest (1.70 mm) was noted in No. 14, which was the same as in case of the maximum, followed by Nos. 3, 12, 13 and 15 (1.80 mm). Average and its s.d. through the whole strains were found to be 1.98 ± 0.24.

Range: The largest (0.95 mm) was obtained in No. 10, which was the same as in case of the maximum, followed by Nos. 7 and 12 (0.60 mm). The smallest (0.20 mm) was noted in No. 2, followed by Nos. 4, 6 and 16 (0.30 mm). Average and its s.d. through the whole strains were found to be 0.47 ± 0.17.

3. Thickness in unhusked grains

Maximum: The thickest (2.45 mm) was obtained in No. 10, which was the same as in cases of the maximum and the range of width, followed by No. 7 (2.20 mm) and Nos. 5, 16 and 17 (1.90 mm). It may be noted that the value was peculiarly large in No. 10. The thinnest (1.75 mm) was noted in Nos. 12 and 15. Average and its s.d. through the whole strains were found to be 1.88 ± 0.18.

Minimum: The thickest (1.90 mm) was obtained in No. 7, which was the same as in case of the minimum of width, followed by No. 10 (1.85 mm) and No. 16 (1.65 mm). The thinnest (1.40 mm) was noted in Nos. 2, 3 and 4. Average and its s.d. through the whole strains were found to be

Table 2. 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	Length			Width			Thickness			Length/Width			Length/Thickness			Width/Thickness		
No.	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range
1	8.85	7.00	1.85	2.45	2.00	0.45	1.80	1.45	0.35	4.00	3.18	0.82	5.36	4.12	1.24	1.49	1.27	0.22
2	8.10	7.20	0.90	2.20	2.00	0.20	1.85	1.40	0.45	4.05	3.35	0.70	5.50	4.16	1.34	1.57	1.11	0.46
3	7.90	6.80	1.10	2.30	1.80	0.50	1.85	1.40	0.45	4.14	3.13	1.01	5.04	3.89	1.15	1.53	1.13	0.40
4	7.80	7.00	0.80	2.30	2.00	0.30	1.80	1.40	0.40	3.90	3.04	0.86	5.38	4.33	1.05	1.64	1.17	0.47
5	8.20	6.65	1.45	2.35	1.85	0.50	1.90	1.50	0.40	4.00	2.83	1.17	5.29	4.03	1.26	1.42	1.05	0.37
6	8.00	6.80	1.20	2.20	1.90	0.30	1.80	1.55	0.25	4.13	3.09	1.04	5.03	4.19	0.84	1.42	1.11	0.31
7	8.30	6.80	1.50	3.10	2.50	0.60	2.20	1.90	0.30	3.10	2.38	0.72	3.95	3.41	0.44	1.48	1.16	0.32
8	8.00	7.20	0.80	2.30	1.85	0.45	1.80	1.55	0.25	4.10	3.26	0.84	5.10	4.06	1.04	1.45	1.09	0.35
9	7.85	6.50	1.35	2.40	1.90	0.50	1.80	1.45	0.35	4.13	3.00	1.13	5.21	4.08	1.03	1.50	1.14	0.36
10	8.35	6.80	1.55	3.25	2.30	0.95	2.45	1.85	0.60	3.12	2.12	1.00	3.91	2.82	1.09	1.55	1.09	0.46
11	8.10	6.80	1.30	2.30	1.85	0.45	1.80	1.45	0.35	4.15	3.16	0.99	5.10	4.12	0.98	1.88	1.11	0.77
12	7.80	7.00	0.80	2.40	1.80	0.60	1.75	1.45	0.30	4.33	3.23	1.10	5.38	4.12	1.26	1.53	1.18	0.35
13	7.95	7.10	0.85	2.35	1.80	0.55	1.80	1.55	0.25	4.28	3.09	1.19	4.87	4.08	0.79	1.52	1.09	0.43
14	7.75	7.20	0.55	2.15	1.70	0.45	1.85	1.50	0.35	4.32	3.35	0.97	5.17	4.14	1.03	1.33	1.00	0.33
15	7.70	7.05	0.65	2.30	1.80	0.50	1.75	1.50	0.25	4.05	3.26	0.79	5.13	4.24	0.89	1.39	1.09	0.30
16	8.80	8.00	0.80	2.50	2.20	0.30	1.90	1.65	0.25	3.86	3.24	0.62	5.15	4.21	0.94	1.47	1.19	0.28
17	9.55	8.45	1.10	2.80	2.45	0.35	1.90	1.50	0.40	3.62	3.19	0.43	5.88	4.63	1.25	1.75	1.37	0.38

1.53±0.15.

Range: The largest (0.60 mm) was obtained in No. 10, which was the same as in case of the range of width, followed by Nos. 2 and 3 (0.45 mm). The smallest (0.25 mm) was noted in Nos. 6, 8, 13, 15 and 16. Average and its s.d. through the whole strains were found to be 0.35±0.10.

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

Maximum: The largest (4.33) was obtained in No. 12, followed by No. 14 (4.32) and No. 13 (4.28). The smallest (3.10) was noted in No. 7, followed by No. 10 (3.12) and No. 17 (3.62). It may be noted that the values were peculiarly small in Nos. 7 and 10. Average and its s.d. through the whole strains were found to be 3.96±0.36.

Minimum: The largest (3.35) was obtained in Nos. 2 and 14, followed by Nos. 8 and 15 (3.26). The smallest (2.12) was noted in No. 10, followed by No 7 (2.38). Average and its s.d. through the whole strains were found to be 3.05±0.33.

Range: The largest (1.19) was obtained in No. 13, followed by No. 5 (1.17) and No. 9 (1.13). The smallest (0.43) was noted in No. 17, followed by No. 16 (0.62) and No. 7 (0.72). It may be noted that the value was peculiarly small in No. 17. Average and its s.d. through the whole strains were found to be 0.90±0.22.

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

Maximum: The largest (5.88) was obtained in No. 17, which was the same as in case of the maximum of length, followed by No. 2 (5.50) and Nos. 4 and 12 (5.38). It may be noted that the value was peculiarly large in No. 17. The smallest (3.91) was noted in No. 10, followed by No. 7 (3.95) and No. 13 (4.87). It may be noted that the values were peculiarly small in Nos. 7 and 10, which was the same as in case of the maximum of L/W. Average and its s.d. through the whole strains were found to be 5.09±0.49.

Minimum: The largest (4.63) was obtained in No. 17, which was the same as in case of the maximum, followed by No. 4 (4.33) and No. 15 (4.24). It may be noted that the value was peculiarly large in No. 17. The smallest (2.82) was noted in No. 10, which was the same as in cases of the minimum of L/W and the maximum of L/T, followed by No. 7 (3.41) and No. 3 (3.89). It may be noted that the values were peculiarly small in Nos. 7 and 10, which was the same as in cases of the maximum of L/W and L/T. Average and its s.d. through the whole strains were found to be 4.04±0.39.

Range: The largest (1.34) was obtained in No. 2, followed by Nos. 5 and 12 (1.26). The smallest (0.44) was noted in No. 7, which was the same as in case of the maximum of L/W, followed by No. 13 (0.79) and No. 6 (0.84). It may be noted that the value was peculiarly small in No. 7. Average and its s.d. through the whole strains were found to be 1.04±0.22.

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

Maximum: The largest (1.88) was obtained in No. 11, followed by No. 17 (1.75) and No. 4 (1.64). The smallest (1.33) was noted in No. 14, followed by No. 15 (1.39) and Nos. 5 and 6 (1.42). Average and its s.d. through the whole strains were found to be 1.53±0.13.

Minimum: The largest (1.37) was obtained in No. 17, which was the same as in cases of the maximum and the minimum of L/T, followed by No. 1 (1.27) and No. 16 (1.19). The smallest (1.00) was noted in No. 14, which was the same as in case of the maximum of W/T, followed by No. 5 (1.05). Average and its s.d. through the whole strains were found to be 1.14±0.09.

Range: The largest (0.77) was obtained in No. 11, which was the same as in case of the maximum of W/T, followed by No. 4 (0.47) and Nos. 2 and 10 (0.46). It may be noted that the value was peculiarly large in No. 11. The smallest (0.22) was noted in No. 1, followed by No. 16 (0.28) and No. 15 (0.30). Average and its s.d. through the whole strains were found to be 0.39 ± 0.12.

7. Length in husked grains

Maximum: The results are given in Table 3. In this table, the maximum, the minimum and its range are shown. The longest (6.90 mm) was obtained in No. 17, which was the same as in case of the unhusked grains, followed by No. 16 (6.40 mm) and No. 1 (6.25 mm). It may be noted that the value was peculiarly large in No. 17. The smallest (5.45 mm) was noted in Nos. 4 and 14, followed by Nos. 3, 13 and 15 (5.50 mm). Average and its s.d. through the whole strains were found to be 5.80 ± 0.41.

Minimum: The longest (6.15 mm) was obtained in No. 17, which was also the same as in case of the unhusked grains, followed by No. 16 (6.00 mm) and No. 13 (5.25 mm). It may noted that the values were peculiarly large in Nos. 16 and 17. The shortest (4.85 mm) was noted in No. 10, followed by Nos. 5, 9 and 11 (4.90 mm). Average and its s.d. through the whole strains were found to be 5.16 ± 0.37.

Range: The largest (1.25 mm) was obtained in Nos. 1 and 10, followed by No. 7 (1.10 mm). The smallest (0.25 mm) was noted in Nos. 4 and 13, followed by No. 14 (0.35 mm). Average and its s.d. through the whole strains were found to be 0.64 ± 0.32.

8. Width in husked grains

Maximum: The widest (2.70 mm) was obtained in No. 10, which was the same as in case of the unhusked grains, followed by No. 7 (2.60 mm) and No. 17 (2.30 mm). These orders of strains were found to be the same as in case of the unhusked grains. The narrowest (1.80 mm) was noted in No. 6, followed by Nos. 8, 12 and 14 (1.85 mm). Average and its s.d. through the whole strains were found to be 2.06 ± 0.26.

Minimum: The widest (2.10 mm) was obtained in No. 10, which was the same as in case of the unhusked grains, followed by Nos. 10 and 17 (2.00 mm). The narrowest (1.40 mm) was noted in Nos. 6, 12, 13 and 14. Average and its s.d. through the whole strains were found to be 1.65 ± 0.23.

Range: The largest (0.70 mm) was obtained in No. 10, which was the same as in case of the unhusked grains, followed by No. 11 (0.65 mm) and Nos. 7 and 13 (0.50 mm). The smallest (0.25 mm) was noted in Nos. 2, 8 and 16. Average and its s.d. through the whole strains were found to be 0.41 ± 0.13.

9. Thickness in husked grains

Maximum: The thickest (2.10 mm) was obtained in No. 10, which was the same as in case of the unhusked grains, followed by No. 7 (2.00 mm) and Nos. 16 and 17 (1.70 mm). These orders of strains were found to be the same as in case of the unhusked grains. The thinnest (1.40 mm) was noted in No. 4, followed by No. 8 (1.45 mm). Average and its s.d. through the whole strains were found to be 1.60 ± 0.19.

Minimum: The thickest (1.70 mm) was obtained in No. 7, which was the same as in case of the unhusked grains, followed by No. 10 (1.60 mm) and Nos. 16 and 17 (1.40 mm). The narrowest (1.00 mm) was noted in No. 12, followed by Nos. 3 and 4 (1.10 mm). Average and its s.d. through the whole strains were found to be 1.26 ± 0.19.

Table 3. Ranges of husked 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	Length			Width			Thickness			Length/Width			Length/Thickness			Width/Thickness		
No.	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range
1	6.25	5.00	1.25	2.00	1.65	0.35	1.60	1.20	0.40	3.47	2.94	0.53	4.63	3.33	1.30	1.42	1.13	0.29
2	5.65	5.00	0.65	1.95	1.70	0.25	1.60	1.20	0.40	3.24	2.63	0.61	4.71	3.44	1.27	1.63	1.19	0.44
3	5.50	5.00	0.50	2.00	1.60	0.40	1.60	1.10	0.50	3.25	2.55	0.70	4.73	3.31	1.42	1.68	1.13	0.55
4	5.45	5.20	0.25	2.00	1.70	0.30	1.40	1.10	0.30	3.18	2.60	0.58	4.73	3.86	0.87	1.82	1.21	0.61
5	5.60	4.90	0.70	2.05	1.60	0.45	1.60	1.25	0.35	3.31	2.44	0.87	4.31	3.38	0.93	1.57	1.07	0.50
6	5.65	5.20	0.45	1.80	1.40	0.40	1.50	1.30	0.20	4.04	2.78	1.26	4.35	3.67	0.68	1.39	1.07	0.32
7	6.05	4.95	1.10	2.60	2.10	0.50	2.00	1.70	0.30	2.74	2.08	0.66	3.28	2.74	0.54	1.38	1.10	0.28
8	5.65	5.00	0.65	1.85	1.60	0.25	1.45	1.20	0.25	3.31	2.94	0.37	4.67	3.79	0.88	1.54	1.10	0.44
9	5.70	4.90	0.80	2.00	1.60	0.40	1.50	1.20	0.30	3.56	2.58	0.98	4.50	3.47	1.03	1.54	1.20	0.34
10	6.10	4.85	1.25	2.70	2.00	0.70	2.10	1.60	0.50	2.83	1.94	0.89	3.31	2.38	0.93	1.44	0.95	0.49
11	5.65	4.90	0.75	2.10	1.45	0.65	1.50	1.15	0.35	3.77	2.43	1.34	4.44	3.50	0.94	1.83	1.07	0.76
12	5.60	5.20	0.40	1.85	1.40	0.45	1.50	1.00	0.50	4.00	2.84	1.16	5.60	3.59	2.01	1.44	1.11	0.33
13	5.50	5.25	0.25	1.90	1.40	0.50	1.50	1.20	0.30	3.93	2.76	1.17	4.46	3.53	0.93	1.58	1.07	0.51
14	5.45	5.10	0.35	1.85	1.40	0.45	1.50	1.20	0.30	3.71	2.76	0.95	4.54	3.53	1.01	1.37	1.00	0.37
15	5.50	5.10	0.40	1.90	1.60	0.30	1.50	1.20	0.30	3.34	2.53	0.81	4.58	3.37	1.21	1.50	1.07	0.43
16	6.40	6.00	0.40	2.15	1.90	0.25	1.70	1.40	0.30	3.20	2.79	0.41	4.32	3.59	0.73	1.43	1.15	0.28
17	6.90	6.15	0.75	2.30	2.00	0.30	1.70	1.40	0.30	3.30	2.70	0.60	4.64	3.77	0.87	1.54	1.24	0.30

Range: The largest (0.50 mm) was obtained in Nos. 3, 10 and 12, followed by Nos. 1 and 2 (0.40 mm). The smallest (0.20 mm) was noted in No. 6, followed by No. 8 (0.25 mm). Average and its s.d. through the whole strains were found to be 0.34 ± 0.09.

10. Ratio of length to width (L/W) in husked grains

Maximum: The largest (4.04) was obtained in No. 6, followed by No. 12 (4.00) and No. 13 (3.93). The smallest (2.74) was noted in No. 7, which was the same as in case of the unhusked grains, followed by No. 10 (2.83) and No. 4 (3.18). It may be noted that the values were peculiarly small in Nos. 7 and 10, which was also the same phenomenon in case of the unhusked grains. Average and its s.d. through the whole strains were found to be 3.42 ± 0.37.

Minimum: The largest (2.94) was obtained in Nos. 1 and 8, followed by No. 12 (2.84) and No. 16 (2.79). The smallest (1.94) was noted in No. 10, which was the same as in case of the unhusked grains, followed by No. 7 (2.08) and No. 11 (2.43). Average and its s.d. through the whole strains were found to be 2.61 ± 0.27.

Range: The largest (1.34) was obtained in No. 11, followed by No. 6 (1.26) and No. 13 (1.17). The smallest (0.37) was noted in No. 8, followed by No. 16 (0.41) and No. 1 (0.53). Average and its s.d. through the whole strains were found to be 0.82 ± 0.30.

11. Ratio of length to thickness (L/T) in husked grains

Maximum: The largest (5.60) was obtained in No. 12, followed by Nos. 3 and 4 (4.73). It may be noted that the value was peculiarly large in No. 12. The smallest (3.28) was noted in No. 7, followed by No. 10 (3.31) and No. 5 (4.31). It may be noted that the values were peculiarly small in Nos. 7 and 10, which was the same as in case of the unhusked grains. Average and its s.d. through the whole strains were found to be 4.46 ± 0.53.

Minimum: The largest (3.86) was obtained in No. 4, followed by No. 8 (3.79) and No. 17 (3.77). The smallest (2.38) was noted in No. 10, which was the same as in case of the unhusked grains, followed by No. 7 (2.74) and No. 3 (3.31). It may be noted that the values were peculiarly small in Nos. 7 and 10, which was also the same phenomenon in case of the unhusked grains. Furthermore, these orders of strains were found to be the same as in case of the unhusked grains. Average and its s.d. through the whole strains were found to be 3.43 ± 0.37.

Range: The largest (2.01) was obtained in No. 12, followed by No. 3 (1.42) and No. 1 (1.30). The smallest (0.54) was noted in No. 7, which was the same as in case of the unhusked grains, followed by No. 6 (0.68) and No. 16 (0.73). It may be noted that the value was peculiarly small in No. 7. Average and its s.d. through the whole strains were found to be 1.03 ± 0.34.

12. Ratio of width to thickness (W/T) in husked grains

Maximum: The largest (1.83) was obtained in No. 11, which was the same as in case of the unhusked grains, followed by No. 4 (1.82) and No. 3 (1.68). It may be noted that the values were peculiarly large in Nos. 4 and 11. The smallest (1.37) was noted in No. 14, which was the same as in case of the unhusked grains, followed by No. 7 (1.38) and No. 6 (1.39). Average and its s.d. through the whole strains were found to be 1.54 ± 0.14.

Minimum: The largest (1.24) was obtained in No. 17, which was the same as in case of the unhusked grains, followed by No. 4 (1.21) and No. 2 (1.19). The smallest (0.95) was noted in No. 10, followed by No. 14 (1.00). Average and its s.d. through the whole strains were found to be 1.11 ± 0.08.

Range: The largest (0.76) was obtained in No. 11, which was the same as in case of the unhusked

grains, followed by No. 4 (0.61) and No. 3 (0.55). The smallest (0.28) was noted in Nos. 7 and No. 16, followed by No. 1 (0.29). Average and its s.d. through the whole strains were found to be 0.43 ± 0.13.

PART II. Relations between the respective two characters

1. Length and width in unhusked grains

C.c. and l.r. of width on length in the same strains were calculated, and are shown in Table 4.

Table 4. Correlation coefficient and linear regression of the three components; width in unhusked grain on length in unhusked grain, thickness in unhusked grain on length in unhusked grain, thickness in unhusked grain on width in unhusked grain

Strain No.	Length and Width		Length and Thickness		Width and Thickness	
	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression
1	0.6248***	Y=0.158X+0.945	0.3643*	Y=0.067X+1.081	0.6722***	Y=0.488X+0.540
2	−0.1113	—	0.1150	—	−0.3740*	Y=−0.758X+3.175
3	0.1770	—	0.4079*	Y=0.156X+0.451	−0.0566	—
4	−0.4560*	Y=−0.191X+3.522	0.6312***	Y=0.251X−0.283	−0.2685	—
5	−0.1614	—	0.2851	—	−0.3459	—
6	−0.0821	—	0.1083	—	−0.2389	—
7	0.1753	—	0.7390***	Y=0.156X+0.868	0.4114*	Y=0.220X+1.445
8	0.2922	—	−0.1925	—	−0.3246	—
9	−0.5334**	Y=−0.251X+3.941	0.3115	—	−0.0038	—
10	0.2249	—	0.4702**	Y=0.153X+0.953	0.5222**	Y=0.326X+1.183
11	−0.3920*	Y=−0.154X+3.247	0.4043*	Y=0.107X+0.808	−0.2098	—
12	0.2636	—	−0.1481	—	0.2244	—
13	−0.5626**	Y=−0.384X+4.974	0.3501	—	−0.3318	—
14	0.1041	—	0.1355	—	0.1441	—
15	0.0218	—	0.0163	—	0.0540	—
16	0.5645**	Y=0.227X+0.507	−0.0289	—	0.0287	—
17	0.3874*	Y=0.168X+1.129	0.3797*	Y=0.200X−0.042	0.4986**	Y=0.606X+0.167

***, **, *; significant at 0.1%, 1% and 5% levels, respectively. d.f.=28.

One, 3, 3 and 10 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 +0.5382 to the degree of freedom of 15, which is significant at 5% level. Generally speaking, the longer is the length, the wider is the width. L.r. of length on width was calculated as follows; $Y=0.772X-9.349$, where Y and X indicate length and width, respectively. This formula indicates that the length becomes 0.772 mm longer, by becoming 1 unit wider the width (0 points, 8.23 mm in length and 2.38 mm in width, respectively).

2. Length and thickness in unhusked grains

Two, 1, 4 and 10 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 +0.2890, showing no significance even at 5% level.

3. Width and thickness in unhusked grains

One, 2, 2 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 +0.8246 to the degree of freedom of 15, which is obviously significant at 0.1% level. Generally speaking, the wider is the width, the thicker is the thickness. L.r. of width on thickness was calculated as follows; $Y=0.942X+1.110$, where Y and X indicate width and thickness, respectively. This formula indicates that the width becomes 0.942 mm wider, by becoming 1 unit thicker the thickness (0 points, 2.38 mm in width and 1.82 mm in thickness, respectively).

4. L/W and L/T in unhusked grains

C.c. and l.r. of L/T on L/W in the same strains were calculated, and are shown in Table 5. Two, 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 +0.7938 to the degree of freedom of 15, 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; $Y=0.619X+2.290$, where Y and X indicate L/W and L/T, respectively. This formula indicates that the L/W becomes 0.619 larger, by becoming 1 unit larger the L/T (O points, 3.15 in L/W and 4.35 in L/T, respectively).

5. L/W and W/T in unhusked grains

Thirteen, 2, 1 and 1 strain showed significances at 0.1%, 1% and 5% levels and no significance even at 5% level, respectively. In the whole strains, c.c. was −0.5119 to the degree of freedom of 15, which is significant at 5% 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; $Y=-0.440X+1.804$, where Y and X indicate L/W and W/T, respectively. This formula indicates that L/W becomes 0.440 larger, by becoming 1 unit smaller the W/T (0 points, 3.15 in L/W and 1.34 in W/T, respectively).

6. L/T and W/T in unhusked grains

Six, 4, 2 and 5 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 +0.0042, showing no significance even at 5% level.

7. Length and width in husked grains

C.c. and l.r. of width on length in the same strains were calculated, and are shown in Table 6. Three, 3, 3 and 8 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 +0.4674, showing no significance even at 5% level.

8. Length and thickness in husked grains

Three, 2, 3 and 9 strains showed significances at 0.1%, 1% and 5% levels and no significance

Table 5. Correlation coefficient and linear regression of the three components; ratio of length to thickness (abbreviated as L/T, and so forth) in unhusked grain on L/W in unhusked grain, W/T in unhusked grain on L/W in unhusked grain, W/T in unhusked grain on L/T in unhusked grain

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	0.7297***	Y=1.224X+0.487	−0.0879	—	0.6154***	Y=0.124X+0.755
2	−0.0117	—	−0.5177**	Y=−0.382X+2.742	0.8609***	Y=0.277X−0.001
3	−0.0528	—	−0.7084***	Y=−0.370X+2.624	0.7379***	Y=0.313X−0.126
4	−0.0257	—	−0.8382***	Y=−0.412X+2.800	0.5638**	Y=0.290X−0.017
5	0.1446	—	−0.7360***	Y=−0.312X+2.380	0.5601**	Y=0.209X+0.322
6	0.3589	—	−0.7219***	Y=−0.264X+2.260	0.3842*	Y=0.139X+0.621
7	0.6317***	Y=0.432X+2.501	−0.8783***	Y=−0.334X+2.264	−0.1908	—
8	−0.0104	—	−0.7029***	Y=−0.342X+2.517	0.7115***	Y=0.316X−0.179
9	0.3864*	Y=0.353X+3.323	−0.7500***	Y=−0.271X+2.261	0.3162	—
10	0.5137**	Y=0.475X+2.311	−0.7338***	Y=−0.304X+2.159	0.1986	—
11	0.2862	—	−0.6876***	Y=−0.389X+2.753	0.2373	—
12	0.4176*	Y=0.443X+3.100	−0.6593***	Y=−0.233X+2.159	0.3658*	Y=0.122X+0.738
13	0.1566	—	−0.8821***	Y=−0.332X+2.472	0.3190	—
14	0.1819	—	−0.7423***	Y=−0.256X+2.150	0.5209**	Y=0.191X+3.255
15	0.1298	—	−0.7801***	Y=−0.284X+2.275	0.5092**	Y=0.200X+0.321
16	0.1604	—	−0.4510*	Y=−0.287X+2.441	0.7837***	Y=0.245X+0.199
17	0.4034*	Y=1.103X+1.359	−0.5524**	Y=−0.039X+1.628	0.8415***	Y=0.218X+0.373

***, **, *; significant at 0.1%, 1% and 5% levels, respectively. d.f.=28.

even at 5% level, respectively. In the whole strains, c.c. was +0.4455, showing no significance even at 5% level.

9. Width and thickness in husked grains

One, 4, 1 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 +0.9193 to the degree of freedom of 15, which is obviously significant at 0.1% level. Generally speaking, the wider is the width, the thicker is the thickness. L.r. of width on thickness was calculated as follows; Y=1.226X+1.325, where Y and X indicate width and thickness, respectively. This formula indicates that the width becomes 1.226 mm wider, by becoming 1 unit thicker the thickness (0 points, 1.98 mm in width and 1.58 mm in thickness, respectively).

10. L/W and L/T in husked grains

C.c. and l.r. of L/T on L/W in the same strains were calculated, and are shown in Table 7.

Table 6. Correlation coefficient and linear regression of the three components; width in husked grain on length in husked grain, thickness in husked grain on length in husked grain, thickness in husked grain on width in husked grain

Strain No.	Length and Width		Length and Thickness		Width and Thickness	
	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression	Correlation coefficient	Linear regression
1	0.6286***	Y=0.182X+0.736	0.3600	—	0.7941***	Y=0.914X−0.239
2	−0.0108	—	0.3929*	Y=0.206X+0.249	−0.0205	—
3	0.3992*	Y=0.329X+0.060	0.6435***	Y=0.647X−2.028	0.1833	—
4	−0.5035**	Y=−0.786X+5.979	0.7587***	Y=0.889X−3.409	−0.3487	—
5	0.1373	—	0.4544*	Y=0.240X+0.126	−0.4936**	Y=−0.487X+2.306
6	−0.2180	—	0.1684	—	−0.0173	—
7	0.2137	—	0.7360***	Y=0.210X+0.680	0.4395*	Y=0.329X+1.065
8	0.5409**	Y=0.228X+0.524	−0.0590	—	−0.4794**	Y=−0.533X+2.274
9	−0.6736***	Y=−0.461X+4.225	0.0331	—	0.2604	—
10	0.1401	—	0.2655	—	0.3290	—
11	−0.4784**	Y=−0.386X+3.841	0.4847**	Y=0.166X+0.457	−0.1577	—
12	−0.4118*	Y=−0.407X+3.851	−0.5018**	Y=−0.489X+3.971	0.4797**	Y=0.474X+0.546
13	−0.5792***	Y=−0.961X+6.853	0.1237	—	−0.2163	—
14	0.0928	—	0.0823	—	0.1215	—
15	−0.1369	—	−0.0247	—	−0.3319	—
16	0.3614*	Y=0.208X+0.721	−0.0920	—	0.1432	—
17	0.1491	—	0.4031*	Y=0.229X+0.079	0.5348**	Y=0.480X+0.535

***, **, *; significant at 0.1%, 1% and 5% levels, respectively. d.f.=28.

Four, 3, 2 and 8 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 +0.8840 to the degree of freedom of 15, 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 calcualted as follows; $Y=0.778X-0.163$, where Y and X indicate L/W and L/T, respectively. This formula indicates that the L/W becomes 0.778 larger, by becoming 1 unit larger the L/T (0 points, 2.75 in L/W and 3.55 in L/T, respectively).

11. L/W and W/T in husked grains

Eleven, 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 −0.2296, showing no significance even at 5% level.

12. L/T and W/T in husked grains

Ten, 3 and 4 strains showed significances at 0.1% and 1% levels and no significance even

Table 7. Correlation coefficient and linear regression of the three components; ratio of length to thickness (abbreviated as L/T, and so forth) in husked grain on L/W in husked grain, W/T in husked grain on L/W in husked grain, W/T in husked grain on L/T in husked grain

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	0.8090***	Y=1.720X−1.323	0.2975	—	0.8014***	Y=0.166X+0.619
2	0.0751	—	−0.5260**	Y=−0.414X+2.578	0.8076***	Y=0.329X+0.057
3	−0.0697	—	−0.5772***	Y=−0.520X+2.866	0.8529***	Y=0.356X−0.063
4	−0.3720*	Y=−0.458X+5.437	−0.8427***	Y=−0.665X+3.356	0.8104***	Y=0.519X−0.725
5	−0.5452**	Y=−0.732X+5.907	−0.8786***	Y=−0.701X+3.350	0.8743***	Y=0.519X−0.637
6	0.3162	—	−0.8774***	Y=−0.305X+2.256	0.1697	—
7	0.6222***	Y=0.453X+1.932	−0.8318***	Y=−0.336X+2.070	−0.0874	—
8	−0.3104	—	−0.6461***	Y=−0.667X+3.378	0.9259***	Y=0.377X−0.212
9	0.5698**	Y=0.593X+2.182	−0.6367***	Y=−0.249X+2.074	0.2697	—
10	0.4365*	Y=0.499X+1.778	−0.5854***	Y=−0.299X+1.966	0.4668**	Y=0.209X+0.676
11	0.2690	—	−0.8736***	Y=−0.394X+2.533	0.2194	—
12	0.6829***	Y=1.188X+0.154	−0.1238	—	0.6168***	Y=0.132X+0.708
13	−0.5919***	Y=−0.052X+4.257	−0.8101***	Y=−0.406X+2.591	0.6258***	Y=0.356X−0.165
14	0.1576	—	−0.7736***	Y=−0.321X+2.237	0.4988**	Y=0.233X+0.265
15	0.2863	—	−0.4997**	Y=−0.270X+2.086	0.6851***	Y=0.246X+0.338
16	0.2676	—	−0.2754	—	0.8508***	Y=0.270X+0.211
17	0.5222**	Y=0.786X+1.794	−0.4213*	Y=−0.202X+1.992	0.5499**	Y=0.175X+0.654

***, **, *; significant at 0.1%, 1% and 5% levels, respectively. d.f.=28.

at 5% level, respectively. In the whole strains, c.c. was +0.2222, showing no significance even at 5% level.

Discussion

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

1. According to the tripartite classification noted by Matsuo[6], the whole strains used here were belonging to C type, *i.e.*, *indica* group or slender group. Moreover, most of them showed relatively small variations, which were located in the shorter length and the thinner width, excluding Nos. 7, 10, 16 and 17. On the other hand, the strains collected in the Ganga Plains can be divided into two groups in accordance with these classification, type B and type C, and were widely distributed in the respective character-ranges[5]. These findings, *i.e.*, the differences of the respective

values and of types, and geographical relations, proposed quite an interesting problem concerning the strain or variety differentiations and geographical variations. There are many samples of the wild rice, which were collected in several tropical countries. Mapping of these distribution in the world, species and strain specificities and their geographical relations are under planning and will be collectively reported in the future.

2. Though the values were peculiarly large or small in the unhusked grains in some cases, the values were found to be the standard level in the husked grains in view of the same strains. For example, strain No. 14 showed the peculiarly large value (3.35) in the minimum of L/W of the unhusked grains, but showed nearly the middle value (2.76) in the minimum of L/W of the husked grains. In the other case, strain No. 17 showed the peculiarly small value (0.43) in range of L/W of the unhusked grains, but showed nearly the middle value (0.60) in the range of L/W of the husked grains.

On the other hand, though the values were found to be the standard level in the unhusked grains in some strains, the values were peculiarly large or small in the husked grains in view of the same strains. For example, strain No. 11 showed nearly the middle value (0.99) in the range of L/W of the unhusked grains, but showed the peculiarly large value (1.34) in the range of L/W of the husked grains. In another case, strain No. 10 showed nearly the middle value (6.80 mm) in the minimum of length of the unhusked grains, but showed the peculiarly small value (4.85 mm) in the minimum of length of the husked grains. These phenomena may partly be due to the grain fullness, ripening ability and responsibility to the environmental conditions.

3. In view of species specificities, the following facts may appreciably be drawn from the data obtained in this experiment. In general, the extremely large values in the respective characters were found in *O. sativa* var. *spontanea* (=annual plant), but the extremely small values in the respective characters were found in *O. perennis* (=perennial plant). These findings proposed quite an interesting problem concerning the species differentiations. Species-geographical relations were, however, not ascertained in these strains, as far as the data obtained here were taken into account.

4. In the maximum of the width, widests (3.25 mm in the unhusked grains and 2.70 mm in the husked grains) were obtained in No. 10, followed by No. 7 (3.10 mm and 2.60 mm in the same order, and so forth) and No. 17 (2.80 mm and 2.30 mm). These orders of strains were fixed to be the same as both in the unhusked and in the husked grains. These phenomena were found in the other 2 cases; *i.e.*, No. 10 (2.45 mm and 2.10 mm), No. 7 (2.20 mm and 2.00 mm) and Nos. 16 and 17 (1.90 mm and 1.70 mm) in the maximum of the thickness; No. 10 (2.82 and 2.38), No. 7 (3.41 and 2.74) and No. 3 (3.89 and 3.31) in the minimum of the L/T. It may be concluded that these strains were almost of the stable status in view of the genetic background, so far as these characters were concerned.

5. It is one of the main problems that the larger is the s.d., the larger is the ranges or not. Even in the wild species, however, these problems were not clear at the present, and are put under calculation.

6. Correlation coefficient of the respective characters in the strain level were fixed to be significant in 112/204 cases, *i.e.*, 54.9% of them. But these in the whole strains were fixed to be significant in 6/12 cases, *i.e.*, 50.0% of the whole. In detail, some characteristics were found. Significant correlations in the strain level were accounted as follows in the order from the character No. 1 to No. 12; 7 strains (41.2%), 7 (41.2%), 5 (29.4%), 6 (35.3%), 16 (94.1%), 12 (70.6%), 9 (52.9%), 8 (47.1%), 6 (35.3%), 9 (52.9%), 14 (82.4%) and 13 (76.5%), respectively. It may be

noticed that the value was peculiarly large in combination with No. 5. Average value and its s.d. through the whole combinations were found to be 9.33 ± 3.42.

In the view of the group-relations, significant correlations in the strain level were counted as follows in the order from group I (combination Nos. 1 to 3), group II (combination Nos. 4 to 6), group III (combination Nos. 7 to 9) and group IV (combination Nos. 10 to 12); 19/51 (37.3%), 34/51 (66.7%), 23/51 (45.1%) and 36/51 (70.6%), respectively. From those data, it might be said that the combinations of 4–6 and 10–12 showed more significant strains than those of the remaining combinations.

On the other hand, 1 strain (No. 17), 2 (Nos. 1 and 4), 2 (Nos. 7 and 12), 3 (Nos. 3, 5 and 10), 5 (Nos. 2, 8, 9, 11 and 13), 1 (No. 16), 2 (Nos. 14 and 15) and 1 (No. 6) showed significant correlations in 11 (91.6%), 9 (75.0%), 8 (66.7%), 7 (58.3%), 6 (50.0%), 5 (41.7%), 4 (33.3%) and 3 (25.0%) combinations, respectively. It may be noted that strain No. 17 showed significances in 11/12 combinations, *i.e.*, 91.6% of the whole, and strain No. 6 showed significances only in 3/12 combinations, *i.e.*, 25.0% of the whole, respectively. Average value and its s.d. through the whole strains were found to be 6.59 ± 1.97.

7. Negative correlations were found in the strain level on some characters, though positive correlations were found in the whole strains on the same characters. Seven, 10, 4, 8, 8 and 5 strains showed negative correlations between L and W, W and T, L/W and L/T in the unhusked grains, L and W, W and T, L/W and L/T in the husked grains, respectively. However, the whole combinations mentioned above showed positive correlations. These unnatural facts and discrepancies are not to be unfortunately fully explained in the present time. It was, however, an interesting phenomenon that these characters were quite the same both in the unhusked and in the husked grains. In a stricter sense, these characters were looked upon as being in possession of stable state, and were exhibited independent of the other characters. It may duely be attributed in the actions of genes concerned in the all events.

8. Relations between L/W and W/T, between L/T and W/T both the unhusked and in the husked grains showed very high significances. Nearly the same results were confirmed in the previous experiments, in which the cultivated species collected also in India were adopted[4]. Accordingly, these facts were fixed to be a common feature in the genus *Oryza*, in disregard of species status. These traits were, in general, looked upon also as something like stable characters and character-combinations, which were controlled by the respective genes. Moreover, it was concluded that these traits were recommended to be adopted for analysing strain or variety differentiations not only in the cultivated as well as in the wild species.

9. In some strains, significant relations were shown in the unhusked grains but not shown at all in the husked grains. These phenomena were found in 8 cases on strain level. The reversed phenomena were found in 12 cases on strain level. These incomprehensible facts were found and already reported in the cultivated[4] and in the wild species[5]. On the other hand, this might be shown as the strain characteristics or locality specificities. However, as the analyses and conclusions have left several points in question in the stricter sense, further analysis may be performed sincerely.

Summary

During the period from December in 1978 to January in 1979, the writer was sent to India for collection of the wild and the cultivated rices. Seventeen strains of wild rice, *i.e.*, *Oryza sativa* var. *spontanea* ROSCHEV. and *O. perennis* MOENCH, were collected in the northeastern India, *i.e.*,

Assam, Meghalaya and northern part of West Bengal. Succeeding to the previous paper, some morphological characters of grains were analyzed and described in the present paper. The main results obtained during this study were summarized as follows:

Ranges shown by 12 characters, *i.e.*, length, width, thickness, L/W, L/T and W/T in the unhusked and the husked grains, were calculated in view of the maximum, the minimum and the pure ranges of them. Basing on the data obtained in these characters, several patterns were found as strain- or species-specificities.

Concerning correlation coefficients among the 12 character-combinations, 112/204 cases, *i.e.*, 54.9% combinations, showed significant relations through the whole cases. It may be noted that combinations between L/W and W/T of the unhusked grains showed significant relations as 94.1%. Average value and its s.d. through the whole combinations were found to be 9.33 ± 3.42. In the strain level, average and its s.d. through the whole strains were found to be 6.59 ± 1.97. It may be noticed that strain No. 17 showed significances in 11/12 cases, *i.e.*, 91.6% combinations.

Species specificities, ecotypic differentiations and validities of the respective characters in analysing procedures were discussed basing on the values ascertained in 12 characters, 12 correlation-combinations and geographical locations.

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