Some Morphological Characters of Cultivated Rice in Indonesia (1)

Akinori NAKAGAMA

(*Laboratory of Crop Science*)

(Received for Publication August 27, 1976)

Introduction

From October to December in 1974, the writer was sent to Malaysia and Indonesia under the project, "Survey on Unused Plants in South East Asia" supported by a Grant from the Ministry of Education, Japan. In this trip, the writer obtained a lot of indigenous rice varieties in Indonesia from Mr. Soejipto Kartowinoto in C. R. I. A., Indonesia.

On the grain morphology of rice varieties, some reports have already been published[1,2,3,4,5]. However, no distinct record reported on the grain morphology of cultivated rice varieties in Indonesia. In this report, only the records of morphological characters of unhusked and husked grains of cultivated rice varieties in Indonesia were described. The records on the comparison of unhusked and husked grains, and considerations on the distribution of cultivated rice varieties in Indonesia shall be reported in the separate paper.

The writer was most grateful to Mr. S. Kartowinoto, C. R. I. A., Indonesia, for his kind seed transfer. The writer wishes to express his hearty thanks to Dr. H. Mikoshiba, Tropical Agriculture Research Center, Japan, for his kind suggestions and helps. The writer expresses his hearty thanks to Dr. T. C. Katayama, Kagoshima University, for his continuous guidance and encouragement. His hearty thanks are also due to Mr. K. Ishihata, the team leader, Mr. M. Hayashi and Mr. Skasdy for their kind helps.

Material and Method

Two hundreds twenty seven varieties of cultivated rice in Indonesia were used for morphological investigations. They are listed up in Table 1.

Table 1. Cultivated rice varieties in Indonesia used in this morphological investigation.

Code No.	Variety name	Code No.	Variety name	Code No.	Variety name	Code No.	Variety name
1	Markoti	7	Mentik Ciasem		Pontianak	19	Duata
2	Omas			13	Padi Lembut	20	Siam putih
3	Segon merah	8	Blaster	14	Sampit	21	Banjar kaya
4	Sentral	9	Menurun	15	Leri	22	Sengkumang
5	Angkong Subang	10	Antomu	16	Gembira	23	Raden Bilis
		11	Lanban	17	Reli	24	Kuntul
6	Balap	12	Angkong	18	Melawi	25	Mujaer

Code No.	Variety name	Code No.	Variety name	Code No.	Variety name	Code No.	Variety name
26	Tambon	58	Randah Talu	96	Revolusi	132	Genjah Abang
27	Cempo kunci	59	Bendang Sigadis	97	Cempo Tomat		
28	Sri makmur			98	Kretekan	133	Rijal
29	Cempo Unel	60	Kuku Balam	99	Kair	134	Upruk
30	Randah Lumut	61	Sirandah cogok	100	Cempo Delle	135	Sri loyo
				101	Laut	136	Rihal
31	Santok Rajo	62	Ciredek	102	Ytem	137	Tumpang Karyo
32	Randah hitam	63	Telita	103	Sidolok		
33	Randah Saura	64	Empat	104	Siredep	138	Rondo makmur
34	Sunting danau	65	Larak	105	Sijambi		
		66	Padi Kining Gaudo Ameh	106	Sipulo	139	Makutri
35	Randah Sungai pagu			107	Sitapas	140	PB. 5 Nganjuk
		67	Padi putih	108	Empun		
36	Lumut hitam	68	Sirumbia	109	Majo	141	Pengamban
37	Ampek rajo	69	Siradin	110	Osak	142	Lemo
38	Lumut	70	Saribanum	111	Kitan Santia	143	Kencana Hantasan
39	Taram Lambau	71	Padi Rasi				
		72	Siad	112	Sri kuning	144	Biduin
40	Kuning biaro	73	Kalurung	113	Siyem	145	Randah Polos
41	Katiak Kasian	74	Parada	114	Cempo Emas		
		75	Ketep	115	Cempo Brentel	146	Raden Layap
42	Randah	76	Genjah Beton			147	Papuyu
43	Sunting baringin-b			116	Kuntul Nebak	148	Banih Kuning
		77	Cempo welut	117	Molok		
44	Sirandah darek	78	Rojolele	118	Merdeka-a	149	Pandak Semarang
		79	Slamet	119	Merdeka-b		
45	Bindang Jambi	80	Tromar	120	Merdeka-c	150	Siam putih
		81	Cembol	121	Cere Lelut	151	Kencana Baliman
46	Randah sasak	82	Bali	122	Cere Selak		
47	Sirandah aji	83	Pendek wesi	123	Cere melati	152	Siam Parupuk
48	Gendok Kiah	84	Sri Kuning	124	Kapos		
49	Ampu Kunyit	85	Relly	125	Randah Padang	153	Canggoreng
50	Sunting baringin-c	86	Klepom			154	Batas
		87	Taher	126	Umbang Telan	155	Bakka Lompo
51	Leci	88	Bali Ketumbal			156	Bakka Bereng[2]
52	H-S I			127	Sampa hiring		
53	H-S II	89	Marinah			157	Bakka Tobong
54	Siak simpur	90	Cempo welut	128	Sumbawa		
55	Padi Pulut	91	Jula-Juli	129	Seribu	158	Bakka Biasa
56	Arai pinang	92	Hoing-b	130	Umbang Katip	159	Lakka Bungkung
		93	Delli				
57	Bendang Lansek	94	Makmur	131	Genjah Kuntulan	160	Pulu Jene
		95	Cempo dara			161	Pulu Bampo

162	Bakka Eiang	179	Ase Andele	194	Pulut	211	Arpin Hiran
163	Nippong	180	Bandar Cilema	195	Pulut Balong	212	Katumping
164	Pare Jara			196	Pulu Banda	213	Beak Ganggas
165	Pada Elo	181	Pulu Balong	197	Banda	214	Tidah perak
166	Balacung	182	Pulu Deni	198	Lantebong	215	Cere Benreum
167	Bakka Eja	183	Ase Baka	199	Pallele Pelleno	216	Ketan Hitam
168	Lilung Kadaro	184	Ase Balanda	200	Lapandaeri	217	Ketan Putih
169	Gading	185	Cela Ringgi	201	Pulu Lotong	218	Ketan Merah
170	Jene Kalengkere	186	Bandar Cikado	202	Bakka Buri	219	Randa Putih
171	Jombe	187	Pulu Banrakaya	203	Banda	220	Tolobo
172	Siang			204	Segong	221	Bali Lonka
173	Pulu Paraka	188	Ase pute	205	Lapang	222	Cemp Randai
174	Ase Balong	189	Bago Panasa	206	Lemo	223	Krowal
175	Pulu Deni	190	Anna Dara	207	Raden Yntal	224	Bogo Brasa
176	Ase Puteh	191	Banda Cela	208	Pandak Ringkan	225	Padi Putih
117	Pullu Baddo	192	Marale	209	Katumbar	226	Pakui
178	Ase Balong[2]	193	Mandi	210	Lakatan waru	227	Pingamban

Investigations were done for length, width and thickness of unhusked and husked grains according to the Katayama's method[1,2]. Measurements were done at the largest positions of the respective character. Twenty grains in each variety were used for measurement. Moreover, calculations were done for determining the ratios of length to width, of length to thickness and of width to thickness of unhusked and husked grains. The calculations were done, using the average values of the respective character.

Results and Discussion

1) Unhusked grains

Two hundred twenty seven varieties of cultivated rice in Indonesia were used for the morphological investigations of unhusked grains.

Lengths of grain were observed to be between 6.46 and 11.24 *mm*. The shortest grain was noted to be 6.46 *mm* in Code No. 212. The longest grain was obtained as 11.24 *mm* in 217. Average value was found to be 8.70 *mm*. The standard deviations of each variety, *i.e.*, showing intra-strain's variation, were relatively small, *i.e.*, obtained as 0.36 ± 0.15.

As shown in Table 2, two varieties of them belonged to the group within 6.40 to 6.60 *mm*, 2 varieties within 7.20 to 7.40 *mm*, 8 varieties within 7.40 to 7.60 *mm*, 15 varieties within 7.60 to 7.80 *mm*, 21 varieties within 7.80 to 8.00 *mm*, 32 varieties within 8.00 to 8.20 *mm*, 26 varieties within 8.20 to 8.40 *mm*, 33 varieties within 8.40 to 8.60 *mm*, 21 varieties within 8.60 to 8.80 *mm*, 10 varieties within 8.80 to 9.00 *mm*, 13 varieties within 9.00 to 9.20 *mm*, 15 varieties within 9.20 to 9.40 *mm*, 13 varieties within 9.40 to 9.60 *mm*, 2 varieties within 9.60 to 9.80 *mm*, 9 varieties within 9.80 to 10.00 *mm*, 3 varieties within 10.20 to 10.40 *mm*, 1 variety within 10.60 to 10.80 *mm* and 1 variety within 11.20 to 11.40 *mm*, respectively. Mode was found to lie within 8.40 to 8.60 *mm*.

Widths of grain were observed to be between 2.35 and 4.38 *mm*. The narrowest grain

Table 2. Classification of length of unhusked grains of cultivated rice varieties in Indonesia. Code numbers used in this table are corresponding to the variety number which was used in Table 1.

Up to (*mm*)	Code No.	No. of varieties
11.2	217	1
11.0		0
10.8		0
10.6	7	1
10.4		0
10.2	27 42 64	3
10.0		0
9.8	2 49 50 58 77 78 112 219 225	9
9.6	95 113	2
9.4	13 30 31 32 34 40 46 57 124 142 173 194 199	13
9.2	3 4 33 35 38 48 59 81 128 130 145 165 170 195 196	15
9.0	19 20 25 37 43 44 53 65 66 122 160 164 181	13
8.8	11 68 99 144 150 172 177 180 184 221	10
8.6	1 39 47 52 55 76 87 105 110 116 140 141 148 163 168 201 205	
	207 215 216 220	21
8.4	28 54 56 61 62 67 72 73 74 75 84 86 100 101 103 104 111	
	118 119 123 139 149 151 152 156 157 171 183 187 188 210 211 218	33
8.2	6 9 12 14 16 18 29 71 79 83 92 98 106 109 120 126 147	
	185 190 192 193 202 203 204 208 214	26
8.0	10 15 17 22 24 41 60 69 70 85 89 93 94 96 107 117 121	
	129 133 134 138 155 158 162 167 175 182 186 198 206 226 227	32
7.8	21 23 26 45 51 80 82 97 102 108 136 137 143 153 154 159 169	
	179 213 222 223	21
7.6	5 8 36 63 88 90 91 114 127 132 135 189 197 200 224	15
7.4	115 125 131 146 161 166 176 178	8
7.2	174 191	2
7.0		0
6.8		0
6.6		0
6.4	209 212	2

was noted to be 2.35 *mm* in 141. The widest grain was obtained as 4.38 *mm* in 220. Average value was found to be 3.09 *mm*. The standard deviations of each variety, *i.e.*, showing intra-strain's variation, were relatively small and smaller than that of length, *i.e.*, obtained as 0.12 ± 0.07.

As shown in Table 3, 1 variety of them belonged to the group within 2.30 to 2.40 *mm*, 2 varieties within 2.40 to 2.50 *mm*, 8 varieties within 2.50 to 2.60 *mm*, 18 varieties within 2.60 to 2.70 *mm*, 23 varieties within 2.70 to 2.80 *mm*, 24 varieties within 2.80 to 2.90 *mm*, 21 varieties within 2.90 to 3.00 *mm*, 25 varieties within 3.00 to 3.10 *mm*, 27 varieties within 3.10 to 3.20 *mm*, 21 varieties within 3.20 to 3.30 *mm*, 19 varieties within 3.30 to 3.40 *mm*, 17

Table 3. Classification of width of unhusked grains of cultivated rice varieties in Indonesia. Code numbers used in this table are corresponding to the variety number which was used in Table 1.

Up to (*mm*)	Code No.	No. of varieties
4.3	220	1
4.2		0
4.1		0
4.0	161	1
3.9		0
3.8	11 73 74	3
3.7	217	1
3.6	110 124 186 187	4
3.5	76 132 166 170 177 185 191 195 197 200 218	11
3.4	24 37 82 105 131 135 172 173 180 184 192 193 194 201 205 216 224	17
3.3	5 84 88 108 117 118 147 153 159 163 168 169 176 178 179 181 189 190 196	19
3.2	61 65 66 80 86 107 115 133 137 140 143 155 158 160 162 171 174 183 222 225 227	21
3.1	10 29 45 48 51 78 81 83 85 97 104 116 120 134 136 138 154 156 164 167 188 202 203 209 212 213 214	27
3.0	8 14 15 25 32 33 43 49 50 53 54 63 87 89 112 114 129 151 157 165 175 182 198 199 204	25
2.9	1 12 18 22 30 31 35 38 46 56 57 93 96 103 113 125 146 149 208 223 226	21
2.8	16 20 26 27 34 36 40 41 47 69 71 90 91 94 100 101 102 119 122 148 210 215 219 221	24
2.7	2 3 4 6 9 19 28 44 52 55 59 60 62 75 77 79 92 98 121 123 139 145 206	23
2.6	7 13 17 21 42 58 64 67 70 72 95 99 109 128 142 152 207 211	18
2.5	39 68 106 111 126 130 144 150	8
2.4	23 127	2
2.3	141	1

varieties within 3.40 to 3.50 *mm*, 11 varieties within 3.50 to 3.60 *mm*, 4 varieties within 3.60 to 3.70 *mm*, 1 variety within 3.70 to 3.80 *mm*, 3 varieties within 3.80 to 3.90 *mm*, 1 variety within 4.00 to 4.10 *mm* and 1 variety within 4.30 to 4.40 *mm*, respectively. Mode was found to lie within 3.10 to 3.20 *mm*.

Thicknesses of grain were observed to be between 1.69 and 2.62 *mm*. The thinnest grains were noted to be 1.69 *mm* in 23 and 70. The thickest grain was obtained as 2.62 *mm* in 220. Average value was found to be 2.06 *mm*. The standard deviations of each variety, *i.e.*, showing intra-strain's variation, were relatively small and were remarkably smaller than that of length and width, *i.e.*, obtained as 0.07 ± 0.01.

As shown in Table 4, 2 varieties of them belonged to the group within 1.65 to 1.70 *mm*,

Table 4. Classification of thickness of unhusked grains of cultivated rice varieties in Indonesia. Code numbers used in this table are corresponding to the variety number which was used in Table 1.

Up to (*mm*)	Code No.	No. of varieties
2.60	220	1
2.55		0
2.50		0
2.45		0
2.40	110	1
2.35	73 74 186 200	4
2.30	124 131 135 161 172 185 192 197 224	9
2.25	84 88 105 163 166 170 180 184 187 191 194 218	12
2.20	11 112 116 118 132 164 173 178 179 189 193 195 201 205 217 225	16
2.15	25 37 78 81 82 86 115 117 153 154 155 156 158 168 174 176 177 181 183 196 203 213 216 222	24
2.10	5 15 51 80 83 93 96 97 107 108 133 137 138 140 157 159 160 171 188 190 202 204 214 219	24
2.05	2 32 34 43 46 50 76 77 85 87 89 113 120 128 129 134 136 147 162 167 169 198 199 227	24
2.00	4 12 13 14 16 24 29 30 35 38 40 45 53 57 61 66 95 100 103 104 114 121 122 139 143 151 165 175 182	29
1.95	1 3 7 9 26 27 28 31 33 52 56 63 65 90 91 92 94 98 99 101 102 119 123 149 208 209 215 221 223 226	30
1.90	8 10 17 36 41 42 44 47 48 49 54 64 68 69 75 109 125 142 145 146 206	21
1.85	6 18 19 20 22 55 58 59 72 106 111 126 130 144 148 150 152 212	18
1.80	39 207 210	3
1.75	21 60 67 71 79 127 211	7
1.70	62 141	2
1.65	23 70	2

2 varieties within 1.70 to 1.75 *mm*, 7 varieties within 1.75 to 1.80 *mm*, 3 varieties within 1.80 to 1.85 *mm*, 18 varieties within 1.85 to 1.90 *mm*, 21 varieties within 1.90 to 1.95 *mm*, 30 varieties within 1.95 to 2.00 *mm*, 29 varieties within 2.00 to 2.05 *mm*, 24 varieties within 2.05 to 2.10 *mm*, 24 varieties within 2.10 to 2.15 *mm*, 24 varieties within 2.15 to 2.20 *mm*, 16 varieties within 2.20 to 2.25 *mm*, 12 varieties within 2.25 to 2.30 *mm*, 9 varieties within 2.30 to 2.35 *mm*, 4 varieties within 2.35 to 2.40 *mm*, 1 variety within 2.40 to 2.45 *mm* and 1 variety within 2.60 to 2.65 *mm*, respectively. Mode was found to lie within 1.95 to 2.00 *mm*.

Basing on the data obtained concerning the grain length and grain width of unhusked grains, cultivated rice varieties used were classified into three grain types, *i.e.*, A (short type), B (large type) and C (long type), according to Matsuo's classification[4]. Ten varieties of them belonged to the A type, 59 varieties to the B type and 158 varieties to the C type, respectively. Average values of length were found to be 7.29 *mm* in 10 varieties belonging

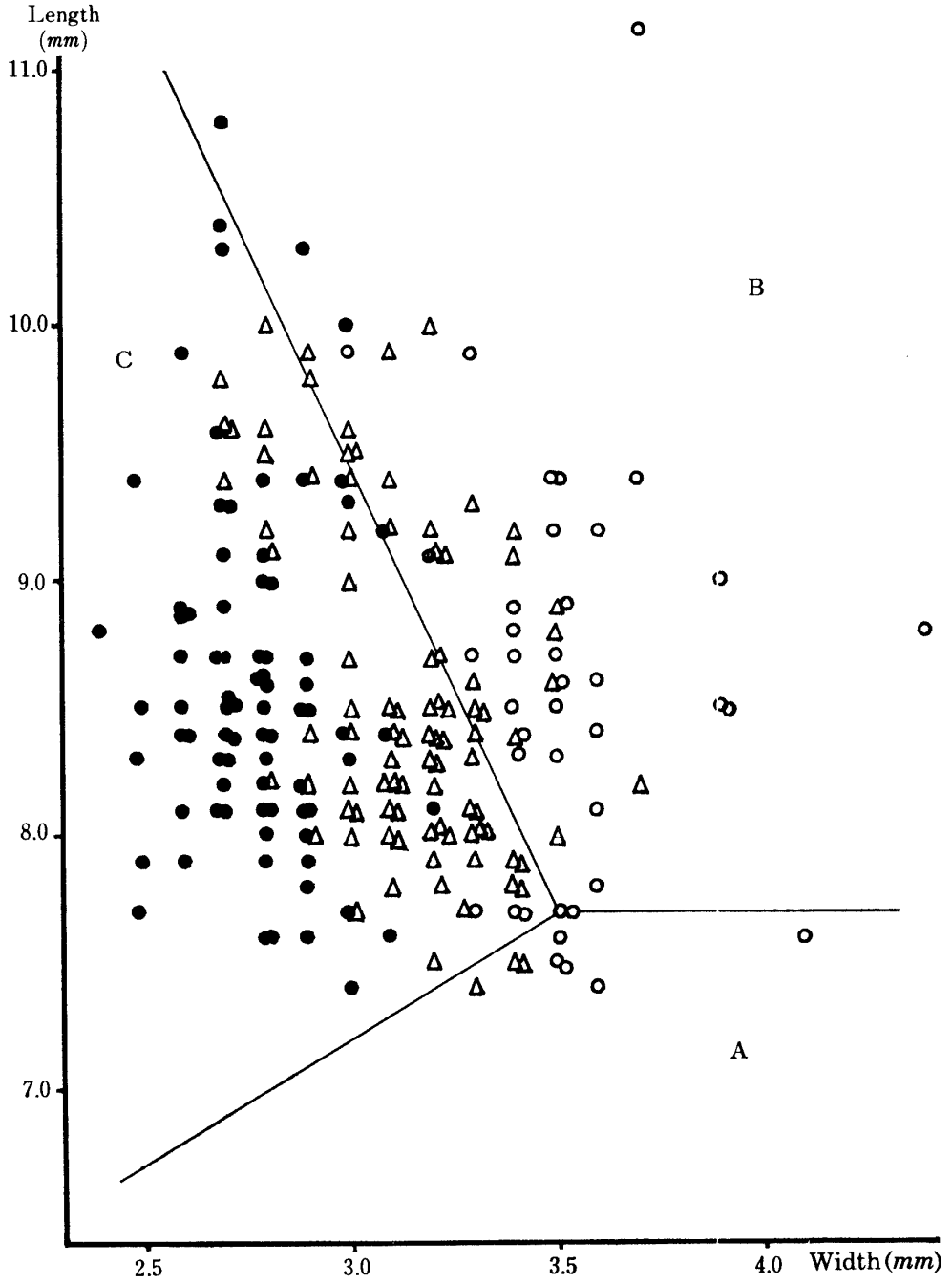

Fig. 1. Relation between length, width and thickness of unhusked grains of cultivated rice varieties in Indonesia. Grouping of varieties according to tripartite classification by Matsuo.[4] Vertical axis: length of grain; abscissa: width of grain; ● : varieties thinner than 2.00 *mm*; △ : varieties between 2.01 and 2.20 *mm*; ○ : varieties thicker than 2.21 *mm*.

to the A type, 9.01 *mm* in 59 varieties belonging to the B type and 8.45 *mm* in 158 varieties belonging to the C type, respectively. Average values of width were found to be 3.44 *mm* in A type, 3.37 *mm* in B type and 2.93 *mm* in C type, respectively. Varieties belonging to the

A type were remarkably short in view of grain length, and varieties belonging to the C type were remarkably narrow in view of grain width. In grain length, standard deviations of whole varieties in the respective type, *i.e.*, showing inter-strain's variations, were 0.40 in the A type, 0.70 in the B type and 0.59 in the C type, respectively. In grain width, standard deviations of whole varieties in the respective type, *i.e.*, showing inter-strain's variations, were 0.26 in the A type, 0.29 in the B type and 0.24 in the C type, respectively.

In Fig. 1, relation between length, width and thickness of unhusked grains was shown. From this figure, it was mentioned that there was apparent relation between B and C type varieties. The narrower is the grain width, the thinner is the grain thickness, so far as only B and C groups were concerned, *i.e.*, ranges more than 2.21 *mm* in typical B type, between 2.01 and 2.20 *mm* in many of varieties situated in intermediate between typical B and C types, and less than 2.00 *mm* in typical C type, respectively. This fact indicates that grain thickness can be used as an index handy to make a phased classification among B and C type varieties. As Katayama[2] pointed out, it is evident that grain thickness is an useful feature for classifying rice varieties. Average values of thickness of the respective type were found to be 2.20 *mm* in A type, 2.19 *mm* in B type and 2.01 *mm* in C type, respectively. The standard deviations of thickness of whole varieties in the respective type, *i.e.*, showing inter-strain's variations, were obtained as 0.15 in the A type, 0.13 in the B type and 0.14 in the C type, respectively.

To make clear the relationships of the three components, *i.e.*, length and width, length and thickness and width and thickness of unhusked grains, correlation coefficient and linear regression between them were calculated.

Correlation coefficient between length and width of unhusked grains was -0.2557 and showed very high negative correlation among them at 0.1% level. It was said that the smaller was the former, the larger was the latter. Linear regression of the length on the width was calculated as follows; $Y = -0.12X + 2.05$, where Y and X indicate the former and the latter, respectively. This formula indicates that the grain length becomes 0.12 *mm* smaller, as it becomes 1.00 *mm* larger in the grain width.

Correlation coefficient between grain length and grain thickness of unhusked grains was 0.6275 and showed very high correlation among them at 0.1% level. It was said that the larger was the former, the larger was the latter. Linear regression of the grain length on the grain thickness was calculated as follows; $Y = 0.14X + 0.28$, where Y and X indicate the former and the latter, respectively. This formula indicates that the grain length becomes 0.14 *mm* larger, as it becomes 1.00 *mm* larger in the grain thickness.

Correlation coefficient between grain width and grain thickness of unhusked grains was 0.8201 and showed very high correlation among them at 0.1% level. It was said that the larger was the former, the larger was the latter. Linear regression of the grain width on the grain thickness was calculated as follows; $Y = 0.41X + 0.80$, where Y and X indicate the former and the latter, respectively. This formula indicates that the grain width becomes 0.41 *mm* larger, as it becomes 1.00 *mm* larger in the grain thickness.

Ratios of grain length to grain width were observed to be between 1.86 and 4.06. The smallest value was noted to be 1.86 in 161. The largest value was obtained as 4.06 in 7. Average value was found to be 2.82. The standard deviation of the whole varieties used, *i.e.*, showing inter-strain's variation, was 0.41.

As shown in Table 5, 1 variety of them belonged to the group within 1.80 to 1.90, 1 variety within 1.90 to 2.00, 2 varieties within 2.00 to 2.10, 6 varieties within 2.10 to 2.20,

Table 5. Classification of ratio of length to width of unhusked grains of cultivated rice varieties in Indonesia. Code numbers used in this table are corresponding to the variety number which was used in Table 1.

Up to	Code No.	No. of varieties
4.0	7	1
3.9	64	1
3.8	42 58	2
3.7	130	1
3.6	13 77 95 141 142	5
3.5	2 27 128	3
3.4	3 39 68 144 145 150 219	7
3.3	19 40 49 59 99 106 111 113 127	9
3.2	4 20 23 30 34 38 44 46 50 67 112 122 126 148 207 211 221	17
3.1	31 32 33 35 47 52 55 57 62 72 75 78 109 152 165 199	16
3.0	1 6 9 17 21 25 28 53 60 70 79 92 98 100 119 123 139 215 217 225	20
2.9	16 48 56 71 81 101 121 149 210	9
2.8	12 18 41 65 66 69 87 94 102 103 160 164 196 208	14
2.7	22 26 36 43 54 90 91 93 96 116 151 157 168 173 194 198 206 226	18
2.6	14 15 29 37 83 85 86 89 104 120 124 125 129 134 138 140 156 162 163 167 170 171 175 180 181 182 183 184 188 195 202 203 204 214 223	35
2.5	10 51 61 63 84 97 105 114 118 136 146 147 154 172 177 190 201 216 227	19
2.4	8 45 76 80 88 107 117 133 137 143 153 155 158 185 192 193 205 213 218 222	20
2.3	5 11 24 108 110 115 159 169 179 187	10
2.2	73 82 132 135 174 176 178 186 189 224	10
2.1	74 131 166 197 200 209	6
2.0	191 212	2
1.9	220	1
1.8	161	1

10 varieties within 2.20 to 2.30, 10 varieties within 2.30 to 2.40, 20 varieties within 2.40 to 2.50, 19 varieties within 2.50 to 2.60, 35 varieties within 2.60 to 2.70, 18 varieties within 2.70 to 2.80, 14 varieties within 2.80 to 2.90, 9 varieties within 2.90 to 3.00, 20 varieties within 3.00 to 3.10, 16 varieties within 3.10 to 3.20, 17 varieties within 3.20 to 3.30, 9 varieties within 3.30 to 3.40, 7 varieties within 3.40 to 3.50, 3 varieties within 3.50 to 3.60, 5 varieties within 3.60 to 3.70, 1 variety within 3.70 to 3.80, 2 varieties within 3.80 to 3.90, 1 variety within 3.90 to 4.00 and 1 variety within 4.00 to 4.10, respectively. Mode was found to lie within 2.60 to 2.70.

Ratios of grain length to grain thickness were observed to be between 3.18 and 5.48. The smallest value was noted to be 3.18 in 161. The largest value obtained as 5.48 in 7.

Table 6. Classification of ratio of length to thickness of unhusked grains of cultivated rice varieties in Indonesia. Code numbers used in this table are corresponding to the variety number which was used in Table 1.

Up to	Code No.	No. of varieties
5.4	7	1
5.3	42 64	2
5.2	49 58	2
5.1	27 141 217	3
5.0	130	1
4.9	59 62 67 142 145	5
4.8	19 39 48 50 70 77 95 144	8
4.7	2 13 20 23 30 31 40 44 79 148 150 207	12
4.6	3 32 33 34 38 46 55 57 65 68 78 113 152 219	14
4.5	4 18 35 47 53 60 66 71 72 99 122 128 165 199 211 221	16
4.4	1 21 43 52 54 56 75 106 111 112 126 132 215 225	14
4.3	6 22 81 101 109 119 127 149 210	9
4.2	9 10 17 25 28 41 87 92 98 100 123 139 160 173 181 196 208	17
4.1	12 16 37 61 69 76 103 104 124 140 151 164 168 170 194 195 226	17
4.0	11 14 24 26 29 36 94 102 120 121 157 171 177 182 188 216	16
3.9	8 83 85 86 89 116 125 129 134 146 147 156 162 167 175 180 183 184 190 198 201 202 206 223 227	25
3.8	51 63 90 91 93 96 105 107 114 118 138 143 163 172 203 204 205 214	18
3.7	15 45 80 84 97 108 133 136 137 193 213 218	12
3.6	5 117 153 154 155 169 187 192 222	9
3.5	73 74 82 110 158 159 179 185	8
3.4	88 115 174 176 178 186 189 212	8
3.3	135 197 220 224	4
3.2	131 166 191 200 209	5
3.1	161	1

Average value was found to be 4.18. The standard deviation of the whole varieties used, *i.e.*, showing inter-strain's variation, was 0.48.

As shown in Table 6, 1 variety of them belonged to the group within 3.10 to 3.20, 5 varieties within 3.20 to 3.30, 4 varieties within 3.30 to 3.40, 8 varieties within 3.40 to 3.50, 8 varieties within 3.50 to 3.60, 9 varieties within 3.60 to 3.70, 12 varieties within 3.70 to 3.80, 18 varieties within 3.80 to 3.90, 25 varieties within 3.90 to 4.00, 16 varieties within 4.00 to 4.10, 17 varieties within 4.10 to 4.20, 17 varieties within 4.20 to 4.30, 9 varieties within 4.30 to 4.40, 14 varieties within 4.40 to 4.50, 16 varieties within 4.50 to 4.60, 14 varieties within 4.60 to 4.70, 12 varieties within 4.70 to 4.80, 8 varieties within 4.80 to 4.90, 5 varieties within 4.90 to 5.00, 1 variety within 5.00 to 5.10, 3 varieties within 5.10 to 5.20, 2 varieties within 5.20 to 5.30, 2 varieties within 5.30 to 5.40 and 1 variety within 5.40 to 5.50, respectively. Mode was found to lie within 3.90 to 4.00.

Ratios of grain width to grain thickness were observed to be between 1.30 and 2.13.

Table 7. Classification of ratio of width to thickness of unhusked grains of cultivated rice varieties in Indonesia. Code numbers used in this table are corresponding to the variety number which was used in Table 1.

Up to	Code No.	No. of varieties
2.10	114	1
2.05		0
2.00		0
1.95		0
1.90		0
1.85		0
1.80		0
1.75	11	1
1.70	24 161 217	3
1.65	65 76 220	3
1.60	5 8 10 18 48 61 66 73 74 124 143 177 187 190 195 216	16
1.55	37 45 49 54 62 70 71 79 82 108 120 132 137 146 147 159 166	
	170 171 173 181 191 201 205 209 210 212 218	28
1.50	14 22 29 31 33 41 50 53 56 60 63 67 80 85 104 105 107	
	117 118 125 131 133 134 136 140 149 151 153 155 158 160 162 165 167	
	168 174 176 178 179 180 182 185 188 189 193 194 196 197 222 224 227	51
1.45	1 12 19 20 21 23 26 27 30 32 35 36 38 43 46 47 51	
	55 57 59 69 78 81 83 84 86 87 88 89 91 97 103 110 115	
	119 129 135 138 145 148 152 154 156 157 163 164 169 172 175 183 184	
	186 192 198 200 202 204 206 208 211 213 214 215 223 225 226	66
1.40	6 9 15 16 17 25 28 39 40 42 44 52 72 75 90 96 98	
	101 102 116 144 203 207 221	24
1.35	3 4 7 34 58 64 68 92 93 99 109 112 113 121 122 123 126	
	127 130 139 141 142 150 199 219	25
1.30	2 13 77 94 95 100 106 111 128	9

The smallest value was noted to be 1.30 in 128. The largest value was obtained as 2.13 in 114. Average value was found to be 1.49. The standard deviation of the whole varieties, *i.e.*, showing inter-strain's variation, was 0.09, which was remarkably smaller than that of ratios of length to width and length to thickness.

As shown in Table 7, 9 varieties of them belonged to the group within 1.30 to 1.35, 25 varieties within 1.35 to 1.40, 24 varieties within 1.40 to 1.45, 66 varieties within 1.45 to 1.50, 51 varieties within 1.50 to 1.55, 28 varieties within 1.55 to 1.60, 16 varieties within 1.60 to 1.65, 3 varieties within 1.65 to 1.70, 3 varieties within 1.70 to 1.75, 1 variety within 1.75 to 1.80 and 1 variety within 2.10 to 2.15, respectively. Mode was found to lie within 1.45 to 1.50.

Ratios of length to width and of length to thickness of unhusked grains fitted comparatively well for three grain types, *i.e.*, A, B and C types, which were determined according to grain length and grain width. In ratio of length to width, average values were found to be 2.13 in A type, 2.71 in B type and 2.91 in C type, respectively. Standard devia-

tions of whole varieties in the respective type, *i.e.*, showing inter-strain's variations, were shown as 0.11 in A type, 0.39 in B type and 0.38 in C type, respectively. In ratio of length to thickness, average values were found to be 3.32 in A type, 4.16 in B type and 4.24 in C type, respectively. Standard deviations of the whole varieties in the respective type, *i.e.*, showing inter-strain's variations, were shown as 0.10 in A type, 0.48 in B type and 0.43 in C type, respectively. In varieties belonging to the A type, average value and standard deviation were relatively smaller than that of varieties belonging to the B and C types. It may be said that both ratios were also useful features for classifying rice varieties. Average values of ratio of width to thickness in the respective type were found to be 1.56 in A type, 1.54 in B type and 1.47 in C type, respectively. Standard deviations of the whole varieties in the respective type, *i.e.*, showing inter-strain's variations, were shown to be 0.06 in A type, 0.10 in B type and 0.08 in C type, respectively.

To make clear the relationships between the three components, *i.e.*, ratios of length to width and of length to thickness, ratios of length to width and of width to thickness, and ratios of length to thickness and of width to thickness of unhusked grains, correlation coefficient and linear regression between them were calculated.

Correlation coefficient between ratio of grain length to grain width and ratio of grain length to grain thickness was 0.5099 and showed very high correlation among them at 0.1% level. It was said that the larger was the former, the larger was the latter. Linear regression of the former ratio on the latter ratio was calculated as follows; $Y=0.56X+1.24$, where Y and X indicate the former ratio and latter ratio, respectively. This formula indicates that the ratio of grain length to grain width becomes 0.56 larger, as it becomes 1.00 larger in the ratio of grain length to grain thickness.

Correlation coefficient between ratio of grain length to grain width and ratio of grain width to grain thickness was -0.5328 and showed high negative correlation among them at 0.1% level. It was said that the smaller was the former ratio, the larger was the latter ratio. Linear regression of the former ratio on the latter ratio was calculated as follows; $Y=-0.14X+1.10$, where Y and X indicate the former ratio and the latter ratio, respectively. This formula indicates that the ratio of grain length to grain width becomes 0.14 smaller, as it becomes 1.00 larger in the ratio of grain width to grain thickness.

Correlation coefficient between ratio of grain length to grain thickness and ratio of grain width to grain thickness was -0.3007 and showed very high negative correlation among them at 0.1% level. It was said that the larger was the former ratio, the smaller was the latter ratio. Linear regression of the former ratio on the latter ratio was calculated as follows; $Y=-0.07X+1.20$, where Y and X indicate the former ratio and latter ratio, respectively. This formula indicates that the ratio of grain length to grain thickness becomes 0.07 smaller, as it becomes 1.00 larger in the ratio of grain width to grain thickness.

2) Husked grains

Two hundred twenty seven varieties of cultivated rice in Indonesia were used for the morphological investigations of husked grains.

Lengths of grain were observed to be between 4.47 and 8.20 *mm*. The shortest grain was noted to be 4.47 *mm* in 212. The largest grain was obtained as 8.20 *mm* in 217. Average value was found to be 6.21 *mm*. The standard deviations of each variety, *i.e.*, showing intra-strain's variation, were relatively small, *i.e.*, obtained as 0.26 ± 0.10.

As shown in Table 8, 1 variety of them belonged to the group within 4.40 to 4.50 *mm*, 1 variety within 4.60 to 4.70 *mm*, 1 variety within 5.10 to 5.20 *mm*, 1 variety within 5.20 to

Table 8. Classification of length of husked grains of cultivated rice varieties in Indonesia. Code numbers used in this table are corresponding to the variety number which was used in Table 1.

Up to (*mm*)	Code No.	No. of varieties
8.2	217	1
.		.
.		.
7.7	64	1
7.6	78	1
7.5	7	1
7.4	27	1
7.3	2 42 77	3
7.2	58 95 219 225	4
7.1	49 50 112 113 130	5
7.0	19 199	2
6.9	13 34 53 57 128 142 165	7
6.8	3 4 46 81 124 194	6
6.7	32 37 40 43 116 145 173 196 221	9
6.6	11 20 30 31 33 35 38 55 59 122 180 184	12
6.5	25 48 68 144 160 170 195 205	8
6.4	44 65 66 83 84 99 110 148 150 164 168 172 181	13
6.3	1 39 47 73 74 76 87 140 163 177 192 201 207 215	14
6.2	52 86 105 119 126 139 141 152 169 171 185 218 220	13
6.1	9 18 56 62 67 92 100 101 103 104 111 118 123 149 151 156 188	
	208 210 211 216	21
6.0	6 10 12 29 54 60 72 75 106 109 157 183 193 202 204	15
5.9	14 15 16 28 61 85 94 98 117 120 121 129 134 138 147 162 187	
	190 198 203 206 213 214 226	24
5.8	21 22 24 41 45 51 69 70 71 79 89 93 96 97 107 133 137	
	155 158 167 179 186 197 222 227	25
5.7	17 23 26 80 82 88 102 108 132 136 143 154 159	13
5.6	5 135 153 178 182 189 223	7
5.5	63 91 114 125 127 131 166 174 175 200	10
5.4	8 36 90 176 191	5
5.3	115 161	2
5.2	224	1
5.1	146	1
.		.
.		.
4.6	209	1
4.5		0
4.4	212	1

Table 9. Classification of width of husked grains of cultivated rice varieties in Indonesia. Code numbers used in this table are corresponding to the variety number which was used in Table 1.

Up to (*mm*)	Code No.																	No. of varieties
3.4	220																	1
3.3																		
3.2	73	74	161															3
3.1	11																	1
3.0	124	131	132	166	185	186	191	197	200	224								10
2.9	24	37	82	105	110	135	176	178	180	184	187	189	195	205	217			15
2.8	76	84	88	117	118	137	153	159	163	170	172	173	174	177	179	190	192	
	193	194	218															20
2.7	10	29	45	61	65	66	78	80	83	86	97	107	108	115	116	120	133	
	140	143	147	154	155	156	158	164	167	168	171	181	183	188	196	201	209	
	216	222	225	227														38
2.6	14	15	43	48	50	51	63	81	85	89	104	134	136	138	151	157	160	
	162	169	202	203	204	212	213	214										25
2.5	8	12	16	22	25	30	31	32	33	35	38	46	49	53	54	87	93	
	96	103	112	114	125	129	165	175	182	198	199	208	223	226				31
2.4	1	4	18	20	26	27	28	34	36	40	41	47	56	57	69	71	91	
	94	100	102	113	121	146	149	219										25
2.3	2	3	6	7	9	17	19	21	44	52	55	59	60	75	77	90	92	
	98	101	119	122	123	139	145	206	210	215	221							28
2.2	5	13	39	42	64	67	70	72	79	95	99	109	128	142	144	148	152	
	207	211																19
2.1	23	58	62	68	111	126	127	130	150									9
2.0	106																	1
1.9	141																	1

5.30 *mm*, 2 varieties within 5.30 to 5.40 *mm*, 5 varieties within 5.40 to 5.50 *mm*, 10 varieties within 5.50 to 5.60 *mm*, 7 varieties within 5.60 to 5.70 *mm*, 13 varieties within 5.70 to 5.80 *mm*, 25 varieties within 5.80 to 5.90 *mm*, 24 varieties within 5.90 to 6.00 *mm*, 15 varieties within 6.00 to 6.10 *mm*, 21 varieties within 6.10 to 6.20 *mm*, 13 varieties within 6.20 to 6.30 *mm*, 14 varieties within 6.30 to 6.40 *mm*, 13 varieties within 6.40 to 6.50 *mm*, 8 varieties within 6.50 to 6.60 *mm*, 12 varieties within 6.60 to 6.70 *mm*, 9 varieties within 6.70 to 6.80 *mm*, 6 varieties within 6.80 to 6.90 *mm*, 7 varieties within 6.90 to 7.00 *mm*, 2 varieties within 7.00 to 7.10 *mm*, 5 varieties within 7.10 to 7.20 *mm*, 4 varieties within 7.20 to 7.30 *mm*, 3 varieties within 7.30 to 7.40 *mm*, 1 variety within 7.40 to 7.50 *mm*, 1 variety within 7.50 to 7.60 *mm*, 1 variety within 7.60 to 7.70 *mm*, 1 variety within 7.70 to 7.80 *mm* and 1 variety within 8.20 to 8.30 *mm*, respectively. Mode was found to lie within 5.80 to 5.90 *mm*.

Widths of grain were observed to be between 1.98 and 3.48 *mm*. The narrowest grain was noted to be 1.98 *mm* in 141. The widest grain was obtained as 3.48 *mm* in 220. Average value was found to be 2.60 *mm*. The standard deviations of each variety, *i.e.*, showing intra-strain's variation, were remarkably smaller than that of grain length, *i.e.*, obtained as 0.09 ± 0.04.

Table 10. Classification of thickness of husked grains of cultivated rice varieties in Indonesia. Code numbers used in this table are corresponding to the variety number which was used in Table 1.

Up to (*mm*)	Code No.	No. of varieties
2.30	220	1
2.25	110	1
2.20		0
2.15	73 74 200	3
2.10	131 161 172 186 197 224	6
2.05	84 124 132 135 166 180 184 185 187 191 192	11
2.00	88 105 112 116 170 173 176 179 193 194 195 201 205 218 225	15
1.95	11 25 78 82 86 115 118 164 168 174 177 178 183 189 196 222	16
1.90	5 15 37 80 81 83 93 96 97 107 117 133 137 138 140 153 155	
	156 158 159 163 181 202 203 204 213 214 216 217	29
1.85	12 29 51 66 76 77 87 108 134 136 147 154 157 160 167 169 171	
	188 190 219 227	21
1.80	2 4 7 14 24 32 34 40 43 45 46 50 53 61 85 89 95	
	100 103 104 113 120 121 128 129 143 151 162 175 182 198 199	32
1.75	3 9 13 16 26 27 28 30 31 33 35 38 57 63 65 92 94	
	99 102 114 122 123 139 165 208 209 221 223 226	29
1.70	1 8 10 41 44 47 48 52 55 56 64 68 69 75 90 91 98	
	101 109 119 142 149 215	23
1.65	6 17 18 19 20 22 36 42 49 54 58 59 111 125 130 145 146	
	150 206 212	20
1.60	39 60 72 106 126 144 148 152 207 210	10
1.55	21 71 127 211	4
1.50	23 67 79 141	4
1.45	62 70	2

As shown in Table 9, 1 variety of them belonged to the group within 1.90 to 2.00 *mm*, 1 variety within 2.00 to 2.10 *mm*, 9 varieties within 2.10 to 2.20 *mm*, 19 varieties within 2.20 to 2.30 *mm*, 28 varieties within 2.30 to 2.40 *mm*, 25 varieties within 2.40 to 2.50 *mm*, 31 varieties within 2.50 to 2.60 *mm*, 25 varieties within 2.60 to 2.70 *mm*, 38 varieties within 2.70 to 2.80 *mm*, 20 varieties within 2.80 to 2.90 *mm*, 15 varieties within 2.90 to 3.00 *mm*, 10 varieties within 3.00 to 3.10 *mm*, 1 variety within 3.10 to 3.20 *mm*, 3 varieties within 3.20 to 3.30 *mm* and 1 variety within 3.40 to 3.50 *mm*, respectively. Mode was found to lie within 2.70 to 2.80 *mm*.

Thicknesses of grain were observed to be between 1.46 and 2.34 *mm*. The thinnest grain was noted to be 1.46 *mm* in 70. The thickest grain was obtained as 2.34 *mm* in 220. Average value found to be 1.84 *mm*. The standard deviations of each variety, *i.e.*, showing intra-strain's variation, were remarkably smaller than that of grain length and grain width, *i.e.*, obtained as 0.07 ± 0.02.

As shown in Table 10, 2 varieties of them belonged to the group within 1.45 to 1.50 *mm*, 4 varieties within 1.50 to 1.55 *mm*, 4 varieties within 1.55 to 1.60 *mm*, 10 varieties within 1.60 to 1.65 *mm*, 20 varieties within 1.65 to 1.70 *mm*, 23 varieties within 1.70 to 1.75 *mm*, 29

Table 11. Classification of ratio of length to width of husked grains of cultivated rice varieties in Indonesia. Code numbers used in this table are corresponding to the variety number which was used in Table 1.

Up to	Code No.	No. of varieties
3.4	64	1
3.3	58 130	2
3.2	7 42 95 141	4
3.1	2 77 142	3
3.0	13 27 128 219	4
2.9	3 19 59 68 106 109 111 113 121 126 144 145	12
2.8	4 34 39 55 57 62 99 112 148 150 221	11
2.7	20 23 40 44 49 50 67 78 122 152 165 199 207 211 215 217	16
2.6	1 6 9 30 31 32 33 38 46 52 53 60 70 72 75 79 92	
	119 123 127 139 178 210 225	24
2.5	21 25 35 43 47 81 98 100 101 196 206	11
2.4	12 16 17 18 28 48 54 56 69 71 87 94 103 116 149 160 168	
	194 208	19
2.3	22 26 37 65 66 83 90 102 104 118 129 151 157 164 170 173 181	
	198 226	19
2.2	10 14 15 29 36 41 76 80 84 85 89 91 93 96 120 124 125	
	134 138 140 156 162 163 171 172 175 177 180 182 183 184 188 192 195	
	201 202 203 204 205 213 214 216 218 223	44
2.1	8 11 45 51 61 63 97 105 107 110 114 117 133 136 143 147 154	
	155 158 159 167 190 193 222 227	25
2.0	108 137 146 153 169 179 185	7
1.9	5 24 73 74 82 86 88 115 132 174 186 187 189 197	14
1.8	131 135 166 176 224	5
1.7	191 200 209 220	4
1.6	161 212	2

varieties within 1.75 to 1.80 *mm*, 32 varieties within 1.80 to 1.85 *mm*, 21 varieties within 1.85 to 1.90 *mm*, 29 varieties within 1.90 to 1.95 *mm*, 16 varieties within 1.95 to 2.00 *mm*, 15 varieties within 2.00 to 2.05 *mm*, 11 varieties within 2.05 to 2.10 *mm*, 6 varieties within 2.10 to 2.15 *mm*, 3 varieties within 2.15 to 2.20 *mm*, 1 variety within 2.25 to 2.30 *mm* and 1 variety within 2.30 to 2.35 *mm*, respectively. Mode was found to lie within 1.80 to 1.85 *mm*.

Basing on grain length and grain width of husked grains, cultivated rice varieties used were classified into 7 types in view of grain shape, *i.e.*, "long-short type", "long-medium type", "long-long type", "short-long type", "short-medium type", "slender-short type" and "slender-medium type", and 5 types in view of grain size, *i.e.*, "very small", "small", "medium", "large" and "very large", according to Nagamatsu's classification[5]. In grain shape, 78 varieties of them belonged to "long-short type", 52 varieties to "long-medium type", 56 varieties to "long-long type", 6 varieties to "short-medium type", 21 varieties to "short-long type", 12 varieties to "slender-short type" and 2 varieties to "slender-medium type", respectively. In grain size, 1 variety of them belonged to "very small",

100 varieties to "small", 117 varieties to "medium", 8 varieties to "large" and 1 variety to "very large", respectively.

To make clear the relationships of the three components, *i.e.*, length and width, length and thickness, and width and thickness of husked grains, correlation coefficient and linear regression between them were calculated.

Correlation coefficient between grain length and grain width of husked grains was −0.1087 and showed no significant correlation among them even at 5% level. It was said that the former is independent of the latter in this case.

Correlation coefficient between grain length and grain thickness of husked grains was −0.0011 and showed no significant correlation among them even at 5% level. It was said that the former is independent of the latter in this case.

Correlation coefficient between grain width to grain thickness of husked grains was 0.6582 and showed very high correlation among them at 0.1% level. It was said that the wider was the width of grain, the thicker was the thickness of grain. Linear regression of width on thickness of husked grains was calculated as follows; $Y = 0.50X + 1.69$, where Y and X indicate the former and the latter, respectively. This formula indicates that the width of grain becomes 0.50 *mm* wider, as it becomes 1.00 *mm* thicker in the thickness of grain.

Ratios of grain length to grain width of husked grains were observed to be between 1.64 and 3.48. The smallest value was noted to be 1.64 in 161. The largest value was obtained as 3.48 in 64. Average value was found to be 2.44. The standard deviation of the whole varieties used, *i.e.*, showing inter-strain's variation, was 0.27.

As shown in Table 11, 2 varieties of them belonged to the group within 1.60 to 1.70, 4 varieties within 1.70 to 1.80, 5 varieties within 1.80 to 1.90, 14 varieties within 1.90 to 2.00, 7 varieties within 2.00 to 2.10, 25 varieties within 2.10 to 2.20, 44 varieties within 2.20 to 2.30, 19 varieties within 2.30 to 2.40, 19 varieties within 2.40 to 2.50, 11 varieties within 2.50 to 2.60, 24 varieties within 2.60 to 2.70, 16 varieties within 2.70 to 2.80, 11 varieties within 2.80 to 2.90, 12 varieties within 2.90 to 3.00, 4 varieties within 3.00 to 3.10, 3 varieties within 3.10 to 3.20, 4 varieties within 3.20 to 3.30, 2 varieties within 3.30 to 3.40 and 1 variety within 3.40 to 3.50, respectively. Mode was found to lie within 2.20 to 2.30.

Ratios of grain length to grain thickness of husked grains were observed to be between 2.31 and 4.48. The smallest value was noted to be 2.31 in 180. The largest value was obtained as 4.48 in 64. Average value was found to be 3.40. The standard deviation of the whole varieties used, *i.e.*, showing inter-strain's variation, was 0.42.

As shown in Table 12, 1 variety of them belonged to the group within 2.30 to 2.40, 1 variety within 2.40 to 2.50, 2 varieties within 2.50 to 2.60, 8 varieties within 2.60 to 2.70, 5 varieties within 2.70 to 2.80, 6 varieties within 2.80 to 2.90, 9 varieties within 2.90 to 3.00, 23 varieties within 3.00 to 3.10, 25 varieties within 3.10 to 3.20, 26 varieties within 3.20 to 3.30, 16 varieties within 3.30 to 3.40, 16 varieties within 3.40 to 3.50, 16 varieties within 3.50 to 3.60, 11 varieties within 3.60 to 3.70, 16 varieties within 3.70 to 3.80, 14 varieties within 3.80 to 3.90, 13 varieties within 3.90 to 4.00, 8 varieties within 4.00 to 4.10, 3 varieties within 4.10 to 4.20, 3 varieties within 4.20 to 4.30, 4 varieties within 4.30 to 4.40 and 1 variety within 4.40 to 4.50, respectively. Mode was found to lie within 3.20 to 3.30.

Ratios of grain width to grain thickness of husked grains were observed to be between 1.12 and 1.60. The smallest value was noted to be 1.12 in 79. The largest values were obtained as 1.60 in 11 and 212. Average value was found to be 1.41. The standard deviation of the whole varieties used, *i.e.*, showing inter-strain's variation, was 2.02.

Table 12. Classification of ratio of length to thickness of husked grains of cultivated rice varieties in Indonesia. Code numbers used in this table are corresponding to the variety number which was used in Table 1.

Up to	Code No.	No. of varieties
4.4	64	1
4.3	42 58 130 217	4
4.2	7 19 49	3
4.1	27 62 141	3
4.0	20 59 67 70 77 95 142 145	8
3.9	2 3 39 50 55 57 79 144 148 150 165 207 211	13
3.8	13 23 34 48 53 60 68 78 113 126 199 210 219 221	14
3.7	4 18 21 30 31 33 35 38 40 43 44 46 71 72 128 152	16
3.6	1 6 32 47 54 65 106 111 119 122 215	11
3.5	9 10 16 22 52 56 66 75 92 99 101 109 127 139 149 225	16
3.4	17 28 37 69 76 81 87 98 103 104 112 123 160 196 206 208	16
3.3	11 25 26 41 83 94 100 116 124 140 151 168 173 181 194 226	16
3.2	12 14 24 29 36 61 85 91 120 121 125 129 147 156 157 162 164	
	170 171 177 184 188 195 198 205 216	26
3.1	8 45 63 86 89 90 108 114 118 134 136 143 146 163 167 182 183	
	190 201 202 203 204 218 223 227	25
3.0	15 51 80 84 93 96 97 105 107 117 133 137 138 155 158 159 169	
	172 175 185 192 193 214	23
2.9	5 73 74 102 153 154 179 187 222	9
2.8	82 88 132 174 178 213	6
2.7	115 186 189 197 212	5
2.6	131 135 166 176 191 200 220 224	8
2.5	110 161	2
2.4	209	1
2.3	180	1

As shown in Table 13, 1 variety of them belonged to the group within 1.10 to 1.15, 2 varieties within 1.20 to 1.25, 13 varieties within 1.25 to 1.30, 24 varieties within 1.30 to 1.35, 46 varieties within 1.35 to 1.40, 76 varieties within 1.40 to 1.45, 32 varieties within 1.45 to 1.50, 25 varieties within 1.50 to 1.55, 5 varieties within 1.55 to 1.60 and 3 varieties within 1.60 to 1.65, respectively. Mode was found to lie within 1.40 to 1.45.

To make clear the relationships between the three components, *i.e.*, ratios of length to width and of length to thickness, ratios of length to width and of width to thickness, and ratios of length to thickness and of width to thickness of husked grains, correlation coefficient and linear regression between them were calculated.

Correlation coefficient between ratios of grain length to grain width and of grain length to grain thickness of husked grains was 0.9212 and showed very high correlation among them at 0.1% level. It was said that the larger was the former, the larger was the latter. Linear regression of the former ratio on the latter ratio was calculated as follows; $Y = 1.46X - 0.16$, where Y and X indicate the former ratio and the latter ratio, respectively. This formula indicates that the ratio of grain length to grain width becomes 1.46 larger, as it becomes 1.00 larger in the ratio of grain length to grain thickness.

Table 13. Classification of ratio of width to thickness of husked grains of cultivated rice varieties in Indonesia. Code numbers used in this table are corresponding to the variety number which was used in Table 1.

Up to	Code No.	No. of varieties
1.60	11 24 212	3
1.55	10 61 62 65 217	5
1.50	5 8 18 22 37 45 48 49 54 63 66 67 70 71 73 74 76	
	08 143 146 147 159 161 190 209	25
1.45	114 20 21 33 35 56 60 82 85 104 114 117 120 124 125 132 137	
	140 153 155 162 166 167 174 176 177 178 185 191 195 205 220	32
1.40	1 16 19 23 26 29 30 31 32 36 38 41 43 46 47 50 51	
	53 69 72 78 80 83 88 89 91 97 101 103 105 107 115 118 119	
	129 131 134 135 136 148 149 151 156 158 160 165 170 171 173 179 180	
	181 183 184 186 187 188 189 193 194 197 198 200 202 204 207 208 210	
	211 216 218 222 223 224 226 227	76
1.35	6 12 15 17 27 28 34 39 40 44 55 57 59 75 81 84 86	
	87 90 94 98 102 116 127 133 145 152 154 157 163 164 168 169 172	
	175 182 192 196 199 203 206 213 214 215 221 225	46
1.30	3 4 7 9 25 42 52 58 92 93 96 100 110 113 121 122 123	
	126 138 139 141 144 150 201	24
1.25	2 13 64 68 77 99 106 109 111 112 130 142 219	13
1.20	95 128	2
1.15		0
1.10	79	1

Correlation coefficient between ratios of grain length to grain width and of grain width to grain thickness was -0.2474 and showed very high negative correlation among them at 0.1% level. It was said that the larger was the former ratio, the smaller was the latter ratio. Linear regression of the former ratio on the latter ratio was calculated as follows; $Y = -0.19X + 0.95$, where Y and X indicate the former ratio and the latter ratio, respectively. This formula indicates that the ratio of grain length to grain width becomes 0.19 smaller, as it becomes 1.00 larger in the ratio of grain width to grain thickness.

Correlation coefficient between ratios of grain length to grain thickness and of grain width to grain thickness of husked grains was 0.0818 and showed no significant correlation among them even at 5% level. It was said that the former ratio is independent of the latter ratio.

3) Nagamatsu[5] pointed out that many types of cultivated rice distributed in low latitudinal areas in view of grain shape and grain size. Matsuo[4] indicated that cultivated rice was differentiated independently from wild rice or from C type of cultivated rice which was considered to be the original type of cultivated rice. Basing on the data obtained in this investigation, it was ascertained that many type varieties of cultivated rice were distributed in Indonesia. It is noticeable that C type varieties occupy 70% of the whole varieties used in this investigation. The geographical distribution of cultivated rice varieties in Indonesia shall be discussed in the next paper after more detailed investigation using the character of grainfullness and others were carried out.

Summary

1) Length, width and thickness of unhusked grains were measured as 8.70 *mm*, 3.09 *mm* and 2.06 *mm* in average values, respectively. Using grain length and grain width, cultivated rice varieties used were classified into three grain types. Ten varieties of them belonged to the A type, 59 varieties to the B type and 158 varieties to the C type, respectively. Correlation coefficients between grain length and grain width, grain length and grain thickness, and grain width and grain thickness of unhusked grains were −0.2557, 0.6275 and 0.8201, respectively. Ratios of grain length to grain width, of grain length to grain thickness and of grain width to grain thickness of unhusked grains were 2.82, 4.18 and 1.49 in average values, respectively. Correlation coefficients between ratios of grain length to grain width and of grain length to grain thickness, ratios of grain length to grain width and of grain width to grain thickness, and ratios of grain length to grain thickness and of grain width to grain thickness were 0.5099, −0.5328 and −0.3007, respectively.

2) Length, width and thickness of husked grains were measured as 6.21 *mm*, 2.60 *mm* and 1.84 *mm* in average values, respectively. Using grain length and grain width of husked grains, cultivated rice varieties used were classified into 7 types in view of grain shape and 5 types in view of grain size. In grain shape, 78 varieties of them belonged to "long-short type", 52 varieties to "long-medium type", 56 varieties to "long-long type", 6 varieties to "short-medium type", 21 varieties to "short-long type", 12 varieties to "slender-short type" and 2 varieties to "slender-medium type", respectively. In grain size, 1 variety of them belonged to "very small", 100 varieties to "small", 117 varieties to "medium", 8 varieties to "large" and 1 variety to "very large", respectively. Correlation coefficients between length and width, length and thickness, and width and thickness of husked grains were −0.1087, −0.0011 and 0.6582, respectively. Ratios of length to width, of length to thickness and of width to thickness of husked grains were observed to be 2.44, 3.40 and 1.41 in average values, respectively. Correlation coefficients between ratios of length to width and of length to thickness, ratios of length to width and of width to thickness, and ratios of length to thickness and of width to thickness of husked grains were 0.9212, −0.2474 and 0.0818, respectively.

References

1) Katayama, T. C., Watabe, T. and Kuroda, T.: *Pre. Rep. Tottori Univ. Sci. Survey 1971*, **1**, 1–47 (1972)
2) ——————— and Kuroda, T.: *ibid.*, **2**, 19–70 (1974)
3) ——————— : *Mem. Fac. Agr. Kagoshima Univ.*, **21**, 41–45 (1976)
4) Matsuo, T.: *Natl. Inst. Agr. Sci. Ser. D* **3**, 1–111 (in Jap. with Eng. Sum.) (1952)
5) Nagamatsu, T.: *Proc. Crop Sci. Soc. Japan* (in Jap.) **14** (2), 132–145 (1952)