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Diallel Cross Experiment among Sikkimese Varieties, Indica and Japonica Testers of Rice, *Oryza sativa* L.

X. Concluding Survey

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Introduction

In view of the historical processes for classifying the cultivated rice, Kato *et al.*[27] proposed at first to divide *Oryza sativa* L. into two sub-species, *i.e., japonica* and *indica*. Terao *et al.*[42] showed that the *javanica* varieties showed a very high affinity with Japanese varieties. These three major-groups have been genetically recognized by many workers. However, the idea of dividing rice-varieties into geographical races is rapidly losing its significance in accordance with the execution of further intensive works[2,17], including extensive collection, inter-group hybridization, international cooperation. Because such classification is considered as convenience, however, it is used frequently at the present by many workers.

The generally accepted origin of *O. sativa* has been the areas embracing South Asia, Southeast Asia and China[38]. Morinaga[34] stated recently that Himalaya is an indigenous center of rice. Katayama[15] held that Sikkim might be one of the differentiation centers of *O. sativa* into *japonica* and *indica*, and also stated that[16] cultivated rice was originated in the north India, and *japonica* type must have been developed later out of the *indica* type. The author's aim in the experiment-series was consistently to study varietal differentiations of the cultivated rice in the hope of getting useful informations on phylogenetic relationships (theoretical) and on breeding program (practical) of *Oryza sativa* L., irrespective of these three groups strictly.

Classification of rice varieties and determination of indigenous center of rice have been looked upon as complex symptoms. In order to confirm the classification of rice varieties, especially Sikkimese rice, and to clarify the relationships between its strains and the type of typical *indica* and *japonica*, the diallel crosses were carried out in this experiment-series. In the previous papers, 38 characters were reported, *i.e.*, crossability, pollen and seed fertilities[17], heading date and growing period[18], some morphological characters of plant[19], morphological characters of unhusked[20] and husked grains[21], comparison of unhusked and husked grains[22], surface area and volume of unhusked and husked grains[24], miscellaneous characters[25], and mutual relationships between the 2 on 34 characters used[26].

In the present paper, summarized data and their analyses in accordance with the tentative grouping[17] were mainly described. In addition to these problems, concluding survey of the present series and the discussions on them from the methodological, the genetical and the evolutional points of views were also mentioned extensively.

Materials and Methods

Fourteen strains of Sikkimese varieties were picked up from 68 strains collected at Sikkim in 1959[28]), and used in the experiment-series. In addition to these, one strain of *indica* and another one strain of *japonica* were used as the testers. They are listed up and classified in Table 1. Procedures of the cross and cultivation conditions of the parental and hybrid plants were minutely mentioned in the previous paper[17]). Thirty-eight characters were used in the third experiment-series (Table 2). Character numbers shown in this table are used consistently through the whole papers. But 4 characters, *i.e.*, No. 1 (phenol reaction), No. 5 (heading date), No. 19 (awn length) and No. 26 (grain color), were omitted mostly in the present experiment, and No. 2 (crossability) was also omitted in view of the pure-line plants, because these data are looked upon as unsuitable ones for analysing on the statistical methods.

Table 1. Materials used in the diallel cross experiment

Strain No.	Stock No.	Origin	Variety	Strain No.	Stock No.	Origin	Variety
1	108	Formosa	Indica	9	C7725	Sikkim	Addey
2	563	Japan	Japonica	10	C7727	〃	Addey
3	C7707	Sikkim	Addey	11	C7729	〃	Addey
4	C7716	〃	Lama	12	C7732	〃	Tapachini
5	C7717	〃	Lama	13	C7734	〃	Fudangay
6	C7718	〃	Tokmor Zo	14	C7735	〃	Fudangay
7	C7719	〃	Tokmor Zo	15	C7754	〃	Champasari
8	C7722	〃	Addey	16	C7757	〃	Addey

Table 2. Characters used in the diallel cross experiment

Series No.	Character No.	Character name	Series No.	Character No.	Character name
I	1	Phenol reaction	V	20	Husked grain; length
	2	Crossability		21	〃 〃 ; width
	3	Pollen fertility		22	〃 〃 ; thickness
	4	Seed fertility		23	〃 〃 ; length/width
II	5	Heading date		24	〃 〃 ; length/thickness
	6	Growing period		25	〃 〃 ; width/thickness
III	7	No. of seeds per panicle		26	Grain color
	8	Weight of unhusked grains	VI	27	Quotient; length
	9	Panicle length		28	〃 ; width
	10	No. of first rachises per panicle		29	〃 ; thickness
	11	No. of tillers per plant		30	〃 ; length/width
	12	Plant height		31	〃 ; length/thickness
IV	13	Unhusked grain; length		32	〃 ; width/thickness
	14	〃 〃 ; width	VII	33	Unhusked grain; area
	15	〃 〃 ; thickness		34	〃 〃 ; volume
	16	〃 〃 ; length/width		35	Husked grain; area
	17	〃 〃 ; length/thickness		36	〃 〃 ; volume
	18	〃 〃 ; width/thickness		37	Quotient; area
	19	Awn length		38	〃 ; volume

Most of the data were picked out from the previous papers and were analysed and re-arranged.

These data sources are as follows; series I[17] (character Nos. 2 to 4), II[18] (No. 6), III[19] (Nos. 7 to 12), IV[20] (Nos. 13 to 18), V[21] (Nos. 20 to 25), VI[22] (Nos. 27 to 32), VII[24] (Nos. 33 to 38), and VIII[25] and IX[26] (ranges and miscellaneous data). The items used here were as follows; (1) average values of the respective characters in parental level of pure-lines (Table 3), (2) average values of the respective characters in parental level of hybrid plants (Table 4), (3) average values of the respective characters in 9 groups in the reciprocal viewpoints (Tables 5 and 6), and summarizing data in the several viewpoints (Table 7).

Basing on the data obtained in the previous paper[17], the groupings of the whole strains were determined as follows; *indica* group — 8 strains (strain Nos. 1, 3, 4, 5, 8, 13, 14 and 15), *intermediate* group — 4 strains (strain Nos. 9, 10, 11 and 16), and *japonica* group — 4 strains (strain Nos. 2, 6, 7 and 12), respectively.

In the present paper, the following abbreviations were adopted; 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), F (female), M (male), c.c. (correlation coefficient), l.r. (linear regression), s.d. (standard deviations), *d* (*indica* type), *t* (*intermediate* type) and *j* (*japonica* type).

Results

1. Average values of the 33 characters in parental level of pure lines

Average value and its s.d. through the whole strains of 33 characters in parental level were calculated, and are shown in Table 3 in view of pure lines. Comparisons of three types, *i.e., indica* type (abbreviated as *d*), *intermediate* type (*t*) and *japonica* type (*j*), were done in regard to the degree of largeness with respective characters. Three abbreviations were used here, *i.e.,* > — the value of the former type is larger than that of the latter type, < — the value of the former type is smaller

Table 3. Average values of the 33 characters in parental level of pure lines

Character No.	*indica*	*intermediate*	*japonica*	Character No.	*indica*	*intermediate*	*japonica*
3	89.99± 9.86	92.33± 3.83	95.99± 1.22	22	1.77±0.09	1.73±0.04	1.78±0.11
4	73.88±11.88	85.66± 2.41	67.74±24.84	23	2.15±0.42	1.99±0.19	1.92±0.17
6	142.38±20.13	158.33± 3.30	121.70±19.19	24	3.22±0.49	3.05±0.20	2.90±0.29
7	95.08±23.46	119.93±49.43	94.13±41.35	25	1.49±0.07	1.55±0.08	1.52±0.08
8	22.48± 2.67	20.13± 1.28	20.83± 1.88	27	0.73±0.02	0.73±0.02	0.71±0.02
9	23.04± 1.43	21.23± 0.70	21.50± 2.30	28	0.83±0.02	0.85±0.03	0.82±0.03
10	11.86± 1.13	12.03± 1.59	11.30± 1.74	29	0.86±0.02	0.86±0.03	0.88±0.02
11	2.71± 0.36	3.25± 1.51	2.23± 0.64	30	0.86±0.02	0.87±0.02	0.86±0.02
12	169.25±16.46	171.63±20.96	151.10±34.56	31	0.85±0.03	0.85±0.05	0.81±0.02
13	7.83± 1.03	7.24± 0.49	7.28± 0.49	32	0.98±0.01	0.99±0.05	0.94±0.04
14	3.14± 0.16	3.17± 0.19	3.28± 0.12	33	24.48±2.27	22.89±1.40	23.91±1.46
15	2.06± 0.10	2.02± 0.12	2.04± 0.11	34	50.54±5.56	46.27±4.34	48.57±2.68
16	2.51± 0.46	2.30± 0.27	2.24± 0.20	35	14.83±1.25	14.02±0.97	13.81±1.18
17	3.80± 0.54	3.61± 0.45	3.60± 0.31	36	26.27±2.49	24.21±1.98	24.56±2.51
18	1.52± 0.07	1.57± 0.03	1.62± 0.13	37	0.61±0.02	0.61±0.04	0.58±0.03
20	5.67± 0.74	5.25± 0.24	5.15± 0.43	38	0.52±0.02	0.53±0.03	0.50±0.03
21	2.63± 0.18	2.67± 0.19	2.69± 0.05				

than that of the latter type, and = — the value of the former is the same as that of the latter type, respectively. The combinations can theoretically be classified into 13 groups.

Practical value: Concerning this character, 9 groups were found. Six characters (character Nos. 16, 17, 20, 23, 24 and 35), 3 (Nos. 27, 31 and 37), 7 (Nos. 8, 9, 13, 15, 33, 34 and 36), 9 (Nos. 4, 6, 7, 10, 11, 12, 28, 32 and 38), 1 (No. 30), 1 (No. 25), 1 (No. 22), 1 (No. 29) and 4 (Nos. 3, 14, 18 and 21) were classified in the groups of $d>t>j$, $d=t>j$, $d>j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $j>d>t$, $j>d=t$ and $j>t>d$ combinations, respectively. It may be noted that 28 characters, *i.e.*, 84.9% of the whole, were classified in the =lacking groups, *i.e.*, $d>t>j$, $d>j>t$, $t>d>j$, $t>j>d$, $j>d>t$ and $j>t>d$, and so forth. Eleven characters showed the superdominant patterns *i.e.*, $t>d>j$, $t>d=j$ and $t>j>d$ (and so froth). Eight characters showed the inferior patterns, *i.e.*, $d>j>t$, $d=j>t$ and $j>d>t$ (and so forth). Ten characters showed the mid-parent patterns, *i.e.*, $d>t>j$ and $j>t>d$ (and so forth).

S.d.: Concerning this character, 10 groups were found. Five characters (character Nos. 3, 16, 17, 23 and 34), 1 (No. 13), 6 (Nos. 6, 8, 20, 24, 33 and 35), 3 (Nos. 14, 21 and 31), 1 (No. 29), 5 (Nos. 7, 11, 15, 32 and 37), 3 (Nos. 25, 28 and 38), 5 (Nos. 4, 9, 18, 22 and 36), 2 (Nos. 10 and 12) and 2 (Nos. 27 and 30) were classified into the groups of $d>t>j$, $d>t=j$, $d>j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>t>d$ and $d=t=j$, respectively. The last combination was not found in the practical value. It may be noted that 26 characters, *i.e.*, 78.8% of the whole, were classified in the =lacking groups. Nine, 11 and 7 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

2. Average values of the 34 characters in parental level of the hybrid plants

Average value and its s.d. through the whole strains of 34 characters in parental level were calculated, and are shown in Table 4 in view of hybrid plants. Comparisons of three types were done in the same way as in case of the former character.

Practical value in the female: Concerning this character, 10 groups were found. Three characters (character Nos. 16, 17 and 23), 3 (Nos. 27, 28 and 38), 1 (No. 37), 4 (Nos. 13, 15, 20 and 24), 1 (No. 18), 4 (Nos. 6, 9, 11 and 29), 3 (Nos. 10, 12 and 22), 8 (Nos. 2, 8, 25, 30, 33, 34, 35 and 36), 1 (No. 31) and 6 (Nos. 3, 4, 7, 14, 21 and 32) were classified in the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>j>d$, $j>d>t$, $j>d=t$ and $j>t>d$, respectively. It may be noted that 28 characters, *i.e.*, 82.4% of the whole, were classified in the =lacking groups. Seven, 13 and 9 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

S.d. in the female: Concerning this character, 11 groups were found. Seven characters (character Nos. 2, 13, 15, 16, 21, 23 and 33), 1 (No. 18), 1 (No. 17), 5 (Nos. 8, 12, 20, 24 and 25), 2 (Nos. 10 and 11), 1 (No. 32), 5 (Nos. 7, 14, 22, 34 and 36), 3 (Nos. 29, 31 and 38), 5 (Nos. 3, 4, 5, 9 and 35), 2 (Nos. 28 and 30) and 2 (Nos. 27 and 37) were classified in the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$ and $d=t=j$, respectively. The last combination was not found in the practical value. It may be noted that 24 characters, *i.e.*, 70.6% of the whole, were classified in the =lacking groups. Eight, 10 and 7 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

Practical value in the male: Concerning this character, 12 groups were found. Six characters (character Nos. 13, 16, 17, 20, 23 and 24), 1 (No. 37), 1 (No. 31), 2 (Nos. 9 and 35), 2 (Nos. 29 and 33), 5 (Nos. 2, 4, 6, 11 and 12), 1 (No. 32), 1 (No. 28), 7 (Nos. 7, 8, 10, 18, 22, 34 and 36), 3 (Nos. 14, 15 and 38), 3 (Nos. 3, 21 and 25) and 2 (Nos. 27 and 30) were classified in the groups of $d>t>j$,

Table 4. Average values of the 34 characters in parental level of hybrid plants

Character No.	*indica*		*intermediate*		*japonica*	
	Female	Male	Female	Male	Female	Male
2	29.00±11.29	30.34± 8.42	16.92± 5.50	31.20±3.05	38.57± 4.84	29.80± 5.59
3	79.68± 5.65	78.69± 5.29	79.78± 4.62	78.72±0.79	81.04± 9.36	85.82± 1.21
4	57.73± 7.25	57.46± 8.66	58.85± 4.79	63.23±2.64	60.52± 9.96	56.67±12.92
6	149.91± 7.21	149.54± 6.44	155.35± 1.85	155.18±1.53	140.45± 8.33	141.37± 8.47
7	126.84±14.88	134.63±16.60	138.60±17.02	126.37±6.91	139.59±16.45	137.30±10.41
8	23.20± 1.15	23.24± 0.87	22.80± 0.92	22.80±0.76	23.62± 0.97	23.53± 0.82
9	24.97± 1.10	25.34± 0.79	25.39± 0.60	24.48±0.69	24.87± 1.50	24.95± 0.80
10	13.68± 0.72	13.97± 0.74	14.42± 1.42	13.95±0.69	14.37± 0.46	14.14± 0.46
11	2.97± 0.33	2.92± 0.29	3.10± 0.61	3.20±0.33	2.78± 0.08	2.77± 0.08
12	194.30±12.22	198.38±12.14	203.47± 4.08	199.83±6.89	197.42± 9.84	188.23± 7.76
13	7.63± 0.58	7.59± 0.37	7.40± 0.31	7.52±0.25	7.53± 0.24	7.47± 0.27
14	3.21± 0.08	3.24± 0.04	3.22± 0.15	3.24±0.06	3.37± 0.11	3.29± 0.07
15	2.21± 0.33	2.12± 0.04	2.11± 0.14	2.12±0.04	2.19± 0.10	2.13± 0.05
16	2.39± 0.26	2.37± 0.13	2.31± 0.17	2.34±0.08	2.25± 0.12	2.28± 0.11
17	3.67± 0.33	3.63± 0.20	3.54± 0.33	3.57±0.15	3.48± 0.23	3.54± 0.19
18	1.54± 0.04	1.54± 0.02	1.53± 0.03	1.53±0.01	1.54± 0.03	1.55± 0.02
20	5.53± 0.42	5.51± 0.26	5.34± 0.18	5.42±0.16	5.41± 0.25	5.38± 0.18
21	2.68± 0.10	2.69± 0.06	2.71± 0.09	2.70±0.05	2.75± 0.03	2.74± 0.04
22	1.79± 0.03	1.81± 0.04	1.83± 0.06	1.80±0.04	1.82± 0.04	1.82± 0.04
23	2.08± 0.24	2.05± 0.14	1.98± 0.13	2.02±0.08	1.97± 0.09	1.98± 0.09
24	3.09± 0.28	3.06± 0.19	2.94± 0.18	3.03±0.12	2.99± 0.19	2.96± 0.14
25	1.50± 0.04	1.49± 0.02	1.49± 0.02	1.50±0.01	1.51± 0.03	1.51± 0.01
27	0.73± 0.01	0.72± 0.01	0.72± 0.01	0.72±0.00	0.72± 0.01	0.72± 0.00
28	0.84± 0.02	0.83± 0.01	0.84± 0.02	0.84±0.01	0.82± 0.03	0.84± 0.01
29	0.86± 0.03	0.86± 0.01	0.87± 0.04	0.85±0.01	0.84± 0.04	0.86± 0.01
30	0.87± 0.02	0.87± 0.01	0.86± 0.02	0.87±0.01	0.88± 0.03	0.87± 0.01
31	0.84± 0.03	0.85± 0.01	0.84± 0.04	0.85±0.00	0.86± 0.04	0.84± 0.01
32	0.97± 0.02	0.97± 0.01	0.98± 0.03	0.99±0.01	0.99± 0.02	0.98± 0.01
33	24.42± 1.26	24.58± 0.89	23.75± 1.10	24.28±0.93	25.42± 1.05	24.58± 0.93
34	50.99± 2.89	52.00± 1.88	50.27± 5.43	51.53±2.31	55.67± 3.98	52.39± 2.18
35	14.79± 0.67	14.80± 0.46	14.46± 0.35	14.60±0.40	14.86± 0.73	14.70± 0.45
36	26.55± 0.88	26.76± 0.54	26.37± 1.04	26.23±0.86	27.05± 0.99	26.78± 0.86
37	0.61± 0.02	0.61± 0.01	0.61± 0.02	0.60±0.01	0.59± 0.02	0.60± 0.01
38	0.53± 0.02	0.52± 0.02	0.53± 0.03	0.52±0.01	0.50± 0.03	0.53± 0.00

$d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$, $j>t>d$ and $d=t=j$, respectively. It may be noted that 24 characters, *i.e.*, 70.6% of the whole, were classified in the =lacking groups. Six, 11 and 9 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

S.d. in the male: Concerning this character, 11 groups were found. Three characters (character Nos. 10, 21 and 38), 3 (Nos. 25, 27 and 36), 12 (Nos. 2, 3, 7, 8, 12, 13, 16, 17, 20, 23, 24 and 25), 2 (Nos. 18 and 31), 1 (No. 11), 1 (No. 34), 1 (No. 33), 3 (Nos. 4, 6 and 9), 1 (No. 15), 1 (No. 14) and 6 (Nos. 22, 28, 29, 30, 32 and 37) were classified in the groups of $d>t>j$, $d>t=j$, $d>j>t$,

$d=j>t$, $t>d>j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$, $j>t>d$ and $d=t=j$, respectively. It may be noted that 21 characters, *i.e.*, 61.8% of the whole, were classified in the =lacking groups, 12 characters were classified in $d>j>t$ group, and 6 characters were classified in $d=t=j$ group, which were clearly different from those of the 3 former characters. Two, 17 and 4 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

Whole: Concerning the whole characters, 13 groups, *i.e.*, the whole groups calculated theoretically, were found. Nineteen, 8, 3, 23, 5, 12, 1, 10, 5, 23, 7, 10 and 10 were classified in the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$, $j>t>d$ and $d=t=j$, respectively. It may be noted that 97 characters, *i.e.*, 71.3% of the whole, were classified in the =lacking groups. Twenty-three, 51 and 29 characters showed the superdominant, the inferior and mid-parent patterns, respectively.

Character No. 11 showed the same pattern, *i.e.*, $t>d>j$, in the 4 columns. Character Nos. 16, 23 and 24 showed the same pattern, in which the former 2 were classified in $d>t>j$, and the last 1 was classified in $d>j>t$, respectively.

Comparison of the female and the male in view of practical value: The data showed nearly the same tendencies. But in detail some differences were found. Two characters (character Nos. 16 and 17), 2 (Nos. 6 and 11), 2 (Nos. 8 and 36) and 1 (No. 3) were classified in the same groups both in the female and in the male, *i.e.*, $d>t>j$, $t>d>j$, $j>d>t$ and $j>t>d$, respectively. In other words, only 7 characters, *i.e.*, 20.6% of the whole, were classified in the same groups. It may be noted that these groups were ascertained to be the =lacking groups.

The other comparative methods were adopted. In each group, data were compared and designated by simple marks. For example, character No. 28 showed as 0.84 and 0.83 in the female and in the male, and was illustrated as $>$ in *indica*, as 0.84 and 0.84 in the female and in the male, and was illustrated as $=$ in *intermediate*, and as 0.82 and 0.84 in the female and in the male, and was illustrated as $<$ in *japonica*, respectively. So, character No. 28 was finally illustrated as $>=<$. The combinations can theoretically be classified into 27 groups. Concerning this character, however, 14 groups were found. Three characters (character Nos. 3, 6 and 38), 1 (No. 27), 1 (No. 28), 7 (Nos. 4, 11, 13, 15, 20, 23 and 24), 1 (No. 25), 2 (Nos. 16 and 17), 2 (Nos. 29 and 37), 1 (No. 18), 2 (Nos. 30 and 32), 6 (Nos. 7, 10, 12, 21, 35 and 36), 1 (No. 22), 1 (No. 9), 1 (No. 8) and 5 (Nos. 2, 14, 31, 33 and 34) were classified in the groups of $>>>$, $>==$, $>=<$, $><>$, $><=$, $><<$, $=><$, $==<$, $=<>$, $<>>$, $<>=$, $<><$, $<=>$ and $<<>$, respectively. It may be noted that 24 characters, *i.e.*, 70.6% of the whole, were classified in the =lacking groups.

Comparison of the female and the male in view of s.d.: The data showed quite different tendencies. For example, 7 and 3, 5 and 12, 5 and 1, and 5 and 3 characters were classified in the groups $d>t>j$, $d>j>t$, $t>j>d$ and $j>d>t$, respectively. One character (No. 21), 4 (Nos. 8, 12, 20 and 24), 1 (No. 11), 1 (No. 34), 2 (Nos. 4 and 9) and 1 (No. 37) were classified in the same groups both in the female and in the male, $d>t>j$, $d>j>t$, $t>d>j$, $t>j>d$, $j>d>t$ and $d=t=j$, respectively. In other words, 10 characters, *i.e.*, 29.4% of the whole, were classified into the same groups.

The other compartive methods were adopted, the result of which was the same as in case of the practical value. The combinations can theoretically be classified into 27 groups. Concerning this character, however, 8 groups were found. Nineteen characters (character Nos. 3, 8, 14, 15, 16, 17, 18, 19, 24, 25, 28, 29, 30, 31, 32, 33, 34, 36 and 37), 2 (Nos. 11 and 23), 4 (Nos. 2, 6, 13 and 21), 3 (Nos. 9, 12 and 35), 2 (Nos. 27 and 38), 1 (No. 7), 2 (Nos. 10 and 22) and 1 (No. 4) were classified in the groups of $>>>$, $>>=$, $>><$, $><>$, $=>>$, $<>>$, $<>=$ and $<><$, respectively. It may be noted that 19 characters, *i.e.*, 55.9% of the whole, were classified into $>>>$, and that 28 characters, *i.e.*, 82.4% of the whole, were classified into the =lacking groups.

Comparison of practical value and s.d.: Nine in practical value and 10 characters in s.d., 4 and 4 (in the same order, and so forth), 2 and 1, 6 and 17, 3 and 2, 9 and 3, 0 and 1, 4 and 6, 1 and 4, 15 and 8, 4 and 3, 9 and 1, and 2 and 8, were classified into the groups, $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$, $j>t>d$ and $d=t=j$, respectively. It may be a peculiar tendency that the numbers of characters were quite different in groups of $d>j>t$, $t>d>j$, $j>d>t$ and $j>t>d$, which were all the =lacking groups. It was noted that 52 (76.5%) and 45 characters (66.2%) were classified in the =lacking groups in practical value and s.d., respectively. Thirteen and 10; 24 and 27; and 18 and 11; characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

3. Average values of the 34 characters in 9 hybrid-combination-groups

Average value and its s.d. through the whole strains of 34 characters in parental level were calculated, and are shown in Tables 5 and 6 in view of hybrid-combination-groups. Comparisons of three types were done in the same way as in cases of the former two chapters.

Practical value in the homogeneous group: Concerning this chapter, the comparisons were instituted in the order of *indica* (♀)×*indica* (♂), *intermediate* (♀)×*intermediate* (♂) and *japonica* (♀)× *japonica* (♂). Concerning this character, 10 groups were found. Six characters (character Nos. 16, 17, 23, 24, 27 and 29), 3 (Nos. 28, 37 and 38), 4 (Nos. 9, 13, 20 and 35), 1 (No. 30), 3 (Nos. 6, 11 and 12), 2 (Nos. 3 and 4), 2 (Nos. 25 and 32), 8 (Nos. 2, 8, 14, 15, 22, 33, 34 and 36), 1 (No. 31) and 4 (Nos. 7, 10, 18 and 21) were classified into the groups of $d(=$*indica*$)>t(=$*intermediate*$)>j(=$*japonica*$)$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$ and $j>t>d$, respectively. It may be noted that 27 characters, *i.e.*, 79.4% of the whole, were classified into the =lacking groups. Five, 13 and 10 characters showed the superdominant, the inferior and mid-parent patterns, respectively.

S.d. in the homogeneous group: Concerning this character, 10 groups were found. Eight characters (character Nos. 7, 13, 16, 20, 21, 23, 25 and 33), 2 (Nos. 18 and 24), 2 (Nos. 22 and 35), 4 (Nos. 3, 4, 6 and 17), 1 (No. 28), 5 (Nos. 8, 9, 10, 34 and 36), 2 (Nos. 29 and 31), 3 (Nos. 11, 14 and 15), 2 (Nos. 2 and 12) and 5 (Nos. 27, 30, 32, 37 and 38) were classified into the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $j>d>t$ and $d=t=j$, respectively. The last combination was not found in the practical value. It may be noted that 22 characters, *i.e.*, 64.7% of the whole, were classified into the =lacking groups. Ten, 7 and 8 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

Practical value in the first intra-group: Concerning this chapter, the comparisons were instituted in order of *indica* (♀)×*indica* (♂), *indica* (♀)×*intermediate* (♂) and *indica* (♀)×*japonica* (♂). Concerning this character, 11 groups were found. Eight characters (character Nos. 12, 13, 16, 17, 20, 23, 24 and 33), 1 (No. 29), 1 (No. 35), 3 (Nos. 27, 30 and 38), 3 (Nos. 6, 11 and 34), 2 (Nos. 9 and 15), 2 (Nos. 31 and 32), 5 (Nos. 3, 7, 8, 18 and 36), 1 (No. 25), 5 (Nos. 2, 4, 10, 14 and 21) and 3 (Nos. 22, 28 and 37) were classified into the groups of $d>t>j$, $d>t=j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$, $j>t>d$ and $d=t=j$, respectively. It may be noted that 24 characters, *i.e.*, 70.6% of the whole, were classified into the =lacking groups. Five, 9 and 13 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

S. d. in the first intra-group: Concerning this character, 11 groups were found. Four characters (character Nos. 3, 12, 17 and 24), 2 (Nos. 7 and 9), 1 (No. 38), 8 (Nos. 8, 11, 13, 16, 20, 25, 33 and 35), 1 (No. 32), 2 (Nos. 21 and 34), 2 (Nos. 18 and 31), 4 (Nos. 2, 4, 6 and 10), 2 (Nos. 15 and 29),

Table 5. Average values of the 34 characters in 5 hybrid-combination-groups

Character No.	*indica* (♀) × *indica* (♂)	*indica* (♀) × *intermediate* (♂)	*indica* (♀) × *japonica* (♂)	*intermediate* (♀) × *indica* (♂)	*intermediate* (♀) × *intermediate* (♂)
2	23.35±18.28	30.56±14.94	33.47±23.69	16.29±15.00	17.92± 9.66
3	77.16±17.93	76.53±14.30	87.80± 9.45	75.19±13.48	90.76± 3.19
4	56.59±20.04	58.57±16.68	58.93±24.06	53.96±21.92	83.66± 7.39
6	150.86±11.54	157.38± 4.88	140.74±16.50	153.58±18.78	157.27± 3.33
7	127.28±41.54	123.45±28.14	129.40±38.42	137.05±41.18	127.65±34.14
8	23.18± 2.06	23.05± 2.18	23.36± 1.74	23.04± 1.75	21.23± 2.27
9	25.24± 3.16	24.36± 2.47	24.62± 2.70	25.57± 2.67	24.55± 3.30
10	13.63± 1.76	13.69± 1.55	13.77± 1.82	14.42± 2.16	14.15± 1.78
11	2.99± 0.77	3.22± 0.92	2.69± 0.74	3.10± 1.04	3.30± 1.13
12	200.24±26.94	198.75±25.20	182.94±25.10	203.30±21.40	203.33±26.08
13	7.68± 0.78	7.64± 0.82	7.52± 0.65	7.46± 0.52	7.28± 0.46
14	3.19± 0.12	3.20± 0.15	3.25± 0.16	3.20± 0.17	3.17± 0.15
15	2.08± 0.11	2.10± 0.11	2.09± 0.14	2.10± 0.17	2.06± 0.16
16	2.42± 0.32	2.40± 0.36	2.33± 0.29	2.34± 0.25	2.30± 0.16
17	3.71± 0.47	3.65± 0.45	3.63± 0.43	3.58± 0.45	3.55± 0.27
18	1.54± 0.06	1.53± 0.08	1.56± 0.08	1.53± 0.06	1.55± 0.05
20	5.58± 0.54	5.51± 0.56	5.47± 0.48	5.42± 0.38	5.26± 0.27
21	2.67± 0.13	2.68± 0.15	2.72± 0.14	2.71± 0.13	2.68± 0.10
22	1.80± 0.07	1.80± 0.08	1.80± 0.10	1.83± 0.09	1.77± 0.07
23	2.10± 0.31	2.08± 0.33	1.96± 0.41	2.01± 0.22	1.97± 0.12
24	3.12± 0.39	3.08± 0.38	3.05± 0.35	2.97± 0.33	2.98± 0.19
25	1.49± 0.07	1.49± 0.09	1.52± 0.06	1.48± 0.05	1.52± 0.05
27	0.73± 0.02	0.72± 0.02	0.73± 0.02	0.73± 0.02	0.72± 0.02
28	0.84± 0.03	0.84± 0.03	0.84± 0.03	0.85± 0.03	0.84± 0.02
29	0.87± 0.04	0.86± 0.04	0.86± 0.05	0.87± 0.04	0.86± 0.05
30	0.87± 0.03	0.86± 0.03	0.87± 0.03	0.86± 0.03	0.85± 0.03
31	0.84± 0.04	0.85± 0.05	0.85± 0.05	0.84± 0.05	0.84± 0.05
32	0.97± 0.04	0.98± 0.05	0.98± 0.04	0.97± 0.04	0.98± 0.04
33	24.45± 2.09	24.40± 2.10	24.39± 1.75	23.91± 1.61	23.11± 2.04
34	51.10± 5.10	51.27± 5.63	50.93± 5.52	50.17± 6.31	47.75± 7.71
35	14.84± 0.98	14.69± 0.99	14.82± 0.92	14.62± 0.75	14.09± 0.98
36	26.62± 1.62	26.34± 1.90	26.64± 2.12	26.73± 1.73	24.91± 2.24
37	0.61± 0.03	0.61± 0.03	0.61± 0.03	0.62± 0.03	0.61± 0.03
38	0.53± 0.05	0.52± 0.04	0.53± 0.05	0.54± 0.04	0.53± 0.05

4 (Nos. 14, 22, 23 and 36) and 4 (Nos. 27, 28, 30 and 37) were classified into the groups of $d>t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$, $j>t>d$ and $d=t=j$, respectively. It may be noted that 24 characters, *i.e.*, 70.6% of the whole, were classified into the =lacking groups. Eleven, 7 and 8 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

Practical value in the second intra-group: Concerning this character, the comparisons were instituted in the order of *intermediate* (♀)×*indica* (♂), *intermediate* (♀)×*intermediate* (♂) and *intermediate* (♀)×*japonica* (♂). Concerning this character, 10 groups were found. Seven characters (character

Table 6. Average values of the 34 characters in 4 hybrid-groups and the whole combinations

Character No.	*intermediate* (♀) × *japonica* (♂)	*japonica* (♀) × *indica* (♂)	*japonica* (♀) × *intermediate* (♂)	*japonica* (♀) × *japonica* (♂)	Whole combinations
2	17.28± 8.32	37.68±21.34	41.78±19.25	36.44±20.14	28.37±17.02
3	81.11± 8.98	82.21±15.46	73.60±15.88	87.13± 9.46	80.09±16.37
4	49.83±24.90	62.39±20.86	57.06±21.29	59.61±12.76	58.70±21.30
6	151.13± 8.55	139.99±16.95	149.11± 8.88	129.78±11.43	148.90±13.75
7	149.29±43.94	144.60±38.57	131.26±34.97	142.08±31.55	133.22±38.90
8	23.49± 1.94	23.55± 1.79	23.45± 1.80	24.03± 1.20	23.20± 1.98
9	25.64± 3.56	25.28± 2.56	24.68± 3.32	24.91± 2.85	24.99± 3.13
10	14.63± 2.16	14.48± 1.77	14.31± 1.70	14.48± 1.45	14.04± 1.85
11	2.93± 0.97	2.63± 0.70	3.08± 1.03	2.76± 0.81	2.95± 0.90
12	203.61±16.91	193.00±27.68	199.32±18.99	181.43±28.00	196.12±25.25
13	7.36± 0.42	7.63± 0.51	7.43± 0.49	7.48± 0.34	7.55± 0.68
14	3.28± 0.22	3.35± 0.17	3.35± 0.14	3.42± 0.13	3.25± 0.17
15	2.16± 0.20	2.18± 0.16	2.20± 0.15	2.19± 0.12	2.12± 0.15
16	2.26± 0.21	2.29± 0.22	2.22± 0.17	2.20± 0.14	2.34± 0.28
17	3.44± 0.41	3.52± 0.38	3.40± 0.39	3.43± 0.29	3.59± 0.43
18	1.52± 0.05	1.54± 0.07	1.53± 0.08	1.56± 0.05	1.54± 0.07
20	5.25± 0.28	5.47± 0.41	5.36± 0.40	5.32± 0.26	5.45± 0.47
21	2.74± 0.10	2.73± 0.10	2.76± 0.08	2.78± 0.04	2.70± 0.14
22	1.86± 0.09	1.81± 0.07	1.83± 0.09	1.84± 0.04	1.81± 0.09
23	1.93± 0.16	2.01± 0.20	1.94± 0.16	1.91± 0.10	2.03± 0.26
24	2.83± 0.25	3.02± 0.32	2.95± 0.32	2.89± 0.19	3.03± 0.35
25	1.48± 0.04	1.51± 0.05	1.52± 0.06	1.51± 0.04	1.50± 0.07
27	0.71± 0.02	0.72± 0.02	0.72± 0.02	0.71± 0.02	0.72± 0.02
28	0.84± 0.04	0.82± 0.04	0.83± 0.03	0.82± 0.03	0.83± 0.03
29	0.86± 0.05	0.84± 0.05	0.83± 0.05	0.84± 0.04	0.86± 0.05
30	0.86± 0.04	0.88± 0.04	0.87± 0.04	0.87± 0.03	0.87± 0.04
31	0.83± 0.06	0.86± 0.06	0.87± 0.06	0.85± 0.04	0.85± 0.05
32	0.97± 0.03	0.98± 0.04	0.99± 0.03	0.98± 0.04	0.98± 0.04
33	24.10± 1.96	25.55± 1.86	24.91± 2.03	25.72± 1.39	24.50± 2.02
34	52.35± 8.21	55.81± 6.56	54.89± 5.76	56.34± 4.91	51.98± 6.48
35	14.39± 0.82	14.91± 0.96	14.80± 1.12	14.79± 0.71	14.72± 0.95
36	26.75± 2.15	27.02± 1.69	26.98± 1.93	27.20± 1.01	26.63± 1.88
37	0.60± 0.03	0.59± 0.03	0.60± 0.03	0.58± 0.03	0.60± 0.03
38	0.52± 0.05	0.49± 0.05	0.50± 0.05	0.49± 0.05	0.52± 0.05

Nos. 16, 17, 20, 23, 27, 37 and 38), 2 (Nos. 28 and 29), 1 (No. 31), 2 (Nos. 13 and 35), 1 (No. 30), 5 (Nos. 4, 6, 11, 18 and 24), 2 (Nos. 25 and 32), 2 (Nos. 2 and 3), 11 (Nos. 7, 8, 9, 10, 14, 15, 21, 22, 33, 34 and 36) and 1 (No. 12) were classified into the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $j>d>t$ and $j>t>d$, respectively. It may be noted that 28 characters, *i.e.*, 82.4% of the whole, were classified into the = lacking groups, and 11 characters were classified into $j>d>t$ group. Nine, 14 and 8 characters showed the superdominant, the inferior and mid-parent patterns, respectively.

S.d. in the second intra-group: Concerning this character, 12 groups were found. Two characters (character Nos. 2 and 13), 3 (Nos. 18, 21 and 32), 1 (No. 25), 7 (Nos. 3, 6, 16, 17, 20, 23 and 24), 2 (Nos. 10 and 22), 2 (Nos. 11 and 12), 4 (Nos. 8, 33, 35 and 36), 2 (Nos. 29 and 38), 5 (Nos. 4, 7, 14, 15 and 28), 2 (Nos. 30 and 31), 2 (Nos. 9 and 34) and 2 (Nos. 27 and 37) were classified into the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$, $j>t>d$ and $d=t=j$, respectively. The last combination was not found in the practical value. It may be noted that 22 characters, *i.e.*, 64.7% of the whole, were classified into the =lacking groups. Six, 14 and 4 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

Practical value in the third intra-group: Concerning this chapter, the comparisons were instituted in the order of *japonica* (♀)×*indica* (♂), *japonica* (♀)×*intermediate* (♂) and *japonica* (♀)×*japonica* (♂). Concerning this character, 11 groups were found. Five characters (character Nos. 16, 20, 23, 24 and 35), 1 (No. 30), 1 (No. 27), 5 (Nos. 4, 7, 9, 13 and 17), 2 (Nos. 10 and 29), 5 (Nos. 2, 6, 12, 31 and 37), 4 (Nos. 25, 28, 32 and 38), 2 (Nos. 11 and 15), 6 (Nos. 3, 8, 18, 33, 34 and 36), 1 (No. 14) and 2 (Nos. 21 and 22) were classified into the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $j>d>t$, $j>d=t$ and $j>t>d$, respectively. It may be noted that 25 characters, *i.e.*, 73.5% of the whole, were classified into the =lacking groups. Eleven, 13 and 7 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

S.d. in the third intra-group: Concerning this character, 9 groups were found. Ten characters (character Nos. 7, 10, 13, 14, 15, 16, 20, 21, 23 and 34), 1 (No. 28), 4 (Nos. 24, 29, 30 and 31), 2 (Nos. 2 and 6), 1 (No. 32), 10 (Nos. 3, 4, 8, 17, 18, 22, 25, 33, 35 and 36), 2 (Nos. 9 and 11), 1 (No. 12) and 3 (Nos. 27, 37 and 38) were classified into the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>j>d$, $j>d>t$ and $d=t=j$, respectively. The last combination was not found in the practical value. It may be noted that 25 characters, *i.e.*, 73.5% of the whole, were classified into the =lacking groups, and that 24 characters, *i.e.*, 70.6% of the whole, were classified in the groups of $d>t>j$, $d=t>j$ and $t>d>j$, in which j was located in the lowest values. Twelve, 4 and 10 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

Practical value in the fourth intra-group: Concerning this chapter, the comparisons were instituted in the order of *indica* (♀)×*indica* (♂), *intermediate* (♀)×*indica* (♂) and *japonica* (♀)×*indica* (♂). Concerning this character, 10 groups were found. Two characters (character Nos. 16 and 17), 1 (No. 23), 2 (Nos. 27 and 29), 3 (Nos. 13, 20 and 24), 1 (No. 18), 6 (Nos. 6, 11, 12, 28, 37 and 38), 2 (Nos. 9 and 22), 9 (Nos. 2, 3, 4, 8, 25, 30, 33, 34 and 35), 2 (Nos. 31 and 32) and 6 (Nos. 7, 10, 14, 15, 21 and 36) were classified into the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t=j>d$, $j>d>t$, $j>d=t$ and $j>t>d$, respectively. It may be noted that 28 characters, *i.e.*, 82.4% of the whole, were classified into the =lacking groups. Eight, 13 and 8 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

S.d. in the fourth intra-group: Concerning this character, 12 groups were found. Seven characters (character Nos. 7, 9, 13, 16, 17, 23 and 24), 1 (No. 25), 5 (Nos. 3, 8, 20, 33 and 35), 2 (Nos. 21 and 38), 1 (No. 11), 1 (No. 22), 5 (Nos. 4, 6, 10, 15 and 36), 1 (No. 14), 2 (Nos. 2 and 12), 4 (Nos. 18, 28, 29 and 30), 2 (Nos. 31 and 34) and 3 (Nos. 27, 32 and 37) were classified into the groups of $d>t>j$, $d>t=j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$, $j>t>d$ and $d=t=j$, respectively. The last combination was not found in the practical value. It may be noted that 22 characters, *i.e.*, 64.7% of the whole, were classified into the =lacking groups. Seven, 9 and 9 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

Practical value in the fifth intra-group: In this chapter, the comparisons were instituted in the order of *indica* (♀)×*intermediate* (♂), *intermediate* (♀)×*intermediate* (♂) and *japonica* (♀)×*intermediate* (♂). Concerning this character, 11 groups were found. Five characters (character Nos. 6, 16, 17, 23 and 24), 3 (Nos. 28, 29 and 37), 2 (Nos. 13 and 20), 4 (Nos. 3, 4, 11 and 38), 1 (No. 18), 1 (No. 12), 1 (No. 25), 11 (Nos. 2, 8, 14, 15, 22, 30, 31, 33, 34, 35 and 36), 2 (Nos. 21 and 32), 3 (Nos. 7, 9 and 10) and 1 (No. 27) were classified into the groups of $d>t>j$, $d=t>j$, $d>j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$, $j>t>d$ and $d=t=j$, respectively. It may be noted that 26 characters, *i.e.*, 76.5% of the whole, were classified into the =lacking groups, and that 11 characters were classified in $j>d>t$ group, which was the same one as in case of the second intra-group. Six, 13 and 8 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

S.d. in the fifth intra-group: Concerning this character, 11 groups were found. Three characters (character Nos. 21, 32 and 33), 1 (No. 14), 7 (Nos. 13, 16, 17, 20, 23, 24 and 25), 2 (Nos. 18 and 28), 2 (Nos. 8 and 12), 5 (Nos. 10, 11, 15, 34 and 36), 2 (Nos. 29 and 38), 6 (Nos. 2, 3, 4, 6, 22 and 35), 2 (Nos. 30 and 31), 2 (Nos. 7 and 9) and 2 (Nos. 27 and 37) were classified into the groups of $d>t>j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$, $j>t>d$ and $d=t=j$, respectively. It may be noted that 25 characters, *i.e.*, 73.5% of the whole, were classified into the =lacking groups. Seven, 15 and 5 characters showed the superdominant, the inferior and the mid-parent pattens, respectively.

Practical value in the sixth intra-group: In this chapter, the comparisons were instituted in the order of *indica* (♀)×*japonica* (♂), *intermediate* (♀)×*japonica* (♂) and *japonica* (♀)×*japonica* (♂). Concerning this character, 9 groups were found, which was the smallest number through the whole comparison-series. Five characters (character Nos. 16, 17, 23, 37 and 38), 1 (No. 27) 2 (Nos. 28 and 29), 5 (Nos. 3, 13, 20, 24 and 25), 4 (Nos. 18, 30, 31 and 32), 2 (Nos. 6 and 12), 5 (Nos. 7, 9, 10, 11 and 22), 4 (Nos. 2, 4, 33 and 35) and 6 (Nos. 8, 14, 15, 21, 34 and 36) were classified into the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>j>d$, $j>d>t$ and $j>t>d$, respectively. It may be noted that 27 characters, *i.e.*, 79.4% of the whole, were classified into the =lacking groups. Seven, 13 and 13 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

S.d. in the sixth intra-group: Concerning this character, 10 groups were found. Nine characters (character Nos. 13, 16, 17, 20, 21, 22, 23, 24 and 35), 2 (Nos. 18 and 25), 1 (No. 29), 2 (Nos. 2 and 6), 1 (No. 32), 10 (Nos. 4, 7, 8, 10, 14, 15, 31, 33, 34 and 36), 2 (Nos. 28 and 30), 2 (Nos. 9 and 11), 2 (Nos. 3 and 12) and 3 (Nos. 27, 37 and 38) were classified into the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $j>d>t$ and $d=t=j$, respectively. The last combination was not found in the practical value. It may be noted that 25 combinations, *i.e.*, 73.5% of the whole, were classified into the =lacking groups, and that 10 characters were classified into $j>d>t$ group, which was the same one as in case of the third intra-group. Fourteen, 5 and 9 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

Practical value through the 7 groups: In this chapter, the comparisons were instituted through the 7 groups mentioned above. Thirty-eight, 6, 12, 22, 12, 28, 7, 16, 5, 54, 7, 27 and 4 characters were classified into the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$, $j>t>d$ and $d=t=j$, respectively. It may be noted that 185 characters, *i.e.*, 77.7% of the whole, were classified into the =lacking groups. Fifty-one, 13 and 65 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

Character No. 16 showed the same pattern, *i.e.*, $d>t>j$, through the whole columns. Character

Nos. 17 and 23, No. 13, No. 6, Nos. 8 and 33 showed the same patterns in 6 columns, *i.e.*, $d>t>j$, $d>j>t$, $t>d>j$ and $j>d>t$, respectively. Character No. 11 and No. 21 showed the same patterns in 5 columns, *i.e.*, $t>d>j$ and $j>t>d$, respectively. It may be noted that these patterns mentioned above were found to be the $=$lacking groups.

S.d. through the 7 groups: Fourty-three, 9, 9, 29, 10, 38, 6, 23, 7, 22, 10, 10 and 22 characters were classified into the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$, $j>t>d$ and $d=t=j$, respectively. It may be noted that 165 characters, *i.e.*, 69.3% of the whole, were classified into the $=$lacking groups. Sixty-seven, 61 and 53 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

Character Nos. 27 and 37 showed the same pattern, *i.e.*, $d=t=j$, through the whole columns. Character No. 13 and No. 8 showed the same patterns in 5 columns, *i.e.*, $d>t>j$ and $t>d>j$, respectively.

The whole data of practical value and s.d. through the 7 groups: Eighty-one, 15, 21, 51, 22, 66, 13, 39, 12, 76, 17, 37 and 26 characters were classified into the groups of $d>t>j$, $d>t=j$, $d=t>j$, $d>j>t$, $d=j>t$, $t>d>j$, $t>d=j$, $t>j>d$, $t=j>d$, $j>d>t$, $j>d=t$, $j>t>d$ and $d=t=j$, respectively. It may be noted that 350 characters, *i.e.*, 73.5% of the whole, were classified into the $=$lacking groups. One hundred and eighteen, 149 and 118 characters showed the superdominant, the inferior and the mid-parent patterns, respectively.

Theoretically, the value may be found in 14 columns as the same pattern, but the values were found in 11 columns in the maximum. Character No. 16 showed the same pattern in 11 columns, *i.e.*, $d>t>j$. Character No. 23 showed the same pattern in 10 columns, *i.e.*, also $d>t>j$. Character No. 17 showed the same pattern in 9 columns, *i.e.*, also $d>t>j$. Character No. 11, No. 2, Nos. 27 and 37 showed the same pattern in 8 columns, *i.e.*, $t>d>j$, $j>d>t$ and $d=t=j$, respectively.

Comparison of practical value and its s.d. through the whole columns: The data shown in the practical value and its s.d. through the 7 groups were compared. The number of characters classified into 5 patterns found in the practical value, *i.e.*, $d=t>j$, $d=j>t$, $t>d=j$, $j>d>t$ and $j>t>d$, were more abundant than those of the remaining 8 patterns. Those belonging to the $=$lacking groups of practical value were clearly numerous more than those belonging to s.d. Number of characters showing the superdominant, the inferior and the mid-parent patterns were accounted to be 51 in practical value and 67 in s.d., 13 and 61, and 65 and 54, respectively. It may be noted that the second comparison might show the specificity of the both characters.

Comparison of the female and the male in view of practical value: The other comparative methods were adopted here, which were nearly the same as in case of the former chapter. In each group, data were compared and designated by the simple marks in the reciprocal viewpoints. For example, character No.20 showed as 5.51 and 5.42 in *indica* (♀)×*intermediate* (♂) and *intermediate* (♀)× *indica* (♂), and was illustrated as $>$, as 5.47 and 5.47 in *indica* (♀)×*japonica* (♂) and *japonica* (♀)×*indica* (♂), and was illustrated as $=$, and as 5.25 and 5.36 in *intermediate* (♀)×*japonica* (♂) and *japonica* (♀)×*intermediate* (♂), and was illustrated as $<$, respectively. So, character No. 20 was illustrated lastly as $>=<$. The combinations can theoretically be classified into 27 groups. Concerning this character, however, 12 groups were found. Four characters (character Nos. 3, 6, 16 and 17), 3 (Nos. 11, 24 and 25), 2 (Nos. 20 and 32), 1 (No. 8), 8 (Nos. 2, 4, 13, 23, 31, 33, 34 and 35), 1 (No. 18), 3 (Nos. 14, 15 and 30), 3 (Nos. 28, 29 and 38), 1 (No. 37), 1 (No. 27), 5 (Nos. 7, 9, 10, 12 and 22) and 2 (Nos. 21 and 36) were classified into the groups of $>>>$, $>><$, $>=<$, $><>$, $><<$, $=><$, $=<<$, $<>>$, $<>=$, $<><$, $<<>$ and $<<<$, respectively.

It may be noted that 25 characters, *i.e.*, 73.5% of the whole, were classified into the =lacking groups.
Comparisons of the female and the male in view of s.d.: The same methods mentioned just above were adopted in the s.d. The combinations may be classified into 27 groups theoretically. Concerning this character, however, 15 groups were found. Three characters (character Nos. 16, 21 and 36), 1 (No. 23), 5 (Nos. 13, 18, 20, 24 and 25), 1 (No. 32), 1 (No. 8), 4 (Nos. 3, 12, 33 and 35), 1 (No. 17), 4 (Nos. 27, 29, 37 and 38), 1 (No. 28), 2 (Nos. 30 and 31), 3 (Nos. 4, 9 and 10), 1 (No. 22), 2 (Nos. 2 and 11), 4 (Nos. 7, 14, 15 and 34) and 1 (No. 6) were classified into the groups of >>>, >>=, >><, >==, ><>, ><<, =>>, ===, =<>, =<=, <>>, <>=, <><, <<> and <<<, respectively. It may be noted that 22 characters, *i.e.*, 64.7% of the whole, were classified into the =lacking groups.

4. Reciprocal comparisons between practical value and the value of hybrid-average

Finally, the summarized data of comparative relations were calculated and discussed about the several characters viewed from reciprocal standpoints, and are shown in Table 7.
Comparisons between parental value and value of hybrid (A column): To make clear the relations between parents and the respective strain-averages, the differences between them were compared, and shown in Tables 7 and 8 of the previous paper[26]. These data were summarized here for grouping methods. In these calculations, the following marks were used; + — value of hybrid-average in the respective characters was larger than those of the respective pure-line-strain, — — it

Table 7. Summarizing data in several viewpoints for grouping methods; A and B — reciprocal relations of comparative values found in 33 characters, C — significant relations found in 34 characters, D — significant relations found in 24 combinations of plant morphology (upper column) and grain morphology (lower column), and E — total values of the data shown in D column

			indica	*intermediate*	*japonica*	Whole strains
A	Female	+	18.25±3.19	21.75±2.86	23.50±2.69	20.44±3.76
		−	13.50±2.87	12.25±3.96	9.25±1.92	12.13±3.46
		=	1.63±1.22	1.75±1.48	1.75±1.48	1.69±1.36
	Male	+	16.88±2.93	17.50±4.15	19.50±2.96	17.69±3.46
		−	12.00±2.40	12.25±2.49	10.00±2.55	11.56±2.62
		=	3.75±1.56	0.50±0.50	2.00±1.00	2.50±1.84
	Whole	+	35.13±5.69	39.25±5.12	43.00±5.24	38.13±6.35
		−	25.50±4.77	24.50±6.23	19.25±3.49	23.69±5.55
		=	5.13±1.54	2.25±1.79	3.75±2.39	4.06±2.19
B		++	15.38±3.08	16.50±3.04	17.75±4.49	16.25±3.61
		−−	10.88±2.89	9.25±3.77	6.50±1.50	9.38±3.39
		==	0.88±0.78	0.25±0.43	0.25±0.43	0.56±0.70
		Total	27.13±2.42	26.00±3.74	24.50±4.72	26.19±3.63
C			12.75±4.35	12.25±3.03	13.25±1.48	12.75±3.53
D			11.75±2.33	13.25±2.39	10.75±1.48	11.88±2.34
			18.50±1.23	17.50±1.12	18.00±1.00	17.50±2.50
E			30.25±2.63	30.75±2.77	28.75±2.39	30.00±2.72

was smaller than those of the respective pure-line-strain, = — it was same as those of the respective pure-line-strain, respectively. For example, panicle lengths of strain No. 1 (♀), when it was used for crossing, and of strain No. 1, when it was used for the parent, were 25.6 cm and 24.3 cm, respectively. So, this relation was illustrated as +. These calculations were done through 33 characters (excluding 1 character from the whole, *i.e.*, character No. 2 = crossability). These relations were accumulated for the respective groups, *i.e.*, *indica* (strain Nos. 1, 3, 4, 5, 8, 13, 14 and 15), *intermediate* (Nos. 9, 10, 11 and 16), *japonica* (Nos. 2, 6, 7 and 12) and the whole strains. For example, + marks were found as 19, 19, 15, 18, 23, 21, 19 and 12 in strain Nos. 1, 3, 4, 5, 8, 13, 14 and 15, respectively, in view of the female for *indica* group. These average value and its s.d. through the 8 strains were found to be 18.25±3.19. Such calculations were done for 3 groups by dividing the female, the male and the total, and are shown in column A of Table 7.

In the female, average values were found in the order of *japonica*>*intermediate*>*indica* for + marks, *indica*>*intermediate*>*japonica* for — marks, and *intermediate*=*japonica*>*indica* for = marks. In the male, average values were found in the order of *japonica*>*intermediate*>*indica* for + marks, *intermediate*>*indica*>*japonica* for — marks, and *indica*>*japonica*>*intermediate* for = marks. In the whole strains, average values were found in the order of *japonica*>*intermediate* >*indica* for + marks, *indica*>*intermediate*>*japonica* for — marks, and *indica*>*japonica*>*intermediate* for = marks.

In comparisons of the female and the male, it was clear that number of + and — marks were more larger in the female than those of the male through the whole groups. Most of the values of *intermediate* group were ascertained to be intermediate between *indica* and *japonica* groups.

Comparison of homogeneous combinations (B column): To make clear the reciprocal relations in these senses, combinations of the female and the male parents were calculated. + (♀) and + (♂) combinations are shown as ++ marks. They may be divided into 2 groups, *i.e.*, homogeneous and heterogeneous groups. The homogeneous combinations meant ++, —— and == ones. The heterogeneous combinations meant +—, +=, —+, —=, =+ and =— ones. The former was picked up here. For example, ++ combinations were found as 15, 19, 15, 13, 19, 17, 16 and 9 in strain Nos. 1, 3, 4, 5, 8, 13, 14 and 15, respectively, in view of the female for *indica* group. These avergage value and its s.d. through the 8 strains were found to be 15.38±3.08. Such calculations were done for 3 groups by dividing them into the female, the male and the total, and are shown in column B of Table 7.

In ++ combinations, average values were found in the order of *japonica*>*intermediate*>*indica*. In —— combinations, the reversed results were found. In == combinations, average values were found in the order of *indica*>*intermediate*=*japonica*. In the total, the order was the same as in case of —— combinations. Most of the values of *intermediate* group were ascertained to be in an intermediate status between *indica* and *japonica* groups.

Significant relations in the respective characters (C column): The reciprocal relations of 34 characters measured were summarized in view of significant levels, and are shown in Table 2 of the previous paper[26]. In the whole strain level, 22/34 characters, *i.e.*, 64.7% of them, showed positive significances. Generally speaking, the larger is the value of the female, the larger is the value of the male.

In this chapter, these data were re-arranged in 3 groups. For example, significant relations were found as 11, 17, 13, 10, 9, 16, 20 and 6 in strain Nos. 1, 3, 4, 5, 8, 13, 14 and 15, respectively, concerning *indica* group. These average value and its s.d. through the 8 strains were found to be 12.75±4.35. Such calculations were done for 3 groups, and are shown in column C of Table 7.

Average values were found in the order of *japonica*>*indica*>*intermediate* groups.

5. Significant relations found in 24 combinations

Significant relations in the two respective characters (D and E columns): Relations of 47 combinations measured were summarized in view of the significant levels, and are shown in Tables 4 and 5 of the previous paper[26]. Character No. 2 to No. 18 (mainly plant morphology) and No. 20 to No. 38 (only grain morphology) were used in Table 4 and Table 5, respectively.

In this chapter, these data of Table 4 in the previous paper were re-arranged in 3 groups. For example, significant relations were found as 13, 11, 12, 12, 9, 8, 16 and 13 in strain Nos. 1, 3, 4, 5, 8, 13, 14 and 15, respectively, concerning *indica* group. These average value and its s.d. through the 8 strains were found to be 11.75±2.33. Such calculations were done for 3 groups, and are shown in upper column D of Table 7. Average values were found in the order of *intermediate*>*indica*>*japonica* groups.

Nextly, these data of Table 5 in the previous paper were re-arranged for 3 groups. For example, significant relations were found as 17, 19, 17, 19, 17, 20, 19 and 20 in strain Nos. 1, 3, 4, 5, 8, 13, 14 and 15, respectively, in *indica* group. These average value and its s.d. through the 8 strains were found to be 18.50±1.23. Such calculations were done for 3 groups, and are shown in lower column D of Table 7. Average values were found in the order of *indica*>*japonica*>*intermediate* groups.

In comparison of the upper and the lower columns, it was noted that the values found in the lower column (grain morphology) were clearly larger than those of the upper column (plant morphology) through 3 groups and the whole strains. Moreover, the values shown by *intermediate* group were the largest in the upper column (plant morphology), but were the smallest in the lower column (grain morphology) in 3 groups, respectively.

The data shown by the upper and the lower D column were accumulated. For example, significant relations were found as 30, 30, 29, 31, 26, 28, 35 and 33 in strain Nos. 1, 3, 4, 5, 8, 13, 14 and 15, respectively, in *indica* group. These average value and its s.d. through the 8 strains were found to be 30.25±2.63. Such calculations were done in 3 groups, and are shown in column E of Table 7. Average values were found in the order of *intermediate*>*indica*>*japonica* groups.

Discussion

Basing on the results obtained in the present experiment-series and the data of other workers, the following problems are to be discussed here, in views of methodology, character check, strain- or variety-specificity, grouping and origin of rice.

1. Diallel cross method: The diallel cross of the preliminarily selected plant materials is rarely used in the practical breeding. For a final testing of the limited number of selected plants which is to be carried out with the aim of forming the basis of a new synthetic varieties or a hybrid, however, the diallel method is very useful not only in agronomic meanings[6,8,17,40], but also in chemical components[1,37], or for other purposes[7,8,41]. In other viewpoints, the use of the diallel cross as an aid in the breeding of outbreeding crop species is considered from two aspects[10]. Firstly, for the strategic survey of populations as the initial material of a breeding program, and secondly for the tactical assessment of the genetic relationships of elite selected genotypes. Comparisons with alternative procedures indicate that the diallel cross scheme is generally only applicable at the occasion where dominance and gene interaction are likely to be of importance. The early forms of

diallel analysis devised by Jinks and Haymann (1953)[12] were for inbred lines and to be valid a number of assumptions had to met which included diploid segregation, homozygous parents, no reciprocal differences, no epistasis, no multiple alleles and uncorrelated gene distribution.

Many works have studied the efficiency of partial diallel in compaison with full diallel in self- and cross-pollinated crops[35]. An effort is made to compare the diallel and partial diallel analyses for the quality components, fitness and grain yield in some varieties of sorghum, differing in grain quality and panicle shape[8].

Haymann[9] stated that at least ten parents should be used for a reasonably accurate estimation of the components of variation. On the other hand, the inferences regarding the optimum number of crosses per parent which has enabled the estimates of different components of genetic variation, and the yield potential and general combining abilities of the lines tested, varied from study to study[8]. However, in general, it was concluded that precision of estimates to be influenced by the nature and magnitude of genetic variability presenting in addition to the value of crosses. Use of the modified diallel analysis for evaluating the progress from recurrent selection may be limited to the populations that have large and effective population sizes and have undergone a large number of cycles of selection[40]. Owing to these informations, diallel cross was reasonably employed in this experiment-series.

2. Reciprocal differences: Most of the earlier studies provide information regarding the comparison of designs in diallel without reciprocals, basing on the assumption that no reciprocal difference exists. However, it is to be seen whether reciprocal differences due to maternal effects, if present, create any disturbance in the precision of the estimates of genetic parameters in the partial diallel as compared to full diallel[8]. It is generally accepted that maternal influence has been indicated in the case of grain weight, protein content and amylose levels, largely because the endosperm is triploid tissue[4].

It has been reported that the reciprocal hybrids are not significantly different in rice[30] and in *Hibiscus* sp.[41]. On the other hand, remarkable differences in the reciprocal hybrids were reported in rice[43], and a considerable amount of cytoplasmic inheritance was held in also rice[39]. In the present series, some combinations showed negative value[25,26]. However, no remarkable significant differences were generally shown[24], especially in affinity-groups[17]. Then, it was concluded that reciprocal differences suggested no considerable cytoplasmic and/or maternal inheritance in these experiment-series.

3. Heterosis: The superiority of F_1 hybrids was estimated on the basis of heterosis, which was illustrated by the mean increase of F_1 hybrids over the mid-parental value (MP) of plants as might be seen in tobacco[32], grain sorghum[44], wheat[1] and rice[24,25,33], and on heterobeltiosis, which was illustrated by the mean increase of F_1 hybrids over the high parent value (HP)[3,5]. In this connection, for example, comparisons of parents and strain-averages were made[26]. Character Nos. 7, 8, 9, 10 and 12, *i.e.*, agronomic characters, showed a significant heterosis or a superdominance in disregard of the varietal status. This phenomenon proposed a problem of great interest concerning the strain differentiations and agricultural development.

Jennings reported[11], basing on data from diallel crosses, that the results suggested strongly a consistent heterotic expression of earliness and/or a dominance of genes for earliness in distantly related non-photoperiodic hybrids. In the previous experiment[18], however, somewhat different results were obtained. Growing periods of No. 13, No. 13 (♀)×No. 8 (♂), No. 13×No. 11 and No. 13×No. 15 were found to be 138.0, 158.0 158.0 and 158.0, respectively. Most of the hybrids, when No. 13 was used as the female parent, showed superdominant phenomena. Nearly the same phenomenon was found in No. 14. On the other hand, No. 11 showed no considerable superdominance at all. Accordingly, it may be concluded that a heterotic expression and/or a dominance of genes in growing period was assumed to be responsible both for earliness and lateness in strain by strain. Through the whole characters used, heterosis was remarkably ascertained, especially in the awn length[20].

In other viewpoints, heteroses were found on weight on unhusked grains in the hybrids, when No. 1 was used as the male parent. However, those were not remarkably found in the hybrids, when No. 1 was used as the female parent[19]. These phenomena were ascertained in several characters[20,22,24]. Then, it was concluded that heteroses or superdominances may be exhibited to some extent by different patterns within the reciprocal relationships.

During the whole series, superiorities of hybrids, *i.e.*, heteroses or heterobeltioses, were recognized in 57.8% (=610/1,056 cases) in comparison with the values found in the parents and the respective strain averages.

On the other hand, character Nos. 3 and 4, *i.e.*, affinity characters, showed significant hybrid weakness, in disregard of varietal status. These phenomena may duely be attributed to the environmental conditions.

The average values of hybrid in the parental level (the former) were sometimes larger than that of the respective parent (the latter) in several characters. For example, 3 characters (length, width and thickness) of husked grains showed larger values in the former than that in the latter, but the other 3 characters (L/W, L/T and W/T) showed the smaller values in the former than that of the latter[21]. It may be concluded that the respective characters were exhibited independently of the each character, and would be used as index for strain differentiations.

4. Differences for the whole strains and for the testers: In this experiment-series, comparisons of the values for the whole strains and for the testers were done by using the differences between the maximum and the minimum values of the respective characters for the whole strains and for the testers. In these calculations, several points were ascertained in views of the strain or variety differentiations.

i] In the almost cases, the values in case of the whole were found to be larger than of the testers, which were fixed to be of reasonable phenomena. In some cases, however, the values in case of the whole were found to be nearly the same as that of the testers[22]. The latter case may duely be considered to be results of the combination-effects, in which both the extreme values were shown in the testers used. Moreover, the latter case may be used as indices of strain differentiations and/or as mark strains for analysing variety-grouping.

ii] To make clear the relations between Sikkimese rice and two testers, the differences in the respective characters at the time when two testers were crossed with Sikkimese rice and its reciprocals were calculated. Most of the calculations were done under the condition, provided that the calculation was made only by the absolute value in disregard of positive or negative directions. If the calculations were made separately for negative and positive values, the states of affairs may be shown remarkably in contract with existing tendencies, because negative values, in general, were ascertained larger than those of the positive values. Viewed from another angle, these differences were larger than that of the practical value, and remarkable differentiations might be fixed in these tendencies[26]. By these new methods, one can distinguish and classify the materials as a *indica-of-center* strain or a *japonica-of-center* strain, etc.

iii] The differences in the respective characters for *indica* and *japonica* were, in general, smaller in the female parent than those in the male parent[19,21,24]. These phenomena were left inexplicable in the present time. It may be assumed that the male (=pollen) was more responsible than in the female (=ovule) for the environmental conditions and was said to have had unstable characters.

5. Correlation relationships: Abundant relations between the respective characters, *i.e.*, practical value, standard deviations, ranges, differences between the maximum and the minimum for the whole strains and for the testers, were analysed, basing on c.c. and l.r. calculated. Most of the relations showed the positive values through the whole characters. During the whole series, the whole strain level and the respective strain level showed positive significant relations in 64.7% (=22/34 cases) and 37.5% (=204/544 cases), respectively, in the reciprocal relations of 34 characters. In the two respective characters of 47 combinations, the whole strain level and the respective strain level showed positive significant relations in 85.1% (=40/47 combinations) and 63.8% (=480/752 cases), respectively. It may be said that positive correlation meant intimate terms with each other and showed evidence as a proof of stability both on the respective characters.

On the other hand, there were negative correlations on some extent. For example, No. 3 (Addey variety) showed very high negative relations in crossability. Average crossabilities were found to be 46.7% and 27.4% in the female and the male, respectively. These phenomena were explained as strain specificity. During the whole series, the whole strain level and the respective strain level showed negative significant relations in 0.0% and 1.2% (=6/544 cases), respectively, in the reciprocal relations of 34 characters. In the two respective characters of 47 combinations, the whole strain level and the respective strain level showed negative significant relations in 10.6% (=5/47) combinations) and 5.9% (=44/752 combinations), respectively. It may be said that negative correlations meant maternal effect, cytoplasmic inheritance on some extent, and antagonistic characters from each other.

In a stricter sense, it may be concluded that the reciprocal differences found in this series suggested no considerable inheritance, basing on the data obtained through this experiment-series.

6. Strain or variety specificities: In views of the strain or variety specificities, several distinctive features were ascertained.

i] Grain lengths of Tapachini variety (strain No. 12) were shown the values larger than of the average in the whole combinations in case of the female parent, but smaller than that in case of the male parent[21]. These tendencies were found in both the unhusked and husked grains, and may be seen as variety specificity. Generally speaking, however, the larger is the one noted at the time when the strain was used as the female parent, the larger is it noted at the time when the strain was used as the male parent.

ii] Strain specificities were frequently found in the respective characters, which was illustrated by a diagonal. For example, hybrid plants, which was made by No. 15 (♀)×No. 16 (♂), were distributed on relatively large portions both in two characters by a diagonal. On the contrary, hybrid plants, which was made by No. 10 (♀)×No. 5 (♂), were distributed on relatively large portion in one character and on relatively small portion in another character. These phenomena were ascertained in mutual characters and in reciprocal relations.

From the data of reciprocal relations, it was clearly ascertained that some sets of combinations were always observed to have been constantly disordered from the standard pattern to be set in exceptional regions for several characters[20]. These tendencies were found in numerous combinations through the whole characters, for example, No. 8 (♀)×No. 2 (♂), No. 8×No. 13, in comparison-characters[22]. It was said that these phenomena could be seen as strain specificities of No. 8. The strains, in which some sets of combinations showed such tendencies, showed, in general, no significance in strain level. However, in view of the summing-up data, it was said that strains were differentiated into two directions, *i.e.*, slip-out and significant combinations, and slip-out and non-significant combinations. These findings proposed an interesting problem for strain or variety specificities.

iii] In this experiment-series, most of the materials were picked out from 68 strains collected at Sikkim[28]. For analysing strain differentiations, samples, which are called as *aus*, *aman*, *boro*, *tjereh*, *bulu*, should be used. Experiments which used these materials are looked upon as having had very important meanings in views of cropping seasons, geographical situations, historical fact, and further studies are performed sincerely.

7. Evaluation of characters used: On the traits of the characters used, detailed evaluations should be discussed separately on the respective characters and character-combinations.

i] Phenol reaction: Kihara *et al.*[28] reported *indica* and *japonica* types in Sikkim rice based on the examination of morphological characters, phenol reaction and seed fertilities. They had found three types, *i.e.*, phenol positive (=*indica*), phenol negative (=*japonica*) and mixed ones. Basing on these phenomena, which had been reported by many workers, phenol reaction could not be used in view of definite conclusion for distinguishing strain differentiations.

ii] Crossability: Crossabilities are said to be relatively affected by environmental conditions. Then, the crossability was placed on more disadvantageously for testing the characters of variety differentiation than pollen and seed fertilities. However, some considerations were drawn basing on the data obtained. Some strain has been said to have always genetically low crossability. Low crossability may be noted in two meanings[17]; the one is to interpolate it as the specific character of the strain, which is due to gene action, and the other is to regard it as a behaviour of opening fertile glumes. The latter was supported by the following feature that some strain opened immediately its lemma and palea during the emasculation in hot water (strain No. 15). Such floret was made wet with hot water during the emasculation and then this opening behaviour may be placed disadvantageously for the following pollination.

iii] Pollen and seed fertilities: All the six anthers forming an apparently normal floret of each plant were used to make a slide for microscopic observation. Three countings of pollen grains counting more than 500 each were made from different areas of the mount. The pollen grains observed were stained in iodine-potassium iodine solution by ordinary method. The pollen fertility-count was recorded as the percentage of the pollen grains stained to the whole pollen grains counted, provided that the counting was made only by the staining pattern in disregard of pollen sizes[17] In some combinations, pollens were mixed by the large and the small ones, which were thoroughly stained. Mixed apparatuses, which were constituted by the large and the small pollens, for the respective parents in view of the female parent were found as follows in the order from No. 1 to No. 16 in the whole combinations (=15 each); 5, 8, 9, 3, 7, 4, 8, 1, 2, 4, 1, 1, 3, 2, 1 and 0, respectively. The average and its s.d. of these through the whole strains were found to be 3.69 ± 2.92. Those values in view of the male parent were as follows in the same order; 3, 8, 5, 1, 2, 1, 4, 5, 4, 8, 3, 2, 1, 2, 6 and 4, respectively. The average and its s.d. through the whole strains were found to be 3.69 ± 2.27. Those values in view of the both sexes were as follows in the same order; 8, 16, 14, 4, 9, 5, 12, 6, 6, 12, 4, 3, 4, 4, 7 and 4, respectively. The average and its s.d through the whole strains were found to be 7.38 ± 4.08. Mode was found in 4 (5 strains). It may be noted that the value was peculiarly large in No. 2. In the total, 59/240 combinations, *i.e.*, 24.6% of them, showed mixed apparatuses. It does not necessarily follow that combination having mixed apparatuses shows lower pollen fertility than others. These phenomena were left inexplicable in the present time.

Jennings[11] stated that pollen fertilities ranged from 2 to 100 percent, using many varieties. The figures in the data obtained in this experiment were clearly higher in the lowest value than that of the his data. The differences found here may be partially due to the differences of the varieties used. It does not again necessarily follow that the strain or combination having mixed apparatuses in its size shows low seed fertility. No further consideration was intended here, as no accurate counting of each size and count of percentage were made here.

Since intervarietal F_1 hybrid sterility frequently occurs in varieties coming from the same geographical area, a large number of crosses must be studied to assess the extent of heterobeltiosis and to identify highly fertile cross combinations[3)].

Pollen and spikelet sterility in partially sterile F_1 hybrids is affected considerably by environment[11)]. Because the plants were grown under controlled greenhouse in the present experiments, the environmental influence may be looked upon as negligible. In the stricter sense, however, some factors, such as day length, light intensity, humidity, may possibly affect on partial sterilities and occurrence of mixed apparatuses.

iv] Growing period: Growing period of Nos. 1, 2 and 12 were shown as extremely shorter than those of other 13 strains in view of parental plants. These 3 strains were ascertained as photoperiodic insensitive[13,18)]. However, average values in the hybrid-averages were shown as extremely shorter in No. 2 than those of the remaining 2 strains. From these actual facts, it may be concluded that gene actions of No. 2, which express for the earliness of growing period, contributed stronger than those of the remaining 2 strains. The following phenomena, moreover, substantiated the fact mentioned above. In combinations, in which No. 2 was used as the female parent, 13/15 combinations, *i.e.*, 86.7% of the whole, showed the minimum values through the respective longitudinal columns[18)]. In combinations, in which No. 2 was used as the male parent, 12/15 combinations, *i.e.*, 80.0% of the whole, showed the minimum values through the horizontal columns.

In diallel experiments of linseed (*Linum usitatissimum* LINN.), days to flowering were found to be under the control of additive gene effects[29)]. They had found the following facts too, that there was partial dominance for days to flower and complete dominance to overdominance for days to maturity; heritability estimates were high for days to flowering and moderate for days to maturity; lateness was dominant over earliness. Though progeny tests had not been made in the present experiments, the data obtained here could be agreed with the results mentioned above.

v] Plant morphology: Six characters were adopted as the plant morphological viewpoints in this experiment-series. In addition to these, number of panicles per plant and number of seeds per plant were also calculated. However, these two characters were omitted for describing in detail, because these values were considered to be biologically less secure and significant than the six characters used, and moreover were ascertained to be very flexible in accordance with the environmental conditions.

Some characters of plant morphology, *i.e.*, ligule length, ligule width and ligule thickness, auricle shape, thickness of culm, angle of leaf blade, leaf color, might be useful characters for analysing strain differentiations. These problems are remained in the future study.

vi] Grain morphology: Awns were found more or less in 143 cases from 240 combinations, *i.e.*, 59.6% of the whole. The differences in awn length were confirmed to be very large in accordance with each set of combinations. Measurement of awn length was very difficult in some cases, because awn was easy to be broken in some case and was very short in another case. So, intensive discussion regarding awn feature is looked upon as nonsense, bioligically.

Red grain color was found almost in 114 cases from 240 combinations, *i.e.*, 47.5% of the whole. In 108 combinations, in which cross was made, using parental strain showing approximately red color for one parent, only 3 combinations showed white color. No segregation into red and white colors was found in the respective combinations. According to these phenomena, it may be concluded that gene for red color was fixed to be dominant over white color.

In the early forms for analysing strain differentiations, length, width and L/W of grains are generally used. In this experiment-series, 24 characters on the grain morphology were adopted. Several interesting problems were revealed.

As pointed by Matsuo[31)], length and width characters are relatively not to be affected by environmental conditions, showing the stable values. In hybrid plants, these facts were also found to be true to some extent. In general, the larger is the value in unhusked grains, the larger is the value in husked grains. In other words, these characters were looked upon of genetically stable status. However, in a stricter sense, some particular features were differently ascertained case by case. At first, relations between L and W showed negative values in several combinations[26)]. It may be assumed that L and W were related to opposite status. Nextly, comparative studies of data reported in comparison category (character Nos. 27–32) have been looked upon as one of the most important characters for ecotypic differentiation in view of evolution. This character means biologically or agronomically the "grain fullness" in its capacity. In evolutional and agronomical viewpoints, it may be said that the larger is the ratio of husked to unhusked grains in the respective characters, the more advanced is the evolutional state of the respective strains.

Before starting this experiment-series, it is not clear whether characters of L/W, L/T, W/T, area and volume of grains could be used for analysing strain differentiations or not[20)]. At the present, however, it may be said that these characters might be looked upon as useful ones and having sort of universal validities as one of the indices for examining strain differentiations in this species at least. Two actual samples are to be mentioned here. In view of L/W, Nos. 12 and 15 showed relatively large values in the differences from the testers, when they were used both as the female and as the male parents[21)]. Nos. 5 and 10 showed the reversed results. It meant clear patterns of strain differentiation. In view of L/T, the relations between the values of respective strain and average in the whole strains were quite the same as the connections, which were checked in the L/W. These patterns were, in general, ascertained both in unhusked and husked grains. As some discrepancies were found[20)], strict conclusion has left several questions, further analysis may be performed sincerely.

In conclusion, these ratio-characters were also recongized as useful procedures for analysing strain differentiations. In addtion to these facts, it was said that these analysing methods were noted as new departures and useful indices in the testing of the strain relationships and to be recommendable ones in the future.

8. Judgement of utility values: On the characters and techniques used in this experiment-series, judgements of utility values of the respective items should be done in the order to estimate and to choose them looking to the future, *i.e.*, useful or unuseful, suitable or unsuitable, stable or unstable, and easy or uneasy.

i] Practical value: In this experiment-series, 38 practical characters were used, in which one of the author's aim was consistently to study in the hope of getting useful informations on analysing methods. Numerous noteworty meanings were shown. In the miscellaneous characters[25)] and and mutual relations[26)], unhusked and husked grains showed universal validities through the whole series, but comparison categories (character Nos. 27–32) showed universal validities in some cases and did not show it in other cases.

Growing periods of Nos. 1, 2 and 12 (photoperiodic insensitive) and the remaining 13 strains (photoperiodic sensitive) were ascertained to be composed very short and long terms, respectively.

It might be taken into consideration that growing period of the latter changes in accordance with the cultivating conditions.

ii] S.d.: In the unhusked and husked grains, s.d. of No. 15 showed larger values in the female than those in the male. This phenomenon was looked upon as one of the strain specificities. In wild rice[23], the thicker is the thickness of unhusked and husked grains, the smaller is the s.d. It is a very interesting and important subject on the genetic background of its strain, whether this strain has still differentiation-possibility or has already been driven on to the deadlock on the evolutional view point.

Practical values of hybrid-average were sometimes larger than those of the respective parents for several characters[20,22]. In view of the s.d., however, it does not necessarily follow that the values of the practical value were larger than that of the respective parental plants.

Average value and its s.d. of L/W (female) of No. 11 were found to be 2.20 ± 0.13[21]. The value (2.20) showed nearly the maximum through the whole strains (=16), but value (0.13) showed nearly the minimum through the whole strains. Average value and its s.d. of L/T (male) of No. 14, however, were found to be 2.82 ± 0.45. The value (2.82) showed nearly the minimum through the whole strains, but value (0.45) showed nearly the maximum through the whole strains. The results of those were looked upon as reversed phenomena, which might be fixed to have been differentiated on the affinity and/or of grade in homozygosity.

iii] Range: Because this character was firstly used in this experiment-series, clear tendency was not unfortunately found in comparison with other characters at the present time. The following facts might be seen only as preliminary assumptions. In some cases, ranges were found always larger in the male than those in the female. In other cases, ranges were always found to be very small. In another case, ranges of the parent were found larger than those of the hybrid-averages, but they were always smaller than those of the hybrid-averages in other case. Suffice it to say that there is possibility of the further investigation in this character.

iv] Correlation coefficient: Several correlation coefficients were counted in this experiment-series. Ratios of significant to non-significant relations were changeable in accordance with the respective characters and character-combinations.

The second terms of l.r. of W/T showed negative direction through the whole strains[22]. Those of T showed positive direction through the whole strains. At the present time, it was not clear how to explain these phenomena, but it was looked upon as one of the character specificities.

In significant relations with 2 respective characters, the following facts were ascertained[26]. It was clearly confirmed that combinations of grain characters showed more remarkable significances than those of the plant morphology. This phenomena suggested the stabilities of the respective characters.

v] Sets of grain morphology: Concerning the relations between the corresponding characters, *i.e.*, 6 sets of grain morphology, largeness of values were compared with each other in view of the female and the male parents, and in view of the whole hybrid-averages, and some noteworthy features were ascertained[26]. For example, the relations of L/W vs. L/T and W vs. T; L/T vs. W/T and L vs. W; and L vs. T and L/W vs. W/T; belonged to the large, the middle and the small significant groups, respectively. So, it was ascertained that the comparing methods using those sets were useful indices for analysing the strain differentiations.

vi] ++, −−, ==, etc.: To make clear the relations between parents and the respective strain-averages, the differences between them were compared. These analysing techniques were firstly adopted in this experiment-series. In this category, + mark meant that the value of hybrid-average in the respective characters was larger than that of the respective pure-line strain. Moreover, these calculations were combined with the female and the male[26]. Character Nos. 7, 8, 9, 10, 12, and Nos. 3 and 4 showed + + marks and — — marks in the most strains, respectively. These phenomena proposed quite interesting problems concerning the heterosis, heterobeltiosis, hybrid weakness, strain differentiations and breeding programs.

vii] Stability: During the experiments, numerous columns were discussed in views of the stability and suitability of the respective characters and combinations. For example[26], in the 6 sets of grain morphology, L and L/W characters showed significances in 85.3% of the whole. Concerning the corresponding character sets, these 2 sets might be looked upon as the indices, which are more stable and suitable ones than the remaining 4 sets. In a stricter sense, character sets of the unhusked and husked grains showed significant relations through the whole components, but in comparison-column it showed no significance at all. So, it was concluded that the former 2 sets might be regarded as the stable and suitable indices for analysing strain- or variety-differentiations.

It is dangerous to jump at a conclusion, however, that the more stable is the character value, the more suitable is the utility values. It might be true that unstable characters are more suitable than the stable ones owing to its flexibilities.

viii] Unused characters: Some characters and character-sets or-combinations, *i.e.*, ligule length, combinations of plant height and fertility, culm length and crossability, etc., were not adopted in this experiment-series. These problems are remained in the future experiment.

ix] Promising: Ranges of the practical values and its s.d. in the strain level for 34 characters were counted separately for the female and the male sexes. However, it is possible to calculate c.c. and l.r. of both sexes within practical value, within s.d. and in comparison of these.

In the future, it should be expected and recommended to make a comprehensive table of utility values in view of the respective characters and character sets.

9. Grouping of strains: The grouping of the 16 strains used were thrice attempted, basing on the data obtained on crossability, pollen and seed fertilities[17]. At first, the grouping was made only in reference to pollen fertility, and 16 strains were divided into 2 groups, *indica* and *japonica*. Some strains, however, showed always relatively high or low affinities for common varieties. At second, 3 strains were found to be of *intermediate* type between *indica* and *japonica* types. This classification may be regarded as useful, but has not been ascertained enough to be recommended. The third grouping was made, using about 40 characters. By these methods, intra-fertile and inter-semi-sterile groups were considerably recognized. Then, this re-classification would be recommendable than that of the former 2 classifications.

In the present paper, the third classification was adopted, basing on the reason mentioned above. Reasonable results were expectedly ascertained to some extent.

Kato *et al.*[27] had pointed out already the existence continuous variations through the whole strains collected from several localities of the world. However, it does not necessarily follow that strain or variety differentiations do not exist in rice plants at the present time. In comparison with parental values and hybrid-averages, +, − and = marks were recorded as 57.8%, 35.9% and 6.3%, respectively[26]. These phenomena suggested considerable differentiations during the processes of geographical distributions of rices. Moreover, strains classified into *japonica* group showed + marks, *i.e.*, superdominance through the whole columns. In other words, they have fundamentally been supplied with predisposition of considerable heteroses.

In view of varietal and geographical points, several issues had be drawn, basing on the data shown during this experiment-series. Varieties belonging to Lama (strain Nos. 4 and 5), Fudangay

(Nos. 13 and 14) and Champasari (No. 15) were classified as *indica* group, and varieties belonging to Tokmor Zo (Nos. 6 and 7) and Tapachini (No. 12) were classified as *japonica* group. On the other hand, varieties belonging to Addey were segregating to *indica* (Nos. 3 and 8) and *intermediate* (Nos. 9, 10, 11 and 16) types. Kihara *et al.*[28] stated that Addey is the most important and popular rice in the mid-altitude of Sikkim and belongs to *Aman* group. So, segregation of Addey variety found here was explained to have had long history, evolving through environmental reasons and human selection into several types having many economic traits of primary interest to rice farmers and breeders. Varieties belonging to *indica* were more abundant than *japonica*. This finding was fitted for the previous paper[28], in which it was said that most of rice varieties in Sikkim belong to *indica* and nearly one tenth of which belongs to *japonica*. Champasari varieties were seen sporadically being cultivated in Sikkim[28]. Other varietal relations were not explained in detail, so far as the analysis was made, using only the data obtained in the experiment-series.

On the data obtained here in *intermediate* type, however, some strains were looked upon *javanica* type in accordance with grain shape and plant morphology. If it were true, not only *indica* and *japonica* types, but also *javanica* type had been gone to have developed in Himalayan areas within the bounds of possibility. In other words, it might have been said that the varietal differentiation in the large scale may have extensively and continuously occurred in these regions for so-called *indica*, *japonica* and *javanica* types.

Referring to the grouping methods, other analytical techniques between the respective groups, *i.e.*, t-test, standard errors, etc., were left inexplicable in the present time.

10. Origin of rice: Chang[2] and Nayar[36] have extensively reviewed the literatures pertaining to the origin and cytogenetics of rice. The origin of rice has been speculated upon from early times, but it is only since about 1950 that cytogenetic work has been taken up in this direction. Later it will be dealt with under the following aspects; time and place or origin, taxonomy of wild rices, progenitor of rice, and mode of speciation.

Progression from wild to cultivated rice was achieved by several speciations, *i.e.*, a reduction of size and alteration of receptacle shape, the shortening of awns, decrease of shedding degree, etc. These procedures were, however, left inexplicable in the present time, because the works, in which mapping of distributions and analyses of wild rice in the world might be extensively done, were looked upon to be of incomplete and be far from its ideal.

Rice has had a diffuse origin both in space and time. Several centers of origin have been proposed for Asian rice, in which northeast foothills of the Himalayas are known to show much varietal variations. The difficulties resulting from considering centers of diversity straightly as centers of origin are well known by many workers. With the ancestral species present in its original habit in all these origins of variability and with the knowledge that this species is found good enough even today for harvesting, the changeover from rice gathering to rice cultivation could have been attempted in each of these regions and at various ages.

Subspeciations of rice have been attempted by many workers. There was some interest in the 1950s to study the nature and inheritance of sterility in inter-racial hybrids, mainly because of the availability of a large amount of experimental materials from an international rice hybridization project operated by FAO for south and southeast Asian countries for developing varieties combining desirable features of different races. There are two broad lines of opinion on the nature of specific differentiations, *i.e.*, chromosomal and genic backgrounds.

It has been indicated already that *O. sativa* may have evolved through disruptive selection, and that the origin was most probably diffuse both in a spatial and a temporal sense[36]. Evolution might have resulted in the formation of only one dominant ecotype or race in some areas of origin case by case and year by year. Whereas, in some other regions where more than one varietal group or ecotype coexist, each adapted itself to different conditions of photoperiod[13] and land type. This ecotypic differentiation could have come from the accumulation of gene mutations affecting perhaps primarily there physiological characteristics such as themo- and photoperiodic-responses, which were constituted by numerous small character-groups[14].

Summary

In order to confirm the classification of rice varieties, *Oryza sativa* L., as well as to clarify the relationships between them, and to ascertain the characters and techniques having universal validity for analysing the strain or variety differentiations, 14 strains of Sikkimese rice varieties and one type of *indica* and another one type of *japonica* were picked up (Table 1), and diallel crosses were carried out, constituting 240 combinations. Through the experiment-series, 38 characters were adopted (Table 2). The main results obtained in this paper were summarized as follows:

Basing on the results obtained during the previous papers, the materials were divided into 3 groups, *i.e., indica, intermediate* and *japonica* types. At the first, average values of the 33 characters in parental level of pure-lines were compared in views of practical value and its s.d. Superdominance, inferior and mid-parent patterns were found in several strains. At the second, average values of the 34 characters in parental level of hybrid plants were calculated in view of practical values in the female and the male parents. Several noteworthy features were ascertained in some characters. At the third, average values of the 34 characters in 9 hybrid-combination-groups were compared in views of homogenous and heterogenous groups. At the fourth, reciprocal comparisons of practical values with the value of hybrid-averages were done. During these 4 experiments, numerous valuable informations were ascertained in view of strain and variety differentiations.

Through the experiment-series, the following problems were widely discussed, *i.e.*, methodology, reciprocal differences, heterosis, comparison of parental and hybrid plants, differences for the whole strains and for the testers, correlation relationships, strain or variety speciations, evalutation of characters, judgement of utility values, grouping of strains and origin of rice. In broad outline, the following conclusions might be said. Diallel cross method was convenient and quite useful for testing species, variety and strain differentiations. Though the various "intermediate types" or "continuous variations" have been found in the experiments, using various materials widely distributed in many countries, the varieties or strains of the world might be divided into a few groups on some extent.

Varietal differentiations might have been occurred in the Indian sub-continent, particularly in Sikkim and its suburbs.

Characters used here (=38), character-combinations and analysing techniques could be separately and individually judged as stable or unstable, suitable or unsuitable, useful or unuseful, and easy or uneasy, for testing variety differentiations, and several valuable items were drawn out.

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