Varietal Screening of Compatibility Types Revealed in F₁ Fertility of Distant Crosses in Rice

Hiroshi IKEHASHI and Hitoshi ARAKI

Okinawa Branch, Tropical Agriculture Research Center,
Maesato 1091 Ishigaki, Okinawa, 907-01

Reproductive barriers between distant groups of rice are anticipated to be overcome through a systematic use of widely compatible varieties in breeding programs. For this purpose a total of 74 varieties were screened for compatibility types in terms of F₁ fertility by crossing them to one each of *indica* and *japonica* testers. The compatibility of a variety to a tester was rated by pollen and spikelet fertility of the F₁ hybrid. The pollen fertility of more than 90 percent and the spikelet fertility of 75-80 percent were rated normal. The compatibility tests showed that the pollen fertility is independent of the spikelet fertility. Therefore, each variety was inspected for four fertility scores, namely, the pollen and the spikelet fertility in each cross to an *indica* and a *japonica* tester. Out of 24 Indonesian upland varieties, 15 showed normal pollen fertility with both testers, and normal spikelet fertility with a *japonica* tester, but gave remarkable spikelet sterility with an *indica* tester. Six showed semi-sterility in all the four scores. Only one variety, Padi Bujang Pendek revealed normal fertility in all the four scores. The remaining two seemed to belong to an exceptional type. A total of 27 Aus varieties showed many types of compatibility including six varieties of *indica* type and five of *japonica*. Five varieties revealed sterility in all the four scores. Only two, Aus 373 and Dular seemed to be widely compatible. The remaining nine were not classified into any definite categories. In the test of 15 varieties which are identified tolerant of salinity, drought or peat soil, ten of strongly photoperiod-sensitive varieties were classified into typical *indica* rice. Two photoperiod-nonsensitive varieties were clearly identified to be *japonica*. In additional tests of some varieties which are notable from previous works, Calotoc, CPSLO 17 and Ketan Nangka were confirmed to be widely compatible. The screening results indicate that the Aus group of rice is a complex of various compatibility types, while a majority of Indonesian upland rices seemed to be of a type which is closer to *japonicas* rather than *indicas*. Only a few varieties were identified as the wide-compatibility type, contrary to the expectation based on earlier works. It was discussed that the upland cultivation has permitted the Aus group to preserve the diverse compatibility types, while photoperiod-sensitive lowland varieties are predominantly of *indica* type.

KEY WORDS : *Oryza sativa*, rice, distant cross, hybrid sterility, varietal group, wide cross

Introduction

In spite of the breeding potential of distant crosses the hybridization between *indica* and *japonica* varieties of rice (*Oryza sativa* L.) is not always productive. Main barrier is hybrid sterility in F₁ and successive generations. Classification of cultivated rices revealed on the other hand that some varietal groups, such as Bulu and Aus varieties which are cultivated in hilly areas of Indonesia and Indian Subcontinent, respectively, give relatively good F₁ fertility when they are crossed either to *indica* or *japonica* varieties.

TERAO and MIZUSHIMA (1939) reported that in addition to the *indica* and the *japonica* group, there is another group which is not necessarily included in *indicas* nor *japonicas*

Received December 3, 1983

in terms of their compatibility. MORINAGA and KURIYAMA (1958) found that Japanese varieties show good compatibility with Bulu and Aus varieties, but poor compatibility with Aman and Tjereh varieties. Tjereh is a name for lowland, photoperiod-sensitive Javanese varieties, and Aman varieties are photoperiod-sensitive lowland rice of Bengal. Aus varieties showed good cross-compatibility with Aman and Tjereh, as well as with *japonica* varieties. Similarly, Bulu produced highly fertile F_1 s with Aman, Tjereh and *japonica* varieties. They concluded that Aus and Bulu varieties cannot be classified either as *japonicas* nor as *indicas*, because they are highly compatible to both types. HEU (1967) chose seven varieties to represent major varietal groups, and crossed them in all possible combinations to study the sterility in their hybrids. An American variety CPSLO 17 showed high fertility in its crosses with all the other varieties except BPI 76. IKEHASHI (1982) emphasized the need of a systematic screening and utilization of the intermediate types to overcome the reproductive barrier between *indica* and *japonica* varieties.

The previous works as reviewed above suggest that some genetic mechanism exists, which permits Aus, Bulu and other varieties to produce fertile hybrids in distant crosses. The mechanism is envisaged to be incorporated in hybrid seed production, since hybrids from distant crosses, if relieved of the hybrid sterility, may be more productive than those obtained within a varietal group. In the present study to identify the wide-compatibility type a total of 74 varieties, most of which are Aus or Bulu varieties, were crossed to an *indica* and a *japonica* tester variety, and the resulting F_1 s were inspected for pollen and spikelet fertility.

Materials and Methods

For a systematic screening of the wide compatibility it is of first importance to choose appropriate standard varieties. Except for a preliminary test where Dee-geo-woo-gen was partly used, IR 36 and IR 50 were used as *indica* testers representing widely cultivated *indica* rices. Nihonmasari and Akihikari were used as *japonica* testers which represent leading varieties in Japan. A breeding line Tohoku 127 was used as a substitute for Akihikari when Akihikari was not available. Tohoku 127 is a progeny from an Akihikari cross.

In 1979 out of the varietal collection of the National Institute of Agricultural Sciences (NIAS) six varieties including Aus and Indonesian varieties were chosen and crossed to each of the *indica* and *japonica* testers. Ten panicles each collected from a single F_1 plant were inspected to measure spikelet fertility. The spikelet fertility was determined by counting numbers of fertile and empty spikelets in each panicle.

From 1980 to 1983, 24 Indonesian native varieties of tall upland type (Bulu) were crossed to an *indica* (IR 36 or IR 50) and to a *japonica* tester (Akihikari or Thoku 127). In the same period 25 varieties from Aus group were crossed to the testers. Also, 16 varieties which have been identified to be tolerant of salinity, drought, or peat soil were tested in the same way. It is anticipated that such stress-tolerant varieties can be primarily used in distant crosses. All the varieties were provided by NIAS, the International Rice Research Institute (IRRI), or Central Agriculture Experiment Station (CAES).

For all the crosses pollen fertility and spikelet fertility of the F_1 hybrids were deter-

mined as the indicator of cross-compatibility. In the determination of the pollen fertility one or two panicles were taken just before flowering for laboratory inspection. Anthers were collected from several opening spikelets on a slide glass on which a drop of acetocarmine was mounted. After dispersing pollen from anthers by pressing cover glass, numbers of fertile and abortive pollen grains were counted with microscope at a magnifying power of 200 times. For each sample the inspection was repeated for ten sights to scan a total of about 300 pollen grains. The spikelet fertility was occasionally affected by pests (bug), cool wind and so on. It was especially so in 1981, so that the maximum spikelet fertility of ten samples was listed for each F_1 hybrid. In the later tests two or three visually good panicles were chosen to give a mean spikelet fertility.

Through the compatibility tests it was shown that the degree of pollen fertility is independent of that of spikelet sterility. Therefore, each variety was inspected for four independent fertility scores, namely, the pollen and the spikelet fertility in each cross to an *indica* and a *japonica* tester.

Results

Preliminary tests. The data of the spikelet fertility for six varieties and their F_1 s are

Table 1. Spikelet fertility of some varieties and their F_1 s with an *indica* or a *japonica* tester at NIAS in 1980

Varieties or F_1 s	Date of heading	Spikelet fertility %		Seed source (NIAS)
		Mean	Range	
Akula	Aug. 6	95.7	98—91	India
Nihonmasari/Akula	Aug. 21	83.0	90—76	
Dee-geo-woo-gen/Akula	Aug. 13	39.8	56—21	
Dahanala	Aug. 13	86.6	95—63	Sri Lanka
Nihonmasari/Dahanala	Aug. 27	45.5	50—38	
Dee-geo-woo-gen/Dahanala	Aug. 12	85.6	94—74	
Panbira	Aug. 8	84.6	93—71	Bangladesh
Nihonmasari/Panbira	Aug. 23	53.5	65—36	
Dee-geo-woo-gen/Panbira	Aug. 10	35.2	54—15	
Calotoc	Aug. 27	78.7	96—60	Philippines
	Sep. 9*	87.7	92—82	
Nihonmasari/Calotoc	Sep. 1	94.0	99—89	
IR 36/Calotoc	Aug. 26	82.3	95—71	Vietnam
Hawara-geporeck	Aug. 23	85.7	89—74	
Nihonmasari/H. geporeck	Sep. 15	91.3	96—78	
IR 36/Ketan Nangka	Aug. 17	25.4	33—14	Indonesia
Ketan Nangka	Aug. 20	86.7	94—71	
Nihonmasari/K. Nangka	Sep. 13	96.2	98—94	
IR 36/Ketan Nangka	Aug. 19	80.2	86—76	
	Aug. 30*	91.2	95—85	
—Control—				
Nihonmasari	Aug. 14	96.3	100—90	Japan
IR 36	Aug. 20	77.7	84—71	Philippines
Dee-geo-woo-gen (DGWG)	Aug. 14	82.6	91—76	Taiwan
Nihonmasari/IR 36	Aug. 30	64.1	73—57	
IR 36/Nihonmasari	Sep. 4	67.9	76—64	
Nihonmasari/DGWG	Aug. 28	60.3	65—55	
DGWG/Nihonmasari	Aug. 30	58.4	64—53	

Note : Spikelet fertility was measured for ten panicles in each of varieties or F_1 s. The data marked with * are from late planted plots.

Table 2. Pollen fertility of some F₁s which produced fertile panicle in 1980 test

Crosses	No. of plants	Pollen fertility %
Calotoc/Nihonmasari	4	98.8
Nihonmasari/Calotoc	18	99.4
Calotoc/IR 36	12	99.3
IR 36/Calotoc	23	99.3
IR 36/Ketan Nangka	19	93.2
Kochihibiki/K. Nangka*	10	93.9
—Control—		
Nihonmasari/IR 36	11	56.6
IR 36/Nihonmasari	13	61.6
IR 36	15	99.0

Note : Kochihibiki is used as a substitute for Nihonmasari.

Table 3. Additional data for the vareities tested in 1980 (1983)

Crosses	Pollen fertility %	Spikelet fertility %	
		Mean	Range
Nihonmasari/Akula	80.0	85.6	91—80
IR 36/Akula	93.1	90.7	94—83
Nihonmasari/Dahanala	64.6	45.0	54—38
IR 36/Dahanala	75.8	74.3	82—64
Nihonmasari/Panbira	66.7	84.8	94—76
IR 36/Panbira	90.9	92.1	97—86
Nihonmasari/Hawara-Geporeck	100	79.8	91—57
IR 36/H. Geporeck	83.8	47.7	55—41

listed in Table 1 along with the spikelet fertility of the F₁s between the testers. The spikelet fertility of varieties, which indicates the level of fertility for a compatible F₁, ranged from the highest of 96.3 percent in Nihonmasari to the lowest of 77.7 in the IR 36, and was more than about 90 percent at the maximum for each variety except IR 36. The fertility of F₁ hybrids between the *indica* and the *japonica* tester ranged from 58.4 to 67.9 percent. Therefore, when the maximum spikelet fertility in an F₁ hybrids is close to 90 percent, the F₁ can be rated as fertile as a variety. On the other hand, when F₁ fertility did not exceed the level of 75 percent, such a cross was identified to be partially sterile.

Based on these criteria two varieties, Calotoc and Ketan Nangka seemed to produce fertile F₁ when they were crossed to an *indica* as well as to a *japonica* tester. The pollen fertility of the F₁ hybrids including Calotoc and Ketan Nangka was inspected in successive tests, and confirmed to be normal (Table 2). The F₁ hybrids between the varieties and a *japonica* tester or IR 36 were tested in 1983 to add pollen fertility data (Table 3). Out of them Dahanala did not seem to be compatible with both the *japonica* tester and IR 36, while Howara-Geporeck was identified to be *japonica*. The data for Akula and Panbira are classified together with other Aus varieties.

Aus varieties. The data for a total of 25 varieties are listed in the Table 4. By the criteria mentioned above many types of compatibility seemed to exist in this group. As

Table 4. Fertility of pollen and spikelet in F_1 s between Aus varieties and indica or japonica testers (TARC, Okinawa, 1981–83)

variety	Source	Fertility of variety		F ₁ -fertility			
		pollen %	Spikelet %	with a japonica tester		with a indica tester	
				pollen %	Spikelet %	pollen %	Spikelet %
Tets with Akihikari and IR 36 as a japonica and an indica tester, respectively, in 1981.							
Achar Bhog	Acc. 25826	97.4	81.5(98)	78.0	71.1(83)	75.1	62.0(79)
Aus 371	Acc. 29157	96.7	86.0(98)	97.9	64.2(80)	93.2	38.1(45)
Aus 402	Acc. 29186	98.1	86.8(92)	55.6	59.8(68)	98.8	85.1(93)
Aus 430	Acc. 29212	99.6	55.4(93)	53.2	41.5(60)	69.9	46.0(69)
DZ 151	Acc. 8541	98.5	62.5(90)	72.2	22.2(36)	59.0	70.2(82)
DV 16	Acc. 8812	97.4	62.8	85.5	19.1(24)	90.4	70.2(83)
Test with Akihikari and IR 50 as a japonica and an indica tester, respectively, in 1982							
Aus 373	Acc. 29158	99.4	92.8	94.3	88.0	89.6	91.3
Dharial	CAES	97.2	—	75.7	32.8	76.8	22.4
Test with Akihikari and IR 36 as a japonica and an indica tester, respectively, in 1983.							
DJ 123	Acc. 8455	98.3	95.7	93.0	87.2	69.4	70.9
DV 149	Acc. 8538	96.6	83.8	49.8	85.1	94.2	86.1
Ingra	Acc. 27552	98.8	97.8	48.2	61.6	97.4	68.3
CH 972	200011	97.2	80.0	58.2	30.5	94.7	84.8
CH 1039	200033	98.1	85.6	58.4	13.2	98.2	96.3
R 11	200035	99.4	85.2	97.9	88.5	85.8	62.3
Kaladumai	200040	99.5	93.0	94.0	94.7	58.4	81.1
Dular	200041	96.6	94.0	97.1	83.7	89.6	86.7
Katakutara	200048	97.2	87.0	66.4	86.9	57.6	43.1
Parambu Vattan	200049	99.5	89.2	98.6	89.1	28.7	34.0
N 136	200052	97.4	91.0	92.9	36.8	87.4	70.8
Marichi Buti	200059	95.8	85.0	81.5	61.5	74.2	50.0
Jhanji	200061	97.2	90.9	85.4	60.8	96.2	93.7
Satika	210003	96.2	91.2	96.1	81.8	83.3	54.4
Kele	210013	98.0	82.2	54.2	69.4	92.2	88.2
Bhutmari 36	210014	98.6	91.7	95.8	53.5	87.6	93.2
Marichibati	CAES	94.4	79.2	98.2	90.8	86.4	48.1

Source number with "Acc." are from IRRI and those with six digits are from NIAS. Figures in parentheses are maximum spikelet fertility of ten samples. In other case the spikelet fertility is a mean from two or three visually good panicles.

summarized in Table 8, six and five varieties were identified to be *indica* and *japonica*, respectively. Five varieties revealed sterility in all the four scores. Only two varieties, Aus 373 and Dular seemed to be widely compatible, although the pollen fertility in their cross to IR variety was marginal. The remaining nine varieties were not classified into any definite categories. In many cases the scores of compatibility for these varieties were marginal, leaving some possibility of re-classification. Contrastingly, the scores in typical *indica-japonica* crosses were clearly differentiated from the marginal ones.

Indonesian upland varieties. The pollen and spikelet fertility for 24 Indonesian varieties and their F_1 s with the *indica* or the *japonica* tester were listed in the Table 5. A majority of 15 varieties (Table 8) were classified into a group by their uniform pollen fertility

Table 5. Fertility of pollen and spikelet in F₁s of Indonesian varieties and indica or japonica testers (TARC, Okinawa, 1981–83)

Variety	Source	Fertility of variety		F ₁ -fertility			
		Pollen %	Spikelet %	with a japonica tester		with an indica tester	
				Pollen %	Spikelet %	Pollen %	Spikelet %
Test with Tohoku 127 and IR 36 as a japonica and an indica testers, respectively, 1981							
Sigabe Taon	180043	99.3	89.0(94)	67.5	63.7(84)	76.3	35.6(51)
Para Roon Dawa	180046	97.7	75.3(89)	98.6	68.8(82)	93.9	39.2(56)
Padi Segutuk	180050	98.3	71.7(90)	91.2	69.1(78)	96.5	37.7
Padi Susu	180051	97.6	immature	97.0	74.5(90)	86.0	38.8(48)
Penu Baru II	180054	99.2	87.7(97)	75.4	44.0(67)	71.7	42.8(56)
Simanuk	180062	99.6	72.0(97)	82.0	57.2(88)	70.2	40.7(47)
Cicih Balanak	180068	99.4	immature	87.1	74.5(83)	93.3	51.5(59)
Page Leoh	180085	99.1	57.7(94)	83.6	65.3(87)	71.5	41.2(47)
Loktjan	NIAS VT 63	99.3	immature	97.0	82.5(92)	93.5	36.9(50)
Test with Akihikari and IR 50 as a japonica and an indica tester, respectively, in 1982.							
Padi Empat Bulan/gogo	180048	100	92.6	99.0	92.9	91.1	51.7
Saba Enim	180058	96.6	80.8	95.2	75.8	99.5	45.1
Banten	180066	98.8	immature	90.2	80.9	94.9	45.4
Baso	180108	99.4	87.4	93.5	88.2	98.9	56.0
Test with Akihikari and IR 50 as a japonica and an indica tester, respectively, in 1983.							
Banten ¹⁾	180066	97.5	69.9	97.8	89.2	97.1	47.0
Padi Bujang Pendek	180076	—	92.5	97.6	90.8	96.7	80.0
Gamah	180110	99.3	83.1	99.6	89.2	92.4	42.4
Karii Ranga	180112	96.5	—	98.7	85.0	98.3	49.4
Test with Akihikari and IR 36 as a japonica and an indica tester, respectively, in 1983.							
Renik Beliti	180057	92.9	80.5	96.6	81.8	98.7	48.2
Sitabo Tabo	180064	98.8	85.3	78.3	85.0	99.0	57.2
Ingsa Putih	180069	94.0	77.8	79.4	78.4	94.2	59.6
Padi Abang/gogo	180074	97.6	79.1	97.5	81.1	92.5	57.1
Cicih Baat	180117	100	88.1	93.9	75.0	94.6	71.7
Cicih Buleleng	180118	98.3	80.7	55.3	85.1	83.1	63.6
Cicih Cepaka	180119	99.7	90.9	91.9	83.0	95.8	51.8
Silewah	IRCTN	98.0	95.6	82.7	69.5	84.7	50.0

¹⁾ This variety was tested also in 1982.

Source number with "Acc." are from IRRI and those with six digits are from NIAS. Figures in parentheses are maximum spikelet fertility of ten samples. In other case the spikelet fertility is a mean from two or three visually good panicles.

both with the *indica* and *japonica* tester, and the normal spikelet fertility with the *japonica* tester, and the clear semi-sterility with the *indica* tester. In another word, these 15 varieties are compatible with the *indica* and the *japonica* tester, but not so in terms of the spikelet sterility with the *indica* tester. Six varieties showed sterility in all the four scores. Two varieties, Sitabo tabo and Ingsa Putih seemed to belong to an exceptional type with the good spikelet fertility with *japonicas* and the good pollen fertility with *indicas*. Only one variety, Padi Bujang Pendek revealed normal fertility in all the four scores. This variety was also marked with its sturdy intermediate plant type.

Varieties tolerant of environmental stress. In this group two varieties, Kinandan Patong and Paedai Kulibungga were not photoperiod-sensitive, and identified clearly to be *japonica*. All the other entries to the test were strongly photoperiod-sensitive except Palar, a weakly sensitive one. Out of them Salumpikit and Pulut Daeng Merakka seemed exceptional due to the medium spikelet sterility with the *japonica* tester despite fertility in other scores. Pokkali was unique by its marginal pollen fertility with the *indica* tester like other varieties from South India, such as Triveni and Eat Samba. The remaining ten varieties with strong photoperiod-sensitivity were identified to be *indica*, although Baelaon and Carreon (Acc.38703) showed marginal pollen fertility with the *japonica* tester (Table 8).

Additional test of some notable varieties. CPSLO 17 was confirmed to be widely compatible (Table 7). Peta was clearly identified to be *indica*. Triveni and Eat Samba were not definitely classified into *indicas* nor *japonicas* like other varieties, Dahanala and Pokkali. In this context, these varieties from South India seemed to be similar to some of Aus varieties.

Table 6. Fertility of pollen and spikelet in F_1 s between stress-tolerant varieties and *indica* or *japonica* testers (TARC, Okinawa 1982-83)

Variety	Source	Origin	Tolerance for	F ₁ -fertility			
				with a japonica tester		with an indica tester	
				Pollen %	Spikelet %	Pollen %	Spikelet %
Test with Akihikari and IR 36 as a japonica and an indica tester, respectively, in 1982—83							
Baelaon	Acc. 4191	Indonesia	peat soil, 1/	88.2	51.5	98.0	86.5
Maraja	Acc. 4197	Indonesia	"	18.9	10.4	91.9	92.3
Palmar	Acc. 4208	Indonesia	"	35.4	42.9	90.5	82.8
Salumpikit	Acc. 5423	Philippines	drought, 2/	92.2	63.9	99.1	82.8
Carreon	Acc. 5993	Philippines	"	58.5	34.6	95.2	95.2
Ketan Cere	Acc. 35719	Indonesia	"	49.3	21.4	90.9	81.3
Carreon	Acc. 38703	Philippines	"	88.8	56.0	98.2	81.7
Kuatik Serai	Acc. 18035	Indonesia	salinity, 3/	19.2	53.2	98.9	93.7
Merak	Acc. 25457	Indonesia	"	75.3	48.4	98.9	95.5
Pokkali	Acc. 26869	India	salinity, 4/	86.8	56.5	83.8	89.6
Test with Akihikari and IR 50 as a japonica and an indica tester, respectively, in 1982—83							
Kuatik Putih	Acc. 18037	Indonesia	salinity, 4/	31.9	44.8	98.4	91.5
Bajar Putih	Acc. 17187	Indonesia	salinity, 3/	17.3	45.6	99.1	86.7
Kuatik Serai Rendah	Acc. 24739	"	"	—	44.6	96.2	91.0
Pulut Daeng Merakka	Acc. 24788	"	"	90.4	63.6	93.7	87.6
Kinandan Patong	Acc. 23364	Philippines	drought, 2/	97.9	89.1	76.2	73.0
Paedai Kulibungga	Acc. 27207	Indonesia	"	91.6	99.1	4.8	12.3

Information source : 1/IRRI Ann. Report for 1978, p. 108

2/Ibid for 1979, p. 86-87

3/Ibid for 1978, p. 108

4/Ibid for 1979, p. 116

Table 7. F₁ fertility of some varieties other than Aus or Bulu group

Varieties or F ₁ s	Source	Year of the test	Flowering	Fertility	
				Pollen %	Spikelet %
CPSLO 17	NIAS	1982,	June 15	98.5	86.5
CPSLO 17/IR 50			June 10	96.1	74.0
CPSLO 17/Akihikari			May 31	98.7	73.6
CPSLO 17		1982,	Oct. 15	98.5	76.7
IR 50/CPSLO 17			Oct. 20	97.6	93.8
Akihikari/CPSLO 17			Oct. 3	92.5	79.2
IR 50/Akihikari (control)			Oct. 1	45.3	42.8
Triveni	NIAS	1983,	Aug. 28	98.3	75.6
IR 36/Triveni			Aug. 28	85.9	85.7
Akihikari/Triveni			Aug. 21	67.0	38.7
Peta	NIAS	1983,	Nov. 5	100	immature
IR 50/Peta			Oct. 8	100	84.8
Akihikari/Peta			Oct. 4	59.0	55.0
Eat Samba	CAES	1983,	Oct. 22	100	immature
IR 36/Eat Samba			Oct. 16	81.7	87.5
Akihikari/Eat Samba			Sep. 20	91.8	90.7

Table 8. Classification of tested varieties into several compatibility types

Indonesian varieties :

- A. Normal fertility with testers except spikelet sterility with indica testers : Banten, Baso, Cicih Baat, Cicih Balanak, Cicih Cepaka, Gamah, Karii Rangka, Loktjan, Padi Abang/gogo, Padi Empat Bulan/gogo, Padi Segutuk, Padi Susu, Para Roon Dawa, Renik Beliti, Saba Enim.
- B. Partial sterility both with indica and japonica testers : Cicih Buleleng, Penu Baru II, Sigabe Taon, Silewah, Simanuk, Page Leoh.
- C. Normal fertility both with indica and japonica testers : Padi Bujang Pendek.
- D. Exceptional type : Ingsa Putih, Sitabo Tabo.

Aus varieties :

- A. Partial sterility both with indica and japonica testers : Achar Bhog, Aus 430, Dhariel, DZ 151, Mariti Buti.
- B. Indica type : Aus 402, CH 972, CH 1039, DV 16, Jhanji, Kele.
- C. Japonica type : DJ 123, Marichibati, Parambu Vattan, R 11, Satika.
- D. Normal fertility both with indica and japonica testers : Aus 373, Dular.
- E. Other types : Akula, Panbira, DV 149 ; Bhutmari 36, Ingra, Kaladumai, Katakutara, N 136, Aus 371.

Tolerance sources :

- A. Indica type : Baelaon, Bajar Putih, Carreon, Carreon, Ketan Cere, Kuantik Serai, Maraja, Merak, Kuantik Putih, Palar.
- B. Japonica type : Kinandang Patong, Paedai Kulibungga.
- C. Other types : Pokkali, Pulut Daeng Merakka, Salumpikit.

Other varieties :

- A. Partial sterility both with indica and japonica testers : Dahanala.
- B. Indica type : Peta.
- C. Japonica type : Hawara-geporeck.
- D. Normal fertility both with indica and japonica testers : Ketan Nangka, Calotoc, CPSLO 17.
- E. Other types : Triveni, Eat Samba.

Discussion

As indicated by previous workers, many varieties in the Aus or Bulu group were not identified to be *indica* nor *japonica* in terms of compatibility type of F_1 s. At the same time it should be emphasized that the Aus or the Bulu group is not just intermediate between *indicas* and *japonias*. The Aus group in particular includes several types of compatibility; those compatible only with *indicas* or with *japonicas*, and those not compatible with both, while many others are not classified into any definite types because of their marginal responses to the testers.

So far the pollen and the spikelet fertility are estimated to be parallel with each other (TERAO and MIZUSHIMA, 1939; OKA, 1953). This point of view may have led to some misjudgement. For example, Akula, Panbira and DV 149 showed low pollen fertility with the *japonica* tester despite good fertility in other scores. If one sees only their spikelet fertility as an indicator of the compatibility, these three Aus varieties would be identified as compatible both with *indicas* and *japonicas*.

Except for a few varieties reciprocal crosses were not attempted in the present study. The possibility of interference by various cytoplasmic effects was limited by hybridizing the testers as a female plant. Yet, some possibility of cytoplasmic sterility remains to be studied later particularly in the crosses where the F_1 fertility was low.

The diversity of the compatibility type in the Aus group was not fully recognized by previous workers who tested only a few varieties from each varietal group. The reason why the Aus group does have such a diversity of the compatibility type can be explained by its proximity to the original center of cultivated rices. Also, it should not be overlooked that this varietal group has been cultivated mainly in hilly areas, and been relieved of chances for further specialization through acquisition of photoperiod-sensitivity, which is essential to traditional lowland cultivation and thereby latitude- or location- specific. In this context, it is noteworthy that almost all the photoperiod-sensitive varieties originally identified as stress-tolerant were found to be of *indica* type.

Upland varieties from Indonesia seemed closer to *japonicas* than to *indicas* as noted in their compatibility scores. Those identified as *japonica* type, such as Howara-Geporeck (in the preliminary test), a long-awned rice from Vietnam, Kinandan Patong and Paedai Kulibungga (in the stress-tolerant group), each photoperiod-nonsensitive rice from Philippines and Indonesia, respectively, can also be included into the Bulu group in the sense that they are low-latitude, photoperiod-nonsensitive rice. In our observation some of *japonica*-like Aus varieties were as cold-tolerant as Japanese varieties. Bulu varieties were generally cold-tolerant, while *indica*-like Aus varieties did not seem to be tolerant. Presumably, the *japonica*-like background of the low-latitude upland rices can be a result of the specialization through the acquisition of cold tolerance which is of some importance in the tropical highlands.

Contrary to the expectation based on earlier works that the Bulu group may include many wide-compatibility type, only one variety was identified as such. A majority of Bulu varieties showed spikelet sterility with *indica* testers. In total, only six varieties were screened out as the wide-compatibility type. Out of them Aus 373 and Dular need

to be retested, because their pollen fertility with the *indica* tester was marginal. CPSLO 17 and Ketan Nangka have been noted as wide-compatibility type. So only two varieties Calotoc and Padi Bujang Pendek are newly added to the list of the wide-compatibility type. To utilize the wide compatibility in breeding programs the genetic background should be analyzed to see whether the wide compatibility is genetically simple or not.

Literature Cited

- HEU, M.H. 1967. Studies on the growth duration and hybrid sterility in remote cross breeding of cultivated rice. J. Korean Soc. Crop Sci. 4: 31~71.
- IKHASHI, H. 1982. Prospects for overcoming barriers in the utilization of *indica-japonica* crosses in rice breeding. Oryza 19: 69~77.
- MORINAGA, T. and H. KURIYAMA 1958. Intermediate type of rice in the subcontinent of India and Java. Japan J. Breed. 7: 253~269.
- OKA, H-I. 1953. The mechanism of sterility in the intervarietal hybrid. Japan J. Breed. 2: 217~224 (In Japanese with English summary).
- TERAO, H. and U. MIZUSHIMA 1939. Some consideration on the classification of *Oryza sativa* L. into subspecies, so called *Japonica* and *Indica*. Japan J. Bot. 10(3): 213~258.

イネの遠縁交雑の F₁ 稔性に関する品種の親和性の検索

池 橋 宏・荒 木 均

(農林水産省熱帯農業研究センター沖縄支所, 石垣市真栄里川原 1091)

イネの遠縁交雑の F₁ 稔性に関して広い親和性をもつ品種を見出す目的で, Aus 群および Bulu 群を主とする 74 品種を, 代表的インド型品種 (IR 36・50) および日本型品種 (アキヒカリなど) のそれぞれひとつと交配し, F₁ の花粉稔性および種子稔性を調べた。花粉稔性および種子稔性は互いに独立な形質であることが判明したので, 各品種についてインド型との F₁ および日本型との F₁ のそれぞれについて, 花粉稔性と種子稔性を調べ, これらの合計 4 項目についての稔性の良否から, 親和性の型を決定した。

Bulu 群 24 品種のうち 15 品種はインド型および日本型品種と正常な花粉稔性を示し, 種子稔性については日本型とは正常で, インド型とは半稔性を示した。わずかに 1 品種がインド型および日本型の双方に完全に稔性を示し, 6 品種は双方と半稔性を示し, 2 品種は例外的な型を示した。Aus 群 27 品種のうちインド型・日本型はそれぞれ 6 品種と 5 品種であり, 5 品種は双方に半稔性を示し, 9 品種はいずれとも判定できなかった。2 品種がインドおよび日本型に対しほぼ正常な稔性を示した。有機質土壌, 塩害もしくは干ばつに耐性のある 15 品種の検定においては, 極端な感光性をもつ 13 品種のうち 10 品種は典型的なインド型であり, 非感光性の 2 品種は典型的な日本型であった。その他数品種の検査結果も含めて, 結局 Calotoc, CPSLO 17, Ketan Nangka, Padi Bujang Pendek, Aus 373 および Dular の 6 品種がインド型および日本型の双方に稔性を示したが, 後二者のインド型テスターとの花粉稔性はさらに検討を要する。

以上の結果を通じて Aus 群は多様な親和性の型を含むことが判明した。これはこの品種群が栽培稲の起源地帯と近接しているためであろう。さらに Aus 群は一般に畑ないし小規模天水田で栽培されており, 伝統的な低地湛水栽培に不可欠な感光性を獲得して, 特殊化する機会を得なかったため, その多様性を保存したと考えられる。これと対照的に, 強い感光性をもつ品種のほとんど全部が典型的なインド型であったことは注目される。

Bulu 群品種は全体として日本型に近い反応を示した。本研究に付ずいた観察では Aus 中の日本型品種に耐冷性のものがあり, インド型品種には耐冷性のものがなく, Bulu 群は全体にある程度の耐冷性を示した。低緯度地帯の丘陵ないし高地では, 耐冷性が必要であることから, Bulu 群は耐冷性の獲得を通じて, 日本型類似のものへと特殊化したものと考えられる。

なおインド型品種と日本型品種の双方に稔性を示す広い親和性を, 一代雑種の利用とか遠縁交配育種に活用するにあたっては, その遺伝が単純であるか否かを今後検討する必要がある。