

## Breeding for high fertility response in Rice\*

by

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**Synopsis:** A unique achievement in the breeding of paddy strains for high fertility conditions with *japonica* x *indica* crosses is described in this paper.

**Introduction:** Breeding of improved strains that respond to high fertility has become one of the main objectives of the rice improvement programme in most of the Rice Research Centres of the Indian Union. With the increased amount of fertiliser application for obtaining higher yields, the problem of developing suitable varieties that respond to higher dose of fertilisers has assumed greater importance. In Madras, breeding work for development of improved rice strains that respond to high fertility was taken up during 1952, when it became one of the participating States for carrying out selection work with the hybrid progenies of the *japonica* x *indica* crosses made at the Central Rice Research Institute, Cuttack under the International Rice Hybridization Project. The success achieved in selection work done at Aduthurai centre in Madras State is discussed in this paper.

**Review of Literature:** The *indica* rice varieties, though hardy and widely adaptable, do not generally stand heavy fertilization which induces rank vegetative growth resulting in severe lodging (Ghose *et al*, 1960). In a study on the effect of heavy manuring of rice, Srinivasan and Rajagopalan (1956) observed that heavy manuring not only increased vegetative growth but also made the plants more prone to lodging resulting in increased amount of chaff.

The *japonicas* on the other hand are noted for their response to heavy fertilization. They were, however, found to be unsuitable for direct introduction as they were poor in growth and tillering habit producing one or two small earheads per plant (Ghose *et al* 1960). Realising the need for combining the high fertilizer response of *japonica* types with the hardiness and adaptation to the tropical conditions of *indicas*, work on inter-racial hybridisation was initiated at Cuttack during 1951 (Anon., 1960). Rajagopalan (1955) while studying the F<sub>2</sub> and F<sub>3</sub> generation of different sets of inter-racial crosses involving *japonica* and *indica* parents met with a few fertile hybrid progenies combining good tillering, thick culm and non-lodging habit and indicated the possibility of fixing up progenies that respond favourably well to high fertility. Subramanyam and Roy (1956) studied the F<sub>2</sub> generation of *japonica* x *indica* rice hybrids which showed segregation in respect to many characters like plant height and flowering duration. They recorded in the progenies, the expression of awn character and presence of coloured grains although the parents involved did not show these

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TABLE I.  
Statement showing details of Crosses between japonica x indica studied and selections made  
(a) japonica x indica — F<sub>2</sub> Progenies received in 1952:

Particulars of crosses	1952-'53 1953-'54 1954-'55 1955-'56 1956-'57 1957-'58 1958-'59 1959-'60 1960-'61 1961-'62 1962-'63											
	F <sub>2</sub>	F <sub>3</sub>	F <sub>4</sub>	F <sub>5</sub>	F <sub>6</sub>	F <sub>7</sub>	F <sub>8</sub>	F <sub>9</sub>	F <sub>10</sub>	F <sub>11</sub>	F <sub>12</sub>	
1. GEB. 24 x Norin 1	1	8	nil	nil	nil	nil	nil	nil	nil	nil	nil	
2. Norin 6 x GEB. 24	1	20	36	36	53	39	31	15	3	2	1	
3. Norin 18 x GEB. 24	1	29	107	52	78	48	41	17	10	6	4	
4. GEB. 24 x Norin 23	1	30	71	48	38	42	31	12	10	6	1	
5. Asahi x GEB. 24	1	27	65	30	35	16	12	9	3	4	-	
6. CEB. 24 x Asahi	1	27	15	13	23	12	5	3	3	1	1	
7. GEB. 24 x Rikk-u. 132	1	18	31	24	21	14	18	9	7	3	4	
8. Rikk-u 132 x GEB. 24	1	33	38	22	38	45	33	16	7	5	4	
9. GEB. 24 x Tihoku. 6	1	38	45	24	17	19	15	5	5	3	1	
10. GEB. 24 x Taichu. 65	1	26	1	5	6	6	9	8	8	4	4	

(b) F<sub>2</sub> Progenies received in 1953:

Particulars of crosses	1953-'54 1954-'55 1955-'56 1956-'57 1957-'58 1958-'59 1959-'60 1960-'61 1961-'62 1962-'63										
	F <sub>2</sub>	F <sub>3</sub>	F <sub>4</sub>	F <sub>5</sub>	F <sub>6</sub>	F <sub>7</sub>	F <sub>8</sub>	F <sub>9</sub>	F <sub>10</sub>	F <sub>11</sub>	F <sub>12</sub>
1. Norin 6 x ADT. 12	1	30	28	37	23	13	6	4	4	4	4
2. Norin 8 x ADT. 12	1	35	19	32	19	14	6	4	6	6	6
3. Norin 8 x GEB. 24	1	20	22	42	17	20	10	8	5	4	4
4. Norin 18 x ADT. 12	1	25	14	17	10	6	5	4	6	8	8
5. Norin 20 x ADT. 12	1	26	12	13	8	8	9	5	3	1	1
6. Norin 20 x GEB. 24	1	6	5	1	-	-	-	-	-	-	-
7. Rikk-u 132 x ADT.	1	86	52	71	31	27	12	5	3	1	1
8. Asahi x ADT. 12	1	22	8	14	9	6	5	4	4	3	3
9. Taichu 65 x ADT. 12	1	26	21	29	12	9	9	4	3	4	4
10. Taichu 65 x GEB. 24	1	21	17	21	8	3	3	4	3	3	4
11. Ginbozu x ADT. 12	1	1	1	1	-	-	-	-	-	-	-

TABLE I. (Contd.)

Particulars of crosses	1954-'55 1955-'56 1956-'57 1957-'58 1958-'59 1959-'60 1960-'61 1961-'62 1962-'63									
	F <sub>2</sub>	F <sub>3</sub>	F <sub>4</sub>	F <sub>5</sub>	F <sub>6</sub>	F <sub>7</sub>	F <sub>8</sub>	F <sub>9</sub>	F <sub>10</sub>	F <sub>10</sub>
<b>Direct Crosses:</b>										
1. Gimbozu x ADT. 12	1	31	35	17	10	5	5	3	5	
2. Norin 8 x GEB. 24	1	5	1	3	—	—	—	—	—	8
3. Norin 20 x GEB. 24	1	6	3	4	7	5	5	4	8	
<b>Back Crosses:</b>										
4. GEB. 24 x (Norin 20 x GEB. 24)	1	5	—	—	—	—	—	—	—	—
5. ADT. 12 x (Norin 6 x ADT. 12)	1	29	43	23	14	11	10	9	6	
6. ADT. 12 x (Norin 8 x ADT. 12)	1	12	17	10	7	3	4	3	1	
7. ADT. 12 x (Norin 20 x ADT. 12)	1	14	15	25	10	9	8	7	10	
8. ADT. 12 x (Asahi x ADT. 12)	1	28	35	25	12	6	5	6	1	
9. ADT. 12 x (Gimbozu x ADT. 12)	1	17	22	20	5	3	3	3	5	
10. ADT. 12 x (Taichu 65 x ADT. 12)	1	12	24	21	7	8	8	3	3	

TABLE 2

Culturo Number	Origin	Flowering Duration	Yield of grain per acre in Kg.			Average for Average yield expressed four years as percentage on control				
			1959-'60	1960-'61	1961-'62	1962-'63	four years	as percentage on control		
1. 2397	Norin 6 x GEB. 24	84	1747	1746	2182	1538	1803	103.7		
2. 2410	do.	82	1686	1993	2182	1608	1867	107.5		
3. 2403	do.	84	1599	1748	1995	1516	1714	99.7		
4. 2425	do.	82	1562	1768	1829	1569	1682	96.2		
5. TKM. 6	{An improved strain (Control) evolved from Co. 18 x GEB. 24	79	1516	1898	2051	1480	1736	100.0		
O. D. if significant			341	99	147	Not significant				
			1960-'61			1961-'62			1962-'63	
			Average of three years			Average of three years			Average of three years	
1. 2914	Norin 8 x GEB. 24	73	1983	2270	1835	2031	122.7			
2. 2915	do.	75	1833	2182	1660	1892	114.3			
3. 2916	do.	77	1837	2100	1606	1848	111.6			
4. 2917	do.	75	1905	2246	1820	1990	120.2			
5. ADT. 20	(Control) an improved strain evolved from ADT. 2 x ADT. 3	74	1369	2107	1193	1656	100.0			
C. D. if significant			180			Not significant			149	

characters. Pawar *et al* (1959) studied the progenies of crosses involving seven *japonica* varieties and two *indica* parents HR. 19 and HR. 22 and recorded a wide range of variability in  $F_3$  generation for height of plant, habit, number of tillers, lodging, shedding, grain type and duration. Three of the cultures possessing non-lodging and non-shedding characters were also found to be superior to the *indica* parent HR.22 with 44 to 48% higher yield of grain.

**Materials and Methods:** Seed materials of 31 cross combinations of *japonica* x *indica* rices comprising of 10  $F_2$  progenies received in 1952, 11  $F_2$  progenies in 1953 and 10  $F_2$  progenies in 1954 from Central Rice Research Institute, Cuttack were grown in successive generations with a view to select plants that respond to high fertility. These 31 cross combinations involve 11 *japonica* parents, namely Norin 1, Norin 6, Norin 8, Norin 18, Norin 20, Norin 23, Gimbozu, Asahi, Rikku 132, Taichu 65 and Taihoku 6 and two premier *indica* strains of the State namely GEB. 24 and ADT. 12. These materials were grown and studied in plots of 5' x 5' size, heavily manured with 30 lb. N in the form of green leaves and 36 lb.  $P_2O_5$  per acre as basal dressing and 40 lb. N per acre in the form of ammonium sulphate, half applied at planting and the other half applied 20 days after transplanting. Seedlings were planted in singles with a spacing of 6" x 6" either way. The observations with regard to growth, tillering, lodging, flowering, sterility, awning, rice colour and other economic characters were recorded. Selection of single plants during early generation was confined to those possessing the desirable economic attributes such as erect habit, heavy tillering, stiff straw, free emergence and good seed setting. The details of the 31 cross combinations studied and the number of single plants selected and grown in each of the subsequent generations are presented in table 1.

**Results and Discussion:** The 10  $F_2$  families of 10 cross combinations received in 1952-53 together with fresh sets of crosses received in 1953-54 and 1954-55 were critically examined for their morphological, physiological and economic characters. In the  $F_2$  generation a wide range of variability was expressed for plant growth habit, number of tillers, lodging character, duration, glume colour and grain size. Sterility was present in most of the crosses and was more pronounced in 13 sets of direct crosses where the *japonica* parents Gimbozu, Norin 8, Norin 18, Norin 20, Asahi, Taichu. 65 and Rikku 132 and *indica* parent ADT. 12 were involved, while it was less in back crosses. Presence of red rice in eight sets and awning in 19 sets of cross combinations was recorded though the parents were devoid of red rice and awns. From the data recorded it was observed that most of the progenies reached a level of homozygosity in  $F_7$  generation. Thirteen of the homozygous derivatives were advanced to yield tests during 1958-'59. Nine were added in 1959-60, nine in 1960-61 and twenty three in 1961-62.

The yield tests were conducted under heavily manured condition in randomised plots replicated six times. Out of a total number of 54 homozygous cultures tested only eight promising ones had completed trials for a period of

three years and more. The grain yield data of the eight cultures are given in table 2. The data show that six cultures have recorded significant increase in yield with 5 to 23 per cent increase over their standards. Out of these, culture 2914 of cross Norin 8 x GEB. 24 and 2410 of cross Norin 6 x GEB. 24 were found to be of great promise combining in them the desirable characteristics of the *japonica* and *indica* parents with average increased yields of 23% and 8% over the popular departmental strains ADT. 20 and TKM. 6 respectively. Culture 2410 possesses fine grain similar to TKM. 6 while culture 2914 is similar to ADT. 20 in grain characters and maturity. Seeds of these two cultures have been supplied to other rice breeding centres of the country to ascertain their performance in the different regions of the union. Arrangements have also been made to conduct trials with the two cultures in cultivators' holdings of the State.

**Summary:** Selection work with the hybrid progenies of *japonica* x *indica* crosses received from Central Rice Research Institute, Cuttack under the International Rice Hybridisation Project, was taken up at Regional Research Station, Aduthurai during the year 1952. As a result of work done in the past ten years a number of economic progenies combining the desirable features of the *japonica* and *indica* parents was under study for their yield performance. Two cultures, 2914 and 2410 have proved to be promising giving consistently higher yields of grain over the local improved strains ADT. 20 and TKM. 6 respectively with which they were compared. Besides high response to fertility, these cultures also possess non-lodging habit. Culture 2410 is similar to TKM. 6 and culture 2914 resembles ADT. 20 in duration and grain and rice characters. The culture 2914 has since been released as strain ADT. 27 for cultivation by ryots and for replacing ADT. 20.

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