Euphytica 3 (1954): 221–228

RESPONSE OF RICE VARIETIES TO SHORT-DAY TREATMENT

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Received 3 Aug. 1954

Rice varieties differ considerably in their response to photoperiod. Several workers, both in India and abroad, have reported reduction in flowering duration by short-day treatment. Very marked response to short-day treatment was obtained by SIRCAR and PARIJA (1) in two *aman* (winter) varieties, *Rupsail* and *Patnai* of Bengal, which flowered in 47 and 79 days respectively instead of the normal 133 and 136 days.

In some early rice varieties from Uttar Pradesh state of India, short-day treatment has been reported to delay flowering (SIRCAR and GHOSE (2), MISRA (3)). SIRCAR (4) has also reported that the degree of earliness induced, increased with the duration of the treatment, showing that the effect of short-day was of a quantitative nature. However, in all the investigations so far carried out, the relationship between flowering duration of a variety under natural day light conditions and response to short-day treatment has not been studied.

In the investigation reported here, a number of rice varieties was subjected to a particular short-day treatment and a relationship between the natural flowering duration and photoperiod response of the varieties has been established. A preliminary report on this was presented at the 3rd meeting of the Working Party of the International Rice Commission held at Bandung (Indonesia) in May 1952 by GHOSE *et al* (5).

MATERIAL

For the execution of the two *japonica-indica* rice hybridization programmes, sponsored at this Institute respectively by the Food and Agriculture Organisation of the United Nations and the Indian Council of Agricultural Research, a number of *indica* varieties from several South East Asian countries and states of India are being used. The *indicas* also include two Chinese varieties which have been introduced into India and have spread considerably in some of the states (Kashmir). The *japonicas* included in the hybridization projects come to flower between 55 to 85 days of sowing under Cuttack conditions, while the *indicas* come to flower much later, and also vary considerably in their flowering durations, from as low as 76 days to 182 days from sowing when sown at the beginning of the normal crop season i.e., about the middle of June.

In order to have parental material ready for crossing throughout the year and also to synchronise the flowering of the parents, monthly sowings throughout the year and short-day treatment of the *indica* parents were undertaken.

For the short-day treatment, the varieties were grown in 12 inch diameter pots with 5 plants per pot and 4 pots for each variety. During the course of hybridization work a technique for short-day treatment has been evolved and standardized at the Institute and was employed in this investigation. This consists of treating 30 days old

seedlings to 8 light hours of sunlight for 20 days. During the period of the short-day treatment, the pots were removed to dark room each day at 3.0 P.M. and brought into sunlight again the next morning at 7.0 A.M. The control plants were kept throughout under natural day light conditions.

The observations on flowering duration of the varieties under short-day treatment were incidental to the main purpose viz., that of hybridization, and the varieties to be sown in any particular month were decided by the requirements of the hybridization schedule; hence all the varieties under study do not appear in all the monthly sowings. The period covered by these observations was two years viz., 1951 and 1952. During 1951 twenty-five varieties were subjected to short-day treatment during the months of April, June, July and August, while in 1952 fifty varieties, including 24 varieties of the previous year, were used in the monthly sowings and given short-day treatment. In both these years the flowering duration of the varieties in the monthly sowings were recorded.

Results

The normal flowering duration of the varieties (i.e., the time taken by the varieties to flower under natural day light conditions when sown about the middle of June) based on the observations of two years, are given in Tables 1 and 2 along with flowering durations of the same varieties under short-day treatment.

In 1951 the flowering durations of 25 varieties sown in April, June, July and August were studied (Table 1). It will be seen that while the normal flowering durations of these varieties ranged from 95 to 176 days (i.e., a difference of 81 days), all the varieties sown in any one month, when given short-day treatment, came to flower within a short period of one another, the difference in flowering being 20–25 days except in April sowings where the difference was only 7 days. The response of the varieties to short-day treatment (i.e., the reduction in flowering duration) increased with the normal flowering duration of the variety. It will be seen that in April sowings the response of variety, *Puang Ngern* (107 days normal flowering duration) was 47.0 days, while that of variety, *Peykeo* (176 days normal flowering duration) was 117.0 days, thus it would seem that there was a relationship between the photoperiod response of a variety and its normal flowering duration. The regression of photoperiod response over normal flowering duration was, therefore, studied for the varieties sown in different months (Table 3) and it was found to be linearly related.

The regression coefficient was found to be significant for all the monthly sowings and was approximately 1.0 and none of the individual regression coefficient values differed significantly from the hypothetical regression coefficient $'b' = 1.0$, thus showing that over the minimum flowering duration of the varieties studied, an increase in the normal flowering duration by one day tended to correspondingly increase the photoperiod response of the variety by one day; the later the variety, the greater was response to short-day and consequently the varieties came to flower within a narrow range of time.

During 1952, fifty varieties, including twenty-four of 1951, were studied and the data are presented in Table 2. The results obtained were similar to that of the previous year. The regression of photoperiod response on the normal flowering duration for

TABLE 1. FLOWERING DURATION UNDER SHORT-DAY TREATMENT IN MONTHLY SOWINGS IN 1951

Variety	Country of Origin	Mean normal flowering duration	April		June		July		August	
			Flowering duration	Response	Flowering duration	Response	Flowering duration	Response	Flowering duration	Response
Thailand	Philippines	95.0	–	–	76.5	18.5	82.8	12.3	–	–
Guiningan	Philippines	103.0	–	–	85.0	18.0	–	–	73.0	30.0
Puang Ngern	Thailand	107.0	60.0	47.0	68.5	38.5	82.8	24.8	69.0	38.0
Mas	Indonesia	114.0	–	–	–	–	–	–	77.0	37.0
Vellailankalayan	Ceylon	115.0	–	–	85.7	29.3	–	–	79.0	36.0
Bengawan	Indonesia	118.0	58.5	67.5	86.0	40.0	79.0	39.0	74.0	52.0
Patnai 23	Pakistan	123.0	61.3	61.7	–	–	–	–	–	–
Latisail	Pakistan	124.0	64.0	60.0	61.0	63.0	–	–	–	–
Nangmol	Thailand	125.0	58.7	66.3	63.0	62.0	79.4	45.6	–	–
Apostol	Philippines	125.0	–	–	69.6	55.4	–	–	72.0	53.0
Nangquot	Indochina	130.0	60.7	69.3	62.3	67.7	–	–	73.0	57.0
Indrasail	Pakistan	131.0	58.5	72.5	–	–	–	–	–	–
Nigersail	Pakistan	134.0	58.0	76.0	65.0	61.0	77.0	57.0	–	–
C.24–102	Burma	138.0	–	–	62.8	75.2	75.6	52.4	65.0	68.0
C.28–16	Burma	139.0	57.3	81.7	62.4	76.6	72.9	66.1	68.0	71.0
D.17–88	Burma	141.0	61.2	79.8	–	–	–	–	72.0	69.0
Pinkaew	Thailand	146.0	–	–	–	–	72.6	73.4	77.0	69.0
Khau Bhu Das	Thailand	146.0	62.8	83.2	66.0	80.0	62.8	73.2	70.0	76.0
Docphung Luna	Indochina	149.0	62.7	86.3	64.0	85.0	–	–	73.0	76.0
Serendah Kuning	Malaya	152.0	61.0	91.0	66.0	86.0	82.6	69.4	72.0	80.0
Nachin 57	Malaya	152.0	–	–	67.7	84.3	82.1	69.9	73.0	79.0
D.25–4	Burma	153.0	61.0	92.0	–	–	–	–	76.0	77.0
Neangmeas	Indochina	158.0	60.0	98.0	69.0	88.0	–	–	81.0	77.0
Elon Elon	Philippines	165.0	–	–	77.0	88.0	–	–	86.0	79.0
Peykeo	Indochina	176.0	59.0	117.0	86.0	90.0	–	–	–	–
		Mean	60.3		70.7		77.2		73.9	

TABLE 2. FLOWERING DURATION UNDER SHORT-DAY TREATMENT IN MONTHLY SOWINGS IN 1952

Variety	Country of origin	Mean normal flowering duration	February	March	April
No. 13	India	76	–	62.7	71.7
Early Kolipi	India	77	–	62.1	70.2
T.136	India	78	–	65.8	67.1
Dharial	India	78	–	64.1	62.3
Ch.47	China	81	–	62.8	–
H.S.19	India	83	–	63.8	66.4
Anterved	India	87	–	63.5	71.7
Saffedhan	India	88	–	66.3	–
R2 Nungi 17	India	89	–	–	68.7
T.56	India	91	79.0	64.8	60.9
H.S.22	India	93	–	62.5	69.0
Ch.45	China	94	71.6	64.5	60.3
Thailand	Philippines	95	–	70.1	65.9
Strain 141	India	96	–	62.3	64.1
Adt.12	India	96	76.9	66.1	64.0
Adt.18	India	97	–	–	–
75 Askhata	India	99	–	–	69.6
Guiningan	Philippines	103	–	–	79.3
Kiribiliya	India	105	–	62.8	67.8
Puang Ngern	Thailand	107	65.6	60.8	61.0
T.1145	India	107	–	66.6	64.6
MO.1	India	110	–	63.7	–
MO.2	India	110	–	63.6	66.9
Strain 36 BK	India	111	–	–	70.2
Strain 317	India	114	–	–	73.8
Mas	Indonesia	114	–	–	75.5
Vellailankalayan	Ceylon	115	–	–	76.8
Local Sanna	India	118	–	64.8	73.0
S.22	India	120	–	64.5	64.2
GEB.24	India	120	–	60.7	60.5
Latisail	Pakistan	124	75.1	–	63.4
Nangmol	Thailand	125	–	–	57.9
Apostol	Philippines	125	–	–	65.4
Nangquot	Indochina	130	66.3	61.4	60.0
S.199	India	130	–	68.9	73.1
Indrasail	Pakistan	131	–	–	67.5
C.24–102	Burma	138	66.3	63.5	60.5
C.28–16	Burma	139	–	–	59.2
D.17–88	Burma	141	–	–	64.0
Khau Bhu Das	Thailand	146	–	–	64.0
Pinkaew	Thailand	146	–	–	66.3
Docphung Luna	Indochina	149	–	–	–
Serendah Kuning	Malaya	152	64.4	60.5	–
Nachin 57	Malaya	152	–	–	60.0
D.25–4	Burma	153	65.4	–	71.5
Neangmeas	Indochina	158	–	–	70.1
Elon Elon	Philippines	165	78.3	–	73.5
Siam 29	Malaya	170	–	–	58.7
Peykeo	Indochina	176	–	67.0	73.9
Kohumawi	Ceylon	182	–	–	–
		Mean	70.9	64.1	66.8

May	June	July	August	September	October	November	December
72.6	71.9	73.0	70.5	–	–	–	–
66.2	66.5	65.8	–	–	–	–	–
75.1	72.1	–	61.5	–	–	–	–
65.3	68.1	–	65.5	–	–	–	–
70.0	69.6	–	62.8	80.9	–	–	–
68.2	68.1	69.8	–	–	–	–	–
72.7	74.3	–	60.2	–	–	–	–
70.6	74.1	–	61.7	79.9	–	–	81.6
–	69.8	–	60.6	76.6	–	–	85.5
65.8	62.0	64.3	74.4	–	–	90.2	83.9
63.2	69.2	72.2	59.4	77.3	–	–	–
68.6	65.4	70.3	69.5	–	–	82.4	76.0
74.1	67.9	74.2	75.8	78.0	–	–	92.1
66.7	67.4	67.1	60.0	–	–	–	–
70.9	69.2	69.5	71.2	79.2	–	95.1	85.7
73.9	67.1	77.3	67.1	–	–	–	–
67.1	–	–	66.8	–	–	–	92.2
–	–	–	–	–	–	–	–
64.8	69.3	70.1	60.9	76.6	–	–	–
71.7	66.2	67.1	67.8	73.5	–	83.4	74.4
–	66.1	67.9	–	75.3	82.2	–	–
66.7	74.6	73.4	63.8	84.4	–	–	–
66.2	71.6	70.6	60.0	82.1	–	–	–
65.8	64.7	78.9	–	–	–	–	–
79.9	66.6	79.2	–	–	–	–	–
–	–	–	–	–	–	–	–
69.5	80.0	77.1	75.6	–	–	101.7	83.8
66.3	64.0	77.5	68.0	84.0	–	–	–
65.6	74.8	70.0	64.6	75.0	–	–	82.5
63.3	67.5	67.7	59.8	78.3	–	–	–
69.6	66.6	65.7	71.4	–	–	82.2	79.9
62.7	66.1	69.0	72.0	91.0	76.2	–	–
65.6	69.8	–	77.6	91.2	63.4	–	–
64.9	63.6	66.8	76.3	–	–	99.0	74.8
71.2	75.2	76.5	60.8	–	–	–	–
64.8	69.8	67.4	73.9	64.0	73.5	–	–
66.2	63.3	67.3	70.7	–	–	97.0	79.7
60.9	67.6	75.4	74.7	71.0	73.6	–	–
66.0	67.8	68.3	76.2	77.3	–	–	–
–	66.7	70.5	75.4	79.6	72.0	–	–
81.2	–	68.2	74.6	–	–	–	–
68.4	65.9	68.3	77.1	73.5	–	–	–
65.5	62.8	65.2	68.4	–	–	83.6	86.7
63.3	61.0	64.6	71.8	74.5	75.0	–	–
77.1	88.4	–	–	–	–	–	–
68.1	71.8	74.9	83.0	83.7	–	–	–
69.5	65.8	76.5	78.3	–	–	91.3	90.5
–	64.2	69.2	77.3	73.4	78.8	–	–
70.6	72.9	78.6	79.9	80.3	–	92.0	88.0
72.4	83.5	82.6	92.0	–	–	–	–
68.6	69.2	71.2	70.2	78.4	74.3	90.7	83.6

TABLE 3. TABLE SHOWING THE REGRESSION OF NORMAL FLOWERING DURATION OVER PHOTO-PERIODIC RESPONSE AND THE DEGREE OF DEVIATION OF REGRESSION VALUES FROM HYPOTHETICAL 'b' = 1.0

Month	Number of types treated	Regression of normal flowering duration over photoperiodic response	Standard error	Significance ('t' test of the deviation of regression from 1.0)
April 1951	16	0.9966	0.1129	Not significant
June 1951	19	1.0289	0.2907	–do–
July 1951	11	1.0780	0.0775	–do–
August 1951	18	0.8963	0.0609	–do–
February 1952	9	1.0569	0.0814	–do–
March 1952	27	0.9975	0.0192	–do–
April 1952	44	1.0230	0.0311	–do–
May 1952	43	1.0072	0.0225	–do–
June 1952	47	0.9954	0.0178	–do–
July 1952	47	0.9844	0.0446	–do–
August 1952	43	0.8115	0.0277	Significant
September 1952	25	1.0299	0.0413	Not significant
October 1952	8	0.9968	0.1174	–do–
November 1952	11	0.9766	0.0800	–do–
December 1952	16	0.9703	0.0535	–do–

all the monthly sowings, except that of August, was not significantly different from 1.0 and there was a good agreement between the regression data of the two years (Table 3).

It will be seen from Tables 1 and 2 that the flowering duration of the same variety under short-day varied a good deal in the different monthly sowings. Generally the varieties took a longer time to flower under short-day when sown in the winter months than in the summer months. The mean flowering durations of the varieties ranged from 64.1 in March to 90.7 in November (Table 2).

The investigation included both period fixed (early) and season bound (late) varieties. While all the varieties, whether period or season bound, came to flower under short-day treatment in the different monthly sowings (Table 1 and 2), the respective control plants in the monthly sowings behaved differently. As was expected, the period fixed varieties came to flower in all the monthly sowings and the season bound varieties when sown between January and April had not flowered at all till August-September and by that time the plants had died.

DISCUSSION

All the varieties, whether period or season bound, responded to the photoperiod treatment given – the response obtained depended on the normal flowering duration of the variety. In the case of early maturing varieties the reduction in flowering duration was small when compared to longer duration varieties and a linear relationship between normal flowering duration and photoperiod response was established. This relationship viz., one day increase in normal duration of the variety being followed by increase in the photoperiod response by one day, is of practical application and helpful in the execution of hybridization projects in which parents differ widely

in their flowering durations. It is, however, to be remembered that the relationship has been established under a particular short-day treatment.

Besides short-day, other factors like the temperature and intensity of light also influence flowering duration. KAR (6) found that warm temperature associated with short-day length was inducive to earliness, while lower temperature and long day length increased flowering duration. SIRCAR and SEN (7) have also shown that the degree of earliness by short days is associated with the temperature and WORMER (8) has indicated that increasing light intensity results in increasing the flowering duration. In the investigation reported here, the flowering duration of the varieties under short-day treatment varied with the month of sowing, the duration being shorter in the sowings done in the summer months than those done in the winter months (Table 2). This, while supporting the views of KAR (*loc. cit.*) and SIRCAR and SEN (*loc. cit.*), does not appear to support the results of WORMER (*loc. cit.*) and would perhaps indicate that the influence of temperature on flowering duration is greater than that of light intensity.

SUMMARY

Synchronisation of flowering was effected in fifty rice varieties, ranging from early to very late duration, by giving 8 light hours photoperiod to 30 days old seedlings for 20 days. The results showed that the later the type, the greater was its response to photoperiod and regression value of photoperiod response over the normal duration of the varieties was approximately 1.0.

ACKNOWLEDGEMENTS

The investigation was carried out with the material assembled for rice hybridization schemes sponsored by the Food and Agricultural Organisation of the United Nations and Indian Council of Agricultural Research at this Institute. We are indebted to Dr N. PARTHASARATHY, Director of the Institute, for his help and suggestions in preparing the manuscript and to Mr T. P. ABRAHAM, Statistician, of this Institute, for his help in statistical interpretation of the data.

SAMENVATTING

Reactie van rijstrassen op kortedag behandeling

Synchronisatie van de bloei werd verkregen bij 50 rijstrassen, variërend van vroeg tot zeer laat, door een photoperiode van 8 lichturen te geven aan 30 dagen oude zaailingen gedurende 20 dagen. De resultaten toonden dat hoe later het type, hoe groter de reactie op de photoperiode is. De regressiewaarde van de photoperiode-reactie op het normale bloeibegin der rassen bedroeg ongeveer 1.0.

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