STUDIES ON THE EFFECT OF 'SHORT' AND 'LONG DAY' TREATMENT ON THE GROWTH PERIOD AND THE FLOWERING DATES OF DIFFERENT PADDY VARIETIES

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Introduction

Difficulties have often been experienced by plant-breeders in effecting crosses between crop varieties differing widely in their flowering dates. This, however, gets more pronounced in a crop like paddy, where the flowering dates differ widely and are more or less fixed for individual varieties or strains, *i.e.*, an early 'Aman' variety shall always flower, under Bihar conditions, in early October whereas the late ones do so at the end of the same month or in early November, when the earlier ones have finished all their flowering and are practically ripe. In such cases, a cross is ordinarily not possible except by utilizing the late tillers of the early variety. This method, however, has its own limitations, specially when the interval between the flowering dates of the varieties to be intercrossed is fairly long. Besides this, the setting in late tillers is usually poor and as such the crosses made at this stage are not always successful. In view of these facts, it was thought that all these difficulties may be successfully solved, if the flowering dates could be suitably altered by increasing or decreasing the 'day length' artificially. This method of altering the time of flowering was initiated by Garner,[4,5,6] who introduced the term photoperiodism to designate the response of plants to the relative length of day and night. Since then many investigators have published results of studies of this phenomenon as it applies to plants. Names of Adams,[1] Evans,[3] Harrington,[7] Ramaley,[8] Shirley,[9] and Tincker[10] may be mentioned as chief workers in the line. Chien-Liang Pan[2] from China published some preliminary results on rice—a crop which does not seem to have been extensively studied and practically no work appears to have been done under Indian conditions. In view of these facts and specially the difficulties encountered by the breeders enumerated above, experiments were taken up to investigate the problem of suitably altering the flowering dates of paddy varieties under Sabour conditions. The results obtained so far are briefly indicated in the present paper.

A. Exposing Plants to Long Day Length

1. *Material and Method*

In the experiment 30-days old seedlings from one pure strain, 46 BK, were transplanted singly in pots, containing well mixed rice field soil. After a lapse of 30 days from transplanting—*i.e.*, when the

seedlings had fully established themselves—pots showing fairly uniform growth were selected for experimentation. For each treatment there were six plants.

Constant illumination was given by exposing the plants arranged in a ring to a 200 C.P. Petromax light which was kept in centre uniformly lighted throughout the period of darkness, *i.e.*, from sunset to sunrise. The distance from the Petromax to the plants was 2½ feet.

Plants were exposed to constant light for various periods and at different stages of the growth fully indicated in Table I. After the completion of the treatment plants received only sun light and their subsequent performance was watched carefully and their general growth along with their flowering dates were noted and the results obtained are are given in Table I.

TABLE I

Statement showing the effect of constant illumination on growth and time of flowering of a timely 'fixed' paddy variety

Period of constant illumination	Date on which the plants came to flower	Remarks
1	2	3
Set A—		
1. 40 days .. .. (Sept. 1–Oct. 10)	Dec. 12	Growth very poor ; flowering delayed by 46 days
2. 30 days .. .. (Sept. 11–Oct. 10)	Nov. 17–18	Growth poor ; flowering delayed by about 21 days
3. 20 days .. .. (Sept. 21–Oct. 10)	Nov. 7–9	Growth fair ; flowering delayed by about 11 days
4. 10 days .. .. (Oct. 1–10)	Oct. 25–27	Growth practically normal ; no change in the flowering date
Set B—		
1. 10 days .. .. (Oct. 1–10)	Oct. 26–27	Growth practically normal ; no change in the flowering dates
2. 20 days .. .. (Aug. 22–Sept. 1)	Nov. 6–9	Growth fair ; flowering delayed by about 10 days
3. 30 days .. .. (Aug. 22–Sept. 20)	Nov. 16–17	Growth fair ; flowering delayed by about 20 days
4. 40 days .. .. (Aug. 22–Sept. 30)	Dec. 8–10	Growth very poor ; flowering delayed by about 42 days
5. In constant light from Sept. 1	..	Plants presented a withered appearance. Treatment was therefore discontinued on Nov. 26
6. Received only the usual sunlight (control)	Oct. 26–27	Normal flowering

2. *Results and their Discussions*

From the above table it is clear that by suitably increasing the length of day, time of flowering can considerably be delayed, in so much so that the plants which received constant illumination continuously for a period extending over 30 days beyond the normal flowering, did not come to flower and ultimately the treatment was abandoned as the plants presented a withered appearance. The above results also show that 10 days of constant illumination does not produce any effect on the flowering dates of paddy whereas a period of 20, 30 and 40 days of constant illumination, irrespective of the stage, earlier (set A) or later (set B) in the growth period, at which it is given, bring about a delay in the flowering dates to the extent of 10, 20 and 45 days respectively, *vide* column 3 of Table I.

After establishing the possibility of delaying the flowering time of paddy by subjecting the plants to increased 'day length', experiments were taken up to study in detail the effect of short 'day length' on flowering time of the various classes of paddy varieties.

B. Exposing Plants to Short Day Length

1. *Material and Method*

The material used in this study consisted of five pure varieties of paddies widely differing in their growth periods, when grown under normal conditions, as indicated below :—

(*a*) *Periodly fixed paddies*, i.e., '*Aus*'.—

(i) 'Sathis' takes about 60 days to come to flower from the date of germination, irrespective of the season.

(ii) 'Aus' No. 28–16–21 : takes about 80 days to come to flower from the date of germination, irrespective of the season.

(*b*) *Timely fixed paddies*, i.e., '*Amans*'.—

(iii) Early 'Aman' (115 BK) : flowers between 8–10 Oct.

(iv) Medium 'Aman' (16 BK) : flowers between 20–22 Oct.

(v) Late 'Aman' (36 BK) : flowers between 28–30 Oct.

Three seeds of each of these five varieties were sown on 27th May in pots containing well mixed rice field soil. Ultimately in each pot seedlings were thin down to one. Seedlings of the following age of the varieties under experimentation, as indicated below, were included in the test. Age of the seedlings was counted from the date they emerged out of the soil.

Paddy varieties		Age of the seedlings in days
'Sathi'	..	7, 15 and 30.
'Aus' 28–16–21	..	7, 15, 30 and 45.
Early 'Aman'	..	7, 15, 30, 45, 60, 75, 90, 105 and 120.
Medium 'Aman'	..	7, 15, 30, 45, 60, 75, 90, 105 and 120.
Late 'Aman'	..	7, 15, 30, 45, 60, 75, 90, 105 and 120.

The 'short days' were given in each case by removing the plants from daylight to a well ventilated dark room at 3 p.m. and 5 p.m. each day. In the following morning at 5 a.m. they were taken out of the dark room and placed outside in the open along with the control plants. Each set was replicated 4 times.

In the following order, the seedlings were subjected to the 'short days' on the dates noted against each of them in Table II.

TABLE II

Paddy varieties	Age of the seedlings in days	Dates on which 'short day' treatment was started
1	2	3
1. 'Sathi', 'Aus' and 'Aman' ..	7	8th June
2. 'Sathi', 'Aus' and 'Aman' ..	15	15th June
3. 'Sathi', 'Aus' and 'Aman' ..	30	30th June
4. 'Aus' and 'Aman'	45	15th July
5. 'Aman'	60	30th July
6. 'Aman'	75	14th August
7. 'Aman'	90	29th August
8. 'Aman'	105	13th Sept.
9. 'Aman'	120	28th Sept.

When the plants came to flower the 'short day' treatment was discontinued in each case and the plants were thenceforth kept in open for further growth along with the controls. Results obtained are fully detailed in Table III.

2. *Results and their Discussions*

It may be seen from Table III that the plants of all the varieties under experimentation in both 3 p.m. and 5 p.m. sets up to 30 days-old seedlings, came to flower at about the same time, end of July, *i.e.*, within 60–63 days of germination. The actual period of earliness in flowering induced by the 'short day' treatment being dependent on the normal flowering dates of these varieties (columns 7 and 8, Table III) is thus different in the different varieties. Consequently the 'Aus' variety flowered 19–20 days earlier than the control whereas the early, medium and late 'Aman' varieties flowered earlier by 67–69, 79–81 and 87–89 days than their respective controls.

The 'Sathi' variety did not at all respond to the treatment. Its 60 days normal period of growth could not be reduced and it thus flowered with the control.

All the varieties in the 45 days set came to flower together on 15th–22nd of August, *i.e.*, about a fortnight later than that of 7, 15 and 30 days sets. In the remaining sets, *i.e.*, 60, 75, 90 and 105, all the varieties under trial flowered together on 1-5th September, 15-18th September, 30th September to 5th October and 14th October to 20th October respectively, *i.e.*,

at fortnightly intervals throughout their growth period. The early paddy in the 105 days set and the medium and late in the 120 days sets, which were near their normal maturity when the light treatment was commenced, did not respond to the treatment and came to flower with the control. The behaviours of the 3 p.m. and 5 p.m. sets, in all these cases as well were almost similar. The induced period of early flowering in these sets as the light treatment was given at later dates (column 3, Table III) was correspondingly shorter as fully detailed in columns 7 and 8 of the table under reference.

It may further be seen from Table III that the seedlings of the age of 30 days and over have taken 30–33 days of the light treatment in both the sets of 3 p.m. and 5 p.m. to come to flower earlier than their controls. But the case of 7 and 15 days old seedlings sets is different in this respect. They have, as may be seen, columns 3 and 4 of Table III, taken longer periods of 'short-days', *i.e.*, 53–55 and 45–47 days respectively in both the sets (3 p.m. and 5 p.m.). When we compare these results with that of the seedlings of older age (30 days and over) it seems highly probable that the extra period of 23–25 days in case of 7 days and 15–17 days in case of 15 days old seedlings have been utilised in vegetative growth to make a total of 30 days and the net period of 'short-days' to induce early flowering is probably only 30–33 days as is the case with older seedlings, *i.e.*, 30 days and over.

It is interesting to note from these studies that a period of 60 days is the very minimum for any variety of paddy to come to flower. The 'Sathi' having 60 days growth period are thus the earliest paddy in nature.

These studies have opened out a new field for hybridization work in paddy by enabling us not only to make paddy varieties widely differing in their normal flowering dates to flower simultaneously, any time in the season, but also to make individual plants of any particular variety to come to flower, one after the other, throughout its growing period—as against hardly for a fortnight at fixed time—and thus get ample material and opportunity for intercrossing it with large number of other varieties and strains with different periods of maturity and flowering dates.

It may incidentally be pointed out that the late variety, which was under study in pots, was also grown in four small beds in one of the paddy fields. When the seedlings were 30 days old, two of them were covered with moveable Tati-covers at 3 p.m. each day. After about 32 days of this treatment, the two experimental beds came to flower. Thus by this light treatment any individual plant or a set of plants in a plot can be made to flower at any suitable earlier date and thus serve a variety of purpose.

It may finally be mentioned that quite a good amount of data have been collected on the growth and yield of the plants subjected to these light treatments, which will form the subject-matter for next paper. But it will not be out of place to mention in a general way that the height of the plants subjected to 'short day' treatment gets increased.

TABLE III

Table showing the effect of shortening the 'day length' at different stages of growth on the flowering dates of different paddy varieties

Age of seedlings before receiving the treatment	Paddy variety	Total number in days for which plants received 'short days' before coming to flower. Figures in brackets show the dates on which the treatment was started in both 3 p.m. and 5 p.m. sets		Date of flowering — Hours for which plants received sunlight		Average period in days of induced early flowering as compared to the control	
		3 p.m. set	5 p.m. set	3 p.m. set	5 p.m. set	3 p.m. set	5 p.m. set
1	2	3	4	5	6	7	8
		(8th June)					
7 days' old ..	'Sathi'	53	53	31st July–1st Aug.	31st July–1st Aug.	Flowered	with control
	'Aus' (28–16–21)	54	53	1st–2nd Aug.	31st July–2nd Aug.	19	20
	Early (115 BK)	53	55	31st July –1st Aug.	2nd–3rd Aug.	69	67
	'Aman' Medium (16 BK)	55	53	2nd–4th Aug.	31st July–2nd Aug.	79	81
	Late (36 BK)	53	55	31st July–2nd Aug.	2nd–4th Aug.	89	87
		(15th June)					
15 days' old ..	'Sathi'	47	45	2nd–3rd Aug.	31st July–2nd Aug.	Flowered	with control
	'Aus' (28–16–21)	45	46	31st July–2nd Aug.	1st–2nd Aug.	20	19
	Early	47	45	2nd–4th Aug.	1st–2nd Aug.	67	68
	'Aman' Medium Do.	45	45	31st July–3rd Aug.	31st July–3rd Aug.	81	81
	Late	46	47	1st–3rd Aug.	2nd–3rd Aug.	88	87
		(30th June)					
30 days' old ..	'Sathi'	31	30	31st July–1st Aug.	30th–31st July	Flowered	with control
	'Aus' (28–16–21)	29	30	29th July–1st Aug.	30th July–2nd Aug.	22	21
	Early	32	30	1st–4th Aug.	30th July–3rd Aug.	68	69
	'Aman' Medium Do.	29	30	29th July–2nd Aug.	30th July–4th Aug.	73	82
	Late	32	30	1st–4th Aug.	30th July–3rd Aug.	88	90

45 days' old	'Aus' (28–16–21)		(15th July)					
	Early		32	30	17th–20th Aug.	15th–18th Aug.	3	5
	'Aman' Medium	Do.	32	30	17th–20th Aug.	15th–18th Aug.	52	54
	Late		35	33	20th–22nd Aug.	18th–21st Aug.	61	63
			36	34	21st–22nd Aug.	19th–22nd Aug.	68	70
60 days' old			(30th Aug.)					
	Early		32	33	1st–3rd Sept.	2nd–3rd Sept.	37	36
	'Aman' Medium	Do.	33	32	2nd–4th Sept.	1st–4th Sept.	48	49
	Late		32	33	1st–4th Sept.	2nd–5th Sept.	57	56
75 days' old			(14th Aug.)					
	Early		31	32	15th–18th Sept.	16th–18th Sept.	23	22
	'Aman' Medium	Do.	32	31	16th–17th Sept.	15th–17th Sept.	34	35
	Late		32	31	16th–18th Sept.	15th–17th Sept.	42	43
90 days' old			(29th Aug.)					
	Early		32	32	1st–4th Oct.	1st–3rd Oct.	7	7
	'Aman' Medium	Do.	31	32	30th Sept.–2nd Oct.	1st–2nd Oct.	20	19
	Late		33	31	2nd–5th Oct.	30th Sept.–4th Oct.	26	28
105 days' old			(13th Sept.)					
	Early		23	22	8th–9th Oct.	7th–8th Oct.	Flowered with control	
	'Aman' Medium	Do.	30	29	15th–16th Oct.	14th–16th Oct.	5	6
	Late		32	31	17th–20th Oct.	16th–20th Oct.	11	12
120 days' old			(28th Sept.)					
	Early		..	..	..	..	..	..
	'Aman' Medium	Do.	18	20	18th–20th Oct.	20th–21st Oct.	Flowered with control	
	Late		29	28	29th–30th Oct.	28th–30th Oct.	Flowered with control	

'Sathi'	31st July–1st Aug.	
'Aus' (28–16–21)	20th–22nd Aug.	Normal flowering date
Early	8th–10th Oct.	
'Aman' Medium	20th–22nd Oct.	
Late	28th–30th Oct.	

Number of tillers, dry weight of straw and yield per plant does not seem to differ very much from that of the control plants.

Lastly, it may be mentioned that other aspects of the problem, such as the effect of 'short day' treatment, given at the seedling stage on the growth and flowering of the transplanted crop and other inter-related questions are under investigation and the results will be presented later.

Summary and Conclusions

A. 'Long day' treatment.

1. By increasing the 'day lengths', *i.e.*, by exposing the plants to artificial light during the night, flowering time of paddy can be suitably delayed—the actual shifting of the flowering dates depends on the duration of the 'long day' treatment given.

B. 'Short day' treatment.

1. Any variety of paddy, irrespective of the class or maturity period to which it may belong, can be induced to flower within 60–63 days of germination.

2. With 'short day' treatment, different paddy varieties with different flowering dates can not only be made to flower simultaneously but individual plants of any particular variety can also be induced to flower, one after another throughout the growing period—thus offering ample material and opportunity for intercrossing it with a number of other varieties with different maturity periods.

3. With this treatment, even 'Aus' varieties, whose period of growth between sowing and flowering is fixed and rather short, can be induced to flower earlier.

4. The 'Sathi' variety did not at all respond to the treatment. Its 60 days normal period of growth could not thus be reduced any further.

5. 'Short day' treatment method has been found to be easier to work with than the 'long day' one specially when Petromax is used as a source of light.

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LITERATURE CITED

1. Adams, J. (1924) .. "Duration of light and growth," *Ann. Bot.*, **38**, 509–23.
2. Chien-Liang Pan (1936) "Length of exposure to light in relation to plant growth in rice," *Jour. Amer. Soc. Agronomy*, **28**, No. 1, 58–63.
3. Evans, M. W. (1931) .. "Relation of latitude to time of blooming of timothy," *Ecology*, **12**, 182–87.
4. Garner, W. W. (1920) "Flowering and fruiting of the plants as controlled by the length of day," *U. S. D. A. Year Book*, **1920**, 377–400.
5. ——— and Allard, H. A. (1920) "Effect of the relative length of day and night and other factors of environment on growth and reproduction in plants," *Jour. Agr. Res.*, **18**, 553–606.
6. ——————— (1931) .. "Effect of abnormally long and short alterations of light and darkness on growth and development of plants," *ibid.*, **42**, 629–51.
7. Harrington, J. B. (1927) "Growing wheat and barley hybrids in winter by means of artificial light," *Sci. Agr.*, **7**, 125–30.
8. Ramaley, F. (1931) .. "Some Caryophyllaceous plants influenced in growth and structure by artificial illumination supplemental to daylight," *Bot. Gaz.*, **92**, 311–20.
9. Shirley, H. L. (1929) .. "The influence of light intensity and light quality upon the growth of plants," *Amer. Jour. Bot.*, **16**, 354–90.
10. Tincker, M. A. H. (1925) "The effect of length of day upon the growth and reproduction of some economic plants," *Ann. Bot.*, **39**, 721–54.