PHOTOPERIODISM IN RICE

IV. Effects of Short Day Length on Three Medium-Early Varieties of Rice of Uttar Pradesh

by Gadadhar Misra, *Department of Botany, Ravenshaw College, Cuttack*

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Introduction

The photoperiodic responses of different varieties of paddy have been markedly different as reported by workers in this field. Pan (1936) working with certain Chinese varieties found that different short-day photoperiods bring about 10 per cent increase in the average height of the treated plants over the controls. Fewer culms were formed in the treated plants of early and medium-maturing varieties. He also observed that the period of maturity in the treated plants was cut short, shortening being more conspicuous in the late-maturing varieties than in the early ones.

Fuke (1931) working on certain Japanese varieties of paddy showed that short days were most effective on freely tillering plants, having 7–9 leaves. Treatments given to more advanced plants, a month prior to heading time, were much less effective. Such treatments were equally ineffective either when provided to very young plants, which had not even entered the 7–9 leaves stage, or to older ones, which were but 16 days behind the natural heading time.

In U.S.A., Beachell (1943) studied the effects of different short-day treatments, administered at different stages of plant development, in 10 varieties of rice grown under field conditions. He concluded that the varieties, based on their reactions to these treatments, could be divided into two groups, (1) 'Sensitive', and (2) 'Less Sensitive'.

The effects of short and long photoperiods on early varieties of U.P. (Misra, 1955*a*), on late varieties of Bihar (Saran, 1950) and Bengal (Sircar, 1942 and 1946) and on one spring variety of Orissa (Misra, 1954*c*) reveal the fact that different varieties of Indian paddy respond differently to different photoperiods. The present investigation was, thus, aimed at finding out the photoperiodic responses of 3 medium-early varieties of paddy of the State of Uttar Pradesh.

Material and Methods

The three different varieties of paddy used for experimentation in this work were as follows:

(1) T. 3, a selection from Basmati of Dehra Dun district,
(2) T. 12, a selection from Hanshraj of Unao district, and
(3) T. 21, a selection from Chawal of Rampur State.

Seeds were first sown in small nursery pots (15″ × 5″) and segregated into half-a-dozen lots. A week after germination, the seedlings belonging to different lots were subjected to 10-hour photoperiodic exposures for 3, 4, 5 and 6 weeks respectively. One of the lots which received the above treatment for 6 weeks in the seed-bed was further provided with this short-day treatment until panicle emergence.

The photoperiodic treatments consisted of a daily 10-hour exposure to natural daylight in the field from 8-0 a.m. to 6-0 p.m. For the remaining 24-hour cycle, the potted plants were removed to a well ventilated dark room. The seedlings were subsequently transplanted into other pots (11″ × 10″) and allowed to grow in the open till maturity. Controls were maintained side by side. Except for differences in the photoperiodic exposures, all plant lots were grown under identical conditions of factor intensity. A brief report was made in this direction in an earlier publication (Misra, 1953).

Experimental Results

Heading in Plants.

Data gathered on the time of panicle emergence are presented in Table I. These observations were subjected to statistical analysis as reported in Table II. At the time of panicle emergence in the control plants, representatives from the control and treated series were photographed to exhibit differences in their growth behaviour (Figs. 1 and 2).

Table I

Time from sowing to ear emergence of the main shoot.

Varieties	No. of days from sowing to ear emergence (Average of 24 plants)			
	T.3	T.12	T.21	Mean
Treatments				
Controls	106·25	99·30	108·70	104·75
S. Day for 3 weeks	106·30	107·55	111·15	108·33 (− 3·58)
S. Day for 4 weeks	107·70	108·90	112·05	109·55 (− 4·80)
S. Day for 5 weeks	109·75	110·25	113·75	111·25 (− 6·50)
S. Day for 6 weeks	112·45	111·85	115·85	113·38 (− 8·63)
S. Day prolonged till ear emergence ..	128·00	121·25	121·55	123·60 (−18·85)

S.E. of a treatment mean = 0·45; C.D. at 5% of a treatment mean = 1·26.
S.E. of an individual mean = 0·78; C.D. at 5% for comparing two individual means = 2·19.

Sowing date: June 18, 1949; transplanting date: June 25, 1949. + indicates earliness; − indicates delaying effect. Figures in brackets indicate difference from controls.

Table II

Analysis of variance.

Source of variation	D.F.	S.S.	M.S.	F.	5% F.	1% F.
Varieties (V)	2	239·22	119·61	39·73**	3·13	4·92
Treatments (T)	5	3,132·47	626·49	208·13**	2·35	3·29
Interaction (V × T) ..	10	351·90	35·19	11·69**	1·97	2·59
Error	72	222·32	3·01			
Total ..	89	3,945·91				

** Indicates significance at 1% level.

A perusal of the data on ear emergence (Tables I and II) clearly shows that there is a gradual delay in the heading of plants as the duration of short-day treatment increases in the seed-bed and thereafter. With 3 weeks of short-day treatment, delay in the ear emergence averaged 0·5, 8·25 and 2·45 days respectively for the three different varieties of paddy, viz., T.3, T.12 and T.21. With 6 weeks of similar treatment, the heading time of these three varieties was delayed by 6·20, 12·55 and 7·15 days respectively. When the short-day treatment was prolonged till ear emergence, the delay in the commencement of heading was much more (Table I).

Although short-day treatments greatly delayed the ear emergence in all the three varieties of paddy, no inhibitory effect by way of complete suppression of some of the ears of the main shoot was observed in the prolonged short-day series. There was another important finding. Of the three varieties of paddy experimented upon, T.12 responded most to the photoperiodic treatments and variety T.3 the least. It may here be noted that T.12 is comparatively an early variety.

Some Morphological Characters.

Observations on the number of tillers, number of leaves and the height of plants, belonging to different treated and control series, were made at four regular intervals in their life-cycle. The final records are presented in Table III. It may be noted that the trend of all such observations was almost the same at the different stages of plant growth.

TABLE III

Certain morphological observations following short-day exposure of seedlings for different periods of three paddy varieties

Paddy varieties	Controls	Short-day exposures for				
		3 weeks	4 weeks	5 weeks	6 weeks	Prolonged till heading
	No. of tillers per plant					
T.3 ..	4·55	4·20	4·45	4·65	4·90	1·70
T.12 ..	4·30	3·00	3·15	3·25	3·05	1·40
T.21 ..	4·05	3·05	3·65	3·60	3·85	2·15
Mean ..	4·30	3·41	3·75	3·83	3·93	1·75
	No. of leaves per plant					
T.3 ..	15·90	16·35	16·55	16·90	17·45	6·85
T.12 ..	14·10	9·10	10·20	11·00	10·35	8·05
T.21 ..	14·15	11·20	11·25	12·65	13·70	9·10
Mean ..	14·71	12·21	12·67	13·51	13·83	8·00
	Height per plant in cm.					
T.3 ..	124·90	123·15	126·50	128·20	132·65	83·85
T.12 ..	135·40	157·70	150·95	157·35	152·25	104·35
T.21 ..	137·25	146·95	143·90	146·30	151·45	107·50
Mean ..	132·51	142·60	140·45	143·95	145·45	98·56

A careful examination of the data (Table III) would reveal the following points of interest:

(*a*) None of the short-day treatments seemingly induce any significant difference in tiller number in plants of paddy variety T.3 as compared with untreated controls. In the other two varieties of plants, a decrease in this respect was well evident, and more so in variety T.12. In all the three varieties, the prolonged short-day treatment, however, reduced the number of tillers, rather considerably.

(*b*) Number of leaves slightly increased following all the seed-bed treatments on plants of paddy variety T.3. In varieties T.12 and T.21 (specially in T.12), leaf number, contrariwise, decreased. There was a marked decrease in this respect in plants of all the three varieties, when subjected to prolonged photoperiodic treatment. These observations were more or less similar to those obtained for tillers.

(*c*) All photoperiodic treatments ranging from 3 to 6 weeks initiated an increase in the height of plants belonging to varieties T.12 and T.21. In variety T.3, however, the treatments for 5-6 weeks only effected such a change In the series of plants, of all the three varieties, subjected to prolonged photoperiodic treatment, the height invariably decreased.

Grain Yield.

The grain yield was recorded in the usual way by weighing the sundried fully mature grains. Average weight of grains per plant is presented graphically in figure 3.

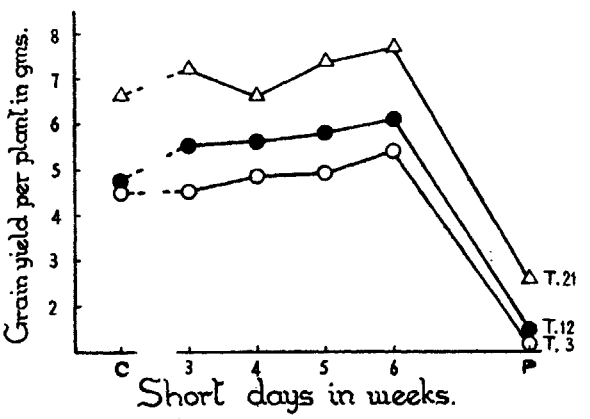
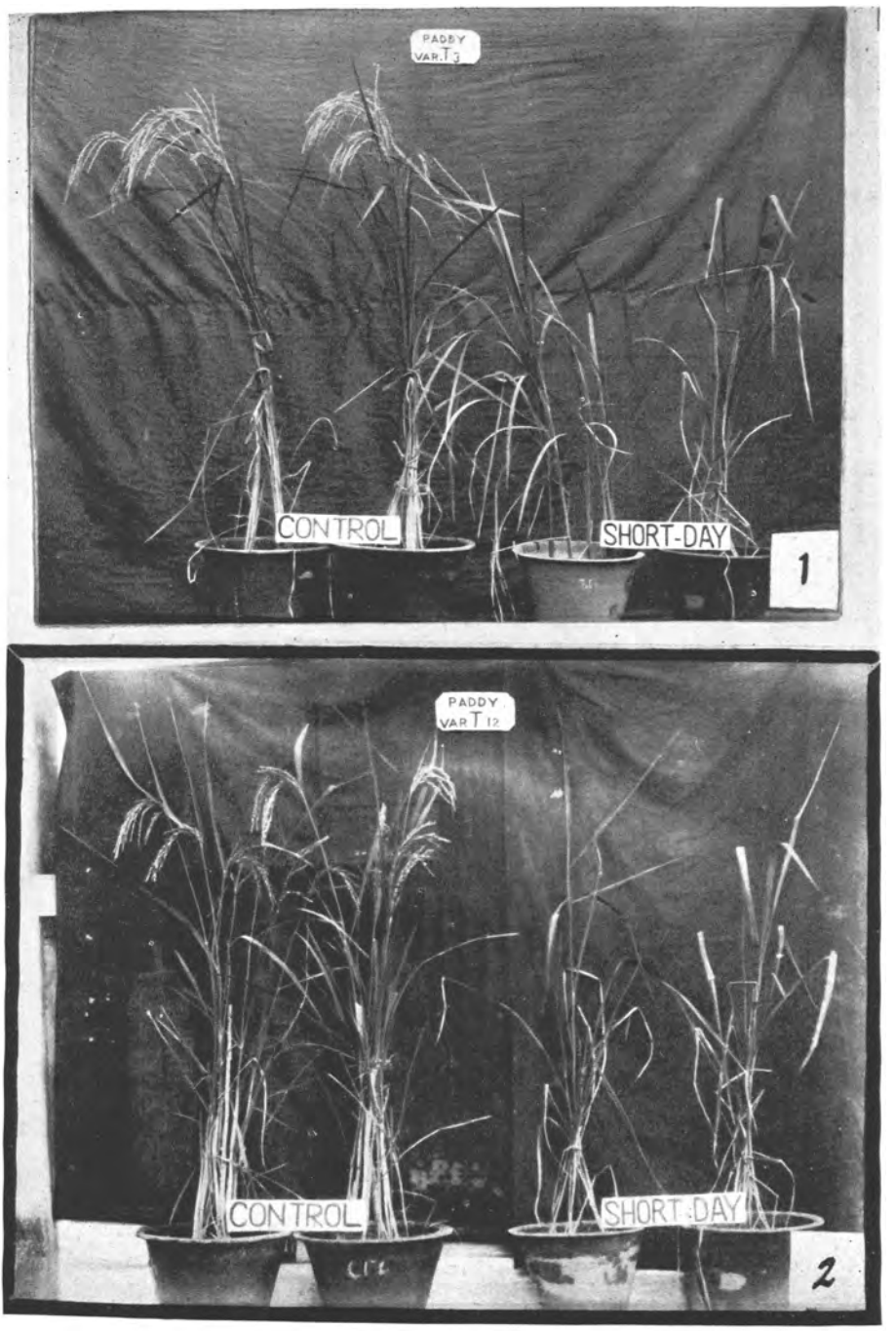


FIG. 3. Grain yield per plant in gms. of the three medium-early varieties T.3, T.12 and T.21 when the 7-day old seedlings were subjected to 10 hour short days for 3, 4, 5, 6 weeks and till ear emergence. The grain yield in prolonged treatment set (P) is considerably less in comparison with the control set (C) receiving full length of natural day.

The data on grain yield were subjected to statistical analysis. It is found that short-day treatment of 3, 4, 5 and 6 weeks durations did not induce any significant difference in yield over the controls in variety T.3. In variety T.12, 5 to 6 weeks treatments initiated higher yields. Similar increases in yield are obtained in variety T.21, following 6-weeks photoperiodic treatments.

The overall effect of treatments in the seed-bed, with regard to increases in grain yield, was significant for all the three different varieties, being 14·3 per cent



FIGS. 1, 2. Earliness and copious flowering in the control plants exhibiting luxuriant growth in the medium-early varieties of rice, T.3 and T.12 as against the prolonged short-day (10 hr.) treated plants which are still continuing a poor vegetative growth. Seed sown June 18. Photographed October 15.

over the controls for the lot receiving short-day treatment for 5 weeks and 21·1 per cent for the one similarly treated for 6 weeks. A highly significant decrease in yield to an extent of 67·3 per cent compared with the controls was, on the other hand, obtained for the experimental lot treated in the like manner till the time of ear emergence.

Components of Yield.

The components of yield, such as, the number and length of panicles, the number of spikelets and grains per panicle, the percentage of grains set per panicle, and the absolute weight (wt. of 1,000 grains) of grains are presented in Table IV. The results of statistical analyses of these data are shown in Table V.

The following observations are made on an analysis of the data presented in Tables IV and V:

(*a*) Of the three varieties of paddy experimented upon, two behaved slightly differently than the third. The number of panicles produced under the influence of 3, 4, 5 and 6 weeks short-day treatments was not significantly different in varieties T.3 and T.21 than those borne by the controls. In variety T.12, however, these very treatments brought about a significant decrease in this respect. When, on the other hand, the short-day treatment prolonged till ear emergence, a conspicuous decrease in the panicle number was obvious in all the three varieties of plants.

(*b*) There was no marked difference in the length of the panicle belonging to the control plants and the ones that received the short-day treatment for 3, 4, 5 and 6 weeks respectively in the varieties T.3 and T.21. An increase in this direction was, however, observed under similar treatments in variety T.12. The short-day treatment prolonged till ear emergence, contrariwise, significantly decreased the length of the panicle, in all the three varieties.

(*c*) The average number of spikelets per panicle greatly increased in the lots receiving short-day treatments for 3, 4, 5 and 6 weeks respectively. Of these, the 6-weeks short-day treatment was more effective for all the three different varieties, T.3 exhibiting the least response and T.12 the maximum. Short-day treatment prolonged till ear emergence, reduced the number of spikelets considerably in all the three varieties of paddy.

(*d*) The number of grains per panicle significantly increased in plants of varieties T.12 and T.21 by short-day treatments of 3, 4, 5 and 6 weeks duration. In variety T.3, however, no significant difference from the controls was observed in this respect in any of the treated lots. When the short-day treatment continued beyond the 6th week stage until ear emergence, an adverse effect on grain formation followed. The effect was very marked and highly significant.

(*e*) The effect of the short-day treatments on the three varieties of paddy was an increase in the percentage of grain setting, particularly in the lots receiving the treatment for 5 and 6 weeks. It is of interest to note that although in the lot where the short-day treatment continued till heading time, the spikelets and grains per panicle considerably decreased relative to controls, the percentage grain setting per panicle was not adversely affected. It was rather high for all the three varieties of paddy.

(*f*) The absolute weight of a thousand grains did not appreciably alter under the influence of any of the short-day treatments for any of the three varieties of paddy used for experimentation.

TABLE IV

Effect of short days on the characters of panicle, spikelets and grains

Paddy varieties	Controls	Short-day exposures for				
		3 weeks	4 weeks	5 weeks	6 weeks	Prolonged till heading
	No. of panicles per plant					
T.3 ..	4·45	3·95	4·25	4·35	4·00	1·65
T.12 ..	3·70	2·75	2·65	2·80	2·60	1·30
T.21 ..	3·30	2·80	2·90	2·80	2·85	1·85
Mean ..	3·81	3·16	3·26	3·31	3·15	1·60
	Length of panicle in cm.					
T.3 ..	23·20	22·54	22·58	23·30	24·24	14·20
T.12 ..	20·18	22·98	22·56	22·74	23·88	12·64
T.21 ..	21·62	23·90	21·42	21·46	21·86	15·02
Mean ..	21·66	23·14	22·18	22·50	23·32	13·95
	No. of spikelets per panicle					
T.3 ..	70·36	80·54	72·08	74·80	85·10	42·38
T.12 ..	89·70	131·26	131·68	120·80	132·64	67·88
T.21 ..	99·38	113·76	110·20	112·88	116·78	66·18
Mean ..	86·48	108·52	104·65	102·82	111·50	58·81
	No. of grains per panicle					
T.3 ..	50·76	59·68	58·66	57·94	64·84	32·14
T.12 ..	63·60	93·54	98·28	96·42	108·14	54·44
T.21 ..	78·92	98·60	90·60	99·30	103·08	57·14
Mean ..	64·44	83·94	82·51	84·55	92·02	47·90
	Percentage of grains set per panicle					
T.3 ..	72·14	74·09	81·38	77·45	79·95	75·83
T.12 ..	70·90	71·26	74·63	79·81	81·52	80·20
T.21 ..	79·41	86·67	82·21	87·96	88·26	86·34
Mean ..	74·15	77·34	79·40	81·74	83·24	80·79
	Weight of one thousand grains in gms.					
T.3 ..	20·12	19·46	19·58	19·60	21·00	21·26
T.12 ..	20·98	21·60	21·74	21·94	22·00	21·16
T.21 ..	25·68	26·34	25·30	26·56	26·38	24·58
Mean ..	22·26	22·46	22·20	22·70	23·12	22·33

TABLE V

Analyses of variance of the data of components of yield

Source of Variation	D.F.	S.S.	M.S.	F.	5% F.	1% F.
			No. of panicles per plant			
Varieties	2	23·68	11·84	40·82**	3·13	4·92
Treatments ..	5	42·48	8·49	29·27**	2·35	3·29
Interaction (V × T) ..	10	6·11	0·61	2·10*	1·97	2·59
Error	72	21·05	0·29			
Total ..	89	93·32				
			Length of panicle			
Varieties	2	13·54	6·77	4·31*	3·13	4·92
Treatments ..	5	954·77	190·95	121·62**	2·35	3·29
Interaction (V × T) ..	10	58·48	5·84	3·71**	1·97	2·59
Error	72	113·10	1·57			
Total ..	89	1,139·89				
			No. of Spikelets per panicle			
Varieties	2	28,460·41	14,230·20	85·16**	3·13	4·92
Treatments ..	5	29,856·93	5,971·38	35·73**	2·35	3·29
Interaction (V × T) ..	10	3,410·47	341·04	2·04*	1·97	2·59
Error	72	12,029·97	167·08			
Total ..	89	73,757·78				
			No. of grains per panicle			
Varieties	2	21,641·47	10,820·73	91·62**	3·13	4·92
Treatments ..	5	20,368·76	4,073·75	34·49**	2·35	3·29
Interaction (V × T) ..	10	2,058·62	205·86	1·74	1·97	2·59
Error	72	8,503·32	118·10			
Total ..	89	52,572·17				
			Weight of one thousand grains			
Varieties	2	516·81	258·40	195·75**	3·13	4·92
Treatments ..	5	9·05	1·81	1·37	2·35	3·29
Interaction (V × T) ..	10	25·36	2·53	1·91	1·97	2·59
Error	72	95·24	1·32			
Total ..	89	646·46				

* Significant at 5% level.
** Significant at 1% level.

Discussion

From the foregoing results, it is clear that short-day treatments of 10 hours per day beginning with 1-week-old seedlings for varying durations of 3, 4, 5 and 6 weeks respectively bring about a gradual delay in the first panicle emergence in each of the three varieties of paddy. When the treatment is continued till heading, the delay in panicle emergence is observed to be much more. The photoperiodic responses of these medium-early varieties of paddy fall in line with the early varieties of U.P., where also a delay in the ear emergence was observed under such treatments (Misra, 1955*a*). Working with early paddy varieties of Bengal, Sircar and Ghosh (1947) noted a similar delay in the onset of heading. This relationship of short photoperiodic treatments with the lengthening in the vegetative period of paddy plants does not appear to be of universal occurrence. Sircar and Parija (1949) did not observe such a relationship with two other varieties of early paddy. Treating two early and eight late varieties of paddy with long and short photoperiods for a fortnight, Kar (1946) concluded that high temperature associated with short day lengths would induce earliness and low temperature or long day lengths would, contrariwise, produce retardation effect. The observations made in the present investigation give evidence but contrary to Kar's generalisations. In the three medium-early varieties of U.P. paddy grown under the prevailing warm climate, short photoperiods instead of inducing earliness bring about a marked delay in heading.

The response of these medium-early varieties to prolonged photoperiodic treatments is rather different than of the late varieties. Using the same photoperiods as in the present investigation until the usual heading time, Misra (1954*a* and *b*) observed a marked earliness in the ear emergence of four early-winter and four late-winter varieties of U.P. paddy.

It is clear that exposure of plants of three medium-early varieties of paddy to short photoperiods for 3 to 6 weeks delayed the ear emergence on an average by 3 to 9 days. Short-day treatments are, therefore, of no avail in obtaining an early crop of paddy. There is, however, an increase in grain yield to an extent of 8 to 21 per cent on an exposure of plants to the same short-day treatments. This increase in yield evidently owes to the larger number of grains formed per panicle and to better setting.

It is found that the number of panicles formed per plant as a result of short-day treatments is actually less than the controls and the absolute weight of grains is seemingly unaffected. All the same if there is no danger of flood or other misfits of nature, the crop can yield about 21 per cent more on standing for a period of about 10 days more than the normal. This increase in yield will certainly prove of importance to paddy growers.

While studying the effects of 24-hour long light periods on these medium-early varieties of paddy, a delaying effect on ear emergence was noticed (Misra, 1955*b*). On the basis of their flowering behaviour in relation to length of day, these medium-early varieties of paddy may, thus, aptly be classified as 'intermediates'. They flower within a definite range of the length of the day and blossom but less readily when photoperiodic exposures are either too short or too long (Allard, 1938 and Allard and Garner, 1940).

Summary

The effect of 10-hour photoperiods was studied on the flowering behaviour of three medium-early varieties of U.P. paddy. The experiments were conducted as pot culture. Altogether 5 different types of short-day treatments were given to different lots of paddy plants in the seed-bed. These included 3, 4, 5 and 6 weeks of short-day treatments and in the fifth lot such a treatment continued till ear emergence.

There was a gradual delay in ear emergence on the main shoots of plants, as the duration of short-day treatment increased in the seed-bed and thereafter.

The short-day treatments for different durations of 3 to 6 weeks respectively, retarded the formation of tillers, leaves and panicles, but, contrariwise, enhanced plant elongation and panicle growth. The number of spikelets and grains per panicle also increased. Although the absolute weight of grains remained unaffected, there was a general improvement in grain setting due to these short-day treatments. The grain yield was consequently higher than the controls.

Short-day treatments prolonged till the usual heading time, caused an all-sided adverse effect, excepting on the absolute weight of seeds.

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