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On the flowering behaviour of the rice crop at the crop weather stations in India

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ABSTRACT. The need for evaluating the type of flowering behaviour of a rice crop for understanding its weather relationship is outlined. An examination of the duration of the vegetative phase on extreme sowing dates (*i*) at a number of stations for early *Kharif* crop and (*ii*) at south Peninsular stations for late *Kharif* crop, is made, to screen varieties for presence or absence of photoperiodic response. The likely alternate flowering month for the photosensitive varieties is indicated.

1. Introduction

The duration of the vegetative phase of a cereal crop can be expected to influence directly the straw yield and indirectly the grain yield. That climate can exert a control on the duration of the vegetative phase of many crops is reflected in the studies reported in the literature utilising two of the concepts, *viz.*, the heat unit accumulation (Reamer 1735) and Hopkins' Bioclimatic Law (Hopkins 1918). In the former the plants are shown to flower after accumulating certain energy as denoted by the product of the duration of the vegetative phase and the mean temperature above a certain limiting value. Hopkins' Bioclimatic Law on the other hand states that, in North America atleast, other things being equal, any natural phenomenon, like flowering, is delayed at the average rate of 4 days per (*i*) degree latitude, (*ii*) 5 degrees of longitude, and (*iii*) 400 feet of altitude.

The flowering behaviour of a rice variety is governed, besides other factors, by its photo and thermo-sensitivity or insensitivity (Grist 1959). Under the Co-ordinated Crop Weather Scheme, different varieties are grown, two per station, at the different stations, under cultural practices which, though varying from station to station, remain constant from year to year at any given station (Table 1).

Many of the varieties grown under the scheme might still be of regional importance and hence used in comparative trials with new high yielding varieties. Also while the early *Kharif* rice varieties have an all India coverage, the late *Kharif* varieties are confined to the south Peninsula. The varieties under study are thus raised in a diffuse equable temperature regime. It was, therefore, decided to examine the nature of flowering response of the rice varieties at each station regarding photosensitivity and to see if the average dates of flowering of the same class of varieties revealed any climatically influenced pattern. It was also felt that such a screening would help to identify varieties for which due importance would be required to be given to the dates of sowing in any study of their weather-yield relationship.

The studies carried out together with the findings are presented here.

2. Differential varietal response

At a given station the two varieties are sown and transplanted on the same dates and are subject to the same cultural treatments. Under these conditions it was found that except at Karjat and Samalkota, the two local varieties under study at a station flowered at nearly the same time. At Karjat the variety K 540 had an average flowering date of 17 September, with a range from 10 to 22 September, while for variety K42 the average flowering date was 5 October with a range from 3 to 18 October. At Samalkota the average date of flowering for the variety SLO15 was 22 October with a range from 13-26 October, while that for the variety SLO13 the average date was 13 October with a range from 11 to 14 October. Therefore, the flowering response of two varieties at Karjat and Samalkota were studied separately.

3. Nature of flowering response of early *Kharif* rice varieties

For determining the nature of the flowering behaviour of the crop at each station, years in which crop had been sown earliest and latest were taken. In these years the dates on which the crop had been transplanted and the panicle has emerged

TABLE 1

Crop varieties* and cultural practices

Station/varieties	No. of seedlings per bunch	Spacing distance		Manure/fertilisers used	
		In rows (cm)	Between rows (cm)	Type	Amount (kg/hec)
		Early Kharif Crop			
Aduthurai (ADT-3, ADT-20)	2	15	15	Compost Sesbania leaves Super phosphate Ammonium Sulphate	37,650 5,602 168 112
Chinsurah (Bhasmanic, Patnaik)	3	22·5	22·5	No manures	—
Cuttack (T141, SL06)	3	15	15	Ammonium sulphate	225
Karjat (I) (K-42)	10	30	30	Ammonium sulphate Super phosphate	225 125
Nagina (T-21, T-137)	3	22·5	22·5	Ammonium sulphate	220
Pattambi (I) (PTB-1, PTB-5)	2	30	15	Green manure Super phosphate Ammonium sulphate	5,682 114 57
Rajendranagar (Teksamal, HR-19)	2	20	20	Farm yard manure Ammonium sulphate Super phosphate	Not specific 340 285
Sabour (BR-7, BR-8)	3	30	30	Ammonium sulphate Super phosphate	250 313
Samalkota (I) (SLO-15)	2	15	15	Green manure Ammonium sulphate Super phosphate	4,500 112 125
Labhandi (Ajan, X-19)	2	15	15	Ammonium sulphate Super phosphate	167 112
Ranchi (BK-36, 498-2A)	3	25	25	Compost Urea Super phosphate	25 cart load 100 275
Karimganj (Lati soil, Swarna soil)	4	22·5	22·5	Cow dung	9,000
Bikramganj (BK-115, BR-34)	3	25	25	Farm yard manure Ammonium sulphate Super phosphate	28,000 168 280
Patna (BK-26, 498-2A)	3	25	25	Ammonium sulphate Super phosphate	225 279
Titabar (Prosad Boag Laodumra)	3	22·5	22·5	Nitrogenous fertiliser	45 kg N.
Samalkota (II) (SLO-13)	2	15	15	Green manure Ammonium sulphate Super phosphate	4,500 112 125
Karjat (II) (K-540)	10	30	30	Ammonium sulphate Super phosphate	225 125
		Late Kharif Crop			
Coimbatore (CO-16, CO-25)	2	15	15	Green leaves Super phosphate Ammonium sulphate	5,600 112 112
Aduthurai (II) (ADT-1, CO-25)	2	15	15	Compost Sesbania leaves Super phosphate Ammonium sulphate	37,650 5,602 168 112
Ollukkara (PTB-21, Chitteni)	2	22·5	22·5	Farm yard manure Ammonium sulphate	1,000 168
Pattambi (II) (PTB-12, PTB-20)	2	30	15	Green manure Super phosphate Ammonium sulphate	5,682 114 57

*Varieties BK-36 and 498-2A are the same as BR-7, BR-8 respectively

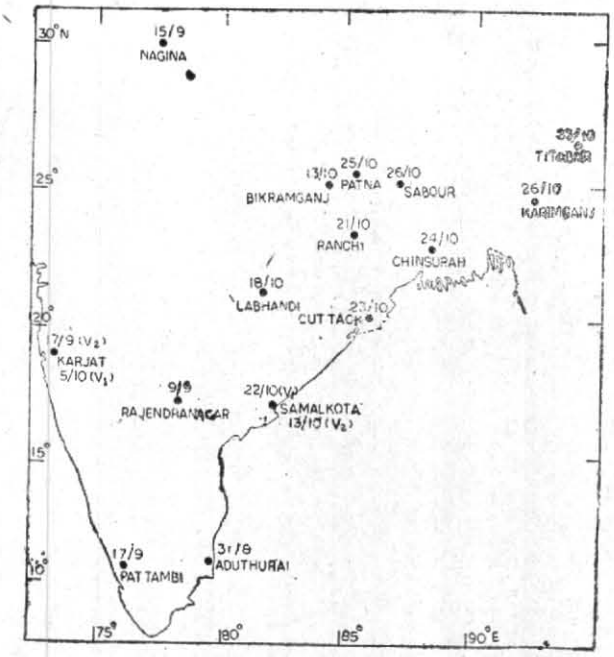

Fig. 1

Average dates of flowering of early *Kharif* rice crop at different Crop Weather Stations

and the duration of vegetative phase were noted. The names of varieties together with the above mentioned data are given in columns 2 to 7 of Table 2. Information on the ranges in the dates of transplanting, age of seedlings, the duration of the vegetative phase and the dates of emergence of the panicle are also given in the remaining columns of Table 2. The emphasis was placed on the dates of sowing and not transplantation as a considerable fraction of the vegetative period of the rice crop is spent in the nursery.

Now in the case of the photoinsensitive varieties one would expect the date of ear emergence to be delayed with delayed sowings resulting in the range in the duration of the vegetative phase showing a very small spread and the range in dates of panicle emergence showing a very big spread. Conversely in the case of the photosensitive varieties one should find the range in duration of the vegetative phase and dates of panicle emergence showing a very wide and narrow spread respectively.

It is seen from Table 2 that the varieties ADT3, ADT20, Teksamal and HR19 (raised at Aduthurai and Rajendranagar) behave as photoinsensitive types only. The other varieties raised under the study, *viz.*, Bhasmanic, Patnaik, T141, SLO6, T21 T137, PTB1, PTB5, BR7, BR8, Ajan, X-19, BK26, Latisail, Swarnasail, BK115, BR34, Prosad Boag, Laodumra, appear to be photosensitive. Though the range in sowing dates at Samalkota and Karjat are small the flowering behaviour of the varieties K40, K42, SLO-13, and SLO15 reveal a photosensitive response.

The average dates of flowering of the early *Kharif* rice crop at the crop-weather stations of India are shown in Fig. 1. It may be seen from this that there is no discernable climatic pattern in the flowering of the photosensitive varieties of the early *Kharif* rice crop.

The reason for this may lie in the fact that the September and October flowering varieties may have a photoperiodic requirement of about $12\frac{1}{4}$ and $11\frac{3}{4}$ hrs respectively, while the latitudinal variation in the photoperiod between 10° and 30°N is 10 minutes in September and about 30 minutes in October (Table 3). The September and October flowering varieties if grown later than September and October can be expected to flower in March and February respectively.

In view of the above the earlier report of Mallik (1964) that the sequence of the dates of flowering of the early *Kharif* rice crop followed a modified form of Hopkins' criteria (being delayed by 3·8 days per degree latitude, 0·2 days per degree longitude and 16 days per kilometre altitude) can be seen to be a spacious one arising out of the inclusion

TABLE 2

Extreme sowing and flowering dates

Station	Varieties		Date of Sowing	Date of Transplanting	Age in days of seedling	Date of panicle emergence	Total No. of days*	Range in days of transplanting	Range in age of seedling	Range in dates of panicle emergence	Range in duration of vegetative phase
					Early Kharif rice crop						
Aduthurai (11°01′, 79°21′; 19 m)	ADT-3	E	27 May 67	24 Jun 67	28	10 Aug 67	75	24 Jun 67		10 Aug to 12 Sep	64 to 73
	ADT-20	L	10 Jul 59	31 Jul 59	21	12 Sep 59	63	3 Aug 48	19/37		
Chinsurah (22°52′, 88°24′; 9 m)	Bhasmanic	E	11 Jun 48	3 Aug 48	53	18 Oct 48	128	3 Aug 48	36/56	18 Oct to 28 Oct	113 to 144
	Patnaik	L	1 Jul 53	6 Aug 53	36	22 Oct 53	113	16 Aug 51			
Cuttack (20°29′, 85°52′; 24 m)	T-141	E	21 Jun 63	3 Aug 63	42	23 Oct 63	124	25 Jul 56	33/65	19 Oct to 2 Nov	109 to 132
	SLO-6	L	9 Jul 66	12 Aug 66	33	25 Oct 66	107	30 Aug 62			
Karjat (I) (18°55′, 73°18′; 52 m)	K-42	E	7 Jun 56	4 Jul 56	27	3 Oct 56	118	1 Jul 55	21/43	3 Oct to 18 Oct	110 to 120
		L	18 Jun 58	9 Jul 58	21	6 Oct 58	110	26 Jul 66			
Nagina (29°55′, 78°24′; 249 m)	T-21	E	17 May 57	12 Jul 57	56	14 Sep 57	120	11 Jul 55	24/56	7 Sep to 23 Sep	80 to 115
	T-137	L	1 Jul 63	25 Jul 63	24	23 Sep 63	84	25 Jul 63			
Pattambi (I) (10°48′, 76°12′; 25 m)	PTB-1	E	20 May 52	8 Jul 52	48	15 Sep 52	117	1 Jul 60	30/49	13 Sep to 23 Sep	95 to 115
	PTB-5	L	15 Jun 64	19 Jul 64	34	21 Sep 64	98	22 Jul 66			
Rajendranagar (17°20′, 78°15′; 543 m)	Teksamal	E	4 Jun 65	28 Jun 65	24	30 Aug 65	87	28 Jun 65	23/48	30 Aug to 23 Sep	81 to 94
	HR-19	L	6 Jul 62	5 Aug 62	30	23 Sep 62	79	5 Aug 62			
Sabour (25°14′, 87°04′; 37 m)	BR-7	E	13 Jun 58	14 Aug 58	62	22 Oct 58	131	27 Jul 54	41/63	22 Oct to 2 Nov	117/136
	BR-8	L	1 Jul 67	2 Sep 67	63	26 Oct 67	117	2 Sep 67			
Samalkota (I) (17°03′, 82°13′; 9 m)	SLO-15	E	8 Jun 58	14 Jul 58	36	23 Oct 58	137	12 Jul 56	27/38	13 Oct to 26 Oct	120 to 137
		L	15 Jun 67	16 Jul 67	31	26 Oct 67	133	16 Jul 57			
Labhandi (21°16′, 81°36′; 289 m)	Ajan	E	12 Jun 51	15 Aug 51	64	14 Oct 51	124	13 Aug 64	36/78	12 Oct to 22 Oct	91 to 123
	X-19	L	14 Jul 54	3 Sep 54	51	22 Oct 54	100	10 Sep 57			
Ranchi (23°25′, 85°20′; 675 m)	BK-36 (BR-7) 498-2A (BR-8)	E	23 Jun 64	12 Aug 64	50	22 Oct 64	122	26 Jul 57	32/63	19 Oct to 25 Oct	106 to 121
		L	11 Jul 67	20 Aug 67	40	25 Oct 67	106	30 Aug 61			
Karimganj (24°40′, 92°30′; 16 m)	Lati Sail	E	15 Jun 63	7 Aug 63	53	29 Oct 63	136	3 Aug 65	37/53	24 Oct to 29 Oct	98 to 136
	Swarna Sail	L	20 Jul 62	26 Aug 62	37	26 Oct 62	98	30 Aug 61			
Bikramganj (25°10′, 84°15′; 87 m)	BK-115	E	13 Jun 64	15 Jul 64	32	12 Oct 64	121	15 Jul 64	—	12 Oct to 15 Oct	107 to 122
	BR-34	L	28 Jun 67	28 Jul 67	30	13 Oct 67	107	4 Aug 62			
Patna (28°30′, 85°15′; 52 m)	BK-26	E	19 Jun 61	2 Aug 61	44	27 Oct 61	130	2 Aug 61	—	23 Oct to 2 Nov	115 to 132
	498-2A (BR-8)	L	10 Jul 67	24 Aug 67	45	2 Nov 67	115	26 Aug 65			

*from sowing to panicle emergence

TABLE 2 (*contd*)

Station	Varieties		Date of Sowing	Date of transplanting	Age in days of seedling	Date of panicle emergence	Total No. of days*	Range in days of transplanting	Range in age of seedling	Range in dates of panicle emergence	Range in duration of vegetative phase
Titabar (26°35′, 94°10′; 99 m)	Prosad Boag	E	17 Jun 61	24 Jul 61	37	21 Oct 61	126	24 Jul 61	29/61	20 Oct to 27 Oct	92 to 126
	Laodumra	L	27 Jul 59	3 Sep 59	38	27 Oct 59	92	3 Sep 59			
Samalkota (II) (17°03′, 82°13′; 9 m)	SLO-13	E	8 Jun 58	14 Jul 58	36	13 Oct 58	127	12 Jul 56	27/38	11 Oct to 14 Oct	118 to 127
		L	15 Jun 67	16 Jul 67	30	14 Oct 67	121	16 Jul 67			
Karjat (II) (18°55′, 73°18′; 52 m)	K-540	E	7 Jun 56	4 Jul 56	27	10 Sep 56	95	1 Jul 55	21/43	10 Sep to 22 Sep	93 to 112
		L	18 Jun 58	9 Jul 58	21	19 Sep 58	93	26 Jul 66			
Late Kharif rice crop											
Coimbatore (11°00′, 77°00′; 431 m)	CO-16	E	27 Jun 61	5 Aug 61	39	2 Dec 61	158	5 Aug 61	39/63	29 Nov to 23 Dec	134 to 158
	CO-25	L	7 Aug 66	19 Sep 66	43	19 Dec 66	134	6 Oct 52			
Aduthurai (II) (11°01′, 79°32′; 19 m)	ADT-1	E	21 Jul 51	3 Sep 51	44	20 Dec 51	152	29 Aug 63	31/54	14 Dec to 25 Dec	129 to 152
	CO-25	L	18 Aug 48	27 Sep 48	40	25 Dec 48	129	27 Sep 48			
Ollukkara (10°32′, 76°16′; 22 m)	PTB-21	E	11 Aug 60	14 Sep 60	34	8 Dec 60	119	14 Sep 60	30/47	8 Dec to 6 Jan	102 to 132
	Chitteni	L	11 Sep 64	12 Oct 64	31	6 Jan 65	118	14 Oct 61			
Pattambi (II) (10°48′, 76°12′; 25 m)	PTB-12	E	19 Sep 48	11 Nov 48	53	20 Dec 48	92	29 Oct 54	32/50	19 Dec to 18 Jan	76 to 96
	PTB-20	L	28 Oct 55	29 Nov 55	32	18 Jan 56	82	29 Nov 55			

*from sowing to panicle emergence

TABLE 3

Duration of sunlight at different latitudes

	Latitude (°N)								
	0	5	10	15	20	25	30	35	40
	h m	*h m*	*h m*	*h m*	*h m*	*h m*	*h m*	*h m*	*h m*
January	12 07	11 52	11 33	11 20	11 04	10 46	10 26	10 04	09 40
February	12 07	11 58	11 49	11 40	11 31	11 21	11 10	10 58	11 44
March	12 07	12 05	12 04	12 04	12 02	12 01	12 00	11 59	11 58
April	12 07	12 14	12 21	12 29	12 37	12 45	12 55	13 05	13 17
May	12 07	12 21	12 35	12 50	13 05	13 22	13 40	14 00	14 24
June	12 07	12 25	12 42	13 01	13 20	13 41	14 04	14 30	15 00
July	12 07	12 23	12 39	12 56	13 13	13 32	13 53	14 16	14 43
August	12 07	12 17	12 27	12 37	12 48	13 00	13 13	13 27	13 43
September	12 07	12 09	12 11	12 13	12 15	12 17	12 20	12 23	12 27
October	12 07	12 01	11 54	11 47	11 41	11 34	11 26	11 17	11 08
November	12 07	11 54	11 40	11 26	11 11	10 55	10 38	10 19	09 58
December	12 07	11 50	11 32	11 14	10 56	10 36	10 14	09 49	09 20

of the photoinsensitive varieties at Aduthurai, ignoring of differential varietal response at Karjat and Samalkota and wrong taking of the height of Samalkota as 845 metres.

4. Flowering of late *Kharif* rice varieties

Only four stations, all in south India, *viz.*, Coimbatore, Aduthurai, Pattambi and Ollukkara, record observations on late *Kharif* rice varieties. For these varieties data similar to that of the early varieties are also given in Table 2. It would appear that the rice varieties PTB12, PTB20, PTB21 and Chitteni (raised on the west coast of Kerala) behave like photoinsensitive types. The varieties ADT1 and CO25 and CO16 (raised at Aduthurai and Coimbatore) appear to evince a photosensitive response.

5. Summary and Conclusions

The early rice varieties ADT3, ADT20, Teksamal, HR9 and the late *Kharif* varieties PTB12, PTB2 PTB21 and Chitteni show a photoinsensitive response.

The early *Kharif* rice varieties Bhasmanic, Patnaik, T141, SLO6, T21, T137, PTB1, PTB5, BR7 BR8, Ajan, X-19, BK26, Latisail, Swarnasail, BK115, BR34, Prosad Boag, Laodumra and the late *Kharif* varieties CO16, CO25 and ADT1 show a photosensitive response.

There is no recognisable climatic pattern of flowering of even the photosensitive early *Kharif* rice varieties.

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