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Thermal time indices and yield correlations for hybrid rice in Terai zone of West Bengal

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Phenology is the development of a plant through successive growth stages. The duration of each growth phase is a result of crop response to external and environmental factors. In this paper, the phenological developments of four rice hybrids grown under field conditions in Cooch Behar, West Bengal are reported. These data, in conjunction with grain yield, were used to develop and validate a crop model especially for use at Pundibari in terai agro-climatic zone of West Bengal.

A field experiment was conducted during wet season (June-September) of 2000 on a low land sandy loam soil at North Bengal Campus Farm (26°19'N, 89°23'E and 43 m above sea level) of Bidhan Chandra Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. Treatments replicated thrice, were arranged in a split-plot design with dates of planting (5th July, 20th July and 5th August, with the seedlings sown on 10th June, 25th June and 10th July, respectively) in main plots and cultivars (Pro Agro 6201, PDSH 35, Nardi 111, CNHR 3) including IR 50 as inbred check in subplots. Twenty five days old rice seedlings were transplanted at a spacing of 20 x 15 cm. Standard agronomic practices were adopted.

Growing degree days (GDD) for each phenophase were calculated following Nuttonson (1955) by taking a base temperature of 8°C. For each phenophase, heliothermal units [Σ(GDD x Bright sunshine hour)] following Singh *et al.* (1990) and photothermal units [Σ(GDD x Day length)] following Nuttonson (1948) were calculated. Correlation studies between thermal and photothermal requirements for each phenological stage and grain yield were made. The regression models through step down approach were developed for each cultivar.

The investigation on the development of crop was carried out by considering different phenophases and the number of days taken for completion of each phenophase and it varied with the dates of sowing and cultivars tested (Table 1). The time taken for maturity ranged from 116.2 to 120.8 days for different sowing dates and 105.0 to 127.3 days for different cultivars tested and the data revealed that the period from fourth leaf emergence to flowering primarily determined the differences in number of days for maturity.

GDD during the periods between sowing and first leaf emergence as well as between fourth leaf emergence and flowering was found to increase with successive delay in sowing. However, 10th July sown crop

Table 1: Effect of sowing dates and cultivars on duration and growth environment on hybrid rice

Treatment	Sowing to emergence of first leaf	Emergence of first leaf to fourth leaf	Emergence of fourth leaf to flowering	Flowering to maturity	Sowing to maturity
(Number of days)					
Sowing dates					
10th June	2.4	17.8	67.4	30.0	117.6
25th June	2.6	19.4	68.8	30.0	120.8
10th July	2.8	16.2	66.4	30.8	116.2
Cultivars					
Pro Agro 6201	2.0	18.3	76.3	30.7	127.3
PDSH 35	2.0	18.3	69.0	29.3	118.7
Nardi 111	2.7	17.7	67.7	30.0	118.0
CNHR 3	4.3	17.3	53.0	30.3	105.0
IR 50	2.0	17.3	71.7	31.0	122.0
(Growing degree days)					
Sowing dates					
10th June	45	317	1318	691	2371
25th June	48	376	1395	532	2351
10th July	56	328	1436	523	2343
Cultivars					
Pro Agro 6201	38	358	1583	521	2500
PDSH 35	38	358	1385	580	2361
Nardi 111	51	344	1362	590	2348
CNHR 3	83	306	1089	617	2094
IR 50	38	338	1496	602	2474
(Heliothermal units)					
Sowing dates					
10th June	52	1290	5969	2931	10242
25th June	110	1870	5819	4107	11905
10th July	365	1868	5648	4340	12220
Cultivars					
Pro Agro 6201	125	1739	6834	3961	12658
PDSH 35	125	1739	5877	3828	11568
Nardi 111	208	1655	5731	3886	11481
CNHR 3	294	1672	4356	3281	9604
IR 50	120	1574	6262	3994	11955
(Photothermal units)					
Sowing dates					
10th June	600	4533	17153	6575	28860
25th June	643	5029	16824	6224	28721
10th July	745	4354	15665	6011	26776
Cultivars					
Pro Agro 6201	505	4777	18525	6027	29834
PDSH 35	505	4777	16883	6090	28256
Nardi 111	685	4597	16606	6222	28111
CNHR 3	1114	4527	13219	6700	25559
IR 50	505	4515	17504	6311	28835

Table 2 : Grain yield of rice hybrids as influenced by trsnsplanting dates

Transplanting date (Sowing date)	Grain yield (t ha^{-1})					Mean
	Pro Agro 6201	PDSH 35	Nardi 111	CNHR 3	IR 50	
5th July (10th June)	5.37	3.51	3.54	3.25	3.67	3.87
20th July (25th June)	5.87	5.17	4.80	3.56	4.83	4.85
5th August (10th July)	5.93	5.68	5.27	4.88	5.01	5.36
Mean	5.72	4.78	4.54	3.90	4.50	
C.D. at 5%	Transplanting date (0.15)	Cultiavar (0.14)	Transplanting date X Cutivar (0.25)			

Table 3: Correlation coefficients of rice grain yield with growing degree days (GDD), heliothermal units (HTU), photothermal units (PTU) and summation of bright sunshine hours (ΣBSH) during various phenophases at different sowing dates

Transplanting date (Sowing date)	Phenophase	GDD	HTU	PTU	ΣBSH
5th July (10th June)	S-1L	-0.405	-0.405	-0.405	-0.405
	1L-4L	0.444	-0.159	0.089	-0.315
	4L-F	0.702	0.533	0.695	0.715
	F-M	-0.999 **	0.752	-0.484	0.181
20th July (25th June)	S-1L	-0.877	-0.875	-0.877	-0.871
	1L-4L	0.651	-0.011	0.654	0.092
	4L-F	0.860	0.908 *	0.951 *	0.901 *
	F-M	-0.483	0.760	-0.754	0.782
5th August (10th July)	S-1L	-0.652	-0.648	-0.652	-0.924
	1L-4L	0.917 *	-0.933	0.914 *	0.962 **
	4L-F	0.656 *	0.640	0.650 *	0.638
	F-M	-0.698	-0.481	-0.779	0.385

*,** significant at 5% and 1% level of probability

S-1L= Sowing to emergence of first leaf; 1L-4L= Emergence of first to fourth leaf; 4L-F= Emergence of fourth leaf to flowering; F-M= Flowering to maturity; S-M= Sowing to maturity

accumulated lower GDD (2343) during the life period as compared to 10th June (2371) and 25th June (2351) sowings, mainly because of lower GDD in ripening period (flowering to maturity). The differences in total GDD as noticed in this study is consistent with the findings of Pandey *et al.* (2001).

The cumulative effect of variation in HTU as observed during emergence phase (sowing to first leaf emergence), seedling phase (first to fourth leaf emergence) and ripening phase (flowering to maturity) determined the differences in total HTU. It is also evident from the data that accumulation of total HTU increased with delay in sowing from 10th June to 10th July, showing a linear relationship with increasing average bright sunshine hour/day (data not shown).

As day length showed a linear decreasing trend after 21st June (summer solstice), the crops raised from sowing 25th June and 10th July met successively lower day length throughout the growing period than early sown (10th June) crop. Accumulation of total PTU decreased with delay in sowing owing to a complex interaction between mean air temperature and day length prevailing during fourth leaf emergence to maturity.

There was an increasing trend in grain yield for each cultivar with delay in planting from 5th July to 5th August (Table 2). This could be explained by the fact that low temperature (25.0° C) with more bright sunshine (357.3) hours prevailed during the ripening period for late (5th August) planted crop as opined by Robertson and De Weille (1973). Correlation studies for summation of BSH and GDD during the ripening period (flowering to maturity) had positive and negative effects (non-significant in most of the cases), respectively on grain yield (Table 3). It is also evident that grain yield was positively correlated with GDD, HTU, PTU, and summation of BSH during the period between fourth leaf emergence and flowering for all three planting dates, however, significant correlation was found in a few cases.

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