

## Crop weather relation in *kharif* rice for North-west Alluvial Plain Zone of Bihar

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### ABSTRACT

Studies on crop weather relationship in rice were carried out over six *kharif* seasons from 2009 to 2014 at Pusa, Samastipur falling under North-west Alluvial Plain Zone of Bihar. Three rice varieties viz. *Rajendra Bhgwati*, *RW 3055* and *Saroj* were grown under irrigated conditions with four sowing dates viz. 31 May, 15 June, 30 June and 15 July. The results revealed that accumulated heat units decreased with delay in sowing till crop reached tillering stage and increased thereafter till crop maturity. The grain yield was higher when maximum temperature ( $T_{max}$ ) during heading phase remained between 32.2 and 32.6 °C and decreased appreciably when  $T_{max}$  was above 33 °C during this phase. Grain yield declines by 4.31 q ha<sup>-1</sup> per 1 °C rise in  $T_{max}$  during heading stage due to reduction in 'pollen viability', resulting in greater spikelet sterility and subsequently lower yield. Except during tillering and flowering phases, the minimum temperature was negatively correlated with grain yield. Daily bright sunshine hours (BSH) of 7 to 8 hours during flowering phase led to enhanced grain yield. However, BSH of less than 7 hours resulted in decline of grain yield. Significant positive correlation was recorded between bright sunshine hours and grain yield.

**Key words:** Weather parameters, rice, grain yield, correlation, regression

Every crop/variety has its own optimal requirements of climatic variables like temperature, sunshine hour, rainfall etc. for potential yield. The responses and requirements of these variables which determine the growth and development of a plant in a given environment may vary from variety to variety within a species. In the same variety, they may also vary from one growth stage to another. The final biomass and yield of crops depend on the integrated effects of weather phenomena prevailing during different growth stages. Phenological development is the most important attribute involved in crop adaptation to varied growing environments. Both, the season length and the relative duration of key phenophases, are critical determinants of grain yield in field crops.

Rice is an important *kharif* crop in Bihar. The total area under rice in Bihar is about 3.18 million hectares with an average productivity of 25.3 quintals per hectare. There is a wide gap between average productivity and potential productivity owing to environmental factors, technology adoption and timely availability of inputs (Diwakar, 2009). Thus, to understand the crop phenology-weather interaction and to enhance the rice productivity in the state, the knowledge of the duration of different developmental phases and their association with yield determining weather factors

is essential. With the help of crop weather relation studies, it is possible to show as to how the changes in rainfall amount, solar radiation and temperatures during different growth stages influence the crop productivity. Many researchers have studied crop weather relations and developed location specific regression models using weather variables for prediction of yields of rice (Agrawal *et al.*, 1980; Khan and Chatterjee, 1987, Devi *et al.*, 2013). In view of above, an attempt has been made here to assess the impact of weather parameters prevailing during different phases of growth on grain yield and thereby quantify the optimum weather conditions for maximizing the rice production at Pusa, Samastipur region under North-west alluvial plains of Bihar.

### MATERIALS AND METHODS

The field experiments were conducted at Pusa Farm (25.8 °N, 86.7 °E and 52 m a.m.s.l), Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar over six *kharif* seasons from 2009 to 2014. The soil of the experimental site is clay loam in texture. The experiment was conducted with rice (varieties *Rajendra Bhgwati*, *RW 3055* and *Saroj*) under irrigated condition and with adequate plant protection measures. The experiment was laid out in Randomized

**Table 1:** Phenophase durations and GDD requirements of *kharif* rice sown on different dates

Dates of sowing	Tillering	Heading	Flowering	Milking	Dough	Maturity
<b>Days after sowing</b>						
31 May	47	89	109	116	133	142
15 June	48	88	103	109	121	131
30 June	48	85	98	104	119	126
15 July	49	85	96	106	124	118
<b>GDD (°C day)</b>						
31 May	955	1793	2175	2316	2622	2622
15 June	949	1748	2043	2156	2366	2366
30 June	979	1751	1941	2050	2307	2307
15 July	987	1676	1864	1965	2299	2299

Complete Block Design with four staggered dates of transplanting *viz.* 25 June, 10 July, 25 July and 10 August with three replications. The 25 days old seedlings were transplanted in rows 20 cm apart. The crop was uniformly fertilized with 120 kg N, 60 kg P<sub>2</sub>O<sub>5</sub> and 40 kg K<sub>2</sub>O ha<sup>-1</sup> in the forms of urea, single superphosphate and muriate of potash, respectively. The occurrence of phenological events like tillering, heading, flowering, milking, dough and maturity were recorded from each plots and average dates of these phases were calculated and used for analysis.

The daily weather data on maximum temperature, minimum temperature and sunshine hours for the growing seasons were collected from the nearby Agromet Observatory, Dr. Rajendra Prasad Central Agricultural University, Pusa. Optimum weather conditions in terms of mean and ranges of maximum temperature ( $T_{\max}$ ), minimum temperature ( $T_{\min}$ ) and bright sunshine hours (BSH) during different crop growth phases were worked out based on daily weather observations.

The accumulated growing degree day (GDD) or heat unit was worked out for different phases of growth using the following equation (Nuttonson, 1955):

$$\text{GDD} = [(T_{\max} + T_{\min})/2 - T_b]$$

Where,  $T_{\max}$  = Maximum temperature of the day in °C

$T_{\min}$  = Minimum temperature of the day in °C

$T_b$  = Base temperature in °C

In the present study,  $T_b$  considered was 8 °C following Alocilja and Ritchie (1991).

Simple correlation coefficients were computed between rice yield and weather parameters (Gomez and

Gomez, 1976). The best-fit regression equations between rice yield and weather parameters occurring at different phases of growth were developed (Draper and Smith, 1966) to examine the rice-weather relationships.

## RESULTS AND DISCUSSION

### *Phase duration and heat unit requirements*

The duration of various phenophases of rice based on six crop season observations presented in the Table 1 revealed that there was a lot of variation in days required to attain different phases when the crop is grown under different micro-environmental conditions. The first three dates could be considered as normal sowing window for rice in the region, whereas 15 July represents late sowing of the crop. The results revealed that there was a decrease in duration of different growth phases with delay in sowing except the tillering phase. The crop sown on 15 July required 2 days more to attain maximum tillering stage than that sown on 31 May. However, the duration required to attain 50% flowering in 31 May and 15 July sown crop were 109 and 96 days, respectively. The crop sown on 31 May attained maturity in 142 days, while crop sown on 31 July reached maturity in 119 days. Kobayashi *et al.* (2010) concluded that higher air temperature and incident radiation tend to advance anthesis in rice. Such variation in durations of different phenophases of the crop may have been due to changes of sowing dates, which led to early or delayed fulfillment of thermal requirements to attain a particular phenophase.

While considering the accumulated GDD (Table 1) required for reaching different phenophases, it was observed that similar pattern like that of phenophase durations was noticed at all phenophases. The accumulated GDD to reach

**Table 2:** Correlation coefficients of weather parameters at different phenophases with grain yield of rice

Weather parameters	Growth phases					
	Tillering	Heading	Flowering	Milking	Dough	Maturity
T <sub>max</sub>	0.15	-0.53**	0.75**	0.14	0.07	0.01
T <sub>min</sub>	0.25	-0.12	0.15	-0.02	-0.11	-0.12
T <sub>mean</sub>	0.12	0.08	0.28	0.46*	0.62**	0.52**
BSH	-0.09	-0.35	0.81**	0.12	0.10	0.36

\* Significant 5 % level, \*\* Significant 1 % level

tillering decreased with delay in sowing, whereas, the accumulated GDD for attaining other growth phases increased. As compared to 15 July sown crop, the 31 May sown crop availed of more GDD for attaining 50 % flowering stage and the respective GDD were 1864, 2175 and 1864 °Cday, respectively. At maturity, the accumulated GDD were 2622, 2366, 2307 and 2299 °Cday for 31 May, 15 June, 30 June and 15 July sown crops, respectively. The days to attain tillering, heading, flowering and maturity demonstrated higher positive correlation coefficients, ranging from 0.73 to 0.99, with their corresponding GDD requirements, and thus indicating the dependence of phasic thermal time requirements on phenophase durations. Requirement of higher thermal time in early sown rice crop for completion of heading corroborates the previous work of Singh *et al.* (2012) in transplanted rice. The June sown crop in present study availed more time of hot summer months than did July sown crop and hence accumulated more thermal time.

#### Crop-weather relations

The performance of a crop is dependent mainly on the growing season weather conditions and the genetic constitution of crop species. Hence, identification of critical weather variables and their quantification at different growth phases is prerequisite for successful crop production in a region. Correlation coefficients (Table 2) between weather parameters at different phenophases of rice and grain yield indicated that there was a significant positive correlation of T<sub>max</sub> with grain yield during flowering, however, a significant negative correlation during heading phase. Except at tillering and flowering phases, T<sub>min</sub> showed negative correlation with grain yield. The BSH exhibited significant positive correlation with grain yield establishing thereby that light plays an important role in the growth and yield of rice during flowering phase. The significant positive association of T<sub>mean</sub> at milking, dough and maturity phases with grain yield was observed; demonstrating thereby that higher T<sub>mean</sub> led to enhanced grain yield.

The relationships of mean BSH during flowering stage and T<sub>max</sub> during heading and flowering stages with grain yield of *kharif* rice have been presented in Table 3. The relationship between grain yield and BSH indicated that mean BSH during flowering stage showed positive linear relationship with grain yield, ascribing to increasing grain yield with lengthening BSH. The coefficient of determination (R<sup>2</sup>) of regression equation (Table 3) involving grain yield and BSH explained 64 per cent of total variability in grain yield. The rate of increase of grain yield per 1 hour rise in sun shine during flowering phase was 2.7 q ha<sup>-1</sup>. Yamagata (1958) reported that the number of tillers and ears (panicles) increased with the intensity and quantity of light. In the present study, BSH during flowering to maturity phases demonstrated positive correlation with grain yield (Table 2), leading to the fact that higher values of BSH prevailing during anthesis to maturity augmented the grain yield and its attributes. De Datta and Zarate (1970) observed significant positive correlation between solar radiation during panicle initiation to crop maturity and grain yield of rice. Analyzing the data recorded at Kolaba district of Maharashtra, Sreenivasan (1979) observed that more sun shine at the time of panicle emergence to fertilization leads to greater yield. It was noted that grain yield was higher at mean BSH between 7 to 8 hours during flowering stage, while yield decreased with BSH of less than 7 hours during this growth stage.

## CONCLUSIONS

Crop weather relationship studies brought out several critical information, which could be useful in achieving attainable yield of *kharif* rice in the state of Bihar. Higher grain yield was observed at T<sub>max</sub> between 32.2 and 32.6 °C during heading phase, while grain yield reduced appreciably when T<sub>max</sub> > 33 °C was recorded during this phase. Daily bright sunshine hour (BSH) of 7 to 8 hours was found to enhance the grain yield, while the yield decreased at BSH of less than 7 hours during flowering stage. Weather during

flowering phase of the crop played most important role by exercising its impact on grain yield.

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