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Study of Phenophasic Climatic Requirement for Maximum Yield of Rice in the Prevailing Weather Conditions

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A B S T R A C T

A field experiment was conducted during *kharif season* of 2017-18 on the topic entitled "Effect of growing environment on growth and development of rice (*Oryza sativa L.*) cultivars." in sandy loam soil of N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.). The experiment consisted of nine treatment combinations comprised of three transplanting dates *viz.* July 5th, July 15th and July 25th and three varieties viz., NDR-97, NDR-3112 and BPT-5204. Results reveal that different phenophases of rice markedly varied with only dates of transplanting but also different weather variables which ultimately create the different crop growing environment to harvest the yield accordingly. Highest Growing Degree days (GDD) was recorded in growing environment of July 5th due to occurrence of long duration. Highest heliothermal and photothermal unit was recorded in Ist date of transplanting on July 5th at vegetative stage.

Introduction

Rice (*Oryza sativa* L.) is the paramount cereal crop after wheat belonging to the grass family, poaceae, extensively cultivated in most parts of the world and is the major staple food for more than half of the global population (FAO, 2013). Rice is a staple food of more than 50 per cent of the world's population (Anonymous, 2011) During 2013-14 in India, rice is cultivated in an area of 46 million ha with a production of 106.5 million tonnes and yield 2424 kg ha1(Agricultural statistics at a glance, 2014). However, productivity of rice in India is much lower than that of other rice producing countries. The impact of air temperature on rice growth would be location-specific because of the different sensitivity of different locations with regard to temperature. In tropical regions, the temperature increase due to the climate change is probably near or above the optimum temperature range for the physiological activities of rice [Baker *et al.*, 1992**]**. Such warming will thus reduce rice growth. Rice productivity is highly dependent upon prevailing weather conditions. Some of the weather parameters like sunshine hours, rainfall and temperature are important natural resources which affect the rice productivity to a greater extent. The optimum utilization of these resources can also vary among different rice genotypes. To study the extent and comparative utilization of these resources some weather based agro indices had been developed were growing degree days (GDD), photothermal units (PTU), heliothermal units (HTU) and heat use efficiency (HUE). GDD is the most common temperature index used to estimate plant development (Qadir *et al.*, 2006). Therefore, it is better to calculate efficiency of utilization of heat in terms of dry matter accumulation depends on crop type, genetic factors and sowing time and has great practical application (Rao *et al.*, 1999). Successful yield estimation by application of yield components considering seasonal change in meteorological conditions may be useful for evaluating the best variety type for achieving high yield based on rice morphology under future environmental conditions, facilitating improvements in the breeding strategies in the future. Because the production of new cultivars generally require at least 10 years for breeders. It is necessary for breeding strategies to be closely coordinated with climate change predictions and to consider several decades.

Materials and Methods

Experimental site

The experiment was conducted at N.D. University of Agriculture and Technology, Kumarganj, Faizabad U.P. India, during *Kharif* season of 2017-18. During cropping period in the average maximum and the minimum temperature were 31°C and 22°C, respectively. The data indicates that the crop received below normal maximum temperature and above normal minimum temperature during its cropping period. The total rainfall received during the cropping period was 681.4 mm. The day length during the cropping period ranges from 11.65 hrs – 12.28 hrs and the average bright sun shine hour was 11.48 hours.

Experimental treatments and procedures

The experiment was conducted in Randomized block design with three replications. The experiment consisted of nine treatment combination comprised of three transplanting dates *viz*. July 5^{th}, July 15^{th} and July 25^{th} and three varieties viz., NDR-97, NDR-3112 and BPT-5204 of rice genotypes having different maturity groups. The details of experiment has been described elsewhere Sandeep Kumar Sharma 2016-17. Statistical analysis and interpretation of results were done by calculating values of GDD, PTU, HTU and HUE.

Heat units

The growing degree days (GDD) was calculated following Nuttonson (1955); taking base temperature of 10°C.

$$GDD = (T_{max}+T_{min})/2 - T_b$$

Where,
T_{max} = Daily maximum temperature (oC)
T_{min} = Daily minimum temperature (oC)
T_b = Base temperature (10^0C for rice)

The heliothermal units (HTU) was calculated as;
HTU = GDD × Actual bright sunshine hours (°C day hours)
The photothermal units (PTU) was calculated as;
PTU = GDD× Day length (°C day hours)
The heat use efficiency (HUE) was calculated as;

Heat use efficiency (kg ha^{-1}°C day^{-1}) =

$$\frac{\text{Grain yield (kg ha-1)}}{\text{AGDD (°C day)}}$$

Where,
AGDD (kg ha^{-1}°C day^{-1}) = Accumulated growing degree days.

Results and Discussion

Crop phenology

Sowing time application had significant effect on phenology of rice. Data pertaining to days taken to different phenophases until the maturity as affected by different growing environment of rice cultivars have been presented in Table 1 data showed that different growing environment influenced rice cultivars.

Maximum days taken to maturity on the basis of date of transplanting (DAT) 116 days were recorded when crop was transplanted on July 5^{th} followed by July 15^{th} and July 25^{th}.The minimum days taken to maturity was recorded 104 days on 3^{rd} date of transplanting. The crop duration decreased with delay in sowing. On the other hand in this experiment rice variety BPT-5204 122 days taken to maturity and followed by NDR-3112 had taken 106 days and last NDR-97 variety taken 100 days. So the BPT-5204 and NDR-97 have significant difference could be observed in the days taken to attain physiological maturity. Also observation was clearly depicted in below given graph (Fig. 1–3).

Growing degree days (GDD)

Early sown crop (5^{th} July) consumed significantly higher heat units as compared to 15^{th} July and 25^{th} July sown crop to attain physiological maturity.

Heliothermal units

Data pertaining to heliothermal unit as affected by different growing environment of rice cultivars have been presented in table 2 and clearly depicted in figure 2 and 3. From table it was revealed that heliothermal unit was recorded highest in I^{st} date of transplanting on July 5^{th} (^{0}days hours) followed by July 15^{th} and July 25^{th}.

Among the varieties highest heliothermal unit at vegetative and reproductive stages were recorded in cultivars BPT-5204 followed by NDR-97 and NDR-3112.

Table.1 Days taken to different phenophases

Treatments Growing Environment	Phenophases		
	Days to panicle initiation	Days to 50%Flowering	Physiological Maturity
5^{th} July	73	83	116
15^{th}July	70	80	111
25^{th} July	68	77	104
Varieties			
NDR-97	61	77	100
NDR-3112	63	79	106
BPT-5204	75	91	122

Fig.1

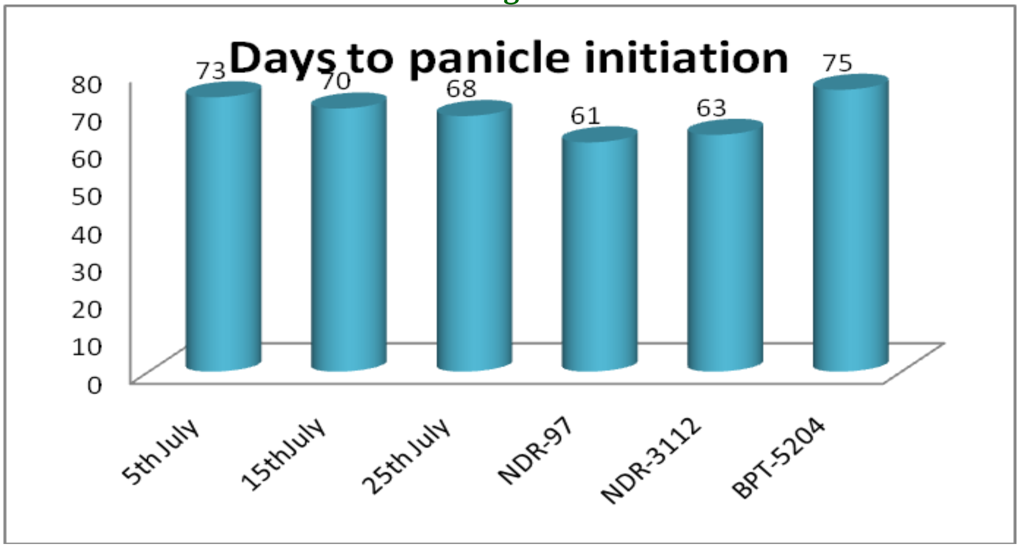


Fig.2

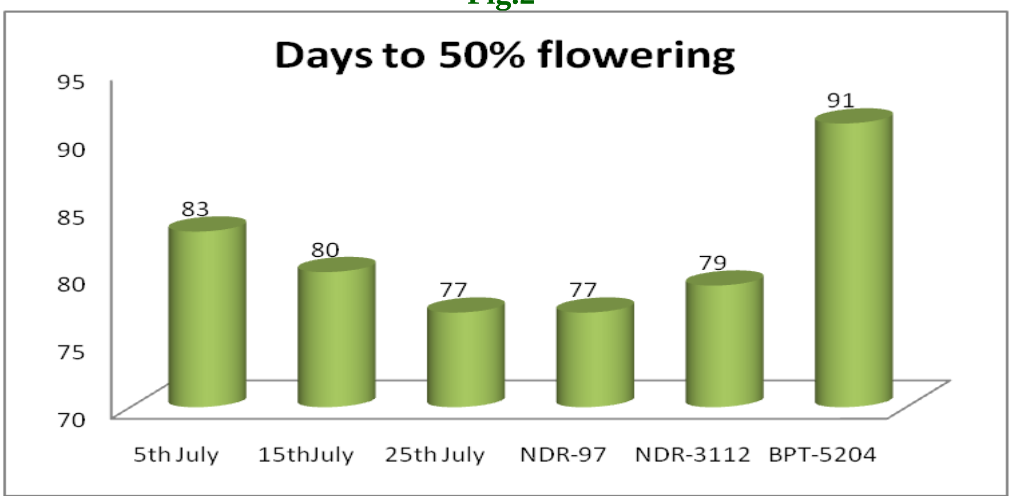


Fig.3

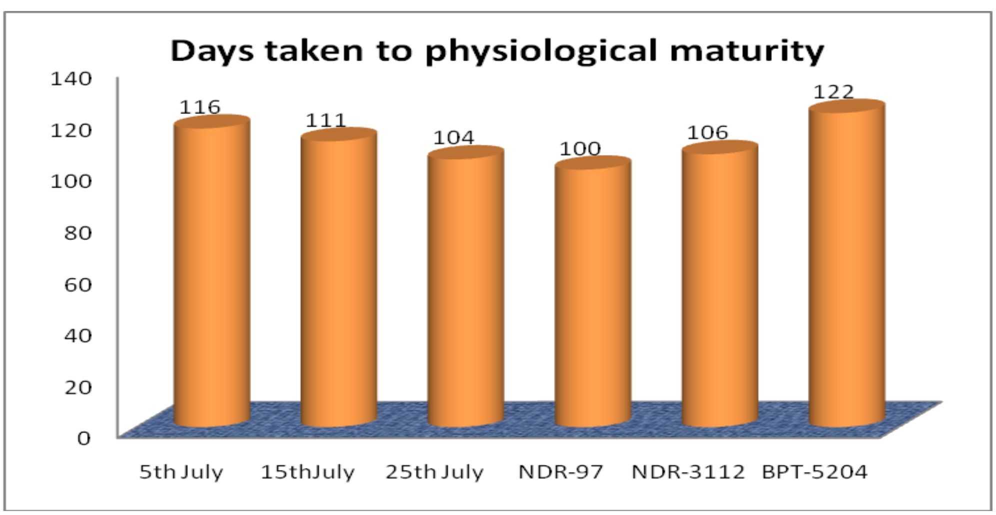


Table.2 Accumulated heliothermal unit as affected by different growing environment of rice cultivars

Treatments	**Phenophases/Stage**	
Growing environment	**Heliothermal unit (^{0}days hrs.)**	
	Vegetative	**Reproductive**
5th July	5369.76	9507.30
15thJuly	4972.44	9045.80
25th July	4636.69	8388.67
Varieties		
NDR-97	3651.54	8957.60
NDR-3112	3896.44	8545.47
BPT-5204	5674.81	9977.37

Fig.4

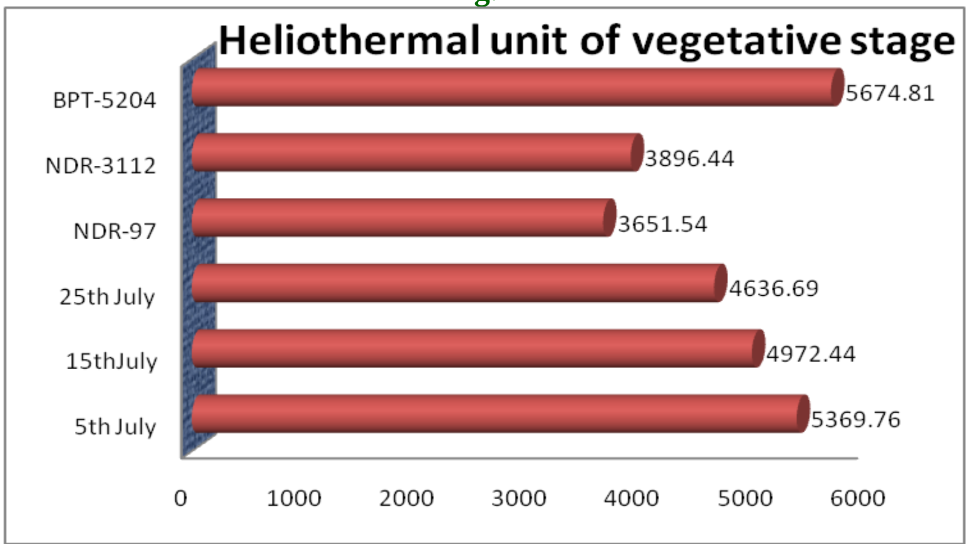


Fig.5

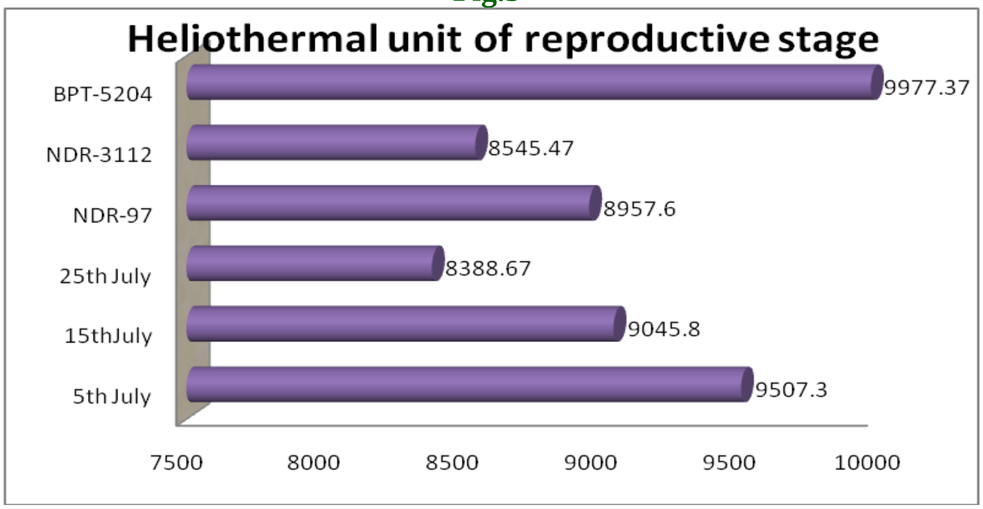


Table.3 Accumulated photothermal unit as affected by different growing environment of rice cultivars

Treatments	Phenophases/Stage	
Growing environment	Photothermal unit (⁰days hrs.)	
	Vegetative	Reproductive
5th July	22270.5	28863.9
15th July	21435.3	28210.6
25th July	20160.0	24417.8
Varieties		
NDR-97	22868.0	26241.9
NDR-3112	21910.2	25802.9
BPT-5204	23741.0	27593.3

Fig.6

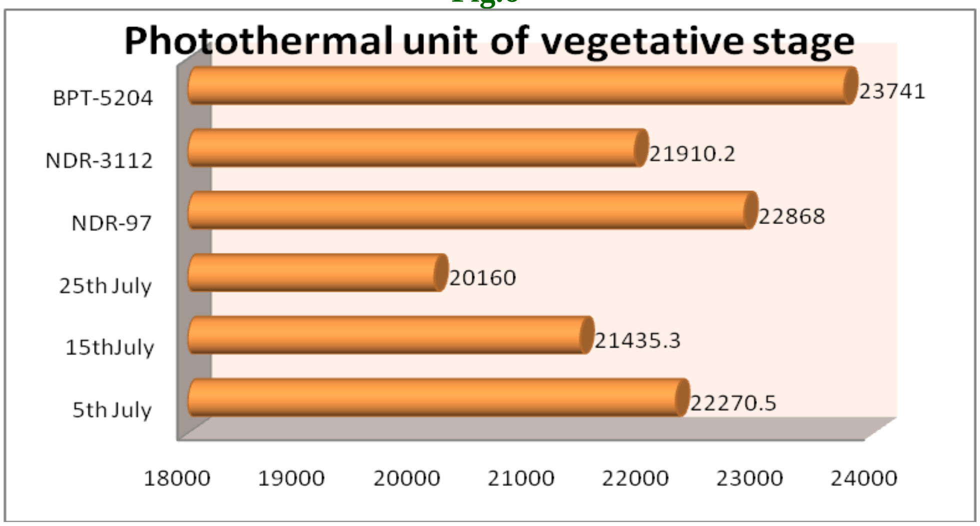


Fig.7

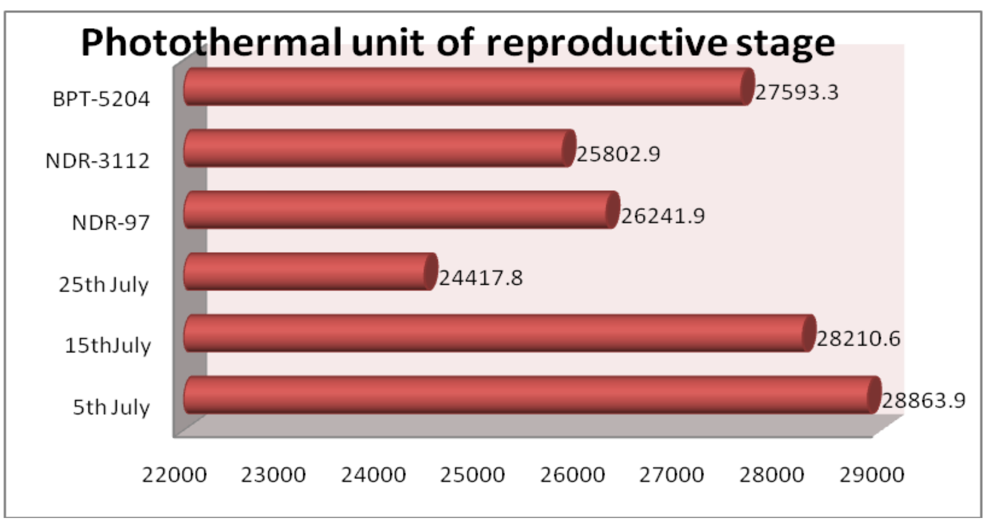


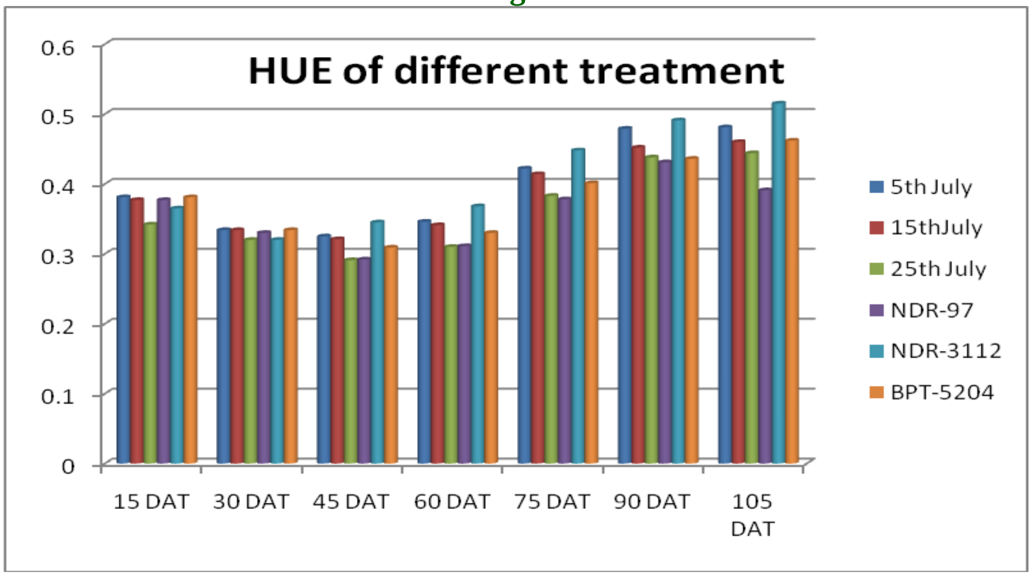
Table.4 Accumulation of Bright sunshine hours as affected by different growing environment of rice cultivars

Treatments	**Phenophases/Stage**	
Growing environment	**Bright sun shine (BSS) (hrs.)**	
	Vegetative	**Reproductive**
5th July	371.2	650.6
15thJuly	326.3	593.1
25th July	320.9	546.7
Varieties		
NDR-97	186.5	435.2
NDR-3112	199.1	479.5
BPT-5204	285.0	583.4

Table.5 Heat use efficiency (HUE) as affected by different growing environment of rice cultivars

Treatments	**Heat use efficiency (g/m^2/^{0}days)**						
Growing environment	**15 DAT**	**30 DAT**	**45 DAT**	**60 DAT**	**75 DAT**	**90 DAT**	**105 DAT**
5th July	0.381	0.334	0.325	0.346	0.422	0.479	0.481
15thJuly	0.377	0.334	0.321	0.341	0.414	0.452	0.460
25th July	0.342	0.320	0.291	0.310	0.383	0.438	0.444
Varieties							
NDR-97	0.377	0.330	0.292	0.311	0.378	0.431	0.391
NDR-3112	0.365	0.320	0.345	0.368	0.448	0.491	0.515
BPT-5204	0.381	0.334	0.309	0.330	0.401	0.436	0.462

Fig.8



Photothermal unit

Data pertaining to photothermal unit as affected by different growing environment of rice cultivars have been presented in table 3 and by graph 6 and 7. From table it was revealed that photothermal unit was recorded highest in Ist date of transplanting on July 5th, at vegetative and reproductive stages as followed by July 15th and July 25th. Among the varieties highest photothermal unit at vegetative and reproductive stages was recorded in variety BPT-5204, followed by NDR-97 and NDR-3112.

Bright Sunshine hours

Bright sunshine (hrs.) of rice cultivars at different growing environment has been depicted in table 4. From table it was revealed that highest bright sunshine (hrs.) was recorded at Ist date of transplanting on (650.6) July 5th followed by (593.1) July 15th and (546.7) July 25th respectively. Among the varieties bright sunshine hours were recorded highest in cultivar BPT-5204 (583.4) followed by NDR-3112(479.5) and NDR-97(435.2).

Heat use efficiency

Heat use efficiency (HUE) (g/m^2/^{0}days) of rice cultivars at different growing environment has been depicted in table 5 and figure 8. From table it was revealed that maximum Heat use efficiency HUE (g/m^2/^{0}days) (0.481) was recorded at Ist date of transplanting on July 5th at 105 DAT followed by July 15th (0.460) and July 25th (0.444). Among the varieties, NDR-3112 possess highest Heat use efficiency (0.515) at 105 DAT followed by BPT-5204(0.462) and NDR-97(0.391).

The study concluded that Highest GDD, HTU and PTU was recorded in growing environment of first date of transplanting at all the phenophases. While among the variety BPT-5204 (2275.9^{0}days) recoded highest GDD due to occurrence of long duration. Variety NDR-3112 found suitable for higher productivity. Highest Heat use efficiency (HUE) was recorded in growing environment of July 5th (0.481 gm^{-20}days) transplanting at all the stage followed by July 15th (0.460 gm^{-20}days) and July 25th (0.444 ^{0}days) transplanting while among the variety NDR-3112 (0.515 gm^{-20}days) recoded highest HUE followed by BPT-5204(0.462gm^{-20}days)and NDR-97 (0.391gm^{-20}days).

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