Original Research Article

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Influence of Bright Sunshine Hours, Photothermal, Heliothermal and HUE of Rice Cultivars Growing under varying Environment

Deependra Singh*, S. R. Mishra, Rakesh Kushwaha and Ram Singh

Department of Agro-meteorology, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, (U.P.) India

*Corresponding author

A B S T R A C T

A field experiment was conducted during kharif season of 2015 at the AN.D.U.A. & T. Kumarganj, Ayodhya (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., Sarjoo-52, NDR-359 and Swarna Sub-1. Highest photothermal unit was recorded in 1st date of transplanting on July 5th at vegetative stage (22270.5 days hrs.) and reproductive stage (28863.9 days hrs.) which was superior over July 15th at vegetative stage (21435.3 days hrs.), reproductive stage (28210.6 days hrs.) and July 25th at vegetative stage (20160.0 days hrs.), reproductive stage (24417.8 days hrs.). Highest Heat use efficiency (HUE) was recorded in growing environment of July 15th (0.499 gm^-2 days) transplanting at all the stage followed by July 5th (0.474 gm^-2 days) and July 25th (0.448 gm^-2 days) transplanting while among the variety NDR-359 (0.503 gm^-2 days) recoded highest HUE followed by Swarna Sub-1(0.475 gm^-2 days) and Sarjoo-52 (0.457 gm^-2 days).

K e y w o r d s
HUE, BSS, Heliothermal, Photothermal

Introduction

Rice (*Oryza sativa* L.) is one of the important foods for most people living in India. It is being grown under diverse agro-climatic condition at wide range of latitudes. It is essential to human diet in India as it is a richest source of carbohydrates and adds the proteins component in human diet too. Generally 6.8 % protein, 78.2 % carbohydrates, 0.5 % fat and 0.6 % mineral matters are found in rice hence it is primarily used as a staple food crop. The rice is cultivated worldwide in area 156.80 million hectare having an annual production of 680.19 million tonnes and an average productivity of 5.15 tonnes per hectare (Anonymous, 2013-14). In the latest report, In India, during 2014-15, the rice crop had production of 103.04 million tonnes. In Uttar Pradesh it was grown on over all area 50.94 million hectare with production of 15.30 million tonnes. The average productivity of Uttar Pradesh is 257.3 kg/ha which is more than the average national productivity. In Uttar Pradesh it is grown in about 6.20 m ha which comprises of 13.5% of total rice in India. (Anonymous, 2013-2014). Rice (*Oryza
*Oryza sativa* L.,) belongs to the family Gramineae, genus *Oryza* and has two cultivated and 22 wild species. The cultivated species are *Oryza sativa* and *Oryza glaberrima*. *Oryza sativa* is grown all over the world while *Oryza glaberrima* has been cultivated in West Africa for the last ~3500 years. Most rice researchers agree that the area of *Oryza sativa* is located in a belt extending from the Assam-Meghalaya area in India to mountain ranges in the mainland Southeast Asia and Southwest China. Rice is the most important staple food for a large part of the world’s population, especially in East and South Asia, the Middle East, Latin America, and the West Indies. As the population increases rapidly in these regions, the demand for rice will grow to an estimated 2000 million metric tons by 2030 (FAO, 2002). In 2010-2011, area covered under rice was 59.25 ha with productivity of 21.20 q/ha. (Dwivedi, 2011).

Rice is grown under different conditions. Rice is the only cereal crop that can grow for long periods of time in standing water. 57% of rice is grown on irrigated land, 25% on rainfed lowland, 10% on the uplands, 6% in deepwater, and 2% in tidal wetlands. Rice is one of the most important cereal crop belong to the family *Gramineae*. It is the staple food for half of the world’s population. Rice is cultivated worldwide in area of 156.80 million hectare having an annual production of 650.19 million tonnes. Among the rice growing countries, India stands first in area and second in production next after China. Uttar Pradesh is largest rice growing state after West Bengal in the country. Rice production in Asia has increased by 2.6 times since 1961, primarily as a result of the “Green Revolution”, which dramatically increased the rice productivity in the high input irrigated system (Khus, 1997). The rainfed systems, which occupy about 32% of the rice-growing area in Asia, have been less from the ‘Green Revolution’. According to GRSP (Global Rice Science Partnership) Annual Report, 2011, rice production on 60 million hectares of rainfed areas in Asia and almost 7 million hectares in sub-Saharan Africa remain low (0.5-2.5 t/ha) and unstable due to frequent drought or flooding.

These events can occurs in different years, or both can happen in the same season during different crop growth periods. The yield of rice is stagnating around ≤ 2.0 t/ha since 2001-2002 except in the year 2002-2003, 2004-2005 and 2009-2010 due to erratic rainfall distribution causes excess water stagnation/drought or both in different years.

**Materials and Methods**

An experiment was conducted during Kharif season of 2015 at Agro-meteorology Research Farm of A.N.D. University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.). The experiment was conducted in Randomized Block Design (RBD) and replicated the three times. The different growth parameters studied were rice as Heat Use Efficiency (HUE), Bright Sunshine Hours (BSS), Heliothermal, Photothermal.

**Results and Discussion**

Heat use efficiency (HUE) (g/m$^2$/days) of rice cultivars at different growing environment has been depicted in (Table 1). The maximum Heat use efficiency (g/m$^2$/days) (0.499) was recorded at 2nd date of transplanting on July 15th at 105 DAT followed by July 5th (0.474) and July 25th (0.448). Among the varieties, NDR-359 possess highest Heat use efficiency (0.503) at 105 DAT followed by Swarna Sub-1(0.475) and Sarjoo-52 (0.457). The similar results found that by Nishad et al., (2018) 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 Highest Heat use efficiency (HUE) was recorded in growing environment of July 25th transplanting at all the stage followed by July 15th and July 5th transplanting while among the variety NDR-3112 recoded highest HUE followed by BPT-5204and NDR-97.

Bright sunshine (hrs.) of rice cultivars at different growing environment has been depicted in (Table 2). From table it was revealed that highest bright sunshine (hrs.) was recorded at II\textsuperscript{nd} date of transplanting on (669.8) July 15\textsuperscript{th} followed by (661.6) July 5\textsuperscript{th} and (598.8) July 25\textsuperscript{th} respectively. Among the varieties bright sunshine hours were recorded highest in cultivar NDR-359 (633.8) followed by Sarjoo-52(633.8) and Swarna Sub-1(627.6). Samanta et al., (2019) Irrespective of years, Swarna cultivar used the radiation more efficiently than the Satabdi cultivar. The mean RUE values were 2.75 and 2.57 gm MJ\textsuperscript{-1} IPAR for Swarna and Satabdi cultivars respectively.

Table.1 Heat use efficiency (HUE) as affected by different growing environment of rice cultivars

| Treatments   | Heat use efficiency (g/m\textsuperscript{2}/\#days) |
|--------------|---------------------------------------------------|
| Growing environment | 15 DAT | 30 DAT | 45 DAT | 60 DAT | 75 DAT | 90 DAT | 105 DAT |
| 5\textsuperscript{th} July | 0.387   | 0.340   | 0.383   | 0.403   | 0.466   | 0.460   | 0.474   |
| 15\textsuperscript{th} July | 0.389   | 0.350   | 0.390   | 0.456   | 0.488   | 0.495   | 0.499   |
| 25\textsuperscript{th} July | 0.351   | 0.334   | 0.375   | 0.353   | 0.436   | 0.445   | 0.448   |
| Varieties    |                                                   |
| Sarjoo-52    | 0.363   | 0.345   | 0.378   | 0.345   | 0.438   | 0.446   | 0.457   |
| NDR-359      | 0.386   | 0.365   | 0.389   | 0.396   | 0.472   | 0.484   | 0.503   |
| Swarna Sub-1 | 0.376   | 0.356   | 0.385   | 0.385   | 0.454   | 0.463   | 0.475   |

Table.2 Accumulated of Bright sunshine hours as affected by different growing environment of rice cultivars

| Treatments   | Phenophases/Stage |
|--------------|-------------------|
| Growing environment | Bright sunshine (BSS) (hrs.) |
| Vegetative | Reproductive |
| 5\textsuperscript{th} July | 487.4 | 661.6 |
| 15\textsuperscript{th} July | 490.5 | 669.8 |
| 25\textsuperscript{th} July | 451.1 | 598.8 |
| Varieties    |                   |
| Sarjoo-52    | 447.0 | 627.6 |
| NDR-359      | 461.7 | 633.8 |
| Swarna Sub-1 | 580.5 | 626.6 |
Table.3 Accumulated heliothermal unit as affected by different growing environment of rice cultivars

| Treatments Growing environment | Phenophases/Stage | Heliothermal unit (°days hrs.) |
|-------------------------------|-------------------|--------------------------------|
|                               | Vegetative        | Reproductive                  |
| 5th July                      | 10241.4           | 13414.6                       |
| 15th July                     | 10006.2           | 13244.9                       |
| 25th July                     | 9273.6            | 11179.7                       |

| Varieties                     |                   |                                |
|-------------------------------|-------------------|--------------------------------|
| Sarjoo-52                     | 10126.3           | 12177.7                       |
| NDR-359                       | 10092.0           | 12165.4                       |
| Swarna Sub-1                  | 11604.4           | 12483.2                       |

Table.4 Accumulated photothermal units as affected by different growing environment of rice cultivars

| Treatments Growing environment | Phenophases/Stage | Photothermal unit (°days hrs.) |
|-------------------------------|-------------------|--------------------------------|
|                               | Vegetative        | Reproductive                  |
| 5th July                      | 22270.5           | 28863.9                       |
| 15th July                     | 21435.3           | 28210.6                       |
| 25th July                     | 20160.0           | 24417.8                       |

| Varieties                     |                   |                                |
|-------------------------------|-------------------|--------------------------------|
| Sarjoo-52                     | 22868.0           | 26241.9                       |
| NDR-359                       | 21910.2           | 25802.9                       |
| Swarna Sub-1                  | 23741.0           | 27593.3                       |

Data pertaining to heliothermal unit as affected by different growing environment of rice cultivars have been presented in (Table 3). From table it was revealed that heliothermal unit was recorded highest in 1st date of transplanting on July 5th (°days hours) followed by July 15th and July 25th. Among the varieties highest heliothermal unit at vegetative and reproductive stages were recorded in cultivars Swarna Sub-1 followed by Sarjoo-52 and NDR-359. Data pertaining to photothermal unit as affected by different growing environment of rice cultivars have been presented in (Table 4). From table it was revealed that photothermal unit was recorded highest in 1st 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 Swarna Sub-1, followed by Sarjoo-52 and NDR-359. Pal et al., (2013) the Higher PTU and HTU were accounted in case of variety PBW-343 followed by WH-542 during all the phenophases of wheat for both the years. Wheat crop sown on 20th November (normal) required less photothermal unit as well as heliothermal unit, while, 09th January (late) sowing accounted higher values of PTU and HTU during crop growth period. Timely sown wheat crop (20th November) produced highest yield, while, with every 25 days delay in sowings reduction in yield was accounted
by 13 to 26.1 percent in the year 2007-08, whereas, 14.6 to 29.3 percent in 2008-09. Diwan et al., (2017) In terms of genotypes heat use efficiency (HUE) was maximum in Mahamaya and radiation use efficiency (RUE) was maximum in MTU-1010.

In conclusion the maximum heat use efficiency (g/m²/day) (0.499) was recorded at I\textsuperscript{nd} date of transplanting on July 15\textsuperscript{th} at 105 DAT followed by July 5\textsuperscript{th} (0.474) and July 25\textsuperscript{th} (0.448). The highest bright sunshine (hrs.) was recorded at I\textsuperscript{st} date of transplanting on (669.8) July 15\textsuperscript{th} followed by (661.6) July 5\textsuperscript{th} and (598.8) July 25\textsuperscript{th} respectively. heliothermal unit was recorded highest in I\textsuperscript{st} date of transplanting on July 5\textsuperscript{th} (\textsuperscript{10}days hours) followed by July 15\textsuperscript{th} and July 25\textsuperscript{th}. it was revealed that photothermal unit was recorded highest in I\textsuperscript{st} date of transplanting on July 5\textsuperscript{th}, at vegetative and reproductive stages as followed by July 15\textsuperscript{th} and July 25\textsuperscript{th}.

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