HEAT UNITS REQUIREMENT FOR DIFFERENT RICE VARIETIES IN THE CENTRAL ZONE OF KERALA

Jasti Venkata Satish, B. Ajithkumar, Laly John C* and Arjun Vysakh

Department of Agricultural Meteorology, College of Horticulture, KAU, Vellanikkara, Thrissur

**Department of Agricultural Statistics, College of Horticulture, KAU, Vellanikkara, Thrissur*

Received: 03/09/2017	Edited: 07/09/2017	Accepted: 15/09/2017

Abstract: *A field experiment was conducted during Kharif season of 2016 at Kerala Agricultural University, Agricultural Research Station, Mannuthy, Thrissur. To study the phenology, and various agrometeorological indices viz., accumulated growing degree days (GDD), helio thermal units (HTU), photo thermal units (PTU), of selected rice cultivars grown under different dates of planting. The rice varieties Jyothi and Kanchana were transplanted on five dates of planting viz., 5th June, 20 th June, 5th July, 20th July and August 5th. Heat units required to attain different phenological stages decreased for both the varieties with every delay in transplanting date. The crop transplanted on 5th June took maximum calendar days, growing degree days, helio thermal units to attain different phenological stages till physiological maturity which increased significantly with subsequent delay in transplanting date whereas photothermal units shows declining trend towards the delayed date of planting. Among varieties, Jyothi consumed highest GDD, HTU and PTU as compared to other varieties.*

Keywords: *Rice, GDD, HTU, PTU.*

Introduction

Rice (*Oryza sativa* L.) is among one of the most important cereal crops grown under different hydrological conditions in Asia. About 90% production and consumption of world's rice occurs in Asia (FAOSTAT, 2014). In India, it is dominating staple food crop of fertile alluvial soils of North-West regions of the country, particularly Indo-Gangetic Plains (Walia and Walia, 2007). Rice contributing around 45% of the total food grain production and being the staple food for more than two third of the population, plays the key role to sustain food sufficiency in the country (Rai and Kushwaha, 2005). India holds second position in production of rice in the world with production of 105.48 million tonnes from 43.90 million hectares, with a productivity of 2390 kg/ha during 2015 (Economic survey, 2015-16). Rice production is affected by various meteorological variables like rainfall, temperature etc (Ji *et al.,* 2007). The extreme climatic conditions, particularly high temperature, reduce the plant growth and yield significantly (Satake and Yoshida, 1978). The crop growth response is mainly influenced by the microclimate of crop canopy. Microclimatic environment in the crop refers to the physical conditions from the canopy top to the soil (up to maximum rooting zone) which affects development and yield of crop. Various environmental factors influencing crop growth are air and leaf temperatures, interception of photosynthetically active radiation, prevailing wind speed, soil moisture availability, relative humidity and concentration of CO_2. Temperature and light radiation are key factors affecting crop production. During crop growth period, the occurrence of various phenological events can be estimated by computing accumulated growing degree days (Gouri *et. al.*, 2005). Accumulated growing degree days (GDD) provides an estimate of harvest date as well as development stages of crop (Ketring and Wheless, 1989). Various developmental stages as well as harvest date of crop can be estimated from the knowledge of accumulated GDD. Thermal time can be used as a tool for characterizing thermal responses in different crops as it is an independent variable to describe plant development (Dwyer and Stewart, 1986). Heat use efficiency (HUE), *i.e.*, efficiency of heat utilization in terms of dry matter accumulation, depends on genetic factors, crop type and sowing time and has great practical application (Rao *et al.,* 1999). Hence, the study was taken up to find out the heat units requirement for different rice varieties, *viz.* Jyothi and Kanchana in the central zone of Kerala.

Materials and Methods

The field experiment were conducted during the period from May 2016 to November 2016 at Agricultural Research Station, Mannuthy, Kerala Agricultural University, Thrissur. It is situated at 10° 31' N latitude and 76° 15' E longitude with an elevation of 10 meters above the mean sea level. The station lies in the central agroclimatic zone of Kerala. The experiment included five dates of transplanting *viz.* 5^{th} June, 20^{th} June, 5^{th} July, 20^{th} July and 5^{th} August as main plot treatments and two varieties namely Jyothi and Kanchana as subplot treatments, resulting in 10 treatment combinations. The experiment was laid out in a split-plot design with four replications. Four plants were randomly selected from each plot and pulled out every time periodically, at 15 days interval starting from 15 DAT till harvest of crop, for recording plant dry matter and then their average weight was taken. The agroclimatic indices namely growing degree days, helio thermal units, photo thermal units were worked out.

Phenological observations

The crop was inspected at frequent intervals (2 or 3 days) to observe the phenological events closely. The phenological events recorded were active tillering, panicle initiation, booting, heading, 50% flowering and Physiological maturity.

Growing degree days (GDD)

Cumulative growing degree days were determined by summing the daily mean temperature above base temperature, expressed in degree day. For *Oryza* species, Tbase is considered 10 °C (Ghadekar, 2001). This was determined by using the following formula as per (Nuttonson, 1995):

$$GDD = \frac{(Tmax + Tmin)}{2} - Tbase \quad \ldots (1)$$

Where,

Tmax = Daily maximum temperature (°C)

Tmin = Daily minimum temperature (°C)

Tbase = Minimum threshold/base temperature (°C)

Heliothermal units (HTU), degree day hrs

The heliothermal units for a day represent the product of GDD and the hours of bright sunshine for that day. The sum of HTU for particular phenophases of interest was determined according to the equation:

$$HTU = \Sigma \{GDD \times BSS\ (n)\} \ldots\ldots (2)$$

Where,

GDD = growing degree days

BSS (n) = bright sun shine hours (hrs)

Photothermal units (PTU), degree day hrs

Photothermal units are the cumulative value of growing degree days, multiplied by the day length. This can be mathematically represented using the following formula:

$$PTU = \Sigma\ (GDD * N) \ldots\ldots (3)$$

Where,

GDD = Growing degree days

N = Maximum possible sunshine hours or day length (hrs)

Results and Discussion

Among the different dates of transplanting, rice transplanted on 5^{th} June took higher number of days to attain physiological maturity followed by 20^{th} June, 20^{th} July, 5^{th} July and 5^{th} August during the *kharif* 2016 crop season (Table 1). These results confirmed the findings of Majos and Pava (1980). Sharma *et al.,* (2011) also reported that the early transplanting took more number of days for maturity as compared to late transplanting. Among the two varieties Jyothi and Kanchana, Jyothi took maximum number of days to attain physiological maturity.

Table 1: Effect of transplanting time on phenophases of rice varieties

Phenophases	Date of transplanting									
	D1		D2		D3		D4		D5	
	J	K	J	K	J	K	J	K	J	K
Active tillering	27	28	27	27	28	27	27	26	27	26
Panicle initiation	35	36	37	37	36	36	37	35	36	35
Booting	57	56	56	57	56	57	57	54	54	54
Heading	63	63	64	63	63	62	62	61	60	60
50% flowering	67	67	67	66	66	65	66	64	64	63
Physiological maturity	103	102	102	102	100	99	101	99	99	98

Growing Degree Days (GDD)

Growing degree days accumulated at different phenophases were calculated during crop season. The highest number of growing degree days were accumulated by 5th August transplanted crop followed by 20th July, 5th July, 20th June and 5th June transplanted crops at all the phenophases. Among the varieties, the maximum growing degree days were accumulated in variety Kanchana than Jyothi to reach physiological maturity during the crop season.

In general, 5th August transplanted crop accumulated higher degree days and with delay in transplanting the degree day accumulation increased during the crop seasons. For different transplanting dates, AGDD to reach physiological maturity ranged from 1583.4 to 1652.0 and 1605.3 to 1652.8 degree days for varieties Jyothi and Kanchana, respectively (Table 2).

Helio Thermal Units (HTU)

Heliothermal units (HTU) required to attain different phenophases of rice were calculated. It was observed that the crop transplanted on 5th August availed higher heliothermal units and with delay in transplanting, HTU accumulation increased in both varieties. Highest heliothermal units were recorded in the crop transplanted on 5th August followed by crops transplanted on 20th July, 5th July, 20th June and 5th June respectively. Among different transplanting dates, AHTU to reach physiological maturity ranged from 5422.1 to 8407.8 degree day hours and 5449.0 to 8560.5 degree day hours for varieties Jyothi and Kanchana, respectively (Table 3). The HTU accumulation was increased with late transplanting for both Jyothi and Kanchana during the crop season.

Photo Thermal Units (PTU)

The accumulated photothermal units (APTU) also showed that PTU were higher in 5th June transplanting followed by 20th June, 5th July, 20th July and 5th August. At physiological maturity stage, higher PTU were recorded in variety Jyothi followed by Kanchana among all the dates of planting, ranged 1987.3 to 5149.6 and 1953.8 to 5149.6 degree day hours for varieties Jyothi and Kanchana, respectively (Table 4).

Table 2: Growing degree days (GDD) requirement of rice varieties at various phenophases under different date of planting

Phenological stages	D1		D2		D3		D4		D5	
	Jyothi	Kanchana	Jyothi	Kanchana	Jyothi	Kanchana	Jyothi	Kanchana	Jyothi	Kanchana
T-AT	422.5	3626.3	409.4	6142.3	427.0	8880.0	445.1	428.5	453.8	438.2
AT-PI	110.1	2315.8	111.1	1881.2	116.1	1742.0	121.4	136.5	115.0	132.7
PI-B	346.7	6516.2	317.4	2275.7	322.7	785.4	319.0	318.3	307.8	323.5
B-H	99.9	426.1	102.1	242.8	98.6	2169.8	85.9	121.8	84.7	102.3
H-F	65.7	1518.0	52.2	133.2	49.7	1123.3	50.9	50.4	51.4	51.8
F-PM	607.2	4303.0	591.3	5149.6	577.8	1953.8	597.2	597.4	597.7	597.3
TOTAL	1652.0	18705.5	1583.4	15824.8	1591.7	16654.3	1619.3	1652.8	1610.3	1645.7

Table 3: Helio thermal units (HTU) requirement of rice varieties at various phenophases under different date of planting

Phenological stages	D1		D2		D3		D4		D5	
	Jyothi	Kanchana	Jyothi	Kanchana	Jyothi	Kanchana	Jyothi	Kanchana	Jyothi	Kanchana
T-AT	644.6	760.5	699.8	699.8	947.3	862.6	1728.5	1728.5	2262.2	2260.6
AT-PI	317.4	318.8	273.1	346.6	451.6	523.3	797.0	838.1	436.1	392.2
PI-B	799.2	726.5	1455.4	1455.4	1778.0	1873.8	1427.5	1326.5	1867.2	1931.7
B-H	397.1	468.3	634.1	583.2	60.2	56.8	514.4	798.3	532.6	608.1
H-F	240.0	240.0	276.7	305.5	333.5	174.9	315.7	335.7	450.8	451.8
F-PM	3023.8	2934.9	2841.8	2841.8	3689.8	3787.2	3082.9	3165.2	2859.0	2916.1
TOTAL	5422.1	5449.0	6181.0	6232.4	7260.4	7278.5	7866.0	8192.4	8407.8	8560.5

Table 4: Photo thermal units (PTU) requirement of rice varieties at various phenophases under different date of Planting

Phenological stages	D1		D2		D3		D4		D5	
	Jyothi	Kanchana	Jyothi	Kanchana	Jyothi	Kanchana	Jyothi	Kanchana	Jyothi	Kanchana
T-AT	3596.7	3626.3	6142.3	6142.3	8921.7	8880.0	4115.6	4115.6	4312.4	2420.8
AT-PI	544.6	2315.8	1839.9	1881.2	1696.4	1742.0	253.3	307.7	1293.9	1421.1
PI-B	8337.1	6516.2	2275.7	2275.7	748.4	785.4	3684.1	3756.4	1243.9	1290.3
B-H	376.4	426.1	236.1	242.8	3209.9	2169.8	202.9	235.4	385.2	434.0
H-F	1518.0	1518.0	137.6	133.2	102.8	1123.3	102.7	125.1	70.2	71.2
F-PM	4342.6	4303.0	5149.6	5149.6	1987.3	1953.8	2773.6	2572.4	2297.4	2285.5
TOTAL	18715.5	18705.5	15781.2	15824.8	16666.5	16654.3	11132.2	11112.5	9602.9	7923.0

Lower grain yields in Jyothi and Kanchana was observed in delayed dates of planting, it was due to higher accumulation of GDD during transplanting to active tillering in delayed dates of planting (Fig.1 and 2). This result was in agreement with Sandhu *et al.* (2013).

The delayed transplanting recorded highest HTU in Jyothi and Kanchana. This result was in agreement with Khavse *et al.* (2015). The highest HTU for Jyothi and Kanchana was recorded on August 5th date of planting in both varieties. In Jyothi and Kanchana HTU was found to be increased with delay in transplanting due to more sunshine hours. In Jyothi and Kanchana, increase in HTU during vegetative phase with delay in transplanting decreases the yield (Fig.3 and 4). Highest PTU was observed in June 5th planting for the both Jyothi and Kanchana. PTU found decreasing trend during Physiological maturity towards the delayed date of planting in both varieties (Fig.5 and 6) respectively.

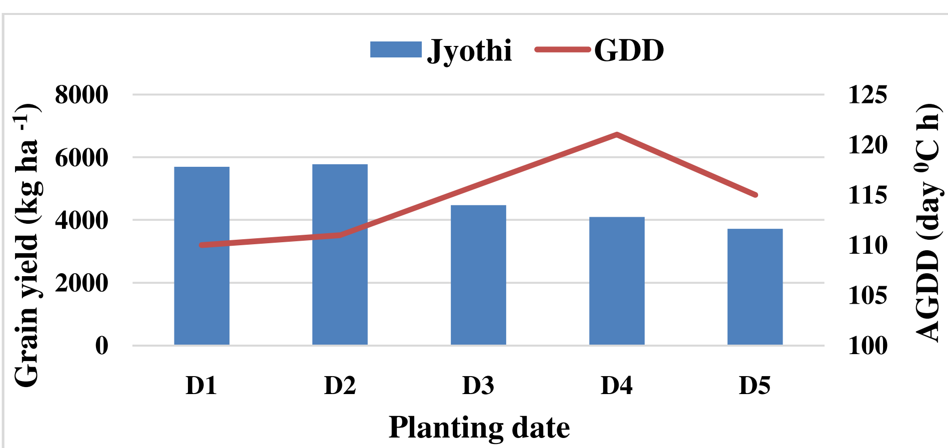

Fig 1: Effect of GDD on grain yield of Jyothi during Active tillering to panicle initiation

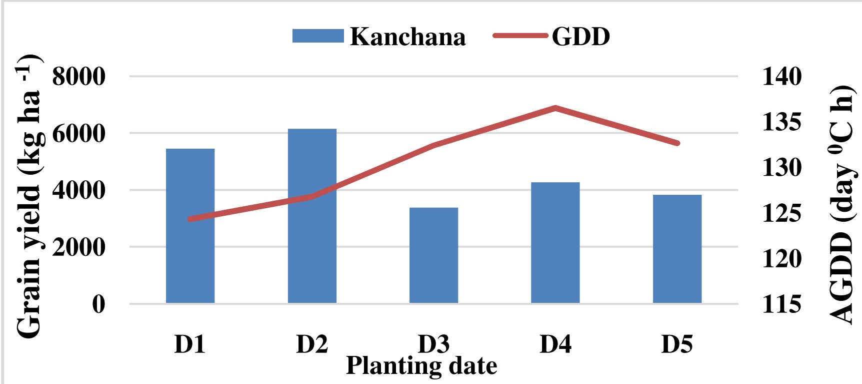

Fig 2: Effect of GDD on grain yield of Jyothi during Active tillering to panicle initiation

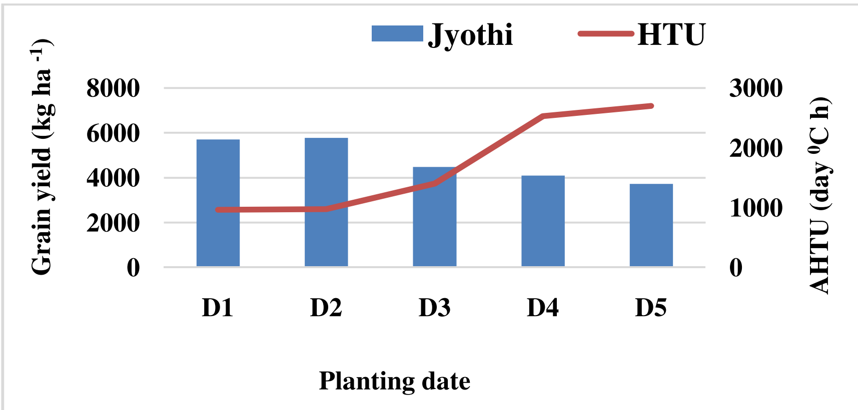

Fig 3: Effect of AHTU on grain yield of Jyothi during Vegetative Phase

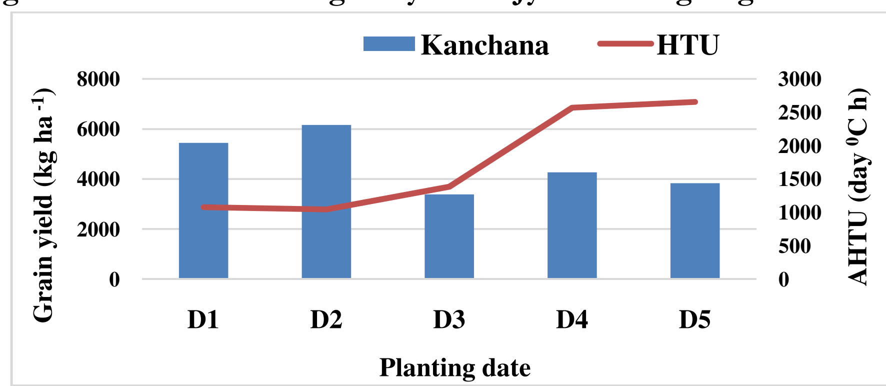

Fig 4: Effect of AHTU on grain yield of Kanchana during Vegetative Phase

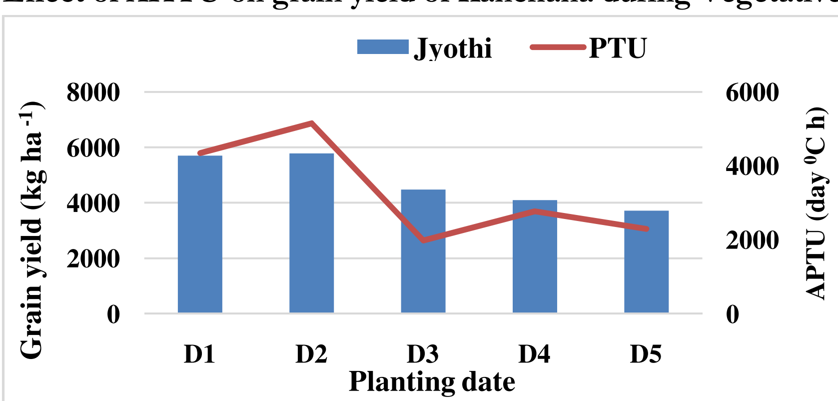

Fig 5: Effect of APTU on grain yield of Jyothi during physiological maturity

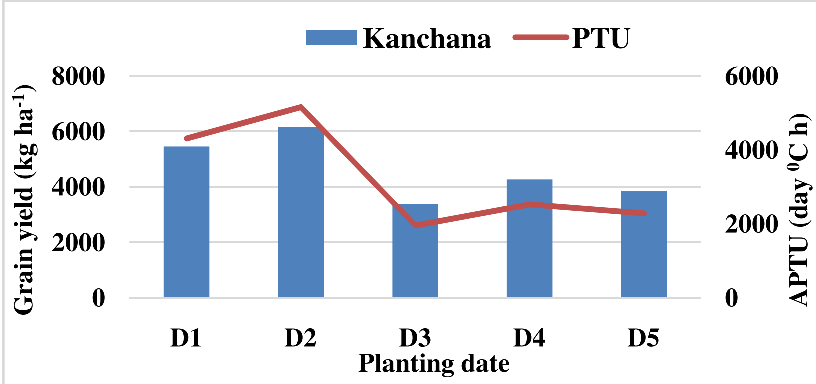

Fig 6: Effect of APTU on grain yield of Jyothi during physiological maturity

Conclusion

The present study indicates that the application of heat units provides a scientific basis for determining the effect of temperature and radiation or photoperiod on phenological behaviour of a standing crop. These provide very clear picture of the amount, pattern and efficiency of heat energy consumption at different dates of planting and phenological stages of the crops.

References:

Dwyer, L.M. and Stewart, D.W. 1986. Leaf area development in field grown maize. *J. Agron.*, 78: 334-48.

FAOSTAT. 2014. FAO Statistical databases, http://www.fao.org, Food and Agriculture Organization (FAO) of the United Nations, Rome.

Gouri, V., Reddy, D.R., Rao, S.B.S.N. and Rao, A.Y. 2005. Thermal requirement of rabi groundnut in southern Telangana zone of Andhra Pradesh. *J. Agrometeorol.*, **7**(1): 90-94.

Ji, B., Sun, Y., Yang, S. and Wan, J. 2007. Artificial neutral networks for rice yield prediction in mountainous regions, *J. Agric Sci.*, 145(3): 249–61.

Ketring, D.L. and Wheless, T.G. 1989. Thermal requirement for phenological development of peanut, J. Agron., 8(16): 910-17.

Khavse, R., Deshmukh, R., and Verma, N. 2015. Thermal requirement of different rice varieties under Raipur condition. *Plant Archives.* 15(1): 319-322.

Majos, N.V. and Pava, H.M. 1980. Influence of ages of seedlings at transplanting on the performance of two low land rice varieties. *J. Agric Food & Nutrition.*, 2(2): 97-104

Sandhu, S. S., Kaur, P., and Gill, K. K. 2013. Weather based agro indices and grain yield of rice cultivars transplanted on different dates in Punjab. Int. J. Trop. Agric. Food Sci. 43(1):73-82.

Satake, T. and Yoshida, S. 1978. High temperature induced sterility in Indica rice at flowering, *Japanese J. Crop Sci.*, 47: 6-17.

Sharma, A., Dhaliwal, L.K., Sandhu, S.K. and Singh, S.P. 2011. Effect of plant spacing and transplanting time on phenology, tiller production and yield of rice (Oryza sativa L.) *Int. J. Agric. Sci.*, **7**(2): 249-253.