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THERMAL REQUIREMENTS FOR ATTAINMENT OF PHENOPHASES OF RICE CULTIVARS UNDER VARIABLE WEATHER CONDITIONS

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Abstract

The present investing was carried out at College Farm of Navsari Agricultural University, Navsari (Gujarat), India; during *Kharif* season of the year 2012. To study the requirement of total GDD for three rice cultivars *i.e.*, Jaya, Gurjari and GNR-2 under three dates of transplanting, *i.e.*, 12 July 2012, 27 July 2012 and 11 August 2012. Results revealed that the growing degree days (GDD) requirement was higher in Gurjari followed by GNR-2 and Jaya. Among dates of transplanting, higher grain yield was obtained in first date of transplanting and progressive decreased grain yield was recorded with delay in transplanting, which was mainly due to total GDD during beginning of grain filling to physiological maturity phase decreases in delayed transplanting results in reduction in grain yield. Further, it was noticed that the total GDD were decreased with delay in transplanting.

Key words : GDD, phenophases, rice cultivars, dates of transplanting.

Introduction

Rice is the important crop in the world. Rice is the staple food for more than 65 per cent of the people and it provides employment and livelihood security to 70 per cent of Indian population. India grows rice in highly diverse conditions starting from below sea levels to hill as high as > 2000 meters. India ranks first in area with about 44 m. ha under rice and second in production with 96.7 metric tons with an average productivity of 2131 kg/ha (Rami *et al*., 2010). India is the second largest producer of rice in the world after China. It has an area of 43 million hectares with the production of 99 million tones and 3.45 t/ha productivity (Anonymous, 2012). Weather variability is considered one of the major factors of inter-annual variability of crop growth and yield in all environments besides rainfall, temperature and bright sun shine hours also have been bearing on crop growth and development as well as yield response of different species to different environments can be quite different.

The heat unit concept assumes that a direct and linear relationship between growth and temperature is advantageous for the assessment of yield potential of a crop in different weather conditions (Kumar *et al*., 2014). Alteration of sowing dates a directly influences growth and development of crops. Crop growth refers to an increase in crop weight, height, volume or area over a certain time scale. Development refers to the timing or progress of the crop from one phasic stage of next (Gudadhe *et al*., 2013). Quantification of these effects may help in the choice of sowing time and match phenology of crop in specific environment to achieve higher heat and radiation use efficiency. The average temperature required throughout the life period of the rice crop ranges from 21^0C to 37^0C. At the time of tillering, the crop requires high temperature for growth. The temperature requirement in reproductive stage is in the range of 26.5^0C to 29.5^0C while at the time of ripening the temperature should be in between 20^0C to 25^0C (De Datta, 1981). The occurrence of different phenological events during a growing season of crop and the effect of temperature on plant growth can be explained using accrued heat units (Sunil and Sharma, 2005). Temperature based agro meteorological indices such as growing degree days (GDD). Growing degree days are based on the concept that real time to attain a phenological stage in linearly related to the temperature range between base temperature (T_b) and optimum temperature (Monteith, 1981).

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Materials and Methods

The field experiment was conducted on College Farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat), India; during *Kharif* season of the year 2012. The Navsari Agricultural University campus is geographically located at 20° 57' N latitude and 72° 54' E longitude at an altitude of 10 m above the mean sea level. The meteorological data *viz.,* maximum temperature, minimum temperature for the period of experimentation (June, 12 to November, 15) were recorded at Agro-meteorological observatory, Navsari Agricultural University, Navsari, Gujarat, India. The degree days for completion of each phenophases were calculated by using following formula :

$$\text{Growing Degree Days (GDD)} = \sum_{i=1}^{n} \frac{(\text{T max} + \text{T min})}{2} - \text{Tc}$$

Where, T max and T min are the maximum and minimum temperatures of the day and Tc is the minimum threshold temperature of the crop, also called as base temperature or minimum threshold temperature. The base temperature of rice crop of 10°C was used for computation of GDD on daily basis (Thomas, 1957).

Results and Discussion

Growing Degree Days (GDD°C days)

Sowing to emergence stage

The value in table 1 indicated that the total number of days taken by crop variety (cv.) Jaya for sowing to emergence stage for first date of sowing (12/06/2012) were six days, four days for second date (27/06/2012), and five days for third date (11/07/2012), with total GDD values for first, second and third date of sowing were 123.7, 76.7 and 91.5 respectively. Similarly, the total number of days in cv. Gurjari of same stage for first date of sowing were five days, three days and three days for first, second and third transplanting, respectively. The total GDD values for first, second and third dates of sowing were 104.0, 58.5 and 54.0, respectively. For cv. GNR-2 the total number of days for sowing to emergence stage for first date of sowing were (6 days), second date (5 days) and third date (6 days) along with total GDD values for first, second and third date of sowing were 123.7, 95.8 and 109.8, respectively. It was also obvious that higher values of GDD were recorded in first date of sowing followed by third and second dates for *cv.* Jaya and cv. GNR-2 (table 1). But in cv. Gurjari the maximum GDD values were observed in first date of sowing followed by second date and third date. During first, second and third of sowing, the maximum and minimum temperature values were ranged between 25.4ºC to 35.3ºC, 24.4ºC to 33.5ºC and 25.3ºC to 31.5ºC, respectively. It is obvious from the above results it is seen that total GDDºC is positively interrelated with duration of stages.

Emergence to tillering stage

It was observed that the total number of days in cv. Jaya for emergence to tillering stage for first date of transplanting (12/07/2012) were 37 days, second date (27/07/2012) 38 days and third date (11/08/2012) 39 days. The total GDD values for first, second and third date of transplanting were 703.7, 700.8 and 703.1, respectively. In the same way, the total number of days in cv. Gurjari for same stage for first date of transplanting were (34 days), second date (37 days) and third date (37 days) and total GDD values for first, second and third date of transplanting were 647.5, 681.7 and 672.2, respectively. The total number of days taken by cv. GNR-2 for emergence to tillering stage for first date of transplanting were 21 days, second date 37 days, and third date (37 days) along with total GDD value for first, second and third date of transplanting were 666.7, 681.6 and 668.0 respectively. It was obvious from table 1 that highest value of GDD were recorded under first date of transplanting followed by third and second for cv. Jaya. For cv. GNR-2 highest values of GDD were recorded in second date of transplanting followed by third and first. In cv. Gurjari the same trend was observed like cv. GNR-2. During first, second and third of transplanting, the maximum and minimum temperature values were ranged between 24.3ºC to33.5 ºC, 24.4ºC to 33.0ºC and 23.5ºC to 31.5ºC, respectively.

Tillering to panicle initiation stage

Overall number of days taken by cv. Jaya for tillering to panicle initiation stage for first date of transplanting were 36 days, second date 34 days and third date 33 days with total GDD values for first, second and third date of transplanting were 642.4, 597.7 and 592.6 respectively (table 1). Similarly, the total number of days in cv. Gurjari for same stage for first date of transplanting were 47 days, second date 41 days and third date 38 days and total GDD values for first, second and third date of transplanting were 859.9, 736.4 and 661.0, respectively. On other hand, the total number of days of cv. GNR-2 for tillering to panicle initiation stage for first date of transplanting were (42 days), second date (38 days) and third date (33 days) along with total GDD values for first, second and third date of transplanting were 752.8, 665.1 and 577.3, respectively. It is quite obvious from data the higher value of GDD were recorded in first date

Table 1 : GDD (°C-days) required for attainment of phenophases of rice cultivars under variable weather conditions at Navsari. Figure in parenthesis shows number of days taken for attainment of phenophase

Cultivars	Transplanting dates	Sowing to emergence	Emergence to tillering	Tillering to Panicle initiation	Panicle initiation to anthesis	Anthesis to beginning of grain filling	Beginning of grain filling to Phy. maturity	Total
Jaya	12/07/2012	123.7 (6)	703.7 (37)	642.4 (36)	598.2 (33)	92.0 (5)	549.7 (30)	2709.8
	27/07/2012	76.7 (4)	700.8 (38)	597.7 (34)	609.7 (34)	131.3 (6)	448.7 (27)	2564.9
	11/08/2012	91.5 (5)	703.1 (39)	592.6 (33)	629.5 (35)	140.5 (9)	239.3 (16)	2396.6
Gurjari	12/07/2012	104.0 (5)	647.5 (34)	859.9 (47)	658.4 (37)	131.9 (7)	419.5 (24)	2821.4
	27/07/2012	58.5 (3)	681.7 (37)	736.4 (41)	677.5 (38)	109.1 (6)	396.3 (25)	2659.6
	11/08/2012	54.0 (3)	672.2 (37)	661.0 (38)	740.5 (41)	110.2 (7)	310.0 (23)	2548.0
GNR-2	12/07/2012	123.7 (6)	666.7 (21)	752.8 (42)	654.0 (37)	110.6 (6)	447.4 (24)	2755.3
	27/07/2012	95.8 (5)	681.6 (37)	665.1 (38)	673.6 (37)	128.9 (7)	401.9 (26)	2647.1
	11/08/2012	109.8 (6)	668.0 (37)	577.3 (33)	645.0 (36)	96.6 (6)	262.0 (17)	2358.9

of transplanting followed by second and third in all genotypes. During first, second and third of transplanting, the maximum and minimum temperature values were ranged between 23.5ºC to 32.5ºC, 23.5ºC to 32.5ºC and 21.8ºC to 33.0ºC, respectively. Overall outcome shows that total GDDºC from tillering to panicle initiation stages decreased with delay in transplanting date and numbers of tillers per plant were also decreased as compare to early transplanting. Rani *et al*. (2012) reported that the heat and radiation use efficiencies decreased with delay in sowing. It is mainly due to the total GDD were decreased with delayed in transplanting. Similarly results are reported by Hundal *et al*. (2005).

Panicle initiation to anthesis stage

The overall number of days in cv. Jaya for panicle initiation to anthesis stage for first date of transplanting were (33 days), second date (34 days) and third date (35 days) with total GDD values for first, second and third date of transplanting were 598.2, 609.7 and 629.5 respectively. In the same way, the total number of days in cv. Gurjari for same stage for first date of transplanting were (37 days), second date (38 days) and third date (41 days) and total GDD values for first, second and third date of transplanting were 658.4, 677.5 and 740.5, respectively. On other hand, the total number of days taken by cv. GNR-2 for panicle initiation to anthesis stage for first date of transplanting were 37 days, second date 37 days and third date 36 days along with total GDD values for first, second and third date of transplanting were 654.2, 673.6 and 685.0, respectively. It was observed from data the higher value of GDD were recorded in third date of transplanting followed by second and first in all genotypes. During first, second and third of transplanting, the maximum and minimum temperature values were ranged between 20.5ºC to 36.7ºC, 20.5ºC to 37.7ºC and15.2ºC to 36.7ºC, respectively. Results shows that total GDDºC from panicle initiation to anthesis stages increased with delay in transplanting date. The total GDD were increased with delayed in transplanting, mainly due to number of days for panicle initiation to anthesis stage are increased in delayed transplanting. The duration of each phenophase determines the accumulation and partitioning of dry matter in different parts as well as crop responses to environmental and external factors (Dalton, 1967).

Anthesis to beginning of grain filling stage

Number of days in cv. Jaya for anthesis to beginning of grain filling stage for first date of transplanting were 5 days, second date 6 days and third date 9 days with total GDD values for first, second and third date of transplanting were 92.0, 131.3 and 140.5 in that order. In the same way, the total number of days in cv. Gurjari for same stage for first date of transplanting were 7 days, second date 6 days and third date 7 days and total GDD values for first, second and third date of transplanting were 131.9, 109.1 and 110.2, respectively. On other hand, the total number of days of cv. GNR-2 for anthesis to beginning of grain filling stage for first date of transplanting were 6 days, second date 7 days and third date 6 days along with total GDD values for first, second and third date of transplanting were 110.6, 128.9 and 96.6, respectively. During first, second and third of transplanting, the maximum and minimum temperature values were ranged between 36.7ºC to 20.5ºC, 36.5ºC to 18.0ºC and 36.5ºC to 15.2ºC, respectively.

Beginning of grain filling to physiological maturity stage

Data revealed that the overall number of days in cv. Jaya for beginning of grain filling to physiological maturity stage for first date of transplanting were 30 days, second date 27 days and third date 16 days with total GDD values for first, second and third date of transplanting were 549.7, 448.7 and 239.3, respectively. Similarly, the total number of days in cv. Gurjari for same stage for first date of transplanting were 24 days, second date 25 days and third date 23 days and total GDD values for first, second and third date of transplanting were 419.5, 396.3 and 310.0 respectively. On other hand the total number of days of cv. GNR-2 for beginning of grain filling to physiological maturity stage for first date of transplanting were 24 days, second date 26 days and third date 17 days along with total GDD values for first, second and third date of transplanting were 447.4, 401.9 and 262.0 respectively. It was quite obvious from data the higher value of GDD were recorded in first date of transplanting followed by second and third in all genotypes. During first, second and third of transplanting, the maximum and minimum temperature values were ranged between 15.2ºC to 36.5ºC, 12.4ºC to 36.5ºC and 12.4ºC to 34.9ºC, respectively. Among dates of transplanting, higher grain yield was obtained in first date of transplanting and progressive decreased grain yield was recorded with delay in transplanting, which was mainly due to total GDD during beginning of grain filling to physiological maturity phase decreases in delayed transplanting results in reduction in grain yield. These findings are in accordance with Sreenivas *et al*. (2005). Influence of temperature on phenology and yield of crop plants can be studied under filed conditions through accumulated heat unit system (Bishnoi *et al*., 1995). In nutshell, results of present study revealed that the cv. Jaya significantly higher value of total GDD was observed at first date of transplanting (2709.8ºC day) followed by second date of transplanting (2564.9ºC day) and third date of transplanting (2396.6ºC day). Similar trend was observed in cv. Gurjari and cv. GNR-2. The results showed that total GDD values were decreased with delay in transplanting.

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