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Short Communication

Thermal requirement of different rice cultivars as influenced by planting methods and water regimes

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Rice (*Oryza sativa* L.) is the backbone of Indian agriculture covering an area of 44 million hectare and production of about 107 million tonnes (Mt) of which *rabi* rice adds 15 Mt while major proportion is from *kharif* rice (92 Mt) (GOI, New Delhi 2015-16). The production is getting limited due to erratic distribution of rainfall leading to poor yield realization. The effect of drought or extreme rainfall, deviation in temperature and sunshine hours on rice is very prominent since rice is staple crop of Odisha where cropping is rainfed. Hence, any sort of deficit or excess rainfall and change in temperature will affect the agrarian economy. Establishment methods mostly followed in Odisha are *beushening* and transplanting followed by puddling which is both water and labor intensive. Dry seeded rice (DSR) and non puddle transplanted rice (NPTR) could be used as alternatives to reduce the use of labor because of mechanization and also reduce the water input by avoiding puddling. Water management approach like alternate wetting and drying, aerobic system, system of rice intensification, use of tensiometer, field pipes etc. are done to save water. Under such condition, selection of proper cultivar may play a deciding role in the performance of rice under changing climate scenario.

Rice being a tropical and sub tropical crop generally requires an optimum temperature of 20-35°C (Yoshida, 1981) throughout its life. The optimum temperature for germination is 20-35°C, anthesis is 30-33°C and ripening is 20-25°C. Any change in temperature will affect the days to attainment of phenophases. Hence, growing degree days (GDD) concept is used to estimate harvest date as well as developmental stages of the crop. Helio thermal unit can be used as a tool for characterizing the thermal responses in different crops as it is an independent variable to describe plant development. Heat use efficiency (HUE) depends on genetic factors, crop type and sowing time and has great practical application. Hence, considering these points the following investigation was carried out to study the thermal requirement of rice cultivars as affected by planting methods and water regimes.

Field experiments were conducted at Research farm of Orissa University of Agriculture and Technology (OUAT), Bhubaneswar (20°15'N, 85°48'E, 30.6m ASL), Odisha during dry (January-May) and wet (June-October) seasons 2014 and 2015. The climate is categorized as subtropical with average annual rainfall of 1451 mm (Odisha Agriculture Statistics, 2013-14). The soil of the experimental field was sandy clay loam with slightly acidic pH tending towards neutrality (6.4) with medium fertility (OC- 4 g kg^{-1} soil, available N, P_2O_5 and K_2O of 144, 38 and 117 kg ha^{-1}, respectively). The experiment was laid out in split-split plot design using two establishment methods viz. dry drill direct-seeded rice (DSR) and non puddle transplanted rice (NPTR) in main plot; three water regimes viz. no stress i.e. irrigation upto 5cm depth was applied to the field as soon as the ponded water disappeared, 10kPa and 40kpa (irrigation was applied based on the tensiometer data which was installed in every subplots at depth of 15cm) allocated to sub plots; five cultivars viz. Lalat, Sahbhagi Dhan, Arize®6129, US323 and Arize®6444 in sub-sub plot being replicated thrice. After commencement of stress, in dry season the number of irrigations under 10kPa was 10 and under 40kPa was 4 whereas in wet season, the number of irrigations under 10kPa was 3 and 40kPa was never attained due to rainfall.

Grain yield was determined by harvesting the plant sample manually from the centre of the plot from an area of $6m^2$ and was expressed as t ha^{-1} at 14 per cent moisture. The heat unit or growing degree days (GDD) was worked out as proposed by Nuttonson (1955). GDD= $(\Sigma (T_{max}+T_{min})/2) - T_{base}$, where, GDD is growing degree days (°C day), Tmax-daily maximum temperature (°C), Tmin-daily minimum temperature (°C) and Tbase –base temperature (10°C). Helio thermal unit was calculated on the basis of GDD and sunshine hours. HTU= Σ(GDD X BSS), Where, HTU is helio thermal unit (°C day hour) and BSS is bright sunshine hours

Table 1: Grain yield (t ha^{-1}), GDD (°C day), HTU (°C day hour) and HUE (kg ha^{-1} $°C^{-1}$ day^{-1}) of rice cultivars under different establishment methods and water regimes

Treatments	Grain yield (t ha^{-1})		GDD (°C day)		HTU (°C day hour)		HUE (kg ha^{-1} $°C^{-1}$ day^{-1})	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Planting method								
DSR	6.0	4.8	2067	2214	18722	9822	2.9	2.2
NPTR	5.9	5.0	2234	2323	17472	10516	2.7	2.1
LSD ($p \leq 0.05$)	NS	NS	49	15	525	71	0.1	NS
Moisture regimes								
No stress	7.0	4.9	2160	2265	525	71	3.2	2.2
10 kPa	6.2	4.8	2150	2266	18220	10156	2.9	2.1
40 kPa	4.6	4.9	2143	2274	18036	10199	2.2	2.1
LSD ($p \leq 0.05$)	0.2	NS	NS	NS	NS	NS	0.1	NS
Cultivars								
Lalat	6.1	4.2	2220	2334	18087	10559	2.5	1.8
SahbhagiDhan	5.2	4.6	2006	2135	18132	9314	2.6	2.1
Arize®6129	5.9	5.4	2075	2222	18088	9894	2.9	2.4
US323	6.2	4.5	2062	2267	18071	10164	3.1	2.0
Arize®6444	6.7	5.8	2391	2383	18079	10913	2.8	2.4
LSD ($p \leq 0.05$)	0.3	0.3	2067	2214	NS	184	0.1	0.1

DSR = direct seeded rice, NPTR = non puddle transplanted rice.

(hour). Heat use efficiency was calculated on the basis of GDD and grain yield. HUE= (Grain yield)/GDD, where, HUE is heat use efficiency (kg ha^{-1} $°C^{-1}day^{-1}$).

All data were analyzed by analysis of variance (ANOVA) using STAR 2.0.1. The comparison of treatment means was made by the least significant difference (LSD) at 5 per cent probability ($p \leq 0.05$).

Grain yield (t ha^{-1})

The grain yield in dry season was 20 per cent greater than wet season (Table 1). In both the seasons, the grain yield was similar with DSR and NPTR but significantly affected by irrigation schedule and cultivars.The yield differed significantly with water regimes. The average yield reduction with 10kPa and 40kPa was 12 per cent and 35 per cent, respectively than no stress. The higher yield in no stress may be because of the availability of water that enhanced the nutrient uptake, and better translocation of dry matter. The canopy temperature at 40kPa was 37.2°C in 2014 and 35°C in 2015 which is around 2°C higher than no stress. The higher canopy temperature might have reduced the filled grains and hence yield. Xie *et al.*,(2009) also revealed that higher temperature during flowering and grain filling stages reduce the grain yield. The grain yield with Arize® 6444 was maximum in both the seasons.

Accumulated growing degree days (GDD)

Higher accumulated GDD was observed in wet season. It may be because in dry season, the initial month after sowing coincided with average low temperature. Hence, GDD accumulation was less in total in dry season compared to wet season. But in wet season (June-October), the average temperature was more. On an average in both the seasons the accumulated GDD was more in NPTR. With the increase in water stress, the days to the attainment of phenophases increased and hence the GDD accumulation was more. Among cultivars, highest GDD accumulation was by Arize®6444 in the dry season (2391°C day) and wet season (2383°C day) (Table 1).Similar result was obtained by Jayapriya *et al.*, (2016) where maximum GDD was accumulated in longest duration rice cultivar.

Accumulated helio thermal units (HTU)

On an average, the HTU was high in dry season compared to wet season. Even though GDD was high in wet season, but HTU was high in dry season. This is because the bright sunshine hours (BSH) was more in dry season (7.6 hours) compared to wet season (4.4 hours). In dry season, the HTU was higher in DSR by 7.2 per cent than NPTR while in wet season, HTU was 7 per cent higher in DSR than NPTR (Table 1). With increase in water regimes, HTU increased. Higher accumulated HTU was observed by Arize®6444 in both the seasons. Since the productivity of crop depends upon the bright sunshine hours so higher yield was in dry season.

Heat use efficiency (HUE)

Heat use efficiency i.e., grain yield obtained per unit of GDD was higher in dry season than wet season (Table 1). It may be because the yield was higher in dry season. HUE of DSR was high in dry season (2.9kg ha^{-1} $°C^{-1}$ day^{-1}) and wet season (2.2 kg ha^{-1} $°C^{-1}$ day^{-1}) than NPTR. With increase in water regimes, HUE decreased in dry season with highest under no stress (3.2 kg ha^{-1} $°C^{-1}$ day^{-1}). Highest HUE was obtained in US323 in dry season. In wet season, HUE was high in both Arize®6129 and Arize®64444.

The agro meteorological indices viz. GDD, HTU and HUE provide a scientific basis for determining the effect of temperature and sunshine hours on the performance of crop. Arize®6444 being a long duration crop has the ability to accumulate higher photoperiod hours at maturity and yielded higher grain yield. It also has better conversion ability of light into dry matter subsequently better yield. Therefore, it can be concluded on the basis of performance of heat indices that Arize®6444 has the capability to produce more during both dry and wet seasons irrespective of the establishment methods and water regimes.

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