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Short communication

Phenology, heat unit accumulation and dry matter partitioning behavior of two rice cultivars transplanted on different dates

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Rice (*Oryza sativa* L.) is the main staple food crop of India and contributes around 45 per cent of the total cereal production, hence hold the key to sustain food security in the country (Rai and Kushwaha 2005). In Punjab this crop is grown during *kharif* season over 2.74 million hectares with total production of 11.0 million tonnes (Anonymous, 2010). Pheotoperiod and temperature are two main environmental factor determining the flowering time in rice (Fukai 1999). Influence of temperature on phenology and yield of crop plants can be studied under field condition through accumulated heat unit system because plant have a definite temperature requirement before they attain certain phonological stage (Rajput *et al* 1987 and Bishnoi *et al* 1995). Several studies in India have shown that a delay of 20 days in transplanting cause a delay in flowering by 8 days (Joseph 1991) or up to 13 days (Murty and Sahu 1979). Thus keeping in mind the differential behavior of rice cultivars, the present investigation was planned to study the phonological behavior, heat unit requirements and dry matter partitioning of long (PR 118) and medium (PAU 201) duration cultivars of rice under different dates of transplanting.

A field experiment was conducted at Students' Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana during *Kharif* season of 2007 and 2008. The site is located at an altitude of 247 m above mean sea level and intersected by 30^0 54' latitude, 75^0 48' longitude and forms a part of the Indo-gangetic alluvial plains. The climate of the area is semi-arid with an average rainfall of 733.6 mm (75-80 % received during July-September), lowest minimum temperature of 0-4 ^{0}C in January and highest maximum temperature of 40-45 ^{0}C in June. The soil (0-15 cm) of the experimental site is sandy loam in texture with bulk density of 1.62 g cm^{-3}, pH 7.29, EC (1:2 soil: water suspension) 0.16 dS m^{-1}, organic carbon 0.26 % and Olsen P 18.6 kg ha^{-1}. The weather parameters were recorded at the meteorological observatory located at a distance of 700 m from experimental site. The experiment was laid out in randomized complete block design with two cultivars (PAU 201 and PR 118) and three dates of transplanting (June 15, June 25 and July 5) with four replications. Both the cultivars PAU 201 and PR 118 are mildly sensitive to photoperiod and inbred lines released by Punjab Agricultural University, Ludhiana. PAU 201 is a medium duration (144 days), while PR 118 is long duration (156) cultivars. The Days taken to 50% flowering and 100 % flowering were counted from the date of transplanting to the date, when 50% of the plants in each plot attain the particular phonological stage. Leaves, stem and panicles were separated at 30 days intervals and oven dried at 60 ^{0}C temperature till constant weight is achieved for dry matter data.

The growing degree days were calculated with base temperature of 10 °C. The helio-thermal units and photo-thermal units were calculated by multiplying the heat units (GDD) to the actual sunshine hours and maximum possible sunshine hours of the day, respectively, recorded at the meteorological observatory, PAU, Ludhiana.

Results revealed that the cultivar PR 118 being a longer duration took 7 and 9 days more to attain 50 % flowering maturity, respectively than PAU 201. On an average PAU 201 took 85 and 106 days to attain 100 % flowering and maturity, respectively. Similarly, PR 118 used 129, 1145 and 1483 growing degree days, helio-thermal units and photo-thermal units more to mature than PAU 201, respectively (Table 1). The dry matter accumulation was statistically at par between both the cultivars however leaves and stem dry matter was significantly higher and panicle weight was significantly lower in PR 118 than PAU 201. Significantly lower grain yield realization with PR 118 might be accounted to inappropriate partitioning of dry matter, which resulted in significantly higher straw yield. Though the interaction between genotypes and date of transplanting was non significant, but 5.4 per cent reduction in grain yield was recorded in case of long duration cultivar, when transplanting was delayed from June 25 to July 5, while PAU 201 registered almost equal grain yield even under delayed transplanting on July 5.

Pooled analysis of two years data revealed that crop transplanted on June 15 took 4 and 6 days more to attain 50 % flowering as compared to June 25 and July 5 transplanted crops, respectively. This difference was remained 3 and 4 days at maturity among June 15 and June 25 or July 5 transplanted crops, respectively. It thus bring out that 10 and 20 days delay in transplanting led to 13 and 24 days reduction

Table 1 : Effect of dates of transplanting on accumulated heat units, helio-thermal units and photo-thermal units at different phonological stages of rice cultivars (Pooled mean of 2007 & 2008).

Treatment	Heat units accumulation			Helio-thermal units accumulation			Photo-thermal units accumulation		
	50 % Flowering	100 % Flowering	Maturity	50 % Flowering	100 % Flowering	Maturity	50 % Flowering	100 % Flowering	Maturity
Dates of transplanting									
June 15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
June 25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
July 5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cultivars									
PAU 201	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PR 118	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 2 : Effect of transplanting dates on dry matter production (q ha^{-1}) and grain yield (q ha^{-1}) of rice cultivars (Pooled mean of 2007 & 2008)

Treatment	Dry leaves	At harvest			Grain yield
		Stem	Panicle	Total	
June 15	26.6	52.3	55.3	134.2	6.57
June 25	24.8	49.1	57.3	131.2	6.76
July 5	22.4	46.5	55.2	124.1	6.60
CD (p=0.05)	1.7	2.9	NS	6.5	NS
PAU 201	22.9	46.9	58.4	128.2	6.93
PR 118	26.3	51.7	53.7	131.7	6.34
CD (p=0.05)	1.5	2.6	2.9	NS	0.19

Table 3 : . Temperature and rainfall events during key growth stages for crops transplanted at three dates during 2007 and

Dates of transplanting	Mean temperature between 31 and 33 °C during tillering (days)	Mean temperature between 31 and 33 °C during pollen development (days)	Rain events during flowering (no.)	Rain events with more than 10 mm during flowering (no.)
2007				
15 June	9	4	3	2
25 June	11	1	2	0
5 July	7	0	2	1
2008				
15 June	3	3	2	1
25 June	3	2	2	1
5 July	3	0	2	1

in total growing cycle of the crop under June 25 and July 5 transplanted crops as compared to June 15 transplanted crop, respectively. This led to reduction in accumulated growing degree days to the tune of 86 and 200 heat units to attain the maturity under June 25 and July 5 transplanted crop as compared to June 15 transplanted crop, respectively (Table 1). Similar trend was observed for HTU and PTU. This could be the possible reason that total dry matter accumulation (DMA) and its partitioning also influenced significantly under three days of transplanting at various growth stages of the crop.

The leaf, stem and total dry matter accumulation was at par between June 15 and June 25 transplanted crops but significantly higher than July 5 transplanted crop, while weight of panicles remained statistically similar under all the dates of transplanting (Table 2). This might be the possible reason that delay in transplanting from June 15 to July 5 did not influence the paddy grain yield significantly, but yield was more in June 25 transplanted crop than June 15 and July 5. The higher yield from June 25 transplanted crop was mainly due to favourable weather conditions especially at the time of tillering and flowering. June 25 transplanted crop received more favourable temperature (Table 3) and comparable sunshine durations especially at tillering stage as compared to late and early transplanted crops. This led to more number of panicles m^{-2}, 1000-grain weight and less spikelet sterility, resulted in higher grain yield. Chahal *et al*., (2007) found a significant relation between rice grain yield and number of days having temperature greater than 37^0C during post transplanting period. Results revealed that June 25 transplanted crop experienced mean temperature between 31^0C and 33 ^{0}C during tillering for more number of days (Table 3), resulted in more productive tillers. De-Datta, (1981) reported that rice yield decreases with late transplanting, due to limited solar radiations and photosynthetic efficiency. Yamada, (1961) reported that grain production depends on the balance between photosynthesis and respiration, therefore air temperature plays major role in potential grain yield realization. The optimum temperature required for germination of pollen is 31-33 ^{0}C (Grist, 1986). For late transplanting, low temperature (below 31^0C) at pollen development stage led to increase in sterility percentage. Similarly in our study June 25 transplanted crop received mean temperature between 31 to 33 ^{0}C for 3 & 1 and 4 & 3 more number of days as compared to June 15 and July 5 transplanted crops during 2007 and 2008, respectively (Table 3). The lower grain yield realization under June 15 transplanted crop may be due to two reasons (a) during flowering to anthesis growth stage of the rice, there were 3 rain events, out of which 2 showers with > 10 mm, damaged the pollen and consequently increased the spikelet sterility (Table 3 & 4) (b) there was attack of leaf folder on the early transplanted crop. Jalota *et al*., (2009) also observed that rain events during flowering to anthesis stage of rice, damaged the pollen and increased the proportion of ears without grains. The yield attributing characters viz. panicle m^{-2}, grains $panicle^{-1}$ and 1000-grain weight did not influence significantly with change in transplanting time from June 15 to July 5. However, spikelet sterility was significantly less under June 25 transplanted crop as compared to July 5 transplanted crop. Low temperature at the pollen development stage led to increase in sterility percentage under delayed transplanting on July 5.

REFERENCES

Anonymous, (2010). Package of practices for crops of Punjab (Kharif). pp. 1-13. Punjab Agricultural University, Ludhiana.

Arora, V.K. (2006). Application of rice growth and water balance model in an irrigated semi-arid subtropical environment. *Agric Water Manage*. 83: 51-57.

Bennett, J. (2003). “Opportunity for increasing water productivity of CGIAR crops through plant breeding and molecular approaches”. (Eds. Kijne, J.W., barker, R., Molden, D). pp. 103-126.

Bhishnoi, O.P., Singh, S. and Niwas, R. (1995). Effect of temperature on phonological development of wheat (*Triticum aestivum* L.) crop in different row orientations. *Indian J. Agric. Sci.* 65: 211-214.

Bouman, B.A.M. and Tuong, T.P (2001). Field and water management to save water and increase its productivity in irrigated lowland rice. *Agric Water Manage*. 49: 11-30.

Chahal, G.B.S., Sood, A., Jalota, S.K., Choudhury, B.U. and Sharma, P.K. (2007). Yield, evapotranspiration and water productivity of rice–wheat system in Punjab (India) as influenced by transplanting date of rice and weather parameters. *Agric. Water Manage*. 88: 14–22.

De Datta, S.K. (1981). Climate effects on rice production. In: Principles and Practices of Rice Production, John Willey & Sons, New York, pp. 9–40.

Fukai, S. (1999). Phenology in rainfed lowland rice. *Field Crops Res*. 64: 51-60.

Grist, D.H. (1986). Charcteristics of the Plant in Rice. Longman, London/New York, pp. 69–98. Harrington, L.W., Fujisaka, S., Morris, M.L., Hobbs, P.R., Sharma, H.C., Singh, R.P., Choudhary, M.K., Dhiman, S.D., 1993. Wheat and Rice in Karnal and Kurukshetra Districts, Haryana, India: Farmers’ Practices, Problems and an Agenda for Action. ICAR, HAU, CIMMYT, Mexico, and IRRI, Los Bano˜ s, The Philippines.

Jalota, S. K., Singh, K. B., Chahal, G. B. S., Gupta, R. K., Chakraborty, S., Sood, A., Ray, S. S. and Panigrahy, S. (2009). Integrated effect of transplanting date, cultivar and irrigation on yield, water saving and water productivity of rice (Oryza sativa L.) in Indian Punjab: Field and simulation study. *Agric. Water Manage*. 96: 11096-1104.

Joseph K (1991) Performance of rice varieties as influenced by the age of seedlings and delayed transplanting.

Indian J. Agron. 36:83-86.

Mahajan, G., Bharaj, T. S. and Timsina, J. (2009). Yield and water productivity of rice as affected by time of transplanting in Punjab, India *Agric. Water Manage*. 96: 525-532.

Murthy, K.S. and Sahu, G. (1979). Effect of age of seedlings at normal transplanting on growth and yield of rice varieties. *Indian J. Agric. Sci.* 49: 797-801.

Patra, A. K. and Nayak, B. C. (2001). Effect of spacing on rice (*Oryza sativa*) varieties of various duration under irrigated condition. *Indian J. Agron*. 46: 449-52.

Rai, H. K. and Kushwaha, H. S. (2005). Performance of upland rice (*Orzya sativa*) under different transplanting dates and soil water regimes in *tarai* conditions. *Indian J. Agric. Sci*. 75: 817-19.

Rajput, R.P., Deshmukh, M.R. and Paradkar, V.K. (1987). Accumulated heat unit and phenology relationships in wheat (*Triticum aestivum* L.) as influenced by planting dates under late sown conditions. *J. Agron. Crop Sci*. 159: 345-348.

Singh, K.B., Gajri, P.R. and Arora, V.K. (2001). Modeling the effects of soil and water management practices on water balance and performance of rice. *Agric Water Manage*. 49: 77-95.

Yamada, N. (1961). Photosynthesis and dry matter production in rice plant. In: Symposium on Rice Problems, Pacific Science Congress.

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