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Effect of plant spacing and transplanting time on phenology, tiller production and yield of rice (*Oryza sativa* L.)

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ABSTRACT

A field experiment was conducted at the Research Farm of Department of Agricultural Meteorology, Punjab Agricultural University, Ludhiana, to study the effect of spacing and transplanting time on phenology, tiller production and yield in rice crop (*Oryza sativa* L.). Two genotypes of rice (PR 116 and PAU 201) were transplanted under two sowing environments (15 June and 30 June) and two plant spacings (20 cm x 15 cm and 30 cm x 10 cm). The number of tillers per plant was more in PAU 201 transplanted on 15 June under plant spacing of 30 cm x 10 cm. The higher quantum of heat units were taken by PR 116 (2957 day°C) under 15 June transplanted crop. The highest yield (43 q/ha) was observed in PAU 201 transplanted on 15 June under 30 cm x 10 cm spacing. The other yield attributes *i.e.* number of effective tillers per square meter, number of effective tillers, test weight, number of grain per panicle and total biomass were more in 15 June transplanted crop as compare to 30 June.

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Key words : Rice crop, Tillers, Heat units, Phenology, Biomass, Yield, Yield attributes

INTRODUCTION

Rice (*Oryza sativa* L.) is grown in all continents of the world due to its wide adaptability to diverse agroclimatic conditions. Rice which is the main staple food crop in India, contributes around 45 per cent of the total production and hence hold the key to sustain food sufficiency in the country (Rai and Kushwaha, 2005). It is the major *Kharif* crop and ranks second after wheat in terms of area, production and productivity in Punjab. An inter-state comparison of productivity of rice over time reveals that Punjab has consistently improved its respective position. Punjab, occupies an area of 2.49 million hectare under rice with production of 8.82 million tons with an average yield of 3545 kg ha^{-1} (Anonymous, 2002).

Temperature and light togeather plays a key role in rice production since the light intensity requirement of rice is higher and temperature dependent. Tillering is a varietal character to some extent but the emergence and development of rice is primarily influenced by the meteorological factors such as temperature, sunshine hours and rainfall. Tiller number per unit area is an important attribute of rice yields, which was reported to decide the physical capacity of the yield and contribute to 60 per cent of grain yield variations in rice crop. Further expansion of area under rice crop is very unlikely due to tremendous increase in population and urbanization. Therefore, the increasing demand of food has to come from increase in productivity per unit area. For achieving this one of the prime requirement and non monetary input is transplanting cultivars at appropriate dimension of time and spacing. The present experiment was, therefore, planned to achieve the target set for sustainable rice production under Punjab conditions.

MATERIALS AND METHODS

A field experiment was conducted at the Research Farm of Department of Agricultural Meteorology, Punjab Agricultural University, Ludhiana (30^0 54'N, 75^0 48'E and 247 m above mean sea level) during *Kharif* 2009.The area is characterized by subtropical and semi arid climate. The experiment was laid out in Randomized Block Design and replicated thrice. One month old seedlings of two rice varieties PR 116 and PAU 201 with row-to-row and plant-to-plant spacing was 20 cm and 15 cm in first treatment and it was 30 cm and 10 cm in second treatment were transplanted on 15 and 30 June, respectively. Plant population was 33 hills per square meter in both the treatments. The fertilizers were applied as per the recommendations by Punjab Agricultural University, Ludhiana. Ten plants were tagged in each plot and their numbers of tillers were counted periodically. The phenological stages *i.e.* tillering, booting, heading, flowering, milking, hard dough and physiological maturity

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were observed in all the treatments. The Growing degree-days (GDD) were calculated as per Nuttonson (1955) using base temperature of 10.0 ^{o}C (Morrison *et al.*, 1990) for rice crop. Yield and yield attributes were calculated based on the data of final harvest of the crop. The variability in the parameters of yield and associated components was tested by the statistical procedures, softwares and modules.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Phenological behaviour and heat unit requirement:

The crop transplanted on different dates subjected to different temperature conditions affected the occurrence of various phenological stages of the rice crop (Table 1 and 2), Growing degree-days concept is widely used for describing the temperature responses linked with growth and development of crops.

The number of days taken by the crop for the completion of each phenophase varied with dates of sowing. PR 116 variety transplanted on 15 June took 76 days and utilized 213 day^{0} C heat units to start heading stage whereas 209 day ^{0}C were used by the PAU 201 in 72 days to attain same stage. Both the varieties, PR 116 and PAU 201 took maximum time (112 DAT and 111 DAT, respectively) and utilized 399 and 453 day^{0}C , respectively under 15 June transplanted crop as compared to 30 June transplanted crop which utilized 262 and 276 day ^{0}C in 108 and 109 days, respectively to complete the physiological maturity of the crop. These results confirmed the findings of Majos and Pava (1980). However, Biswas (2008) reported that the early transplanting took more number of days for maturity as compared to late transplanting.

Tiller count:

Tiller count per plant which is one of the main yield components was taken into account and observed in all the treatments. The periodic number of tillers for both the varieties were higher in wider spacing (30 cm x 10 cm) under both the transplanting dates. This may be due

Table 1 : Phenological calendar of rice variety PR 116 during *Kharif* 2009

Phenological stages	Treatments			
	15 June transplanting		30 June transplanting	
	Julian day	DAT	Julian day	DAT
Nursery sowing	135	-	149	-
Transplanting	166	-	181	-
Tillering (start)	176	10	193	12
Booting (start)	231	65	249	68
Heading (start)	242	76	259	78
Grain filling (start)	250	84	264	83
Hard Dough	257	91	273	92
Physiological maturity	278	112	289	108

DAT – Days after transplanting

Table 2 : Phenological calendar of rice variety PAU 201 during *Kharif* 2009

Phenological stages	Treatments			
	15 June transplanting		30 June transplanting	
	Julian day	DAT	Julian day	DAT
Nursery sowing	135	-	149	-
Transplanting	166	-	181	-
Tillering (start)	175	9	192	11
Booting (start)	227	61	243	62
Heading (start)	238	72	261	80
Grain filling (start)	246	80	267	86
Hard Dough	253	87	273	92
Physiological maturity	277	111	290	109

DAT – Days after transplanting

to more radiation interception, favourable soil and air temperature in the crop canopy during the growing cycle of the crop. Biswas (2008) also observed that periodic number of tillers was higher in wider spacing (20 cm x 20 cm) as compare to closer spacing (20 cm x 15 cm). Narasimharao *et al.* (1999) reported that the number of tillers increased with the increase in temperature. The variability in the microclimatic conditions of a crop alters the number of tillers per hill which is linked with number of panicles per unit area and variability in the yield.

The tiller numbers differed significantly with varieties possibly due to their genetical traits. The mean tiller count was higher in PAU 201 as compared to the PR 116 (Fig 1 and 2). Dhaliwal *et al.* (2007) also reported the same results. The number of tillers was increased as the vegetative growth of crop increased, but at later stages the number of tillers decreased due to improper utilization of radiation interception. Mahajan *et al.* (2008) revealed that 15 June transplanted crop experienced mean temperatures between 31^0 C and 33^0 C during tillering stage for more number of days. This led to more production of tillers m^{-2} as compared to 25 June and 5 July transplanted crops.

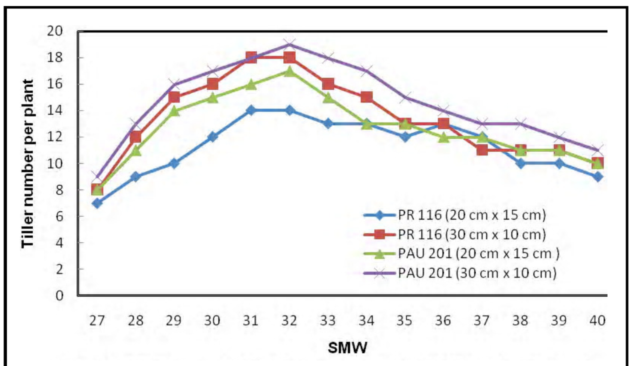

Fig. 1 : Comparison of tiller number per plant under two spacings in 15 June transplanted crop

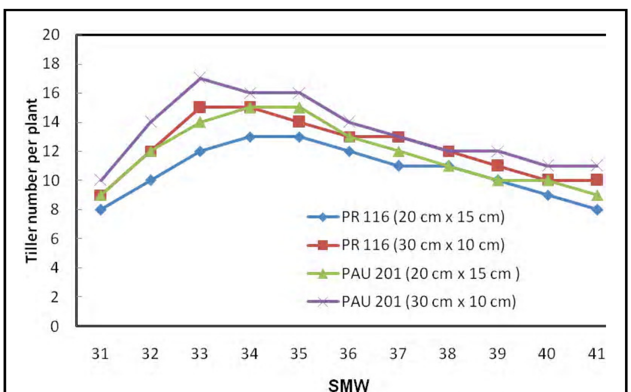

Fig. 2 : Comparison of tiller number per plant under two spacings in 30 June transplanted crop

Yield and yield contributing characteristics:

The transplanting time influenced the effective tillers per square meter in both the varieties. The maximum tillers per square meter were observed in the crop transplanted on 30 June as compared to transplanted 15 June (Table 3 and 4). In 30 June transplanted crop, number of effective tillers were significantly more (16) in 30 cm x 10 cm spacing as compared to 20 cm x 15 cm spacing (13). However, the differences in the number of effective tillers per square meter were found non significant and at par as regard with the PR 116 and PAU 201. The number of grains per panicle did not show any significant difference among the treatments. Similar results were obtained by Om *et al.* (1997) and Gill *et al.* (2006).

The grain yield increased with increase in spacing in both the sowing environment (15 June and 30 June) and it was observed that the grain yield was higher in 30 cm x 10 cm spacing as compared to 20 cm x 15 cm. PAU 201 contributed more yield (43 q/ha) as compared to PR 116 (40 q/ha) (Table 4 and 5). Bali *et al* (1995) observed that June was the optimum planting time for obtaining higher yield of rice in northwest India. They also observed that crop transplanted beyond mid-June was exposed to low minimum and maximum temperatures (12.5^0 C and 23.6^0 C, respectively) at flowering stage (from last week of August to first week of September), whereas early transplanted crops flowered when temperatures were favourable for fertilization. The optimum temperature required for the germination of pollen is 31 to 33^0 C (Grist 1986). For late transplanting, low temperature at the pollen development stage may cause a sharp decline in fertile or filled spikelets particularly in the photo insensitive cultivars. Late transplanting, poor pollen germination may be another reason for decline in yield. Similarly the 15 June transplanted crop received temperatures between 31^0 C and 33^0 C for 6 consecutive days during flowering, while in 25 June and 5 July transplanted crops, mean temperature always remained below 31^0 C as a result grains m^{-2} decreased due to poor pollen development. Gill *et al.* (2006) reported that reduction in grain yield under delayed transplanting owed to reduction in favorable growing period, because at Ludhiana temperature starts falling during end of September/ beginning of October and reproductive phase coincide with low temperature, thus affected badly, leading to poor grain filling and low yield. Similar results were also obtained by Om *et al.* (1997).

Total biomass of paddy was also influenced

Table 3 : Heat units accumulated by rice crop between different phenological events during *Kharif* 2009. (T_b = 10°C)

Phenological stages	Varieties			
	PR 116		PAU 201	
	15 June	30 June	15 June	30 June
Nursery sowing to transplanting	711 (711)*	719 (719)	711 (711)	719 (719)
Transplanting to tillering(start)	217 (928)	249 (968)	194 (905)	249 (968)
Tillering (start) to Booting (start)	1137 (2065)	1110 (2078)	1088 (1993)	1025 (1993)
Booting (start) to Heading (start)	213 (2278)	172 (2250)	209 (2202)	314 (2307)
Heading (start) to grain filling (start)	162 (2440)	115 (2365)	151 (2353)	121 (2428)
Grain filling (start) to hard dough	118 (2558)	129 (2480)	118 (2471)	117 (2545)
Hard dough to physiological maturity	399 (2957)	262 (2742)	453 (2924)	276 (2841)

* Figures in parenthesis are successive cumulative totals of heat units from sowing to respective phenological events

Table 4 : Effect of different plant spacings on yield attributing characteristics of two rice varieties transplanted on 15 June

Treatments	Number of tillers per square meter	Number of effective tillers (no.)	1000 grain weight (g)	Number of grains per panicle	Total biomass (q/ha)	Grain yield (q/ha)
S_1V_1	80	12	24	100	118	35
S_2V_1	81	13	25	112	134	40
S_1V_2	83	14	25	103	123	37
S_2V_2	84	16	25	113	136	43
C.D. (P=0.05)	NS	NS	NS	NS	7.82	5.6

where, V_1 – PR 116 and V_2 – PAU 201 NS=Non-significant
S_1 – 20 cm x 15 cm, S_2 – 30 cm x 10 cm spacing

Table 5 : Effect of different plant spacings on yield attributing characteristics of two rice varieties transplanted on 30 June

Treatments	Number of tillers per square meter	Number of effective tillers (no.)	1000 grain weight (g)	Number of grains per panicle	Total biomass (q/ha)	Grain yield (q/ha)
S_1V_1	77	13	22.5	98	107	35
S_2V_1	95	16	25.5	103	131	40
S_1V_2	78	14	21.5	99	108	36
S_2V_2	97	16	24.5	109	134	40
C.D. (P=0.05)	15	1.1	NS	NS	10.8	1.5

where, V_1 – PR 116 and V_2 – PAU 201 NS=Non-significant
S_1 – 20 cm x 15 cm, S_2 – 30 cm x 10 cm spacing

significantly with time of transplanting. On an average biomass yield decreased with delay in transplanting from 15 June to 30 June. Higher biomass was recorded in PAU 201 (136 q/ha) under 30 cm x 10 cm spacing which was at par with PR 116 (134 q/ha) under 30 cm x 10 cm spacing and these were significantly better than under 20 cm x 15 cm spacing in PR 116 and PAU 201 varieties. Total dry matter in PR 116 was 118 q/ha under 20 cm x 15 cm spacing and in PAU 201 it was 123 q/ha in 20 cm x 15 cm spacing. In 30 June transplanted crop the varieties PR 116 (134 q/ha) and PAU 201 (131 q/ha) with 30 cm x 10 cm spacing were at par with each other. Patel (1999) reported significantly higher biomass in early transplanted crop (15 June) as compared to delayed transplantings (30 June and 30 July), might be resulted from better availability of favourable environment for proper growth and development of crop. Reedy (2002) also observed significant reduction in straw yield of paddy with delay in transplanting.

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