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A STUDY OF THERMAL CHANGES ON PHYSIOLOGY AND PADDY YIELD OF FINE RICE CULTIVARS UNDER SUBTROPICAL CONDITIONS

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ABSTRACT

A thematic research was planned to find out the effects of thermal changes on crop physiology and paddy yield of fine rice under subtropical conditions. Various parameters related to crop physiology and yield were recorded in order to establish the causes underlying the variations in paddy yield associated with transplanting date and cultivar. Throughout the growth period of different rice cultivars, early transplanting (1st of July) significantly enhanced LAI over subsequent late transplanting (15th and 30th of July). LAI of different cultivars was also significant. Maximum LAI values were found at 75 DAT in all the treatments. LAD was positively correlated with paddy yield. Percent increase in NAR (g m^{-2} d^{-1}) in case of 30th July was 14.3, followed by 15th July 10.97 as compared to 1st July. While in case of varieties, NAR (g m^{-2} d^{-1}) was not significantly affected by different varieties. Paddy yield also decreased in the subsequent transplanting dates from 4.71 t ha^{-1} to 4.22 t ha^{-1}and 4.01 t ha^{-1} in 1st, 15th and 30th July, respectively. Paddy yield of different cultivars was also significantly different and it was highest in case of cv. Basmati-515 as compared to other cultivars. Increase in temperature decreased paddy yield.

Keywords: Transplanted dates, Cultivars, Harvest index, Seasonal, Linearly

INTRODUCTION

Among factors causes low yield, one strategy that farmers can use to maintain or increase crop yields in the face of a changing climate is to adjust planting dates (Lauer *et al.,* 1999).

Photosensitivity is an important character of fine rice in Pakistan. Thermal and photoperiodic conditions significantly affect the vegetative and reproductive development of the crop. Variations in thermal conditions are crucial for three main reasons. Firstly, vegetative growth occurs during a period of suitable temperature and maximum levels of solar radiation. Secondly, it ensures the cold sensitive stage when the minimum night temperatures are historically the warmest. Thirdly, it assures that grain filling happens when milder autumn temperatures are more likely, hence good quality of grain is obtained (Farrell *et al.,* 2003).Ali *et al.* (2006) and Shimono *et al.* (2007) asserted that the minimal temperature of 12 °C is vital for 30 days after rice sowing for producing suitable seedling and the temperature below 12°C brings about poor germination, low seedling vegetation and reduction in desirable seedling growth. Less vegetative growth results under late transplanting of basmati varieties (Mann, 1987). Ehsanullah *et al.* (2001) stated that the growth season duration and temperature average have significant effects on rice yield during different growth stages; therefore, planting date plays a substantial role in rice production. The principal objective in modern agriculture is better understanding of crop’s growth and increment for the optimal usage of natural resources and consequently achieving greater yield. Accordingly, suitable transplanting date is one of the major factors in efficient agricultural management playing a significant role in production control. The proposed study was conducted with the following objectives to analyze the physiology and paddy yield response of different fine rice varieties transplanted at different dates under the climatic conditions of Sheikhupura, Punjab, Pakistan.

MATERIALS AND METHODS

A field study was conducted at Adaptive Research Farm, Sheikhupura, Punjab, Pakistan

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during 2011 to evaluate the impact of thermal changes on physiology and paddy yield of fine rice. A composite soil sample to a depth of 30 cm was obtained from the experimental area with soil auger prior to sowing of crop. The sample was analyzed for its physico - chemical properties. The experiment was conducted in split plot design having three replications. Treatments were three transplanting dates (1st July, 15th July, 30th July) was randomized in main plots, and three genotypes (cv. Super Basmati, cv. Bsmati-515, cv. Basmati- 2000) was randomized in sub-plots. The net plot size will be 3.0 x 2.3 m^2. Nursery of crop was sown during the month of June and then transplanted according to transplanting dates as mentioned in treatments keeping 23 cm spacing, using a seed rate of 15 kg ha^{-1}.Nitrogen, phosphorus and potassium were applied at the rate of 120-100-75 kg ha^{-1}, respectively in the form of Urea, DAP and SOP. Half dose of nitrogen and all of P and K fertilizer were applied at time of transplanting. Remaining of N was applied in two splits at 30 and 50 days after transplanting. All plots were irrigated to maintain a flooded condition continuously throughout the active growth period of the rice. Half of the plot area was used for growth and developmental studies and the remaining half for the assessment of the harvest data. Three plants from each plot were harvested at ground level after 15 days interval leaving appropriate borders. Fresh and dry weight of component fractions of plant (leaf, stem and panicle) was determined. A subsample of 10g in each fraction was taken to dry in an oven to a constant weight. Also, an appropriate subsample of green leaf lamina was used to record leaf area on leaf area meter (Model Cl-202, USA). From the measurements of leaf area and dry weights following parameters was calculated. Leaf area was measured on leaf area meter (Model Cl-202, USA), by taking 5g of leaf lamina from each plot. Leaf area index (LAI) was then calculated as the ratio of leaf area to land area (Hunt, 1978).

$$\text{LAI} = \text{Leaf area}/\text{land area}$$

LAD was determined as suggested by Hunt (1978).

$$\text{LAD} = (\text{LAI}_1 + \text{LAI}_2) \times (T_2 - T_1) / 2$$

Cumulative LAD was calculated at final harvest by adding all the LAD values obtained at different intervals.

Crop growth rate (CGR) was calculated as proposed by Hunt (1978) for each growth harvest after 15 days interval.

$$\text{CGR} = (W_2 - W_1) / (T_2 - T_1)$$

Where W_1 and W_2 are the dry weights harvested at times T_1 and T_2, respectively.

The NAR was estimated by using the formula of Hunt (1978).

$$\text{NAR} = \text{TDM} / \text{LAD}$$

Where TDM and LAD are the total dry matter and LAD, respectively

All plants were threshed mechanically for the estimation of plot yield and converted into t ha^{-1}. All weather data for the study was obtained from measurements made at the nearest meteorological observatories around the experimental sites (Table 1). Data collected on phenology, growth and yield was analyzed statistically by employing the Fisher's analysis of variance technique and significant of treatment means were tested using least significance difference (LSD) test at 5% probability level (Steel *et al.,* 1997).

Table 1: Mean monthly weather data for rice growing season 2011 in Adaptive Research Farm, Sheikhupura, Pakistan

Month	Mean Temperature (°C)	Relative Humidity (%)	Rainfall (mm)
July	30.52	67.55	10.6
August	33.17	73.00	8.65
September	29.52	70.70	4.80
October	27.27	53.53	0.00
November	21.25	60.80	0.00

RESULTS AND DISCUSSION

Leaf area index

The data regarding the effect of different transplanting dates and varieties on LAI is presented in table 2. From the data, it has been found that LAI was significantly affected by different planting dates and varieties. In case of different transplanting dates, maximum LAI was shown when the transplanting date was 1st July, followed by 15th July and 30th July. The mean values of LAI were significant among different transplanting dates i.e. 1st July, 15th July and 30th July were 7.06, 5.91 and 5.78 respectively. Percent increase in LAI in case of 1st July was 22.1, followed by 15th July 2.2% as compared to 30th July. While in case of varieties, LAI was significantly affected by different varieties. Maximum LAI was shown by the Basmati-515, followed by Basmati 2000 and Super Basmati. The mean values of LAI shown by different varieties i.e. Basmati-515, Basmati 2000 and Super Basmati were 6.61, 6.24 and 5.89 respectively. Percent increase in LAI in case of Basmati 515 was 12.2, followed by Basmati 2000 5.9 as compared to Super Basmati. However, in case of interaction effect of different transplanting dates and varieties was not statistically significant.

Data showed in figure 1 that at first destructive sampling (45 DAT) LAI was compatibility lower. Plant started developing its canopy with the passage of time and LAI increased in second destructive sampling (60 DAT) and it reaches its maximum value at 75 DAT. Then it start decreasing in 90 and 105 DAT. LAI was least in 6th destructive sampling (120 DAT). 1st July sown crop attained higher leaf area at early stages and showed maximum LAI value at 75 DAT. In third and second transplanting, LAI was almost parallel to each other. Similar trend was observed in case of varieties; Basmati-515 attained higher LAI at early stages and possesses the maximum LAI at 75 DAT. Basmati-2000 and super basmati showed lower LAI as compared to Basmati-515 at 75 DAT (Fig. 2). Same results were reported by Campbell (2000), Grigg *et al.* (2000) and Zhong *et al.* (2003).

Table 2: Effect of different planting dates and varieties on maximum leaf area index of rice

Transpl--anting date	Varieties			
	Super Basmati	Basmati 515	Basmati 2000	Mean
1st July	6.62	7.58	6.98	7.06 A
15th July	5.81	6.08	5.84	5.91 B
30th July	5.27	6.17	5.92	5.78 B
Mean	5.89 B	6.61A	6.25 AB	

Means having different letters differ significantly at 5 % level of probability
LSD value for transplanting date (A) = 0.6583
LSD value for Variety (B) = 0.4233

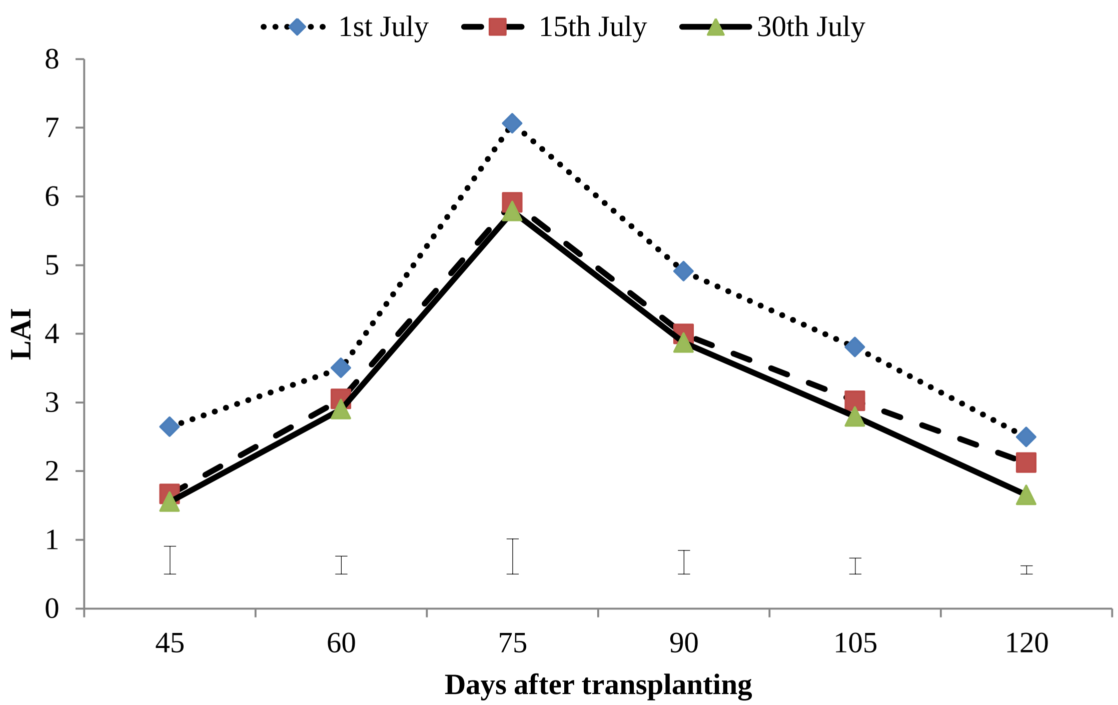

Fig 1. Effect of different planting dates on leaf area index of rice

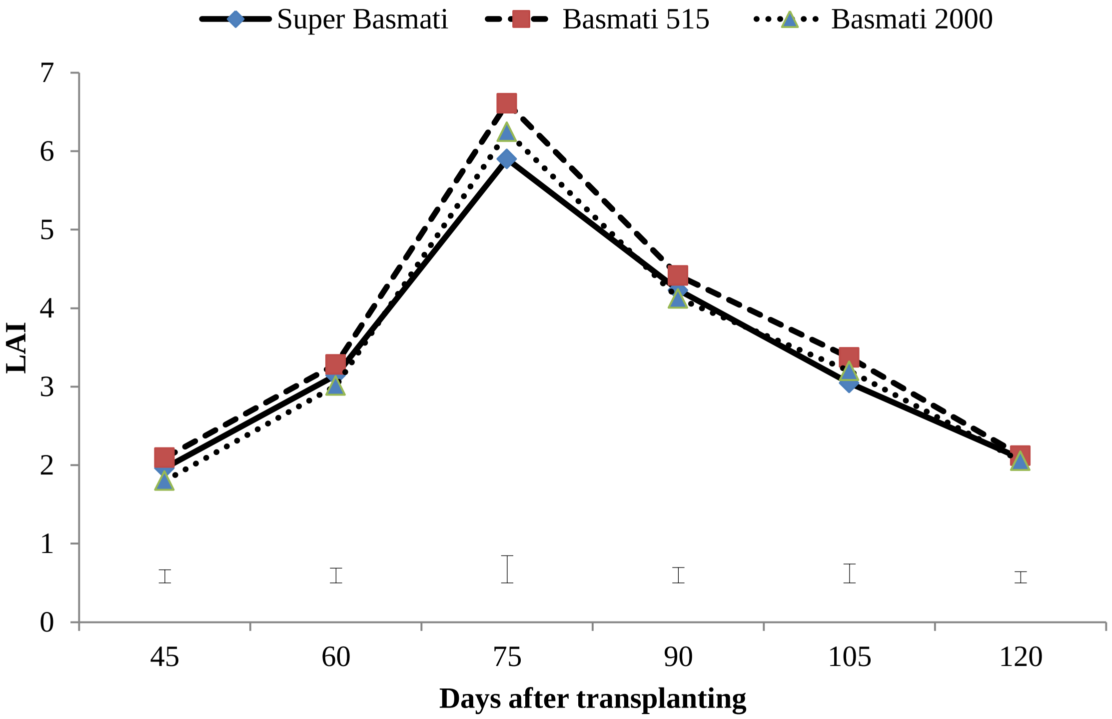

Fig 2 Effect of different varieties on leaf area index of rice

Leaf area duration (days)

In table 3, the data regarding the effect of different transplanting dates and varieties on LAD (days) is presented. Data showed that LAD (days) is significantly affected by different planting dates and varieties. In case of different transplanting dates, maximum LAD (days) was shown when the transplanting date was 1st July, followed by 15th July and 30th July. The mean values of LAD (days) at different transplanting dates i.e. 1st July, 15th July and 30th July were 327.54, 267.94 and 254.21 days respectively. Percent increase in LAD (days) in case of 1st July was 28.8, followed by 15th July 5.4 as compared to 30th July. While in case of varieties, LAD (days) was significantly affected by different varieties. Maximum LAD (days) was shown by the variety Basmati-515, followed by Basmati 2000 and Super Basmati. The mean values of LAD (days) shown by different varieties i.e. Basmati-515, Basmati 2000 and Super Basmati were 296.88, 277.67 and 275.15 days respectively. Percent increase in LAD (days) in case of Basmati-515 was 7.9, followed by Basmati 2000 0.9 as compared to Super Basmati. However, in case of interaction effect of different transplanting dates and varieties was not statistically significant. Figure 3 and 4 show LAD for different transplanting dates and varieties, respectively. 1st transplanted crop produce maximum LAD at 120 DAT as compared to 15th and 30th July. Similarly Basmati-515 showed maximum LAD at 120 DAT as compared to

Table 3: Effect of different planting dates and varieties on leaf area duration (days) of rice

Transpl--anting date	Varieties			
	Super Basmati	Basmati 515	Basmati 2000	Mean
1st July	318.53	341.58	322.53	327.54 A
15th July	264.03	280.85	258.95	267.94 B
30th July	242.90	268.20	251.53	254.21 C
Mean	275.15 A	296.88 B	277.67 B	

Means having different letters differ significantly at 5 % level of probability

LSD value for transplanting date (A) = 9.4446

LSD value for Variety (B) = 6.6947

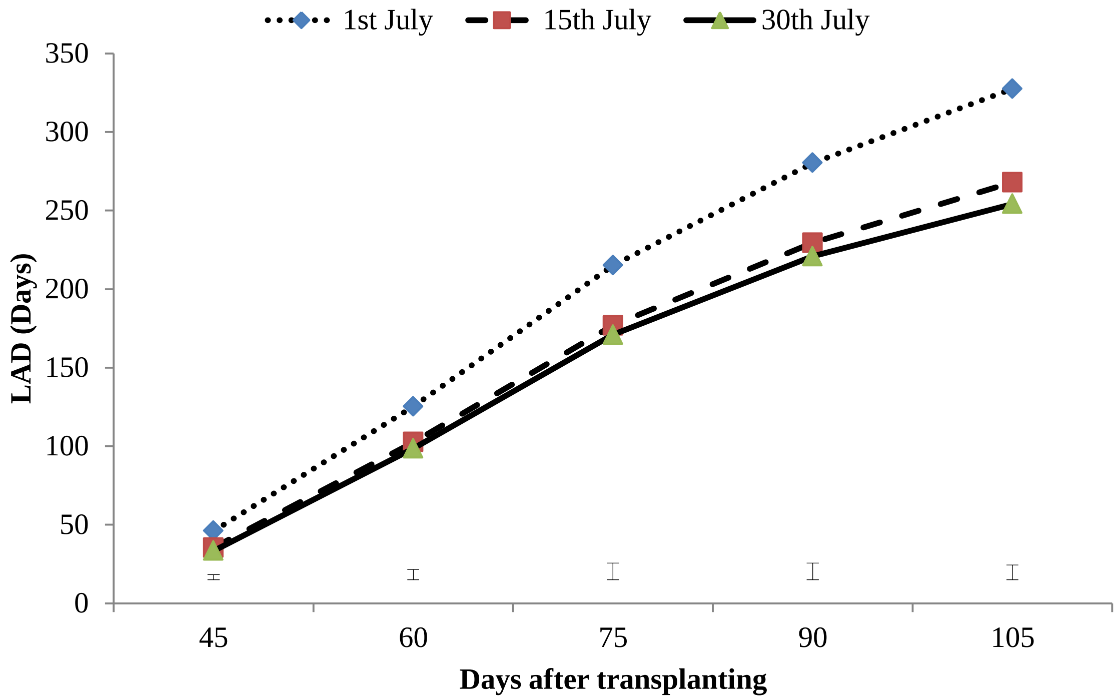

Fig 3 Effect of different transplanting dates on leaf area duration (days) ofrice

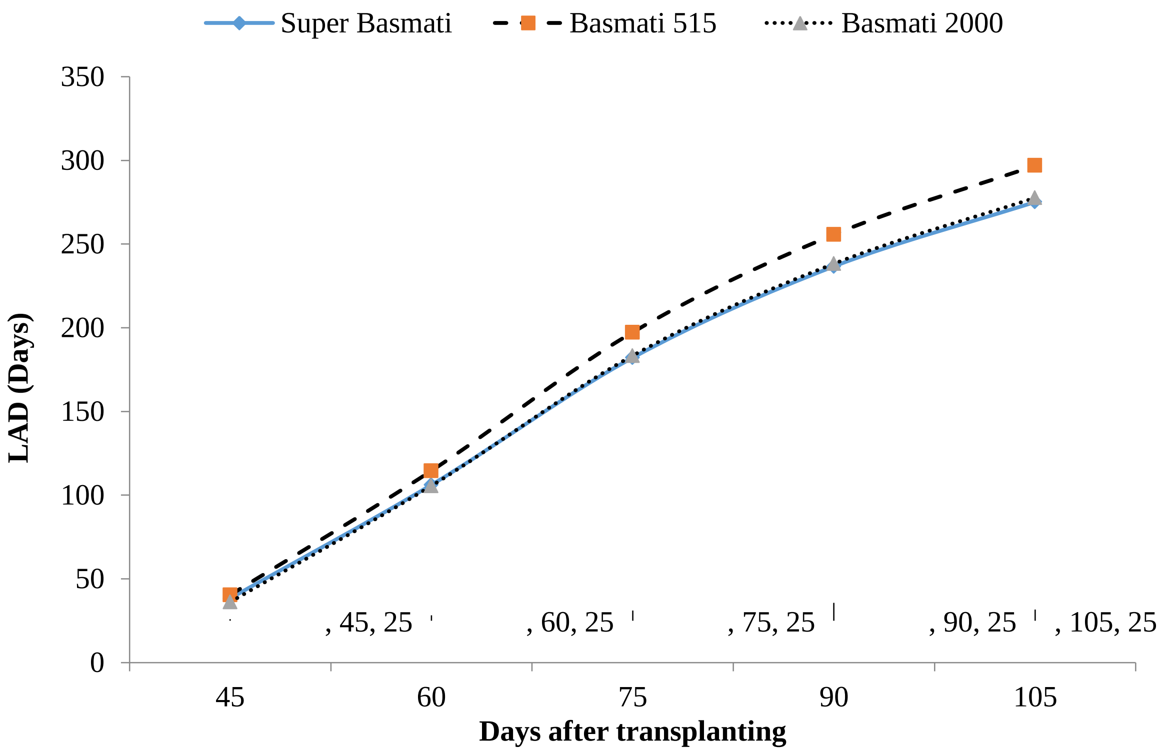

Fig 4 Effect of different varieties on leaf area duration (days) of rice

Mean crop growth rate (g m^{-2} d^{-1})

The data presented in table 4 shows the effect of different transplanting dates and varieties on MCGR (g m^{-2} d^{-1}) From the data illustrated in the table 4, it has been found that MCGR (g m^{-2} d^{-1}) is significantly affected by different planting dates and varieties. In case of different transplanting dates, maximum MCGR (g m^{-2} d^{-1}) was shown when the transplanting date was 1st July, followed by 15th July and 30th July. The mean values of MCGR (g m^{-2} d^{-1}) at different transplanting dates i.e. 1st July, 15th July and 30th July were 13.58, 12.27 and 12.24 (g m^{-2} d^{-1}) respectively. Percent increase in MCGR (g m^{-2} d^{-1}) in case of 1st July was 10.9, followed by 15th July 0.2 as compared to 30th July. While in case of varieties, MCGR (g m^{-2} d^{-1}) was significantly affected by different varieties. Maximum MCGR (g m^{-2} d^{-1}) was shown by the variety Basmati-515, followed by Basmati 2000 and Super Basmati. The mean values of MCGR (g m^{-2} d^{-1}) shown by different varieties i.e. Basmati-515, Basmati 2000 and Super Basmati were 13.05, 12.83 and 12.23 (g m^{-2} d^{-1}) respectively. Percent increase in mean crop growth rate (g m^{-2} d^{-1}) in case of Basmati-515 was 6.7, followed by Basmati 2000 4.9 as compared to Super Basmati. However, in case of interaction effect of different transplanting dates and varieties was not statistically significant. So, it can be concluded form the data presented in this table that MCGR (g m^{-2} d^{-1}) is significantly affected by different transplanting dates and different varieties and their interaction is statistically non-significant.

Table 4 Effect of different planting dates and varieties on mean crop growth rate (g m^{-2} d^{-1}) of rice

Transpl--anting date	Varieties			
	Super Basmati	Basmati 515	Basmati 2000	Mean
1st July	13.13	14.02	13.60	13.586 A
15th July	11.83	12.54	12.44	12.272 B
30th July	11.72	12.58	12.44	12.247 B
Mean	12.23 B	13.05 A	12.83AB	

Means having different letters differ significantly at 5 % level of probability
LSD value for transplanting date (A) = 0.6302
LSD value for Variety (B) = 0.6831

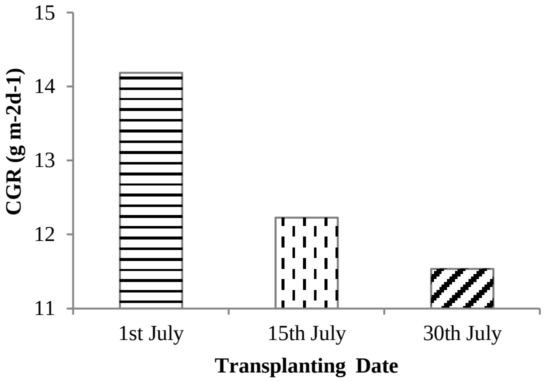

Fig 5. Effect of different transplanting dates on mean crop growth rate (g m^{-2} d^{-1}) of rice

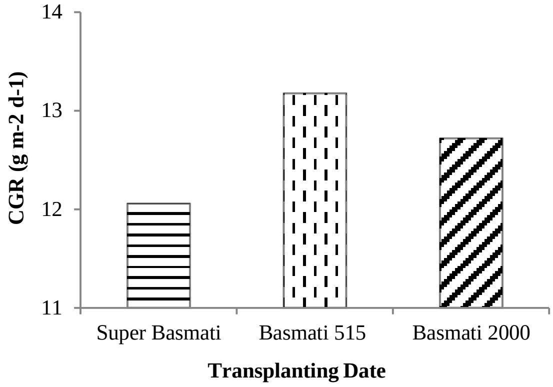

Fig 6 Effect of different varieties on mean crop growth rate (g m^{-2} d^{-1}) of rice

Net assimilation rate (NAR) (g m^{-2} d^{-1})

The effect of different transplanting dates and varieties on NAR (g m^{-2} d^{-1}) is tabulated in table 5. Data showed in the table 5, it has been found that NAR (g m^{-2} d^{-1}) is significantly affected by different planting dates and varieties. In case of different transplanting dates, maximum NAR (g m^{-2} d^{-1}) was shown when the transplanting date was 30th July, followed by 15th July and 1st July. The mean values of NAR (g m^{-2} d^{-1}) at different transplanting dates i.e. 30th July, 15th July and 1st July were 4.79, 4.65 and 4.19 (g m^{-2} d^{-1}) respectively. Percent increase in NAR (g m^{-2} d^{-1}) in case of 30th July was 14.3, followed by 15th July 10.97 as compared to 1st July. While in case of varieties, NAR (g m^{-2} d^{-1}) was not significantly affected by different varieties. Maximum NAR (g m^{-2} d^{-1}) was shown by the variety Basmati 2000, followed by Super

Basmati and Basmati-515. The mean values of NAR (g m^{-2} d^{-1}) shown by different varieties i.e. Basmati 2000, Super Basmati and Basmati 515 were 4.62, 4.55 and 4.45 (g m^{-2} d^{-1}) respectively. Percent increase in NAR (g m^{-2} d^{-1}) in case of Basmati 2000 was 3.8, followed by Super Basmati 2.2 as compared to Basmati-515. However, in case of interaction effect of different transplanting dates and varieties was not statistically significant. So, it can be concluded form the data presented in this table that NAR (g m^{-2} d^{-1}) is significantly affected by different transplanting dates but the effect of different varieties and their interaction is statistically non-significant. Same results have been reported by Thakur and Patel (1998) and Lu *et al.* (2000).

Table 5 Effect of different planting dates and varieties on net assimilation rate (g m^{-2} d^{-1}) of rice

Transpl-anting date	Varieties			
	Super Basmati	Basmati 515	Basmati 2000	Mean
1st July	4.19	4.14	4.24	4.1922 B
15th July	4.60	4.54	4.80	4.6500 A
30th July	4.86	4.67	4.84	4.7933 A
Mean	4.5544 A	4.4544 A	4.6267 A	

Means having different letters differ significantly at 5 % level of probability
LSD value for transplanting date (A) = 0.2189
LSD value for Variety (B) = 0.1803

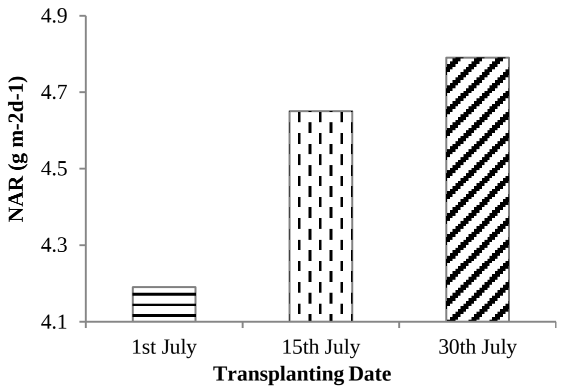

Fig 7. Effect of different planting dates on net assimilation rate (g m^{-2} d^{-1}) of rice

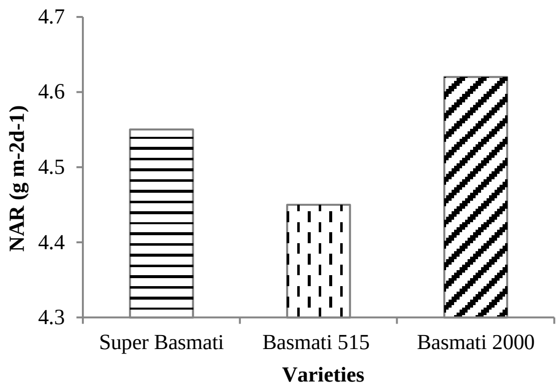

Fig 8. Effect of different varieties on net assimilation rate (g m^{-2} d^{-1}) of Rice

Paddy yield (t ha^{-1})

The effect of different transplanting dates and varieties on paddy yield (t ha^{-1}) is presented in table 6 and it shows that paddy yield (t ha^{-1}) is significantly affected by different planting dates and varieties. In case of different transplanting dates, maximum paddy yield (t ha^{-1}) was shown when the transplanting date was 1st July, followed by 15th July and 30th July. The mean values of paddy yield (t ha^{-1}) at different transplanting dates i.e. 1st July, 15th July and 30th July were 4.71, 4.22 and 4.00 t ha^{-1} respectively. Percent increase in paddy yield (t ha^{-1}) in case of 1st July was 17.7, followed by 15th July 5.5 as compared to 30th July. While in case of varieties, paddy yield (t ha^{-1}) was significantly affected by different varieties. Maximum paddy yield (t ha^{-1}) was shown by the variety Basmati-515, followed by Basmati 2000 and Super Basmati. The mean values of paddy yield (t ha^{-1}) shown by different varieties i.e. Basmati-515, Basmati 2000 and Super Basmati were 4.57, 4.24 and 4.12 t ha^{-1} respectively. Percent increase in paddy yield (t ha^{-1}) in case of Basmati-515 was 10.9, followed by Basmati 2000 2.9 as compared to Super Basmati. However, in case of interaction effect of different transplanting dates and varieties was not statistically significant. The relationship of grain yield with TDM was found to be positive and highly significant (R^2 =0.95, fig.4.18). So, it can be concluded form the data presented in this table that paddy yield (t ha^{-1}) is significantly affected by different transplanting dates and different varieties and their interaction is statistically non-significant. Similar results have been observed by Dixit and Patro (1994), Ehsanullah *et al.* (2001) and Meena *et al.* (2003).

Table 6 Effect of different planting dates and varieties on paddy yield (t ha^{-1}) of rice

Transpl--anting date	Varieties			
	Super Basmati	Basmati 515	Basmati 2000	Mean
1st July	4.5333	4.9400	4.6567	4.71 A
15th July	4.0433	4.4533	4.1667	4.22 B
30th July	3.7867	4.3167	3.9200	4.00 C
Mean	4.12 B	4.57 A	4.25 B	

Means having different letters differ significantly at 5 % level of probability
LSD value for transplanting date (A) = 0.2061
LSD value for Variety (B) = 0.2284

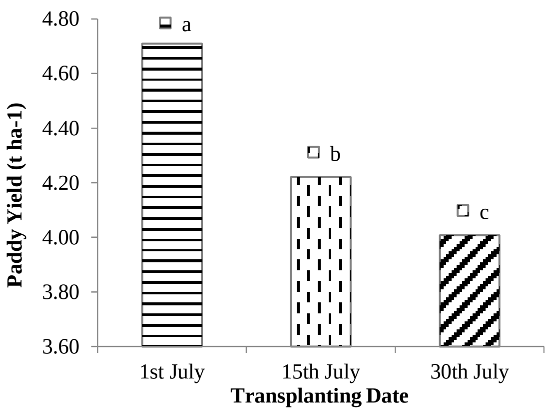

Fig 9. Effect of different planting dates on paddy yield (t ha^{-1}) of rice

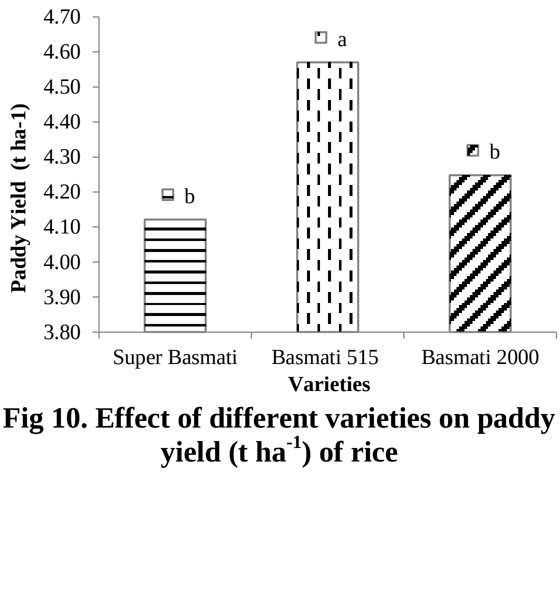

Fig 10. Effect of different varieties on paddy yield (t ha^{-1}) of rice

CONCLUSIONS

Optimization of transplanting date showed that delay in transplanting date from third week of July decreased crop duration and economic yield. But transplanting of Basmati-515 in 3rd week of July will boosted the economic return while Basmati-2000 and Super Basmati performed better if early transplanted under subtropical conditions of Sheikhupura, Punjab, Pakistan.

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