



Full Length Article

Influence of Transplanting Date and Nitrogen Management on Productivity of Paddy Cultivars under Variable Environments

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ABSTRACT

A field study was conducted to evaluate the effect of transplanting date and nitrogen split application on yield and yield components of two paddy cultivars at Faisalabad, Kala Shah Kaku and Gujranwala during 2004 and 2005. Paddy yield responded to transplanting date and nitrogen split application that varied widely among sites and cropping years. The highest yield (4-5 t ha⁻¹) was obtained when the rice crop was transplanted earlier in the season. Paddy yield was also significantly increased when nitrogen was applied in 2 or 3 splits as compared to full application. Yield increases were attributed to number of panicles and grains per unit area. It was concluded that a greater than 5 t ha⁻¹ paddy yield would be a reasonable commercial expectation for all the locations provided early transplanting of rice with better management of nitrogen could be established.

Key Words: Transplanting date; Nitrogen management; Paddy cultivars

INTRODUCTION

Rice is one of the most important cereal crops and is the staple food of majority of the people of the world. In Pakistan it ranks 2nd in consumption after wheat. During 2006-07 Pakistan earned US \$ 1617.2 million in the form of valuable foreign exchange from the export of fine rice GOP (2007). Rice accounts for 5.7% value added in agriculture and 1.2% in GDP. In Pakistan, 94% of Basmati (fine) rice is produced in Punjab. It was grown on an area of 2581 thousand hectares with average yield of 2107 kg ha⁻¹ (GOP, 2007), which is far below the potential of Basmati varieties ranging from 4.5-6.0 t ha⁻¹.

Planting time is a major factor in rice cultivation and indirectly determines soil temperature and weather conditions to which young seedlings and rice plants are exposed during different development stages. Rao *et al.* (1996) observed that transplanting during 15-25 July gave the highest paddy yield and a delay in transplanting up to 4 August reduced the yield by 38.9%. Mahmood *et al.* (1995) reported a marked decrease in paddy yield and yield related traits with delay in transplanting.

Correct timing of nitrogen application is an important aspect of overall nitrogen management in rice for its efficient utilization. One of the major disadvantages of applying all the nitrogen at planting is that it induces excessive foliage and encourages development of weeds. Several workers (Patel & Thakur, 1997; Ehsanullah *et al.*, 2001; Manzoor *et al.*, 2005) reported that the levels and

time of nitrogen application play an important role in increasing rice production. They reported higher paddy yield (4-5 t ha⁻¹), where nitrogen fertilizer was applied in two or three splits as compared to full nitrogen application at the time of transplanting. Briefly describe the behavior of rice cultivars with respect to transplanting, N response and adaptation under variable environments. These studies lack the effects of agronomic treatments on paddy yield under different locations. Thus, a better scientific understanding is required so that farmers can avoid applying nitrogen when and where poor responses are most likely. This paper describes the effects of transplanting date and nitrogen split application on yield and yield components of Basmati rice under variable environments.

MATERIALS AND METHODS

Site and soil. Field studies were conducted to investigate the effect of transplanting date and nitrogen split application on growth and yield of paddy cultivars under three agro-environments as, (1) Faisalabad (31.25oN, 73.9oE, 184.4 m), (2) Kala Shah Kaku, (31.6oN, 74.6 oE, 217 m) and (3) Gujranwala (31.7oN, 73.8 oE, 221 m) during 2004 and 2005.

Soil analysis. Composite soil samples to a depth of 30 cm were obtained from the experimental sites with soil Auger prior to sowing of crop. Soil analysis showed that all the three sites had pH near to 8.0 and were rated as deficient in the main elements like N, P and K, etc. At Faisalabad soil

was sandy clay loam (coarse-silty, mixed, hyperthermic Typic calciargids) in texture, whereas at Kala Shah Kaku and Gujranwala the soils were loam (Course-silty, mixed, hyperthermic Fluventic Haplocambids) and heavy loam (Fine, mixed, hyperthermic Ustic Endoaquerts), respectively.

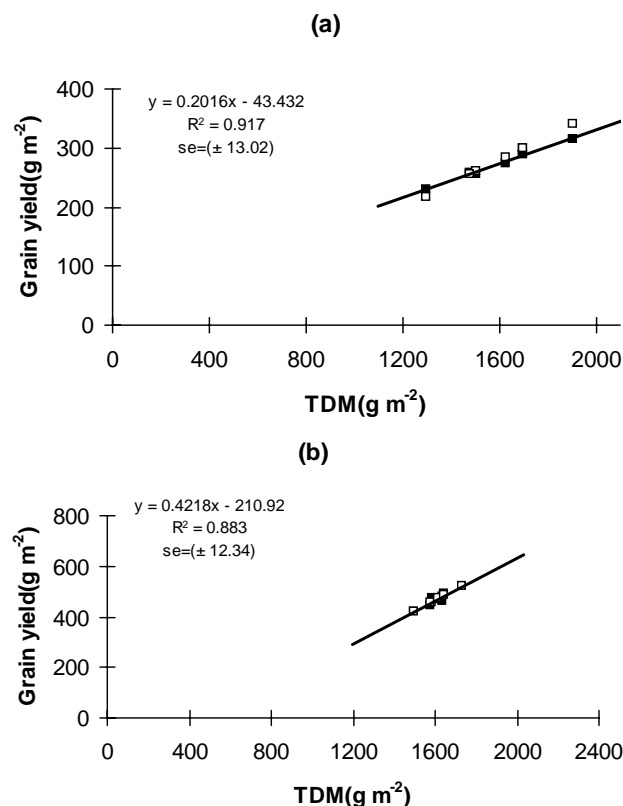
Design and treatments. The experiments were laid out in split-split plot design with three replications. Transplanting dates (1st week of July, 3rd week of July) were placed in main plots, cultivars (Super Basmati & Basmati-2000) in sub-plots and nitrogen (N) split application as full N at transplanting, ½ at transplanting + ½ at 30 days after transplanting (DAT) and 1/3 at transplanting + 1/3 at 30 DAT + 1/3 at 50 DAT in sub-subplots. Net plot size was 1.8 m by 12 m with row to row and plant to plant spacing of 22.5 cm.

Crop husbandry. The nursery was sown by dry method in the 1st and 3rd week of June during both the seasons at three sites. In each season the wetland preparation (puddling) method was used for preparing the paddock for transplanting. Thirty days old seedlings were transplanted manually in the puddled field in standing water at 22.5 cm x 22.5 cm plant to plant and row to row distance. Phosphorous (79 kg ha⁻¹) as single super phosphate (SSP) and potash (62 kg ha⁻¹) as sulphate of potash (SOP) were applied before transplanting while nitrogen (136 kg ha⁻¹) as urea was applied as per treatment. All plots were irrigated to maintain a flooded condition continuously throughout the active growth period of the crop. All other cultural practices such as weeding, plant protection, etc. were kept normal for all the crops. At final harvest, in each experiment, paddy yields were assessed on a 7.5 m² area in each plot and sub-sample of 20 plants was taken for the determination of yield components. Data collected on yield and yield components were analysed statistically and significance of treatment means was tested using least significant difference test at 5% probability level. Pooled analyses were carried out within location across years/seasons (Gomes & Gomes, 1984).

RESULTS AND DISCUSSION

Paddy yield. Transplanting in the first week of July significantly enhanced paddy yield as compared to transplanting in the third week of July at Kala Shah Kaku and Gujranwala but not at Faisalabad (Table I). Averaged over the locations paddy yield was 25.76% higher (4.15 t ha⁻¹ vs 3.30 t ha⁻¹) in early than late transplanting. Cultivar differences in paddy yield were only significant at Faisalabad where cv. Super Basmati enhanced paddy yield by 13.28% over Basmati-2000. N split application significantly affected paddy yield at Faisalabad and Kala Shah Kaku but not at Gujranwala. Averaged over three locations paddy yield was 3.59, 3.77 and 3.81 t ha⁻¹ in full N and two and three N splits. Average paddy yield was higher at Kala Shah Kaku than at Gujranwala and Faisalabad. The

Fig. 1. Relationship between grain yield and final TDM (a) at Faisalabad and (b) at Kala Shah Kaku



paddy yield was linearly and positively correlated with TDM production at Faisalabad and Kala Shah Kaku (Fig. 1). The regression accounted for 88.3% to 91.7% of the variance in the yield. The early transplanting significantly increased paddy yield over late transplanting, and this response was significantly higher in two or three N splits only in the first week of July transplanting (Table II).

Paddy yield responded to N split application at the final harvest. Increased paddy yields were obtained with early transplanting and two or three split application of 136 kg N ha⁻¹ for Faisalabad (3.16 t ha⁻¹), Kala Shah Kaku (5.21 t ha⁻¹) and Gujranwala (4.07 t ha⁻¹). The present study corroborate the findings of Manzoor *et al.* (2005) who reported that fine rice (cv. Basmati-2000) produced maximum grain yield in response to N application in three splits. Paddy yield increased from 4.15 t ha⁻¹ in early transplanting treatment compared with 3.30 t ha⁻¹ in late transplanting, largely because of longer duration. This increased the number of grains in the former than in the later. The positive effects of N split application on number of grains per panicle enhanced paddy yield, mean grain weight was not affected significantly by the treatments. Many workers showed increased paddy yield with N split application (Mandal *et al.*, 1991; Andrade *et al.*, 1992; Ehsanullah *et al.*, 2001).

Total dry matter. Early transplanting of rice significantly enhanced total dry matter (TDM) over late transplanting at

Table I. Effect of transplanting date and nitrogen split application on productivity and harvest index of two paddy cultivars grown at three locations

Treatment	Paddy yield (t ha ⁻¹)			TDM (t ha ⁻¹)			Harvest index (%)		
	Faisalabad	Kalashah Kaku	Gujranwala	Faisalabad	Kalashah Kaku	Gujranwala	Faisalabad	Kalashah Kaku	Gujranwala
A=Date of transplanting									
1st Week of July	3.16 N.S	5.21 a	4.07 a	19.06 a	17.33 a	18.05 a	16.59 N.S	30.18 N.S	23.53 a
3rd Week of July	2.30	4.18 b	3.42 b	12.96 b	14.94 b	17.07 b	17.48	27.95	20.32 b
B=Cultivar									
Super Basmati	2.90 a	4.76 N.S	3.80 N.S	19.89 a	15.88 b	18.39 a	17.17 N.S	29.96 a	20.91 b
Basmati -2000	2.56 b	4.63	3.70	15.04 b	16.39 a	16.73 b	16.90	28.17 b	22.94 a
C=N split application									
Full N at transplanting	2.57 b	4.47 c	3.73 N.S	14.78 b	15.77 b	17.01 b	17.17 N.S	28.21 b	22.45 N.S
½ N at transplanting + ½ N at 30 DAT	2.88 a	4.68 b	3.76	16.98 a	16.17 ab	17.35 a	17.26	28.84ab	22.21
1/3 N at transplanting + 1/3 after 30 DAT + 1/3 N at 50 DAT	2.74 a b	4.94 a	3.75	16.28 a	16.46 a	18.32 a	16.67	30.15 a	21.11
Year Effect	*	**	*	N.S	N.S	*	N.S	*	*
Mean	2.73	4.69	3.75	16.01	16.13	17.56	17.04	29.03	21.93

all locations (Table I). Super Basmati out-yielded Basmati-2000 at Faisalabad and Gujranwala, but not at Kala Shah Kaku. Averaged over the locations Super Basmati recorded 12.65% higher TDM (18.08 t vs 16.05 t ha⁻¹) as compared to cv. Basmati-2000 (Table I). N split application significantly enhanced TDM yield over full N application at all the three sites. Differences in TDM between the two and three N splits were, however, non-significant except at Gujranwala where N applied in three splits was superior in TDM production than that applied in two splits. Mean TDM yield was 15.85, 16.83, and 17.02 t ha⁻¹ in full, two split and three N split applications, respectively.

Marked differences in TDM production among transplanting dates or N split application treatments were probably caused by differences in their LAD values. Schinir *et al.* (1990) reported that in transplanted rice, TDM increased steadily after crop establishment until maturity and responded positively to early transplanting or N split application. Generally, early transplanting and split N application contributed to increased vegetative growth and thus greater biomass production.

Harvest index. Differences in harvest index (HI) between the transplanting dates were non-significant at Faisalabad and Kala Shah Kaku. However, at Gujranwala, early transplanting significantly increased HI by 25.64% (23.53% vs 20.32%) over late transplanting (Table I). Differences in HI between cultivars were significant at Kala Shah Kaku and Gujranwala. Super Basmati increased HI by 6.35% (29.96 vs 28.17%) over Basmati-2000. In contrast, at Gujranwala, Basmati-2000 significantly increased HI by 9.7% (22.94 vs 20.91%) Super Basmati.

N split application did not significantly enhance HI over full N application at Faisalabad and Gujranwala. At Kala Shah Kaku three N split applications significantly increased HI over two splits or full N application treatments. Mean HI was 22.61%, 22.77% and 22.64% in full N, two N split and three N split applications, respectively (Table I). Overall, HI was 17.04%, 29.03% and 21.93% at Faisalabad, Kala Shah Kaku and Gujranwala, respectively.

Table II. Interaction between date of transplanting and nitrogen split application affecting paddy yield (t ha⁻¹) at Kalashah Kaku.

Nitrogen split application	Date of transplanting	
	1 st . week of July	3 rd . week of July
Full N at transplanting	4.98 b	3.96 d
½ N at transplanting + ½ N at 30 DAT	5.33 a	4.03 d
1/3 N at transplanting + 1/3 N at 30 DAT + 1/3 at 50 DAT	5.33 a	4.54 c
LSD5% = 0.26		

Mean sharing different letters differs significantly at $P \leq 0.05$

Table III. Interaction between date of transplanting and nitrogen split application affecting harvest index (%) at Kalashah Kaku

Nitrogen split application	Date of transplanting	
	1 st . week of July	3 rd . week of July
Full N at transplanting	29.89 a	26.53 b
½ N at transplanting + ½ N at 30 DAT	30.82 a	26.83 b
1/3 N at transplanting + 1/3 N at 30 DAT + 1/3 at 50 DAT	29.85 a	30.47 a
LSD5% = 2.05		

Mean sharing different letters differs significantly at $P \leq 0.05$

Early transplanting did not affect HI, irrespective of N application treatments. However, in late transplanting this response was significantly higher in three N split application compared to full N or two N split application (Table III). HI varied little in response to transplanting date or cultivar at all the locations. At Gujranwala, early transplanting significantly increased HI over late transplanting only when Super Basmati was transplanted. Paddy yield was, therefore, determined by TDM production. This was confirmed by a linear relationship between paddy yield and TDM (Fig. 2).

Components of Yield

Number of tillers m⁻². Transplanting date had non-significant effect on the number of fertile tillers m⁻² (Table IV). Differences in the number of tillers between the two

Table IV. Effect of transplanting date and nitrogen split application on yield components of two paddy cultivars grown at three locations

Treatment	Number of panicle bearing tiller m ⁻²			No. of grains panicle ⁻¹			1000-grain weight (g)		
	Faisalabad	Kalashah Kaku	Gujranwala	Faisalabad	Kalashah Kaku	Gujranwala	Faisalabad	Kalashah Kaku	Gujranwala
A=Date of transplanting									
1 st Week of July	176.81 N.S	189.00 N.S	186.25 N.S	90.99 a	111.41 a	101.17 N.S	19.69 N.S	24.80 N.S	22.42 N.S
3 rd Week of July	168.97	195.19	178.17	83.82 b	104.27 b	98.58	19.39	24.91	22.39
B=Cultivar									
Super Basmati	176.47 N.S	208.94 a	177.61 b	84.85 b	95.56 b	107.50 a	19.23 b	23.30 b	23.97 a
Basmati-2000	169.31	175.25 b	186.81 a	89.97 a	120.12 a	92.25 b	19.94 a	26.41 a	20.83 b
C=N split application									
Full N at transplanting	173.67 N.S	188.38 N.S	183.75 N.S	84.96 b	111.12 N.S	99.5 N.S	19.44 N.S	24.91 N.S	22.0 N.S
½ N at transplanting + ½ N at 30 DAT	175.69	190.86	184.67	87.93 a	106.33	97.88	19.44	24.73	22.33
1/3 N at transplanting + 1/3 after 30 DAT + 1/3 N at 50 DAT	169.33	197.04	178.21	89.34 a	106.07	102.25	19.87	24.92	22.88

cultivars were significant at Kala Shah Kaku and Gujranwala, but not at Faisalabad. Super Basmati produced 19.4% (209 m² vs 175 m²) more tiller per unit area as compared to Basmati-2000 at Kala Shah Kaku. In contrast at Gujranwala, Basmati-2000 gave 5.1% higher number of tillers than Super Basmati. N split application treatments did not affect the number of tillers m⁻² at all the locations (Table IV). Similar number of productive (panicle bearing) tillers at all the three locations may be attributable to optimum supply of NPK in these treatments. Average number of tillers (173 to 192 m⁻²) obtained in these studies compares favorably (220 to 249 m⁻²) to those reported by other workers in similar environments (Ali *et al.*, 2005; Manzoor *et al.*, 2005).

Number of grains per panicle. Early transplanting significantly increased the number of grains per panicle at Faisalabad and Kala Shah Kaku but not at Gujranwala (Table IV). Basmati-2000 reported higher number of grains per panicle at Faisalabad and Kala Shah Kaku but at Gujranwala Super Basmati gave higher number of grains. N split application significantly increased the number of grains per panicle over full N application only at Faisalabad site. Differences in the number of grains between the two split treatments were, however, non-significant (Table IV). Overall mean number of grains per panicle was 87.4, 107.8 and 99.9 at Faisalabad, Kala Shah Kaku and Gujranwala, respectively.

Interaction between transplanting date and N application affecting the number of grains per panicle was significant at Faisalabad and Gujranwala (Table V). Early transplanting significantly increased the number of grains over late transplanting, when three N split applications were applied. Differences between two N splits or full N application were, however, non-significant. Higher number of grains per panicle among various treatments was probably due to differential activity of tillering under variable environmental conditions at the three sites. Dingkuhn *et al.* (1990) reported that tillering is restricted in transplanting by transplanting 'shock'. Tiller number is usually reduced by 30-40% by tiller abortion during the reproductive growth phase after panicle initiation. The filled

Table V. Interaction between date of transplanting and nitrogen split application affecting number of grains per panicle**(a) Faisalabad**

Nitrogen split application	Date of transplanting	
	1 st week of July	3 rd week of July
Full N at transplanting	87.31 c	82.61 e
½ N at transplanting + ½ N at 30 DAT	90.18 b	85.68 cd
1/3 N at transplanting + 1/3 N at 30 DAT + 1/3 at 50 DAT	95.49 a	83.18 de
LSD5% = 2.60		

Mean sharing different letters differs significantly at $P \leq 0.05$

(b) Gujranwala

Nitrogen split application	Date of transplanting	
	1 st week of July	3 rd week of July
Full N at transplanting	92.42 d	100.6 ab
½ N at transplanting + ½ N at 30 DAT	101.3 bc	94.42 cd
1/3 N at transplanting + 1/3 N at 30 DAT + 1/3 at 50 DAT	109.8 a	94.75 cd
LSD5% = 7.91		

Mean sharing different letters differs significantly at $P \leq 0.05$

spikelet number was therefore due to positive response to N application. Ehsanullah *et al.* (2005) reported number of grains per panicle at 137-142 for cv. Basmati-2000 at Kala Shah Kaku. A significant increase in number of tillers, spike length and number of grains per panicle in cv. Basmati-2000 was also noted by others (Manzoor *et al.*, 2005).

1000-grain weight. The effect of season on mean grain weight was significant at all sites (Table IV). Transplanting date did not affect 1000-grain weight at any site. Cultivar differences in the mean grain weight were significant and differentially affected at different locations. Basmati-2000 gave significantly higher grain weight than Super Basmati at Faisalabad and Kala Shah Kaku whereas at Gujranwala Super Basmati showed 15.1% higher grain weight than Basmati-2000 (23.97 g vs 20.83 g). Non-significant differences were observed in the 1000-grain weight among various N application treatments. Averaged over all the locations mean grain weight was 22.12, 22.17 and 22.56 g

in full, two splits and three N splits, respectively. Overall, mean grain weight was lower at Faisalabad than at Kala Shah Kaku and Gujranwala (Table IV).

It was concluded that greater than 5 t ha⁻¹ paddy yield would be a reasonable commercial expectation for all the locations provided early transplanting of rice with better management of nitrogen could be established.

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