Performance of rice on beds and puddled transplanted flats in Punjab, India

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Abstract

Transplanted and direct seeded rice on fresh and permanent beds (TRB, DSRB) were compared with puddled transplanted rice (PTR) on sandy loam and loam soils in Punjab, India. The treatments were irrigated daily (CF or "continuous flooding" of flats and furrows) or 2d after the floodwater had disappeared. The furrows in DSRB-CF on the loam drained within 8-10 h, while they remained shallow flooded on the sandy loam. Highest grain yield occurred in PTR-CF, followed in order by PTR-2d, TRB-2d and DSRB-2d on both soils. Yields of TRB on the sandy loam were reduced due to nematode infestation, while yields of DSRB were reduced due to severe Fe deficiency, except for DSRB-CF on the sandy loam. DSRB also required 2-4 hand weedings to supplement herbicide application, while TRB required 1-2 weedings. On these soils, successful production of DSRB may require early Fe sprays prior to the appearance of Fe deficiency symptoms, measures to control nematodes, and early irrigation to germinate weeds followed by herbicide application prior to sowing,

Media summary

Growing rice on beds requires measures to prevent iron deficiency, nematodes and weeds.

Key words

matric potential, grain and biomass yields, Fe deficiency, nematode infestation

Introduction

Rice-wheat (RW) is the major cropping system of Punjab, India (Timsina and Connor 2001). Rice is typically grown by transplanting 25-30 day old seedlings into puddled soil. The current RW cropping system is not sustainable and there is an urgent need to reduce water use while maintaining or increasing productivity. Farmer and researcher trials in the Indo-Gangetic Plains (IGP) suggest irrigation water savings of 12 to 60% for DSRB and TRB, with similar or lower yields for TRB compared with PTR, and usually slightly lower yields with DSRB (Humphreys et al. 2004). There are also several reports of reduced irrigation amounts or time (18-50%), with similar or higher yields, for wheat on beds compared with conventional tilled wheat (Humphreys et al. 2004). The use of permanent beds for RW can also reduce energy and labour costs for tillage, and enable more timely sowing of wheat. Permanent beds also offer the flexibility of rapidly switching to lower water use, waterlogging sensitive crops in response to market opportunities. The present experiment was therefore conducted to compare the performance of rice on bed and flat layouts in a RW cropping system.

Methods

Field experiments were established in November 2002 on two soils at Ludhiana (sandy loam) and Phillaur (loam) in Punjab, India. The sites were cultivated and wheat was sown on the flat or on fresh beds. After harvest the wheat straw was removed and rice (PR115) was transplanted into puddled flat plots and transplanted or direct seeded onto the beds in the second and third weeks of June 2003. DSRB was sown at 40 kg/ha and 2 x 24-30 day old seedlings were transplanted at 20 cm x 15 cm in the flats and at 10 cm plant spacing in two rows 25 cm apart on the beds. All treatments received 13 kg P/ha, 25 kg K/ha and 15 kg Zn/ha prior to planting, and 125 kg N/ha as urea in broadcast split applications. In transplanted rice, ⅓ of the N was applied prior to reshaping of the beds and transplanting, and the remainder was applied 21 and 42 days after transplanting. In DSRB, ? of the N was applied before reshaping of the beds and the remainder was applied in 3 splits 21, 42 and 63 days after sowing (DAS). Weeds were controlled in PTR using butachlor @ 3,000 ml/ha (a.i. 1,500 ml/ha) 2 d after transplanting. Sofit (pretilachlor+safener) @1,250 ml/ha (a.i. 470 ml/ha) was applied to DSRB 5-6 d after sowing. All treatments were irrigated daily for the first 2 weeks after planting, and thereafter 2 d after the floodwater had disappeared, except for PTR-CF and DSRB-CF which were irrigated daily. Plant samples were collected towards the end of tillering and at anthesis and maturity. Soil matric potential was determined at 10 and 20 cm in DSRB-2d at both sites, and in DSRB-CF and PTR-2d on the sandy loam. The tensiometers were placed between the rows on the beds, about 4 cm from one row, and read before each irrigation. Results are means of 4.

Results

Total rainfall and pan evaporation at Ludhiana during June to September were close to the long term averages of 524 mm and 651 mm, respectively. However rainfall was better distributed than normal (Fig. 1). The number of irrigations ranged from 31 in PTR-2d on the sandy loam to 99 on DSRB-2d. The PTR-CF treatments remained flooded at both sites throughout the season, however the water disappeared from the furrows in DSRB-CF within 8-10 h on the loam, while the furrows on the sandy loam generally retained 1-3 cm prior to irrigation.

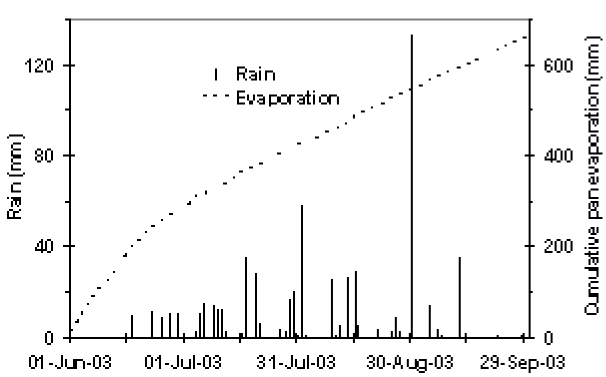

Figure 1. Rain and pan evaporation at Ludhiana

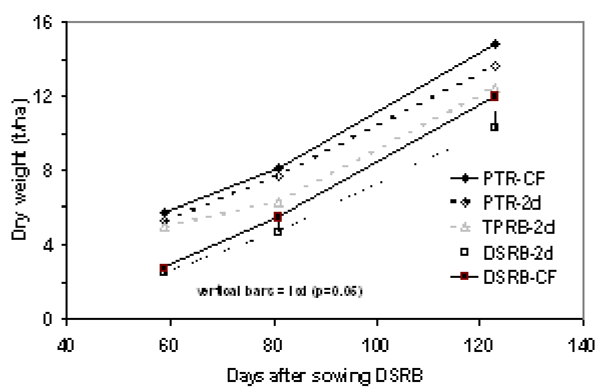

Figure 3. Total biomass (grain+ straw) on the loam

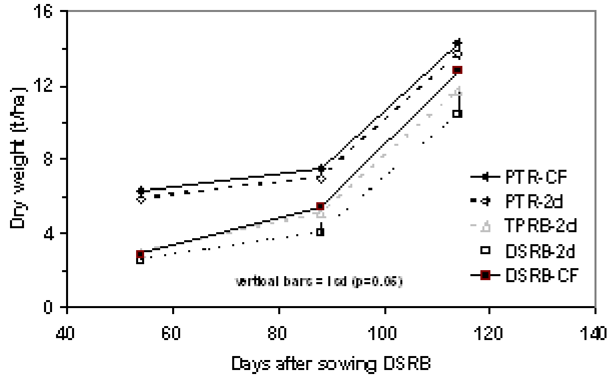

Figure 2. Biomass production on the sandy loam

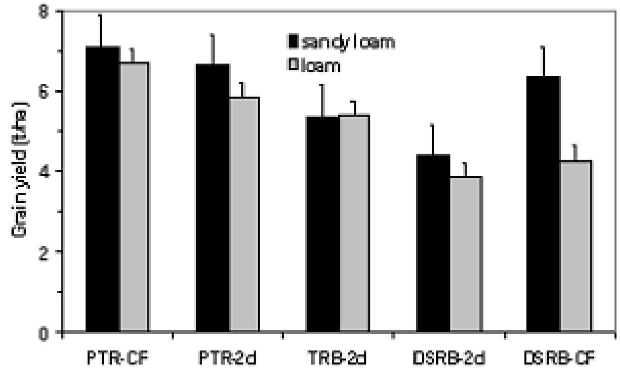

Figure 4. Grain yield (14%) (vertical bars are lsd's (p=0.05) within soil type)

Symptoms of severe Fe deficiency (stunted growth, yellowing of new leaves with green mid-ribs) were observed in both DSRB treatments at both locations 15-20 days after sowing, therefore a 1% solution of Fe_2SO_4 (250 l/ha) was applied twice on the sandy loam and four times on the loam where the deficiency was more severe. On the sandy loam TRB-2d was seriously affected (visual cyst number score 7 out of 10) by rice root rot nematodes (*Meloidogyne graminicola*), while PTR-2d was moderately affected (score 4) and PTR-CF was the least affected (score 0.4). Chemical weed control was good in PTR, however 1-2 hand weedings were required in TRB and 3-4 in DSRB at both sites.

Around 57 DAS, biomass production in all bed treatments on both soils was about half the biomass production in both PTR treatments with the exception of TRB-2d on the loam (Figs 2, 3). Between 57 DAS and anthesis and between anthesis and maturity, growth rates on the beds were similar or higher than on the flats, except TRB-2d on the loam prior to anthesis. On the loam, tiller density around 57 DAS in PTR-CF was significantly ($p<0.05$) higher than in PTR-2d, which was higher than in all bed treatments. The rate of tiller production between 57 DAS and anthesis on the loam was similar in all treatments. On the sandy loam, tiller density was significantly lower in TRB-2d and DSRB-2d than in all other treatments around 57 DAS. Between 57 DAS and anthesis the rate of tiller production was higher in both DSRB treatments than in all other treatments.

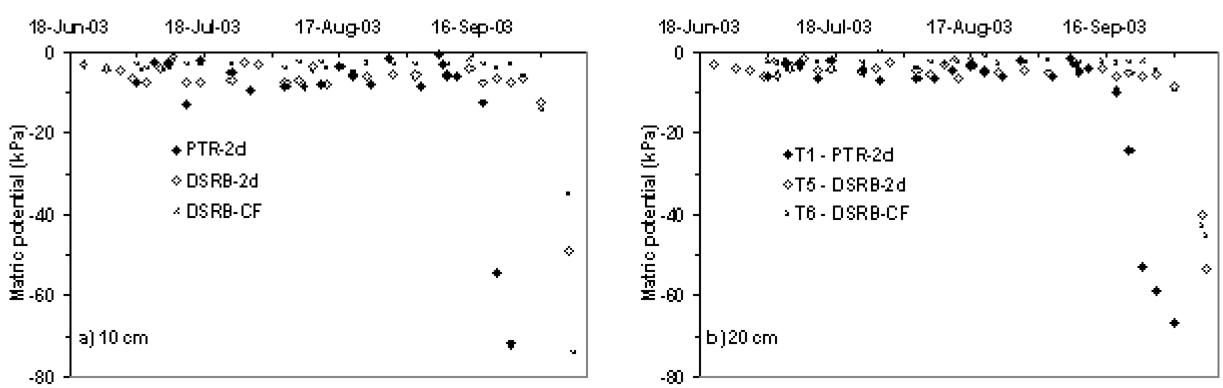

Figure 5. Soil matric potential on the sandy loam

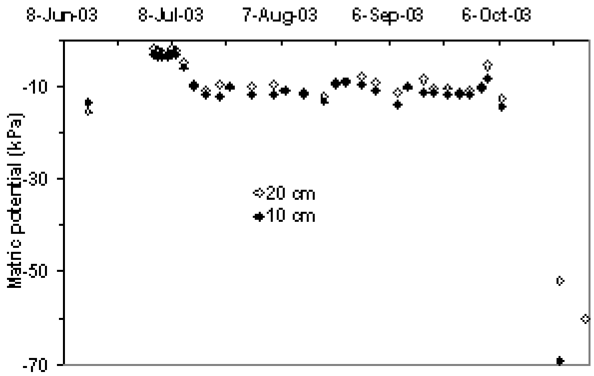

Figure 6. Soil matric potential in DSRB-2d on loam

There was a consistent trend across sites for highest grain yield in PTR-CF, followed in order by PTR-2d, TRB-2d and DSRB-2d (Fig. 4, Table 1). The higher yields were generally due to both higher panicle density and number of grains per panicle. Yield of DSRB-CF was similar to PTR-2d on the sandy loam, but much lower and similar to DSRB-2d on the loam. Panicle density was significantly lower in TRB-2d than all other treatments on the sandy loam, and the number of grains per panicle was least in the DSRB treatments at both sites. There was a trend for lower grain weight in DSRB-2d, with significant differences on the loam.

Soil matric potential remained below -10 kPa throughout the season at 10 and 20 cm in PTR-2d and both DSRB treatments on the sandy loam, and the soil tended to be wetter in the beds than on the flats, more so in DSRB-CF (Fig. 5). The soil dried slightly more in DSRB-2d on the loam at 10 and 20 cm, to -9 to -14 kPa (Fig. 6).

Discussion

Rice yields generally decrease as soil water content declines below saturation, however many studies in northwest India have shown that yields are maintained at reasonable levels with irrigation around 2 d after the floodwater has disappeared (Humphreys et al. 2004). Hira et al. (2002) found that yields of PTR were not affected by scheduling irrigations when matric potential at 15-20 cm reached -16 kPa. Matric potential in our experiments was less than this, suggesting that soil water status was adequate for rice on flats and beds. The poor performance of rice on beds in our study suggests that soil water status at depths shallower than 10 cm may be an important factor directly influencing rice performance, or indirectly via its influence on Fe availability in the surface soil, and/or that puddling plays an important role in increasing iron availability, perhaps through reducing infiltration and therefore transport of oxygen into the surface soil layers.

Many farmer and researcher trials in the IGP have also found similar yields for TRB and PTR, and generally slightly lower yields with DSRB (Humphreys et al. 2004). However there are also some reports of large yield losses for DSRB (Singh et al. 2002), largely attributed to increased incidence of nematodes and Fe and Zn deficiencies. The lower yield of TRB on the sandy loam in our study was probably due to nematode damage, which impaired tiller and subsequently panicle production. The lower yield of DSRB at both sites was probably primarily due to Fe deficiency, which was more severe on the loam. The crop growth rate recovered following application of Fe sprays, however yield potential had already been impaired through reduced tiller and subsequently panicle production and number of grains per panicle on the loam. Grain weight in DSRB-2d was also reduced, indicating that this treatment was stressed throughout the vegetative and reproductive periods. Where visual symptoms of Fe deficiency occur, rice yield potential may be reduced, even with the application of remedial Fe sprays (Nayyer and Takkar 1989). On these soils, early Fe sprays prior to the appearance of Fe deficiency symptoms, and fumigation for control of nematodes, may be necessary for successful production of rice on beds.

Table 1. Grain yield and yield components

Wheat tmt pre-rice[A]	Rice tmt[B]	No. panicles /m^2	No. grains /panicle	Average grain wt (g)	Grain yield 14% (t/ha)	Straw yield (t/ha)	HI
			Sandy loam				
CTW	PTR-2d	269	139	19.3	6.64	8.04	0.42
CTW	PTR-CF	299	145	19.4	7.12	7.71	0.43
WB	TRB-2d	243	130	19.2	5.38	8.23	0.39
WB	DSRB-2d	282	112	18.4	4.40	5.94	0.36
WB	DSRB-CF	307	120	19.5	6.35	4.82	0.42
lsd(p=0.05)		*23*	*7*	*NS*	*0.76*	*6.75*	*NS*
			Loam				
CTW	PTR-2d	272	125	19.6	5.84	8.65	0.37
CTW	PTR-CF	294	137	19.3	6.70	8.66	0.39
WB	TRB-2d	251	120	19.6	5.40	9.02	0.37
WB	DSRB-2d	226	104	18.5	3.86	7.47	0.32
WB	DSRB-CF	239	108	19.3	4.29	5.32	0.31
lsd (p=0.05)		*20*	*11*	*0.5*	*0.37*	*6.20*	*NS*

[A]CTW conventionally tilled wheat on the flat; WB wheat on fresh beds
[B]PTR puddled transplanted rice on the flat; 2d irrigated 2 days after the floodwater has disappeared; CF "continuously flooded" or daily irrigation; TRB transplanted rice on beds; DSRB dry seeded rice on beds

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