Performance of wheat on beds and flats in Punjab, India

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Abstract

The performance of wheat on flat and bed layouts was compared on three soil types (sandy loam, loam and reclaimed sodic loam) in Punjab, India during the winter of 2002/3. Mid-season conditions were unusually foggy and cool and the crops virtually stopped growing during the month prior to anthesis. On the sandy loam total biomass and grain yield were significantly lower on the beds (4.3 t ha^{-1}) than on the flats (4.8 t ha^{-1}), but were similar on the beds and flats on the two loams. The lower yields on the beds on the sandy loam appeared to be due to failure of the crop to tiller as a result of water deficit stress during early crop growth. The recommended practice of delaying the first irrigation until 3-4 weeks after sowing may need to be revised to 2-3 weeks after sowing for wheat on beds on sandy loam soils.

Media summary

The timing of the first irrigation for wheat on beds may need to be earlier than the recommended practice for wheat on flat layouts on the coarse textured soils of north west India.

Key words

raised beds, matric potential, water use

Introduction

Wheat grown in rotation with rice is a major contributor to food grain production in the Indo-Gangetic plains of South Asia (Timsina and Connor 2001). The sustainability of this system is at risk due to declining groundwater levels, deteriorating soil properties and increased incidence of pests and diseases. In the past decade it has been shown that wheat can be grown successfully on beds with substantial irrigation water savings and similar or higher yields (Dhillon et al. 2000; Hobbs and Gupta 2003). However, conclusive evidence about the amount and nature of the water savings and yield gains on different soil types is lacking. The present study was therefore designed to quantify components of the water balance and crop performance for wheat grown on beds and conventional flat layouts on three representative soils in Punjab, India. The effect of beds and flats on crop performance is reported in this paper.

Methods

Field experiments were conducted on three soil types at Ludhiana (sandy loam), Phillaur (loam “P”) and Kapurthala (reclaimed sodic loam “K”) in Punjab, India during the ‘rabi’ or winter season of 2002/3. Following rice harvest, the stubble was removed and the fields were irrigated prior to cultivation and bed formation. Recommended sowing and fertilizer practices were used at all sites. Wheat (PBW343) was sown at 100 kg ha^{-1} on the flats and 75 kg ha^{-1} on the beds with diammonium phosphate (26 kg P ha^{-1}, 23 kg N ha^{-1}) and potassium chloride (25 kg K ha^{-1}) in early November. The flat plots were sown with a tractor-driven combine seed drill with 20 cm row spacing, while the beds were formed and sown simultaneously with a bed planter. Bed width (mid-furrow to mid-furrow) was 67 cm, with a furrow width of 30 cm. There were two rows per bed spaced 20 cm apart. Urea (37 kg N ha^{-1}) was broadcast prior to sowing and bed formation and a further 60 kg N ha^{-1} was topdressed on the bed surface between the rows, and broadcast in the flat plots, prior to the first irrigation. Irrigation treatments commenced after the first common irrigation 16 days after sowing (DAS) on loam P, 26 DAS on the sandy loam, and 31 DAS on loam K. Irrigations (80 mm) were applied to the flat treatments when cumulative pan evaporation minus rain (CPE-R) reached 80 mm, consistent with the recommended practice (Prihar et al. 1974, 1976), while the beds received 40 mm at CPE-R = 40 mm. There were four replicates in a randomized block design. Further details are provided in Humphreys et al. (2004).

Plant samples were collected at early tillering, late tillering, anthesis and maturity. Soil matric potential was monitored at depths of 10, 20, 40 , 60, 80, 100, 120 and 140 cm using tube tensiometers read with a SoilSpec[?] vacuum gauge, and irrigation applications were measured using a propeller flow meter in the tubewell outlet pipe.

Results and discussion

Weather and irrigations

Mean monthly maximum and minimum temperatures were close to average except during January, when the mean maximum temperature was about 5?C lower than the long term average. January was unusually foggy, with average sunshine hours reduced by almost 50% to about 3 h d^{-1} and less than 2 h of sunshine on 11 days. Rainfall in February was higher than average (30 mm), with at least 130 mm in two events about 10 days apart at all sites. Total irrigation applications for the flats and beds were similar at respective sites: sandy loam - 151 mm (flats), 180 mm (beds); loam P - 227 mm (flats), 205 mm (beds); loam K - 140 mm (flats), 128 mm (beds).

Crop performance

Plant population after establishment was significantly ($p<0.05$) higher on the flats (183-208 plants m^{-2}) than on the beds (125-134 plants m^{-2}) at all three sites, consistent with the higher sowing rate on the flats. The crops were very uniform in all treatments at all sites, and biomass accumulation at all sites was similar up to anthesis (mean 7-7.4 t ha^{-1} at anthesis) (Fig. 1). There was very little dry matter accumulation from about 75 DAS to anthesis, reflecting the foggy, cool conditions during this period. Total biomass at harvest was much higher on loam P (mean 13.8 t ha^{-1}) than at the other two sites (mean 10.0 t ha^{-1} on loam K and 11.3 t ha^{-1} on the sandy loam). There was lodging in all treatments on loam K around the end of tillering, following which the crop grew vertically producing L-shaped stems. Total biomass tended to be higher on the flats than on the beds during late tillering and anthesis at all sites, with some small but significant differences. At maturity total biomass and N uptake were not affected by layout on the two loam soils, but on the sandy loam they were significantly higher on the flats (11.9 t ha^{-1}, 130 kg N ha^{-1}) than on the beds (10.6 t ha^{-1}, 111 kg N ha^{-1}). Grain yield was also significantly higher on the flats (4.8 t ha^{-1}) than on the beds (4.3 t ha^{-1}) on the sandy loam, while yields of the flats and beds on the loam soils were similar at respective sites (Fig. 2). Yields were lower on loam K (3.5-3.6 t ha^{-1}) compared with the other two sites (4.3-4.8 t ha^{-1}), probably due to the early lodging.

There were very few tillers produced beyond 75 DAS (Fig. 3). There was a consistent trend for higher tiller density in the flat treatments at all sites, and the difference was much larger and always significant on the sandy loam. Tiller density on the beds on the sandy loam was lower than on the loam soils, while tiller density on the flats on loam P was lower than at the other two sites. The number of tillers per plant at anthesis (calculated using the plant population after establishment) was significantly higher on the beds than on the flats on the loam P, while it was similar in beds and flats on the sandy loam (Fig. 4). The number of tillers per plant on the beds on the loam soils was higher than in both treatments on the sandy loam. Spike density on the beds (396 spikes m^{-2}) was significantly lower than on the flats (493 spikes m^{-2}) on the sandy loam. The lower grain and total biomass yields on the beds on the sandy loam were probably due to the lack of tillering to compensate for the lower plant population in the bed layout. The cause of the lower tillering on the beds on the sandy loam is unlikely to have been due to inadequate N in the 2002/3 season in which yield potential was reduced due to lack of radiation. Furthermore, in an adjacent rice-wheat field during the same season on the same soil type, yields of wheat on beds and flats increased with N rate up 120 kg N ha^{-1}, with no further response at 160 kg N ha^{-1} (Yadvinder-Singh 2003).

Soil matric potential

Soil water content was reasonably high throughout the profile at the time of sowing, with soil matric potential less than -20 kPa at 80 cm and deeper until around the end of grain filling. The surface soil (10, 20 cm) in the beds generally dried faster than on the flats after sowing (Figure 5), however on the loam soils matric potential at 10 and 20 cm did not increase beyond -50 k Pa prior to the first irrigation, or beyond -40 to -70 kPa prior to the second irrigation. In contrast, the tensiometers broke down (matric potentials in excess of -70 to -80 kPa) prior to the first and second irrigations in both treatments at 10 cm on the sandy loam, and exceeded -70 kPa on the beds at 20 cm (Fig. 5). The data suggest that the failure of the plants to produce more tillers on the beds on the sandy loam was due to water deficit during early crop growth.

Figure 1. Total biomass production (grain+straw) on the three soils (vertical bars are lsd p=0.05)

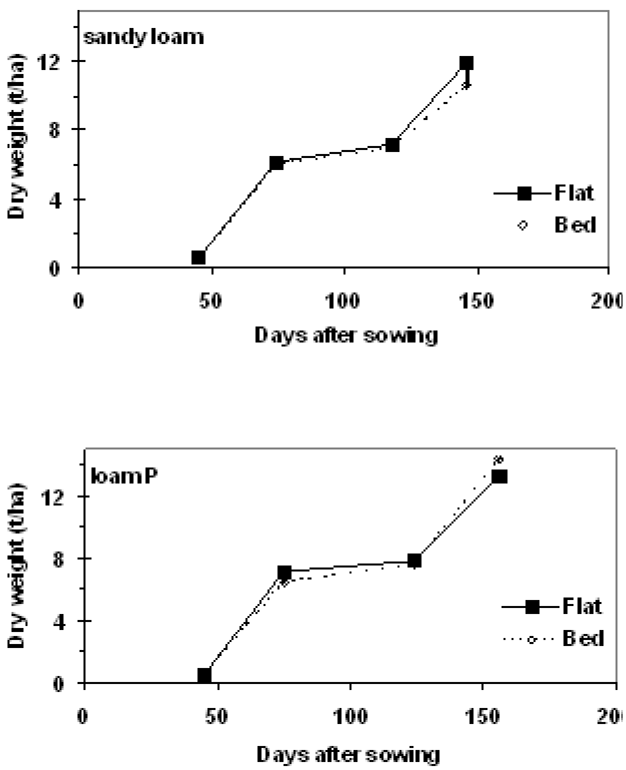
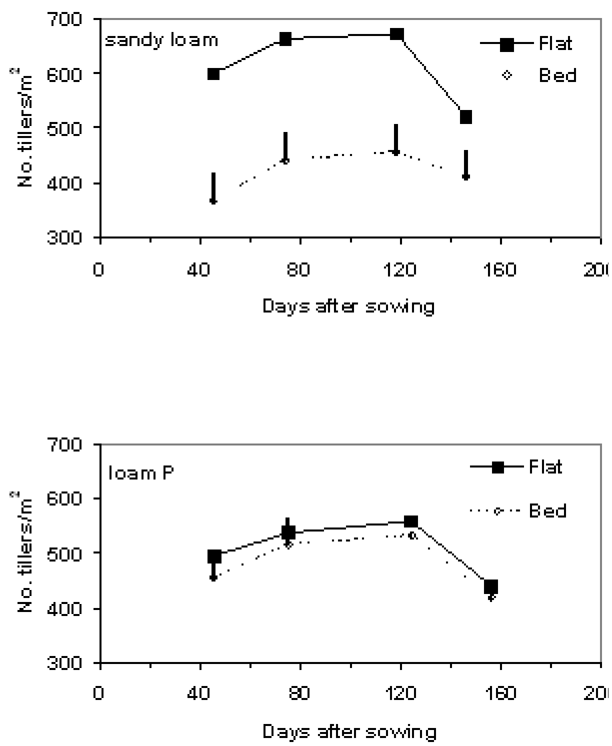
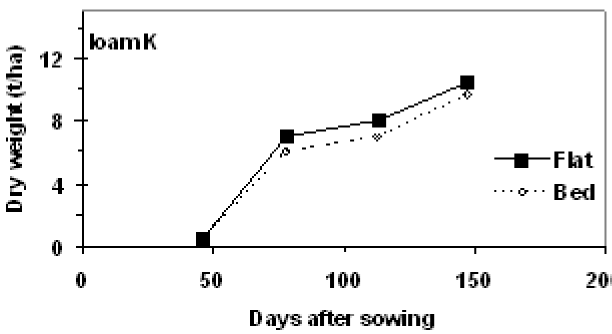


Figure 3. Tiller density on the three soils (vertical bars are lsd p=0.05)





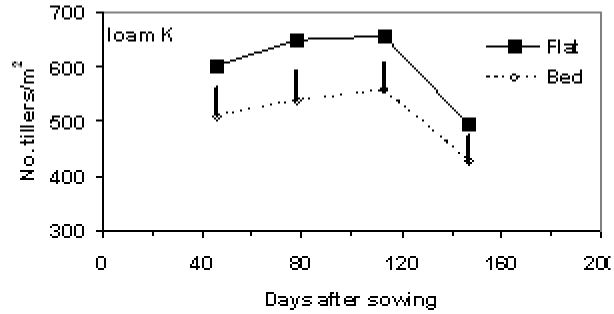
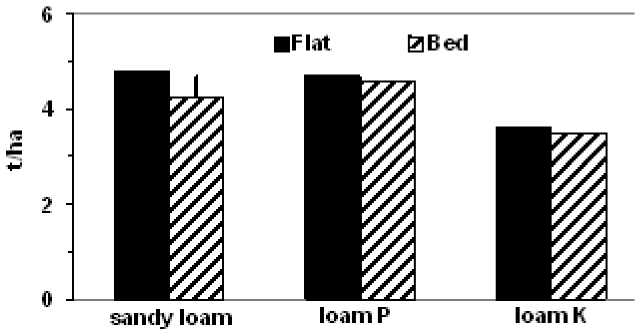


Figure 2. Grain yield (dry) (vertical bar is lsd (p=0.05) on sandy loam)

Figure 4. Number of tillers per plant at anthesis (vertical bar is lsd (p=0.05) on loam P)



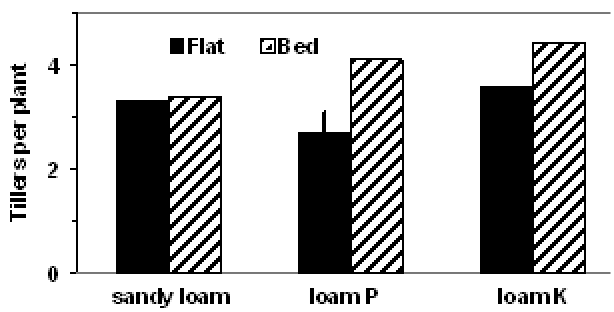
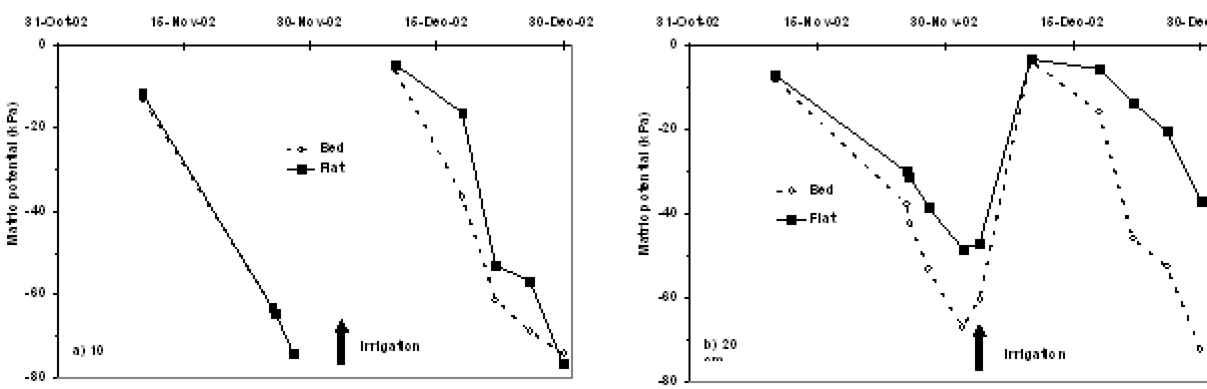


Figure 5. Soil matric potential on sandy loam at a) 10 cm and b) 20 cm depth



General discussion

Wheat yields on the beds were lower than on the flats on the sandy loam, and similar on the two loam soils. Sharma et al. (2002) also reported significantly higher grain yield and spike density for conventionally tilled wheat on the flat compared with beds on a marginally sodic loam. Most other studies and many farmer participatory trials have found similar or higher yields on beds (Dhillon et al 2000; Hobbs and Gupta 2003). Our results suggest that the surface soil dries down more rapidly on the beds than on the flats, and that the crop on the sandy loam suffered water deficit stress during early crop growth, impairing tillering and ability of the crop on beds to compensate for the wider row spacing and associated lower plant population. The recommended practice of delaying the first irrigation until 3-4 weeks after sowing may need to be revised to 2-3 weeks after sowing for wheat on beds on sandy loam soils.

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