Impact of renovating permanent raised beds on water use productivity under vertisol

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Summary

Permanent raised beds (PRBs) performance was variably affected by different renovation methods evidenced by changes of up to: 5% in bulk density, 47% in cumulative infiltration and 48% in water advance that resulted variations of up to: 31% in application efficiency, 13% in distribution uniformity, 26% in dry biomass and 27% in water use productivity. Freshly renovated PRB improved infiltration but negatively affected irrigation performance due to poor irrigation management.

Introduction

PRBs renovation methods are diverse around the globe, and depend on traditional practices, farmer preferences, crop type, and available machinery. Generally, renovation methods have drawn less attention in past. However, it has been shown to affect irrigation performance and crop yield in light clay soil (Akbar et al. 2010). Thus, this research study was aimed to improve the options and methods for PRB renovation on a heavy clays soil with the view of maximising both irrigation efficiency and production.

Methods and Materials

This study was conducted on a Vertosol in the eastern Darling Downs Queensland, Australia. Three renovation treatments were applied to PRBs; (T1): furrow cleaning and no till seeding, (T2): furrow cleaning and cultivation to 15 cm depth (with soil inversion), plus no till seeding and (T3): furrow cleaning and blade ploughing to 30 cm (with no soil inversion), plus no till seeding. Treatments were replicated three times on recently (1 year) realigned PRB for wheat (2009-10). Hemp was planted without any renovation prior to seeding except furrows of all treatments were cleaned after seeding with bed former. Eight rows of wheat and six rows of hemp crops were planted with 6 m wide no till seeder at a seed rate of 30 kg ha^{-1} for all treatments. Single irrigation to wheat crop and four irrigations to hemp crop were applied under 465 m long blocked ends furrows. Soil bulk density, soil moisture, bed furrow configuration, irrigation, and dry biomass data were collected. Irrigation performance was evaluated using IPARM (Gillies and Smith 2005) and SIRMOD (Walker 2003) models. Water use productivity (*WUP*) was calculated as a ratio of crop dry biomass at harvest to total water used.

Results & Discussion

Average bulk density of (0-30 cm) soil profile was the largest for T1 at 1.07 gm cm^{-3} during wheat season and 1.08 gm cm^{-3} during hemp crop season. Average bulk density was 3% to 4% lower in T2 and 4% to 5% lower in T3 as compared to T1 in both seasons. Cumulative infiltration varied significantly among different treatments of both crops at 5% significance level. Cumulative infiltration was 12% and 47% larger for T2 and T3 than T1 (80 mm) during wheat season and; 3% less and 4% greater for T2 and T3 than T1 (46 mm) during hemp season after 400 minutes of infiltration opportunity time. Average water advance time to furrow tail end (*Ta)* was 21%, 11% longer for treatments T2 and 48%, 34% longer for T3 than

T1 (787 min, 870 min) during wheat and hemp crop seasons respectively. The reasons for low bulk density, higher infiltration capacity and longer *Ta* for T3 were attributed to increased macro porosity and sorptivity caused by deep soil loosening without inversion.

Application efficiency (*Ea*) and distribution uniformity (*DU*) were higher for T1 followed by T2 and then T3 during wheat crop season. However, the difference declined during the hemp crop season following bed subsidence (Table 1). Requirement efficiency (*Er*) was higher under freshly renovated beds in wheat crop than the settled beds during hemp crop season. Soil moisture deficit was not fully met especially during early irrigations to hemp crop. Thus, no renovations negatively affected irrigation performance of hemp crop (Table 1) and made it difficult to achieve optimum irrigation management.

Wheat dry biomass was larger for T1 (9.24 ton ha^{-1}) followed by T2 (6% less than T1) and then T3 (26% less than T1). The dry biomass was comparable among the three treatments for hemp crop as indicated in Table 1. Water use productivity (*WUP*) of wheat crop was 11% and 27% less for T2 and T3 than T1 (27 kg ha^{-1} mm $^{-1}$) respectively. For hemp crop *WUP* was 4% less and 3% larger for T2 and T3 than T1 (29 kg ha^{-1} mm $^{-1}$) respectively. Interestingly, dry biomass of hemp was the least for T3 but its *WUP* was the highest. The reason was the less total water consumption by T3 due to larger water storage capacity.

One of the reasons for low yield on freshly renovated T2 and T3 treatments was the poor control on seeding depth and density due to frequent clogging of no till seeder with loose stubbles from previous soybean crop. The less steering control under T2 and T3 was due to loose soil in furrows that also affected the smoothness of bed surface.

It can be inferred from these results that renovations need to be carefully implemented by ensuring minimum soil disturbance which can be achieved by: better control on machinery, choosing correct soil moisture and using the right equipment. Treatment T3 has been identified with greater potential for *WUP* improvement if renovated with better equipment and operating control.

Table 1: Irrigation and crop performance of three renovation treatments of permanent raised beds during two cropping seasons under Vertosol (Standard deviations in brackets)

Treatment	**Field measured data**				**WUP (kg ha^{-1} mm^{-1})**	**SIRMOD simulated results**		
	Crop	**Q (L s^{-1})**	**Tco (min)**	**Biomass (ton ha^{-1})**		**Ea (%)**	**Er (%)**	**DU (%)**
T1	Wheat	1.89(0.10)	870(75)	9.24(0.7)	27(2)	90(02)	95(03)	86(07)
	Hemp	1.79(0.08)	409(29)	8.87(2.2)	26(6)	94(04)	65(10)	75(10)
T2	Wheat	1.90(0.02)	970(32)	8.71(1.0)	24(4)	79(01)	95(02)	77(04)
	Hemp	1.77(0.06)	438(30)	8.83(1.5)	25(5)	90(05)	66(08)	69(10)
T3	Wheat	2.18(0.02)	1175(27)	6.88(1.3)	20(7)	59(01)	98(01)	73(06)
	Hemp	1.99(0.06)	403(14)	8.48(2.2)	27(6)	90(03)	68(03)	70(08)

It can be concluded that different PRB renovation methods can largely change soil infiltration properties thus require optimised irrigation management to avoid irrigation water losses and better machinery design and operation to avoid poor crop establishment due to soil disturbance.

References

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