Investigating irrigation management in sorghum – Breeza 2015

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AGRONOMY

Introduction

The time and expense associated with irrigation can become a major financial burden for farmers. By investigating irrigation management, growers can become aware of the effects and the factors associated with developing a sustainable irrigation management strategy.

A varied rate irrigation trial was established at the Breeza Research Station to improve knowledge around the ability of sorghum to efficiently use applied irrigation water. By evaluating various irrigation treatments the aim was to improve the irrigation management of a sorghum crop, leading to better water use efficiency (WUE) and productivity (yield).

Key findings

Hybrid choice and plant population had a significant impact on the yield of sorghum with irrigation. MR Buster yielded significantly higher than the other hybrids evaluated, while the higher population rates of 100,000 and 150,000 plants/ha yielded higher compared with the lower planting rates.

The development and yield potential of the late season heads was compromised, and therefore the later developing sorghum did not take full advantage of the greater soil moisture of the intensive irrigation rate.

Site details

Location:	**Gunnedah**
Co-operator:	**NSW DPI Breeza Research Station**
Sowing Date:	**19 January 2015**
Planter set up:	**Monosem precision planter on 1 m row spacing**
Harvest date:	**9 June 2015**

Treatments

Hybrids	MR 43 85G33 MR Buster MR Scorpio
Population	50,000 plants/ha 75,000 plants/ha 100,000 plants/ha 150,000 plants/ha
Irrigation	I-2 – full irrigation strategy, refill set at a 50 mm soil water deficit I-1 – two in-crop waters: at 7-leaf stage and at head emergence I-0 – rain fed

Results

Tiller and head production

Hybrid choice had a limited effect on tiller and head production (Figure 1). MR Scorpio produced slightly more tillers and heads per plant than the other hybrids, but this can be explained by the lower plant establishment of this hybrid, as it still resulted in the lowest tillers on a per metre of row basis compared with the other three hybrids in the experiment.

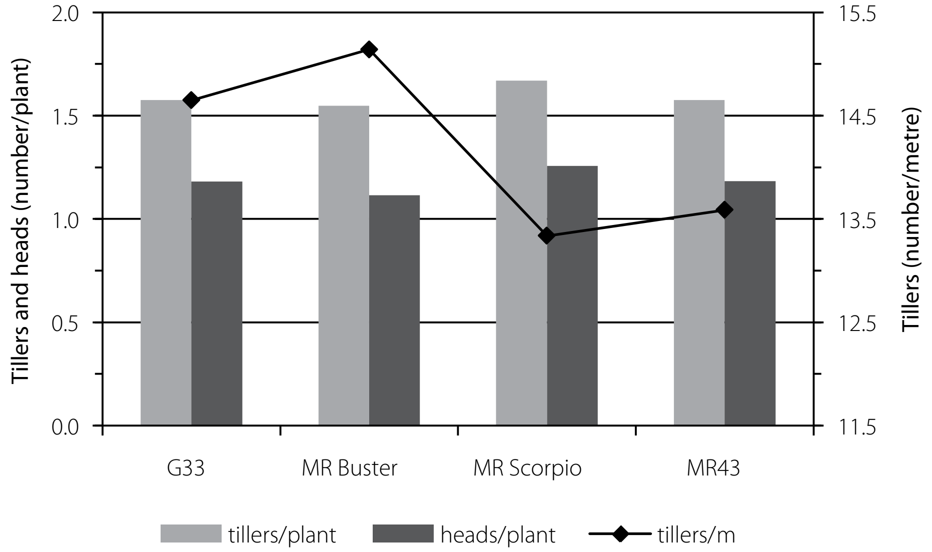

Figure 1. *Hybrid impact on tiller and head production*
Tillers/m (p<0.001), tillers/plant (p<0.01), heads/plant (p<0.05)

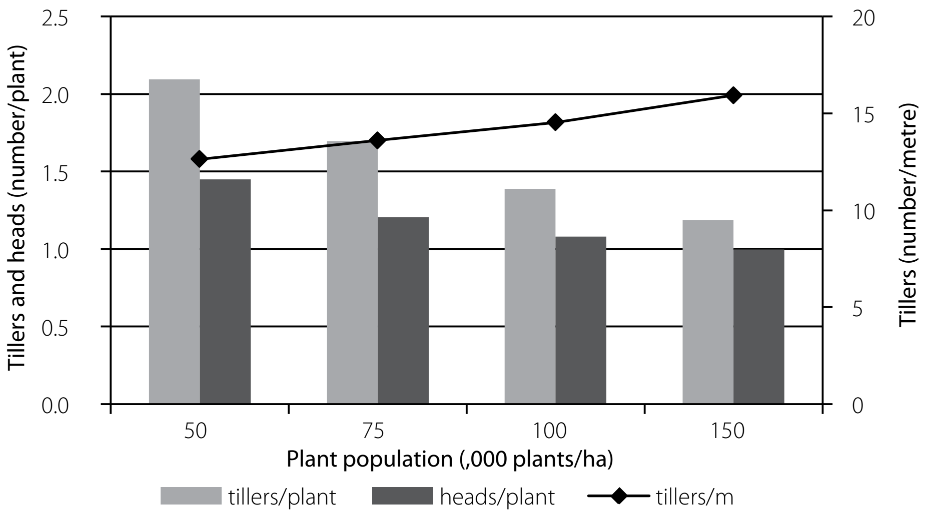

Figure 2. *Population rate (,000 plants/ha) effect on tillers and heads*
Tillers/m, tiller/plant and heads/plant (p<0.001)

The I-1 irrigation treatment had the greatest number of heads per plant (1.24) compared with I-2 (1.22) and I-0 (1.10) (Figure 3). I-2 had the greater tiller production per plant and on a per metre basis.

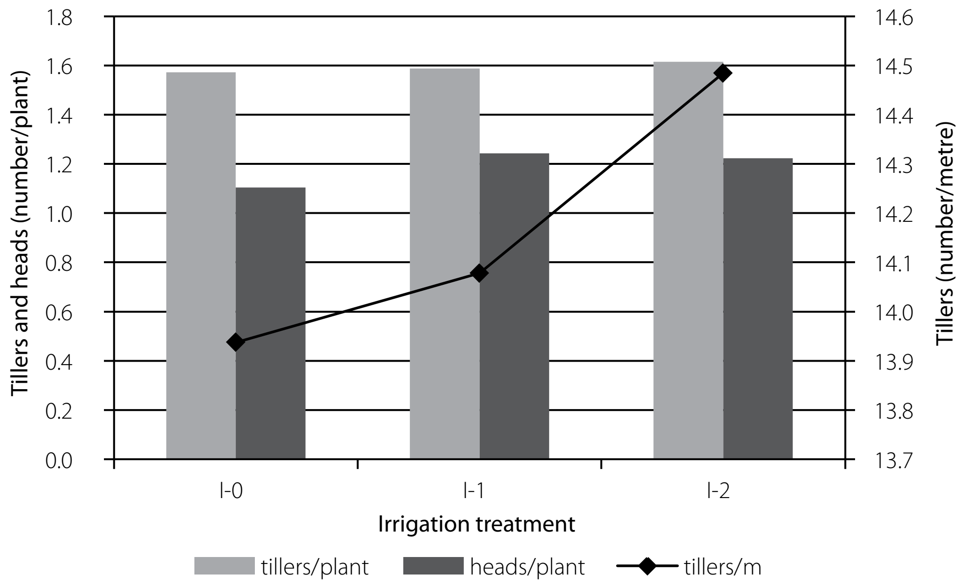

Figure 3. *Irrigation impact on tiller and head production*
Heads/plant (p<0.05), tillers/m and tiller/plant NS

Water use efficiency

A neutron moisture meter (NMM) was used to monitor the experimental crop water use. One hybrid (MR Scorpio) at two populations (100,000 and 150,000 plants/ha) across the three irrigation treatments (I-0: rain fed, I-1: two in-crop water and I-2: full irrigation – set at a refill point of 50 mm soil water deficit) were monitored for comparison.

All treatments received a pre-water to ensure a full soil moisture profile at planting. The I-1 irrigation treatment received two irrigations with the timing set at plant growth stages 7-leaf (19 Feb 2015) and head emergence (19 Mar 2015), with a total of 133 mm of water applied. The I-2 treatment had four in-crop irrigations applied at the 7-leaf stage (19 Feb 2015), booting stage (3 Mar 2015), head emergence (19 Mar 2015) and at grain fill (31 Mar 2015). The I-2 treatment had 203 mm of water applied in total with an average of 51 mm applied per irrigation. Effective in-crop rainfall during the trial was 152 mm.

The water use efficiency was evaluated by calculating the irrigation water use index (IWUI = yield/applied water) and gross production water use index (GPWUI= yield/ total available water) (Figure 4). IWUI is an important tool for evaluating the benefits of applying irrigation water to the crop. The I-1 irrigation treatment IWUI averaged over 20 kg/mm/ha greater than the I-2 treatment (55.18 kg/mm/ha and 31.72, respectively).

The GPWUI is the crop's ability to produce grain from all moisture available during the growing season (starting moisture, plus applied water, plus effective rainfall, minus ending soil moisture). The I-0 irrigation treatment averaged a GPWUI of 20.55 kg/mm/ha compared with 18.40 kg/mm/ha for the I-1 treatment and 14.09 kg/mm/ha for the I-2 treatment (Figure 4). Statistical analysis proved that the I-0 and I-1 irrigation treatments had significantly greater GPWUI than the I-2 treatment ($p \leq 0.05$). Treatments with the lower amounts of applied irrigation water had an advantage when calculating GPWUI in this trial.

The IWUI and GPWUI calculations highlighted a trend that the higher plant population improved sorghum's WUE with the target population of 150,000 plants/ha having a greater WUE than the 100,000 plants/ha population (Figure 4). The trend could be explained by the theory that the higher population rates were able to take better advantage of the high levels of plant-available water present throughout the experiment.

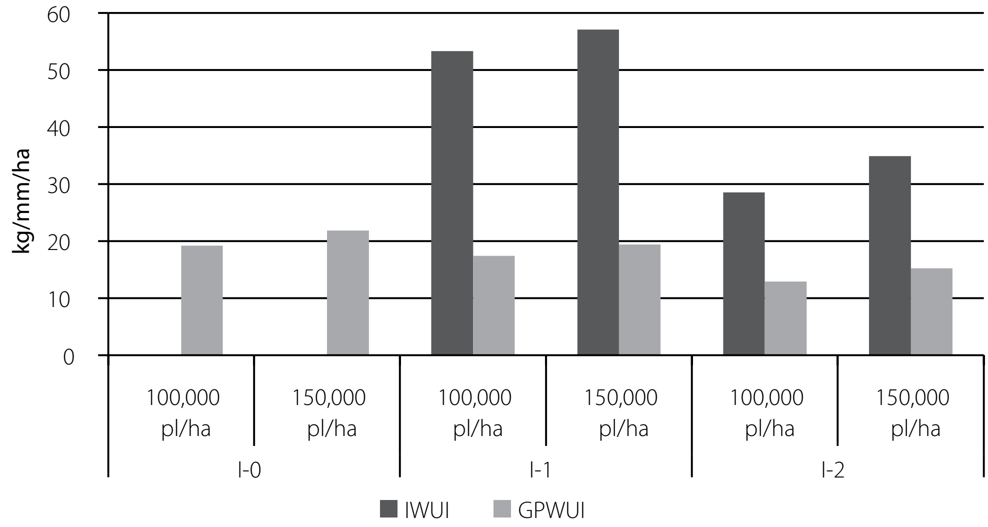

Figure 4. *Experiment IWUI (yield/applied mm) and GPWUI (yield/total in-crop mm)*

Plant growth characteristics

Plant growth measurements were taken to understand the experimental treatment effects on sorghum plant growth. Hybrid selection and irrigation treatment both had significant effects on plant height (Figure 5). MR Scorpio and MR 43 had an average plant height of over 113 cm, significantly higher than MR Buster (109 cm) and G33 (107 cm). Plant population had no significant effect on plant height.

Plant height can be an indicator of a crop's level of moisture stress with irrigation having the largest effect on plant height. The I-0 treatment resulted in a height of 103 cm, while the I-1 and I-2 treatments averaged 115 cm and 119 cm, respectively (Figure 5).

In contrast, the irrigation treatments had no effect on head length, while hybrid selection and planting rates did have significant effects (Figure 5). Interestingly, MR Buster resulted in the smallest head size but, as detailed below, it significantly out yielded the other hybrids. Unlike plant height, the planting rate did have an impact on head length with the lower population (50,000 plants/ha = 30.8 cm head length) producing longer heads than the higher planting population of 150,000 plants/ha (28.96 cm).

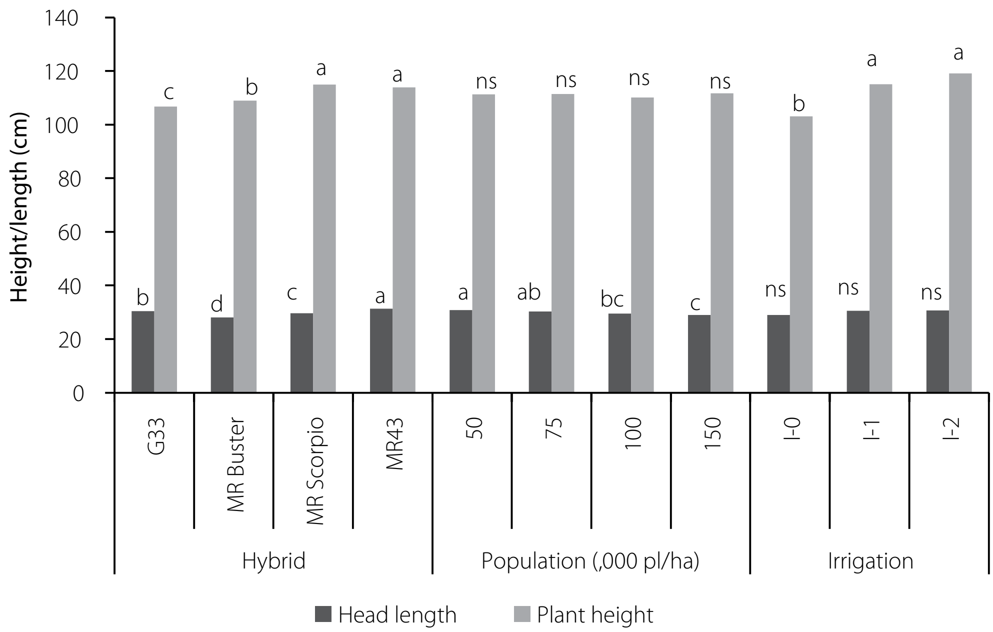

Figure 5. *Treatment effects on sorghum height and head length*
Plant height–Hybrid: LSD>1.87 (p≤0.05), Irrigation: LSD>8.7 (p≤0.05), Population NSD
Head length–Hybrid: LSD>0.79 (p≤0.05), Population: LSD>0.99 (p≤0.05), Irrigation NSD

Grain yield

The yield of the border trial plots were compromised by bird feeding and moderate levels of midge activity. The delayed planting date resulted in later than optimum timing for head development especially with the I-2 irrigation treatment, and was considered a constraint to potential yield. The low yield of I-2 treatments compared with I-1 and in some cases to I-0 highlights this constraint (Figure 6).

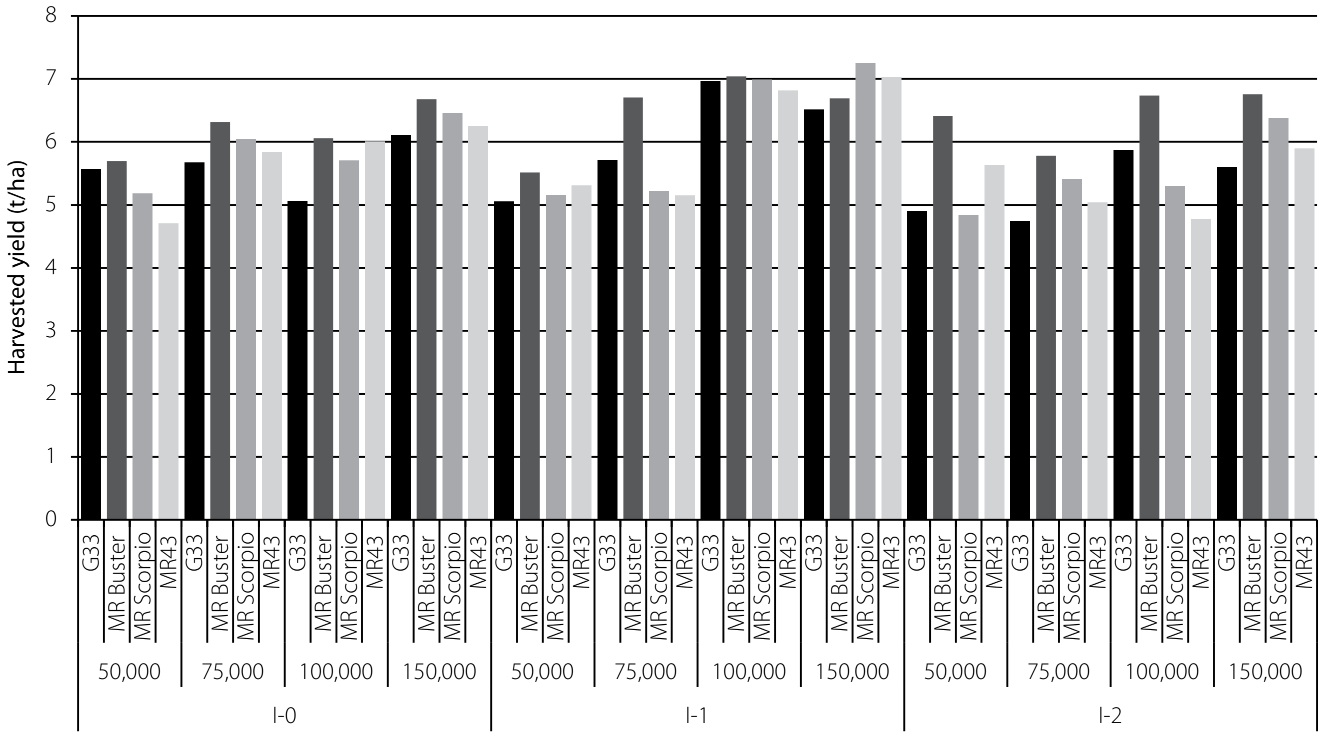

Figure 6. *Impact of treatments on grain yield*
Treatment yield = NSD

Population and hybrid impact on yield

The population treatment of 150,000 plants/ha resulted in significantly higher yield than populations of 50,000 and 75,000 plants/ha (Figure 7). This trend is a continuation from the WUE analysis which indicates that the higher plant populations in the experiment were better placed to fulfill their yield potential.

The hybrid MR Buster yielded significantly higher than the other three hybrids in the experiment (Figure 7). MR Buster trended towards higher or equivalent yield to the other three hybrids in 11 of the 12 treatment interactions across the experiment (irrigations x3 by populations x4; Figure 6).

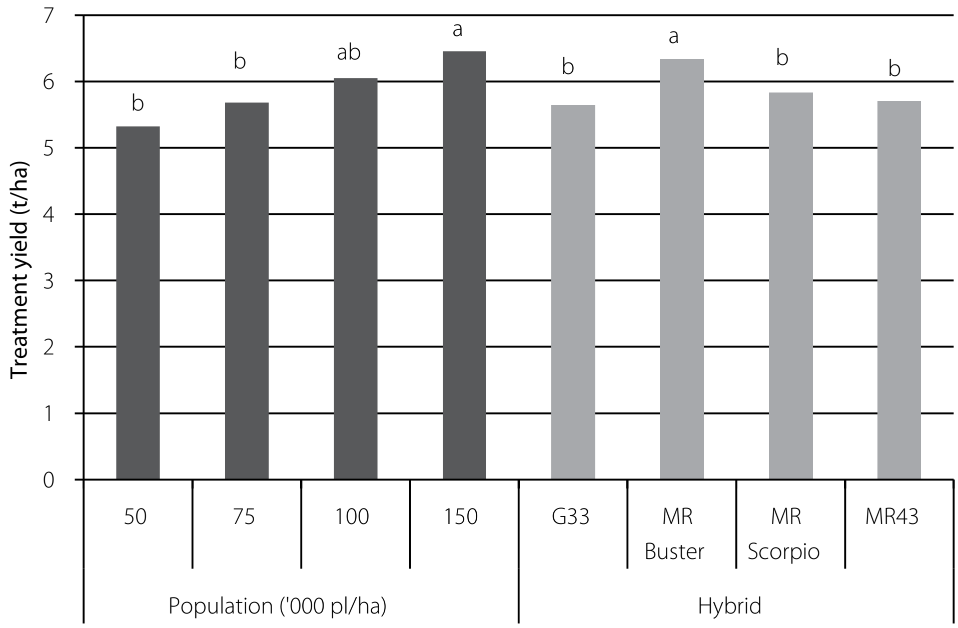

Figure 7. *Population and hybrid effects on grain yield*
LSD–POP >0.75, HYB>0.29
Bars within population or hybrid treatments with the same letter are not significantly different (p≤0.05)

Irrigation impact on yield

Sorghum yields were not statistically different across irrigation treatments. There was a trend for improved yield with the I-1 irrigation treatment (6.19 t/ha) compared to the I-0 treatment (5.83 t/ha), but the poor yields associated with delayed maturity of sorghum across the I-2 treatment resulted in the lowest yield (5.63 t/ha; Figure 8). This can be explained by the longer irrigation period, which meant the sorghum was developing grain in sub-optimum conditions and also the higher incidence of midge activity in the later maturing heads.

As stated previously, the agronomic issues that have affected the sorghum within irrigation treatment I-2 greatly impacted on the findings in regards to the effects of the various irrigation management techniques on sorghum yield.

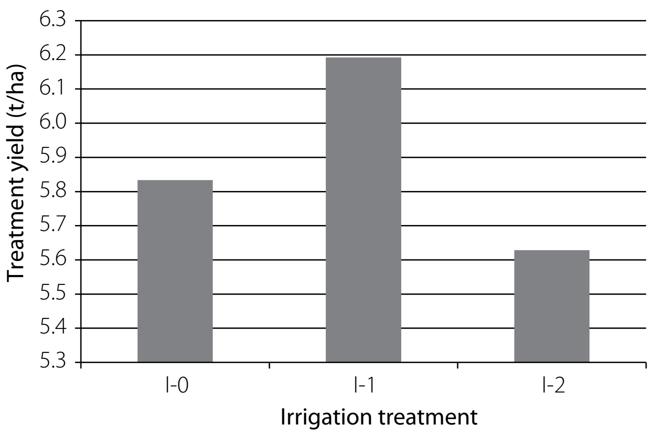

Figure 8. *Effect of irrigation treatments on grain yield*
Irrigation Effect on Yield – NSD

Finishing soil water

Soil cores were taken after harvest to examine finishing plant available water (PAW) remaining under the hybrid MR Scorpio at the populations of 100,000 and 150,000 plants/ha and the three irrigation treatments (Figure 9). Both plant populations in the I-0 treatment followed a similar trend line, where there was levels of PAW remaining above the 20 cm soil depth due to late rainfall, but soil moisture was limited (less than 5 mm PAW) from the 40 cm depth down.

The irrigated treatments of I-1 and I-2 had greater PAW remaining below the 40 cm depth than treatment I-0 with the late irrigation for I-2 leaving the most residual soil moisture. The higher PAW remaining in the I-2 treatment would potentially benefit production of the following crop, especially if managed in a double cropping rotation sequence.

Soil moisture measurements after harvest also showed that the higher plant population rates with both I-1 and I-2 irrigation treatments left lower levels of PAW in the soil profile indicating that the higher plant populations used more soil moisture during the experiment.

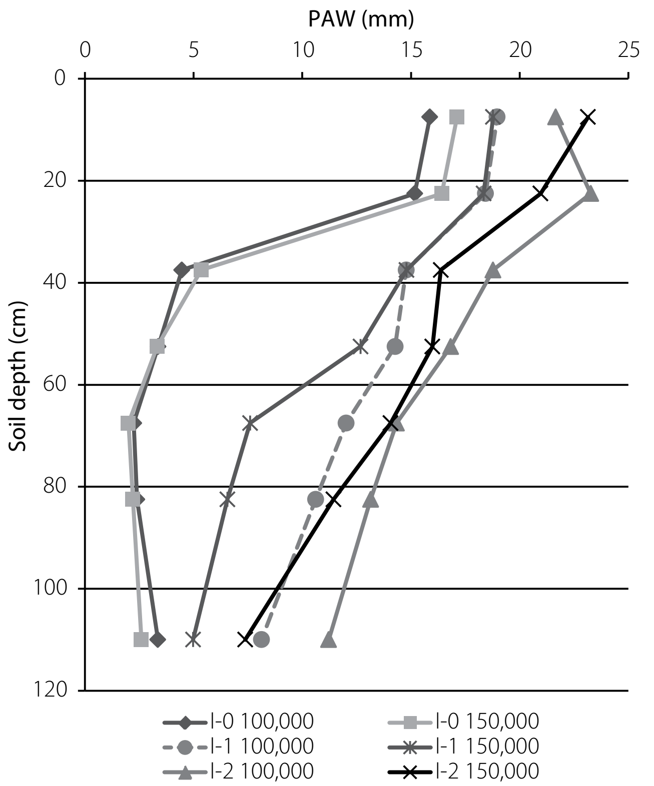

Figure 9. *Plant available water (PAW) after crop harvest*

Conclusions

This experiment demonstrates that growers could make considerable productivity gains by selecting the right hybrid and target plant population with irrigated sorghum production. Irrigation management can significantly influence the growth of sorghum hybrids, affecting plant height, and grain development. Plant population impacted on yield with the higher planting populations of 100,000 and 150,000 plant/ha resulting in significantly higher grain yield than the 50,000 or 75,000 plants/ha treatments. The higher plant populations appear to have taken better advantage of the high PAW present in the irrigation treatments.

Acknowledgements

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