Effects of irrigation regime, bed architecture and sub-soiling on potato yield and water use

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Abstract

For most potato crops management of water supply has one of the largest influences on final yield. However irrigation is a limited and expensive resource on many farms. A field experiment was set up at Lincoln (Canterbury) to assess the effect of potato bed architecture, subsoil tillage and irrigation regime on soil water content and crop water use throughout the season. The treatments consisted of two bed architectures (flatbed versus ridge/furrow), a cultivation treatment (sub-soiling versus none) and two irrigation regimes (high and regular irrigation versus low irrigation). Soil water content was recorded at five minute intervals in the top 300 mm using automated logging reflectometers, and twice weekly below 300 mm using a neutron probe. Yield increased with irrigation and there was some evidence that it was higher for plots with a flatbed architecture. Total water use (WU) was affected by sub-soiling (2-way interactions). It increased with sub-soiling under low irrigation. WU also increased with sub-soiling in beds with a flatbed architecture. There was no effect of bed architecture on water use efficiency (WUE). The WUE was affected by sub-soiling (2-way interactions), decreasing with sub-soiling under low irrigation and with sub-soiling in the plots with a flatbed architecture. As this experiment was conducted on a single site during a single season with a single cultivar ('Bondi') results will need to be confirmed by repeating the study, possibly at other sites and with other cultivars.

Additional keywords: *Solanum tuberosum*, ridge and furrow, flatbed, water use efficiency, subsoil tillage, irrigation management

Introduction

Current standard agronomic practices for potato production in New Zealand are based on a ridge/furrow bed architecture. The ridge is formed at planting, with additional moulding occurring post emergence on some farms. The original rationale behind this bed architecture is that it prevents water logging in the ridge, improving the growing environment for roots and tuber. It also protects the crop from late frosts, prevents the greening of the tubers and helps with controlling scab (Bailey, 1990). However, where there is insufficient rainfall and/or overhead sprinklers are used, this architecture can lead to a dry zone in the centre of the ridge and result in water stress for the plant (Robinson, 1999; Starr *et al.*, 2005; Cooley *et al.*, 2007). This process can be exacerbated throughout the season as the canopy grows and acts as an umbrella (Saffigna *et al.*, 1976). Rainfall or irrigation then moves into the furrow where infiltration rates are often slow.

The Canterbury plains account for a large part of New Zealand's potato production and are characterised by low summer rainfall (NIWA, 2016). Irrigation is therefore essential for intensive agricultural production in this region. However as water is a limited resource the storage of water by the soil and the efficiency with which the crop uses this water to produce biomass must be optimal in order for farming systems to be economically and environmentally viable. Therefore bed architecture should aim to maximise water infiltration and storage near the seed row rather than deflecting the water away and potentially creating a dry zone around the seed and the majority of the root system.

Previous work by Harms and Konschuh (2010) has shown that water savings can be made in dry climates by altering the shape of the ridge to either a flat-topped or wide-bed ridge. This allows the ridge to retain more irrigation or rainfall water. Other work by Mundy *et al.* (1999) has shown no yield gain from planting potatoes in wide beds although it was shown that a flatbed architecture retained more water than a ridge/furrow architecture. Another study showed a yield gain from growing potatoes in a flatbed compared with a ridge/furrow bed (Fisher *et al.*, 1995).

Soil compaction can cause yield reduction in potato crops by restricting root development (Flocker *et al.*, 1960; Stalham *et al.*, 2007). Subsoil tillage is recommended by some agronomists to reduce soil compaction and improve potato yields. However this technique has not produced consistent increases in potato yields and its effectiveness seems to be linked closely to water management (Ibrahim and Miller, 1989; Copas *et al.*, 2009).

The objective of this study was to quantify the effects of two contrasting bed architectures and sub-soiling on water use efficiency of potatoes, along with tuber yield and size distribution.

Materials and Methods

The experiment was conducted at The New Zealand Institute for Plant & Food Research Limited, Lincoln (43° 83' S, 171° 72' E), Canterbury, New Zealand. The soil at the site is a deep (>1.6 m), well-drained Templeton silt loam (Udic Ustochrept, USDA Soil Taxonomy) with an available water-holding capacity of about 190 mm/m of depth (Jamieson *et al.*, 1995). Physical characteristics of the soil were described by Martin *et al.* (1992). This site had a long cropping history, not including potatoes in the last 15 years and is characterised by a dense silt loam subsoil layer at about 250 mm depth, which extends for up to 400 mm.

The experiment was set up as a split-plot design with four replicates at the split-plot level. The main plots were two irrigation regimes. A high irrigation treatment consisted of alleviating any water limitation for the crop by irrigating close to full capacity once a week early in the season, then twice a week once the crop had reached full canopy cover. A low irrigation treatment consisted of the application of a severe water stress through occasional irrigation applied once the soil water deficit in the top 400 mm of soil was close to wilting point. Table 1 gives the details of irrigation amounts applied to both treatments alongside rainfall data (seasonal and historical). The split plots consisted of a factorial combination of two different bed architectures and two different cultivation treatments. Bed architecture consisted of a conventional ridge/furrow or a flatbed system. Cultivation treatment was either sub-soiled to 370 mm depth or not sub-soiled. Several implements were tested to break the dense subsoil down to 500 mm but none of these would go below 370 mm. Each split plot was 12 rows (0.8 m spacing) by 10 m with 1 m gap between plots. Irrigation was applied using a single span lateral irrigator. To allow for a buffer area between irrigation treatments the main plots (each containing four split plots) were separated by a 12 m buffer of fallow soil.

Table 1: Amounts (mm) of irrigation applied to both treatments alongside rainfall (historical average from 1982-2010 in brackets).

Month	High irrigation	Low irrigation	Rainfall
October 2015	0	0	9 (51)
November 2015	20	0	13 (49)
December 2015	65	30	57 (53)
January 2016	50	10	91 (42)
February 2016	95	20	24 (41)
March 2016	30	0	34 (47)
April 2016	0	0	10 (45)
Total	260	60	238 (328)

The site was out of a two year pasture and was cultivated in autumn by deep ploughing (250 mm depth), followed by one pass of a Cambridge roller, then left fallow over winter. The sub-soiling treatment was applied in late autumn to the corresponding plots using a sub-soiler which broke through some of the dense subsoil layer down to 370 mm depth on average. The whole experimental site was then maxi-tilled (100 mm depth) to level the soil surface, then maxi-tilled (100 mm depth) a second time two weeks before planting to control weeds. Base fertiliser was applied to the whole site with a boom spreader prior to planting in the form of a DAP (N=17.6%, P=20%, S=1%), Triple Super (P=20.5%, S=1%, Ca=16%), Potassium Sulphate Granular (K=42%, S=18%), Potassium Chloride (K=50%) and Kieserite (S=20 %, Mg=15%) mix. Rates were, respectively, 450, 225, 575, 150 and 250 kg/ha and were based on analysis of soil samples taken from the whole site down to 150 mm depth and standard farm practices. The site was then maxi-tilled (100 mm depth) a third time to incorporate the fertiliser.

The cultivar used for the experiment was 'Bondi'. Whole seed tubers were used and these were graded at a commercial seed store. The grading was done manually to reduce variability and all the seed tubers were between 100 and 150 g. Planting was done on the 19 and 20 October 2015. All flatbed plots were planted on the first day by using a modified spring tine implement attached to a power harrow to create furrows and then hand shovelling to maintain a 200 mm depth. Seed tubers were hand planted at that depth with a 280 mm seed spacing. All rows were sprayed with Amistar® and Actara® using a knapsack sprayer. The beds were then levelled to create a flat surface by using rakes. All conventional ridge/furrow plots were planted over the two days by forming the beds with a two row rotary-hoe bed former and planting with a two row planter at 280 mm seed spacing and with in-furrow application of Amistar® and Actara®. The rows were moulded after emergence giving a final seed tuber depth of 200 mm.

Standard grower practises were used for the fertiliser, herbicide, fungicide, and insecticide management of the crop. There was no nutrient limitation on yield, and pests and diseases control was optimal. Two side dressings of urea, both at a rate of 75 kg N/ha, were applied to all the plots on 30 December 2015 (prior to canopy closure) and 15 January 2016 (early tuber bulking).

Measurements

A neutron probe (NP) access tube was installed in each split plot after moulding of the ridge/furrow split plots had occurred. The tube was located in the ridge between two plants. Soil volumetric water content (VWC) was measured using NP (model 503DR Hydroprobe, Instro Tek Inc.) in 200 mm increments from 200 to 1000 mm depth (relative to normal ground level). These measurements were carried out weekly at first, then twice weekly (before and after irrigation) once irrigation had started. VWC at 0 to 200 mm depth (relative to normal ground level) was measured using automated reflectometers (model CS616 Water Content Reflectometers, Campbell Scientific Inc.) installed in the ridge in between two plants (0.3 m away from the NP access tube). Water use efficiency (WUE) was calculated as the relationship between the gross tuber fresh yield and total seasonal crop water use (WU). WU was calculated from the change in VWC, from 0 to 1000 mm depth, during the measurement period (ΔVWC) using the following equation: $WU = \Delta VWC + I + R$, where I and R stand for irrigation and rainfall, respectively. Drainage losses were assumed to be negligible. Total WU was determined for all treatments throughout the growing period.

Final tuber yield was assessed after canopy senescence by hand digging 8 m of four rows (25.6 m^2 area). Plants and stems number were recorded. Tubers were graded based on reject (less than 65 cm length) and marketable (65 cm or more length), as per industry standard for processed potatoes in Canterbury (McCain Foods Ltd, pers. comm.). Tuber dry matter content was measured from the final harvest tuber subsample by drying it in a fan-forced oven at 60°C for 48 hours.

Data analyses

Data was analysed accounting for the hierarchical split-plot nature of the design using analysis of variance (ANOVA) in GenStat version 17 (VSN International Ltd, UK) and is presented in tables. For WU and WUE there were 2-way interactions between some of the treatments and these are presented in graphs for ease of interpretation. Data from the treatment not involved in the interaction was pooled. An estimate of the variation associated with predicted means is provided by a 5% least significant difference (LSD) for both tables and graphs.

Results

Yield and yield components

There were no 3-way or 2-way interactions between the irrigation, bed architecture and sub-soiling treatments (Table 2). Also none of the variables displayed in Table 2 were affected by the sub-soiling treatment.

Gross fresh tuber yield was higher under the high irrigation treatment (P<0.001). Gross fresh yield was 87.0 and 65.9 t/ha in the flatbed plots, under high and low irrigation, respectively (Table 2). Gross fresh yield was 81.4 and 63.7 t/ha in the conventional ridge/furrow bed plots, under high and low irrigation, respectively. Gross fresh yield was also affected by bed architecture (P=0.004) but the differences between irrigation treatments were more prominent. Plots with a flatbed architecture yielded 5.6 and 2.2 t/ha more than plots with conventional ridge/furrow beds, under high and low irrigation, respectively (Table 2).

Marketable fresh tuber yield was affected by the irrigation (P<0.001) and bed architecture (P=0.004) treatments in the same pattern as the gross fresh yield. Marketable yield was 85.1 and 63.5 t/ha for the flatbed plots, under high and low irrigation, respectively (Table 2). Marketable yield was 79.0 and 61.2 t/ha for the conventional ridge/furrow bed plots, under high and low irrigation, respectively. Differences in marketable yield were less prominent between bed architecture treatments than between irrigation treatments. Plots with a flatbed architecture yielded, under high and low irrigation respectively, 6.1 and 2.3 t/ha more marketable tubers than plots with conventional ridge/furrow beds (Table 2).

Mean tuber fresh weight was affected by irrigation (P=0.004). Mean tuber fresh weight was 319 and 269 g for the flatbed plots, under high and low irrigation, respectively (Table 2). Mean tuber fresh weight was 303 and 243 g for the conventional ridge/furrow bed plots, under high and low irrigation, respectively. There was also evidence that mean tuber fresh weight was affected by bed architecture (P<0.001). The mean tuber fresh weight difference between plots with flatbed architecture and plots with conventional ridge/furrow architecture was 16 and 26 g, under high and low irrigation, respectively (Table 2).

Tuber dry matter content was affected solely by the irrigation treatment (P=0.041) but the differences in dry matter content between the two irrigation treatments were only 1 and 2%, for flat and conventional ridge/furrow beds, respectively (Table 2).

Gross dry tuber yield was affected by irrigation (P<0.001). Gross dry yield was, under high and low irrigation respectively, 19.6 and 16.1 t/ha in the flatbed plots and 18.8 and 15.7 t/ha in the conventional ridge/furrow bed plots (Table 2). There was a small indication that bed architecture affected gross dry tuber yield (P=0.054) but yield differences were minor between bed architecture treatments when compared with differences between irrigation treatments.

Table 2: Effect of bed architecture on potato yield and yield components under two contrasting irrigation regimes (means).

Bed architecture	Irrigation	Gross fresh yield (t/ha)	Marketable fresh yield (t/ha)	Gross dry yield (t/ha)	Tuber dry matter fraction	Mean tuber[a] fresh weight (g)
Flat	High	87.0	85.1	19.6	0.23	319
Flat	Low	65.9	63.5	16.1	0.24	269
Conventional	High	81.4	79.0	18.8	0.23	303
Conventional	Low	63.7	61.2	15.7	0.25	243
$LSD_{(0.05)}$		2.8	3.0	0.9	0.01	20
Irrigation		<0.001	<0.001	<0.001	0.041	0.004
Bed architecture		0.004	0.004	0.054	0.233	<0.001
Sub-soiling		0.442	0.542	0.725	0.725	0.732
Irrigation x bed architecture		0.161	0.144	0.474	0.573	0.289
Irrigation x sub-soiling		0.760	0.884	0.197	0.160	0.548
Bed architecture x sub-soiling		0.440	0.500	0.730	0.103	0.518
Irrigation x bed architecture x sub-soiling		0.715	0.744	0.863	0.327	0.585

[a] Mean tuber fresh weight (g) of marketable tuber

Water use

Individual VWC results are not presented in the paper; only calculated WU and WUE estimates for the season are given here. For both total WU and WUE there were no 3-way interactions between irrigation, bed architecture and sub-soiling treatments (Table 3).

For total WU there were indications that the sub-soiling treatments were interacting with the irrigation (P=0.008) and bed architecture (P=0.018) treatments separately. Those 2-way interactions are presented in Figures 1 and 2. Total WU increased significantly with sub-soiling under low irrigation (Figure 1) but the difference between sub-soiled and not sub-soiled treatments under high irrigation was negligible. Total WU was, for plots without and with sub-soiling respectively, 445 and 441 mm under high irrigation (Figure 1). Total WU was, for plots without and with sub-soiling respectively, 308.1 and 340 mm under low irrigation. In the interaction between bed architecture and sub-soiling total WU increased with sub-soiling in the flatbed plots but sub-soiling made little difference in the conventional ridge/furrow bed plots (Figure 2). Total WU was, for plots without and with sub-soiling respectively, 381 and 410 mm in the flatbed plots (Figure 2). Total WU was, for plots without and with sub-soiling respectively, 372 and 371 mm in the conventional ridge/furrow bed plots.

Total WU was affected by the irrigation (P<0.001) and bed architecture (P<0.001) treatments although there was no interaction between the two treatments (Table 3). As expected total WU increased with irrigation from 331 to 460 mm in the flatbed plots and from 317 to 426 mm in the conventional ridge/furrow bed plots (Table 3). Total WU was higher in the flatbed plots compared with the conventional ridge/furrow bed plots but the difference was less prominent than between the irrigation treatments.

Table 3: Effect of bed architecture and sub-soiling on potato water use under two contrasting irrigation regimes (means).

Bed architecture	Irrigation	Sub-soiling	Total water use (mm)[a]	Water use efficiency (kg Fwt/ha/mm)[b]
Flat	High	None	458	189.4
Flat	High	Sub-soiling	462	185.0
Flat	Low	None	303	222.9
Flat	Low	Sub-soiling	359	180.2
Conventional	High	None	432	186.0
Conventional	High	Sub-soiling	421	191.0
Conventional	Low	None	313	204.1
Conventional	Low	Sub-soiling	322	198.9
$LSD_{(0.05)}$			22	22.1
Irrigation			<0.001	0.055
Bed architecture			<0.001	0.910
Sub-soiling			0.028	0.047
Irrigation x Bed architecture			0.110	0.903
Irrigation x Sub-soiling			0.008	0.043
Bed architecture x Sub-soiling			0.018	0.048
Irrigation x Bed architecture x Sub-soiling			0.218	0.224

[a]Total water use (mm) for the whole growing season

[b]Water use efficiency (kg Fwt/ha/mm) calculated using gross fresh yield and total water use

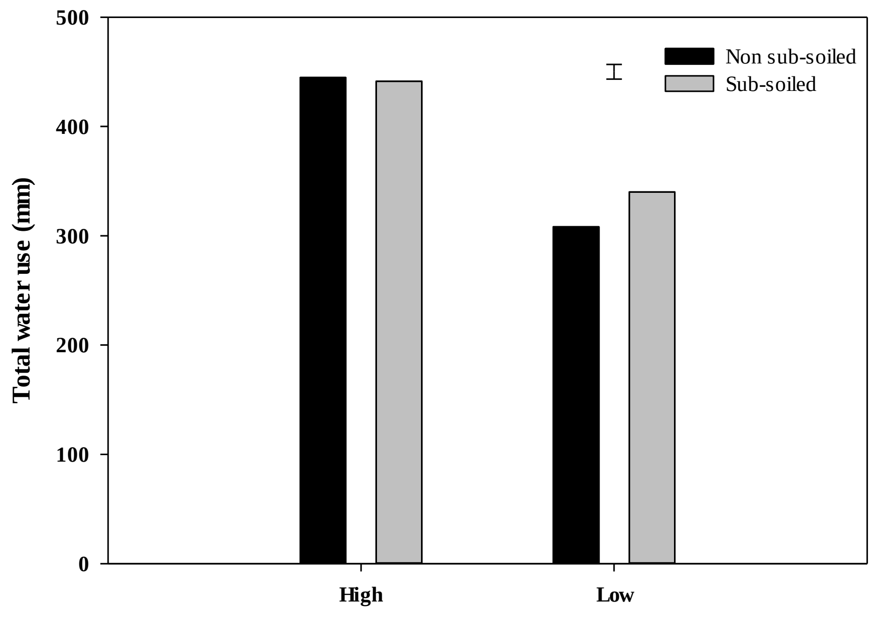

Figure 1: Total water use (WU, mm) for "Bondi" potatoes grown under different irrigation regimes (High and Low) and sub-soiling treatments (Non-sub-soiled and Sub-soiled). Data from seedbed architecture treatments was pooled to display the two-way interaction between irrigation and sub-soiling treatments. The bar represents the least significant differences ($LSD_{0.05}$).

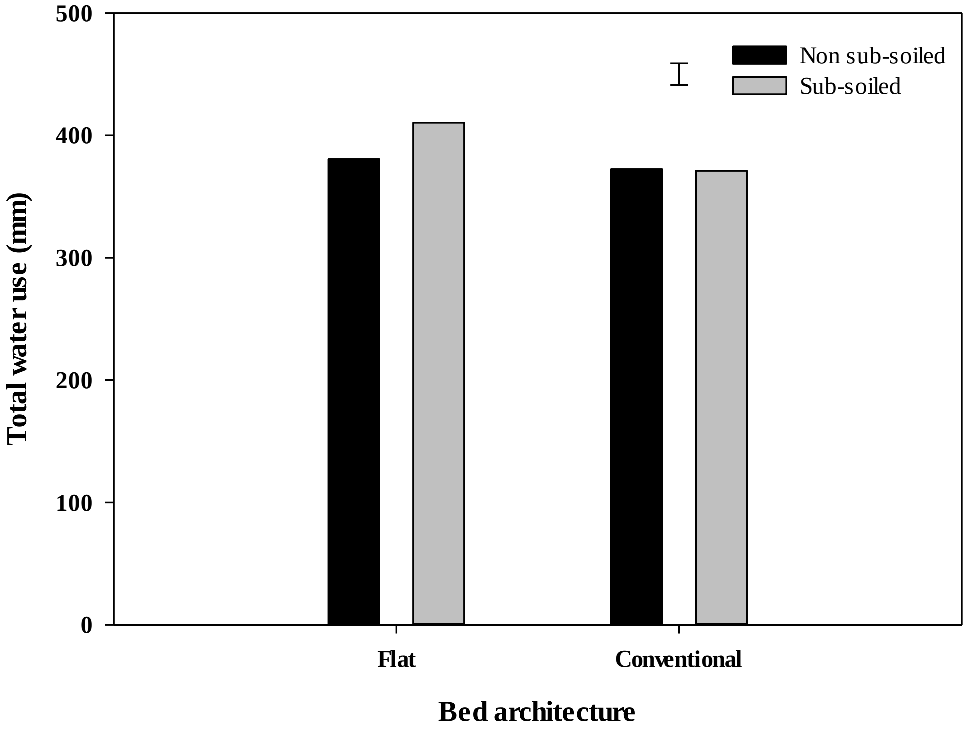

Figure 2: Total water use (WU, mm) for "Bondi" potatoes grown under different seedbed architectures (Flat and Conventional (ridge/furrow)) and sub-soiling treatments (Non-sub-soiled and Sub-soiled). Data from irrigation treatments was pooled to display the two-way interaction between seedbed architecture and sub-soiling treatments. The bar represents the least significant differences ($LSD_{0.05}$).

There was some evidence of 2-way interactions for WUE between the sub-soiling treatment and either the irrigation (P=0.043) or bed architecture (P=0.048) treatments, and these are presented in Figures 3 and 4. There was no interaction between the irrigation and bed architecture treatments. The WUE was not affected by sub-soiling under high irrigation however it was higher with sub-soiling under low irrigation (Figure 3). The WUE was, for plots without and with sub-soiling respectively, 187.7 and 188.0 kg fresh weight (Fwt)/ha/mm under high irrigation. The WUE was, for plots without and with sub-soiling respectively, 213.5 and 189.6 kg Fwt/ha/mm under low irrigation. The WUE was not affected by sub-soiling in the plots with a conventional ridge/furrow bed (Figure 4). In the plots with a flatbed WUE was highest when no sub-soiling was carried out. The WUE was, for plots without and with sub-soiling respectively, 206.2 and 182.6 kg Fwt/ha/mm for the flatbed treatment. In the conventional ridge/furrow bed plots the WUE was 195 kg Fwt/ha/mm for both sub-soiling treatments.

There were some indications of an effect of the irrigation treatment on WUE (P=0.055). The WUE was highest for the low irrigation treatment at 201.5 kg Fwt/ha/mm against 187.9 kg Fwt/ha/mm under high irrigation (Table 3). The WUE was not affected by bed architecture.

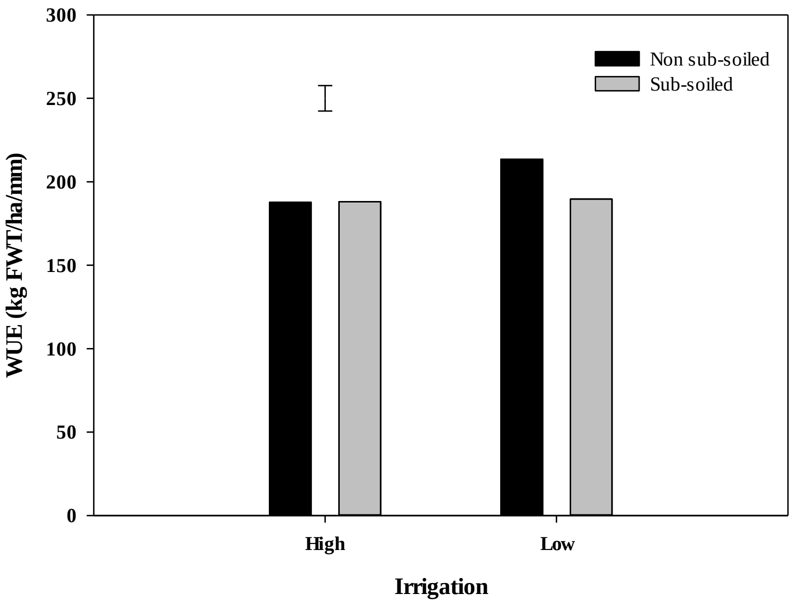

Figure 3: Water use efficiency (WUE, kg Fwt/ha/mm) for "Bondi" potatoes grown under different irrigation regimes (High and Low) and sub-soiling treatments (Non sub-soiled and Sub-soiled). Data from seedbed architecture treatments was pooled to display the two-way interaction between irrigation and sub-soiling treatments. The bar represents the least significant differences ($LSD_{0.05}$).

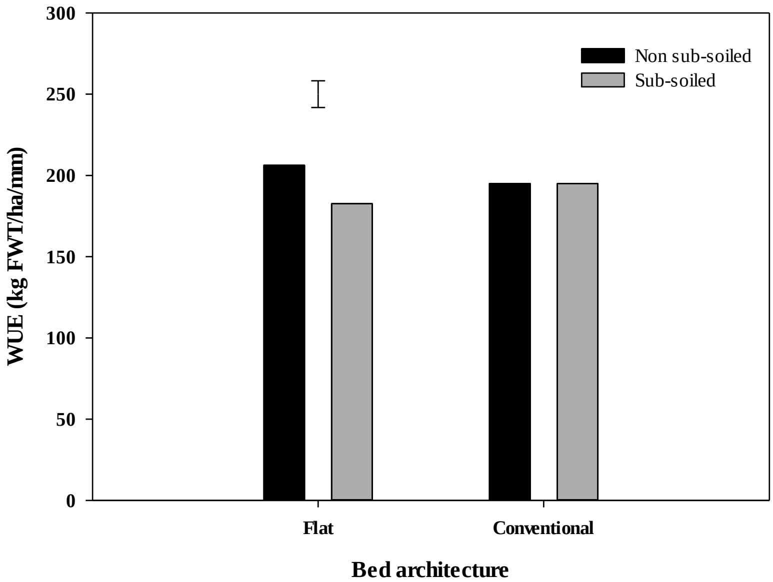

Figure 4: Water use efficiency (WUE, kg Fwt/ha/mm) for "Bondi" potatoes grown under different seedbed architectures (Flat and Conventional (ridge/furrow)) and sub-soiling treatments (Non-sub-soiled and Sub-soiled). Data from irrigation treatments was pooled to display the two-way interaction between seedbed architecture and sub-soiling treatments. The bar represents the least significant differences ($_{0.05}$).

Discussion

Both gross and marketable yields increased significantly with irrigation which was expected given the water stress imposed on the low irrigation treatment. The fact that sub-soiling did not affect the yield was consistent with previous reports which found that sub-soiling had a limited effect on yield unless the crop was grown under severe drought conditions and on strongly compacted soils (Copas *et al*., 2009; Johansen *et al*., 2015). The water stress imposed on the low irrigation treatment in this study was important but, due to seasonal rainfall distribution, it was not as severe as in these previous studies, in which the water stress for the crop was severe and continuous. The ineffectiveness of sub-soiling in the current study could also be attributed, in part, to the fact that the subsoil tillage did not break through the dense subsoil layer completely, only part of it (120 mm out of 400 mm). Both yields were also higher in the flatbed plots compared to the plots with a conventional ridge/furrow bed architecture. This was consistent with the work by Fisher *et al.* (1995) which reported higher yields for potatoes grown in beds than in ridge/furrow architecture. Work by Mundy *et al.* (1999) showed no yield gain from planting potatoes in flatbeds compared with conventional ridge/furrow planting. However this was attributed to compaction due to excessive traffic in the flatbed. In the current study traffic was actually less in the flatbed than in the conventional ridge/furrow bed. The higher yields observed in the flatbeds could be explained by the fact that the potatoes had more space to develop horizontally in flatbeds than in the conventional ridge/furrow beds. Pits were dug in late February (start of canopy senescence) down to one metre depth in one of the replicates (data not shown) to assess root development. Visual observation from those pits showed that in the flatbed plots the root system of the potato plants was well developed across the bed, with plenty of healthy roots distributed quite evenly in the topsoil (horizontally). However roots did not seem to penetrate the dense subsoil layer, even in the plots that had been sub-soiled. In the conventional ridge/furrow plots the ridge had almost no compaction in the top soil but the wheel track, and the furrow to a lesser extent, appeared to have considerable compaction in the top soil that significantly slowed or even stopped root development when it reached these areas. Roots did not appear to have penetrated the dense subsoil layer in those plots, even where sub-soiling had occurred. Soil compaction has been shown to reduce potato yield by slowing root development (Stalham *et al.*, 2007). In comparison, as compaction is distributed evenly across a bed under a flatbed architecture, roots are able to develop horizontally and explore a greater soil volume. This could also explain the small difference in mean tuber fresh weight. However irrigation had the biggest effect on this yield component and this is consistent with reports that irrigation tends to increase the average tuber fresh weight (Belanger *et al.*, 2002; Walworth and Carling, 2002). Finally, the difference in yield between the bed architecture treatments could be linked to the creation of a dry zone in the centre of the ridge as previous work by Robinson (1999) has shown. This could have caused water stress for the crop. VWC data measured through the season showed that under low irrigation the amount of water in the top 200 mm of soil was lower in the ridge/furrow plots than in the flatbed plots. This trend was not obvious under high irrigation.

All these trends were also observed with dry yield but to a lesser extent for the effect of bed architecture. This was probably due to the fact that irrigation was the main factor affecting tuber dry matter content, which was expected.

Although sub-soiling did not translate into yield differences, total WU was affected by sub-soiling which was interacting separately with either the irrigation or bed architecture treatments (2-way interactions). However there were no interactions between all three treatments at once or between irrigation and bed architecture treatments. Total WU was higher in the flatbed plots than in the plots with a conventional ridge/furrow bed architecture and this is consistent with previous reports which showed that a flatbed is capable of retaining more water than a ridge/furrow bed (Mundy *et al.*, 1999; Harms and Konschuh, 2010). However the differences in WU in this study are small and so these results need to be interpreted with caution since the differences could have been due to drainage. Overall, seasonal rainfall was lower than the historical average (Table 1); however there was a high rainfall event in January that could have caused some drainage. There was an important difference in total WU between high and low irrigation but this was expected given that plots under high irrigation had received 200 mm more of water than those under low irrigation. Interestingly sub-soiling did increase total WU in flatbed plots but not in the conventional ridge/furrow bed plots. The dense subsoil layer was not shattered by the subsoil tillage which only broke through part of it. However the subsoil tillage was done before the beds were formed and so could have affected WU differently depending on the bed architecture. Total WU was also increased with sub-soiling under low irrigation but not under high irrigation. Under high irrigation the soil water content was replenished often and close to field capacity so that the crop would not suffer any water stress. In contrast under low irrigation an important water stress was imposed on the potato crop and so sub-soiling could have allowed the roots to explore deeper and extract more water.

The WUE was not affected by bed architecture but there was some evidence that it was affected by the irrigation treatment. It was higher under low irrigation and this is likely because some of the extra 200 mm received by plots under high irrigation was lost to evaporation from the soil and possibly drainage rather than used by the crop to produce more biomass.

Interestingly under low irrigation WUE was higher in the plots without sub-soiling. This means that the higher WU observed in the plots with sub-soiling did not translate into a subsequent yield increase or that drainage occurred on those plots. Under high irrigation sub-soiling did not make any difference in WUE. Finally, in plots with a flatbed architecture WUE was higher without sub-soiling. Again, the higher WU observed in those plots was not linked to an increase in yield. In the plots with a conventional ridge/furrow bed sub-soiling did not affect WUE.

Summary

This study was conducted using a single cultivar at a single site (single soil type) and during a single season. Results need to be confirmed by repeating the experiment, possibly at different sites (and on different soil types) using different cultivars. Nonetheless there was some evidence that a flatbed architecture could potentially help to increase potato yield and WU compared with a conventional ridge/furrow architecture. Subsoil tillage could increase WU but it does not necessarily translate into higher yields. The advantages of using a flatbed architecture in potato crops in Canterbury, and possibly the rest of New Zealand, should be further explored to assess if it could improve productivity and sustainability.

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