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Deep banded phosphorus effect on chickpea root growth

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Key findings

- Deep phosphorus (P) placement at a depth of 20 cm resulted in root proliferation in desi chickpeas at Terry Hie Hie.
- Deep P applied in the plant line produced more vegetative biomass compared with deep P placed between alternate plant lines (66 cm spacing) four weeks after sowing.

Introduction

In northern New South Wales (NSW) and southern Queeland (Qld), long-term cropping on dryland farming systems has depleted P from the soil (Bell & Lester 2012). This has created a need to research nutrient replacement methodologies to improve fertility in the sub soil with the intention to increase yield (Dalal & Probert 1997; Bell et al. 2010; Bell & Lester 2012). Starter fertilisers are applied at sowing in most farming systems; however, secondary roots do not access the surface-applied P and thus may become nutrient limited. The role of P and its effect on roots at depth in cereal crops has been reported previously (Li etal. 2014), but not with respect to chickpeas. The aim of this research was to study root development under a chickpea crop and quantify root growth due to the addition of P at a depth of 20 cm.

Site details

Location	'Maneroo', Terry Hie Hie (150°05'37'E, 29°39'35"S)
Co-operator	David Anderson
Sowing date	4 July 2016
Variety	PBA HatTrick⁽ᵈ⁾
Plant population	Target 30 plants/m^2 with 33 cm row spacing.
Fertiliser treatments	0, 10, 20, 40, 80 kg/ha MAP (nitrogen (N) 10; P 21.9; potassium (K) 0; sulfur (S) 1.5) treatments placed 20 cm under the plant line, mid row (33 cm), and alternate row (66 cm).
Weed management	Post-sowing pre-emergent: Balance® 750 WG @ 100 g/ha and Simazine 1 L/ha on 4 July. In crop: two applications of Verdict™ at 100 ml/ha before flowering to control grass weeds.
Disease management	Targeting ascochyta blight: three applications of fungicides (Mancozeb) at1 kg/ha before rainfall events (July, August, September).
Harvest date	Due to waterlogging, the trial was not harvested.

Soil type and nutrition

Grey vertosol, pH_{Ca} = 7.3 (0–150 cm)
Soil at this site is a self-mulching, grey vertosol (Figure 1a.) with an average cation exchange capacity (CEC) of 33.2 meq/100g. Soil is sodic below 0.9 m with an exchangeable sodium percentage (ESP) of 7.8%. P status down the soil profile before starting the experiment is displayed in Figure 1b and soil chemistry characteristics for the site are listed in Table 1. The plant available water content (PAWC) at sowing was 166 mm to 1.5 m. The Crop Lower Limit (CLL) and Drained upper limit (DUL) are shown in Figure 2.

Nutrition and soils

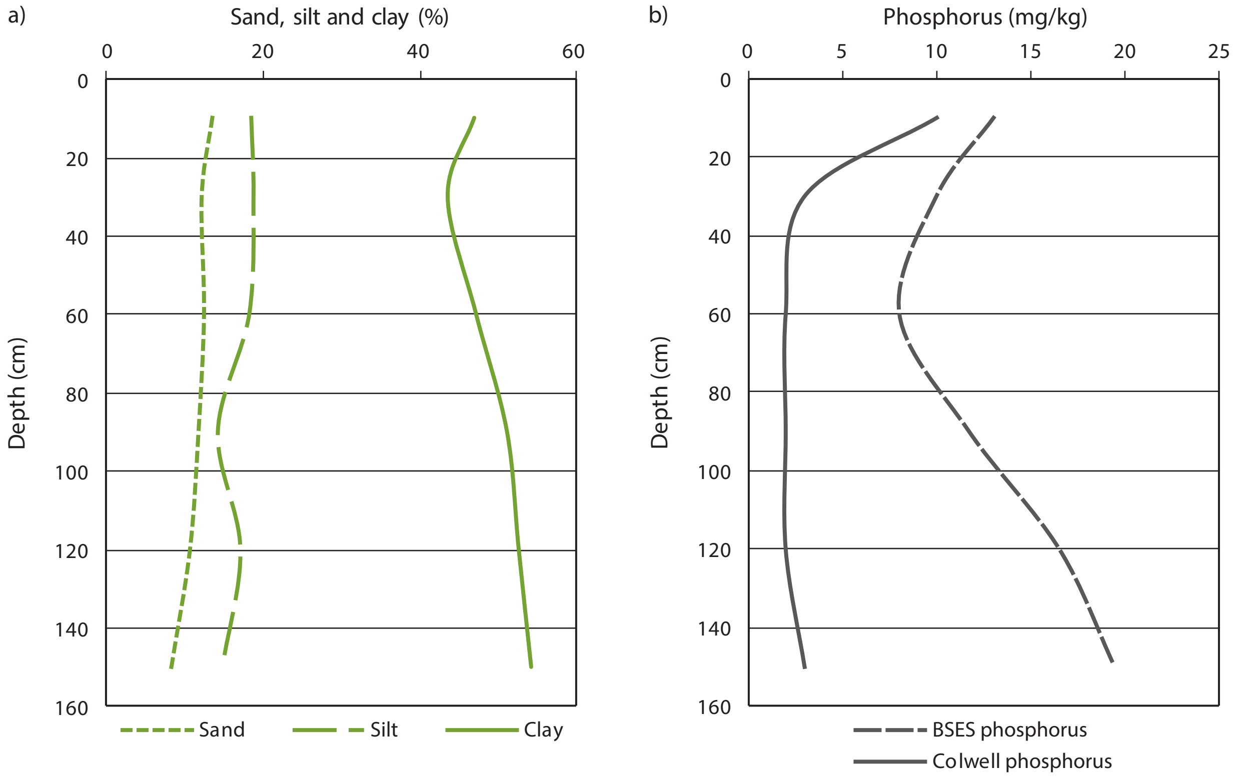

Figure 1. a) Soil particle size analysis (%); b) P content down the soil profile (mg/kg, Colwell and BSES) – Terry Hie Hie 2016.

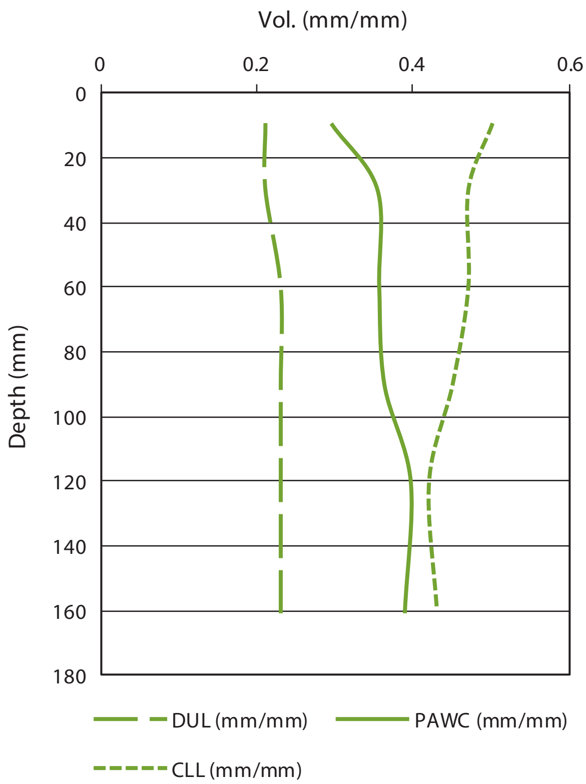

Figure 2. The plant available water content (PAWC) at sowing in July 2016 at Terry Hie Hie.

Table 1. Site soil chemical characteristics for 0–150 cm depth at Terry Hie Hie in 2016.

Characteristic	Soil depth (cm)					
	0–10	10–30	30–60	60–90	90–120	120–150
pH (1:5 $CaCl_2$)	6.2	7.2	7.4	7.7	7.7	7.5
Aluminium Exc. (meq/100 g)	0.10	0.09	0.10	0.09	0.10	0.06
Nitrate N (mg/kg)	14	9	8	6	6	6
Sulfur (mg/kg)	3.5	3.3	3.7	7.6	24.8	203.8
P (Colwell) (mg/kg)	10	3	<2	<2	<2	3
Organic Carbon (%)	0.78	0.50	0.48	0.33	0.22	0.25
CEC (meq)	29.34	33.23	32.85	34.00	34.84	34.91

Rainfall and temperature

There was a total of 384 mm of rainfall (Figure 3a) during the growing season and by November, the crop had succumbed to a combination of waterlogging and disease and was not harvested. The maximum and minimum temperatures during the growing season are shown in Figure 3b. Flower abortion was suspected due to the majority of the season experiencing night time temperatures below 15 °C up to November 2016. The maximum temperatures did not exceed 35 °C during the growing season (the maximum temperature when chickpea flowers are aborted).

Trial design

The experiment was a randomised complete block design.

Treatments

Product placement (3): Plant line, 33 cm (mid-row) and 66 cm (alternate)

Phosphorus rate (5): 0, 10, 20, 40 and 80 kg P/ha to a depth of 20 cm.

Reference treatment (4): farmer reference (no ripping tyne), control (ripping tyne no P) and 10 kg deep P/ha and 80 kg deep P/ha

Methods

The treatments were applied in January 2016.

Only the deep P bands at 33 cm spacing (mid row) to a depth of 20 cm were studied with the treatments applied on the 22 January at rates of 0, 10, 20, 40, 80 kg/ha. The crop was sown between the deep P bands at 33 cm spacing using Trimble® EZ-Pilot® with TMX-2050™ display for accurate placement and sowing.

A normalised difference in vegetation index (NDVI) reading (Trimble® Greenseeker®) was taken on the 16 August with the sensor height at 75 cm and crop height at approximately 10–15 cm. A BTC-2 minirhizotron video camera and an I-CAP image capture system (Bartz Technology Corp., Carpentaria, CA, USA) were used to capture root growth in August and November. Root tracing software, RootFly®, was used to quantify root growth in these images. Clear polycarbonate tubes were installed to a depth of one metre at 45° in the first three replicates under the three reference treatments.

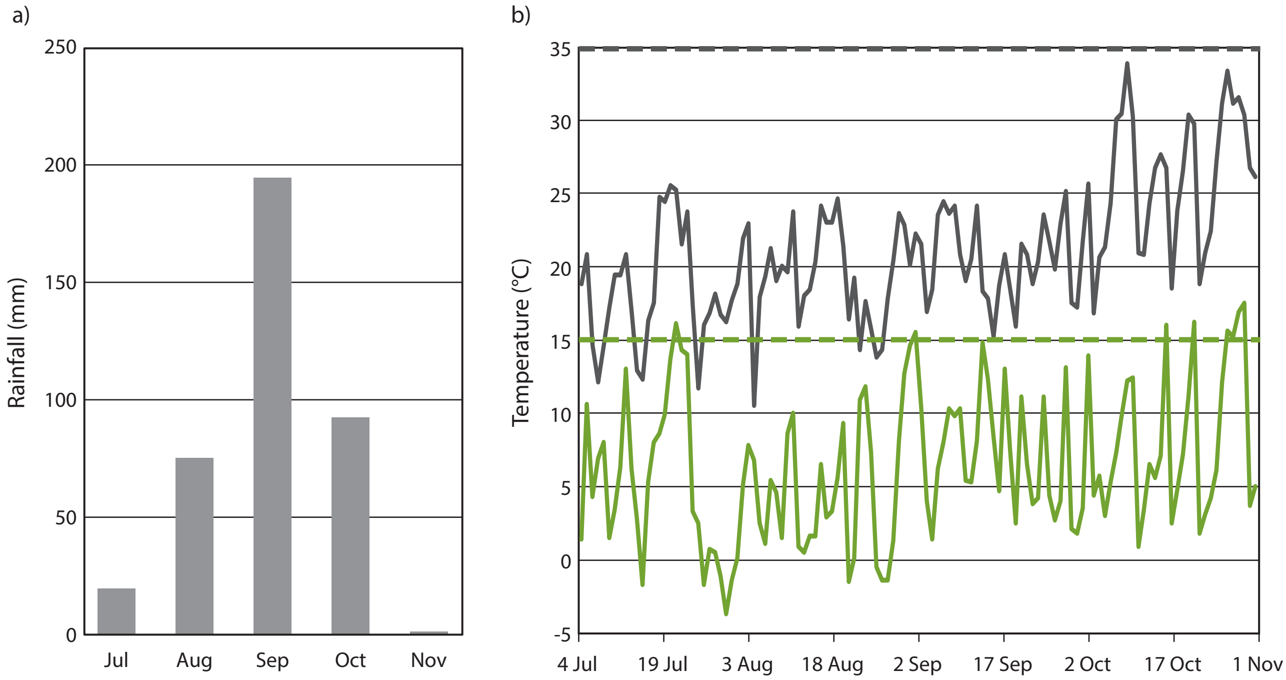

Figure 3. a) Growing season rainfall for 'Maneroo' in 2016; b) Maximum (—) and minimum (—) temperatures at Terry Hie Hie during the chickpea growing season. Note: Flower abortion occurs below 15 °C and above 35 °C.

Results

Root counts

Root counts were measured to a depth of 80 cm below the chickpea crop in the mid row banded treatment (Figure 4). The treatments used for these measurements were the reference treatments of; farmer reference, 0 kg P/ha, 10 kg P/ha and 80 kg P/ha. The root counts from the August (Figure 4a and 4b) and November (Figure 4c and 4d) measurements showed contrasting results. In August, the 80 kg/ha deep-banded P treatment revealed high root counts both in the surface and at depth under the plant line (Figure 4a). However, the root intensity changed from the plant line in August to the deep P band in November (Figure 4d); there were fewer root counts in the surface and more at depth (Figure 4d). Minirhizotron tubes were not installed in the plant line and alternate row treatments.

Crop biomass

An NDVI image was captured in August, approximately six weeks after sowing and shortly after the first minirhizotron measurements, to confirm if more roots translated to an increase in biomass. The NDVI data supported this relationship as shown in Figure 5. The NDVI index at V8 (eight nodes; four branches) indicated that the 80 kg/ha of deep P in the mid row was being accessed (Figure 5, $P<0.1$ *). Under the mid row, the chickpea roots were exploring 15 cm either side of the plant line and accessing the deep P band at 20 cm. The minirhizotron tubes were not installed in the plots where deep P was applied under the plant line or alternate rows.

Root length, diameter and volume

The root length, diameter and volume were higher under the 10 kg/ha and 80 kg/ha of deep P in the 33 cm mid row treatment compared with the farmer reference and control treatments (Figure 6 a–d).

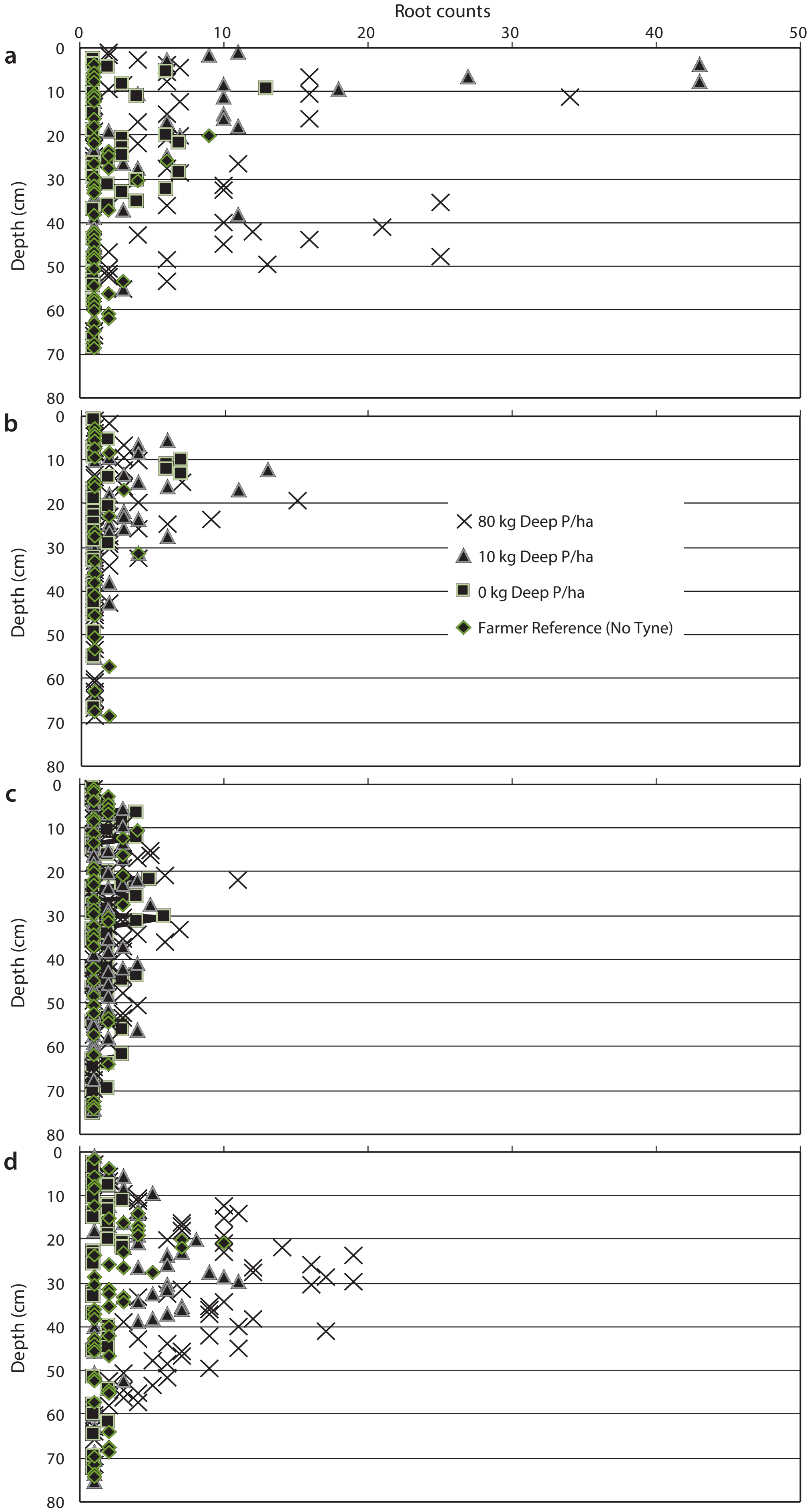

Figure 4. Root counts taken in August and November: a. Plant line (August); b. Mid row (August); c. Plant line (November); and d. Mid row (November).

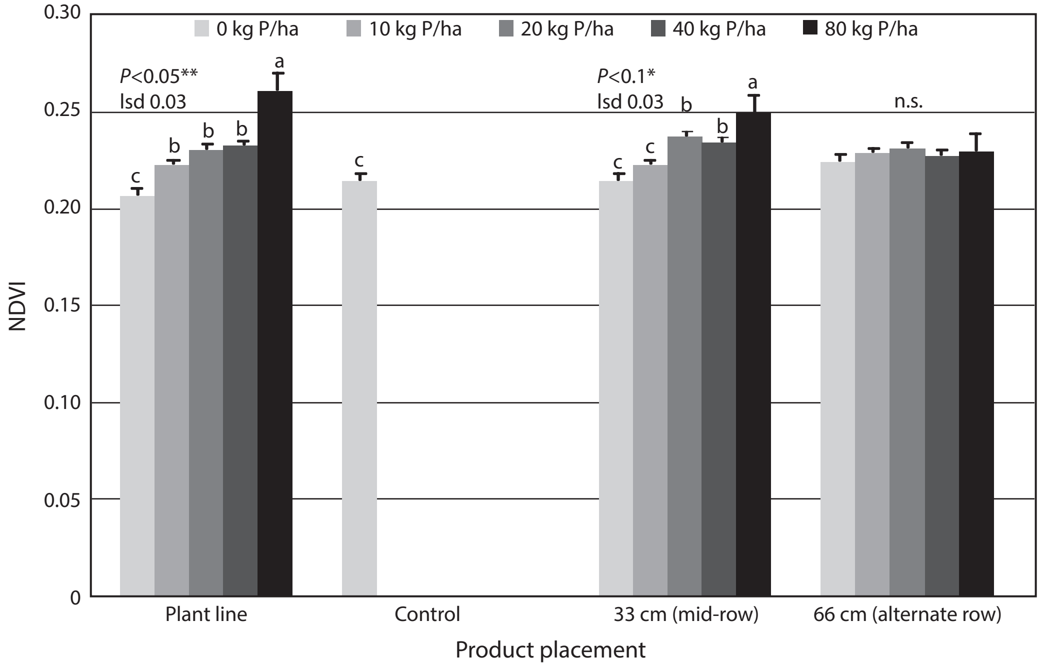

Figure 5. Normalised difference vegetative index (NDVI) of chickpea across the deep P site at Terry Hie Hie August 2016.

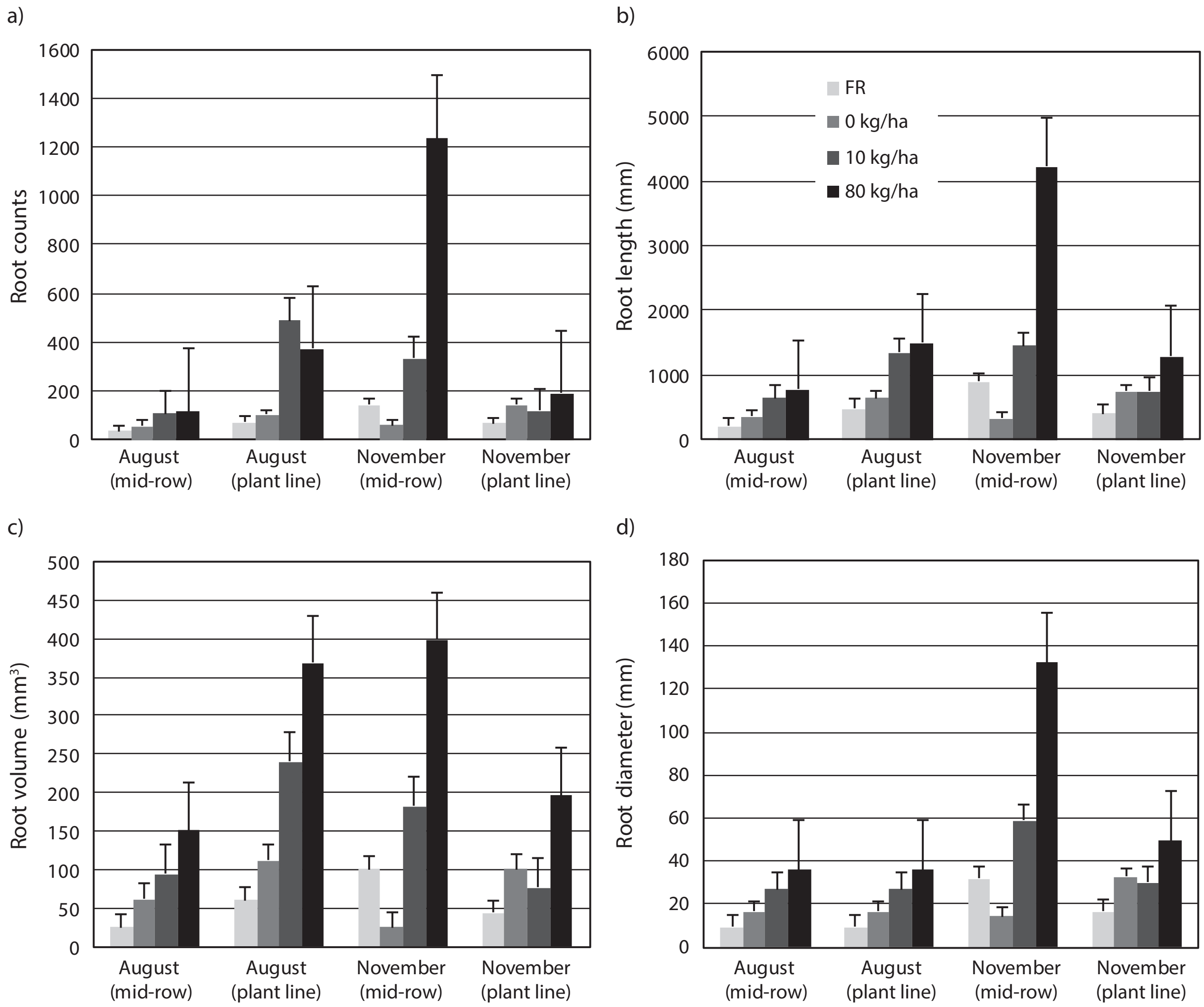

Figure 6. a) Number of roots to a depth of 80 cm; b) Root length; c) Volume; and d) Root diameter measured in August and November 2016 during the chickpea crop.
*Treatments were farmer reference (FR), 0 kg deep P/ha, 10 kg deep P/ha and 80 kg deep P/ha.

Conclusions

Placing P 20 cm into the soil was shown to stimulate root growth. Placing the deep P band between the plant line showed that initially root growth occurs at the surface, however, after the crop was waterlogged due to high rainfall in September and October, the root count reduced under the plant line and increased in and around the deep P band and below 20 cm. The root length and root volume also increased in the presence of deep P bands.

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Acknowledgements

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