The Influence of planting date, sowing depth and soil type on chickpea production with no-tillage in northern New South Wales

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Abstract
Planting date and sowing depth effects on chickpea cultivars production in two contrasting soil types at Tamworth, New South Wales were examined in 2003 and 2004. Planting dates had significant effects on crop biomass and grain yield in both soil types for all cultivars in both years. Maximum biomass and yield occurred for all cultivars planted in May. The difference in biomass between the first and last plantings was up to 4 t/ha while the difference in grain yield was up to 2 t/ha. Grain yields for the May and June plantings in 2003 were not significantly different for all cultivars, except Yorker, grown on the grey clay soil. In 2004, the yield of all cultivars was lower for the June planting compared to May, irrespective of soil type. Lodging varied among cultivars, with Howzat having the highest incidence. Increased lodging with early planting in 2003 was associated with higher crop biomass and grain yield. Lodging also increased with shallower (5 cm vs. 10 cm) sowing depth but only on the grey clay soil. There were significant effects of planting dates, cultivars, and sowing depths on the height of the lowest pod (LPH). The cultivars Flipper and Jimbour were easier to harvest because of their greater LPH. Water use efficiency for grain decreased with later planting date and was lower on the red-brown earth compared to the grey clay soil.

Key Words
chickpea, time of sowing, sowing depth, grain yield, water use efficiency

Introduction
Chickpeas are generally sown between early May and late June in northern NSW (NSW DPI, 2012). The wide adoption of no-tillage practices for chickpeas has enabled it to be sown directly into cereal stubble from previous crops. The optimum sowing depth is 5-8cm (Siddique and Loss 1999). Deeper sowing depths are used when the top soil layer is dry or where greater "depth" protection is needed from residual herbicides used on the soil surface (Lucy et al. 2005). However, deeper sowing can result in greater soil disturbance and delayed crop emergence although it helps to reduce lodging of the crop.
Earlier sowing times usually result in greater crop biomass, higher risk of lodging at the end of the season and increased risk of frost damage during flowering and pod setting. However, these risks can be outweighed by a longer growing season and subsequently higher yield potential. The optimum sowing time for maximizing yield varies with location. In south-western Australia, early May is recommended (Regan and Siddique 2006) while in southern Queensland the optimum time is 10 May to 20 July (Brinsmead, 1992). This experiment investigated whether earlier sowing times can improve crop yields in northern NSW.

Methods
Site description: The trials were conducted in 2003 and 2004 at the Tamworth Agricultural Institute (31° 09'S., 150°59'E.; altitude 430 m) in northern New South Wales. Two contrasting soil types less than 1 km apart were chosen in each year, a hard setting red-brown earth (Chromosol) and a grey clay (Brown Vertosol).
Experimental design and treatments: The experiment design was a split-plot, with 3 replicates as main blocks and sowing dates in the sub-blocks. Individual plots were cultivar by sowing depth treatments which were randomised within the sub-blocks.
Agronomic practices: Planting date treatments were early-May (D1), late-May (D2), June (D3), July (D4) and August (D5) with four sowing times in 2003 and five in 2004 (Table 1). The plots were 10m long, 2m wide and had four crop rows at a spacing of 50cm between rows. The sowing rates were adjusted for each cultivar to give an established population of 35 plants/m^2.

Measurement and Analysis
Rainfall and air temperature were recorded daily by automatic weather stations supplemented by manual observations. Soil moisture was determined immediately prior to each planting time and at maturity (1–3 weeks before harvest) by soil sampling at 30 cm intervals to a depth of 120 cm. Plant establishment (density) was determined by counting the number of plants in two 1 m sections of the central two rows in each plot approximately four weeks after planting. Time to flowering was measured, only in 2004 and was the time (in

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days) for 50% of the plants in a plot to reach anthesis. Plots were mechanically harvested to determine grain yield. The dry matter was assessed by cutting a 2 m^2 quadrant at about 3 to 4 weeks before harvest. Plant height and lowest pod height were measured by sampling two plants from each plot at crop maturity. Lodging was assessed by a visual score from 1 to 9 where 1=no lodging; 9=all plants lodged. The crop water use, for only one cultivar (Howzat), was calculated by the difference in soil water content at the time of sowing and crop maturity, plus the in-crop rainfall.

Statistical analysis

All crop data were analysed by analysis of variance (ANOVA) to determine the significance of the planting date, cultivar and sowing depth and their interactions using the GENSTAT statistical package version 10 (Lawes Agricultural Trust 2005).

Results and discussion

Climate

In-crop rainfalls for sowing dates in 2003 were lower than their equivalents in 2004 (Table 1). Despite this, 2003 was a more favourable growing season with higher rainfall during pod setting in the period from October to December. The plant available water (PAW) of the soil at sowing also was higher in 2003. The number of frosts received in the growing season decreased with late sowing date and 2003 had more frost events than 2004.

Grain yield

The average grain yield, across all cultivars, sowing times, soil types and sowing depths, was higher in 2003 (3.2 t/ha) than in 2004 (2.2 t/ha). Yields were higher on the grey clay soil than on the red-brown earth in both years (Figure 1). The ANOVA showed that planting date accounted for the majority of the observed yield variation, generally decreasing with later sowing time. This was particularly evident on the red-brown earth soil however, on the grey clay soil, sowing could be delayed until June (D3) in 2003 and late May (D2) in 2004 without incurring substantial yield loss. The highest yielding cultivar was Jimbour (ranked either 1 or 2 in all trials) which yielded significantly more than Amethyst and Flipper (ranked 3, 4 or 5 in all trials). The effect of sowing depth was significant in only one trial, the grey clay in 2003, where shallow sowing (5 cm) improved the yield by 0.12 t/ha compared to deep sowing (10 cm). There was a significant planting date x sowing depth interaction in this trial with shallow sowing improving the yield for the planting dates D3, D4 and D5.

Table 1. Planting and harvest dates, in-crop rainfall (mm), plant available soil water at sowing (PAW), water-use efficiency (WUE) and frost occurrence of sowing treatments for red-brown earth (RBE) and grey clay (GC) in years 2003 and 2004.

Planting date treatment	Planting date	Harvest date		In-crop rainfall (mm)[A]	PAW (mm)[B]		WUE (kg/ha/mm)[C]		Frosts[D]
		RBE	GC		RBE	GC	RBE	GC	
2003									
D1	-	-	-	-	-	-	-	-	-
D2	19.v.03	1.xii.03	30.xi.03	232	197	191	11.5	11.4	9
D3	16.vi.03	1.xii.03	30.xi.03	239	200	189	9.2	12.0	7
D4	16.vii.03	10.xii.03	9.xii.03	195	187	202	8.2	10.3	6
D5	12.viii.03	10.xii.03	9.xii.03	231	191	185	8.2	9.6	2
2004									
D1	6.v.04	19.xi.04	19.xi.04	246	152	138	8.7	10.7	8
D2	28.v.04	29.xi.04	29.xi.04	282	146	141	6.6	8.5	3
D3	22.vi.04	29.xi.04	3.xii.04	247	142	139	6.1	7.6	1
D4	16.vii.04	16.xii.04	17.xii.04	249	151	157	4.3	4.9	1
D5	9.viii.04	16.xii.04	17.xii.04	226	167	174	3.8	5.8	0

[A] Cumulative rainfall from sowing to physiological maturity.
[B] Average PAW for 1.2 m deep soil profile for plots with Howzat cultivar.
[C] Water-use efficiency for grain yield. (l.s.d. = 1.4 and 2.1 for both soil types in 2003 and 2004 respectively)
[D] Number of days in the growing season with frosts – terrestrial temperature below 0°C.

Lodging

There was a significant effect of planting date and cultivar on lodging scores in all trials. Lodging declined with late sowing time, as did plant biomass, in all trials. Sowing depth did not affect lodging score on the red-brown earth, however on the grey clay sowing depth was significant and was more severe in the shallow (5 cm) sowing treatments (not shown). A particularly high lodging score of 3.8 and 4.8 was observed for Howzat sown on the first planting dates (D2) in 2003 and (D1) in 2004, respectively.

Phenology

In 2004 the crop duration from sowing to maturity decreased with late sowing time and was similar for both soil types. As a consequence, the interval between flowering and crop maturity also decreased with later sowing time from 76 to 54 days. Lowest pod height (LPH) decreased significantly with late sowing times. There was also a significant effect of sowing depth on LPH with shallow sowing (5 cm) increasing the LPH by 2 cm compared to deep sowing (10 cm). There was a significant difference between cultivars with Flipper having the greatest LPH, followed by Jimbour, Amethyst, Yorker and Howzat. These rankings agree with previous findings of Knights et al. (2005). The varieties Flipper and Jimbour also had the highest plant height.

Plant density

There was a significant effect of soil type on plant density in 2003 and 2004. The grey clay had a higher plant density than the hard setting red-brown earth. Sowing time also was significant with increased density with later sowings in 2003. In 2004, density increased from D1 to D3 and then decreased for D4 and D5. The depth of sowing was only significant in 2003 on the grey clay with lower density for the 10cm treatment.

Water use efficiency

The water use efficiency for grain yield (WUE_{gr}) declined with late sowing in both years and was higher on the grey clay than the red-brown earth (Table 1). The average WUE_{gr} in 2004 was 40% lower than in 2003. The highest WUE_{gr} was 12 kg/ha/mm for Howzat sown in June 2003 (D3) on the grey clay. There was a significant effect of planting date on the WUE_{gr} in all trials. In-crop rainfall, from sowing to maturity, was higher in 2004 than in 2003 for all planting dates except August (D5) (Table 1). The WUE_{gr} in 2003 was higher than in 2004, despite the higher in-crop rainfall in 2004. However, there was more stored water at sowing in 2003 (higher PAW Table 1) and hence the higher $WUE_{gr.}$

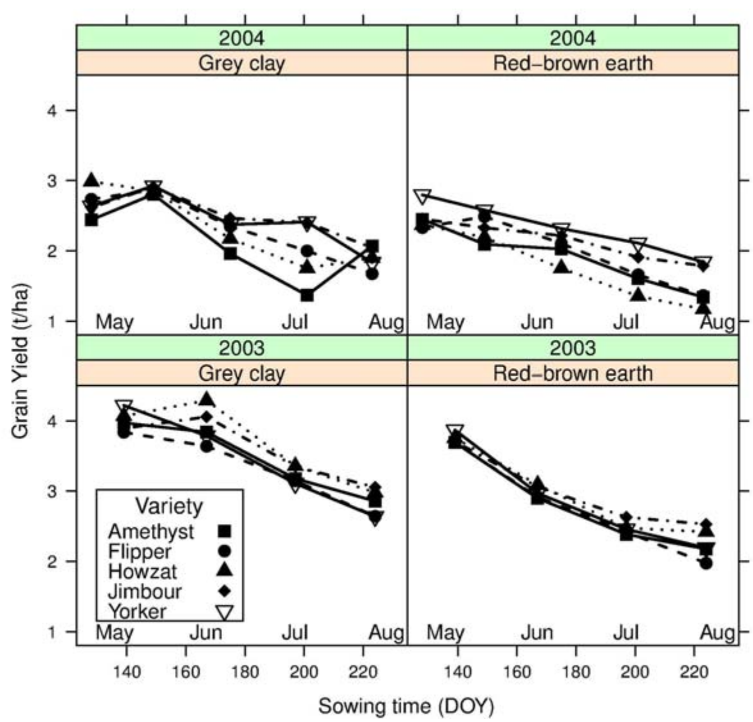

Figure 1. Grain yield versus sowing time (day of year, DOY) for cultivars Howzat, Jimbour, Amethyst, Yorker, Flipper for years 2003 and 2004 with soil types Grey clay and Red-brown earth.

Grain yield decreased with late sowing and supports earlier findings (Horn et al. 1996) that the optimum sowing time is May to early June in the northern NSW and southern Queensland environments on cracking clay soils. However, different sowing dates may be used according to the soil type. Sowing could be delayed to June on the grey clay while on the red-brown earth sowing should occur in early May to maximize grain yield. Grain yields in this experiment were higher than those reported in Queensland (Horn et al. 1996) and are indicative of the more favorable climatic conditions for chickpeas in northern NSW.

The sowing depth did not have a substantial influence on the grain yield of chickpea grown in this study. This indicates that deeper sowing can be used if moisture at the surface is limited or protection from herbicide residues is required.

The maximum WUE_{gr} in each year was higher than those reported for chickpea grown in Mediterranean climates (Zhang et al. 2000; Siddique et al. 1987). An on-farm assessment of chickpea grown in northern NSW and southern Queensland reported a range of WUE_{gr} from 2.5 to 13 kg/ha/mm (Whish et al. 2007). The WUE_{gr} declined with later sowing and similar declines have been reported when sowing was delayed from May to July at Merredin WA (Siddique et al. 1987) and SE Queensland (Horn et al. 1996).

It should be noted that early sown crops can suffer from lodging due to excessive vegetative growth. This was particularly evident in the early May sown crops in 2004. The taller cultivars Howzat and Jimbour were more susceptible to lodging. This would be of concern on better soil types such as the grey clay in seasons of higher yield potential.

Conclusions

Planting date was the most important factor determining yield in both years and on both soil types. Delaying sowing until July substantially reduced crop biomass and grain yield and this trend was consistent across all cultivars. Sowing depth did not reduce yield in the majority of trials in this study. Lodging was most severe in the crops sown in May on the grey clay and deeper sowing significantly decreased this lodging.

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References

Brinsmead RB (1992). Chickpea cultivar by planting time studies in Queensland. In `Proceedings of the 6th Australian Society of Agronomy Conference'. (Eds KJ Hutchinson, PJ Vickery) pp. 244–6. (University of New England: Armidale)

Horn CP, Birch CJ, Dalal RC and Doughton JA (1996) Sowing time and tillage practice affect chickpea yield and nitrogen fixation. 1. Dry matter accumulation and grain yield. Australian Journal of Experimental Agriculture 36, 695–700.

Knights E, Ryan M, Thompson J, Hobson K, Materne M, Khan T, Clarke H, Moore K, Wood J (2005). Review of chickpea breeding in Australia. In ´Chickpeas in farming systems'. Eds E Knights, M Ryan pp. 20–31, Pulse Australia.

Lucy M, McCaffery D, and Slatter J (2005). ´Northern grain production – a farming systems approach´. Cranbrook Press, Toowoomba, Queensland.

NSW DPI (2012) Winter crop variety sowing guide 2012. Accessed 31-07-2012 http://www.dpi.nsw.gov.au/agriculture/broadacre/guides/winter-crop-variety-sowing-guide

Regan K and Siddique KHM (2006). When to sow chickpea in south-western Australia. In ´Proceedings of the 13th Australian Agronomy Conference´. (Eds Turner NC, Acuna T, Johnson RC) Perth, Western Australia. (Australian Society of Agronomy).

Siddique KHM and Sedgley RH (1987). Canopy development modifies the water economy of Chickpea (Cicer arietinum L.), in South-western Australia. Australian Journal of Agricultural Research 37, 599–610.

Siddique KHM and Loss SP (1999). Studies on sowing depth for chickpea (Cicer arietinum L.) , fababean (Vicia faba L.) and lentil (Lens culinaris Medik) in a Mediterranean-type environment of South-western Australia. Journal of Agronomy and Crop Science 182, 105-112.

Whish JPM, Castor P, Carberry PS and Peake AS (2007). On-farm assessment of constraints to chickpea (Cicer arietinum L.) production in marginal areas of northern Australia. Experimental Agriculture 43, 505–20.

Zhang H, Pala M, Oweis T and Harris H (2000). Water use and water-use efficiency of chickpea and lentil in a Mediterranean environment. Australian Journal of Agricultural Research 51, 295–304.