Department of Primary Industries

Chickpea phenology and grain yield response to sowing date – Wagga Wagga and Leeton 2019

Mark Richards, Dr Aaron Preston, Dr Lance Maphosa, Dr Maheswaran Rohan, Karl Moore and Scott Clark (NSW DPI, Wagga Wagga); Daniel Johnston, Reuben Burrough and Tony Napier (NSW DPI, Leeton)

Key findings

- There was diversity in phenology between varieties.
- Early sowing extended the crop vegetative period, but increased exposure to frost damage during the flowering phase.
- Desi varieties PBA Striker(Ф), PBA Slasher(Ф), PBA Boundary(Ф) and CICA1521 were the highest yielding varieties at both sites.
- Dry conditions severely limited chickpea grain yield in 2019, but favoured early maturing varieties, particularly with mid May sowing.

Introduction

Grain yield can be optimised by ensuring that critical growth phases such as flowering and podding avoid abiotic stresses such as frost, heat and drought.

In southern NSW, critical growth periods, overall phenology, and environmental effects on pulses are poorly understood. Experiments were conducted in 2019 at Leeton and Wagga Wagga, aiming to determine the optimum sowing date to reduce effects from abiotic stresses and increase grain yield in chickpea. These experiments also aimed to identify phenological drivers of crop development in chickpea and determine which varieties are best adapted to the target environments. Varieties were selected based on prevalence in growing area, performance and diversity in phenology. Four sowing dates (SDs) were assessed, mid April (SD1), late April (SD2), mid May (SD3) and late May (SD4).

Site details – 1

Location	Wagga Wagga Agricultural Institute
Soil type	Red kandosol
Soil pH_{Ca}	6.6 (0–5 cm), 5.0 (5–10 cm), 4.6 (10–15 cm), 4.9 (15–20 cm), 5.4 (20–25 cm)
Previous crop	Wheat
Fertiliser	Granulock®Z Soygran 100 kg/ha (nitrogen [N]: 5.5, phosphorus [P]: 15.3, potassium [K]: 0.0, sulfur [S]: 7.5)
Post sowing water application	SD1: 15 mm on 17 April
Rainfall	• Fallow (November 2018–March 2019): 253 mm • In-crop (April 2019–October 2019): 145 mm • In-crop long-term average: 322 mm
Target plant density	45 plants/m^2

This research paper is an extract from the publication *Southern NSW Research Results 2020*, available at https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/southern-nsw-research-results

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

	Weed management	Knock down herbicide • 2 L/ha Gladiator® CT (450 g/L glyphosate) on 18 April. Pre-emergence (at sowing) • 900 g/ha Terbyne® Xtreme (875 g/kg terbuthylazine). • 1.7 L/ha Avadex® Xtra (500 g/L tri-allate), incorporated by sowing (IBS). • 300 g/ha Terbyne® Xtreme (875 g/kg terbuthylazine), post sowing pre-emergent (PSPE). Post-emergence (18 June) • 300 mL/ha Select® Xtra (360 g/L clethodim), 500 mL/ha Uptake™ spraying oil (582 g/L paraffinic oil).
	Disease management	• Dithane® (750 g/kg mancozeb) 2.2 kg/ha on 2 July and 22 July. • Fortress® 500 (500 g/L procymidone) 500 mL/ha on 6 August and 23 August.
	Pest management	• Talstar® 250 EC (250 g/L bifenthrin) 30 mL/ha on 18 June. • Trojan® (150 g/L gamma-cyhalothrin) 20 mL/ha on 3 September and 4 October.
	Harvest date	Harvest index cuts were taken as varieties reached maturity and plots were machine harvested on 29 November 2019.
Site details – 2	**Location**	Leeton Field Station
	Soil type	Red dermosol
	Soil pH_{Ca}	6.0 (0–10 cm), 6.4 (10–30 cm)
	Previous crop	Barley
	Fertiliser	Utiliser pulse mix 55 kg/ha (N: 7.48, P: 17.64, K: 6.24, calcium [Ca]: 6.4, zinc [Zn]: 0.32)
	Water application	• Pre sowing flood irrigation on 8 April (approximately 2 ML/ha) • Post sowing: none
	Rainfall	• Fallow (November 2018–March 2019): 310 mm • In-crop (April 2019–October 2019): 162 mm • In-crop long-term average: 193 mm
	Target plant density	30 plants/m^2
	Weed management	Knock down herbicide • 3 L/ha Sprayseed® 250E (135 g/L paraquat dichloride, 115 g/L diquat dibromide) on 11 April. • 3 L/ha Roundup PowerMax® (540 g/L glyphosate) on 15 April. Pre-emergence (at sowing) • 900 g/ha Terbyne® Xtreme (875 g/kg terbuthylazine). • 1.6 L/ha Avadex® Xtra (500 g/L tri-allate), incorporated by sowing (IBS).

	• 2 L/ha Rifle® 440 (440 g/L pendimethalin). Post-emergence • 300 g/ha Terbyne® Xtreme (875 g/kg terbuthylazine), post sowing pre-emergent (PSPE). • 85 mL/ha Verdict® 520 (520 g/L haloxyfop) on 14 May (SD1), 6 June (SD2), 18 June (SD3) and 20 June (SD4). • 190 mL/ha Leopard® 200EC (200 g/L quizalofop-p-ethyl) on 2 August and 7 August.
Disease management	• Dithane® (750 g/kg mancozeb) 2.2 kg/ha on 14 May (SD1), 6 June (SD2), 26 June and 6 August. • Amistar® 250 SC (250 g/L azoxystrobin) 500 mL/ha, Oriuso® 430SC (430 g/L tebuconazole) 500 mL/ha, Cheers® 720 (720 g/L chlorothalonil) 1.8 L/ha on 18 July and 25 July. • Veritas® (200 g/L tebuconazole, 130 g/L azoxystrobin) 1 L/ha on 2 August. • Dithane® (750 g/kg mancozeb) 2.2 kg/ha on 6 August. • Sumisclex® 500 (500 g/L procymidone) 1 L/ha on 8 August. • Veritas® (200 g/L tebuconazole, 130 g/L azoxystrobin) 1 L/ha, Cheers® 720 (720 g/L chlorothalonil) 2 L/ha on 8 August and 26 August. • Aviator® Xpro® (150 g/L prothioconazole, 75 g/L bixafen) 600 mL/ha on 4 September. • Veritas® (200 g/L tebuconazole, 130 g/L azoxystrobin) 1 L/ha, Cheers® 720 (720 g/L chlorothalonil) 2 L/ha on 15 September. • Cheers® 720 (720 g/L chlorothalonil) 2 L/ha on 26 September and 1 October.
Insect management	• Transform® (500 g sulfoxaflor) 300 mL/ha on 8 August. • Pirimidex (500 g/kg pirimicarb) 150 g/ha, Success® Neo (120 g/L spinetoram) 200 mL/ha on 4 September and 27 September.
Harvest date	Hand cuts for harvest index: 5 November and 6 November; machine harvest: 13 November.

Treatments

Eight chickpea varieties, five Desi and three Kabuli, were sown on four sowing dates.

Desi varieties

PBA Boundary$^{\Phi}$, PBA Striker$^{\Phi}$, PBA Slasher$^{\Phi}$, CICA1521 and PBA HatTrick$^{\Phi}$

Kabuli varieties

Genesis™ 079, Genesis™ 090 and Kalkee

Sowing date (SD)

SD1: 15 April

SD2: 30 April

SD3: 15 May

SD4: 30 May

Results

Seasonal conditions

The drought conditions in the 2019 growing season reduced yield potential at both sites. Wagga Wagga received 145 mm rainfall from April to October, which is significantly lower than the long-term average of 322 mm. Leeton received 162 mm rainfall from April to October and was closer to the long-term average of 193 mm. In addition, several severe frosts at both sites during winter and spring impeded crop growth and pod set. Below average rainfall and above average temperatures also affected the September and October flowering and grain filling periods.

Phenology

Time to emergence took longer when sowing date was delayed, ranging from nine days (SD1 at Wagga Wagga) to 29 days (SD4 at Leeton). This delayed emergence was due to decreased soil temperature in late autumn, requiring a longer time to satisfy the minimum growing degree days required for emergence.

Interactions between variety (V) and sowing date (SD) were found with PBA Striker(D) the first variety to emerge at Leeton, while Genesis™079 emerged earliest at Wagga Wagga. Averaged across varieties, SD2 had the highest establishment (47 plants/m^2) at Wagga Wagga while SD4 had the highest establishment (47 plants/m^2) at Leeton.

Generally, the vegetative, flowering and podding phases shortened when sowing was delayed (Figure 1). However, podding initiation generally occurred at the same time, because chickpea in general will not set and/or retain pods until a mean daily temperature of around 15 °C is achieved (Berger et al., 2004; Clarke and Siddique, 2004; Warren et al., 2019).

Table 1 Grain yield at Leeton and Wagga Wagga in 2019.

Variety	Leeton					Wagga Wagga				
	Grain yield (t/ha)					Grain yield (t/ha)				
	SD1	SD2	SD3	SD4	Mean	SD1	SD2	SD3	SD4	Mean
CICA1521	1.06	1.10	1.91	1.70	1.44	0.14	0.64	0.92	0.94	0.66
Genesis079	1.20	1.51	1.51	1.52	1.44	0.24	0.60	0.76	0.68	0.57
Genesis090	0.92	1.51	1.19	1.28	1.23	0.18	0.60	0.64	0.64	0.52
Kalkee	0.56	1.29	1.30	1.04	1.05	0.15	0.59	0.75	0.60	0.52
PBA Boundary	0.90	1.89	1.42	1.62	1.46	0.13	0.48	0.85	0.71	0.54
PBA HatTrick	0.51	1.37	1.56	1.20	1.16	0.10	0.48	0.67	0.75	0.50
PBA Slasher	1.12	1.86	1.78	1.72	1.62	0.15	0.60	0.75	0.79	0.57
PBA Striker	1.32	1.88	1.76	1.73	1.67	0.28	0.81	0.98	0.87	0.74
Mean	0.95	1.55	1.55	1.48		0.17	0.60	0.79	0.75	
l.s.d. ($P \leq 0.05$)										
Variety	0.21					0.08				
SD	0.13					0.06				
Variety × SD	n.s					0.13				

l.s.d., least significant difference.
n.s., not significant.

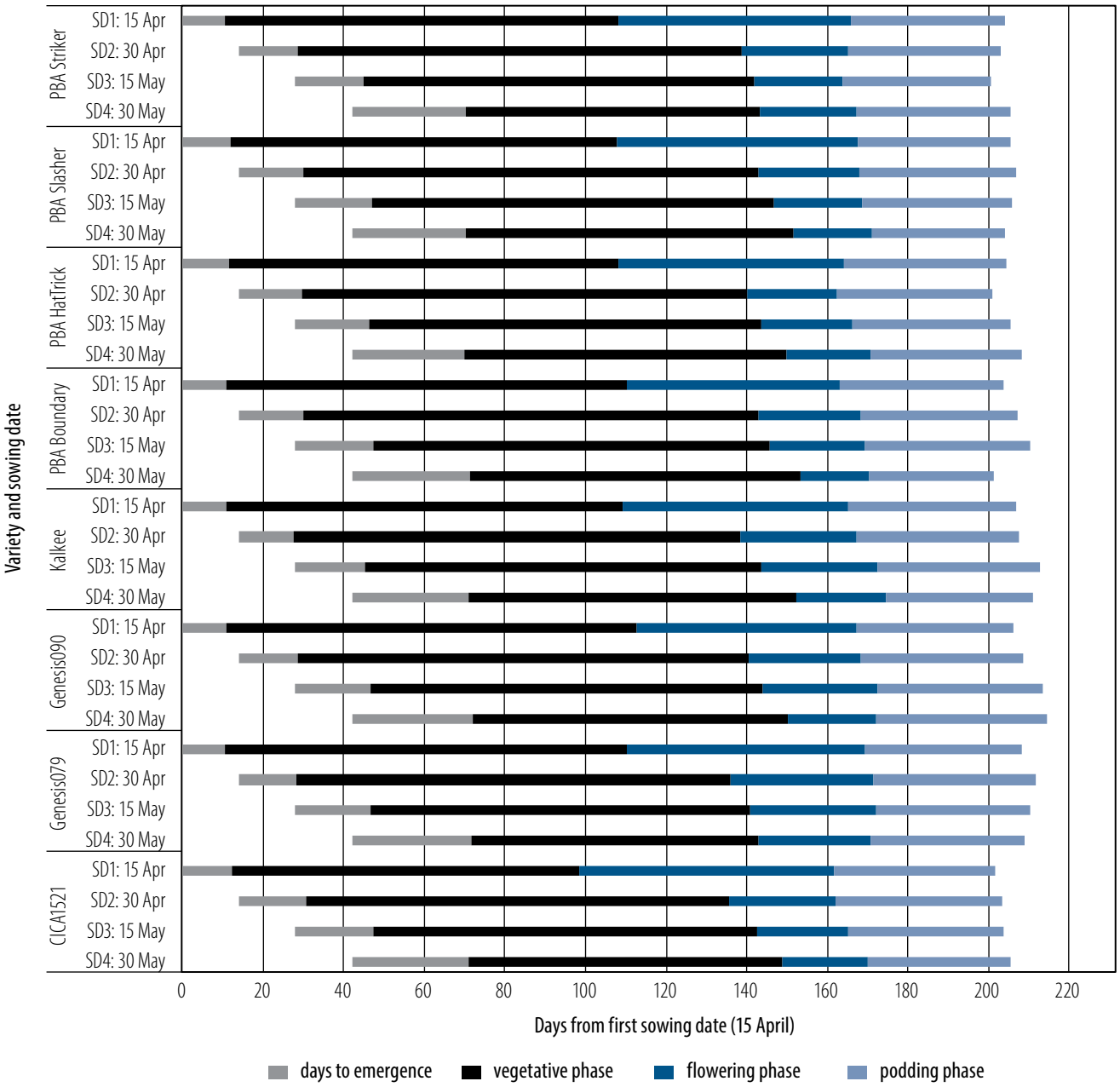


Figure 1 Influence of sowing date at Wagga Wagga on emergence, start and duration of key chickpea phasic growth stages.

Grain yield and yield components

Averaged across varieties, SD2, SD3 and SD4 were equal highest yielding at Leeton, while at Wagga Wagga SD3 and SD4 had the highest grain yields (Table 1).

The varieties PBA HatTrick$^{\Phi}$ and Kalkee were the lowest yielding at Leeton, while at Wagga Wagga the lowest yielding varieties were Kalkee and Genesis™090. Kalkee was consistently low yielding and therefore is likely not suited to the environments of southern NSW. PBA Striker$^{\Phi}$, an early maturing variety, was the highest yielding at both sites. This highlights the importance of early–mid season maturity for avoiding late season abiotic constraints such as heat and/or moisture stress.

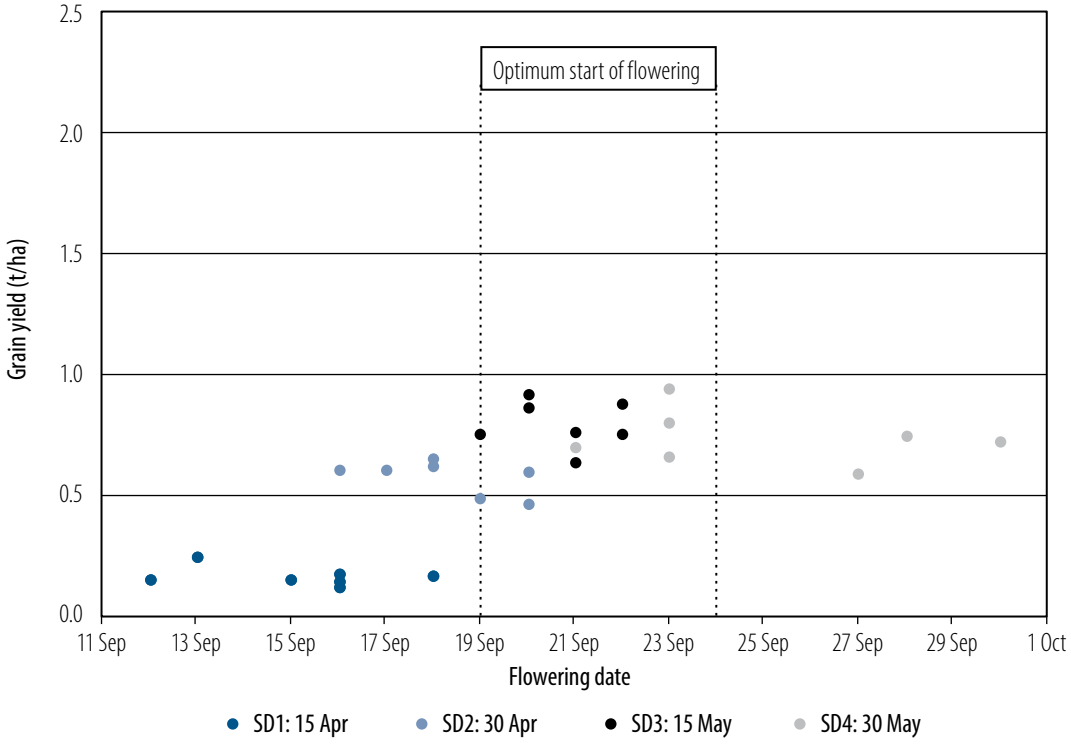
Filled pods, total pod number and seed numbers per plant were lowest for SD1 at both sites. The low number of pods could be due to pod abortion and/or drop during prolonged unfavourable conditions (frost/heat stress). Also, ascochyta blight infection was first observed in SD1 at Leeton and a management program was implemented to minimise disease effects across all treatments.

Harvest index ranged from 0.13 (SD1) to 0.37 (SD4) at Leeton and 0.04 (SD1) to 0.38 (SD4) at Wagga Wagga, with V × SD interactions at both sites (data not presented). Later sowing resulted in lower biomass, ranging from 3.96 t/ha (SD4) to 7.36 t/ha (SD1) at Leeton and 1.94 t/ha (SD4) to 4.58 t/ha (SD1) at Wagga Wagga, with V × SD interactions at Wagga Wagga only (data not presented). However, the higher biomass from SD1 was not correlated with greater grain production, probably due to SD1 depleting available soil water before grain filling was complete.

Relationship between phenology and grain yield

The optimum start of flowering was deduced to be around 19 September to 24 September for Wagga Wagga and 6 September to 13 September for Leeton from the 2019 data (figures 2 and 3). The later start at Wagga Wagga is driven by the cooler weather at this location relative to Leeton. In 2019, starting flowering around these dates ensured that chickpea avoided abiotic stresses, such as frost, early in the growing season, and heat and terminal drought later in the season.

Experiments conducted in 2019 have been combined with data collected in 2018; variety phenology and performance have been analysed to create a two-year average. This analysis was used to generate a preliminary guide for optimal sowing periods in southern NSW (Table 2). As data was collected over two years that had low rainfall and increased incidence of abiotic stresses, these guidelines are only suitable for similar seasons.



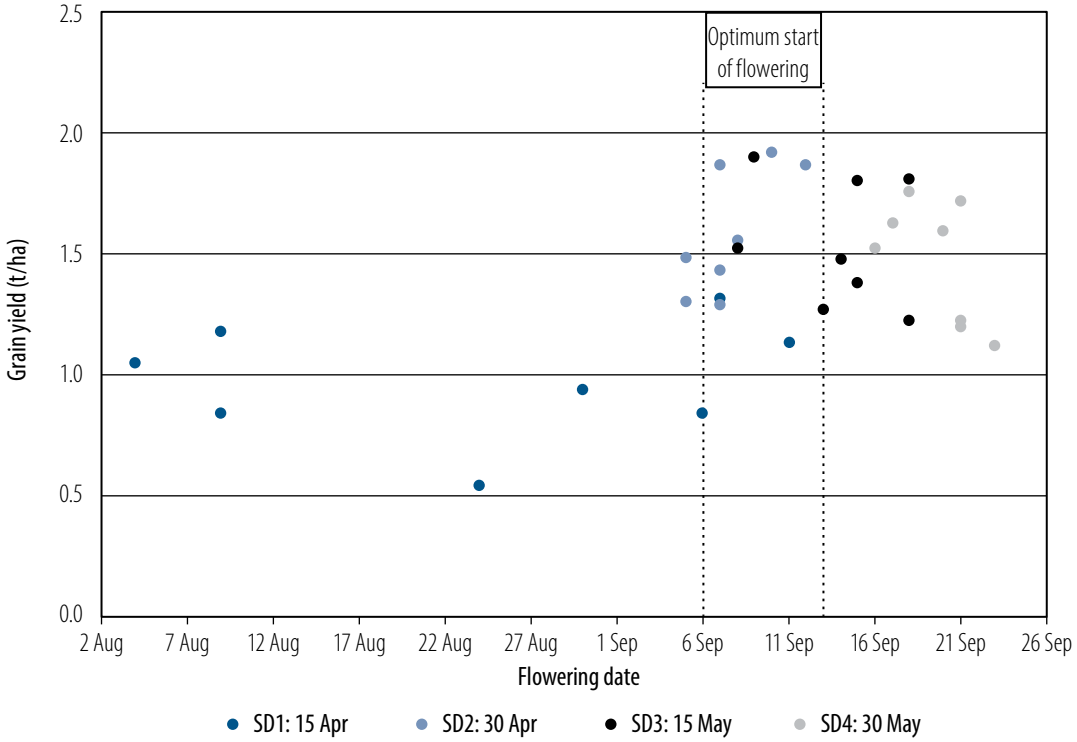
Dots represent date of 50% flowering by varieties across sowing dates, optimal start of flowering is marked by vertical lines.

Figure 2 Optimum start of flowering for chickpea at Wagga Wagga in 2019.

Table 2 Preliminary guidelines for optimum sowing periods for chickpea varieties common across 2018 and 2019 experiments.

Variety	Maturity	Optimum sowing period for yield (southern NSW, low rainfall season)			
		Mid April	Late April	Mid May	Late May
CICA 1521	Early				
PBA Striker	Early				
PBA Boundary	Mid/late				
PBA Slasher	Early				
Genesis079	Early				
Kalkee	Late				
Genesis090	Mid/late				

Dark grey indicates unsuitable sowing time, light grey indicates earlier or later than recommended, yield reduction likely, light blue indicates preferred sowing time. Guidelines only suitable for low rainfall seasons.



Dots represent date of 50% flowering by varieties across sowing dates, optimal start of flowering is marked by vertical lines.

Figure 3 Optimum start of flowering for chickpea at Leeton in 2019.

Conclusion

The 2019 experiments indicate that sowing date can be used to target the optimum start of flowering to maximise grain yield for the different locations. It is important to note that this data was collected during a year that was characterised by significantly drier than average growing conditions, increased incidences of abiotic stresses, and lower yields.

Matching sowing date and varietal phenology (sowing date × variety combination) ensures that the sensitive growth stages such as flowering and podding occur at optimal times. Results from 2019 indicate that sowing around mid May in these environments gives the varieties tested the best opportunity to avoid abiotic stresses and allows efficient conversion of biomass to grain yield. Early sowing or longer maturing varieties are at greater risk of exposure to potential frost damage and late

season adverse conditions such as terminal drought and heat stress. Early sowing also results in low harvest index as most of the accumulated biomass is not converted to grain yield.

Preliminary optimal sowing guidelines for chickpea in southern NSW in low rainfall seasons have been developed using this data. Additional research is required to quantify the affect on chickpea phenology and grain yield in average or high rainfall years.

References

Berger JD, Turner NC, Siddique KHM, Knights EJ, Brinsmead RB, Mock I, Edmondson C and Khan TN, 2004. Genotype by environment studies across Australia reveal the importance of phenology for chickpea (*Cicer arietinum* L.) improvement. *Australian Journal of Agricultural Research*, vol. 55, pp. 1071–1084.

Clarke HJ and Siddique KHM, 2004. Response of chickpea genotypes to low temperature stress during reproductive development. *Field Crops Research*, vol. 90, pp. 323–334.

Warren A, Graham N, Raman R and Hobson K, 2019. The physiology and genetics of cold temperatures in chickpeas – what do we know and where is the research heading? https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2019/02/the-physiology-and-genetics-of-cold-temperatures-in-chickpeas-what-do-we-know-and-where-is-the-research-heading. Viewed 27 May 2020.

Acknowledgements

This experiment was part of the 'Adaptation of profitable pulses in the central and southern zones of the northern grains region' project, BLG112, March 2018 to June 2020, a joint investment by GRDC and NSW DPI under the Grains Agronomy and Pathology Partnership (GAPP).

Thank you to Nelson West and Ollie Owen for their technical assistance.