# Chickpea response to sowing date and water treatment in southern NSW

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**Abstract**
Management practices such as time of sowing and irrigation significantly affect chickpea yield responses. Field experiments were conducted in 2020 at Wagga Wagga and Leeton in New South Wales (NSW) using four cultivars across three sowing dates under rainfed and irrigated conditions. The highest grain yields at both locations where associated with mid to late sowing (15 May and 5 June), with significant penalties in sowing too early (24 April). Furthermore, at both locations there was a decrease in yield due to spring irrigation. Irrigation led to an increase in crop duration, lodging and a decrease in plant density due to disease (sclerotinia). The newly released cultivar, CBA Captain was highest yielding at both locations, indicating its potential suitability to the southern NSW environments.

**Keywords**
Chickpea, sowing time, irrigation, genotype-by-environment interactions.

**Introduction**
Chickpea yield potential is influenced by a range of environmental conditions including soil water availability. The impact of moisture stress on chickpea productivity depends on the severity of the moisture stress, and the length and timing of exposure on the growth stage. Moisture stress generally shortens the duration of the crop cycle (Richards et al., 2020), limits biomass accumulation and reduces overall grain yield (Kashiwagi et al., 2015). The decrease in yield is often due to reduced grain number rather than weight (Pushapavalli et al., 2015). The crop mitigation mechanisms for moisture stress include: accelerated development leading to early maturity (escape), developing deeper rooting systems which allow extraction of water at depth (avoidance) or continuing to grow and function at reduced water content (tolerance). The objective of this study was to examine the response of chickpea to moisture availability and the influence of sowing time on chickpea development and productivity.

**Methods**
*Experimental locations and management*
Field experiments were conducted at Wagga Wagga and Leeton in southern New South Wales in 2020, under rainfed and irrigated conditions. Climatic data was recorded using in-paddock weather stations and had been compared to the long term average temperature and rainfall from the Australian Bureau of Meteorology (BOM) website (http://www.bom.gov.au/).

Four varieties, CBA Captain, PBA Drummond, PBA HatTrick and PBA Striker were sown across three sowing times (24 April (SD1), 15 May (SD2) and 5 June (SD3)) at both sites, in 6 rows with 25 cm row spacing, 3-5 cm sowing depth and targeted plant density of 45 plants/m$^2$ in 12 m long plots. A split plot design with three replicates was used with water treatment as main plot, sowing date assigned to subplot and genotypes randomised within subplots. The water treatment comprised of a water limited (rainfed only) and a non-water limited (rainfed plus additional water as needed) treatment. At Wagga Wagga, additional water was applied by K-line irrigation pods when neutron probe readings indicated a decline in water in the profile. Water was applied at the Leeton site by flood on a border check irrigation layout using evapotranspiration rates to determine irrigation scheduling. Local best management practices of herbicide, fungicide and insecticide application were used to minimise the effects of weeds, diseases and insect pests.

*Soil water measurements*

The soil of each plot was sampled to a depth of 120 cm in 20 cm increments immediately before sowing and after harvest. The volumetric soil water content of these soil samples was determined by oven drying to constant weight at 105 °C. At Wagga Wagga neutron probe access tubes were installed to a depth of 105 cm in the 18 plots sown to the variety PBA HatTrick. Soil water was measured every 2 weeks between 09/07/2020 and 07/12/2020.

*Plant measurements*

Phenological development was measured as days to physiological maturity (measure of crop duration). Plot health was assessed at Wagga Wagga, while a lodging score was recorded at Leeton due to the higher impact of lodging. At harvest, plant counts, biomass and grain yield were collected from two 1.2 $m^2$ (1.0$m^2$ at Leeton) quadrant cuts of the four inner rows and expressed on a $m^2$ basis.

*Statistical analysis*

Statistical analysis was done using the Restricted Maximum Likelihood (REML) spatial linear model algorithm in GenStat 20$^{th}$ Edition. This methodology captures the genotype x environment (G × E) interaction using factor analytic models.

## Results and Discussion

*Climate and irrigation*

Rainfall was atypical for Wagga Wagga and Leeton, with above average rainfall during the pre-sowing period (April) and again in spring (October) preventing significant declines in soil moisture throughout much of the growing season. At Wagga Wagga neutron probe data indicated a decline in soil water in mid-September and so an additional 56mm of water was applied by K-line irrigators to the wet treatment over 5 events from late September to mid-November to maintain a non-water limited environment. Additional water was applied three times at the Leeton site by flood on a border check irrigation layout..

*Water use and water use efficiency (WUE)*

The early sown treatment was more advanced in terms of growth and development and extracted more water from the soil (Figure 1). However, at maturity the remaining stored water was similar across the sowing dates. Early sowing resulted in lower WUE (4.7 ta/ha/mm) compared to SD3 (6.3 ta/ha/mm), and irrigation decreased it from 6.6 to 4.3 ta/ha/mm.

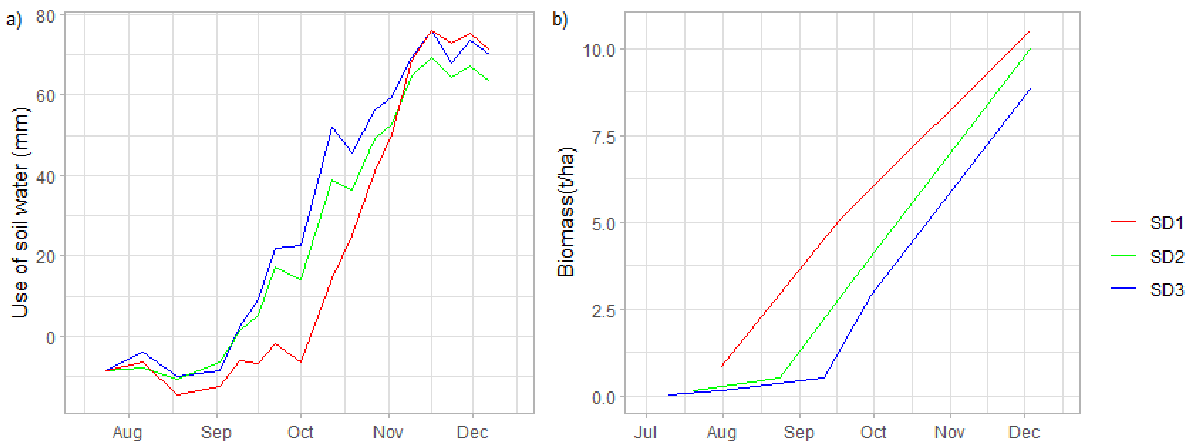


**Figure 1. Changes in a) soil water stored and b) biomass accumulation of the genotype HatTrick at Wagga Wagga over time. The data are averaged across the irrigated and dryland treatments at Wagga Wagga.**

Crop duration, biomass accumulation, grain yield and harvest index were influenced by both main and interaction effects at both Wagga Wagga and Leeton (Table 1). Neither location exhibited genotypic differences in time to physiological maturity. Crop duration was affected by sowing date and water treatment at Wagga Wagga, whereas an interaction between sowing date × genotype and sowing date × water treatment was observed at Leeton, all taking longer to reach physiological maturity with early sowing and irrigation. Genotypic differences were observed in accumulated dry matter at both sites, but the effect of sowing date was observed only at Wagga Wagga while the effect of water treatment was observed only at Leeton. Dry matter at both locations showed genotype × sowing date interaction and at Leeton interactions were observed at the genotype × water treatment, and genotype × sowing date × water treatment level. Grain yield was affected by sowing date at Wagga Wagga and differed between genotypes at Leeton. For grain yield, genotype × sowing date interaction was observed at both locations, with further genotype × water treatment, sowing date × water treatment, and genotype × sowing date × water treatment interactions observed at Leeton. All the main effects influenced harvest index, and there was genotype × sowing date, and genotype × sowing date × water treatment interactions in both locations. In addition, at Leeton, genotype × water treatment, and sowing date × water treatment effect on dry matter, grain yield and harvest index was observed.

**Table 1. Effect of sowing date and water treatment on chickpea development and yield at Wagga Wagga and Leeton in 2020.**

| | | | **Wagga Wagga** | | | | | **Leeton** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WT | Genotype | Sowing date | Time to maturity (days) | Harvest dry matter (t/ha) | Grain Yield (t/ha) | Harvest Index | Harvest Plant count | Time to maturity (days) | Harvest dry matter (t/ha) | Grain Yield (t/ha) | Harvest Index | Harvest Plant Count |
| Dry | CBA Captain | 1 | 221 | 11.38 | 2.327 | 0.21 | 52 | 203 | 11.14 | 2.644 | 0.24 | 33 |
| | | 2 | 197 | 10.05 | 2.739 | 0.27 | 50 | 184 | 10.19 | 3.714 | 0.36 | 37 |
| | | 3 | 180 | 7.92 | 2.268 | 0.29 | 41 | 163 | 8.96 | 4.252 | 0.47 | 36 |
| Wet | CBA Captain | 1 | 227 | 11.41 | 1.711 | 0.14 | 40 | 207 | 15.87 | 4.787 | 0.3 | 35 |
| | | 2 | 205 | 10.29 | 1.850 | 0.18 | 44 | 186 | 13.88 | 3.981 | 0.29 | 35 |
| | | 3 | 185 | 8.51 | 2.166 | 0.26 | 45 | 165 | 11.75 | 3.705 | 0.31 | 39 |
| Dry | PBA Drummond | 1 | 220 | 10.99 | 2.260 | 0.20 | 34 | 200 | 11.11 | 3.053 | 0.27 | 40 |
| | | 2 | 199 | 8.38 | 2.036 | 0.24 | 47 | 182 | 10.78 | 4.038 | 0.37 | 41 |
| | | 3 | 180 | 7.75 | 2.196 | 0.28 | 54 | 165 | 9.64 | 4.553 | 0.47 | 41 |
| Wet | PBA Drummond | 1 | 227 | 10.16 | 1.770 | 0.17 | 40 | 200 | 11.99 | 2.052 | 0.17 | 34 |
| | | 2 | 206 | 8.74 | 1.287 | 0.15 | 53 | 184 | 12.52 | 2.931 | 0.23 | 42 |
| | | 3 | 184 | 7.87 | 1.700 | 0.21 | 49 | 165 | 9.82 | 2.441 | 0.25 | 42 |
| Dry | PBA HatTrick | 1 | 220 | 10.21 | 1.671 | 0.16 | 51 | 200 | 10.50 | 3.037 | 0.29 | 35 |
| | | 2 | 200 | 10.19 | 2.546 | 0.25 | 56 | 179 | 9.62 | 3.399 | 0.36 | 39 |
| | | 3 | 179 | 8.59 | 2.164 | 0.26 | 49 | 165 | 9.54 | 4.248 | 0.45 | 42 |
| Wet | PBA HatTrick | 1 | 226 | 10.85 | 1.490 | 0.14 | 41 | 207 | 12.72 | 2.671 | 0.21 | 35 |
| | | 2 | 205 | 9.76 | 1.969 | 0.20 | 49 | 184 | 13.37 | 3.264 | 0.24 | 36 |
| | | 3 | 185 | 9.05 | 1.884 | 0.20 | 46 | 165 | 12.32 | 2.809 | 0.23 | 41 |
| Dry | PBA Striker | 1 | 221 | 7.74 | 1.800 | 0.24 | 36 | 200 | 8.24 | 2.418 | 0.29 | 41 |
| | | 2 | 201 | 8.84 | 2.383 | 0.27 | 49 | 179 | 9.15 | 3.42 | 0.37 | 41 |
| | | 3 | 179 | 6.97 | 2.487 | 0.36 | 45 | 165 | 8.11 | 3.815 | 0.47 | 41 |
| Wet | PBA Striker | 1 | 226 | 7.38 | 1.253 | 0.18 | 35 | 205 | 6.00 | 0.792 | 0.13 | 37 |
| | | 2 | 205 | 8.33 | 1.915 | 0.23 | 37 | 186 | 10.28 | 2.644 | 0.25 | 41 |
| | | 3 | 185 | 7.95 | 1.701 | 0.22 | 48 | 165 | 12.34 | 2.299 | 0.19 | 42 |
| G (*P* value) | | | 0.4 | <0.001 | 0.12 | <0.001 | 0.01 | 0.071 | <0.001 | <0.001 | <0.001 | <0.001 |
| l.s.d | | | n.s | 0.726 | n.s | 0.02 | 4 | n.s | 0.597 | 0.268 | 0.02 | 2 |
| Sowing Date (*P* value) | | | <0.001 | <0.001 | 0.01 | <0.001 | <0.001 | <0.001 | 0.393 | 0.056 | <0.001 | 0.02 |
| l.s.d | | | 0.7 | 0.629 | 0.212 | 0.02 | 3 | 2.2 | n.s | n.s | 0.02 | 2 |
| WT (*P* value) | | | <0.001 | 0.67 | <0.001 | <0.001 | 0.03 | <0.001 | <0.001 | <0.001 | <0.001 | 0.168 |
| l.s.d | | | 0.6 | n.s | 0.173 | 0.01 | 3 | 0.9 | 0.466 | 0.208 | 0.01 | n.s |

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| G × Sowing Date *(P* value) | 0.245 | 0.01 | 0.015 | 0.042 | 0.01 | 0.01 | <0.001 | 0.004 | 0.025 | 0.543 |
| l.s.d | n.s | 1.261 | 0.411 | 0.03 | 7 | 2.6 | 1.39 | 0.603 | 0.03 | n.s |
| G × WT *(P* value) | 0.436 | 0.942 | 0.627 | 0.255 | 0.1 | 0.082 | <0.001 | <0.001 | <0.001 | 0.48 |
| l.s.d | n.s | n.s | n.s | n.s | n.s | n.s | 0.854 | 0.383 | 0.02 | n.s |
| Sowing Date × WT *(P* value) | 0.149 | 0.487 | 0.436 | 0.168 | 0.37 | 0.005 | 0.08 | <0.001 | <0.001 | 0.112 |
| l.s.d | n.s | n.s | n.s | n.s | n.s | 2 | n.s | 0.542 | 0.02 | n.s |
| G × Sowing Date × WT *(P* value) | 0.292 | 0.885 | 0.567 | 0.022 | 0.09 | 0.19 | <0.001 | 0.002 | 0.004 | 0.238 |
| l.s.d | n.s | n.s | n.s | 0.04 | n.s | n.s | 1.739 | 0.764 | 0.04 | n.s |

SD1 = 24/04/2020; SD1 = 15/05/2020; SD1 = 05/06/2020; G = genotype; WT = water treatment

A number of factors could have caused irrigation to reduce grain yield. For example, at Wagga Wagga the plant density in the harvest cuts was lower (Table 1) due to higher disease incidence observed. Above average pre-sowing rainfall in March and April, combined with favourable conditions throughout the growing season recorded in southern NSW were conducive for disease development (Ascochyta, sclerotinia and botrytis grey mould), and overall crop lodging. Our results suggest soil water did not limit yield in either the irrigated and dryland treatments, but the dryland had lower disease incidence, resulting in higher plants counts than the irrigated treatment, and hence higher yields.

Irrigation extended the crop growing season, and late maturity largely resulted in a yield decrease, except for PBA Captain at Leeton. The lack of advantage due to irrigation is partly because the experiment was irrigated just after the sensitive podding stage. At that point seed number, a key driver would have been determined. While additional water increased seed size (results not shown), it did not compensate for the decrease in seed number mainly due to reduced plant density from disease.

## Conclusion

The 2020 seasonal conditions were characterised by favourable temperatures, a lack of abiotic stress and non-limiting soil water throughout most of the growing season, all of which influenced grain yield responses to sowing date and irrigation. While irrigation is likely to increase chickpea grain yield when applied to alleviate water stress at critical growth stages, it is likely to have the opposite effect of increasing biomass, foliar disease and lodging in non-water limited conditions. The decrease in yields were more pronounced in the early sowing (SD1), which accumulated more biomass but did not efficiently convert it into yield resulting in low harvest index. Wet treatments drove changes in pod/seed fill dynamics, favouring greater seed weight at the expense of seed number, a known driver of yield. At both locations SD1 had lower yields compared to later sowings under both water treatments, and cultivar CBA Captain was the highest yielding.

## References


Kashiwagi J, et al., (2015). Scope for improvement of yield under drought through the root traits in chickpea (*Cicer arietinum* L.). Field Crops Research 170, 162–174.

Pushpavalli R, et al., (2015) Higher flower and seed number leads to higher yield under water stress conditions imposed during reproduction in chickpea. Functional Plant Biology 42, 47–54.

Richards MF, et al., (2020). Sowing date affects the timing and duration of key chickpea (*Cicer arietinum* L.) growth phases. Plants 10, 1257.