Mungbean: response to different levels of soil nitrogen—Hopeland (summer)

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Research questions: *How much nitrogen is required to maximise mungbean yield? | Can well-nodulated mungbean achieve the same yield as fertilised crops? | How does differing the concentrations of soil nitrogen impact nitrogen fixation?*

Key findings

1. Mungbean responded to nitrogen fertiliser with a yield of +2 t/ha when planted on a low starting soil nitrogen profile (~ 50 kg N/ha).
2. One irrigation at pod-fill increased yields by up to 850 kg/ha.
3. Applying irrigation during high temperatures reduced canopy temperature, which is believed to also improve pod filling and reduce flower abortion.
4. Mungbean can increase levels of charcoal rot.

Background

Over the past two years the Mungbean Agronomy team have investigated the impact of applied nitrogen (N) fertiliser on yields of inoculated versus uninoculated mungbean. Grower consultation identified a gap in knowledge regarding the nutritional management of mungbean, specifically nitrogen. Industry bodies have indicated that most mungbean crops are inoculated. However, poor nodulation commonly results in N deficiency and significant yield reductions (up to 50%) where residual N levels are low. To counteract poor nodulation, a proportion of the industry have decided that it may be easier and more efficient to apply N to maximise yield.

As mungbean are a very short duration crop, some people consider that even with good nodulation, the fixation process is too slow to supply the required amount of N to maximise yield. Past research results have been inconsistent, with mungbean often not responding to N applied at planting. Anecdotal evidence from industry is that mungbean yields increase in response to higher nitrate levels in the profile when N is applied in the fallow.

In the 2018/19 season, a series of trials investigated the impacts of timing and placement of applied nitrogen on mungbean yields compared to well-nodulated mungbean. A constant rate of nitrogen was applied, both during the fallow and at planting, at different positions within the soil profile. This established treatments with varying amounts of available N at different positions within the soil profile. There were no statistically significant differences detected. As a result, the project adapted the research question and experimental design to further investigate this issue by investigating a range of rates of nitrogen. The research was conducted in spring and repeated in summer. This report is for the summer crop; the spring crop is reported separately in this publication.

What was done

A field experiment was conducted at Hopeland, near Chinchilla. The site was selected for its low soil mineral nitrogen at the time of preliminary sampling (50 kg N/ha, 0-90 cm, 19/07/2019), and the ability to flood irrigate. Both a spring and summer planted trial were planted in the same field, this report outlines details of the summer planted trial. Deep phosphorus (P) was applied across the whole site on 2 September 2019 to rectify a potential P deficiency. The P was applied as MAP at a rate of 100 kg/ha, 20-25 cm depth and 50 cm spacing.

A cover crop of Panorama millet was planted on 11 October 2019 to draw down the nitrogen status of the soil. The cover crop was desiccated on 23 December 2019 and slashed on 8 January 2020. Nitrogen was applied the same day by banding the fertiliser 10 cm offset from the plant row (Table 1). All treatments were replicated four times and repeated with and without irrigation to alter yield potential. The soil N status at planting was 52 kg N/ha for the irrigated trial and 91 kg N/ha for the dryland site (control plots only), even though these were side by side in the same paddock. When comparing the summer and spring crop planting N, the cover crop was effective at maintaining the low N status of the summer trial, effectively buffering against mineralisation increasing available N from October to January.

Jade-AU⁽ᵈ⁾ mungbean was planted on 29 January 2020 with 50 cm row spacings with 40 L/ha of Flowphos 13Z. All treatments (except Treatment 1) had inoculant applied at planting through water injection. Micro-plots were planted with non-nodulating soybeans in each plot, as reference plants for the natural abundance method (^{15}N isotope) to measure the proportion of N in the plants that was fixed from the atmosphere (%Ndfa) by the mungbean plants under each treatment.

Table 1. Treatments applied at Hopeland.

	Treatment	Inoculation	Irrigation
1	No applied N	- inoculation	+/- irrigation
2	No applied N	+ inoculation	+/- irrigation
3	No applied N	+ inoculation	+/- irrigation
4	30 kg N/ha	+ inoculation	+/- irrigation
5	60 kg N/ha	+ inoculation	+/- irrigation
6	90 kg N/ha	+ inoculation	+/- irrigation
7	120 kg N/ha	+ inoculation	+/- irrigation
8	150 kg N/ha	+ inoculation	+/- irrigation

The trial received 200 mm rainfall within the first month of planting; as a result the irrigated trial only received one subsequent irrigation at podding. The crop was harvested on 24 April 2020. AMF levels were low, and no nematodes were detected.

Results

The summer mungbean crop experienced almost ideal conditions, with most days below 33 °C from flowering to desiccation (Figure 1). These conditions combined with the first month's rainfall, resulted in the dryland crop averaging 1.25 t/ha and 2.1 t/ha for the irrigated crop (Figure 2). Follow-up irrigation trial treatments were scheduled for pre-flowering and early pod-fill to maximise yield. However, due to the early rainfall only one irrigation (at pod fill) was applied (Figure 1).

The combination of low starting N (52 kg N/ha), high rainfall and mild temperatures resulted in a response to applied N. Both the irrigated and dryland trials show an upwards trend as nitrogen rates increased. The irrigated trial recorded statistically significant yield increases when N was applied compared to the zero N treatments. The 150 kg N/ha was significantly higher than zero N + incoc treatment by ~250 kg/ha, but was not significantly different to the other N rates except for 60 kg N/a. Both trials had the same starting water and experienced the same conditions; the only difference was one timely irrigation that resulted in an 850 kg/ha yield benefit (Figure 2).

Although no significant results were recorded, there was an upwards trend of increasing biomass as N rates increased (data not shown).

A major focus of this research was the impact varying amounts of mineral soil nitrogen have on nitrogen fixation. There was a significant difference between treatments (Figure 3). Both the uninoculated and inoculated 0 kg N/ha treatments fixed similar amounts of N. This was not surprising as both treatments nodulated, most likely due to background rhizobia in the

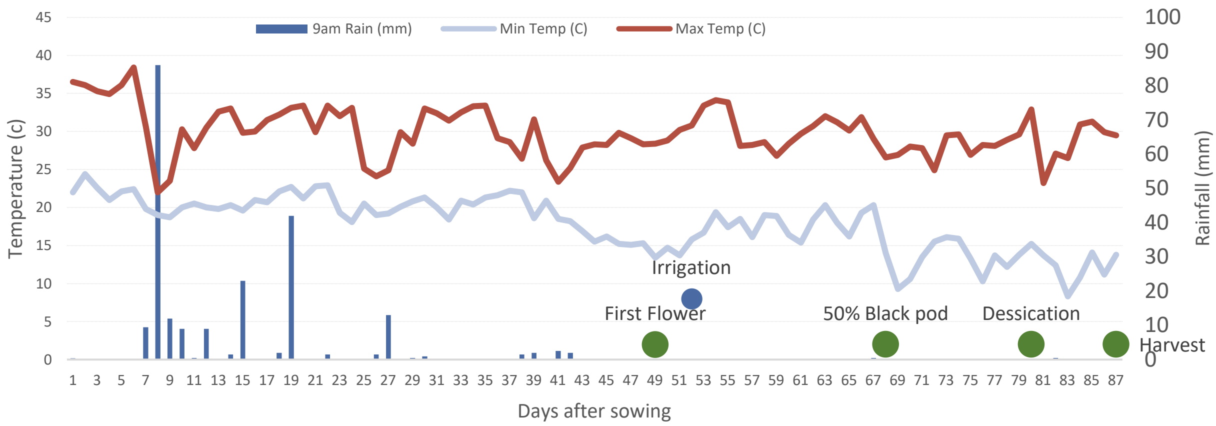

Figure 1. Maximum and minimum daily air temperatures, daily rainfall total, irrigation applications and crop phenology throughout mungbean growth period.

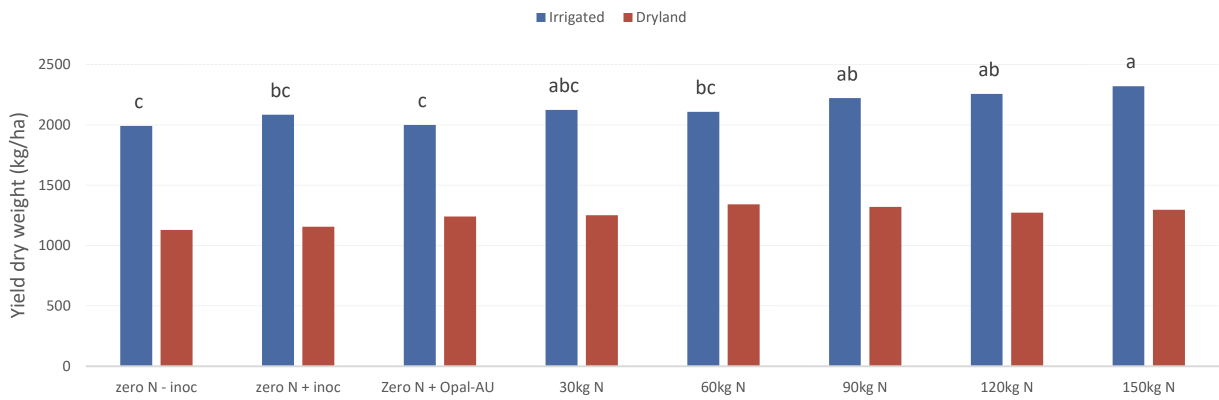

Figure 2. Mungbean yield.
The letters on each bar are presented to show significant differences at P(0.05).

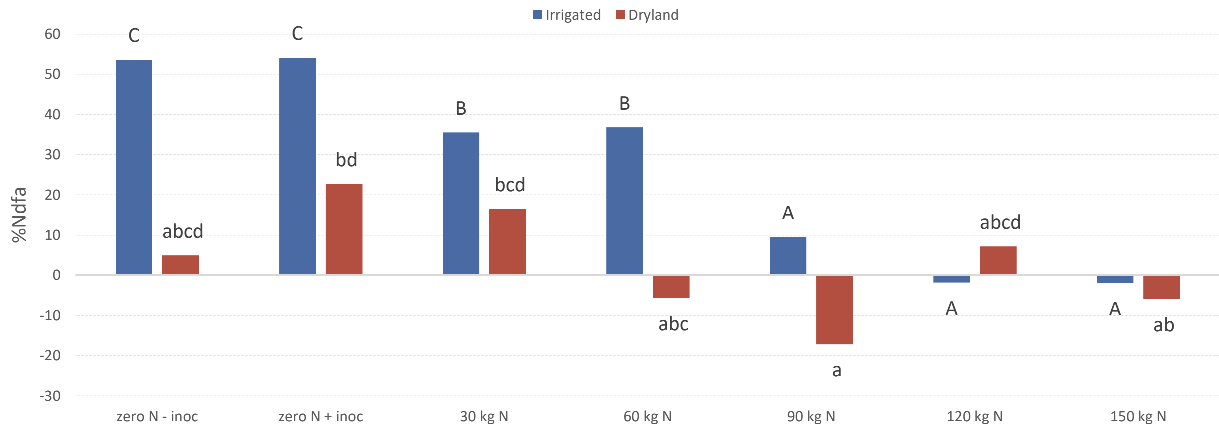

Figure 3. Nitrogen derived from the atmosphere percentage.
Within each experiment, means with same letters are not significantly different at P(0.05), using a protected lsd test.

paddock. The N fixation (%Ndfa) decreased as the N rate increased, with the higher N rates not fixing any N at all. Fixation was greatest in the higher yielding irrigated crop, which also had the lower mineral N at planting. These data confirm that N fixation of mungbean decreases as soil mineral N increases. With very little difference in yield across these treatments, it appears that mungbean can switch from utilising fixed N to nitrate N with no yield penalty.

Irrigation reduced canopy temperature in the trial. After the irrigation was applied at 52 days after sowing (early pod fill, Figure 1), the temperature in the mungbean dropped (Figure 4) and remained below 34 °C until desiccation (79 days after sowing). The maximum difference between canopy temperatures was 12 °C approximately 5 days after irrigation. This cooling effect could be attributed to several factors, including cooling of the soil surface due

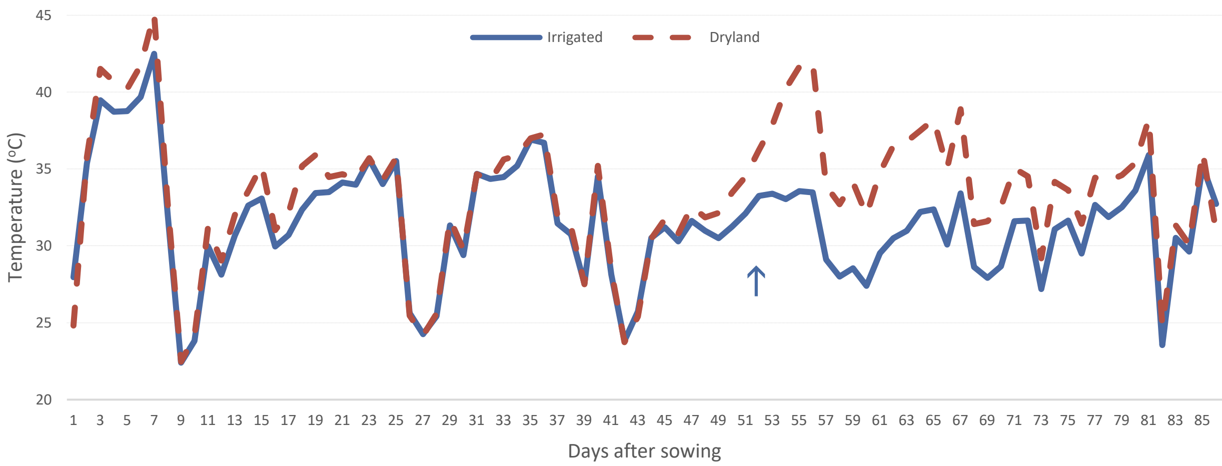

Figure 4. Maximum canopy temperatures. One irrigation was applied at early pod fill 52 days after sowing (indicated by arrow).

to the water, rapid biomass response to irrigation resulting in canopy closure and increased evapotranspiration. Hence, this yield response to irrigation may be due to both increased plant available water (PAW) and a cooler, more humid microclimate during critical times of crop development (flowering and pod fill). Mungbean yield potential begins to significantly decline when temperatures are higher than 33 °C during flowering and pod fill.

Charcoal rot (*Macrophomina phaseolina*) increased during this mungbean crop (Figure 5). A ‘low risk’ rating at planting rose at harvest to a ‘medium risk’ rating for the dryland crop and a ‘high risk’ rating for the irrigated crop.

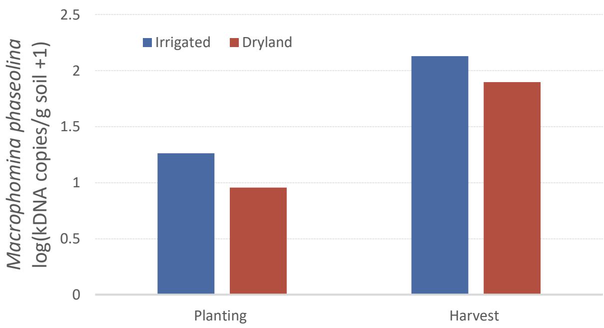

Figure 5. Charcoal rot - log DNA/g soil *Macrophomina phaseolina* at planting and harvest.
Population density levels (from PREDICTA® B manual): below detection <0.3; low 0.3-<1.61; medium 1.61-2; high >2.

Implications for growers

High yielding mungbean (+2 t/ha) can respond to nitrogen fertiliser if less than 50 kg N/ha is available (and accessible) in the soil at planting. However, in normal field conditions when yield potential is below 2 t/ha and available soil N levels are higher, then there is enough N to maximise yield. As N fixation decreases with increasing levels of soil N, it is possible that a mungbean crop will not fix any free N but will instead only utilise soil nitrates. This will reduce the amount of N available for the following crop. Consider measuring starting available nitrates and the yield potential of the crop to determine whether to apply N fertiliser. Inoculation is still recommended to ensure adequate N is available under all N profiles.

Mungbean have high water requirements when evaporative conditions are high (low humidity, high temperatures) and need in-crop rainfall/ irrigation to maximise yield. However, in-crop water may still not maximize yields under very hot conditions during flowering through to pod fill. Plant mungbean on a full soil profile of water and try to time flowering and podding to avoid hot conditions if possible. Often this means planting mungbeans later in summer. Mungbean increases levels of charcoal rot so do not follow with crops (e.g. sorghum) that are susceptible to this disease.

Acknowledgements

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Trial details

Location: Hopeland
Crop: Mungbean
Soil type: Grey Vertosol
Nutrients present in initial soil test:

	0-10 cm	10-30 cm
Phosphorus Colwell (mg/kg)	25	12
Phosphorus BSES (mg/kg)	33.5	14.1
Potassium Colwell (mg/kg)	189	86
Organic carbon (%)	0.89	0.73

In-crop rainfall: 200 mm
Fertiliser: 100 kg MAP/ha, 20-25 cm depth and 50 cm spacing prior to plant
N treatments as described above

Hopeland summer mungbean crop