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

Cameron Silburn and Jayne Gentry
Queensland Department of Agriculture and Fisheries

***Research questions**: How much nitrogen is required to maximise mungbean yield? | Can well-nodulated mungbean achieve the same yield as fertilised crops?*

Key findings

1. Mungbean did not respond to nitrogen fertiliser with a 1 t/ha yield and a starting soil nitrogen of ~90 kg N/ha.
2. Mungbean has limited ability to maintain its water balance in high evaporative conditions. Timely in-crop rainfall/irrigation may still not maximize yields under very hot conditions during flowering to pod fill.
3. Irrigation decreased canopy temperatures by up to 8 °C.
4. Charcoal rot levels increased, with the greatest rise occurring in the irrigated trial.

Background

Over the past two years the Mungbean Agronomy team has 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 is 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. There is further anecdotal industry evidence that mungbean yield increases 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 how the timing and placement of nitrogen impacted 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.

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 conducted in the same field; this report outlines details of the spring 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.

Nitrogen applications were surface spread on 24 September 2019 (Table 1). All treatments were replicated four times and repeated with and without irrigation to alter yield potential. A pre-sowing irrigation (flood) was applied across the site on 3 October 2019 to enable planting. Mungbean was then planted on 14 October 2019 with Jade-AU$^{\Phi}$ at 50 cm row spacing with 40 L/ha of Flowphos 13Z. The 'double starter' treatment had 80 L/ha applied.

The paddock nitrogen status at planting (control plots only) was 58 kg N/ha for the irrigated trial and 89 kg N/ha for the dryland trial. All treatments, except treatment 1, were inoculated at planting through water injection.

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, Double starter	+ 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 irrigated trial received two subsequent irrigations, one at pre-flowering and a second at podding. The crops were harvested on 2 January 2020. AMF levels were low with nematodes detected.

Results

The mungbean crop experienced very hot and dry conditions; a large proportion of days were over 35 °C from flowering to harvest, combined with no significant in-crop rainfall (Figure 1). This resulted in the dryland trial only yielding approximately 300 kg/ha. The irrigated crop however yielded approximately 800 kg/ha, almost 500 kg/ha more from the two irrigations at pre-flowering and mid-pod fill.

All treatments nodulated well, even the non-inoculated treatment. Considerable care was taken to avoid contamination with inoculant in the uninoculated treatment. However, it appears that residual rhizobium in the paddock and soil movement between plots caused nodulation.

It is interesting to note the cooling effect of the irrigations on the mungbean (Figure 2). When irrigations were applied, the canopy temperature rapidly dropped compared to the dryland trial and remained lower for 10 days.

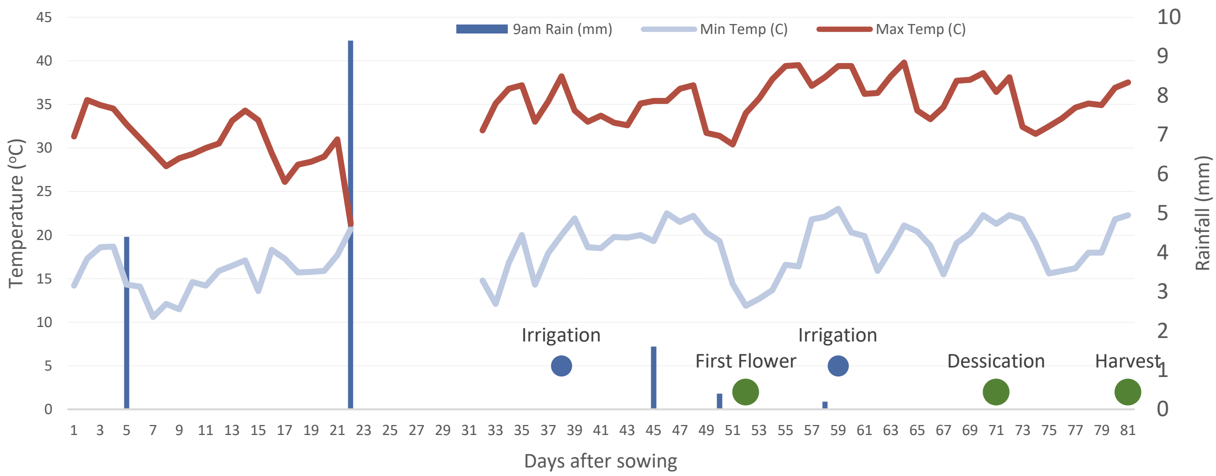

Figure 1. Crop weather. Maximum and minimum daily air temperatures, daily rainfall total, irrigation applications and crop phenology throughout mungbean growth period. Gap in temperatures due to weather station failure.

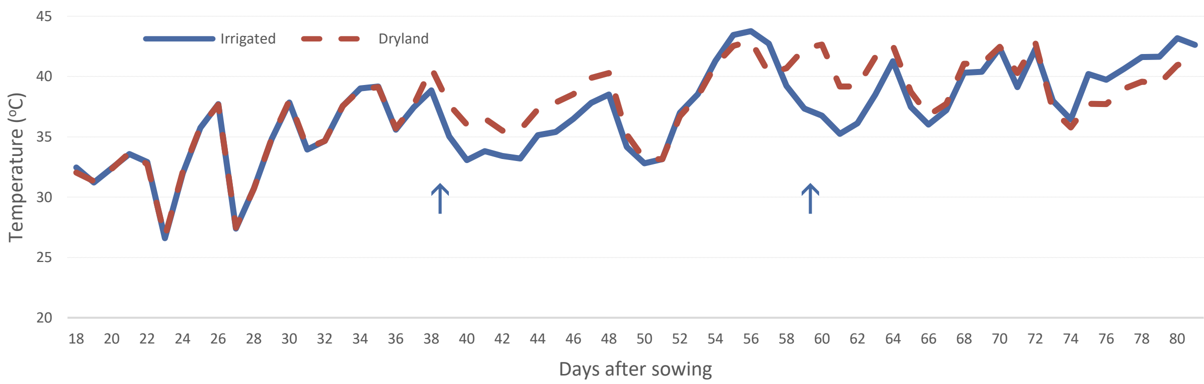

Figure 2. Maximum canopy temperatures. First irrigation at 38 days after sowing, second irrigation at 59 days after sowing (indicated by arrows).

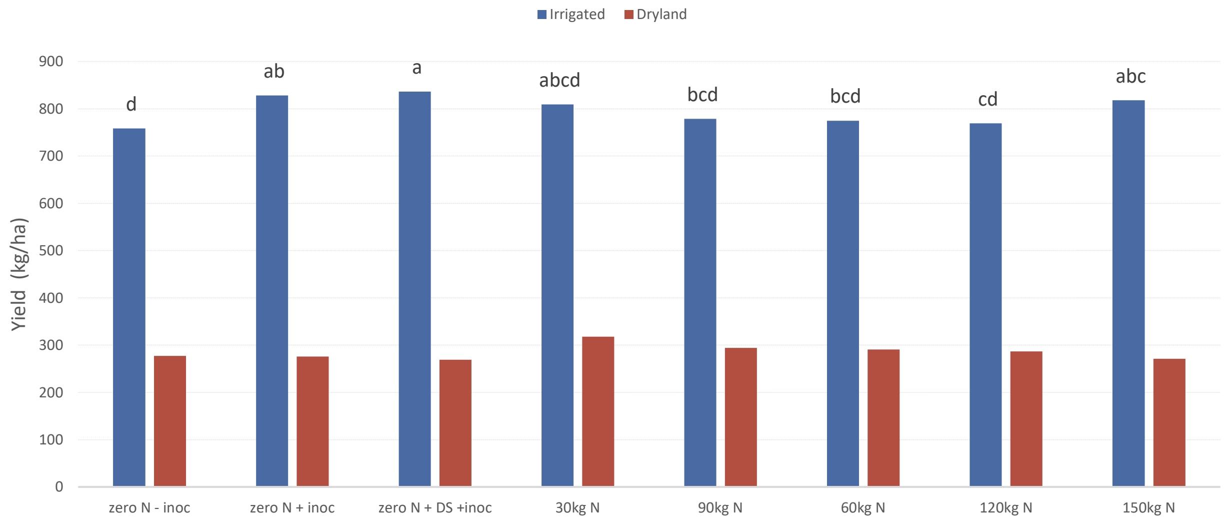

Figure 3. Machine harvested yield.
The letters on each bar are presented to show significant differences at P(0.05).

This cooling effect could be attributed to several factors, including cooling of the soil surface due 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. Critical times include flowering and pod fill; mungbean yield potential significantly declines when temperatures reach more than 33 °C.

There were no significant yield differences between treatments in the dryland crop (Figure 3). This crop was unlikely to record any significant responses to nitrogen, due to severe moisture stress and high temperatures during critical periods of flowering and podding, limiting yield and hence reducing N requirement.

Currently, it is believed that a one tonne mungbean crop requires 60 to 70 kg N/ha. The dryland crop would only have required approximately 20 kg N/ha, so the soil N available at planting (89 kg N/ha) was more than adequate, even before any contribution of fixed N due to nodulation.

The irrigated crop did record significant yield differences. Like the dryland trial, all treatments nodulated. The highest yielding treatments were the zero N + double starter, zero N + inoculant, 30 kg N/ha and 150 kg N/ha. Again, the lack of response to nitrogen is not surprising given the low crop requirements due to an average yield of 800 kg/ha (~55 kg N/ha).

Although inoculant was not applied and all efforts were made to ensure this treatment did not nodulate, its nodulation was most likely due to residual rhizobia in the soil or irrigation

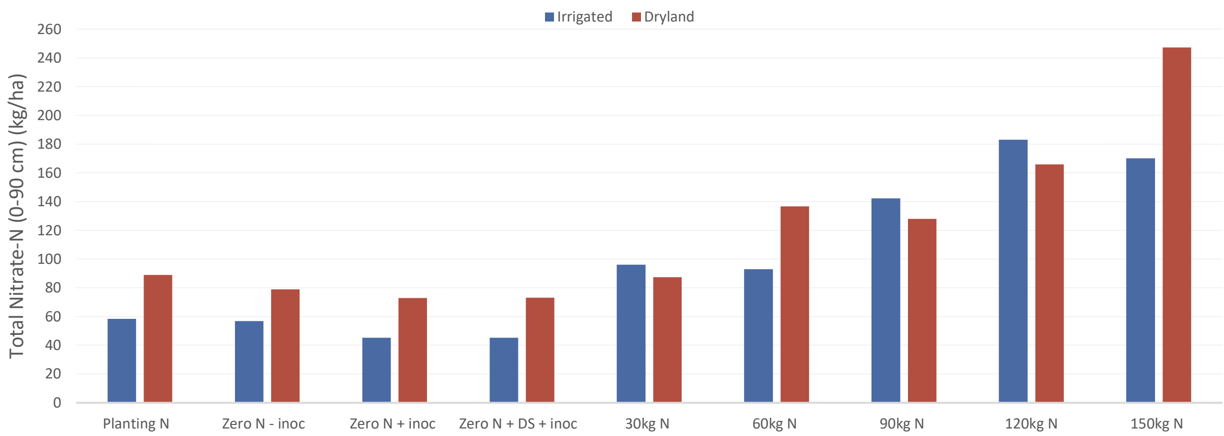

Figure 4. Total soil N status at harvest to 90 cm for dryland and irrigated crops.

water. As a result, the nodules would have been formed later than the other treatments, hence providing fixed N slower and in lesser quantities.

The nitrogen status was also measured after harvest. The harvest soil N results show very little change in N levels in all the zero N treatments (Figure 4).

Biomass samples collected at flowering and maturity didn't show any clear trends towards the application of N (data not shown). The irrigated crop had approximately double the biomass compared to the dryland crop at maturity. Irrigation was clearly able to increase the crop's yield potential, however irrigation alone couldn't maximise yield as the irrigated crop only yielded 800 kg/ha. It appears that the very high temperatures during flowering and pod fill dramatically reduced the yield potential of this crop.

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.

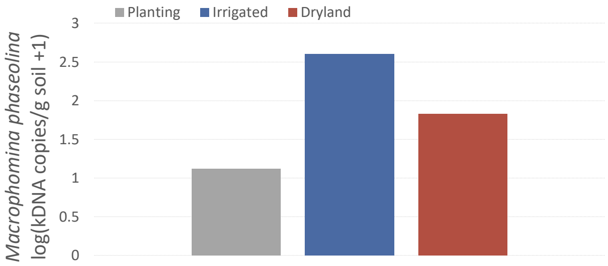

Figure 5. Charcoal rot - log DNA/g soil *Macrophomina phaseolina* at planting (grey) and harvest.

Population density levels (from PREDICTA® B manual): below detection <0.3; low 0.3-<1.61; medium 1.61-2; high >2.

Flood irrigation of spring mungbean 38 days after sowing at Hopeland.

Implications for growers

Mungbean crops of less than 1 t/ha are unlikely to respond to nitrogen fertiliser if ~90 kg N/ha is available (and accessible) in the soil at planting. Yields below this are common as rain and heat often limit yield potential. Hence there is sufficient available N to support this yield, whether it is mineral N or fixed N. Consider the starting available N and yield potential of the crop to determine whether to apply N fertiliser.

Mungbean have high water requirements when weather conditions promote high evaporative demand (low humidity and 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: 15 mm

Fertiliser: 100 kg MAP/ha, 20-25 cm depth and 50 cm spacing prior to plant

N treatments as described above