Optimising
# Irrigated Grains

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

FAR AUSTRALIA

Irrigated Cropping Council
*Promoting irrigated agriculture*

# Key Learnings:

## 2020 and 2021

SOWING THE SEED FOR A BRIGHTER FUTURE

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## Key learnings in:

# GRDC Optimising Irrigated Grains (OIG) Project

## *Project Code:*

### *Key Learnings – 2020 & 2021*

The following key learnings have been derived from growing crops at two irrigated research centres at Finley, NSW on a red duplex soil under surface and overhead irrigation and Kerang, VIC on a grey clay with surface and sprinkler irrigation. The research was conducted in the 2020 and 2021 seasons.

## Grain Maize

### *i) Nitrogen rates and timing targeting 20t/ha for irrigated grain maize*

***Key Points:***

***a) Nitrogen fertilisers***

- ***Grain maize crops yielding 16 - 19t/ha with dry matters of 33 - 35t/ha commonly remove 400kg N/ha from the soil, but in results generated over the last three years these crops do not respond significantly to N fertiliser inputs greater than approximately 250kg N/ha.***
- ***Of the nitrogen removed by the crop canopy at harvest, approximately 30 – 35% of the N is returned to the soil as stover residues, so based on a 400kg N offtake approximately 120 - 140kg N/ha is returned to the soil as harvest residues.***
- ***Applications of nitrogen in excess of 250kg N/ha with up to 550kg N/ha experimented upon in the project have been largely uneconomic; these applications lost up to $400/ha (in the season of application) depending on the price of N fertiliser and the exact rates of N applied.***
- ***If the additional N fertiliser is "N banked" in the soil, then it may be concluded that a proportion of the excess N fertiliser is recovered the following year, but in terms of economics for the grain maize it was not economic to exceed 250kg N/ha applied.***
- ***Fertility of the farming systems as a whole was shown to provide the additional N nutrition required to produce high yielding crops of 33 – 35t/ha biomass and 16 - 19t/ha grain yields.***
- ***Whilst in an irrigated system it is unclear how much of the excess N is available the following season, research conducted indicates that we need to re-think the profitability of such large N doses in excess of 250kg N/ha, or at a minimum take account of soil mineralisation for nitrogen applications in irrigated summer crops, which logically will be higher in wet and warm soils.***
- ***Whilst we cannot "mine" our soils without regard to this contribution, the research has illustrated that in-crop mineralisation in the summer months is an extremely significant contributor to the N budget calculations under irrigation.***
- ***Additionally, if the farming system is returning grain maize residues to the soil these typically contain 120 - 140kg N/ha with high yielding crops.***
- ***The fertility of the farming system will clearly influence how much mineralisable N can be sourced by the crop, however the work conducted in OIG would suggest that growers need to be circumspect with regards to N applications in excess of 300kg N/ha.***
- ***N timing has failed to generate significant yield effects but there has been some evidence to suggest split applications, with an emphasis on later applications (up to tasselling), has been associated with higher grain protein.***
- ***In addition, if large applications were made at sowing as single doses, there was evidence to suggest nitrification inhibitors (eNpower) have a role, but yield increases were not statistically significant.***

Clearly, the level of organic carbon in the soil will vary and contribute different amounts of soil N supply through the course of a season, however the key finding from the OIG project has been our inability to generate significant yield responses up to the levels of fertiliser being applied on farm (250 – 500kg N/ha. The following example graphs indicate at Peechelba (Red loam over clay) and Kerang

(Grey clay) in Victoria the grain yield response to applied nitrogen and the partition of N between stover residue and grain at harvest.

### A) Peechelba East, Victoria – Overhead Irrigation (6.08 Mega L/ha applied)

**Table 1:** Grain yield (t/ha @ 14% moisture) test weight (kg/hL) and harvest index (HI %), 31 May 2020. – Peechelba East, Victoria cv Pioneer hybrid 1756.

| Treatment | | | | Seed Yield and Quality | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-drill kg N/ha | Post drill* kg N/ha | Total kg N/ha | Yield t/ha | | Test Wt kg/hL | | H.I % | |
| **1** | 0 | 207 | **207** | 18.12 | - | 81.0 | - | 49.8 | - |
| **2** | 45 | 207 | **252** | 18.80 | - | 81.0 | - | 50.3 | - |
| **3** | 90 | 207 | **297** | 18.32 | - | 81.3 | - | 46.7 | - |
| **4** | 135 | 207 | **342** | 19.02 | - | 81.2 | - | 45.8 | - |
| **5** | 180 (Farm) | 207 | **387** | 18.63 | - | 81.3 | - | 44.9 | - |
| **6** | 225 | 207 | **432** | 18.12 | - | 81.6 | - | 46.2 | - |
| **7** | 270 | 207 | **477** | 18.54 | - | 80.8 | - | 47.1 | - |
| **8** | 315 | 207 | **522** | 18.34 | - | 81.2 | - | 52.3 | - |
| | **LSD** | | | NS | | NS | | NS | |
| | **Mean** | | | 18.49 | | 81.1 | | 47.8 | |
| | **P Val** | | | 0.991 | | 0.926 | | 0.296 | |
| | **CV** | | | 8.82 | | 1.01 | | 8.99 | |

** Post sowing nitrogen (207 N) was applied via fertigation with applications on V4 (46N), V8 (60N), pre-tasselling (101 N) on 10 Dec, 26 Dec, 14 Jan and Jan 15*
*Available soil N assessed prior to sowing 33 kg N/ha (0-60cm)*
*Harvest index based on grain and stover recorded at 0% moisture*

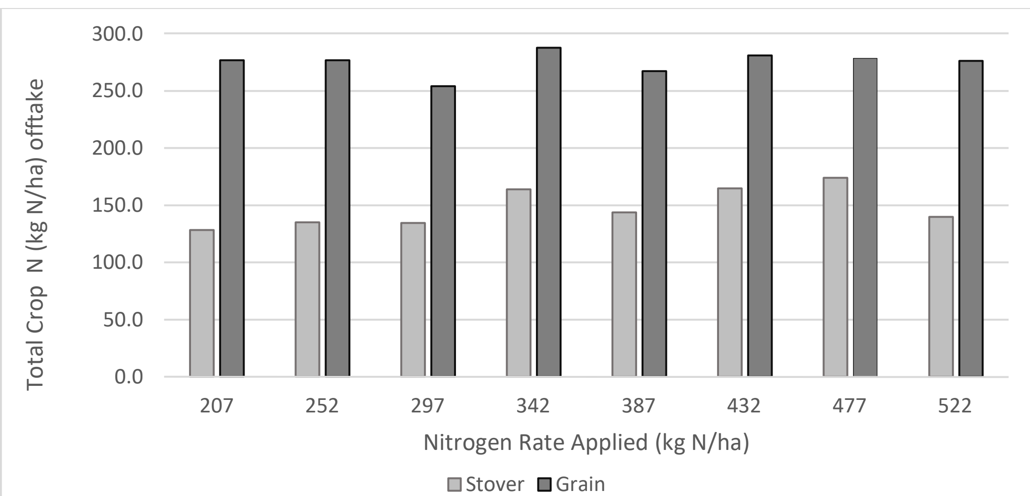


**Figure 1.** Total crop N (kg N/ha) offtake at harvest in the stover (stalks, leaves, husk) and grain 31 May 2020. Peechelba East, Victoria cv Pioneer hybrid 1756.

### B) Kerang, Victoria – Flood Irrigation (9.6 Mega L/ha applied)

**Table 2:** Grain yield (t/ha @ 14% moisture), dry matter (t/ha), test weight (kg/hl) and harvest index, 20 May 2022 cv Pioneer hybrid 1756.

| Treatment | | | Grain Yield, Dry Matter Yield and Quality | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Yield | | DM | | Test Wt | H.I |
| Pre-drill | Post drill | Total kg | t/ha | | t/ha | | kg/hL | |
| **1** 0 | 0 | **Nil** | 10.34 | d | 22.64 | d | 81.7 | 0.40 |
| **a** 40 | 40 | **80** | 11.98 | c | 29.33 | c | 82.7 | 0.36 |
| **3** 80 | 80 | **160** | 15.05 | bc | 33.94 | bc | 83.0 | 0.39 |
| **4** 120 | 120 | **240** | 17.13 | a | 31.42 | ab | 82.0 | 0.47 |
| **5** 160 | 160 | **320** | 16.66 | ab | 32.53 | ab | 80.0 | 0.44 |
| **6** 200 | 200 | **400** | 17.76 | a | 35.56 | ab | 80.7 | 0.43 |
| **7** 200 | 200 | **480** | 17.04 | a | 33.66 | a | 81.1 | 0.44 |
| **8** 280 | 280 | **560** | 17.03 | a | 34.28 | a | 80.9 | 0.43 |
| **LSD Yield** | **(p=0.05)** | 1.659 | **P Val** | | <0.001 | | cv% | 7.3 |
| **LSD DM** | **(p=0.05)** | 3.398 | **P Val** | | <0.001 | | cv% | 5.8 |
| **LSD Test Wt** | **(p=0.05)** | ns | **P Val** | | 0.094 | | cv% | 1.8 |
| **LSD HI** | **(p=0.05)** | ns | **P Val** | | 0.059 | | cv% | 11.0 |

*Figures followed by different letters are considered to be statistically different (p=0.05)*

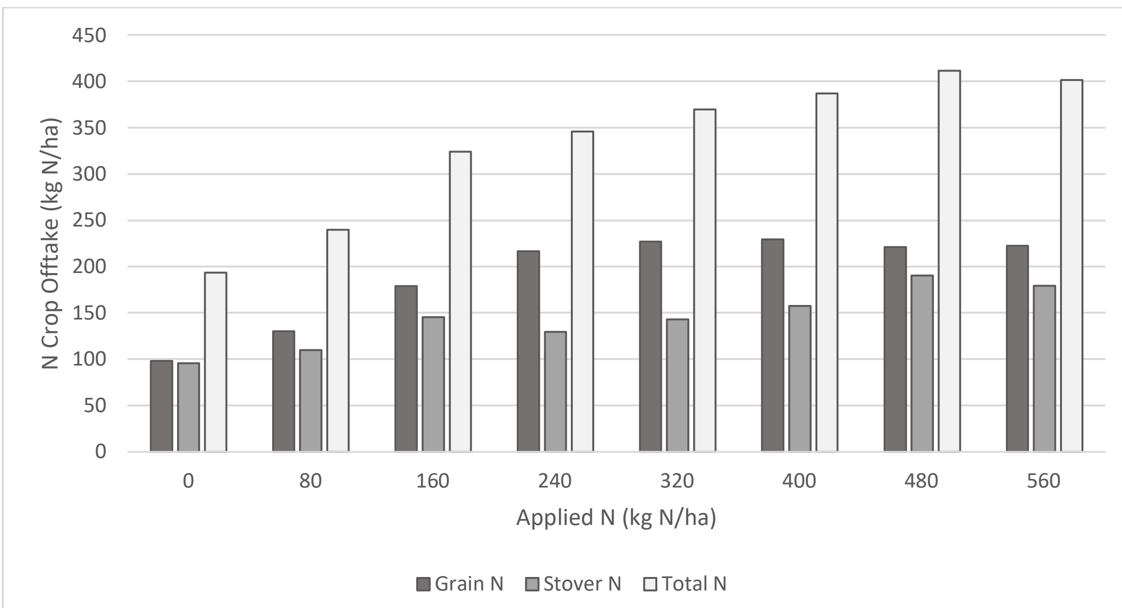


**Figure 2.** Total crop N (kg N/ha) offtake at harvest in the stover (stalks, leaves, husk) and grain 31 May 2022. Kerang, Victoria cv Pioneer hybrid 1756.

***b) Foliar feeding and additional basal fertiliser***

- ***The project with the assistance and support of industry evaluated a number of different foliar applications of both macro and micronutrients in 2021 and 2022 applied in additional to grower standard practice.***
- ***These liquid fertilisers (based on calcium nitrate and Natures K) to date whilst having an effect on biomass have not been observed to increase grain yield. It is hoped that this work can continue in the future.***

### *ii) Crop structure and Plant population*

- ***Results suggested no disadvantage to narrower 500mm row spacing compared to 750mm in OIG project work.***
- ***Advantages of narrower row spacing was more pronounced when plant population was increased, since narrower rows gave better plant spacing within the row compared to wider rows.***
- ***However, the differences in biomass and grain yield between narrow row and wider row spacing were rarely statistically significant.***
- ***For the highest yielding scenarios (18-19t/ha) experienced in the project the optimum population for a cost-effective return with Pioneer hybrid 1756 was approximately 90-93,000 plants/ha.***
- ***Lower yielding maize on maize rotation positions gave optimum populations no higher than this when using the 1756 hybrid.***
- ***Later sowing of grain maize (Pioneer hybrid 9911) in the third week of December did not respond to increasing plant population between 78,000 and 102,000 plants/m$^2$.***

### *iii) Fungicide application in grain maize*

- ***In the five fungicide trials conducted on grain maize there has been no benefit from using either DMI triazole fungicides (prothioconazole) or QoI strobilurin (pyraclostrobin) fungicides in OIG grain maize trials.***
- ***There were no significant yield effects of fungicide application at either V8 (8 leaf) or V14 in the absence of noticeable disease.***
- ***Despite strobilurin fungicides being used that are associated with green leaf retention no such effects were observed in these trials.***

## *Barley under irrigation*

### *i) Germplasm, Crop structure and Plant population*

***Key Points:***

- ***Irrigated barley has benefited from PGR application with greater yield benefits associated with crops that are irrigated earlier in the grain fill period.***
- ***The spring barley RGT Planet (8.13t/ha) has been significantly higher yielding than Cassiopee winter barley (7.83t/ha) when averaged over 2 years (2020 & 2021) and 4 treatments in a plant growth regulator trial at the Finley Irrigated Research Centre (IRC).***
- ***Applying a plant growth regulator (PGR), either as a split application (GS31 & GS33) or as a single application (GS31) resulted in a significantly higher yield (8.40t/ha) compared to the untreated plots (7.79t/ha), averaged over both varieties over two years.***
- ***The winter barley Cassiopee experienced significantly more lodging than RGT Planet and was less suitable for irrigated systems. PGR application did reduce lodging, although in Planet differences in lodging were relatively small.***
- ***PGR application and grazing both had a similar reduction (average 7cm) in crop height compared to the untreated plots when measured over both varieties and both years.***
- ***Defoliation of RGT Planet at GS30-31 to simulate grazing generated 722kg DM/ha RGT and 1937 kg DM/ha in Cassiopee.***
- ***Valued at 25 cents per kg/dry matter the dry matter was valued at $180/ha and $484/ha respectively which in both cases compensated for the loss of grain yield with defoliation.***
- ***Grazing a late April sown Planet required a minimum 4 cents/kg return on dry matter (DM) to offset the grain loss associated with 722kg DM/ha removal at GS30, whilst with Cassiopee it was 8 cents/kg DM when 1937kg DM/ha was removed at GS30. To grow Cassiopee in place of Planet in order to take advantage of the extra forage required 19 cents/kg DM to counter the loss of $359/ha in grain.***

Irrigated barley at the Finley IRC has consistently shown yield benefits to the application of Plant Growth Regulators (PGRs) in the OIG project, even though responses have not always been statistically significant (Figure 1).

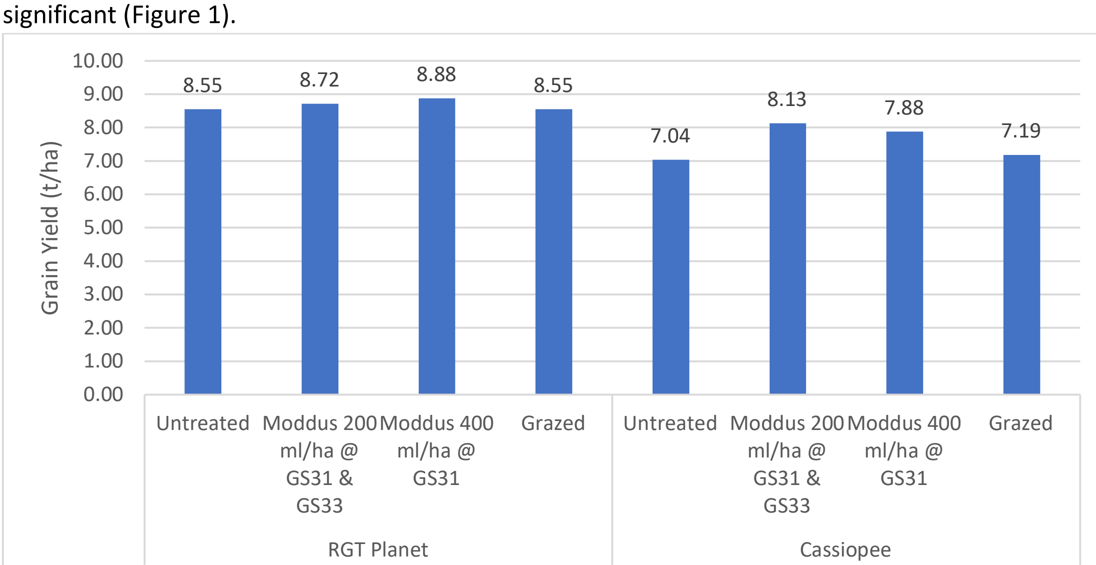

**Figure 1.** Influence of plant growth regulator on seed yield (t/ha) using RGT Planet spring barley and Cassiopee winter barley in 2 irrigated trials conducted at Finley – 2020 and 2021.

These PGRs, either single applications or splits of Moddus Evo (trinexapac ethyl) have been observed to reduce or delay the onset of crop lodging during grain fill. It is this reduction and delay and lodging that is thought to be related to the yield increases that have been observed (Figure 2).

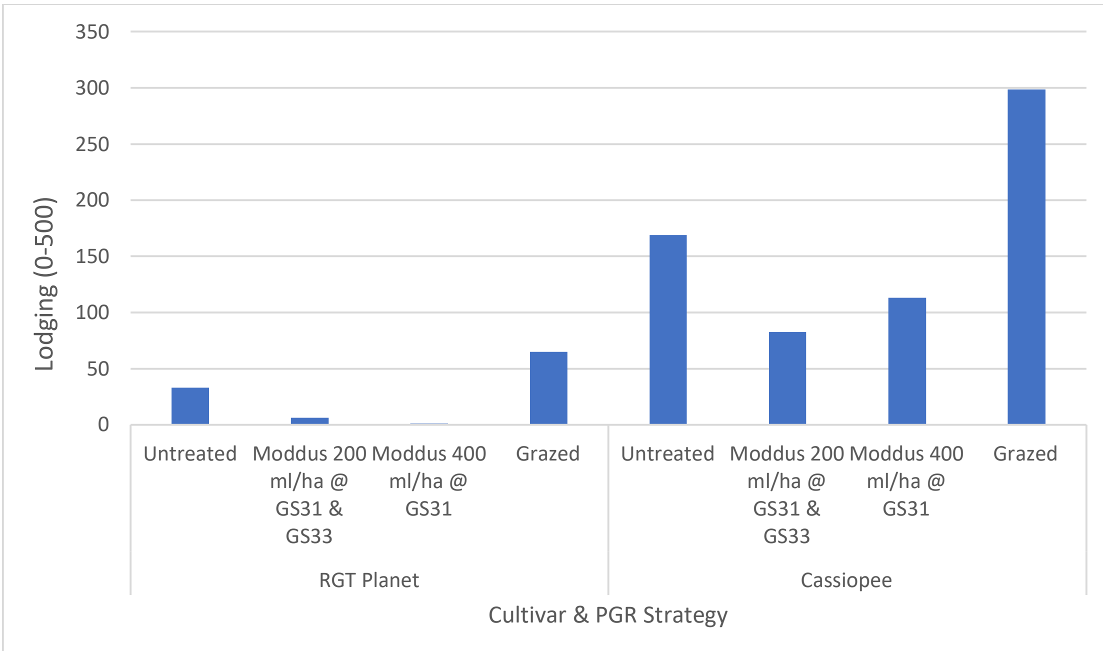


**Figure 2.** Influence of plant growth regulator on crop lodging using RGT Planet spring barley and Cassiopee winter barley in 2 irrigated trials conducted at Finley – 2020 and 2021.

Defoliation of the crop at GS30-31 (start of stem elongation) to mimic the effect of grazing produced significantly more dry matter with the winter barley that reached stem elongation later than the spring cultivar Planet (Figure 3).

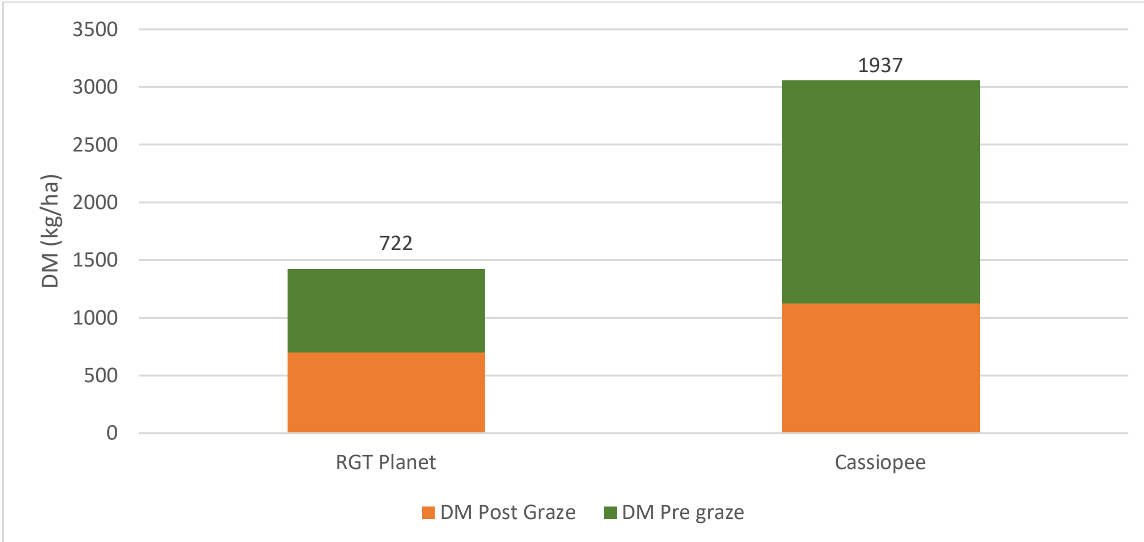


**Figure 3.** Influence of cultivar on dry matter (DM) kg/ha harvested by simulated grazing using a lawn mower to remove biomass at GS30-31 in two years of trials at Finley – 2020 and 2021. Figures above bars show the amount of biomass removed by simulated grazing.

The return in $/ha from PGR application with Planet was marginal, since the split application of Moddus (GS31 and GS33) was less cost effective than the untreated, whilst the single application (GS31) was slightly more cost effective. With the weaker strawed winter barley Cassiopee both single and split applications were very cost-effective applications (Table 1).

**Table 1.** Net income after PGR treatment, exclusive of grazing income.

| Cultivar | Treatment | Yield (t/ha) | Gross Income[1] ($/ha) | PGR cost[2] ($/ha) | Net Income[3] after PGR ($/ha) |
|---|---|---|---|---|---|
| **RGT Planet** | Untreated | 8.55 | 2052 | - | $ 2,052 |
| | Moddus Split GS31 & GS33 | 8.72 | 2092 | 61.72 | $ 2,030 |
| | Moddus @ GS31 | 8.88 | 2130 | 46.72 | $ 2,083 |
| | Grazed | 8.55 | 2052 | - | $ 2,052 |
| | | | | | |
| **Cassiopee** | Untreated | 7.04 | 1688 | - | $ 1,688 |
| | Moddus Split GS31 & GS33 | 8.13 | 1950 | 61.72 | $ 1,888 |
| | Moddus @ GS31 | 7.88 | 1890 | 46.72 | $ 1,843 |
| | Grazed | 7.19 | 1724 | - | $ 1,724 |

*[1]Gross income based on $240/t for feed barley delivered Finley, (protein was above 12% for all treatments in these trials and therefore unable to achieve malt quality). [2]PGR cost based on Moddus Evo at $79.30/L and application cost of $15/ha. [3]Net income has no other costs of production included only the PGR costs and its application cost.*

Table 1 does not include the value of dry matter grazed at GS30-31. In Table 2 the value of the reduction in grain yield is equated to a value for DM to justify grazing. In RGT Planet only 4 cents/kg DM was required to offset grain loss associated with removal of 722kg DM at GS30. With Cassiopee where defoliation produced nearly 2 t/ha DM the grain loss at harvest was greater (0.94t/ha compared to PGR treated) and 8 cents/kg DM was required to offset grain loss compared to the most effective PGR treatment or to warrant growing Cassiopee instead of RGT Planet 19 cents/kg DM.

**Table 2.** Grazing value required to ensure same income as ungrazed, PGR treated plots grain yields

| | | | **Penalty for grazing cf. highest net income ($/ha)** | | **c/kg required from GS30 DM to offset grain loss** | |
|---|---|---|---|---|---|---|
| **Cultivar (Grazed)** | Net Income ($/ha) | Grazed DM (kg/ha) | cf. Planet ($2083/ha)[1] | cf. Cassiopee ($1888/ha)[2] | $2083/ha | $1888/ha |
| **RGT Planet** | $ 2,052 | 722 | -31 | | $ 0.04 | |
| **Cassiopee** | $ 1,724 | 1937 | - 359 | -164 | $ 0.19 | $ 0.08 |

[1]Gross income achieved with RGT Planet and single PGR application. [2]Gross income achieved with Cassiopee and split PGR application.

cf. Compared to

## *Canola under irrigation*

### *i) Crop structure and Plant population*

***Key Points:***

- ***The penalty for growing canola crops that are too thin is significant under irrigation.***
- ***At $700/t the influence of thinner canola populations can result in productivity losses of $448-$532/ha.***
- ***Under irrigation it's better to have hybrid canola populations that are too thick than too thin when assessing seedbed conditions and establishment.***
- ***80 seeds/m$^2$ resulting in plant populations averaging 43-45 plants/m$^2$ were the most profitable populations tested under surface and overhead irrigations systems.***
- ***If autumn surface irrigation 80-100mm (0.8-1.0 Mega litre) was followed by heavy winter rainfall on poorly drained red duplex soil, canola establishment could be severely reduced (2-9 plants/m$^2$) and productivity reduced to yields of 1-2.5t/ha.***
- ***Under irrigation at Finley on a red duplex soil the yield advantage of RR hybrid over TT hybrid has been 17% (0.64t/ha) resulting in a $488/ha increase in productivity at $700/t.***
- ***In the warmer irrigation region of Kerang on grey clay the advantage of the RR hybrid has been approximately half that observed at Finley with a yield advantage valued at $231/ha.***
- ***Higher plant populations resulted in test weights that achieved the minimum standard (62kg/hL) which was not the case with the lowest TT plant populations tested.***

***Crop structure and Plant population***

Growing canola under irrigation with the aim of producing 5t/ha has illustrated significant penalties in yields and margins from growing crops that are too thin. With higher yield potential under irrigation small differences in plant population have a "magnifying" effect in terms of yield. With plant populations below the optimum there are significant yield penalties, whilst in the same varieties' populations that might be regarded as above the optimum have been either equal or higher yielding than the optimum. As a result, dropping to populations between 10-20 plants/m$^2$ can produce a significant drop in productivity compared to plant populations that are above 40 plants/m$^2$ when canola has been grown under irrigation. In the research looking at optimum crop canopy performance for irrigated canola the following key learnings have emerged over the last two years.

*Influence of hybrid RR vs. TT*

- Higher yields under irrigation magnify differences relative to dryland. Roundup Ready hybrid 45Y28 has been consistently higher yielding than the hybrid TT HyTTec. A mean 17% advantage (range 15-18% mean 0.64t/ha) advantage has been observed at Finley Irrigated Research Centre worth $448/ha at $700/t.
- The advantage of 45Y28 over HyTTec Trophy in the warmer region of Kerang on grey clay was approximately half that observed at Finley (9%-0.33t/ha) worth $231/ha.

*Influence of plant population*

- Roundup ready hybrid 45Y28 has shown 15% higher productivity (mean of 0.64t/ha) from an average plant population of 45 plants/m$^2$ (based on 80 seeds/m2) compared to populations of 14 plants/m$^2$ (based on 20 seeds/m$^2$) (Figure 1). Thicker canopies based on 45 plants/m$^2$ under irrigation generated a $448/ha return for an investment of approximately $110/ha in extra hybrid seed planted (additional 3kg/ha seed). Approximately $4 return for each $ spent on additional seed.

- The differences in hybrid TT populations under irrigation produced even greater differences in productivity and again illustrated that growing crops with higher plant populations was important to secure the additional productivity offered by irrigation. Hybrid TT HyTTec Trophy has shown 23% higher productivity (mean of 0.76t/ha) from a mean population of 43 plants/m$^2$ with this thicker crop generating an additional $532/ha return from a similar $110/ha investment in additional seed. Approximately $5 return for each $ spent.

*Influence of irrigation system (relative to winter rainfall)*

- The poorest yield results so far observed in the project resulted from autumn irrigation immediately post sowing in early May following sowing in late April. Poor drainage and flow of surface irrigation at the Finley site led to early winter water logging and very low plant establishment. Crop establishment that fell to between 2-9 plants/m$^2$ yielded 0.83-2.67t/ha with 45Y28 and 3-7 plants/m$^2$ with HyTTec Trophy yielding 1.14-1.71t/ha.

The results illustrate that under irrigation the penalty of growing crops too thinly is increased with very large losses of income if population falls to 10-15 plants/m$^2$. Although hybrid plant populations of 25-30 plants/m$^2$ removes much of this penalty, productivity and profitability has been increased further with populations at 40-50 plants/m$^2$, despite the additional cost of seed.

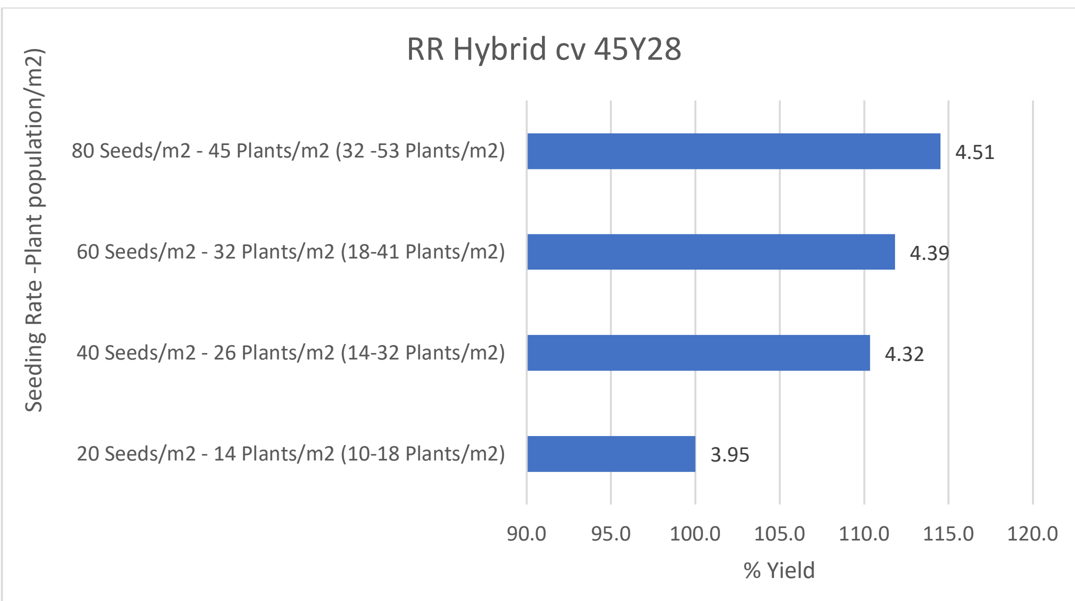


**Figure 1.** Influence of plant population on seed yield (t/ha) using the RR hybrid 45Y28 in 6 irrigated trials conducted at Finley and Kerang – 2020 and 2021.

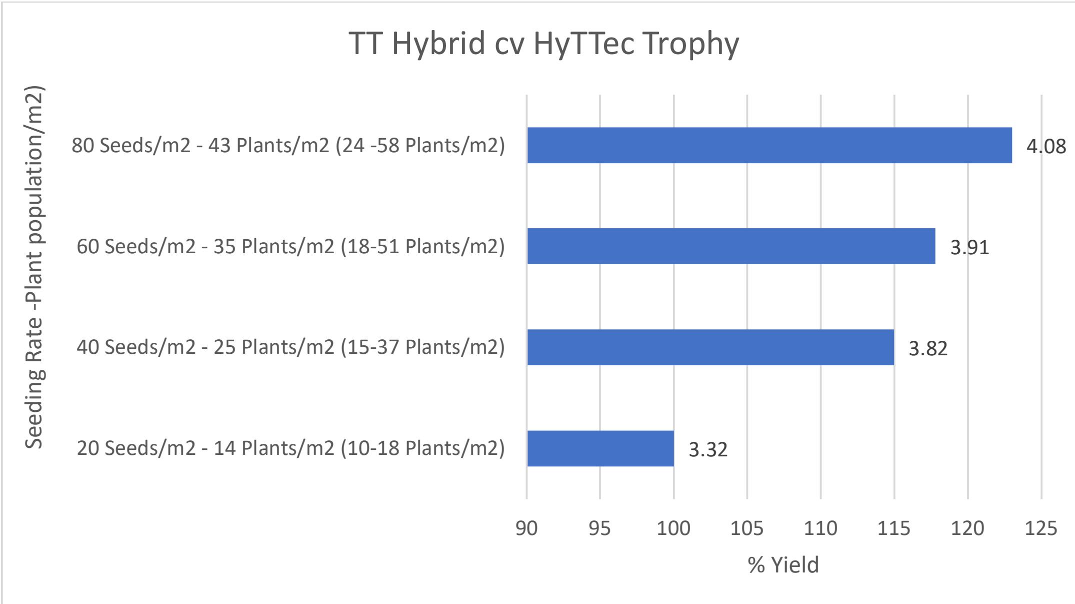


**Figure 2.** Influence of plant population on seed yield (t/ha) using the TT hybrid HyTTec Trophy in 6 irrigated trials conducted at Finley and Kerang – 2020 and 2021.

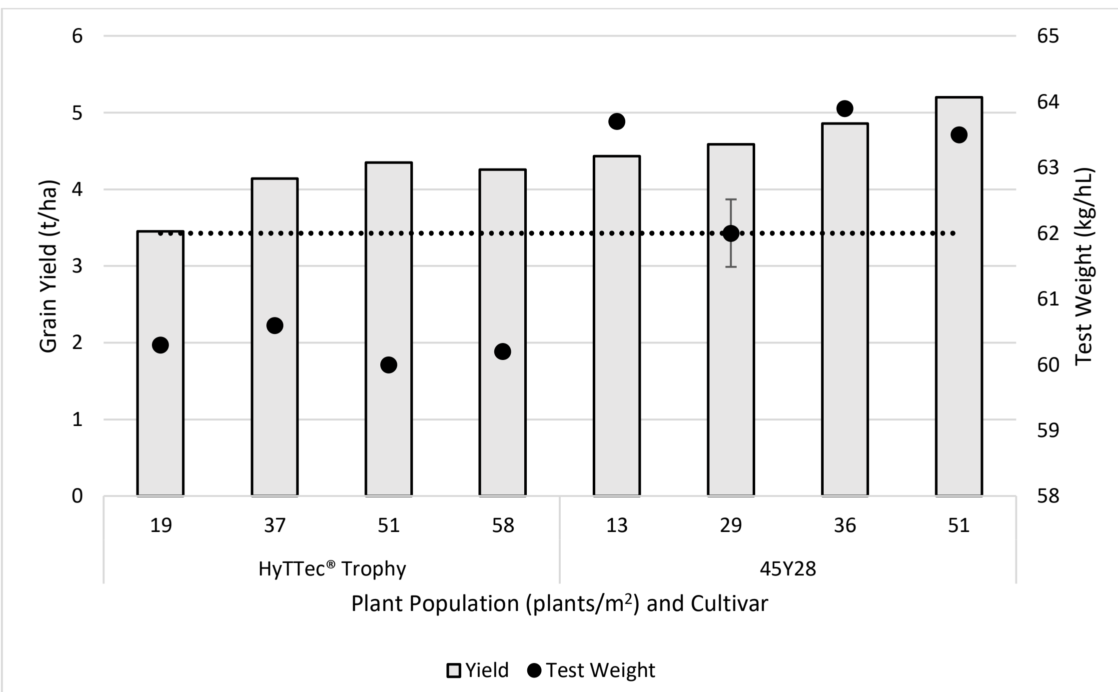


**Figure 3.** Influence of plant population and cultivar on seed yield (t/ha) and test weight (kg/hL) using the TT hybrid HyTTec Trophy - Finley 2021.

### ***ii) Nitrogen applications for 5t/ha irrigated canola***

***Key Points:***

- ***Growing 5t/ha canola crops under irrigation does not require very large quantities of artificial nitrogen, it requires a fertile farming system that enables large crop canopies to draw down from a high soil N reserve in order to satisfy crop demand.***
- ***Optimum N rates in OIG project trials required to grow 4-5t/ha canola crops have not exceeded 240kg N/ha applied as N fertiliser (urea 46% N).***
- ***At Finley 200kg N/ha would be an appropriate target with a range of 160-240kg N/ha (upper end of range with low soil fertility or lower rate of range with high fertility).***
- ***In trials conducted so far there have been few, if any differences in seed yield due to N timing with N rate being the most important. Timings of 6 leaf, green bud and yellow bud using split applications have had little difference to yield or oil content so far.***
- ***When crops respond to higher levels of N input (above 240kg N/ha) it is often where crops cannot efficiently access the N fertiliser applied, a common occurrence in dryland scenarios. With irrigated crops the efficiency of N applied is improved considerably.***
- ***The highest yielding irrigated canola crops in the project have been produced in paddocks where inherent fertility is high with applied artificial N rates typically no more than 160-240kg N/ha at Finley and 80-120kg N/ha at Kerang.***
- ***These fertile irrigated paddocks can often produce reasonable crops with little or no artificial N as soil N mineralisation provides a greater proportion of the N supply e.g. Finley and Kerang 2020 yields were in excess of 3t/ha achieved with only MAP at sowing.***

During 2020 at Kerang on grey clay canola yields varied from 3.00-3.63 t/ha based on 0 to 320kg N/ha applied with an optimum of 80kg N/ha. In 2021 from the same N range the canola yields were 2.74-4.36t/ha with an optimum of 120kg N/ha. In Finley during 2020 yields ranged from 3.91-4.71t/ha (Figure 4) with an optimum of 160-200kg N/ha and in 2021 from 2.21-4.22 t/ha with an optimum of 240kg N/ha from the same yield range.

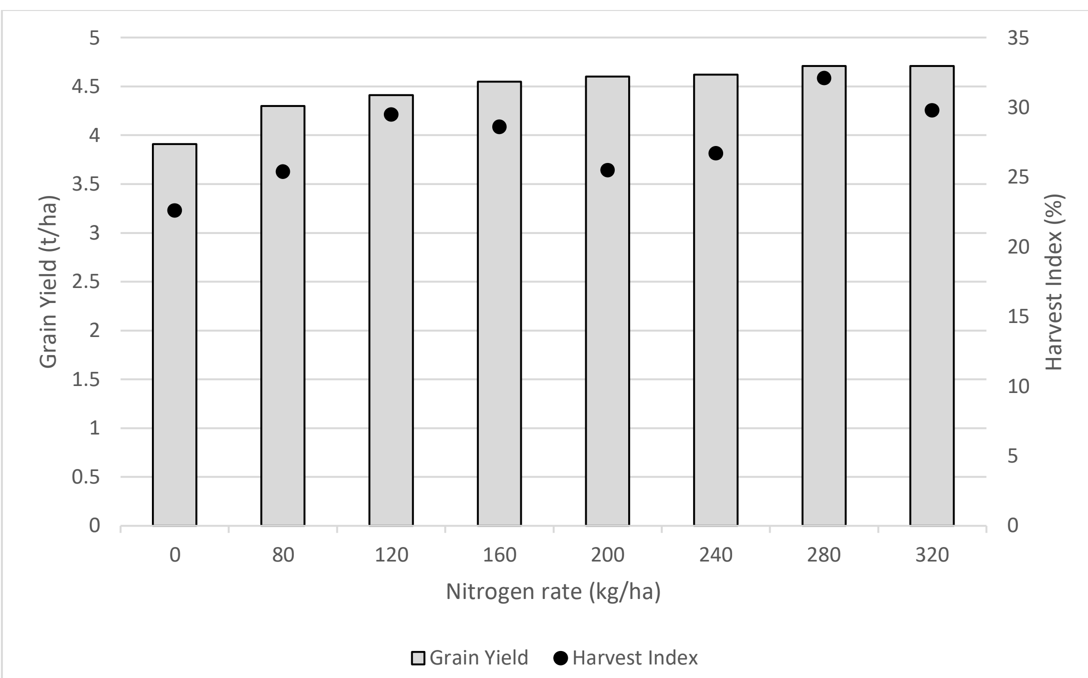

**Figure 4.** Influence of applied N rate on seed yield (t/ha) and harvest index (%) – cv RR Hybrid 45Y28, Finley, NSW 2020

### *iii) Disease management in irrigated canola*

***Key Points:***

- ***To date in the project trials at Finley in 2020 and 2021 the maximum responses to disease management strategies have been relatively small (0.13t/ha and 0.28t/ha) in irrigated canola crops of ATR Bonito.***
- ***The research work conducted on canola has been subject to upper canopy blackleg and crown canker but not sclerotinia.***
- ***In these cases, flutriafol in furrow followed by Miravis at 4-6 leaf has been one of the most effective treatments, although the yield increases have been small and only statistically significant in 2021.***

### *iv) PGR management – controlling crop height and lodging*

Experimental PGR applications (based on a gibberellin inhibitors) have been successfully employed to reduce crop height in irrigated canola, however the effects of the PGR which have been manifest at flowering have largely worn off by harvest. So far, these transient reductions in crop height have not been associated with any improvement in seed yield.

## *Chickpeas under irrigation*

### *i) Crop structure and Plant population*

***Key Points:***

- ***Chickpea yields under irrigation have reached yields over 4.0t/ha.***
- ***35 seeds/m$^2$ resulting in plant populations averaging 21-25 plants/m$^2$ were the most profitable populations tested under surface and overhead irrigations systems from a late April sowing.***
- ***The influence of lower chickpea populations can result in productivity losses of 1.0t/ha.***
- ***Higher yields have come from April sowing compared to May sowing. Where sowing is delayed, populations need to be increased to 35 plants/m$^2$.***
- ***Yields have not been stable between the two years of trials. Yields from the Finley site were approximately half in 2021 compared to 2020, with the overhead irrigation suffering the higher yield reduction. Kerang 2021 yields were similar between seasons.***
- ***Lodging has been observed in higher plant populations, but this is also influenced by cultivar choice.***

***Crop structure and Plant population***

Growing chickpeas under irrigation has demonstrated that there are yield penalties for crops that have reduced biomass. With early pod set determined by temperature (>15 degree C) and grain fill impacted by high temperatures later in spring, there is a window of opportunity for maximising yield by taking advantage of higher biomass promoted by higher seeding rates or earlier sowing (Figure 1).

### *ii) Inoculation of Chickpeas*

***Key Points:***

- ***As chickpeas require a specific inoculum (Group N), it is highly recommended that seed be inoculated before sowing.***
- ***Using higher rates of Alosca granules resulted in increased nodulation in 2020 but there was no advantage to higher rates over 10kg/ha in 2021. Untreated plants had few root nodules.***
- ***While yields were lower in the untreated plots, there was no statistically significant difference between inoculated and uninoculated crops in the trials.***
- ***Applying artificial nitrogen (40kg N/ha) has not influenced nodulation in research conducted so far, but equally it hasn't been associated with yield increase.***
- ***High soil N at sowing may have the effect of removing some of the reliance on nitrogen fixed by the crop.***

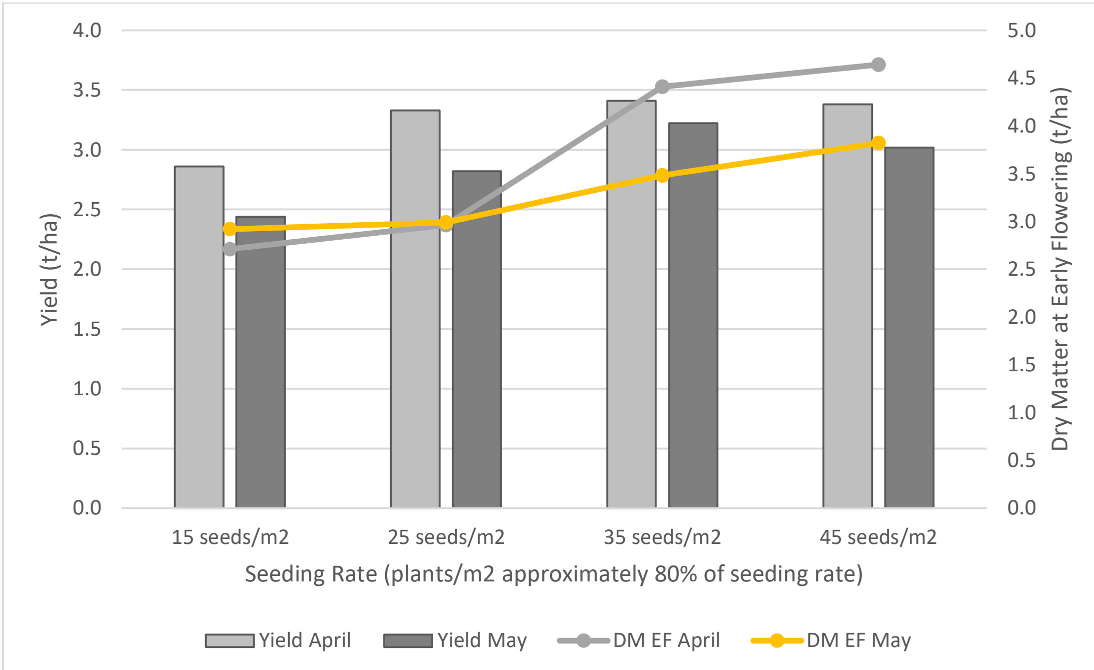


**Figure 1**: Chickpea yield (t/ha) and dry matter (t/ha) at early flower (EF) averaged from two cultivars – Finley, NSW cv Genesis 090 and PBA Royal.

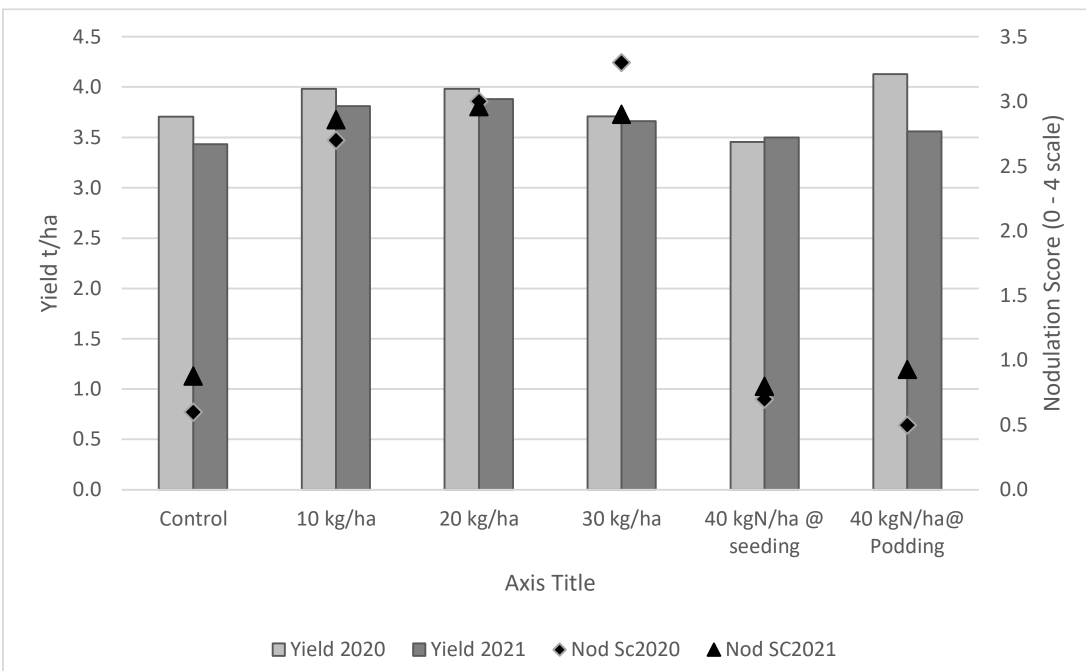


**Figure 2**: Influence of inoculant (ALOSCA granules) rate (kg/ha) and applied nitrogen kg N/ha on chickpea yield (t/ha) and Nodulation Score (NodSc) from the Kerang, Vic 2020 and 2021 trials – cv PBA Royal.

Inoculation has resulted in a significant improvement in nodulation scores assessed 9 weeks after sowing. However, the grain yields have not followed a similar trend, with yields regarded as statistically similar.

### *iii) Disease management in irrigated chickpeas*

**Key Points:**

- ***Chickpeas have been more susceptible to foliar disease, specifically ascochyta, than faba beans at both research sites.***
- ***The disease rating of the cultivar was an important indicator of cultivar yield performance.***
- ***The benefit of an 'Expensive' strategy using a combination of SDHI (group 7) and QoI (Group 11) chemistry gave significantly better disease control and significantly higher yields than 'Cheap' strategy based on chlorothalonil and tebuconazole, but only with PBA Monarch at both sites.***
- ***Genesis 090 showed good response to fungicide but there was far less advantage to the more expensive fungicide strategy.***
- ***While the untreated yields at Kerang were approximately 50% of the yields where disease was controlled, the actual grain produced in the untreated was unlikely to have any commercial value due to the number of small and discoloured chickpeas in the sample.***

The OIG project has been looking at the influence of newer fungicide chemistry in chickpeas grown under either surface or overhead irrigation compared to historic standards using chlorothalonil (Table1).

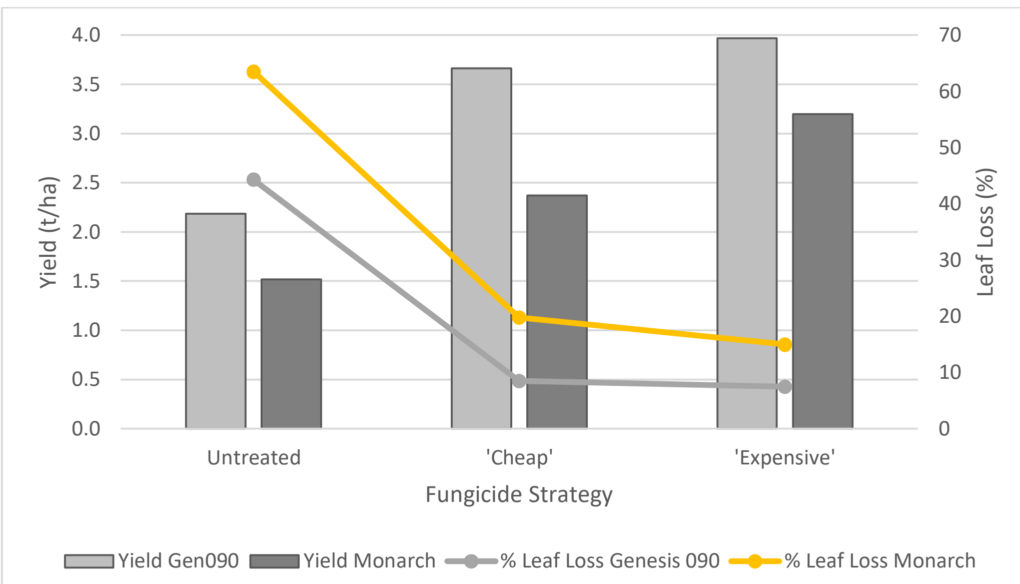


**Figure 3:** Influence of cultivar and fungicide strategy (based on three applications) on yield (t/ha) and % leaf loss – Kerang, VIC, cv Genesis 090 and Monarch.

**Table 1.** Trial treatment summary.

| TRT | Variety | Management Strategy | 4-5 weeks post emergence | Pre-Flower | Late Flower |
|---|---|---|---|---|---|
| **1** | | Untreated* | - | - | - |
| **2** | | Cheap | Chlorothalonil 720 1 l/ha | Chlorothalonil 720 1 l/ha | Chlorothalonil 720 1 l/ha |
| **3** | | Expensive | Veritas 1l/ha | Aviator Xpro 600ml/ha | Veritas 1l/ha |

## *Durum under irrigation*

### *i) Nitrogen (N) strategy for yield and quality*

***Key Points:***

- ***The ability to use irrigation to improve the efficiency of later N timings is ideal for producing a crop that requires high protein levels to achieve the grade required.***
- ***Provisional results illustrate that later N timings of main N doses in durum maintain yield potential whilst at the same time giving high proteins.***
- ***The ability to delay all the N until GS32 (second node) and GS37 (flag leaf just visible) will need to be considered in the light of available soil N in the profile at late tillering and GS30.***
- ***Very low levels of soil N available at GS30 may require a small late tillering dose in order to feed the crop (40N). With high levels of available of soil N this can be delayed until GS32.***
- ***In 2020 at Finley high soil fertility (232kg N/ha in the 0-90cm soil profile at sowing) resulted in no response to applied N fertiliser with no significant difference in grain yield between 28-378kg N/ha applied.***
- ***In a scenario of lower soil fertility in 2021 (measured 47kg N/ha in the soil, 0-90cm, 23rd August) increasing applied N rates (Urea 46% N) from 0-350kg N/ha had no significant effect on grain yield above 100kg N/ha, but to be certain of having 13% grain protein for DR1, N levels had to be increased to 200kg N/ha since 150kg N/ha achieved only 12.5% grain protein.***
- ***A separate adjacent nitrogen timing trial demonstrated that protein above 13% could be achieved with 100kg N/ha by delaying the timing to GS32 and GS37 (Table 1).***
- ***The same trials at Kerang (2020 & 2021), with starting soil N 77-130 kg N/ha, showed that maximum yield was achieved with N rates of 100-200kg N/ha and 13% protein could be achieved with no more than 200kg N/ha if timing was delayed to GS32 & GS37.***

Durum has been an important crop in the OIG research programme over the last two years. The research has covered all aspects of agronomy, but nutrition has been a key component of the work. How can we reliably achieve 7t/ha plus with protein levels that meet the 13% level? Work has been centred on N rates and N timing. In 2020 high residual soil N (232N-0-90cm profile) built up from the drier previous seasons resulted in no yield response for N applied above starter N (28N). In 2021 soil available N was much lower at the start of spring (47N-0-90cm) and there were yield responses up to 100kg N/ha with 13% grain protein achieved at 200kg N/ha applied (Figure 1). A separate adjacent nitrogen timing trial demonstrated that protein above 13% could be achieved with 100kg N/ha by delaying the timing to GS32 and GS37 without sacrificing yield. (Table 1). At both Kerang and Finley similar findings have been identified with regards to later N timings under surface and overhead irrigation whereby later N timings give the optimum combinations of yield and grain protein.

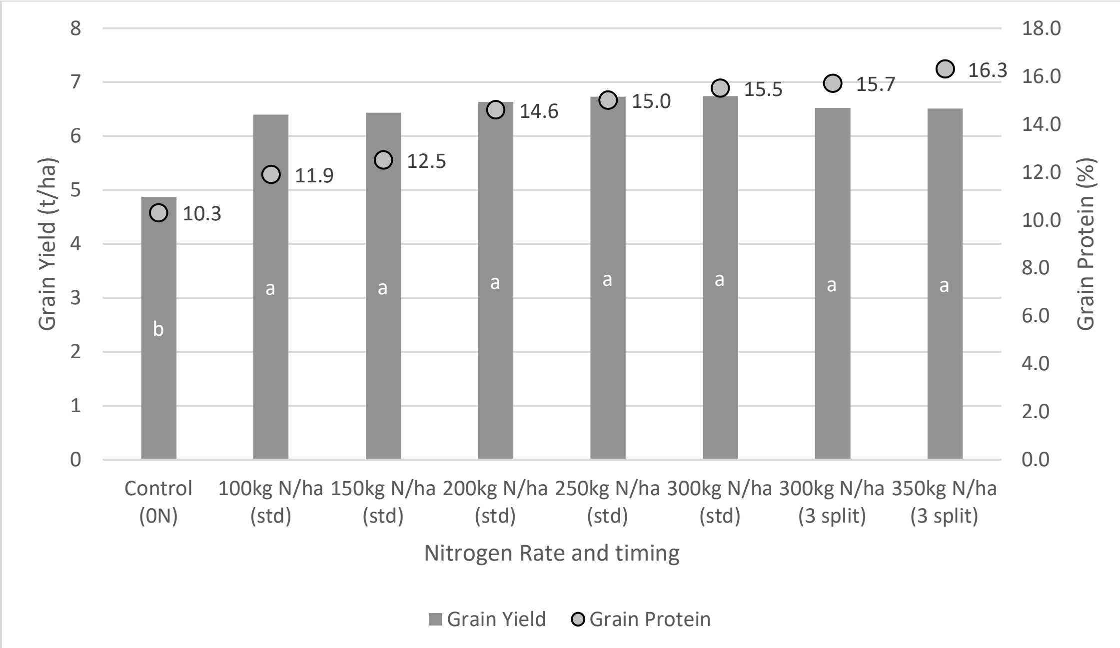


**Figure 1.** Influence of applied nitrogen at stem elongation on grain yield (t/ha) and protein content (%). – Finley 2021 Notes. Std – nitrogen split 50:50 between GS30 and GS32. 3 split – 100kg of nitrogen withheld until GS39 with the remainder split 50:50 between GS30 and GS32. *Yield bars with different letters are considered statistically different*

**Table 1.** Influence of N rate and timing strategies on grain protein (%) based on split application rates (0-300kg N/ha).

| | Nitrogen Application Rate | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0kg/ha N | | 100kg/ha N | | 200kg/ha N | | 300kg/ha N | | Mean | |
| **Nitrogen Timing** | **Protein %** | | **Protein %** | | **Protein %** | | **Protein%** | | **Protein%** | |
| **PSPE & GS30** | 10.9 | - | 12.4 | - | 13.8 | - | 15.0 | - | **13.0** | **b** |
| **GS30 & GS32** | 10.6 | - | 12.5 | - | 13.7 | - | 15.0 | - | **13.0** | **b** |
| **GS32 & GS37** | 10.9 | - | 13.4 | - | 15.3 | - | 16.4 | - | **14.0** | **a** |
| **Mean** | **10.8** | **d** | **12.8** | **c** | **14.3** | **b** | **15.5** | **a** | | |
| | | | | | | | | | | |
| **N Timing** | | | LSD | | 0.4 | | **P val** | | <0.001 | |
| N Rate | | | LSD | | 0.5 | | **P val** | | <0.001 | |
| N Timing x N | | | LSD | | ns | | **P val** | | **0.235** | |

Soil N available – 47kg N/ha 0-90cm

### *ii) Crop lodging control and use of PGRs*

**Key Points:**

- ***Aurora durum is prone to greater lodging problems during grain fill than Vittaroi.***
- ***PGR applications at Finley and Kerang in 2020 and 2021 in Aurora have consistently resulted in a reduction in both crop height and lodging during grain fill.***
- ***At Kerang in 2021, treatments where Moddus at 200ml/ha and Errex at 1.3l/ha were applied at various timings gave an average yield increase of 1.97t/ha over the untreated control plots (Table 1).***

Four trials were conducted at 2 sites (Finley and Kerang) over 2 years (2020 and 2021). Moddus Evo mixed with Errex and an unregistered experimental product were used at various rates and timings. A grazing treatment was added where plots were mowed twice (GS22 and GS30) to simulate grazing. Responses to plant growth regulator (PGR) chemicals have resulted in a reduction in crop height and reduced lodging. The yield results have varied from 0-2.04t/ha. In most cases grazing has led to a reduction in lodging, however it almost always led to reduction in yield compared to the highest yielding plots in each trial. Table 1 illustrates the trial where the biggest penalty to not using a PGR occurred.

**Table 1.** Influence of PGR strategy on Grain yield (t/ha) and Screening (%) - Kerang 2020 cv Aurora.

| **PGR Treatment** | | | **Grain yield and quality** | | | |
|---|---|---|---|---|---|---|
| | | | **Yield** | | **Plant Height** | |
| **No.** | **Product and Rate** | **Timing** | **t/ha** | | **cm** | |
| **1.** | Untreated | | 7.61 | d | 100 | a |
| **2.** | Moddus Evo 200mL/ha + Errex 1.3L/ha | GS31-32 | 9.49 | ab | 83 | ef |
| **3.** | Moddus Evo 100mL/ha + Errex 0.65L/ha<br>Moddus Evo 100mL/ha + Errex 0.65L/ha | GS30<br>GS32 | 9.59 | ab | 81 | f |
| **4.** | Errex 1.3L/ha<br>Moddus Evo 200mL/ha | GS30<br>GS32 | 9.65 | a | 86 | de |
| **5.** | Errex 0.65L/ha<br>Moddus Evo 100mL/ha | GS30<br>GS32 | 8.17 | cd | 98 | ab |
| **6.** | Moddus Evo 200mL/ha + Errex 1.3L/ha<br>FAR PGR 20/01 0.75 L/ha | GS31-32<br>GS39 | 9.64 | a | 81 | f |
| **7.** | Moddus Evo 100mL/ha + Errex 0.65L/ha<br>Moddus Evo 100mL/ha + Errex 0.65L/ha<br>FAR PGR 20/01 0.75 L/ha | GS30<br>GS32<br>GS37 | 8.95 | abc | 84 | ef |
| **8.** | FAR PGR 20/01 0.75 L/ha | GS39 | 7.81 | d | 98 | ab |
| **9.** | Grazing (twice GS22 & GS30) | GS22 &<br>GS30 | 8.61 | abcd | 91 | cd |
| **10.** | FAR PGR 20/01 0.75 L/ha + Errex 1.3 L/ha | GS32 | 8.53 | bcd | 95 | bc |
| | **Mean** | | **8.81** | | **89.7** | |
| | **LSD** | | 1.08 | | 4.52 | |
| | **P val** | | 0.001 | | <0.001 | |

## *Faba Beans under irrigation*

### *i) Crop structure and Plant population*

***Key Points:***

- ***High yielding faba bean crops greater than 7t/ha are achievable under both overhead and surface irrigation systems.***
- ***The penalty for growing faba bean crops that are too thin is significant under irrigation.***
- ***Aiming for populations above the optimum is less risky, with little to no penalty for canopies that are above optimum.***
- ***With plot yields varying from 2.5t/ha to 8t/ha, the older variety Fiesta VF consistently out yielded the newer variety PBA Amberley by 8%.***
- ***Surface irrigation combined with growing season rainfall at both Finley and Kerang was at least 500mm in order to achieve 7t/ha plus. Overhead irrigation systems in 2020 associated with 400mm of GSR and irrigation combined produced only 4-5t/ha with lower pod numbers/m² and harvest dry matter.***

***Cultivar and Population***

Fiesta out yielded PBA Amberley by 8% across the two years of research trials under irrigation. This increased yield is consistent over plant populations that vary from low to high density, however at the high populations (plus 40 plants/m$^2$) PBA Amberley appears to drop in yield slightly.

Irrigated grain yield plateaus at around 30 plants/m$^2$ and there is little gained going above 25 plants/m$^2$. However, when plant populations start dropping below 20 plants/m$^2$ the yield loss can be significant. With higher yield potentials under irrigated cropping systems, the small drops in plant populations have a “magnifying” effect on grain yield loss (loss of approx. 1.5t/ha when dropping from 20 to 10 plants/m$^2$). In contrast, moving from 20-30 plants/m$^2$ increased yield by 0.5t/ha and whilst higher populations were rarely higher yielding, the risk of poorer performance was very slight in comparison to populations dropping below the optimum.

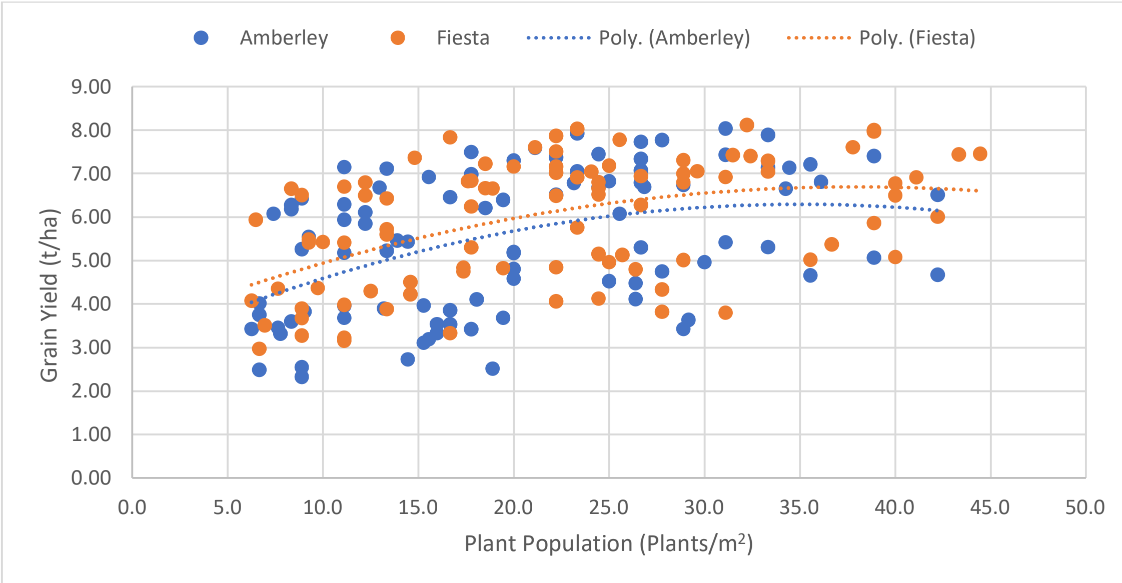


**Figure 1.** The influence of faba bean plant populations on grain yield (t/ha). Data points from 6 trials across 2 years and 2 sites.

If aiming for 20 plants/m$^2$, there are greater negative consequences if populations fall below that target than where populations are higher than the target, even up to 35-40 plants/m$^2$. Therefore, there is less risk of losing yield if aiming for higher populations (25-30 plants/m$^2$) than falling short.

**What makes a 7-tonne crop?**

When growing faba beans under irrigation plant populations is one of many components making up the yield achieved at the end of the season. Other yield drivers include biomass production, stem numbers, pod numbers, seeds per pod and thousand weight (TSW).

Two years of achieving high yielding irrigated faba beans has allowed us to estimate some matrix figures around what makes up a 7+ t/ha faba bean crop. When achieving 7t/ha at our Finley irrigated research site a minimum established population of 20 plants/m$^2$ was the establishment foundation required. From this point, at least 60 stems are required and approximately 8 pods per stem to reach the target of 7t/ha.

**Table 1.** Yield components of a high yielding (+7t/ha) irrigated faba bean crop.

| | Population (plants/m$^2$) | Harvest Dry Matter (t/ha) | Stems/m$^2$ | Pods/m$^2$ | Grain Yield (t/ha) |
|---|---|---|---|---|---|
| **Amberly 2020** | 20 | 13.59 | 60 | 453 | 7.45 |
| **Amberley 2021** | 21 | 11.66 | 60 | 490 | 7.18 |
| **Fiesta 2020** | 27 | 15.15 | 70 | 557 | 7.06 |
| **Fiesta 2021** | 23 | 13.68 | 60 | 624 | 7.23 |
| **Amberley 2020** | 32 | 9.05 | 61 | 351 | 5.17 |

Despite achieving +20 plants and +60 stems/m$^2$ in one trial in 2020, a yield of only 5t/ha was achieved due to lower biomass and pod numbers. In this example irrigation was provided by overhead and the GSR and irrigation combined fell below 400mm, whilst in 2020 the only crops to achieve 7t/ha plus had surface irrigation of approximately 500mm at Finley (Red Duplex) and 580mm at Kerang (Grey Clay).

### *ii) Nitrogen Fixation*

**Key Points:**

- ***Using current estimates, high yielding faba bean crops are removing more nitrogen in the grain than they are supplying in nitrogen fixation.***

Current rules of thumb (for dryland bean crops) for nitrogen fixation are 20kg of N fixed per tonne of dry matter biomass at flowering and estimates of nitrogen removal are 40kg of N per tonne of grain.

Using these estimates, our irrigated faba bean crops are removing up to 300kg N/ha while only supplying 110-190kg N through fixation leaving a large N deficit.

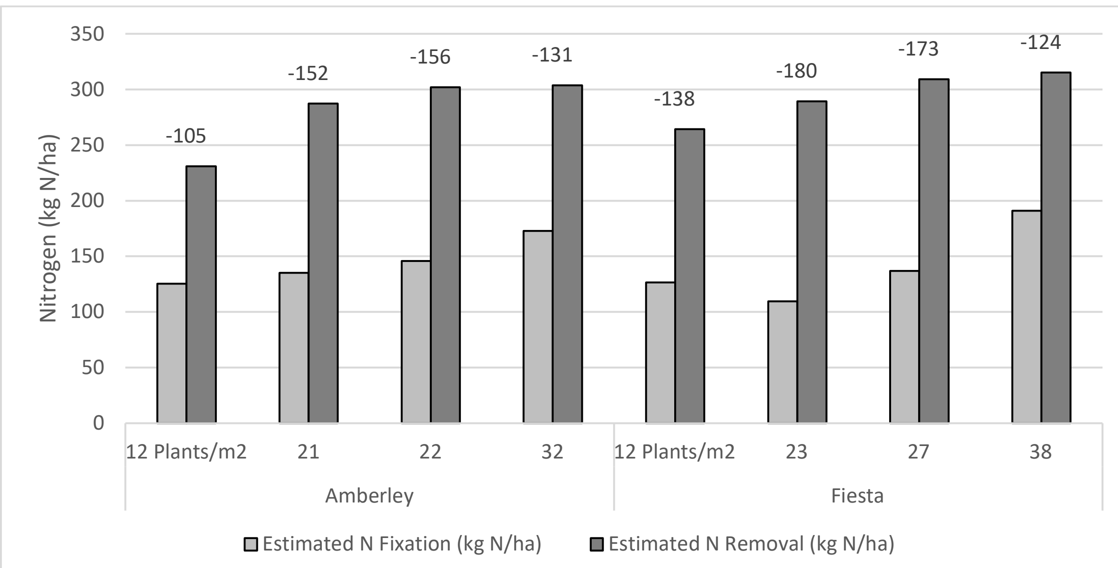


**Figure 2.** Estimates of nitrogen fixation and removal from high yielding irrigated faba bean crops. Data labels show the nitrogen deficit.

## *Pre irrigation – it's not just 'add water' and enjoy the high yields*

**Key Learnings:**

- **Water savings can be made with improved irrigation infrastructure such as overhead sprays.**
- **Irrigation districts have varying access to water during the winter season, with some irrigators having no access from mid-May to mid-August.**
- **Not having sufficient soil moisture going into winter may leave the crop susceptible to 'winter drought', that can have a negative impact on yield.**
- **Similarly, having a full soil profile at the beginning of winter may increase the risk of waterlogging, particularly with surface irrigation in systems that don't drain well.**
- **Soil type, location and appetite for risk all play a part in irrigators' decisions regarding pre-irrigation.**

Two years of GRDC's Optimising Irrigated Grains (OIG), on top of research conducted under the 'Smarter Irrigation for Profit' project, have highlighted the irrigation decisions that need to be made by irrigators on how and when to use their irrigation water to set up their irrigated crops to be the most profitable.

The changing irrigation environment has seen irrigation water become an input where the price can be highly variable based on seasonal conditions and allocations. Efforts to make irrigation more efficient has seen investment in improved layouts and infrastructure such as overhead sprinklers or fast flow surface irrigation, giving irrigators flexibility in the amount of water applied and the choice of crops.

Pre-irrigation (where fallow paddocks are irrigated prior to the sowing of a crop) has always been a judgment call by irrigators, based on timing to enable timely sowing and adequate moisture for the crop to develop over winter. Using surface irrigation, this could mean using anywhere between 0.75 to 2.0 Mega litres/ha (75-200mm/ha) to wet up the soil profile. The timing of pre-irrigation must be considered in order to allow the paddock to dry sufficiently to enable sowing on time, but not to dry too much and then be at the mercy of 'the autumn break' for sowing similar to a dryland grower. Many irrigators have a story about the pre-irrigation that went badly – where it rained, and sowing couldn't proceed or winter waterlogging was detrimental to the crop as the soil profile was full going into winter. However, pre-irrigation does provide soil moisture over winter as some irrigation regions do not have access to water between 15 May and 15 August to allow the water authorities to service and repair the water delivery network.

Irrigators have installed overhead irrigation as a means to be able to have more control over the amount of water applied. Instead of the large volume of water applied via surface irrigation as a pre-irrigation, irrigators can apply enough water to ensure timely establishment of their crop. This can be a considerable saving of water but does then run the risk of a 'winter drought' if the winter period is dry and winter rainfall is inadequate to meet the needs of the crop. In these cases, yield potential is lost before the irrigation water becomes available in the spring. In shorter season crops or in warmer regions where spring growth occurs earlier (before mid-August) yield potential starts to be reduced since crops are stem elongating but without the water reserve to sustain this period of rapid development.

The OIG project, with its geographically diverse project partners, has illustrated the different thinking that drives irrigators decision making on irrigation. Higher rainfall regions are unlikely to pre-irrigate due to the risk of autumn irrigating leading to waterlogging if they go into winter with a full profile.

Similarly, those in the east of the Murray and Murrumbidgee valleys are more confident of a timely break for sowing and follow-up winter rainfall to get the crop through to the spring when irrigation can commence. Those to the west who have soils (e.g. grey clays) that require more water to fill the profile, are less confident of the break being in late April/early May and have lower winter rainfall to tide them over until the irrigation season opens in the spring. Depending on the crop type, restoration of yield potential with spring irrigation following a winter drought can be more limited with early maturing wheat, since it has already started developing rapidly whilst the crop is under spring drought conditions. In some cases, the restoration of yield potential is adequate (e.g. faba beans) but this does depend on whether heat stress was additional to the lack of soil moisture and becomes part of the yield equation. These geographical differences also manifest themselves in the responses to disease management where irrigation does not appear to favour conditions that promote the fungal diseases compared to the naturally more disease prone high rainfall zones.

# NOTES

# NOTES

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