Optimising Irrigated Grains

Thursday 15th September 2022

SOWING THE SEED FOR A BRIGHTER FUTURE

Optimising Irrigated Grains Project Partners:

VISITOR INFORMATION

We trust that you will enjoy your day with us at the Finley Irrigated Research Centre. Your health and safety is paramount, therefore whilst on the property we ask that you both read and follow this information notice.

HEALTH & SAFETY

- COVID-19: Please ensure you practice social distancing rules and use the hand sanitiser provided.
- All visitors are requested to follow instructions from FAR Australia and Southern Growers staff at all times.
- All visitors to the site are requested to stay in your designated groups.
- All visitors are requested to report any hazards noted directly to a member of FAR Australia or Southern Growers staff.

FARM BIOSECURITY

- Please be considerate of farm biosecurity. Please do not walk into farm crops without permission. Please consider whether footwear and/or clothing have previously been worn in crops suffering from soil borne or foliar diseases.

FIRST AID

- We have a number of First Aiders on site. Should you require any assistance, please ask a member of FAR Australia or Southern Growers staff.

LITTER

- Please take your litter away with you, please do not dispose of any litter on site.

VEHICLES

- Vehicles will not be permitted outside of the designated car parking areas. Please ensure that your vehicle is parked within the designated area(s).

SMOKING

- There is No Smoking permitted on site.

Thank you for your cooperation, enjoy your day.

WELCOME TO THE FINLEY IRRIGATED RESEARCH CENTRE 2022 FIELD DAY

FEATURING OPTIMISING IRRIGATED GRAINS

On behalf of the project team, I am delighted to welcome you to the 2022 Finley Irrigated Research Site Field Day featuring 'Optimising Irrigated Grains'.

Today FAR Australia will showcase its field research site which has been set up in collaboration with Southern Growers as part of a GRDC funded Initiative "Optimising Irrigated Grains". The irrigated research site aims to assist NSW and Victorian growers in realising the genetic potential of irrigated grain crops grown under higher yield potential in the region. The research programme looks at crops grown under overhead irrigation and flood-based systems with the aim of covering the major irrigation types distributed across the Murrumbidgee and Murray Valleys of southern NSW.

Today's topics will include:

- Introduction to WaterCan Profit, a decision framework that allows users to select profitable crop rotations, optimise a limited allocation of irrigation water across the whole farm.
- Maximising returns from irrigated canola - Nick Poole reviews the influence of N rate and timing, disease management and PGRs. Is there a role for "N banking" under irrigation?
- How do we achieve high yields in Faba beans and high protein in Durum?
- Management of multiple soil constraints in irrigated cropping?
- Can we achieve 25kg/mm with barley in irrigated or dryland situations and how?
- Irrigation Scheduling to maximise production and yield through optimal water usage with "Schedule it".
- Whole Farm Irrigation Automation with Rubicon, see a hands-on practical demonstration of how we have fully automated our trial farm.
- How do Vetch Varieties respond to various irrigation strategies, and what is the optimum cutting time? (supported by Dairy Australia)?
- Join some local farmers for a panel session on some on farm demonstrations achieved through the optimising irrigated grains.

Should you require any assistance throughout the day, please don't hesitate to contact a member of the FAR or Southern Growers team who will be more than happy to help.

Thank you once again for taking the time to join us today; we hope that you find the trials tour and presentations useful, and as a result, take away new ideas which you can perhaps implement in your own farming business. Have a great day and we look forward to seeing you again at future project events.

This is the last year of the project, and we would like to thank all of you who have supported us. I would like to thank the GRDC for investing in this research programme on display today and to Southern Growers as site host. I would also like to thank the FAR Australia Mulwala team for all their hard work on the trials programme over these last three years.

Nick Poole
Managing Director, FAR Australia

FAR1906-003RTX: Development and validation of soil amelioration and agronomic practices to realise the genetic potential of grain crops grown under a high yield potential, irrigated environment in the northern and southern regions is part of a wider GRDC funded project in irrigated grain production called "Optimising Irrigated Grains" involving a wide range of collaborators.

The season so far:

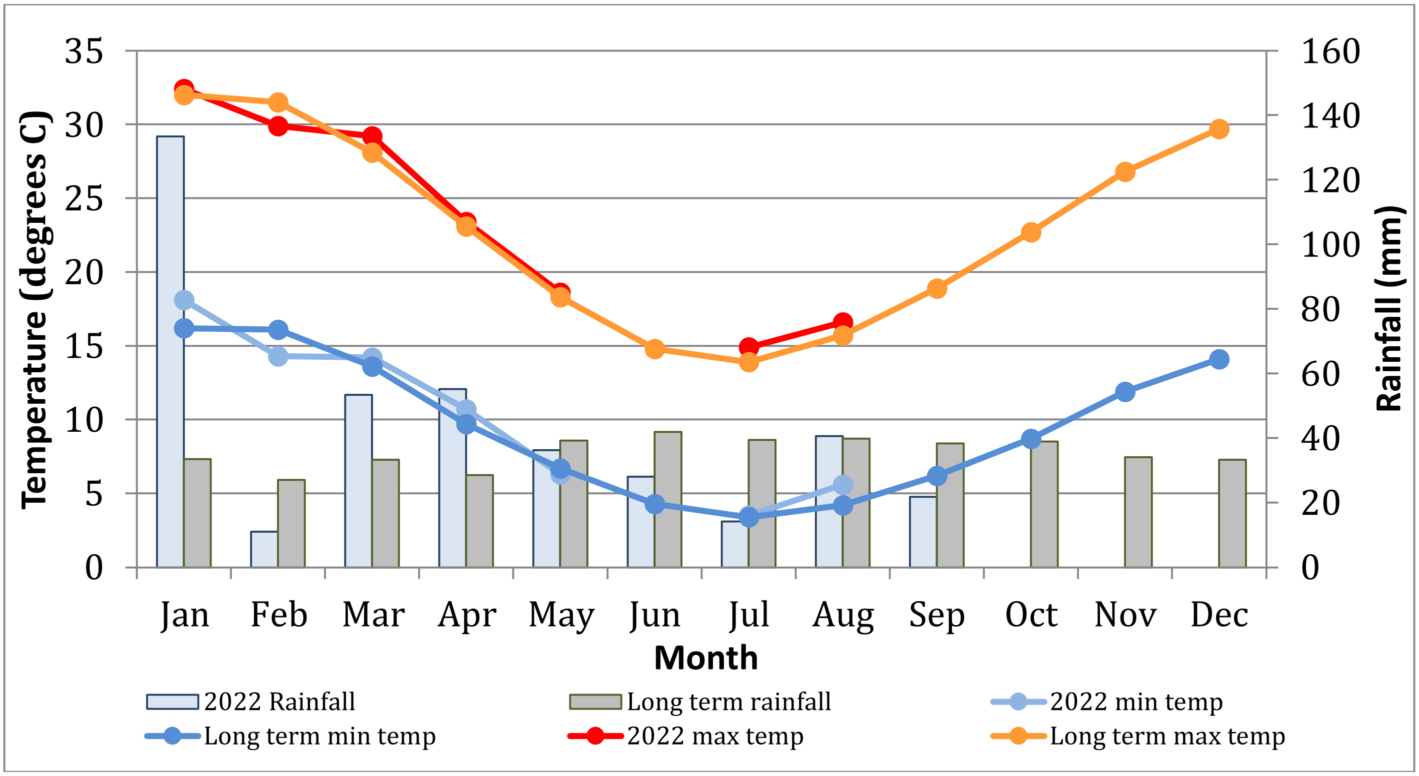

Figure 1. 2022 rainfall and long-term rainfall (1990-2021) (recorded at Finley), min and max temperatures and long-term min and max temperatures recorded at Tocumwal (1897-2021) for the year to date. July and August temperatures measured at Eagle I, Finley. June temperature not available.
Rainfall for the growing season to date, April to September = 196.0mm.

Autumn Irrigation

No irrigation applied in the Autumn.

Spring Irrigation

Flood – no irrigation applied up to 15th September.
Overhead – 1 application of 15mm on Durum, Canola and legumes 31st August. 1 application of 25mm on barley and wheat, 31st August.

Canola

HyTTec® Trophy, 45Y28, Diamond & Bonito - Sown 28th April

- Optimum Plant Population Under Overhead and Flood Irrigation
- Nitrogen Use Efficiency – N Rates
- Nitrogen Use Efficiency – N Timing
- Fungicide Management Strategies
- Plant Growth Regulation
- Legacy nutrition following vetch

Faba Beans

Amberley, Fiesta, Bendoc & Samira - Sown 19th May

- Optimum Plant Population Under Overhead and Flood Irrigation
- Rhizobium Inoculation
- Disease Management Strategies
- Plant Growth Regulation

Barley
Pixel, Planet, Leabrook & Cyclops - Sown 29th April and 9th and 28th May

- Nitrogen Use Efficiency – N Rates
- Nitrogen Use Efficiency – N Timing
- Plant Growth Regulation
- Early Sown NGN Barley Agronomy
- Late Sown Barley

Wheat
RGT Accroc, Rockstar, V12167-048, DS Bennett, Coota, Illabo, Longsword, Valiant and Sunflex - Sown 10th and 28th May

- Slow Spring Wheats
- Late Sown Dryland Wheat

Durum
Aurora & Vittaroi - Sown 10th and 24th May

- Optimum Plant Population Under Overhead and Flood Irrigation
- Nitrogen Use Efficiency – N Rates
- Nitrogen Use Efficiency – N Timing
- Germplasm and Disease Management Interaction
- Disease Management – Products, Rates & Timings
- Plant Growth Regulation

Chickpeas
Genesis 090 & PBA Monarch - Sown 10th and 16th May

- Optimum Plant Population Under Overhead and Flood Irrigation
- Disease Management Strategies

Soil Amelioration Trial
Durum - Vittaroi - Sown 20th May

Key learnings from the Optimising Irrigated Grains Economics Team

Albert Muleke, Marta Monjardino, Rowan Eisner, Matt Harrison
9 August 2022

Impacts of climate change on flowering times and optimal flowering windows

1. Optimal flowering times are affected by the risk of frost (if flowering happens too early) and the risk of heat stress (if flowering occurs too late). Tables 1 and 2 show the timing of optimal flowering across multiple regions for early maturity varieties of durum wheat.
2. Global warming shortens crop lifecycles. This results in earlier flowering of winter crops, increasing risk of exposure to frost. However, use of irrigation prevents shortening of the crop lifecycles, because water stress is reduced, crop lifecycle is extended, and the risk of frost exposure during flowering is reduced.
3. We found that use of irrigation extended the duration of crop growing seasons (crop lifecycles) by reducing water stress. This improved the long-term average yields of durum wheat compared with dryland crops. For regions in southern Australia, irrigation improved durum yield by: -
    - 146% in Griffith, 57% in Finley and 58% in Coleambally regions of New South Wales.
    - 83% in Kerang and 90% in Yarrawonga regions of Victoria.
    - 62% in Keith and 26% Frances regions of South Australia.
    - 27% in Hagley, Tasmania.
4. We showed that when all other factors (cultivar, technology, agronomy etc) are kept constant except for climate over the last 110 years, the long-term average yield of durum wheat would decline by 11% for irrigated crops and by 29% for rainfed crops. This demonstrates the effect that changes in climate over the last century *would have* had on yields in the absence of new technology, agronomy and genotypes.
5. Over the long-term, we showed that early sowing dates for fast maturity (early) varieties of durum wheat produce higher yields than late sowing. The optimal sowing dates vary across southern Australia (see Tables 1 and 2):
    - In New South Wales and Victoria, sowing ranges from early-May to mid-June for rainfed durum and from late-May to early-July for irrigated crops.
    - In South Australia, optimal sowing varies from mid-May to early-June for rainfed durum wheat and from mid-June to early-July for the irrigated.
    - In Tasmania, sowing for rainfed durum wheat starts in early-June to early-July, while for irrigated sowing ranges from late-June to early-July.
6. Optimal flowering windows for the early maturity durum wheat across southern Australia range from early-September to early-November in dryland conditions and late-September to mid-November under irrigation, depending on the region (see Tables 1 and 2).

Table 1 Optimal sowing and flowering periods for early maturity rainfed varieties of durum wheat for regions across the southern Australia cropping zone.

State	**Region**	**Optimal range of flowering**		**Optimal range of sowing**	
		Start	**End**	**Earliest**	**Latest**
New South Wales	Griffith	7-Sep	21-Sep	3-May	17-May
	Finley	16-Sep	3-Oct	10-May	24-May
	Coleambally	27-Sep	7-Oct	17-May	14-Jun
Victoria	Kerang	23-Sep	8-Oct	3-May	24-May
	Yarrawonga	8-Oct	22-Oct	24-May	21-Jun
South Australia	Keith	18-Oct	30-Oct	17-May	7-Jun
	Frances	17-Oct	31-Oct	7-Jun	5-Jul
Tasmania	Hagley	1-Nov	11-Nov	7-Jun	5-Jul

Table 2 Optimal sowing and flowering periods for early maturity irrigated genotypes of durum wheat for regions across the southern Australia cropping zone (simulated over the long-term).

State	Region	Optimal range of flowering		Optimal range of sowing	
		Start	End	Earliest	Latest
New South Wales	Griffith	26-Sep	11-Oct	24-May	21-Jun
	Finley	11-Oct	26-Oct	31-May	5-Jul
	Coleambally	19-Oct	30-Oct	7-Jun	5-Jul
Victoria	Kerang	3-Oct	23-Oct	24-May	5-Jul
	Yarrawonga	25-Oct	4-Nov	7-Jun	5-Jul
South Australia	Keith	16-Oct	23-Oct	21-Jun	5-Jul
	Frances	21-Oct	31-Oct	14-Jun	5-Jul
Tasmania	Hagley	6-Nov	17-Nov	21-Jun	5-Jul

Agronomic and irrigation infrastructure adaptations for improving farm profit

1. A modelling study was conducted using real climate data and prices, for a case study farm in the Riverina, near Finley in NSW. The focus was on four whole-farm agronomic adaptations (*Current*, *Diversified*, *Intensified*, *Simplified*) by four irrigation methods − surface irrigation by gravity (*Flood*) and by pumps (*Pipe & Riser*), pressurised irrigation by overhead spray (*Pivot*) and micro-dosing (*Drip*).
2. A system profit gap of ~$10 M was quantified for the irrigated farm area over 30 years.
3. Relative to the *Baseline* – current system with flood-irrigated wheat-canola − significant long-term profit gains were identified for the *Intensified* (+273%) and *Diversified* (+80%) scenarios.
4. *Current* and *Simplified* scenarios were less profitable than the Baseline (-16% and -37%, respectively).
5. On a per ML basis, *Diversified* and *Simplified* crop rotations were more profitable (e.g., up to $160/ML for *Diversified_Drip)*.
6. On a per hectare basis, *Intensified* systems were more profitable (e.g., up to $491/ha for *Intensified_Pipe & Riser),* thus more suited to farmers targeting area-based rather than water-based returns.
7. Diversified scenarios with surface (flood, pipe & riser) and pivot irrigation and all *Simplified* scenarios reduced downside risk relative to the baseline. E.g., CVar0.2 was reduced for *Diversified* scenarios from 1% (*Diversified_Pivot*) to 19% (*Diversified_Flood*), but not with *Drip* (-12%).
8. Taking infrastructure investment into account, the IRR was lowest for *Current_Pivot* (4.9% return on investment, and 14.4 years to pay it back), whereas *Intensified_Flood* had the highest IRR (26.8%) and the lowest payback period (3.1 years).
9. For the study assumptions, agronomic system had greater relative influence on financial performance than irrigation infrastructure (agronomic system: 0.15−0.83 variance with 14-56% confidence; irrigation infrastructure: 16.33−21.30 variance with 100% confidence). These results provide useful insights to tailor agronomy to infrastructure, and vice versa.
10. The complex trade-offs between water scarcity, price volatility, irrigation investment, environmental impacts, and farmers' attitude to risk influence irrigation decisions, so insights from this study could inform pathways towards the closure of the irrigated profit gap.

Amelioration of hostile subsoils via incorporation of organic and inorganic amendments and subsequent changes in soil properties, crop water use and improved yield, in a medium rainfall zone of south-eastern Australia

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Key words

dispersive alkaline subsoils**,** amendments, soil pH, exchangeable sodium percentage, root growth, grain yield

GRDC code

DAV00149

Take home messages

- Deep placement of organic and inorganic amendments increased grain yield in the order of 20 to 50% for five successive years on an alkaline dispersive subsoil at Rand
- Deep placement of organic and inorganic amendments increased root growth and crop water use from the deeper clay layers during the critical reproductive stages of crop development
- Improvements in grain yield with deep placement of organic and inorganic amendments were associated with a reduction in subsoil pH and improvement in soil aggregation.

Background

Sodicity, salinity and acidity are significant surface and subsoil constraints that reduce crop productivity throughout the cropping regions of Australia (Sale *et al.,* 2021). The majority of cropping soils contain at minimum one, but more multiple constraints (McDonald *et al.*, 2013). The economic impact to Australian agriculture, expressed by the 'yield gap' between actual and potential yield, attributable to subsoil constraints was estimated to be more than A$1.3 billion annually by Rengasamy (2002), and as much A$2.8 billion by Hajkowicz and Young (2005). Of the 'three', sodicity is thought to be the most detrimental to productivity, resulting in the greatest yield gap. In Australian wheat-cropping regions alone, this 'gap' was estimated to be worth A$1.3 billion per annum in lost income (Orton *et al.,* 2018), while close to 20% of Australia's land area is thought to be sodic.

Sodic soils, which are characterised by an excess of sodium (Na^+) ions and classified as those with an exchangeable sodium percentage (ESP) greater than 6% (Northcote and Skene, 1972), are often poorly structured, have a high clay content, high bulk density, and are dispersive. These factors result in poor subsoil structure that can impede drainage, promote waterlogging (low water infiltration), and increase de-nitrification (nutrient imbalance), and soil strength (Orton *et al.*, 2018). These properties also impede the infiltration of water into and within the soil, reduce water and nutrient storage capacity, and ultimately the plant available water (PAW) content of the soil. Subsequently, root growth and rooting depth are impeded, as is crop ability to access and extract deeper stored water and nutrients (Passioura and Angus, 2010). This is particularly problematic in environments characterised by a dry spring, where the reproductive phase often coincides with periods of water stress, and when the conversion of water to grain has the greatest effect both on yield (Kirkegaard *et al.,* 2007), and the likelihood and magnitude of a yield gap (Adcock *et al.,* 2007).

In southern NSW, winter crops commonly have sufficient water supply during their early growth stages either from stored soil water or rainfall. However, the reproductive phase is often affected by water stress or terminal drought and this is thought to be the major cause of variable grain yield (Farooq *et al.*, 2014). The effect of water stress in the reproductive phase is further impacted by shallow root depth induced by subsoil sodicity. Under such conditions, a key to improving crop productivity is to improve root growth in and through sodic subsoils to enable use of deep subsoil water later in the growing season. Water use at this late stage has a 2 to 3 fold greater conversion efficiency into grain yield (Kirkegaard *et al.,* 2007) than seasonal average based conversions efficiencies (e.g. 20 – 25 kg/mm verses 50 – 60 kg/mm).

While there are large advantages to be gained by improving the soil environment of sodic subsoils, the various amelioration approaches (deep ripping, subsoil manuring, applying gypsum, improved nutrition and use of ‘primer-crops’) have produced variable results (Adcock *et al.,* 2007; Gill *et al.,* 2008). Furthermore, the use of subsoil organic material is also impacted by limited local availability, the high cost of suitable organic ameliorants delivered in-paddock, the sometimes large quantities required, the lack of suitable commercial-scale machinery and the poor predictability of when and where the amelioration will benefit crop productivity (Gill *et al.,* 2008; Sale *et al.*, 2019).

Gypsum application has been the most widespread traditional approach used to correct subsoil sodicity. However, problems have included; surface application when the problem is evident in the subsoil, the large quantities of gypsum required to displace significant amounts of sodium and the somewhat low solubility of gypsum.

This paper reports on the performance of a barley-wheat-canola-wheat rotation on a Sodosol (Isbell, 2002) soil two sites in Rand and Grogan in southern New South Wales in the five (Rand) and four (Grogan) years immediately following incorporation of a range of amendments, and the residual effects of ‘subsoil manuring’ on crop performance, soil physical properties, and access to PAW stored in the soil profile over subsequent seasons. A range of treatments comprising deep-ripping and subsoil incorporation of organic and inorganic amendments at a depth of 20–40cm were compared to, and contrasted with, surface applications, ripping-only and untreated controls. Amendments that could be easily procured or produced as part of a farming system were used in the trial. It is hypothesised that subsoil incorporation of organic or inorganic amendments will provide significant improvements in grain yield, which are associated with changes in the physical properties of the subsoil that result in improved root growth, and access to, and use of, deep soil water.

Method

Rand amendment site

The trial sites were located at Rand and Grogan in southern New South Wales in paddocks that had been under a continuous cropping (cereal-canola) for more than 50 years. The soil at both sites was a Sodosol with a texture-contrast profile increasing in clay content at depth, and with physical and chemical properties (Table 1.) unfavourable for root growth, including a high bulk density and low hydraulic conductivity.

Table 1. Chemical and physical properties of the soils at different depths at the Rand trial site

Depth (cm)	pH (H_20)	EC (1:5) (μS/cm)	Nitrate N (mg/kg)	Exchangeable cations (cmol/kg)	Exchangeable sodium percentage (%)	Bulk density (g/cm^3)	Volumetric water content (θv)
0–10	6.6	132.1	20.6	16.1	3.8	1.40	0.120
10–20	7.8	104.0	5.8	22.6	7.3	1.52	0.163
20–40	9.0	201.5	4.1	26.7	12.5	1.50	0.196
40–50	9.4	300.5	3.0	27.5	18.1	1.48	0.232
50–60	9.5	401.3	3.0	28.8	21.8	1.53	0.237
60–100	9.4	645.0	2.9	29.7	26.4	1.55	0.218

The trials were established in February 2017 (Rand) and March 2018 (Grogan) as a randomised complete block with a range of treatments (Table 2) and four replicates. Experimental plots were arranged in two blocks (ranges) of 26 plots, separated by a 36m cropped buffer. Individual plots within each block were 2.5m wide (south-north) × 20m long (east-west), separated on their long sides by 2m buffers of uncultivated ground. Plots were ripped to a depth of 40cm, and amendments incorporated into the soil via a custom built 3-D ripping machine (NSW DPI), comprising a 'Jack' GM77-04 5-tyne ripper (Grizzly Engineering Pty Ltd, Swan Hill, VIC, Australia), configured to 500mm tyne spacings, and topped with a custom designed frame supporting two purpose built discharge hoppers (bins) and a 300L liquid cartage tank. The larger, ~1.6 cubic meter-capacity hopper was designed to deliver organic materials and can accommodate approximately 1000 kg of material, roughly equivalent to a standard 'spout top, spout bottom' bulk bag. The organic amendments were obtained in pellet form for ease of application and consisted of dried pea straw pellets (1.13% N, 0.05% P, 1.34% K; extrusion diam. 7–10mm, length 6–35mm), wheat stubble pellets (0.34% N, 0.15% P, 1.59% K; diam. 7–10mm, length 6–35mm), and dried poultry manure pellets marketed as Dynamic Lifter® (3% N, 2% P, 1.7% K; diam. 7–10mm, length 6–35mm). The amendments were applied three months prior to sowing the first season.

In 2017, experimental plots were sown to Barley (cv. LaTrobe⌽) on the 11th of May at a seeding rate of 70 kg/ha (target plant density 100 plants/m^2). Monoammonium phosphate (MAP) was applied at 80 kg/ha as a starter fertiliser at sowing. The crop was sown after spraying with Boxer Gold® (800 g/L prosulfocarb + 120 g/L S-metolachlor), Spray.Seed® (135 g/L paraquat dichloride + 115 g/L diquat dibromide) and Treflan™ (480 g/L trifluralin). The crop was harvested on the 21st of November.

In 2018, wheat (cv. Lancer⌽) was sown on the 15th of May at a seeding rate of 80 kg/ha (target plant density 150 plants/m^2). MAP was applied at 80 kg/ha as a starter fertiliser at the time of sowing. The crop was sown after spraying with Spray.Seed, Sakura® (850 g/kg pyroxasulfone), Logran® (750 g/kg triasulfuron) and Treflan. Urea (46% N) at 110 kg/ha (50.6 kg/ha N) was applied at 106 DAS. The crop was harvested on the 6th of December.

In 2019, Canola (Pioneer® 45Y92CL) was sown on the 10th of April at a seeding rate of 4.4kg/ha (target plant density 40 plants/m^2). MAP was applied at 90 kg/ha (9 kg/ha N, 19.8 kg/ha P) as a starter fertiliser at the time of sowing. The crop was sown after spraying with Roundup® (360 g/L glyphosate, present as the isopropylamine salt in a tank mix with Kamba® 750 (750 g/L dicamba). Urea at 220 kg/ha (101.2 kg/ha N) was applied as a top-dressing at 119 DAS, and Prosaro® (210 g/L prothioconazole + 210 g/L tebuconazole) at 50% bloom as a preventative for Sclerotinia stem rot (132 DAS). The crop was harvested on the 30th of October.

In 2020, wheat (cv. Scepter⦶) was sown on the 16th of May at a seeding rate of 63 kg/ha (target plant density of 120 plants/m^2). Diammonium phosphate (DAP) was applied at 78 kg/ha as a starter fertiliser at the time of sowing. The crop was sown after spraying with Spray.Seed, Roundup, Sakura and Treflan. Urea at 150 kg/ha (69 kg/ha N) was applied as a top-dressing 7 DAS prior to rain. The crop was harvested on the 7th of December.

The long-term average annual rainfall at the site is 553mm with a reasonably uniform average monthly rainfall. In 2017, in-season rainfall (April-November) totalled 329mm, while 244mm and 242mm, respectively, were recorded for the same period in 2018 and 2019. Rainfall in both 2018 and 2019 was approximately 25% less than that recorded for 2017, and approximately 65% of the long-term average seasonal rainfall. The long-term average monthly rainfall, and average monthly maximum and minimum temperatures, daily (bars) rainfall events and monthly rainfall at the Rand experimental site for the period 2017–2021 (Figure 1).

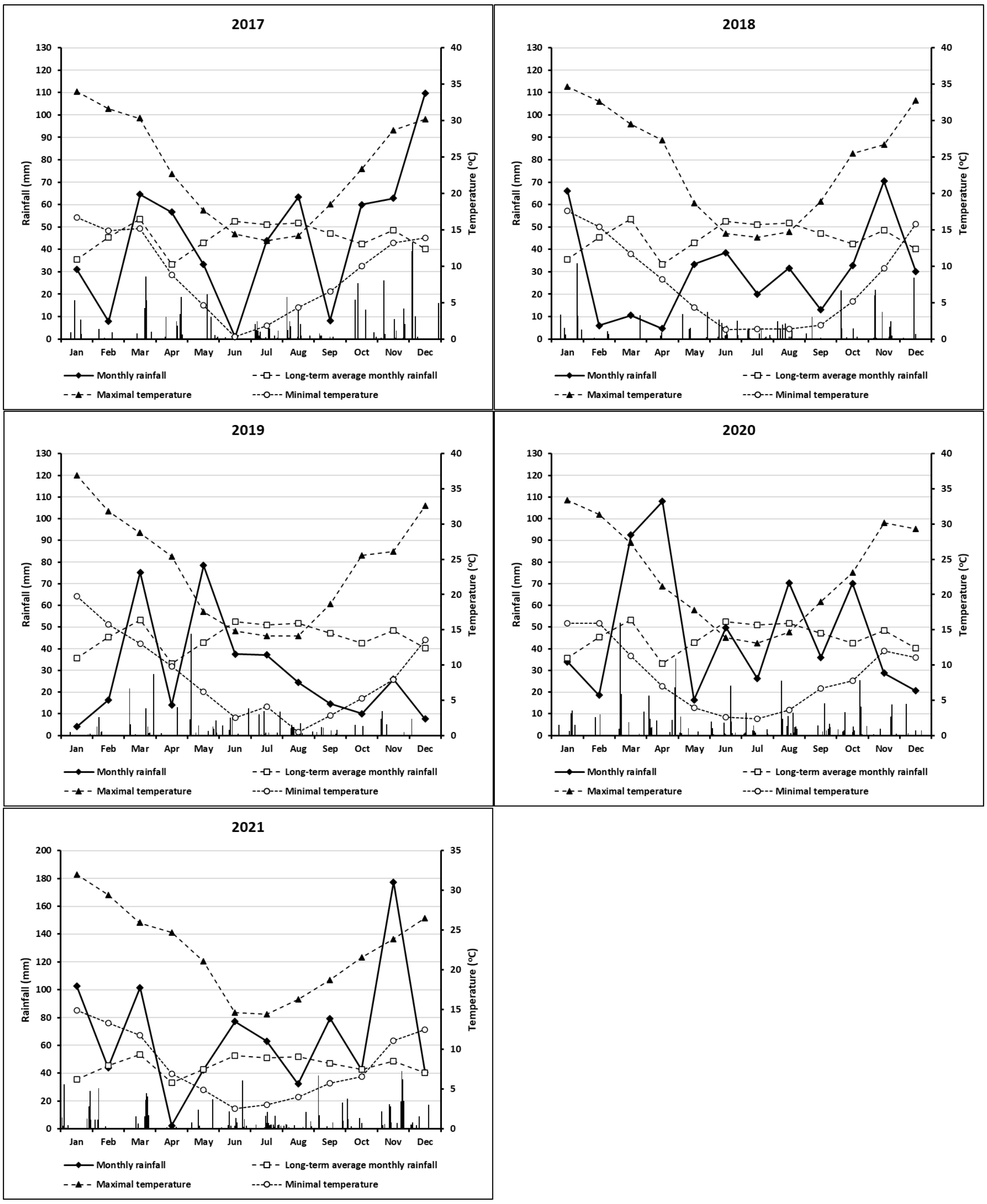


Figure 1. Long-term average monthly rainfall, and average monthly maximum and minimum temperatures, daily (bars) rainfall events and monthly rainfall at the Rand experimental site located at Urangeline East, NSW.

Table 2. Description of the treatments and organic and inorganic amendments used in the trial.

Treatment	Description	Amount of amendment added
1	Control	Direct sowing
2	Deep gypsum	5 t/ha, incorporated to depth of 20-40 cm
3	Deep liquid NPK	Incorporated to depth of 20-40 cm, the amount of NPK added was matched to NPK content of chicken manure
4	Deep chicken manure	8 t/ha, incorporated to depth of 20-40 cm
5	Deep pea straw	15 t/ha, incorporated to depth of 20-40 cm
6	Deep pea straw +gypsum+NPK	12 t/ha, 2.5 t/ha, incorporated to depth of 20-40 cm,
7	Deep pea straw+NPK	15 t/ha, incorporated to depth of 20-40 cm
8	Deep wheat stubble	15 t/ha, incorporated to depth of 20-40 cm
9	Deep wheat stubble +NPK	15 t/ha, incorporated to depth of 20-40 cm
10	Ripping only	To depth of 40cm
11	Surface gypsum	5 t/ha, applied at soil surface
12	Surface chicken manure	8 t/ha, applied at soil surface
13	Surface pea straw	15 t/ha, applied at soil surface

At late flowering soil coring was completed using a tractor-mounted hydraulic soil-coring rig and 45 mm diameter soil cores. The break core method was used to estimate rooting depth and exposed roots were recorded at the following depths 0 - 10, 10 - 20, 20 - 40, 40 - 60, and 60 – 100 cm. Quadrat samples of $2m^2$ were taken at physiological maturity to measure plant biomass and grain yield.

Grogan subsoil amelioration experiment

In 2018 an experiment was conducted near the township of Grogan in southern NSW, which included 27 amendments in a row column design with four replicates. The soil profile was slightly acidic in the top 10cm ($pH_{1:5\ water}$ 5.9) and pH dramatically increases with depth (Table 3). The changes in soil sodicity (exchangeable sodium percentage, ESP) followed a similar trend of soil pH with exchangeable sodium percentage (ESP) at 10.5% in the topsoil and increasing up to 40% in the subsoil (Table 3).

Table 3. Site characterisation for the Grogan experimental site. Values are means (n=5).

Soil depths (cm)	EC (µs/cm)	pH (1:5 water)	Colwell-P (µg/g)	CEC (cmol($^+$)/kg)	Exchangeable sodium percentage
0-10	309.40	5.87	58.80	16.66	10.53
10-20	133.00	7.65	7.40	22.06	11.97
20-30	136.90	8.76	2.62	24.53	15.94
30-40	207.66	9.12	2.50	25.55	20.12
40-60	338.94	9.60	1.34	27.17	26.27
60-80	530.40	9.53	1.00	31.63	36.68
80-100	897.20	9.43	1.48	34.07	40.25
100-120	1148.20	9.38	1.50	35.28	40.35

The agronomic management of the trial was similar to Rand site as outlined above. However, the effect of several additional treatments including elemental sulphur, and lucerne hay was investigated.

Results

Rand and Grogan amendment trial

The one-off application of various amendments (Table 2) significantly affected the crop grain yield over 5 consecutive years at the Rand site. For example, in 2021, canola grain yield (relative to control) increased following the deep placement of wheat stubble, wheat stubble + nutrient and manure by 15-12% ($P < 0.001$) (Figure 2). At the Grogan site, canola grain yield (relative to control) increased following the deep placement of manure, lucerne hay and gypsum + pea hay+ nutrient by 45, 42 and 39% respectively ($P < 0.001$) (Figure 2). The variations in yield in response to surface application of amendments or ripping only was not significantly different from the control at both sites.

At the Rand site, a multi-year cumulative analysis of grain yield response (2017-2021) indicated that deep placement of plant-based stubble, gypsum and their combination resulted in significant and consistent improvements in crop yield (Table 4). A preliminary cumulative gross return is also presented in Table 4.

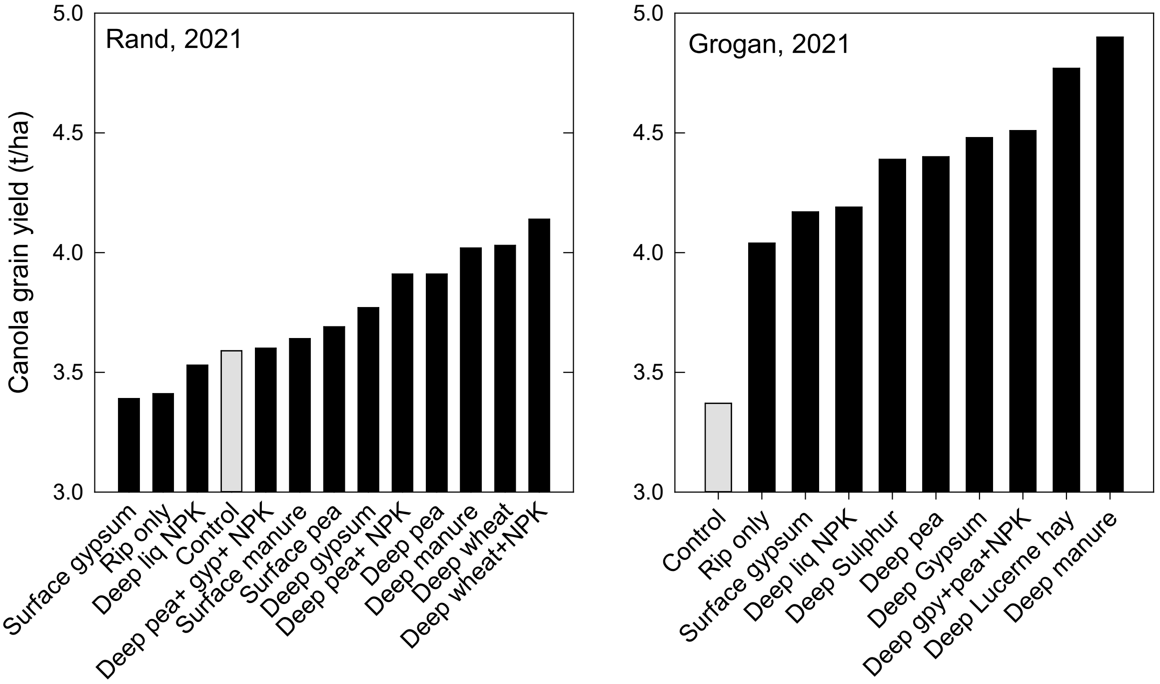


Figure 2. The mean effect of surface or deep-placed amendments on grain yield of canola (cv. Dimond(b)) grown in an alkaline dispersive subsoil at Rand (left) and Grogan (right), SNSW in 2021. Values are mean (n=4). LSD$_{0.05}$ = 0.28 (left) and 0.78 (right).

Table 4. Cumulative grain yield (2017-2020) and cumulative gross return ($) for barley (2017; $220/t), wheat (2018; $250/t), canola (2019; $600/t) and wheat (2020; $250/t), canola (2021; $800/t) at Rand.

Treatment	Yield (t/ha)		$	
Rip only	19.3	a	7465	a
Control	19.3	a	7497	a
Surface gypsum	19.1	ab	7550	ab
Deep liq NPK	20.6	ab	7671	ab
Surface pea	19.7	bc	7769	ab
Surface manure	20.6	bc	7981	bc
Deep pea+gyp+NPK	23.0	cd	8577	cd
Deep wheat	22.3	cd	8614	cd
Deep pea	22.7	cd	8635	d
Deep manure	22.3	d	8645	cd
Deep pea+NPK	22.3	d	8682	d
Deep wheat+NPK	22.6	d	8698	d
Deep gypsum	22.7	d	8700	d

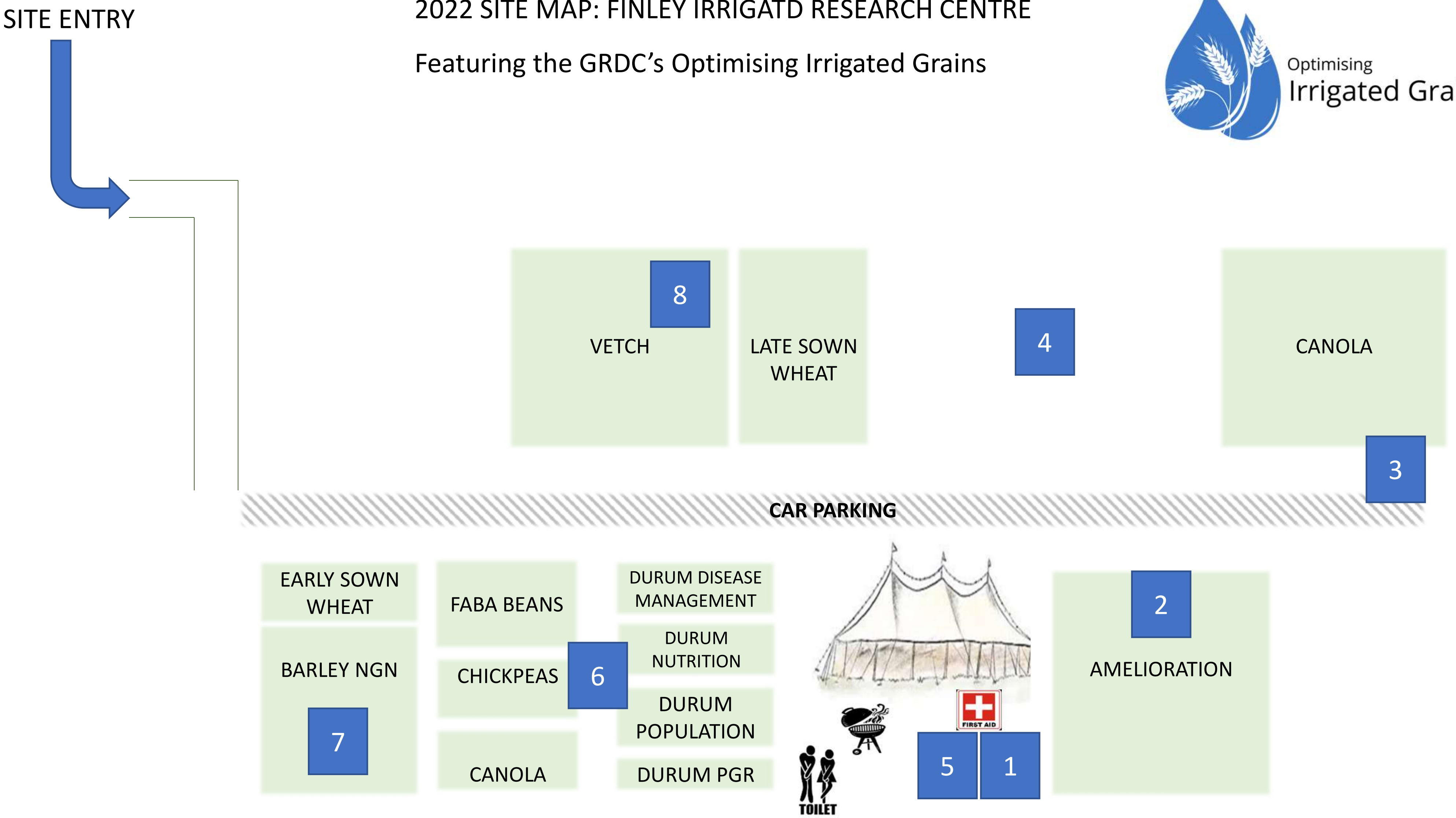
*Results with the same letter after them are not significantly different P < 0.05

Over the course of this study several key measurements of soil and crop parameters were made to investigate the impact of various amendments on soil: plant interactions. Selected data from the Rand trial is reported below.

2022 SITE MAP: FINLEY IRRIGATD RESEARCH CENTRE

Featuring the GRDC's Optimising Irrigated Grains

Optimising
Irrigated Grains



Optimising
Irrigated Grains

TIMETABLE

FINLEY IRRIGATED RESEARCH CENTRE FIELD DAY: THURSDAY 15 SEPTEMBER 2022

Featuring the GRDC's Optimising Irrigated Grains Project

In-field presentations	**Station No.**	**9:45**	**10:00**	**10:30**	**11:00**	**11:30**	**12:00**	**12:45**	**1:00**	**1:30**	**2:00**	**2:30**	**3:00**
Assoc. Prof. Matthew Harrison *Introduction to WaterCan Profit, a decision framework that allows users to select profitable crop rotations, optimise a limited allocation of irrigation water across the whole farm.*	1	Nick Poole (FAR Australia) welcome and introduction to the day	1				Lunch kindly provided by Tocumwal Pre-School	Address by Dr Kaara Klepper GRDC's Farming Systems North Manager			3	2	Close and refreshments kindly sponsored by Southern Growers
Dr Wyne Pitt, NSW Department of Primary Industries *Management of multiple soil constraints in irrigated cropping?*	**2**		2	1								3	
Nick Poole, FAR Australia *Maximising returns from irrigated canola - Nick reviews the influence of N rate and timing, disease management and PGRs. Is there a role for "N banking" under rrigation?*	**3**		3	2	1								
Brett Orwin, Schedule it and Kevin Saillard, Rubicon Water ***1.*** *Irrigation Scheduling to maximise production and yield through optimal water usage with "Schedule it".* ***2.*** *Whole Farm Irrigation Automation with Rubicon, see a hands-on practical demonstration of how we have fully automated our trial farm.*	**4**			3	2	1							
Stephanie Chappell, Southern Growers and Jake Plattfuss, Grower *Join some local farmers for a panel session on some on farm demonstrations achieved through the optimising irrigated grains project.*	**5**				3	2			1				
Ben Morris, FAR Australia *How do we achieve high yields in Faba beans and high protein in Durum?*	**6**					3			2	1			
Tom Price and Rebecca Murray, FAR Australia *Can we achieve 25kg/mm with barley in irrigated or dryland situations and how?*	**7**								3	2	1		
Russell Ford, Southern Growers *How do Vetch Varieties respond to various irrigation strategies, and what is the optimum cutting time? (supported by Dairy Australia)?*	**8**									3	2	1	
In-field presentations	**Station No.**	**9:45**	**10:00**	**10:30**	**11:00**	**11:30**	**12:00**	**12:45**	**1:00**	**1:30**	**2:00**	**2:30**	**3:00**

For the afternoon's presentations, we would be obliged if you could remain within your designated group number.

Thank you for your cooperation.

1	**GROUP 1**
2	**GROUP 2**
3	**GROUP 3**

The number of visible roots in the amended subsoil layer (20 – 40cm depth) were significantly (P < 0.05) affected by different amendments (Figure 3). Deep placement of both manure and pea hay increased the number of visible roots by more than 3-fold. Neutron probe readings taken in September also indicate that the highest root counts were associated with the driest soil water profile (Figure 4). Variation in soil pH measured at the amended layer is shown in Table 5. Compared to the control, deep placement of gypsum reduced the soil pH by 0.86 units (8.99 to 8.13) at 20 – 40cm depth. However, pH was not affected by other treatments.

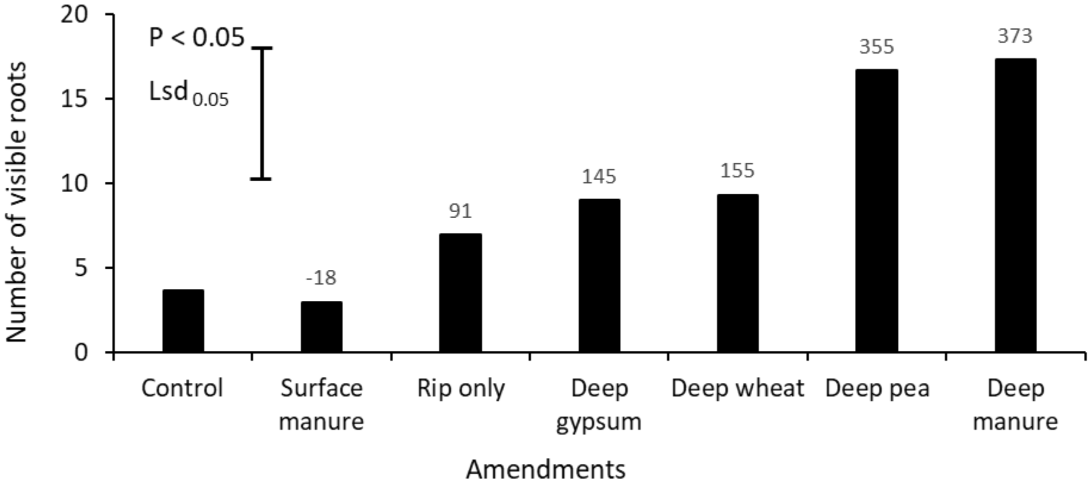


Figure 3. The mean effect of surface or deep-placed amendments on the number of visible roots at 30cm at late flowering of canola (cv. Pioneer 45Y91CL) grown in alkaline dispersive subsoil at Rand, SNSW in 2019. Values on the top of each bar represents the percent change of visible roots compared to control.

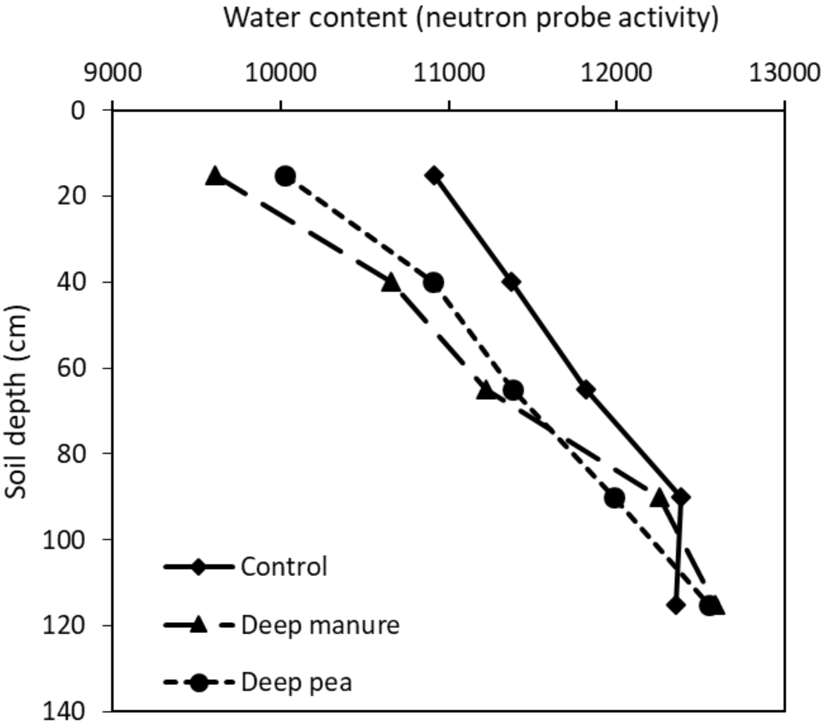


Figure 4. Neutron probe readings taken in September at the Rand amendment site for contrasting treatment comparisons. Results are based on the neutron activity (raw data) where higher values represent higher water content in the soil profile. Values are averages (n = 4).

Table 5. Mean soil pH (20-40 cm) in selected treatments at the Rand site. Samples were collected in May 2020. $LSD_{0.05}$ = 0.27.

Amendment	Predicted mean	Significant difference group
Control	8.99	a
Deep liq NPK	8.96	a
Rip only	8.94	a
Deep wheat+NPK	8.93	ab
Surface gypsum	8.92	ab
Deep pea	8.87	ab
Deep wheat	8.83	ab
Deep manure	8.60	bc
Deep pea+gyp+NPK	8.52	c
Deep gypsum	8.13	d

Discussion

In Alkaline dispersive soils, several properties of subsoils including, high pH, high levels of soluble carbonate species, poorly structured dense clay, and dispersion together with overall poor chemical fertility, represent a hostile environment for crop roots. Here we demonstrate the impact of various amendments on these properties and the potential to re-engineer these hostile subsoils for improved crop performance.

Barley, wheat, canola, wheat and canola were grown in 2017–2021, respectively. Growing season rainfall (April to November total) was average in 2017 (decile 5), and declined in 2018 (decile 1.5), with still drier conditions in 2019 (decile 1.0), when only 45 mm of rain (decile 0) fell during the spring months from September to November. This improved in 2020 and 2021 where the Rand trial received > 401 mm during growing the season. The amendments that consistently resulted in significant yield increases above the control, were the deep-placed combination of pea straw pellets, gypsum and liquid fertilizer nutrients, and the deep-placed gypsum and deep placed pea straw (Table 4). Improvements in subsoil structure were measured in the winter of 2019. The deep crop residue amendments significantly increased macro aggregation, as measured on the rip-line at a depth of 20-40 cm. Similarly, deep gypsum and the deep gypsum/pea straw/nutrient combination markedly increased water infiltration into the soil profile, with higher saturated hydraulic conductivities measured on the rip-line. Our results to date indicate that independent modes of action of various amendments (e.g., crop residue vs gypsum) are required in the amendment mix, in order to ameliorate these subsoils. For example, adding gypsum reduced pH in the amended subsoil to below 8.5 (Table 5). This indicates that significant changes in soil pH can occur with realistic application rates of gypsum in subsoil. Given high alkalinity also increases negative charges on the surfaces of clay particles (Rengasamy *et al.,* 2016), which increases clay dispersion, a reduction in pH following gypsum application also resulted in significant improvement (reduction) in soil dispersion (Tavakkoli *et al.*, 2015). In alkaline sodic soils, high ESP and high pH are always linked together and it is difficult to apportion their effects on the resulting poor soil physicochemical conditions and consequently on crop growth.

The addition of pea straw and nutrients provides substrate for enhanced biological activity resulting in increased macro aggregation and improved subsoil structure. When combined together, organic and inorganic amendments may result in additive effects to improve soil physical and chemical properties (Fang *et al.,* 2020a; Fang *et al.,* 2020b).

In a year of intensive drought like 2019, the grain yield improvements at Rand may be attributed to the additional root growth in the amended subsoil layer (Figure 3), which facilitated the use of extra subsoil water (Tavakkoli *et al.,* 2019 and Figure 4). Under dryland conditions, water captured by roots in the subsoil layer is extremely valuable as its availability coincides with the grain filling period and has a very high conversion efficiency into grain yield (Kirkegaard *et al.,* 2007; Wasson *et al.,* 2012). A major focus of this current research is to understand the amelioration processes of the subsoil application of organic and inorganic amendments. A tentative, but promising, finding from our field and controlled environment trials, is that farm grown products like wheat and pea stubbles when mixed with nutrients improve soil aggregation, root growth, water extraction and grain yield and these treatments are comparable to animal manures and gypsum. If confirmed, this means that grain growers have a potentially large supply of relatively inexpensive organic ameliorants already available in their paddocks, which will increase the application options and viability of correcting subsoil sodicity.

Conclusions

The findings from the current field studies demonstrate promising results of ameliorating alkaline dispersive subsoils in medium rainfall zones of southern NSW. Deep placement of organic and inorganic amendments resulted in significant yield improvement in successive years at Rand and Grogan. This yield improvement was facilitated by a reduction in soil pH and ESP% and increased microbial activity that can lead to improved soil aggregation. Furthermore, deep placement of organic and inorganic amendments increased root growth, which in turn increased soil water use from the deeper clay layers during the critical reproductive stages of crop development, thereby increasing grain yield.

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Canola under irrigation – aiming for 5t/ha

Nick Poole – FAR Australia

Following two years of experimentations the following are the preliminary learnings that the project team have formulated from conducting this work. At the field day Nick Poole will discuss these key learnings in the context of achieving 5t/ha canola crops 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/m2 resulting in plant populations averaging 43-45 plants/m2 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/m2) 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.

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.

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.

The primary role of Field Applied Research (FAR) Australia is to apply science innovations to profitable outcomes for Australian grain growers. Located across three hubs nationally, FAR Australia staff have the skills and expertise to provide 'concept to delivery' applied science innovations through excellence in applied field research, and interpretation of this research for adoption on farm.

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SOWING THE SEED FOR A BRIGHTER FUTURE

A multidisciplinary approach to improving agricultural water efficiencies for a more productive future

Business management guru Peter Drucker once said, “If you can’t measure it, you can’t manage it”. This mantra can be closely applied to the irrigation sector. Thankfully, recent technological advances are creating significant opportunities for productivity increases to be achieved at each stage of the irrigation process.

The holistic combination of precise irrigation scheduling, delivery, and application technologies deployed throughout irrigation areas can result in substantial productivity gains for governments, irrigation districts and farmers.

Off-farm improvements for an on-demand supply

On the distribution side, accurate measurement and control systems installed into existing canal and pipeline infrastructure provide farmers with an on-demand service. This precise on-demand delivery to farms eliminates water loss and ensures that only the correct amount of water is diverted, leaving more water in storage for future beneficial use. These automated systems are **achieving distribution efficiencies better than 90% in modernised areas**, resulting in improved serviceability and equitability of water to farmers located along the network.

A benchmark example can be witnessed in Australia’s Murray-Darling Basin, where automation has played a vital role in making the basin arguably one of the most efficient food bowls in the world. Over the past two decades, more than 20,000 automated gates and metering devices have been installed to increase water efficiencies from 50-70 per cent to more than 90 per cent in modernised areas. The delivery systems have led to more efficient in-field application, introducing **flow-on benefits to farmers** through better use of available water, better crop production and ultimately, increased farmer revenue.

On-farm improvements

Significantly improving distribution efficiencies to the farm gate is one element. An equally important aspect is the need to replicate these efficiencies at the farm level.

With water supplied on-demand and at the desired flow rates, farmers be confident that their investments in on-farm application technologies can be leveraged. Irrigators are increasingly adopting accurate measurement and remote-control technology to improve their on-farm operations.

Implementing automated surface irrigation on-farm can **improve application efficiencies to 85% or better** while significantly reducing labour costs and enhancing yields. Precision surface irrigation has minimal input energy requirements, allowing high application efficiencies to be achieved with low energy bills.

This technology, combined with accurate water deliveries, enables irrigators to apply the optimal amount of water to crops to save water, labour costs and improve overall on-farm productivity.

The introduction of automated infrastructure, along with in-field sensors for soil moisture, micro-climate inputs, water levels, plus irrigation scheduling tools and communications via IoT-enabled nodes will help farmers know, with precision, when to irrigate their crops and how much water to apply.

Precision Irrigation Scheduling techniques, with on-farm automation and on-demand water distribution, present an opportunity to achieve an additional 20+% gain in on-farm water-use efficiency.

Adopting this holistic approach to irrigation modernisation through the combination of disciplines involved in water distribution, scheduling and application will create a productive outlook for the future of irrigated agriculture.

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How do we achieve high yields in Faba beans and high protein in Durum?

Ben Morris, Research Manager FAR Australia

Faba Beans - Irrigation in faba bean canopies magnify the difference caused by plant populations

In rainfed farming systems, 20-25 plants/m2 is the often-recommended plant density for faba bean crops. In irrigation, with higher yield potentials, we have found thicker canopies to be more profitable. When planting at recommended seed rates, sometimes problems occur and the plant numbers fall below desirable densities. In dryland situations the yield loss from a less than optimum plant population is small and economically insignificant. Under irrigation, the yield loss between an optimum plant density and a sub-optimum plant density (~12 plants/m2) can equate to 1.0 t/ha (0.9-1.2 t/ha). At present prices, this represents a loss of income of around $400/ha.

Disease Management. With lower average humidity than southern high rainfall zones, Finley has much lower disease pressure in faba bean crops. Low levels (5% leaf are index in the lower canopy) of chocolate spot has been observed in plots that have not been treated with fungicide. Application of fungicide has led a to an observed reduction in disease, however this has not led to a yield increase. Less chocolate spot has been observed in the newer cultivar PBA Amberley , than the older cultivar Fiesta VF. Interestingly, Fiesta VF has been 8% higher yielding than PBA Amberley over the 2 years of research at Finley.

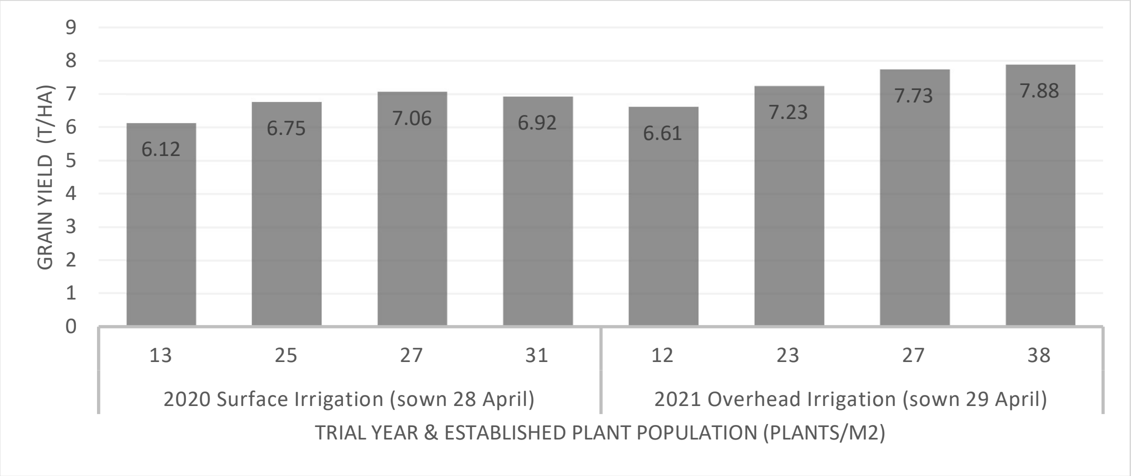

Figure 1. Effect of Faba Bean plant density on grain yield. 2020 and 2021 Finley Irrigated Research Centre.

Durum – Can we achieve high yields and meet the target of minimum 13% protein?

2020 trials at Finley showed no response to nitrogen applications as the previous site history of faba beans and fallow had led to high residual soil nitrogen (232 kg N/ha 0-90cm). Minimum protein levels were easily achieved. In 2021 available nitrogen was measured at early stem elongation showed 47 kg/ha of available nitrogen. Yields plateaued at 100kg of N applied split between GS30 and GS32. At the same timing, 200 kg of N was required to achieve 13% protein required to meet DR1 classification. In a separate nitrogen timing trial, 13% protein was achieved with 100kg N/ha when timing was delayed to GS32 & GS37, without any loss in yield.

Disease Management. In two years of trials at Finley, there have been small yield increases in Durum from fungicide applications (average 0.4 t/ha). One aspect of disease control that farmers should make themselves informed of is the benefits of at seeding fungicide treatments. Systiva & Jockey were applied as seed treatments and Flutriafol was applied as a fertiliser treatment. These applications were then followed with a foliar treatment of Amistar Xtra at Flag leaf emergence (GS39). Flutrifol, in combination with a GS39 spray was able to control 90% of stripe rust. Please note that a susceptible cultivar may require an additional fungicide application at GS31.

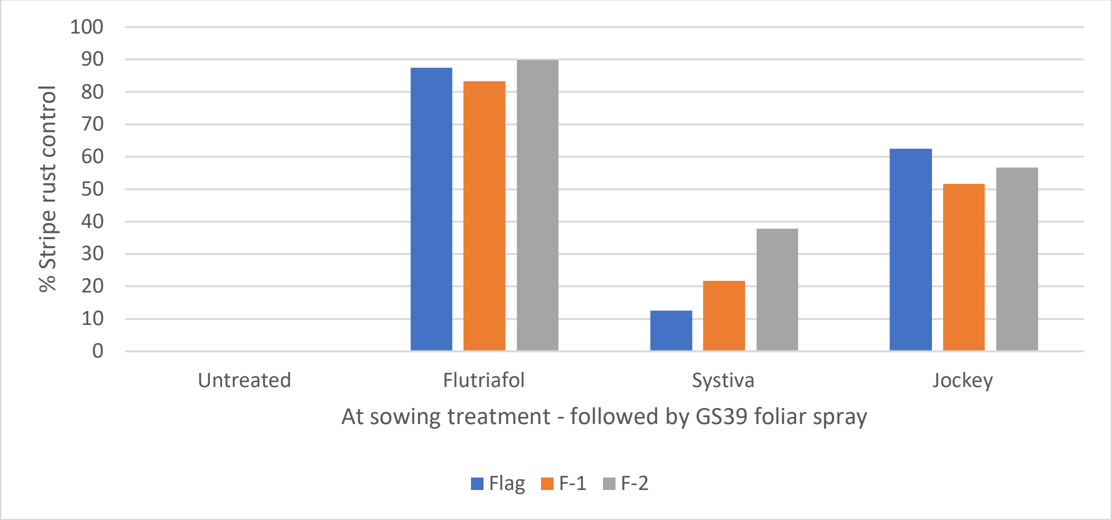

Figure 2. Effect of seed treatment fungicides on control of stripe rust in durum wheat, cv. DBA Vittaroi. 2020 Finley Irrigated Research Centre.

Barley Management options to close the yield gap and reduce pre harvest losses

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Background: While it is assumed the new frontier for barley is 25kg.ha.mm this has rarely been demonstrated. Outside of variety selection recent research has demonstrated that canopy management in barley through the use of fungicides, sowing time, and plant growth regulation can explain yield responses ranging from 3 – 8 t/ha within similar genetics in cooler and milder production environments. These factors have been more important than Nitrogen management, particularly where yield potential exceeds 5t/ha and on fertile soils. There may be more scope to close the yield gap in the short to medium term with improvements in disease management, head loss, brackling and lodging control but has not been replicated in lower yielding environments.

Project Aims

We aim to achieve and derive water limited potential yields in 4 contrasting environments defined by heat, frost and terminal drought during grain fill. Our primary objective is to update management guidelines to achieve water limited yield potentials in LRZ – MRZ barley.

We have generated factorial treatment structure that is coordinated across production environments to link crop physiology with agronomy at different yield potentials in warmer dry environments. The experiment at Finley will be conducted side by side under a dryland system and lateral irrigator to explore the differences in the yield gap attributed to water limitation. The trials will be conducted in 2022 and 2023.

Production environments:

- LRZ: Birchip 2 – 4 t/ha potential
- MRZ: Hart SA 3 – 6t/ha
- MRZ: Finley: Dryland 3 – 6 t/ha potential
- Non-Water Limited: Finley Irrigated 10t/ha potential
-

Field Treatments:

Eight levels of increasing management intensity will be applied to each environment that replicates standard through to intensive management (Full disease control, Canopy Controlled, and Nitrogen for a decile 9 season). There are 2 Nitrogen treatments at all fungicide levels control to assess yield gap related to N and disease. There are 3 Canopy interventions at high N to assess yield gap related to canopy control.

Trt	Treatment name	Fungicide	Canopy	Nitrogen
1	Nil Fungicide	Nil	Nil	Low - Intermediate
2	Intermediate	1 Unit	Nil	Low - Intermediate
3	Full Potential	Full	Nil	Low - Intermediate
4	Nil Fungicide	Nil	Nil	Non-Limiting
5	Intermediate	1 Unit	Nil	Non-Limiting
6	Full Potential	Full	Nil	Non-Limiting
7	Full Potential	Full	PGR	Non-Limiting
8	Dual Purpose System	Full	Defoliation	Non-Limiting

Cultivars

1. RGT Planet (High Yielding but disease susceptible)
2. Cyclops (High yielding low rainfall erect cultivar. but brackling prone)
3. Leabrook (Vigorous lodging check, Compass type).

Vetch 2021 Key Results

Russell Ford, Southern Growers

- Seed rates at 80 plants/m^2 produced significantly better dry matter production than 50 plants/m^2
- Crude protein values were lower with later cut timings across all varieties.
- Morava best DM performance (6.6t/ha at R2), Capello (6.23 t/ha at R4), Timok (6.02 t/ha at R6).
- Autumn and Spring Irrigations combined delivered an average DM production increase of 0.6 tonne over the three harvest timings compared to dryland.
- No significant difference was found in DM production for Autumn or Spring only irrigation treatments.
- Cultivar only had an effect of neutral detergent fibre (NDF) when cut early at R2 with Morava having the lowest value. NDF Values for all cultivars ranged from 52.1 to 58.2%.

The Trial

VARIETY	SEED RATES (seeds/m^2)	IRRIGATION TIMING
Capello	50	Dry
Timok	80	Autumn only
Morava		Spring Only
RM4		Autumn and Spring

SOWING THE SEED FOR A BRIGHTER FUTURE

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