Final Technical Report Template

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Locally relevant spring and/or summer sown cropping opportunities for grain growers following excessive winter waterlogging – South-Western Australia.

Project code:	SCF2109-001SAX
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REPORT SENSITIVITY

Does the report have any of the following sensitivities?

Intended for journal publication	YES
Results are incomplete	NO
Commercial/IP concerns	NO
Embargo date	N/A

Abstract

The project was set up in response to the severe waterlogging experienced in the region along the south coast of WA in 2021, and it presented an opportunity to look at the agronomic and economic opportunities of summer crops to use the excess soil moisture and mitigate waterlogging in the following season. There was also a need to understand the year-on-year impact of summer cropping and how these crops impact the following winter crop.

The project aimed to provide production and economic information from both farm-scale demonstrations and a small plot trial to inform good business decisions in regard to spring/summer sown crops.

In 2021/22, six successful field trials were spread across the medium to high rainfall zones of the Central Wheatbelt, Great Southern and Southern Coastal regions of WA. Excessive winter waterlogging occurred in the 2021 season across all trial locations.

The results showed that:

- Extremely late (October) sown cereals can be profitable on the South Coast of WA when sown into a full soil moisture profile.
- Growing a summer crop may conserve more soil moisture than a chemical (bare) fallow.
- There was no negative impact in any of the trials/demonstrations of the summer crop on the productivity of the following winter crop.
- Summer forage crops can be profitable, or at least pay for themselves, if more than one grazing can be achieved.

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Executive Summary

<u>Background & Methodology</u>

The project was set up in response to the severe waterlogging experienced in the region along the south coast of WA in 2021. SILO data shows that the entire Great Southern region received decile 8-10 rainfall, with the key seeding months of April-June receiving well above the 51-year average rainfall. In addition, the region had also received above-average rainfall for the 2019-2020 summer. As a result, growers attempted to sow crops very late or re-seed paddocks that had failed with limited success.

The seasonal conditions presented an opportunity to look at the agronomic and economic opportunities of summer crops to use the excess soil moisture and mitigate waterlogging in the following season. There was also a need to understand the year-on-year impact of summer cropping and how these crops impact the following winter crop.

As such, the investment aimed to locally validate previous R&D investment relating to spring sown crops (albeit include newer crop types and varieties where suitable), building local grower and adviser knowledge to inform decisions when managing excess soil moisture. It aimed to provide production and economic information from both farm-scale demonstrations and a small plot trial to inform good business decisions in regard to spring/summer sown crops.

The trials evaluated the crop performance on a range of metrics to provide a thorough assessment of summer crops, and the role they can play in agronomic systems, and the potential they have to reduce the waterlogging risk.

In 2021/22, six successful field trials were spread across the medium to high rainfall zones of the Central Wheatbelt, Great Southern and Southern Coastal regions of WA. Excessive winter waterlogging had occurred in the 2021 season across all trial locations. The field trials included:

- A small plot trial (led by Nutrien Ag Solutions) – multiple crops for grain production
- Two multi crop type farm-scale demonstration trials (led by SCF & Southern Dirt)
- Three single crop type farm-scale demonstration trials (led by SCF, Facey Group & Southern Dirt).

<u>Small plot trial key learnings</u>

The small plot trial highlights the grain production potential for extremely late sown crops on the South Coast of WA, when there is a full soil moisture profile. Wheat and barley crops sown as late as October yielded well over 2 t/ha, and the economic analysis shows that these were profitable treatments that went some way to 'making-up' for the failure of the previous winter crop. The grain prices for some more uncommon 'high value' summer crops also give growers the confidence to attempt to grow these after waterlogging, as low yields can still be profitable i.e., in the case of hemp. Grain prices and market access should be confirmed prior to growers experimenting with these crop types.

Also positive, is the apparent lack of impact the summer crops had on the following winter crop (barley).

<u>Multi crop type demonstrations</u>

It was shown at both sites that growing a summer crop increased the fallow efficiency i.e., there was more soil moisture in the soil profile for the following winter crop. This was particularly interesting given the dry summer over which the summer crops were grown. This is likely to have occurred through the summer crops providing soil cover and reducing evaporation and/or allowing rainfall that was received to better infiltrate into the soil profile, rather than runoff.

In terms of grazing, it was evident at the Green Range site that if a summer crop could be grazed twice it paid for itself and if a third grazing was managed, profit could be made. Sorghum held up better to multiple grazings than the millet or millet/lab lab mix at this site, but possibly due to preferential grazing of the millet initially.

The 2022 winter crop production for each of the multi crop type trials also highlighted that there was no significant yield disadvantage as a result of growing summer crops. This is likely a result of three key contributing factors. Firstly, the paddocks in which the summer crops were produced are relatively infertile sandy soils, with very little nutrient holding capacity and it was unlikely nutrients had been 'robbed' by the summer crops. The winter crops produced on these soil types, obtain the vast majority of their nutrients from a combination applied fertiliser and stubble turnover via mineralization. Secondly, there was an apparent increase in soil moisture where the summer crops were sown and finally, the root channels from the summer crop may have aided rainfall infiltration and reduced non-wetting issues to some extent. This could be further investigated.

Single crop type demonstrations

The single crop type demonstrations sites show that grain yield is the profit driver over the grazing. It should be noted, however, that the grazing income was calculated on a very conservative 90c/head/week figure and many growers would argue that this is not representative due to different markets and classes of stock. As winter canola and winter wheat grows in popularity along the South Coast of WA, it shows that there may be room for review of graze and grain principals (or perhaps more research with newer varieties available) to ensure crops are being grazed to minimize impact of grain yields.

Economic analysis

For the demonstration sites, both single and multi crop type, and within the broad assumptions set, the economic analyses essentially show that summer/spring sown crops are profitable if you can graze them at least twice, where they are not taken though to grain. Where these crops are then taken through to grain (i.e., winter wheat and canola), it is the grain yield driving the profitability. Grazing does impact on final grain yield, so understanding how to graze crops is very important.

For the small plot trial, it is very evident that price of grain plays an important role. Even though hemp yields were low (0.28 t/ha), the price of grain (estimated to be $3000/t) still made this a profitable treatment. The analysis also shows the profitability of late sown wheat, barley and rye.

Conclusion

The results from 2021/2 summer phase of this project, highlight the viability of the summer crops sown in tough conditions (dry summer), and indicates that the risk of seeding summer crops could be significantly lower than the currently held consensus. A key learning is also that crop selection and operational adaptability is critical to the success of the crop and the ability to maximise returns.

It is recommended the fallow efficiency of summer crops be investigated further and graze and grain principals be reviewed.

Contents

Tables & Figures

Background

The project was set up in response to the severe waterlogging experienced in the region along the south coast of WA in 2021. SILO data shows that the entire Great Southern region received decile 8-10 rainfall, with the key seeding months of April-June receiving well above the 51-year average rainfall. In addition, the region had also received above-average rainfall for the 2019-2020 summer. As a result, growers attempted to sow crops very late or re-seed paddocks that had failed. This was done with limited success due to trafficability issues. Large swathes of land in southern WA remained severely waterlogged throughout the season with many growers and advisors seeking relevant data on alternative cropping options to use the excess soil moisture.

Growers in the Great Southern Region of WA typically run mixed farming enterprises and have dabbled with summer crops for forage, with mixed success, for more than 50 years. Previous GRDC investments (DAW722 and SDI1801-001SAX) found summer forage crops to be successful, not only due to the summer/autumn livestock grazing opportunity presented but also by reducing soil water recharge (where waterlogging was an issue) and successfully providing nitrogen to the following winter crop where a summer legume had been sown.

The 2021 season presented an opportunity to look at the agronomic and economic opportunities of summer crops to use the excess soil moisture and mitigate waterlogging in the following season. There was also a need to understand the year-on-year impact of summer cropping and how these crops impact the following winter crop. It would likely be a balance between the economic benefits of a single summer crop, in financial recovery of the winter crop loss the previous year, and the potential impact summer crops may have on the following winter crop (positive or negative). It was also thought that summer crops may have a year-in-year out fit in the high rainfall zone of the Great Southern Region.

Overall, this investment aimed to provide growers with a range of spring/summer sown cropping options to address the impacts of excessive winter waterlogging and explore summer production opportunities.

Project objectives

This investment aimed to locally validate previous R&D investment relating to spring sown crops (albeit include newer crop types and varieties where suitable), building local grower and adviser knowledge to inform decisions when managing excess soil moisture. It aimed to provide production and economic information from both farm-scale demonstrations and a small plot trial to inform good business decisions in regard to spring/summer sown crops.

The trials evaluated the crop performance on a range of metrics to provide a thorough assessment of summer crops, and the role they can play in agronomic systems, and the potential they have to reduce the waterlogging risk.

GRDC Outcome:

By February 2023, 20% of Western Region Growers who farm in areas with a medium to high-risk of regular waterlogging will have built the knowledge and confidence to profitably sow a crop in spring or summer on paddocks were winter crops/pastures have failed due to excessive waterlogging or where soil moisture levels permit in future years.

To achieve this outcome, Stirlings to Coast Farmers (SCF) worked with a number of other Grower Groups to ensure the key learnings of the trial were broadly and successfully extended to growers in the Great Southern Region of WA.

Methodology

In 2021/22, six successful field trials were spread across the medium to high rainfall zones of the Central Wheatbelt, Great Southern and Southern Coastal regions of WA. Excessive winter waterlogging had occurred in the 2021 season across all trial locations. The field trials included:

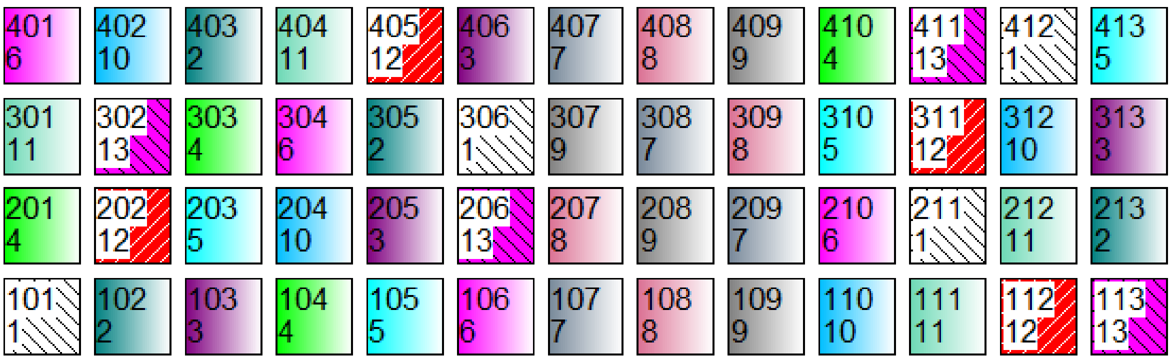
- A small plot trial (led by Nutrien Ag Solutions)
- Two multi crop type farm-scale demonstration trials (led by SCF & Southern Dirt)
- Three single crop type farm-scale demonstration trials (led by SCF, Facey Group & Southern Dirt).

Small Plot Trial

A replicated small plot trial was implemented and managed by the Nutrien Ag Solutions trials team and was located in Green Range, WA. The plots were sown on 14 October, 11 and 25 November 2021, with the different sowing dates due to seed availability, and obtaining permits in the case of the industrial Hemp.

The grain harvest for each of the treatments that produced grain, were conducted by taking hand cut sub-samples from each plot. This was done to ensure that the crops were 'harvested' at their optimal maturity. The hand cuts were threshed later using a stationary trial harvester provided by the DPIRD office in Albany. Grain samples were weighed after threshing and the grain yields of the small plot treatments were determined. The treatments and trial design are shown in Figure 1.

The plots were over sown with barley in Autumn 2022, in order to understand the impact of the summer crop to the following winter crop. NDVI, harvest yield were recorded.



Treatments:

Trt	Code	Description
1	CHK	Fallow
2		Spring Wheat Vixen 100 kg/ha
3		Spring Barley Mundah 100 kg/ha
4		Spring Canola Emu 2 kg/ha
5		Ryecorn BPS Ryecorn 15 kg/ha
6		Millet Grain Shirohie 10 kg/ha
7		Sorghum Grain Liberty 5 kg/ha
8		Lab Lab Highworth 20 kg/ha

9		Cowpea Ebony 30 kg/ha
10		Linseed BPS Linseed 40 kg/ha
11		Sunflower Grain AussieStripe 5 kg/ha
12		Lucerne Sardi Grazer 10 kg/ha
13		Safflower Safflower 15 kg/ha

All treatments will be oversown with a cereal in 2022 growing season. The Variety will be chosen to best suit maturity at time of sowing.

Figure 1: Trial design and treatment list for the small plot trial, Green Range, WA.

The small plot trial measurements/assessments were taken as follows:

Spring/Summer 2021/21

- Soil test prior to sowing Spring 21.
- Rainfall observations.
- Assess early plant establishment (counts) and biomass (NDVI).
- Measure maximum rooting depth of treatments.
- Grain yield and quality assessments for each treatment.

Autumn/Winter 2022

- Soil test Fallow v Legume (highest biomass) v Grass (Shirohie) prior to sowing Autumn 22.
- Harvest Grain yields

Multi Crop Type Demonstrations

Two multi crop type summer cropping trials were sown in late 2021. These were located in Scotts Brook and Green Range. The trial at the Scotts Brook site included Sunflower, sorghum and millet treatments. The trial in Green Range included millet, sorghum and a millet/Lab lab mix. It was intended that the Scotts Brook trial be taken through to grain harvest, but not the Green Range trial which was only intended for grazing.

Soil moisture was a key aspect investigated in the two multi crop type demonstrations with numerous soil moisture measurements taken for each treatment at each location. Each growers' motivation to grow summer crops varied between the two sites, with the grower in Green Range seeking to dry out the soil to mitigate winter waterlogging in 2022, and the grower in Scotts Brook hoping to conserve soil moisture.

The trial design for each of these sites is shown in Figures 2 and 3.

The measurements/observations recorded for the two multi crop type demonstrations included:

- Soil volumetric water content (3 timings) – prior to sowing of the summer crop, at termination of the summer crop and at harvest of the following winter crop
- Biomass (dry matter t/ha)
- Grazing records (summer crop only)
- Following winter crop establishment (plants/m2)
- Following winter crop harvest yield (t/ha)

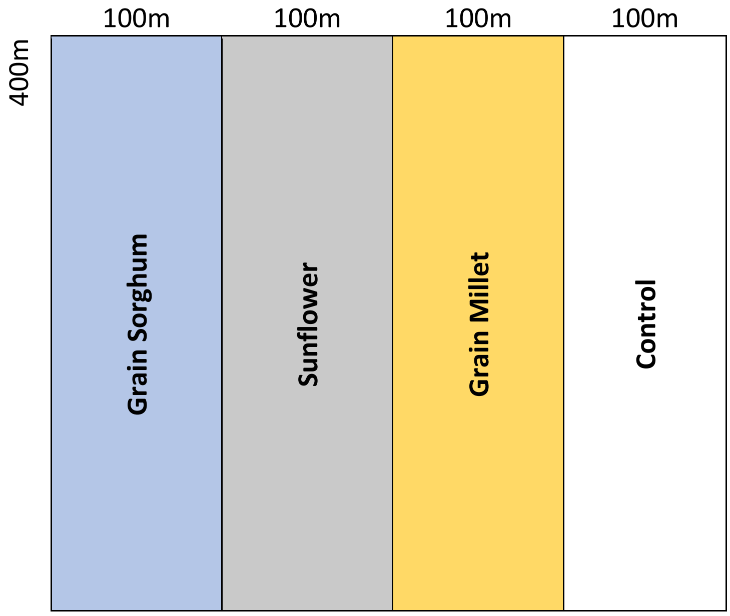


Figure 2: Multi crop type demonstration site design, Scotts Brook, WA.

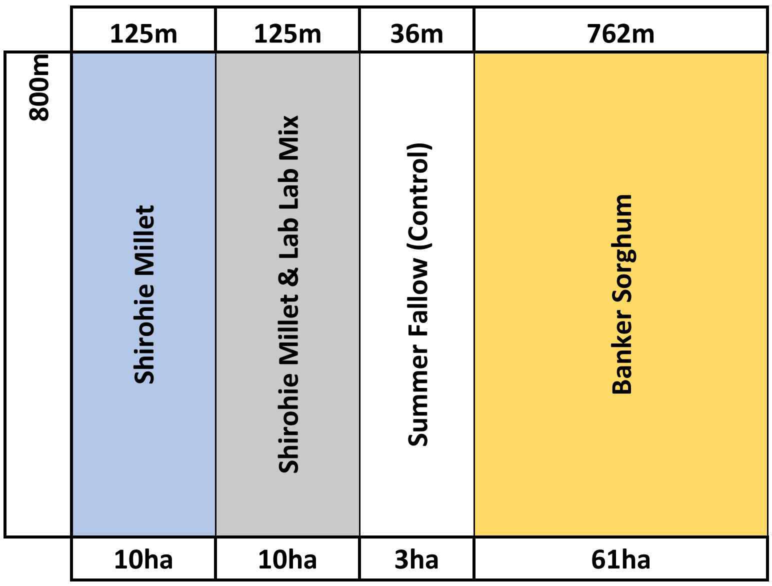


Figure 3: Multi crop type demonstration site design, Green Range, WA.

Single Crop Type Demonstrations

Three single crop type demonstrations were implemented in Kojonup, South Stirling and Wickepin. The Kojonup and South Stirling sites were sown to winter canola (both Hyola 970 @ 3kg/ha) in spring 2021 and the Wickepin site sown to winter wheat (2 varieties – Denison and Illabo) in early autumn 2022. All sites included a grazing component and were then taken through to harvest in 2022.

The following measurements/observations were recorded for each of the single crop type demonstrations:

- Crop establishment (plants/m2)

- Feed value analysis
- Grazing records
- Harvest yield (t/ha)

Economic Analysis

As part of the project, Farmanco Management Consultants conducted a broad economic analysis on the Nutrien small plot site and each of the grower demonstration sites. The analysis for the small plot site included the summer crop and following winter crop income/costs. The analysis for the multi crop type demonstration sites only included the summer period up until they were terminated prior to the sowing of the winter crop. As such, only grazing value was accounted for. The economic analysis conducted for each of the single crop type demonstrations, which were all sown to either winter wheat or winter canola, included both the grazing and harvest data as each of these sites were taken through to harvest in 2022. To conduct the analysis, the following overall broad assumptions were made, including:

- Value gain of running sheep on fodder crop (after management & operating costs considered) was assumed to be 90 cents per head per week.

- Variable operating costs for sowing a summer crop (seed, machinery, fuel but minimal fertiliser and chemical inputs) was assumed to be $120/ha. This is not applicable the winter canola/wheat sites, where cost was more accurately assigned.

- Overhead costs (depreciation, insurances, rates & management time) were assumed to be $125/ha, but only for the sites taken through to harvest (winter wheat & canola).

- Grain prices for canola were $825/t and for wheat $400/t.

Location

NOTE: Where field trials have been conducted please include location details: Latitude and Longitude, or nearest town, using the table below (please add additional rows as required):

	Latitude (decimal degrees)	Longitude (decimal degrees)
Trial Site #1 & 2 SCF – Multi-species & small plot - SCF	-34.592958	118.396094
Nearest Town	Green Range	
Trial Site #3 – Single species - SCF	-34.582541	118.145782
Nearest Town	South Stirling	
Trial Site #4 – Multi-species - SD	-33.887281, 116.774793	
Nearest Town	Scotts Brook	
Trial site #5 – Single -species - SD	-34.129919, 116.917714	
Nearest Town	Kojonup	
Trial Site #6 – Single Species- Facey	Wickepin	
Nearest Town	-32.774570, 117.497236	

If the research results are applicable to a specific GRDC region/s (e.g. North/South/West) or Agro - Ecological Zone/s please indicate which in the table below:

Research	Benefiting GRDC Region (can select up to three regions)	Benefiting GRDC Agro-Ecological Zone (see link: http://www.grdc.com.au/About-Us/GRDC-Agroecological-Zones) for guidance about AE-Zone locations	
Locally relevant spring and/or summer sown cropping opportunities for grain growers following excessive winter waterlogging – South-Western Australia	Choose an item. Choose an item. Western Region	☐ Qld Central ☐ NSW NE/Qld SE ☐ NSW Vic Slopes ☐ Tas Grain ☐ SA Midnorth-Lower Yorke Eyre ☐ WA Northern ☐ WA Eastern ☐ WA Mallee	☐ NSW Central ☐ NSW NW/Qld SW ☐ Vic High Rainfall ☐ SA Vic Mallee ☐ SA Vic Bordertown-Wimmera ☐ WA Central ☒ WA Sandplain

Results

Rainfall 2021/22

The rainfall received between October 2021 was above average, this was followed by an average November and very dry December, January and February (Figure 4). As a result of the lack of summer rainfall, some of the spring/summer sown crop did not perform as well as expected.

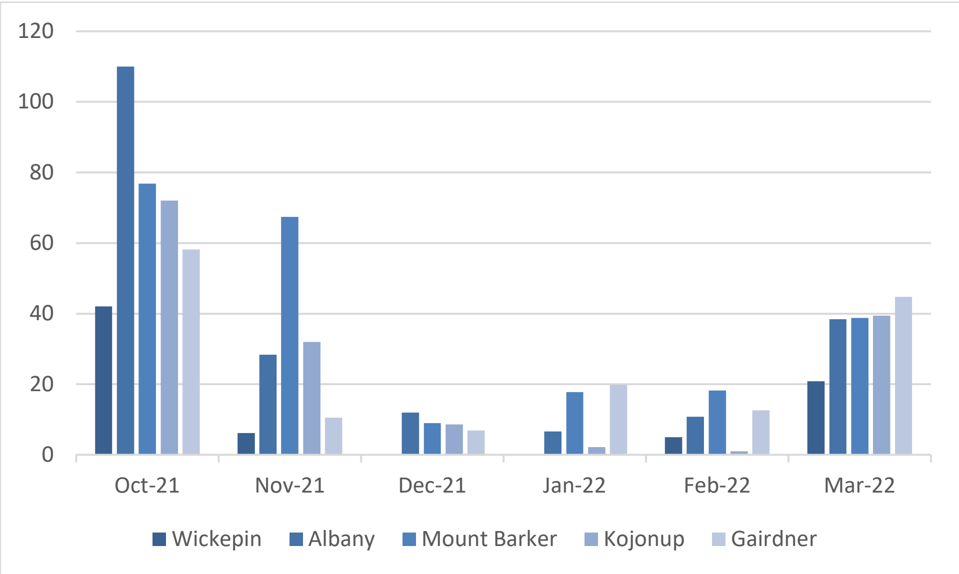


Figure 4: Rainfall (mm) received at weather stations located in the Great Southern Region of WA, October 2021 – March 2022.

Small Plot trial – Green Range

The small plot trial located in green Range and managed by Nutrien Ag Solutions consisted of 11 different varieties of spring and winter crops. Eight of the 11 crops were carried through to grain, whilst three failed to produce a viable grain yield.

Plant Establishment

Plant establishment was variable for the summer crop treatments (Figure 5). Linseed and the wheat and barley had the highest plant counts/m2. The variability can also be somewhat attributed to seeding rate.

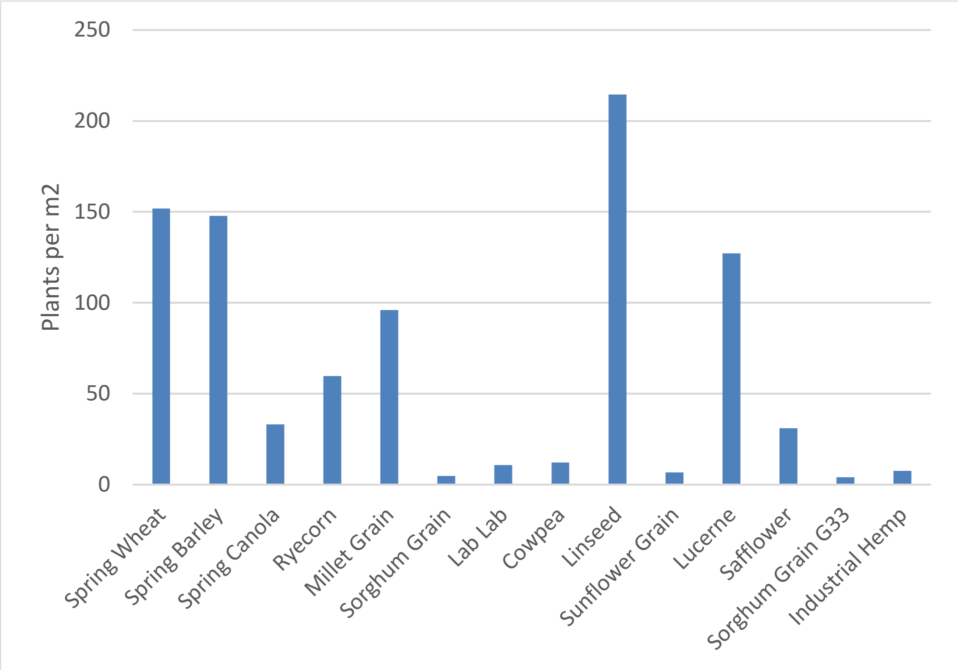


Figure 5: Plant establishment (plant/m2) for each of the Green Range small plot treatments, 2021.

Biomass

Biomass readings were taken, however, the due to the rainfall around time of seeding of the summer crop treatments, the trials were very weedy. Once the weeds had been hand-pulled out of the trial, the canopies of each of the treatments had closed over showing full coverage.

Rooting Depth

Rooting depth was assessed for each of the summer crop treatments. The rooting depths were all uniformly between 20-30cm, which was the depth to clay across the site.

Grain yield – Summer & Winter crops

Of the crop types that were seeded, the ryecorn, spring wheat, spring barley, and industrial hemp produced the greatest yield (Figure 6). **Note:** The estimated value of hemp seed is $3,000/tonne, which is why the 283kg/ha yield is economically significant.

There was no significant impact on the yield of barley sown over the summer crop treatments in the Green Range small plot trial (Figure 7). If one key learning was to be pulled from this graph, it is that the summer crops did not appear to have any impact on the yields of the following winter crop, if anything, yields were assisted.

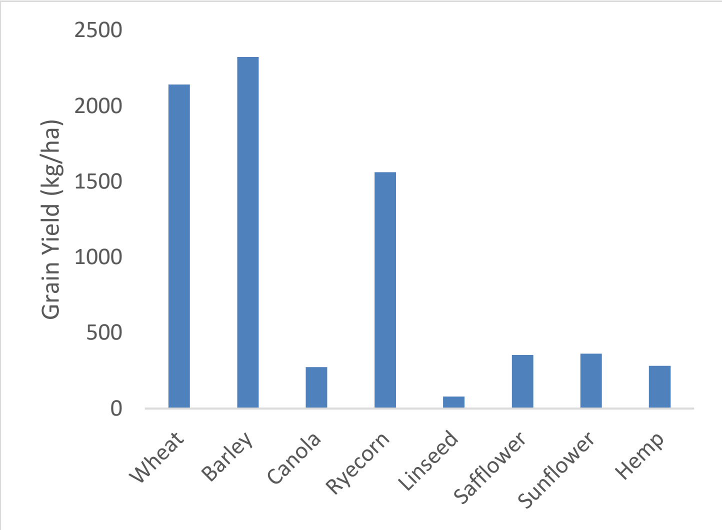


Figure 6: Small plot trial site grain yields for each treatment harvested (t/ha), Green Range, WA.

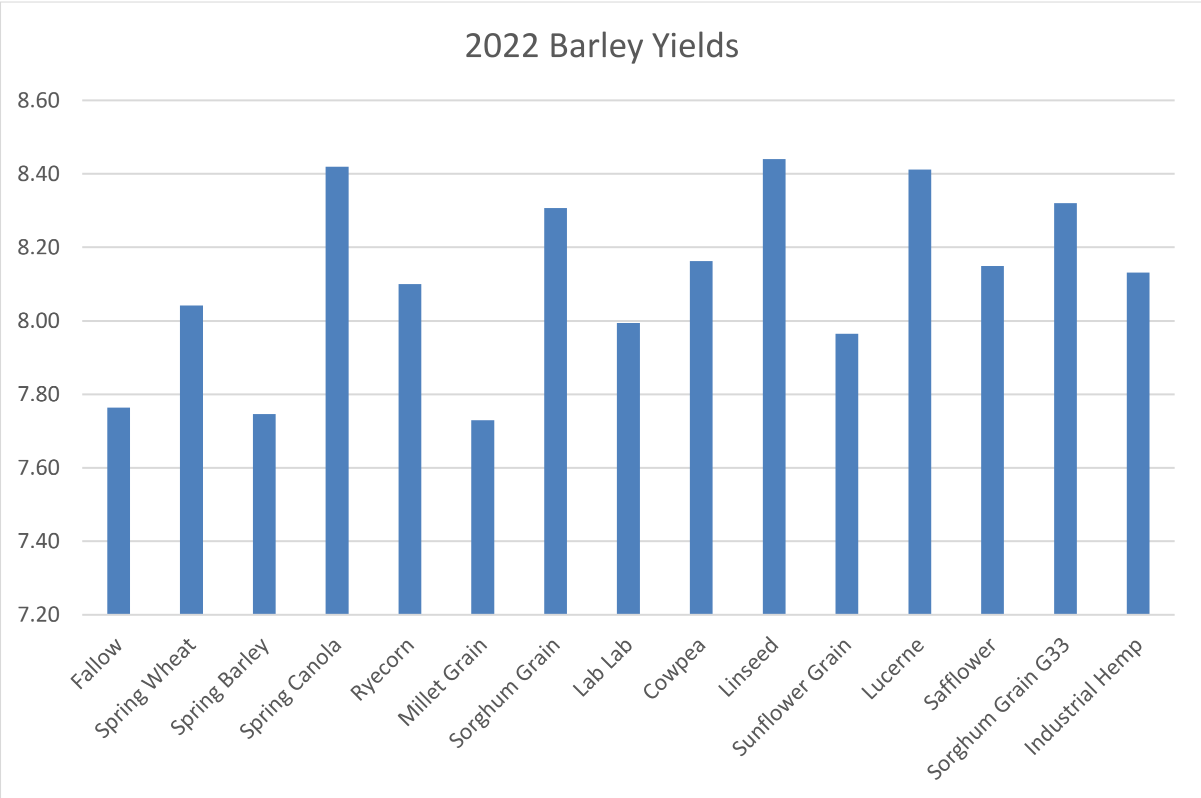


Figure 7: Grain yield (t/ha) for the barley sown over the Green Range small plot summer crop treatments, 2022.

Multi crop type demonstrations – Scotts Brook (SB) & Green Range (GR)

The two multi crop type trials at Scotts Brook (SB) and Green Range (GR), were seeded in early November 2021 into a full soil profile, after a decile 10 growing season. At each of these sites the winter crop had failed due to waterlogging.

The objectives of each grower host initially varied, with the Scotts Brook site intended for grain harvest and the Green Range site for grazing only. As a result, data collected from each site varied somewhat.

Soil moisture

The summer crops were monitored for soil moisture, with measurements taken at the beginning and the end of the summer period to assess the impact of the summer crops on plant available water in comparison to a bare fallow (standard practice). The measurements provided a comparison of the fallow efficiency for each cropping treatment. The cereal varieties of summer crops at both the GR and SB sites resulted in a greater volumetric water content percentage (VWC%) at time of termination compared to the bare fallow treatments (Figure 8 and 9). This gain in fallow efficiency compared the bare fallow is likely because the summer crops reduced evaporation and increased infiltration of summer rain, coupled with the stock defoliating the plants before they reached the stage (booting) of peak water demand.

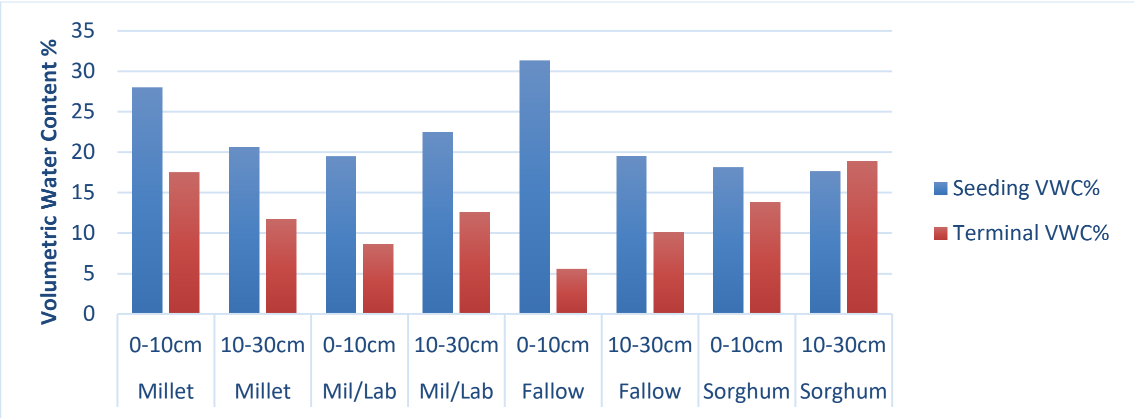


Figure 8: Starting and terminal volumetric water content percentage (VWC%) at Green Range (GR) for the 0-10cm and 10-30cm soil depth, 2021/22.

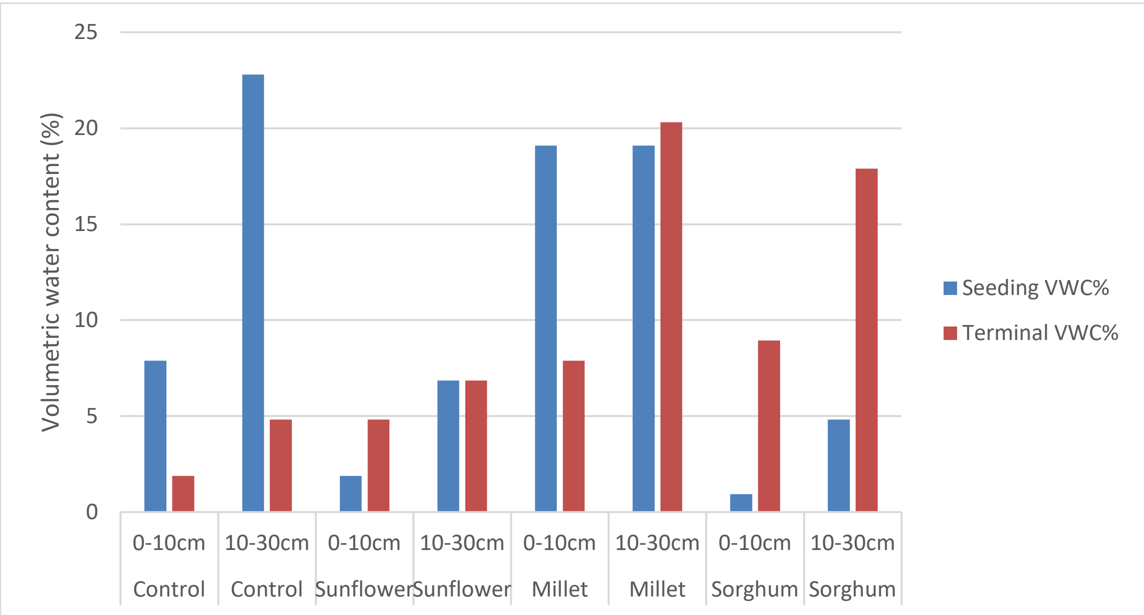


Figure 9: Starting and terminal volumetric water content percentage (VWC%) at Scotts Brook (SB) for the 0-10cm and 10-30cm soil depth, 2021/22.

Biomass production

The biomass production at each of the two multi crop type sites was impacted by the dry summer (Figure 4). The site at GR was grazed before reaching peak biomass (growth stage five for millet &

sorghum), to maximise the likelihood of a re-growth period, while mitigating plant mortality due to heat and drought stress in the height of the summer period. There was also a preferential grazing trend observed at GR where the stock grazed the millet and millet/lab lab mix before moving onto the sorghum. As a result, the two millet-based treatments were overgrazed, which impacted their ability to recover after the prolonged dormant spell due to the dry weather (Table 1). The multi-species trial at SB was established with the objective to be carried through to harvest, however the prolonged dry period severely impacted the crop growth, and harvest was aborted. The site at SB was able to reach peak biomass before termination at GS70, at which point it was grazed (Table 2).

Table 1: Biomass (dry matter t/ha) production at the first grazing period and at termination, when the ewes were rotated onto the paddock for the final time at Green Range.

Treatment	Biomass at First Graze (t/ha)	Terminal Biomass (t/ha)
Millet	2.41	0.71
Millet/Lab Lab	2.59	0.56
Sorghum	3.81	2.48

Table 2: Prior to grazing & termination biomass (dry matter t/ha) for the multi-species trial at Scotts Brook grown over the 2021/22 summer period.

Treatment	Terminal Biomass
Sunflower	5.12
Sorghum	3.00
Millet	2.17

Grazing data

Both multi crop type demonstration sites were grazed. The site at GR was established with the objective of maximising grazing returns. The SB site was established with the objective to carry the crops through to harvest. When it was decided that this would not be feasible (due to lack of rain), the site was grazed, albeit late. The site at GR was grazed three times and the site at SB was grazed once.

The site at GR was heavily grazed, with the purpose to quickly reduce the plant biomass, and defoliate the plants to give them the best opportunity to survive the dormant periods and generate significant regrowth. The millet and millet/Lablab mix were preferentially grazed at this site in the first grazing, which likely impacted the millets recovery and subsequent biomass production. The demonstration trials at GR and SB were both established in larger paddocks, where one predominant species (sorghum) was planted surrounding the trial area, and the paddocks were grazed as a single field.

Table 3: Number of ewes that grazed the 79ha demonstration site at Green Range, and the approximate weight they maintained during the grazing periods.

Stock numbers	Approximate weight (kg)	Start date	Days Grazing
2300	65	8-Jan	27
2300	65	20-Mar	10
1800	60	19-Apr	14

The site at Scotts Brook was grazed at the end of the summer fallow period, once it became clear that summer cropping treatments were not feasible to harvest. The demonstration site was grazed late-April to early-May by 1500 ewes for five weeks.

Winter crop

In 2022, the two multi crop type demonstration sites were seeded to barley (GR) and winter wheat (SB). These crops were monitored to observe the effect of the various summer crop types on the following winter crop.

Plant counts were taken for the GR site only and showed that the summer crops had no influence on the plant establishment (Figure 10).

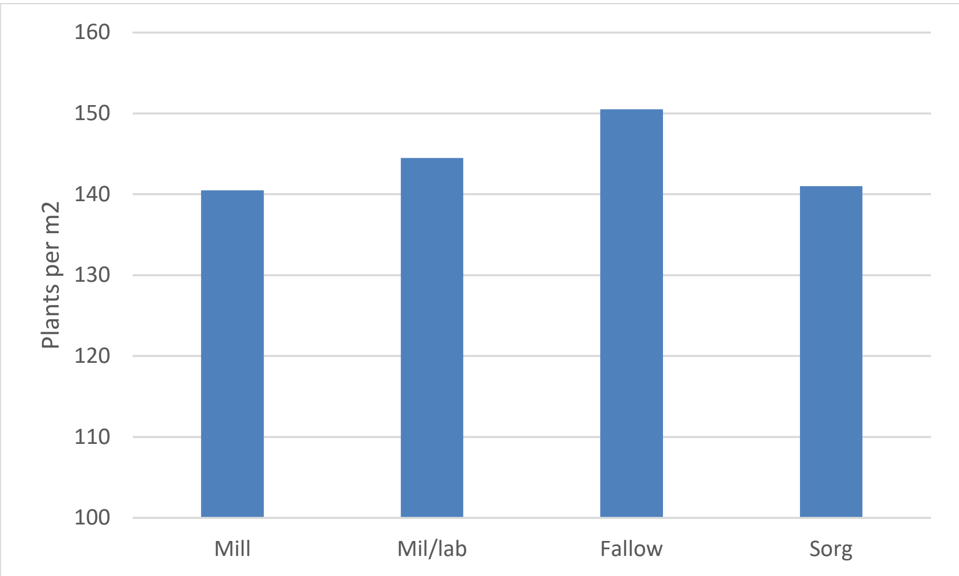


Figure 10: Plant counts per m2 for the barley sown over each of the summer crop treatments for the Green Range demonstration, 2022.

Harvest yields for both GR and SB were gathered via hand harvest, in lieu of the growers having a yield mapping system or a way of segregating grain from each plot. The harvest yields at both sites (Figure 11 and 12) showed that the summer crops had no significant impact on crop yields when compared to the fallow treatment at each site.

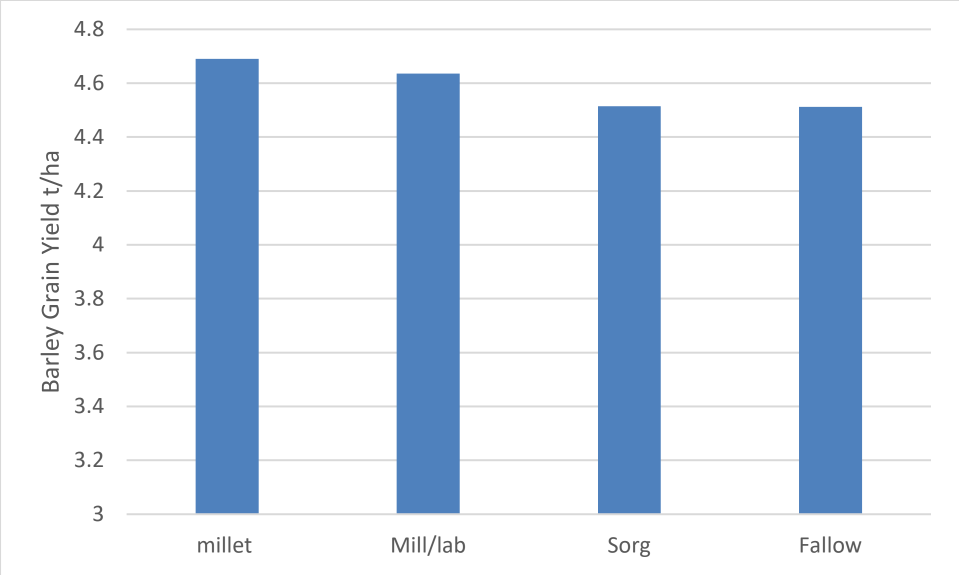


Figure 11: Harvest yield (t/ha) for the barley sown over each of the summer cropping treatments at the Green Range demonstration, 2022.

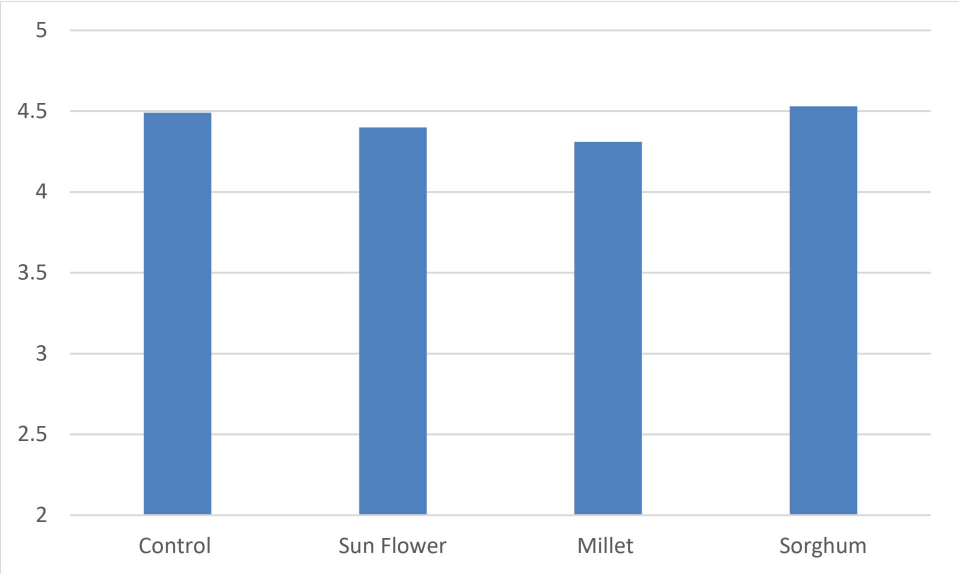


Figure 12: Harvest yield (t/ha) for the winter wheat sown over each of the summer cropping treatments at the Scotts Brook demonstration, 2022.

The plant available water content at termination of winter crop for both the GR and SB site showed no significant flow-on impact of the summer crops (Figure 13 and 14) on soil moisture levels. It does show significant in-paddock variability, however, this is more likely due to paddock topography.

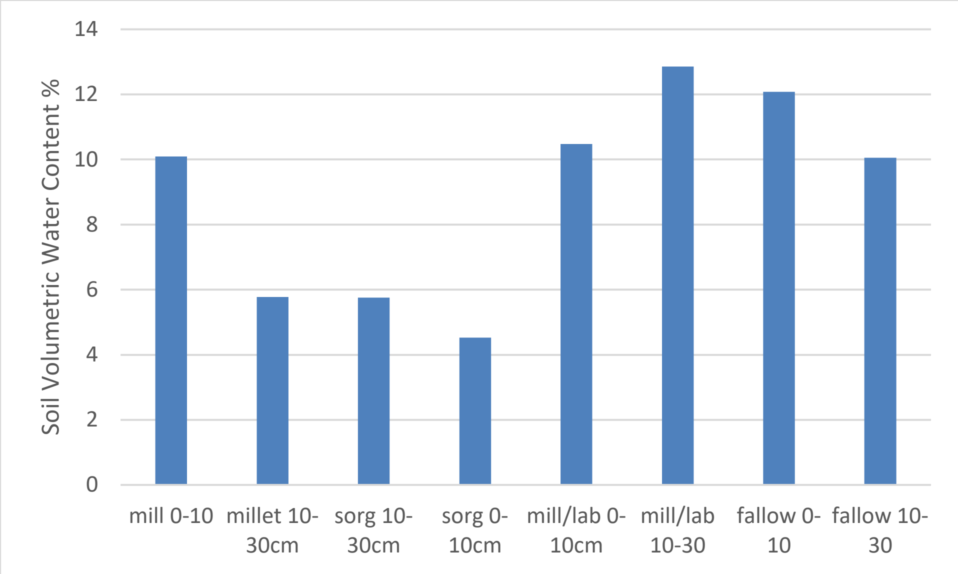


Figure 13: Soil volumetric water content (%) at time of harvest of the winter crop (barley) sown over the summer cropping treatments at the Green Range demonstration, 2022.

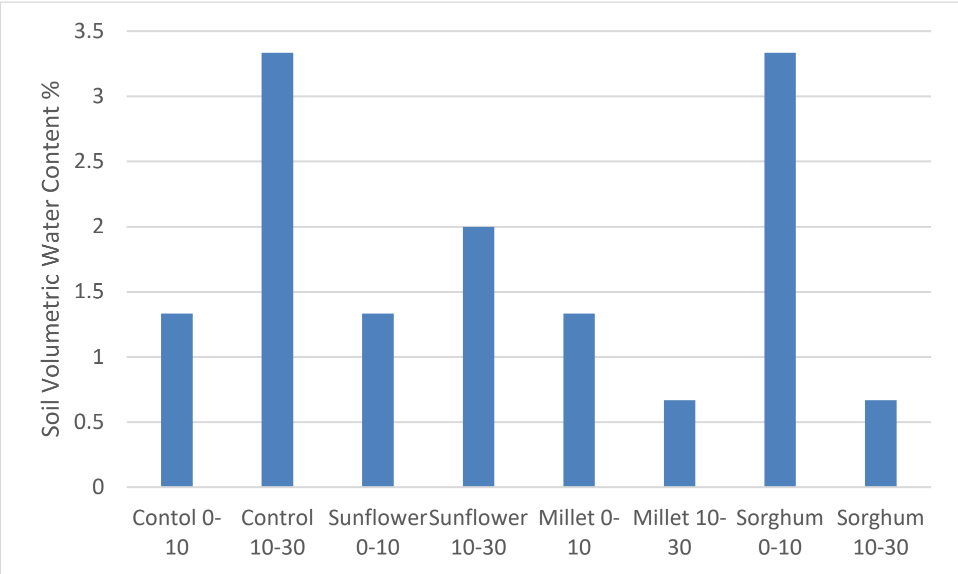


Figure 14: Soil volumetric water content (%) at time of harvest of the winter crop (wheat) sown over the summer cropping treatments at the Scotts Brook demonstration, 2022.

Single crop type demonstration trials – Kojonup (KO), South Stirlings (SS) and Wickepin (WP)

The three single species trials were whole paddocks that were sown to either winter canola or winter canola. The Kojonup (KO) site and South Stirlings (SS) sites were sown to winter canola in early October 2021 and the Wickepin (WP) demonstration was sown to two varieties of winter wheat (Illabo and Denison) in April 2022.

Plant Establishment

Plant establishment was recorded at the WP and SS demonstration sites only. For the WP site, tha counts showed that the Denison wheat established better than the Illabo (Figure 15). Both were seeded at the same rate. At the SS demonstration, plant counts were recorded twice, at establishment and post grazing. Figure 16 shows that plants count had reduced after grazing.

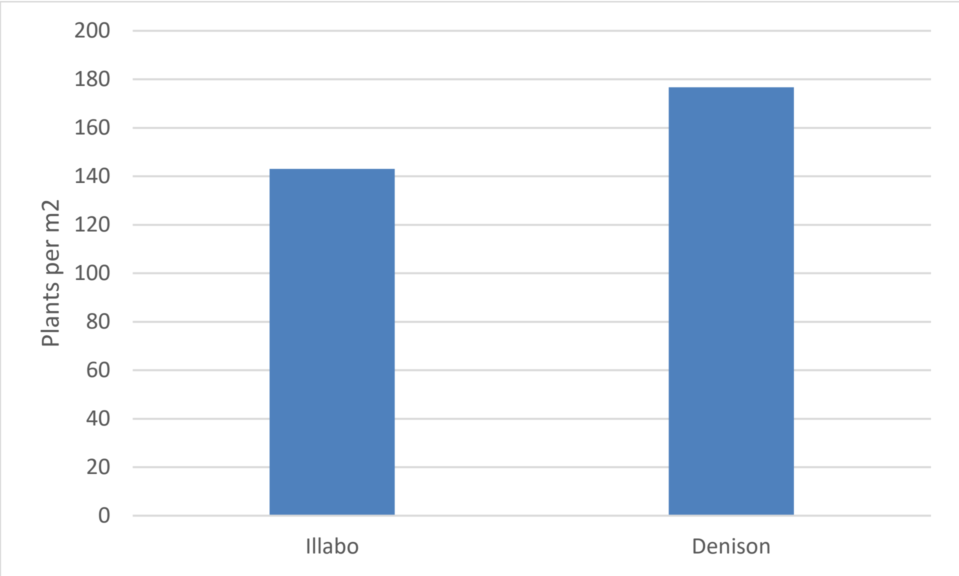


Figure 15: Crop establishment measurement (plant/m2) for the Wickepin (WP) demonstration, 2022.

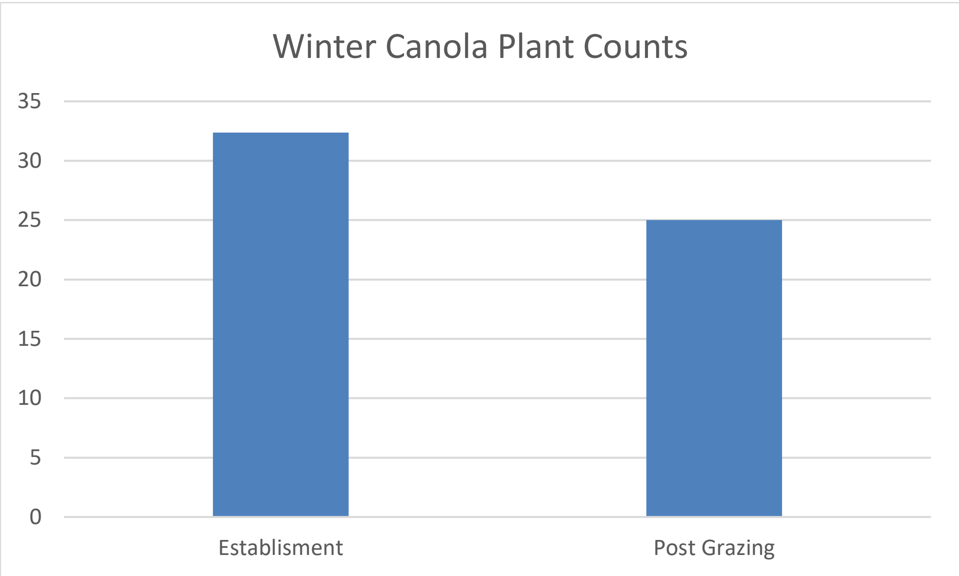


Figure 16: Crop establishment measurement (plant/m2) for the South Stirlings (SS) demonstration, 2022.

Feed Value

The average feed values were very good across the board for both the winter wheat (WP) and winter canola (KO & SS). There were no issues flagged for sheep in terms of digestibility or metabolizable energy (Table 4, 5 and 6).

Table 4: Feed values for the Wickepin (WP) Demonstration (winter wheat), 2022.

Sample	Dry Matter	Crude protein	ME (mj/kg)	Relative feed value
LSW Sample 1 Illabo	25.5	36.7	12.01	251
LSW Sample 3 Illabo	26.8	31.4	11.73	212
LSW Sample 5 Illabo	27.4	33.5	11.41	207
ILLABO AVERAGE	26.57	33.87	11.72	223.33
LSW Sample 2 Dension	23	40.3	12.06	222
LSW Sample 4 Dension	25.4	40.9	11.96	221
LSW Sample 6 Dension	25.2	39.4	11.69	218
DENISON AVERAGE	24.53	40.20	11.90	220.33

Table 5: Feed values for the Kojonup (KO) Demonstration (winter canola), 2022.

Dry matter	8.60%
Crude Protein	33.50%
Neutral Detergent Fibre	20.50%
Digestibility	88.30%
Digestibility (DOMD)	81.7%
Metabolisable Energy	13.6 MJ/kg DM
Fat	5%
Ash	12.90%

Table 6: Feed values for the South Stirling (SS) Demonstration (winter canola), 2022.

Dry matter	10.4%
Crude Protein	26.4%
Neutral Detergent Fibre	28.5%
Digestibility	81.2%
Digestibility (DOMD)	75.6%
Metabolisable Energy	12.3 MJ/kg DM
Fat	4.4%
Ash	10.5%

Grazing Data

The two canola sites were both heavily grazed at the start of the summer fallow period, with the first grazing at the SS site beginning on the 21/11 and finishing on the 5/1, at which point, the crop went into a dormant summer period. The paddock was grazed another two times before it was locked up for the winter grain production.

After being seeded in October, the canola in the KO demonstration was grazed three times over the summer period.

The long season wheat trial was seeded in April 2022, and was grazed by 600 ewe hoggets, at a stocking rate of 8.5/ha, for ten days. Prior to being locked up for grain production.

Grain Yield

Exclusion cages and hand harvest were used to capture the grain yields, with and without grazing for the two winter wheat varieties at the WP demonstrations site. The yield data shows a significant impact of the grazing on the winter wheat yields, and more so for the Illabo wheat (Figure 17).

The average canola yield for the KO winter canola demonstration was 1.6 t/ha and the average winter canola yield for the SS demonstration was 1.45 t/ha.

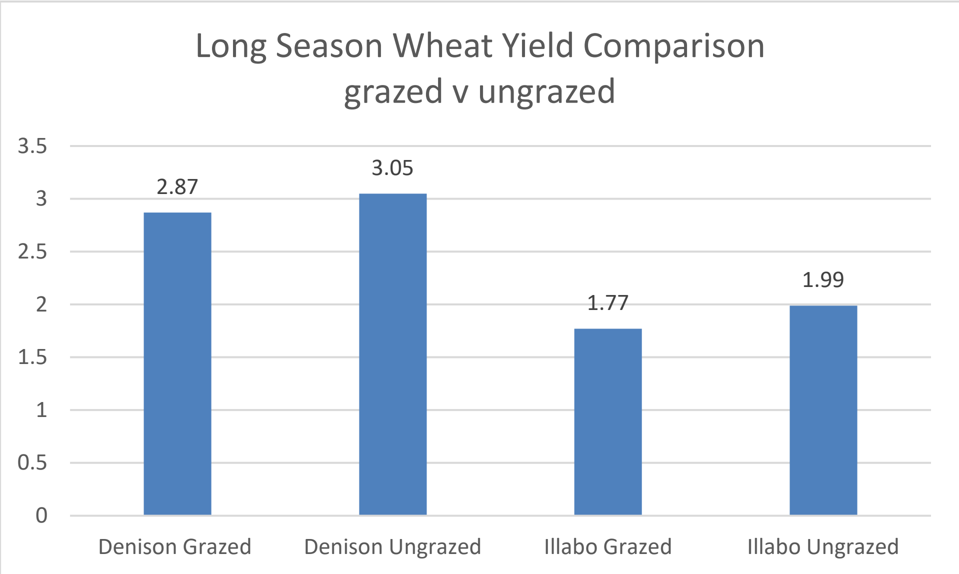


Figure 17: Harvest yield for the winter wheat (Denison and Illabo), both grazed and un-grazed, at the Wickepin (WP) demonstration, 2022.

Economic Analysis

Although a single crop type demonstration site at Wickepin (wheat), two varieties were investigated, Illabo and Denison (grazed and un-grazed). The economic analysis shows that the Denison outperformed the Illabo wheat, yielding 1 t/ha more than the Illabo in both the grazed and un-grazed treatments (Table 7). Given costs were similar, this has a significant impact on profitability.

The paddock used in the Kojonup single crop type demonstration was sown to winter canola at the beginning of November. Decent rain fell in November but then it was very dry for the rest of the summer. It was grazed and then taken through to grain harvest in summer 2022. The paddock averaged 1.6 t/ha. The grain sales over-shadowed the grazing value (Table 8).

The operating profit for the South Stirling demonstration site was calculated to be almost $250/ha (Table 9). The grain income (yield 1.4 t/ha) made up a significant proportion of the income generated. Grazing value was a lesser contributor; however, this is within the set assumption of 90c/head/week. It is very debateable that the grazing could be valued much higher, however, this is very variable between classes of stock and farm businesses, hence a standard figure has been used.

In the Green Range multi crop type demonstration, the gazing value essentially off-set the variable operating costs to put the crop in (Table 10). This was more so for the Sorghum which achieved an estimated Operating Gross Margin of $68/ha. Only the sorghum was still alive and productive at time of the second grazing, hence the higher margin. The Millet and millet/lab lab mix did not recover after the initial grazing.

It was intended that the multi crop type demonstration at Scotts Brook be taken through to harvest. The site was sown to sunflowers, grain millet and grain sorghum. As the summer cropping season progressed it was evident that harvest was not going to be viable and stock were put on to graze the entire trial, albeit late on. It is possible that had this decision been made sooner, the grazing value may have been higher (Table 11). Also worth noting, that the sunflowers were not grazed by stock very well.

Table 12 shows the economic analysis for the small plot trial site, however, only for the crop types that were taken through to harvest. Of these, the hemp (due to price/t) and the wheat were the outstanding treatments with an operating profit of $533 and $522, respectively.

Table 7: Wickepin single crop type (wheat) demonstration site economic analysis, 2022.

Crop Enterprise		Illabo	Illabo Grazed	Denison	Denison Grazed
Yield	t/ha	1.99	1.77	3.05	2.87
Average Grain Price (FIS)	$/t	$400	$400	$400	$400
Grain Sales	$	$796	$708	$1,220	$1,148
Grazing Value	$		$28		$28
Total Income	$	**$796**	**$736**	**$1,220**	**$1,176**
Variable Operating Costs	**$/ha**	$/ha	$/ha	$/ha	$/ha
Seed, Treatment & EPR's		$20	$20	$26	$26
Grain Freight (Up Country)		$4	$4	$7	$6
Grain Cartage Payments		$34	$30	$52	$49
Grain Handling Charges		$18	$16	$28	$26
Crop Contract		$20	$20	$20	$20
Other Crop Costs & Crop Ins		$35	$35	$35	$35
Wages Gross		$50	$50	$50	$50
R&M Mach./Plant/Vehicle		$60	$60	$60	$60
Fuel & Oil		$55	$55	$55	$55
Fertiliser, Lime & Gypsum		$251	$251	$209	$209
Pesticide		$130	$130	$120	$120
Variable Operating Costs		**$658**	**$651**	**$636**	**$631**
Operating Gross Margin	$/ha	$138	$84	$584	$545
Fixed Operating Costs	$/ha	**$125**	**$125**	**$125**	**$125**
Total Operating Costs	$/ha	**$783**	**$776**	**$761**	**$756**
Operating Profit (BIT) $/Ha	$/ha	**$13**	**($41)**	**$459**	**$420**

Table 8: Kojonup single crop type (winter canola) demonstration site economic analysis, 2021/22.

Crop Enterprise		Canola CL970
Yield	t/ha	1.60
Average Grain Price (FIS)	$/t	$825
Grain Sales	$	$1,320
Grazing Value	$	$90
Total Income	$	**$1,410**
Variable Operating Costs	**$/ha**	$
Seed, Treatment & EPR's		$30
Grain Freight (Up Country)		$4
Grain Cartage Payments		$27
Grain Handling Charges		$15
Crop Contract		$20
Other Crop Costs & Crop Ins		$35
Wages Gross		$50
R&M Mach./Plant/Vehicle		$60
Fuel & Oil		$55
Fertiliser, Lime & Gypsum		$251
Pesticide		$130
Variable Operating Costs		$676
Operating Gross Margin	$/ha	**$734**
Fixed Operating Costs	$	$125
Total Operating Costs	$	$801
Operating Profit (BIT) $/Ha	$	**$609**

Table 9: South Stirling single crop type (winter canola) demonstration site economic analysis, 2021/22

Crop enterprise		Hyola 970 CL
Yield	t/ha	1.4
Average Grain Price (FIS)	$/t	825
Grain Sale	$	826.4
Grain Value	$	196.908
Total Income	$	1023.308
Variable Operating Costs	$/ha	
Seed/treatment & EPR's		72
Grain Freight		5.3
Grain Cartage Payments		18.06
Grain Handeling Charges		15
Other Crop Costs/inputs		35
Fungicide		33
Pesticide		130
Wages		15.15
R&M Mach/Plant/Vihicle		60
Fuel & Oil		16.66
Ferteliser		248.95

Variable Operating Costs		649.12
Operating Gross Margin	$/ha	374.188
Fixed Operating Costs	$	125
Total Operating Costs	$	774.12
Operating Profit (BIT) $/ha	$	249.188

Table 10: Green Range multi crop type demonstration site economic analysis (grazing data only), 2021/22.

Crop Enterprise		Millett	Sorghum	Millet/Lablab
Grazing Value	$	$135	$188	$135
Variable Operating Costs		$120	$120	$120
Operating Gross Margin	$/ha	$15	$68	$15

Table 11: Scotts Brook multi crop type demonstration site economic analysis (grazing data only), 2021/22.

Crop Enterprise		Summer crop
Summer Crop Grazing Income	$/ha	$255
Summer crop Costs	$/ha	$120
Summer crop Profit	**$/ha**	**$135**

Table 12: Economic Analysis for the small plot trial treatments taken through to harvest (Green Range, 2022)

Crop Enterprise		Wheat	Barley	Canola	Ryecorn	Linseed	Safflower	Sunflower	Hemp
Yield	t/ha	2.14	2.32	0.27	1.56	0.08	0.35	0.36	0.28
Average Grain Price (FIS)	$/t	$400	$330	$825	$410	$800	$650	$800	$3,000
Total Income	$	**$856**	**$766**	**$223**	**$640**	**$64**	**$228**	**$288**	**$840**
Variable Operating Costs	**$/ha**	$	$	$	$	$	$	$	$
Seed, Treatment & EPR's		$20	$20	$20	$20	$20	$20	$20	$20
Grain Cartage Payments		$36	$39	$5	$27	$1	$6	$6	$5
Grain Handling Charges		$20	$20	$20	$20	$20	$20	$20	$20
Other Crop Costs & Crop Ins		$10	$10	$10	$10	$10	$10	$10	$10
Wages Gross		$20	$20	$20	$20	$20	$20	$20	$20
R&M Mach./Plant/Vehicle		$25	$30	$30	$30	$30	$30	$30	$30
Fuel & Oil		$20	$20	$20	$20	$20	$20	$20	$20
Fertiliser, Lime & Gypsum		$75	$75	$75	$75	$75	$75	$75	$75
Pesticide		$45	$45	$45	$45	$45	$45	$45	$45
Variable Operating Costs		$271	$279	$244	$266	$241	$246	$246	$244
Operating Gross Margin	$/ha	**$585**	**$487**	**$21**	**$373**	**$177**	**$18**	**$42**	**$596**
Fixed Operating Costs	$	$63	$63	$63	$63	$63	$63	$63	$63
Total Operating Costs	$	$334	$342	$307	$329	$303	$308	$308	$307
Operating Profit (BIT) $/Ha	$	**$522**	**$424**	**$84**	**$311**	**$239**	**$81**	**$20**	**$533**

Discussion of Results

Small plot Trial – Green Range

The small plot trial highlights the production potential for extremely late sown crops on the South Coast of WA, when there is a full soil moisture profile. Wheat and barley crops sown as late as October yielded well over 2 t/ha and the economic analysis shows that these were profitable very treatments. Notably, the ryecorn yielded 1.56 t/ha, which falls within the spectrum of yields (0.4 – 1.8 t/ha) that experienced ryecorn growers in Victoria typically achieve. The grain prices for some more uncommon 'high value' summer crops also give growers the confidence to attempt to grow these after waterlogging. Grain prices and an available market should be confirmed prior to growers experimenting with these crop types.

Also positive, is the apparent lack of impact the summer crops had on the following winter crop (barley). Albeit 2022 was a good year in general, yields for some of the over-sown treatments were over 8 t/ha. It is likely, given the soil type (sand over clay), that summer crops do not impact the following winter crop as it does not take much (South Coast) rainfall to re-fill up the soil water bucket.

Multi Crop Type Demonstrations

The multi crop type demonstrations at Green Range and Scotts Brook, focussed on better understanding the soil water dynamics where summer crops are grown. There were two trains of thought, that summer crops may increase fallow efficiency, providing a co-benefit and acting as a drought mitigation strategy or that summer crops may dry out the soil profile and impact adversely on the following winter crop (unless waterlogging was an issue). It was shown at both sites that growing a summer crop increased the fallow efficiency i.e., there was more soil moisture in the soil profile for the following winter crop. This was particularly interesting given the dry summer over which the summer crops were grown. This is likely to have occurred through the summer crops providing soil cover and reducing evaporation and/or allowing rainfall that was received to better infiltrate into the soil profile, rather than runoff.

In terms of grazing, it was evident at the Green Range site that if a summer crop could be grazed twice it paid for itself and if a third grazing was managed, profit could be had. It is important to also note the economic analysis did not take into account the alternative – trail feeding to supplement stubbles. From a grain cost and labour point of view, this may be more costly to a grower both in terms of dollars and lifestyle.

The 2022 winter crop production for each of the multi crop type trials also highlighted that there was no significant yield disadvantage as a result of growing summer crops. This is likely a result of three key contributing factors. Firstly, the paddocks in which the summer crops were produced are relatively infertile sandy soils, with very little nutrient holding capacity and it was unlikely nutrients had been ‘robbed’ by the summer crops. The winter crops produced on these soil types, obtain the vast majority of their nutrients from a combination applied fertiliser and stubble turnover via mineralization. Secondly, there was an apparent increase in soil moisture where the summer crops were sown and finally, the root channels from the summer crop may have aided rainfall infiltration and reduced non-wetting issues to some extent. This could be further investigated.

Single Crop Type Demonstrations

The single crop type demonstrations sites show that grain yield is the profit driver over the grazing. It should be noted, however, that the grazing income was calculated on a very conservative 90c/head/week figure and many growers would argue that this is not representative due to different markets and classes of stock. As winter canola and winter wheat grows in popularity along the South Coast of WA, it shows that there may be room for review of graze and grain principals (or perhaps more research with newer varieties available) to ensure crops are being grazed to minimize impact of grain yields.

Economic Analysis

For the demonstration sites, both single and multi crop type, and within the broad assumptions set, the economic analyses essentially show that summer/spring sown crops are profitable if you can graze them at least twice, where they are not taken though to grain. Where these crops are then taken through to grain (i.e., winter wheat and canola), it is the grain yield driving the profitability. Grazing does impact on final grain yield, so understanding how to graze crops is very important.

For the small plot trial, it is very evident that price of grain plays an important role. Even through hemp yields were low (0.28 t/ha), the price of grain (estimated to be $3000/t) still made this a profitable treatment. The analysis also shows the profitability of late sown wheat, barley and ryecorn.

Conclusion

Key learnings can be drawn from the small plot trial which took multiple summer crop types through to harvest and the farm-scale demonstrations which included a combination of grazing and harvest.

The small plot trial demonstrated the viability of barley, rye, and wheat to produce an economically viable yield, even when planted as late as October 14. The industrial hemp produced an economically viable yield (due to its high grain price) from the very late sowing date of November 25. More research is required in the area to determine the yield potential of a hemp crop when sown in September or October. This trial also showed there was no impact of the summer crop on the following winter crops yields when compared to a bare fallow.

In terms of grazing, local anecdotal grower-held belief is that a single grazing opportunity will make a summer crop economically viable, either via fattening lambs or maintaining ewe condition in a crucial feed gap. Each of the summer crops achieved enough biomass for one grazing event. The Scotts Brook trial was grazed twice, and the Green Range trial was grazed three times.

The multi crop type demonstrations at Scotts Brook and Green Range also showed an improvement in fallow efficiency where the cereal summer crop varieties were planted compared to the bare fallow. These results echo research conducted in the northern agricultural region of Australia, where certain varieties of winter cover crops have been shown to increase fallow efficiency. It should be noted that this was not an objective of the Green Range grower going into the summer cropping period. The motivation for planting the summer crop was to lower the fallow efficiency and reduce the likelihood of waterlogging in the 2022 season after the extremely wet year in 2021. However, this may be a drought resilience tool going forwards. This highlights the importance of selecting a summer crop type tailored to you overall objective. Whilst highly efficient C4 species such as Sorghum and Millet are ideal for producing biomass in a short period of time, if the growers objective is to reduce the fallow efficiency and dry out the soil profile a brassica species with a low water use efficiency would be preferable.

With the extremely dry 2021/2 fallow period it was predicted that there would be a benefit resulting from the summer cropping treatments (due to the additional soil moisture) compared to the bare fallow. This wasn't apparent in the winter crop yields but it did show no negative impact of the summer crop on the winter crop (particularly given the dry summer).

A key takeaway from the single crop winter canola sites was the ability for these crops to be grazed down and survive a dry summer. Once grazed down the winter canola crops became dormant and were able to survive over a month with minimal summer rainfall and high temperatures. It highlights the ability for these long season varieties to utilise existing soil moisture in the spring for good plant establishment and provide a feed source to fill the feed gap throughout the summer. However, it is critical that there is enough soil moisture at the time of seeding to ensure the crop can successfully reach the first grazing phase, pre-dormancy. Some better understanding of grazing these to maximise grain yield would still be beneficial, as it is the grain yield driving the profitability of these crops.

The results from 2021/2 summer phase of this project, highlight the viability of these crops in tough conditions, and indicates that the risk of seeding summer crops could be significantly lower than the currently held consensus. A key learning is also that crop selection and operational adaptability is critical to the success of the crop and the ability to maximise returns.

Implications

There are a number of positive implications for the grains industry:

- The data from this project may give growers the confidence to have a go at some alternative 'high value' crops where waterlogging has occurred and there is a full soil moisture profile.
- It gives growers data-driven confidence that late sown cereals (where winter crops have failed due to waterlogging) can assist in recovering some of the costs and can be profitable in their own right, without impacting on the following winter crop.
- It shows that summer crops may actually conserve soil moisture better than a chemical fallow. This requires more investigation, however, could be game-changing for carrying livestock over a summer period.
- The date gives growers the confidence to plant winter canola in spring and take these crops through to harvest (after some grazing). This is becoming an increasingly used practice along the South Coast and in the lower Great Southern Region of WA.

Recommendations

1. Soil moisture data recorded in this project shows that where summer crops were grown, the fallow efficiency was greater than where a bare fallow was maintained. This was the case for both the site along the South Coast and a site in Kojonup, with the Kojonup site receiving significantly less January and February rainfall than the South Coast site. If this is the case, then the grower notion that a chemical fallow should be maintained to conserve moisture may be false, and an opportunity to grow a summer forage crop after a waterlogging event may not only be a profitable decision for the livestock enterprise but also the following winter grain crop.
2. As winter canola and winter wheat grows in popularity along the South Coast of WA, it shows that there may be room for review of graze and grain principals, as well as more research with newer varieties available, to ensure crops are being grazed efficiently to minimize impact of grain yields.

Stirlings to Coast Farmers recommend that these two aspects be further investigated to provide growers with more data to inform their summer cropping decisions.

References

Nil

Social Media Posting

GRDC uses social media to showcase research investments and disseminate timely, relevant and practical information to key stakeholders in the grains industry. Our audiences are predominantly growers and agricultural advisers.

Brad Westphal on Twitter: "Great to see our summer cropping trials looking so great. Trying to look at how to make money out of a small bucket of water, even after a wet year. Credit to @Kieran_Zilm for the work so far. Working with @GRDCWest @Stirlings2Coast and @NutrienWAagri. Thanks to @jezwalks https://t.co/1BsO9axoap" / Twitter

Stirlings to Coast Farmers on Twitter: "A morning well spent looking at the @AuNutrien and @theGRDC Summer Crop and Forage plot trial out at Green Range. From your cereals and brassicas right through to sunflowers & hemp. Certainly one to watch throughout the year. https://t.co/BeCcWFobqN" / Twitter

Stirlings to Coast Farmers on Twitter: "@NutrienWAagri and @theGRDC are hosting a Summer Crop & Forage Field Walk THIS TUESDAY - 25th @ 7:30am in Green Range. https://t.co/EOHcyDrYVo" / Twitter

PROJECT SOCIAL MEDIA ACCOUNTS

Image 2 - Green Range millet next to sorghum at first graze, before

Image 1 - Green Range millet next to sorghum at first graze, after terminal

Image 3 - Green Range: Grazed Millet/Lablab mixture on left and grazed sorghum on right before the final grazing in March 2022

Image 4- Grain sorghum on wide row spacing at Scotts Brook

Image 5- Grain sorghum on wide row spacing at Scotts Brook.