Growing Summer Legumes for Winter Crop Nitrogen

Adams Family, Woogenellup

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Key Messages

- The 2023/24 summer and following autumn period were extremely dry with only 22.4mm of rainfall received and as a result, the legumes in Trial 2 were irrigated twice.
- Not all plots within Trial 2 produced viable legumes but measurements taken from viable plots showed soybean to be the best performing legume in 2024 with 2.75 t/ha of above-ground biomass produced in very challenging conditions.
- Over sown wheat yields in Trial 2 yielded marginally better on the legume plots compared to the fallow (control) plots. However, there was no impact on grain quality.
- Second-year results for Trial 1 showed there was no significant legacy impact of the successfully grown 2023 summer legumes on wheat yields in 2024.
- Soil nitrogen balances were positive across all treatments in 2024, compared to mostly negative in Trial 1 in 2023 (except for the high N-contributing 2023 faba bean plots). This is likely due to the overall reduced wheat grain yields in 2024 compared to 2023.

BACKGROUND

Fertiliser prices are a concern for growers in Western Australia, particularly those in the highly productive (and high-risk) high rainfall areas of the Albany Port zone. Farmers in this region have also found it challenging to incorporate a suitable and profitable legume into the winter crop rotation.

As a potential solution, SCF aimed to investigate the possibility of including a legume-based cover crop as a replacement to the typical summer chemical fallow. This was hypothesised as a viable option due to out-of-season rainfall in this region over harvest, summer, and early autumn is becoming more common.

Broadly, this project aims to pilot the effectiveness of a legume cover crop in the HRZ of the Albany port zone, in place of a summer chemical fallow, to supply following winter grain crops with residual soil nitrogen that will justify cutting nitrogen fertiliser rates without compromising productivity outcomes.

METHODOLOGY/TREATMENTS

In the summer of 2023 and 2024 two small plot trials were implemented in Woogenellup. The treatment lists are shown in Table 1. The trials were randomised with 3 replicates and sown with irrigation to replicate a summer rainfall event (simulating at least 25mm).

TERMINATION

The summer legume plots were chemically terminated on 7 May 2024. The plots were left for a period of ten days before being tilled into the ground on 17 May 2024. The trial was then over-seeded on 21 May (14 days after termination). The seeding date of the winter crop was delayed, allowing the summer legume to maximise biomass production. Only a low nitrogen, K-Till starter fertiliser was applied at seeding. No further nitrogen fertiliser was applied in-season to either trial to better highlight the impact of the summer legumes.

Measurements were taken for each trial that included assessing the productivity and nitrogen production of

Table 1. Legume species and control fallow treatments for Trial 1 (2023) and Trial 2 (2024).

TRIAL 1 **2023 Trial Treatments (sown 2 February 2023)**	**TRIAL 2** **2024 trial Treatments (sown 19 January 2024)**
Faba Beans	Faba beans
Common Vetch	Woolly Pod Vetch
Chickpea	Pigeon Pea
Lablab	Lablab
Cowpea	Cowpea
Soybean	Soybean
Chemical fallow (farmer practice control)	Chemical fallow (farmer practice control)
Tilled fallow (tillage effect control)	Tilled fallow (tillage effect control)

the summer legumes, soil nitrogen to depth and the productivity of the following winter crop (second winter crop for TRIAL 1).

RESULTS AND DISCUSSION

TRIAL 2 – 2024 Legume Cover Crop

The cover cropping phase only produced a viable cover crop on some of the plots. Fortunately, there was a viable crop for each treatment from which to take summer legume samples and conduct on-going measurements (into the wheat phase). It appeared that the plots that did germinate well were located where there was less stubble although this was not always the case. The trial received an initial 25mm of irrigation to replicate the conditions in which a farmer would undertake the practice of growing a cover crop after a summer rainfall event. The crops were irrigated again in February 2024 with a further 15mm and then only received 22.4 mm in rainfall, compared to 80.4 mm received in 2023, over the same period. In 2023, the summer crops grown were more successful.

NOTE: Trial 2 results are taken from the best performing legume plots for each treatment, given many of the plots failed to germinate well. They are not an average of the three replicated plots.

Nodulation assessment

All legume species were inoculated at seeding with the assigned inoculant group. Legume nodulation scores were assessed at time of chemical termination. Cowpea recorded the highest nodulation followed by vetch and faba beans.

Plant Establishment

Plant counts were taken at termination to reflect the plant survival over the summer period (Figure 1). There was a large amount of variability between the treatments, largely reflecting the difficulties with establishment early in the growing season. The faba beans and vetch notably suffered from the hot and dry conditions present at the time of sowing.

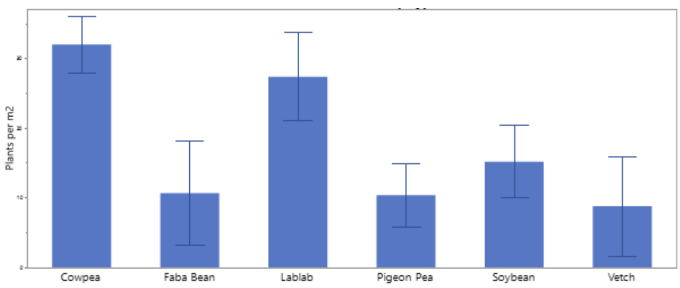

Figure 1: Trial 2 - Legume cover crop establishment (plants/m2), 2024.

Plant Nitrogen

Plant tissue samples were taken at time of termination and analysed for percentage nitrogen concentration (Figure 2). Each crop type had a differing plant tissue nitrogen percentage with the vetch having the highest percentage. This shoot nitrogen percentage is driven by a range of factors such as plant physiology, crop growth stage and the plant's nitrogen demand curve, as well as the level of nodulation and nitrogen fixation.

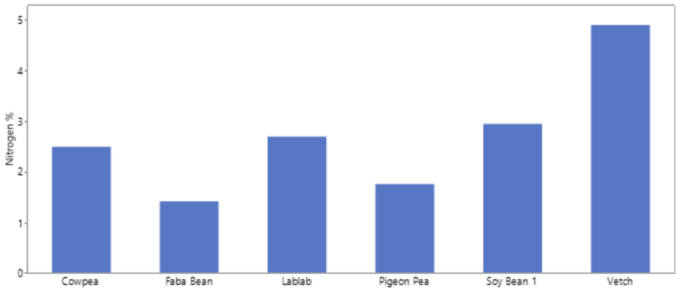

Figure 2: Trial 2 - Percentage (%) shoot nitrogen for each legume treatment, 2024.

Legume Biomass & Above Ground Nitrogen Production

Plant biomass cuts were taken prior to chemical termination. The results clearly indicate that soybean produced the highest biomass at 2.75 t/ha. Given the summer growing season, this was a good result. Soybean was followed by cowpea and lablab. The limited vetch and faba bean legume biomass was driven by two factors, a later/staggered germination, reducing the time in which the plants had to produce biomass, and low plant numbers compared to the other crop types.

A calculation of above ground nitrogen was determined using the plant biomass (t/ha) and plant tissue nitrogen % (Figure 3). It shows that the plant biomass drove the above ground nitrogen with the soybean (80 kg/ha) outcompeting the other legumes (highest plant biomass also). Lablab and cowpea were relatively similar at 55 kg/ha and the lowest result was in the faba bean treatment which produced only 10 kg/ha. This is compared with over 250 kg/ha in a similar trial the year before (2023), most likely due to better initial germination.

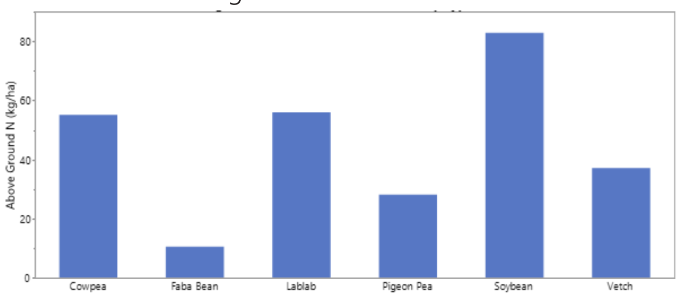

Figure 3: Trial 2 - Above ground nitrogen (calculated from plant biomass & plant tissue N%) for each treatment, 2024.

TRIAL 2 & 1- 2024 Winter Crop

The winter cereal (Rockstar wheat) was sown over the summer legume and control treatments, and back over Trial 1, on the 21 May 2024. The wheat was sown into soil moisture. Germination was slow after seeding and somewhat staggered across both trial sites.

Establishment counts were undertaken on the 28 June 2024 and are shown in Figures 4 and 5. Plant numbers were somewhat reduced; however, this is representative of many crops in the region due to the very dry and challenging start.

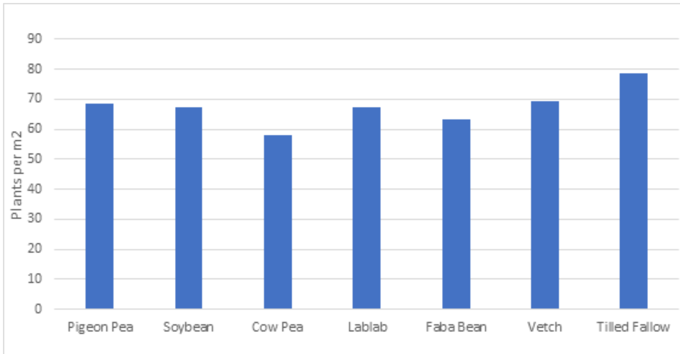

Figure 4: Trial 2 - Average plant counts (plants/m2) for the wheat sown over each summer treatment, 2024.

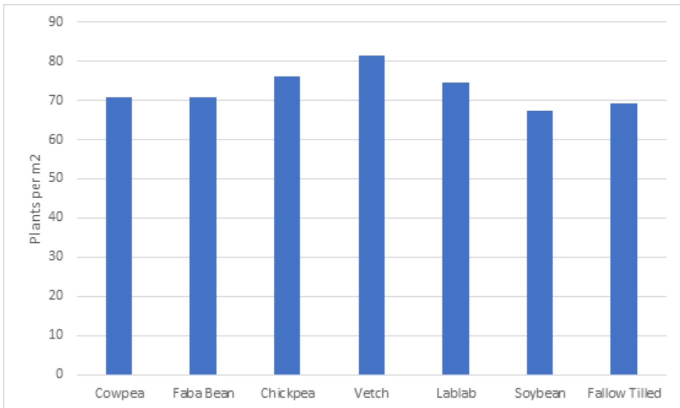

Figure 5: Trial 1 - Average plant counts (plants/m2) for the wheat sown over each summer treatment, 2024.

TRIAL 2 – Nitrogen Accounting 2024

The first year of wheat yields on Trial 2 (grown directly after the legumes) were somewhat higher in the legume plots (with the exception of Pigeon Pea), compared to the two control plots. There was no trend identified in the wheat protein levels, and the highest protein level was recorded in the 'Fallow Control' treatment and lowest in the 'Soybean' treatment (which was also highest yielding). As a result of the nitrogen produced by the legumes, and the lower wheat yields (due to the season) the soil N balance was positive across all treatments (Table 2).

Table 2: Trial 2 - Nitrogen account for the 2024 season (2024 wheat crop only).

	Pigeon Pea	Soybean	Cow Pea	Lablab	Faba Bean	Vetch	Fallow Tilled Control	Fallow Control
2024 Wheat Yield (t/ha)	1.95	2.74	2.53	2.26	2.11	2.60	1.99	1.88
Starting Soil N (kg/ha)	84.77	87.37	73.83	85.38	85.98	87.35	108.43	85.52
Legume N (kg/ha)	28.33	82.95	55.30	56.16	54.14	20.38	0.00	0.00
Adjusted Starting N balance (kg/ha)	113.10	170.32	129.13	141.54	140.12	107.73	108.43	85.52
Protein (%)	10.80	10.77	10.90	11.07	11.10	11.76	10.93	11.43
Grain N (%)	1.86	1.86	1.88	1.91	1.91	2.03	1.88	1.97
Grain N removal (kg/ha)	36.37	50.86	47.60	43.12	40.44	52.72	37.58	37.06
Soil N Balance (kg/ha)	76.73	119.46	81.52	98.42	99.68	55.02	70.86	48.46

TRIAL 1 – Nitrogen Accounting 2024

The 2024 wheat grain yields on trial one (second year of cropping) were significantly lower than the 2023 wheat yields, keeping in mind it was the second year without nitrogen fertiliser (Table 3). This was irrespective of the level of carryover N. The starting N measured in the soil prior to seeding the 2024 wheat crop did not reflect the adjusted N account after the harvest of the 2023 wheat crop. This highlights the potential influence of both mineralisation and N losses over the season. The trend in wheat yields and protein in 2024 suggests that starting soil N had a greater influence on crop yield than the amount of nitrogen contributed by the legume biomass grown over the 2022/3 fallow period and that starting soil N did not correlate (in this instance) with the legume biomass grown in 2023.

Table 3: Trial 1 - Nitrogen account for the 2024 season (2024 wheat crop only).

	Vetch	Faba bean	Soybean	Cowpea	Lablab	Chickpea	Fallow Tilled Control	Fallow Control
2024 Wheat Yield (t/ha)	2.86	2.81	2.35	2.76	2.85	2.39	2.71	2.17
Starting Soil N kg/ha)	103.71	114.90	88.25	83.06	129.20	102.76	101.39	101.17
Protein (%)	10.40	11.30	10.87	10.63	10.96	10.87	10.53	10.07
Grain N Removal (kg/ha)	38.09	51.10	51.61	49.08	56.38	59.58	44.36	37.49
Soil N Balance (kg/ha)	65.62	63.86	36.63	33.97	72.81	43.18	57.03	63.62

CONCLUSIONS

The extremely dry and hot summer in 2023/24 led to significantly poorer results in terms of above ground nitrogen production compared to the legume cover crops grown in the 2022/23 summer. Although the plots were irrigated, the lack of subsoil moisture (after a dry spring) coupled with the high temperatures (at times more than 40 degrees) led to the soil profile drying out quickly after irrigation. This caused issues early on with poor establishment, and the surviving plants lacked the ability to establish a robust root base before the profile dried out. The hot and dry conditions also proved hostile to the rhizobium resulting in very low nodulation rates. Although a difficult year it was interesting that the soybean stood out from the other legumes, especially given it was also the second top-performing legume in the 2022/23 summer trial.

This project has so far shown that if a viable summer legume can be produced in place of a chemical fallow, it can have a positive influence on the following winter cereal crop. However, the impact of the legumes on cereal production vastly reduced in the second season post legumes, under a nil nitrogen strategy over the two years. The rate at which the legume biomass breaks down was not measured in this project, and variance in the breakdown rates of the biomass of each legume species is an area that needs to be further explored to fully understand the lasting impact of the legumes. Summer active legumes can be effective at fixing N, even in the relatively hostile summer conditions experienced in this trial. However, how that N then influences the following crop needs to be further explored before fallow replacement legumes become a viable alternative to grain legumes in a high rainfall zone farming system.

This project will continue in 2025, with the seeding of the legumes delayed until early Autumn. The reason for this is two-fold. Autumn sown legumes may be more successful/viable year-in-year-out and more easily adoptable by growers, particularly as local research has shown later sown cereals (in this case on the back of a terminated autumn legume) can yield very well. Secondly, we are interested in exploring how cereal disease and the need for fungicide applications can be reduced in a late cereal directly following an autumn legume.

ACKNOWLEDGMENTS

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