



Impact of Time of Sowing on Yield of Various Grain and Feed Legumes and Faba Bean Variety Trial in the Kwinana West Port Zone

GRDC/Grower Group Alliance/Facey Group

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BACKGROUND

Apart from lupins in the Kwinana West Zone of Western Australia, grain legumes are not extensively grown or adopted in crop rotations. Recent advances in grain legume genetics, acid tolerant rhizobia, management strategies, and weed and disease protection products could enable more producers in this region to grow grain legumes. To achieve this, Facey Group evaluated a variety of grain legumes to learn more about these varieties for this region and what varieties work well. The results from this project will lead to further assessment of grain legumes in this zone. In a recent study conducted by Facey Group as part of a GRDC-funded project, chickpeas were sown across two different sowing times. The results demonstrated a clear benefit of early sowing.

The trial component of this project assessed the impact of sowing time on a variety of chickpeas, faba beans, peas, and vetch varieties. In 2022, a small plot trial was undertaken. A variety of grain legumes were seeded at two different sowing times, early sowing (22nd April) and later sowing (9th June) and integrated with the grower's seeding program. A farmer demonstration trial was also undertaken to assess two varieties of faba beans for their yield potential. The two varieties differ in their resistance to fungal pathogens. 2023 results indicated significant effects of sowing time and crop type on wheat yield, reaching 4.5–5.0 t/ha following a grain legume crop, compared to 3.7 t/ha following wheat. The current season aims to monitor further the legacy effects of grain legumes on subsequent cereal crops, which could enhance the economic viability of legumes in local rotations.

AIM

This project aims to assess the benefits of multiple types of legumes that have not been commonly grown in the Facey Group area. It will examine how sowing time influences biomass production, grain yield, and residual effects on subsequent crops.

SMALL PLOT TRIAL

Property:	Clint Hemley and Skye Moxham
Plot Size & Replication:	4.2x12m 8 treatments, 3 replicates
Soil Type:	Duplex Sand
Crop Rotation	2022 Legume Species
Crop Variety:	Scepter Wheat
Sowing Date:	16/05/2024
Seeding Rate:	80kg/ha
Fertiliser:	Seeding/ha – 60kg DAP, 60L Flexi N, 300ml Uniform, 200g Copper, 400g Zinc
Herbicides:	Pre-Seeding/ha – 2L Glyphosate 45,. 300ml Ester 680
Insecticides:	200ml Gaucho
Fungicides:	Post-emergent all- 500ml/ha Aviator

METHODOLOGY

In 2022, various grain legume species and varieties were sown at two different times alongside cereal plots sown on the same dates. The trial followed a split-plot design with two factors: grain legume species (eight levels) and time of sowing (two levels), replicated three times, resulting in 16 treatments. Each plot measured 4.2 m in width and 12 m in length.

A cereal crop was sown across the trial in both 2023 and 2024 to assess the residual nitrogen effects of legumes on subsequent cereal crops. The 2024 trial retained the original layout from 2022 and 2023, allowing the evaluation of the second-year carry-over benefits of legumes on cash crops sown within the same timeframe.

The trial included multiple varieties from four grain legume species, along with a mixed treatment: chickpea (Captain, Genesis), faba bean, field pea (Twilight), and vetch (Morava, RM4, Volga). The mix treatment consisted of a faba bean and vetch combination. To minimise edge effects, two wheat plots were sown as buffers on either side of the trial. The early sowing occurred in mid-April 2022, while the late sowing took place in mid-May 2022.

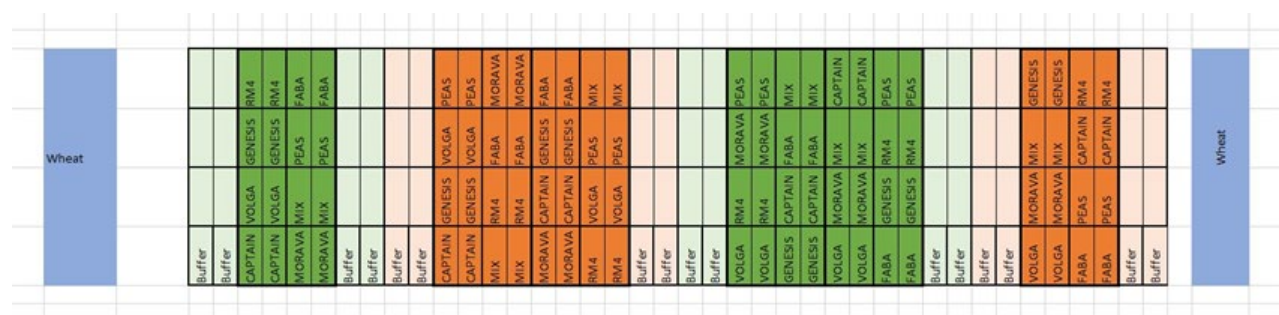


Figure 1. Plot scale trial. Treatments include. Bendoc Faba Bean, Genesis Chickpea, Captain Chickpea, Volga Vetch, Morava Vetch, RM4 Vetch, Twilight Field Peas, and a intercrop mix of Bendoc Faba Beans and Volga Vetch.

Analytics for the Australian Grains Industry (AGI) undertook statistical analysis using generalised linear mixed-effects models (GLMMs) fitted with ASReml-R or glmmTMB to analyse yield data, selecting distributional families based on response characteristics. Model assumptions were checked via residual diagnostics, with model selection guided by AIC/BIC and Wald tests used to assess fixed effects significance.

The yield gap analysis was estimated using a modified French/Schultz model equation, which accounts for seasonal water supply, evaporation, and the maximum transpiration efficiency of wheat (French and Schultz, 1984). The 2023 economic analysis was based on Free-in-Store

(FIS) market prices from GRDC gross margin guides. Farming operational costs, including seeding, harvesting, and applications, were derived from regional averages across WA (Merredin, Mullewa, Carnamah, Geraldton, Kojonup, Nyabing, Grass Patch, and Munglinup). At the same time, additional expenses such as fuel, repairs, maintenance, and grain storage were based on 2022 data. Farm gate costs were determined using the 2022–2023 average of CBH fees and charges in Wickiepin. Yield data from the 2022 legume crops and the 2023 wheat rotations were incorporated to evaluate economic performance, with gross margin analysis conducted using both trial data and GRDC’s typical industry yield, input costs, and 2023 FIS prices.

RESULTS AND DISCUSSION

Table 1. 2024 monthly rainfall statistics from nearest BOM weather station – Wickiepin WA, station number 010654 (mm).

Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
13.2	3.4	32.0	0.0	40.8	34.4	72.0	84.4	29.0	14.8	22.0	0.0	346

Table 2. Summary of statistics of data for the Small Plot trial

Response	Reps	P-value Grain Legume	P-value TOS	P-value Grain Legume: Time of Sowing
Soil Moisture	3	0.39	0.22	0.08
Soil Nitrogen	3	0.88	0.39	0.97
Establishment	3	0.31	0.80	0.14
Weed Density	3	0.01***	0.4	< 0.01***
NDVI	3	0.83	0.01***	0.08
Plant Tissue N	3	0.04***	0.53	N/A
Plant Tissue P	3	< 0.01***	0.25	N/A
Plant Tissue K	3	0.49	0.95	N/A
Handcut Yield t/ha	3	0.06	0.01***	0.05

The statistical results for the small plot trial across the respective responses are represented in *p*-values. Effects are significant when the corresponding *p*-value is less than 0.05 and are further signified by ***.

Soil Pre-Seeding Nitrogen and Moisture Analysis

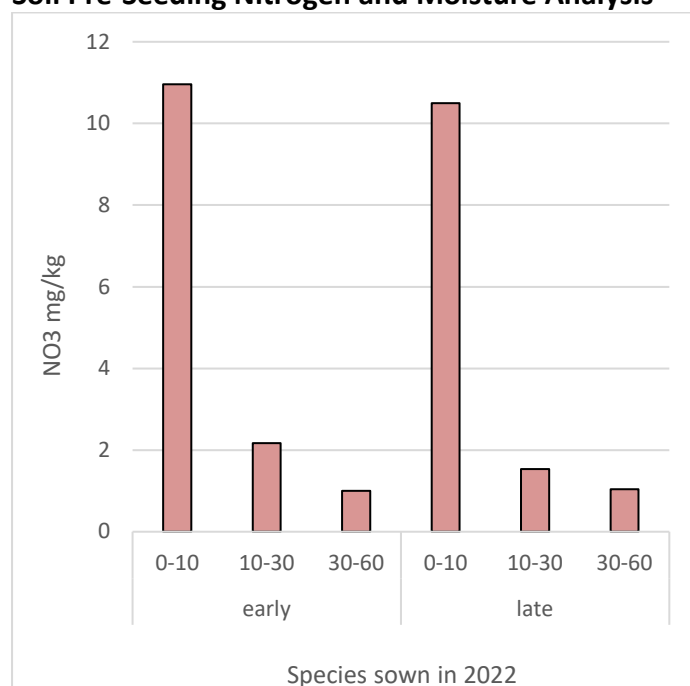


Figure 2. 2024 Pre-seeding soil test average NO3 levels by time of sowing.

Species and sowing time did not significantly affect soil nitrogen concentrations or moisture levels. However, early sown plots showed slightly higher nitrogen availability, averaging 10.95 mg/kg compared to 10.5 mg/kg in late-sown plots of the upper layer. This trend was consistent in the following layer (10-30 cm), whereas in the deepest layer (30–60 cm), the opposite pattern was observed (Figure 2).

Plant Establishment, NDVI, and Weed Count

Table 3. Plant establishment and weed concentration by grain legume and time of sowing.

Crop Rotation 2022	Establishment plants/m ²	Re-Emergence of 2022 crop	Average of Weed/m ²
Early Sown	116	7	18
Captain	102	11	28
Faba Bean	110	7	18
Genesis	122	5	13
Mix	118	7	17
Morava	117	7	16
Peas	112	7	18
RM4	115	12	29
Volga	121	11	27
Wheat	124	0	0
Late Sown	108	5	12
Captain	120	10	26
Faba Bean	102	13	31
Genesis	98	7	17
Mix	103	3	7
Morava	114	4	9
Peas	105	1	3
RM4	96	6	16
Volga	116	0	1
Wheat	117	0	0
Overall Average	112	6	15

There was no effect of species or sowing time on establishment. However, early-sown 2022 grain legume plots showed a general trend toward higher plant density than late-sown plots. On average, late-sown plots had lower weed density (6 weeds/m²) than early-sown plots, but no statistical difference was found between times of sowing (Table 3).

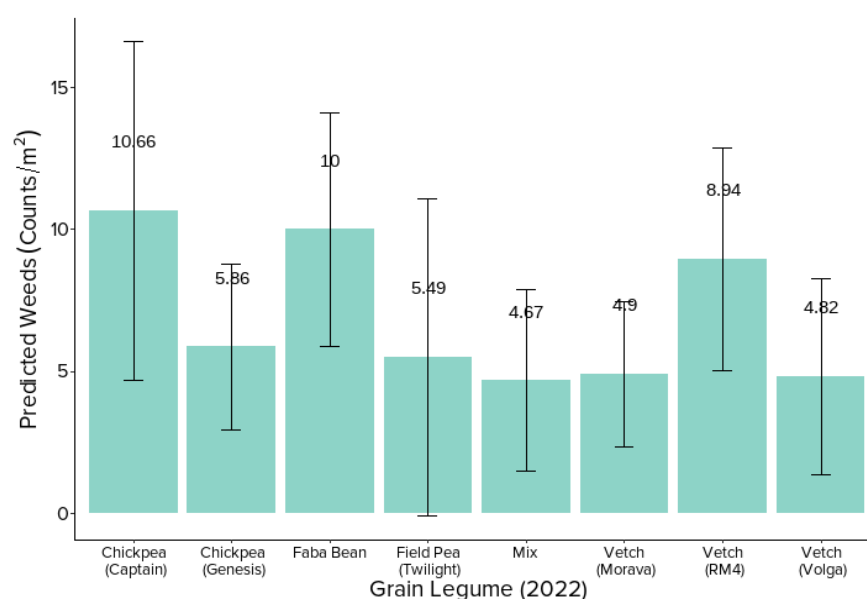


Figure 3: Barplots comparing average post-seeding weed densities per square meter by 2022-sown grain legume.

Weed density control differed significantly by grain legume. Figure 3 shows that plots with previously sown chickpea (Captain), faba bean and vetch (RM4) were associated with higher weed densities, while chickpeas (Genesis), field peas (Twilight), mix, vetch (Morava), and vetch (Volga) plots were linked to lower densities. Wheat-on-wheat rotation showcased no weed density.

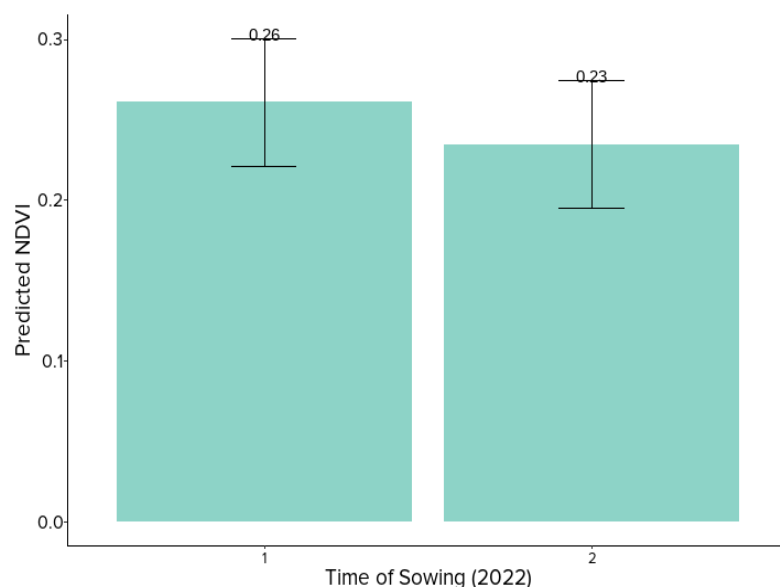


Figure 4: Barplots comparing average NDVI by time of sowing.

Normalised Difference Vegetation Index (NDVI) was significantly affected by sowing time, though the observed difference was relatively small, with early-sown plots averaging 0.03 higher than late-sown plots (Figure 4).

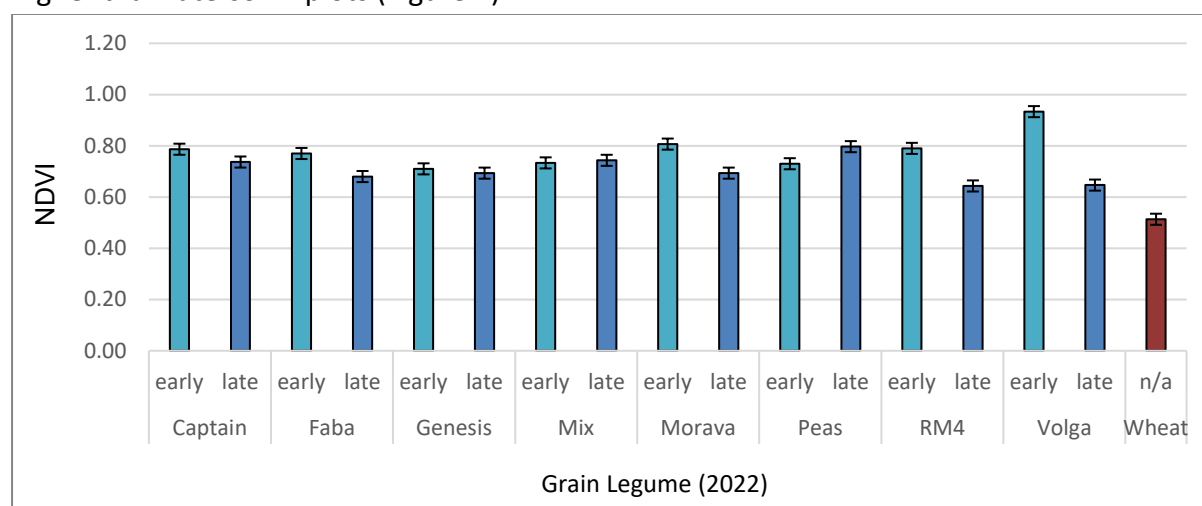


Figure 5. 2042 NDVI results by time of sowing and grain legume.

While the interaction between grain legume type and sowing time was not significant ($p = 0.08$), early-sown plots, particularly vetch (Volga), showed a trend of higher NDVI (+0.28). Overall, grain legume plots had higher NDVI than wheat-on-wheat rotations (Figure 5).

Plant Tissue Analysis

Table 3. Plant tissue test showcasing nutritional targets, N, P, and K % of w/w at the start of stem elongation by grain legume and time of sowing.

Species	N (%w/w)	K (%w/w)	P (%w/w)
Target	3.00 - 4.50	3.30 - 5.00	0.30 - 0.50
Captain	2.79	3.51	0.39
early	2.6	3.3	0.37
late	2.98	3.71	0.4
Faba Bean	2.29	3.21	0.31
early	2.42	3.46	0.31
late	2.15	2.96	0.31
Genesis	2.72	3.72	0.36
early	2.65	3.69	0.36
late	2.79	3.74	0.35
Mix	2.3	3.19	0.32
early	2.24	3.13	0.32
late	2.36	3.25	0.31
Morava	2.86	3.53	0.39
early	2.8	3.72	0.35
late	2.91	3.34	0.42
Peas	2.36	3.04	0.32
early	2.58	3.29	0.33
late	2.13	2.78	0.31
RM4	2.64	3.35	0.35
early	2.63	3.38	0.35
late	2.65	3.32	0.35
Volga	2.59	3.45	0.34
early	2.33	3.05	0.32
late	2.84	3.84	0.36
Wheat			
	2.35	3.21	0.36

Nitrogen deficiency was observed across all trial plots, while phosphorus levels remained within the target range. Potassium deficiency was detected in wheat following 2022-sown mix legumes, field peas (Twilight), wheat-on-wheat plots, and early-sown vetch (Volga). Target nutrient ranges and results (Table 3) were based on Summit Fertilizers recommendations for optimal wheat nutrition.

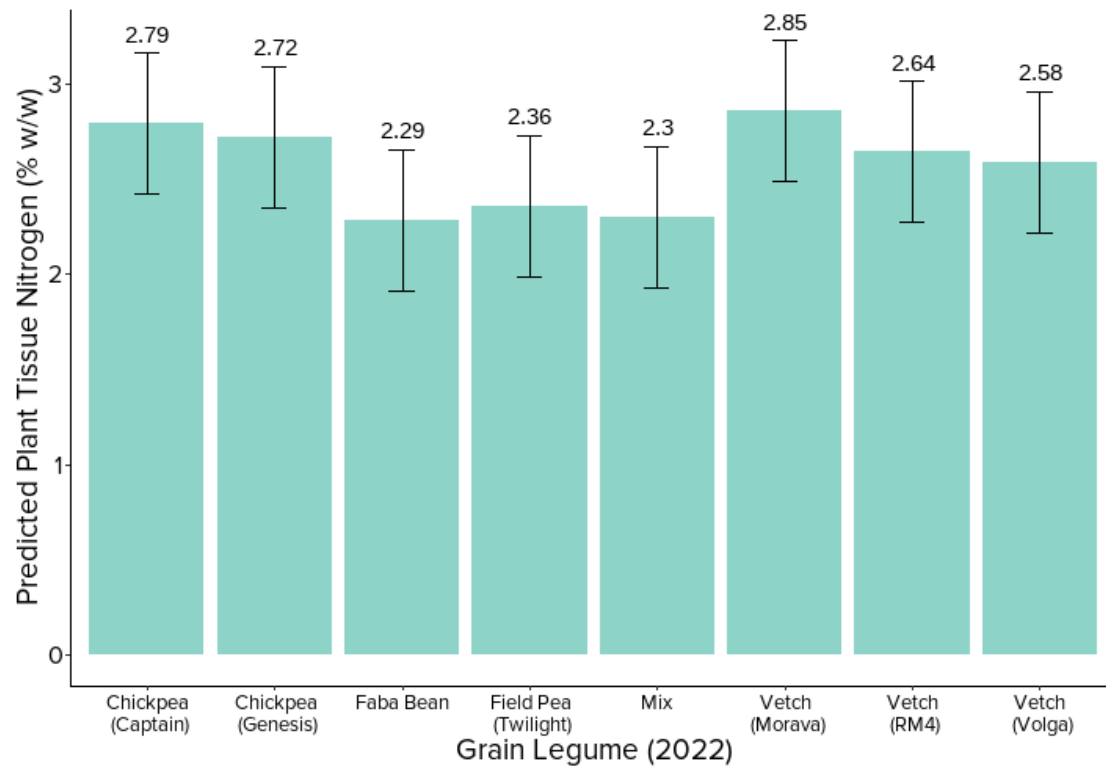


Figure 6. Barplots comparing average N in wheat by grain legume.

Significant differences in wheat nitrogen and phosphorus levels were observed based on the 2022-sown grain legume type. Chickpea (Captain), chickpea (Genesis), and vetch (Morava) had the highest concentrations, while faba bean, mix, and field pea (Twilight) had the lowest. Vetch varieties RM4 and Volga showed intermediate nitrogen levels (Figure 6).

Harvest Yields and Grain Weight

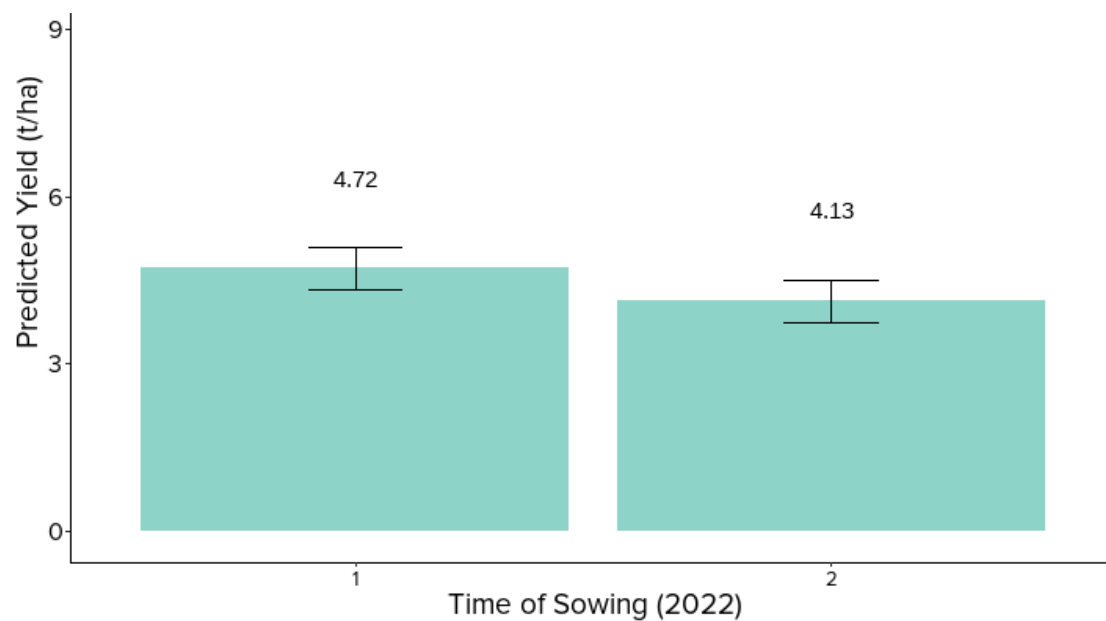


Figure 7. Barplots comparing average yield by time of sowing.

The Time of Sowing (TOS) of the legume varieties in 2022 had a significant effect on grain weight at harvest in 2024, with early sowing corresponding to a higher predicted yield compared to late sowing. The difference between GW predictions for each TOS was about 0.59 t/ha (Figure 7).

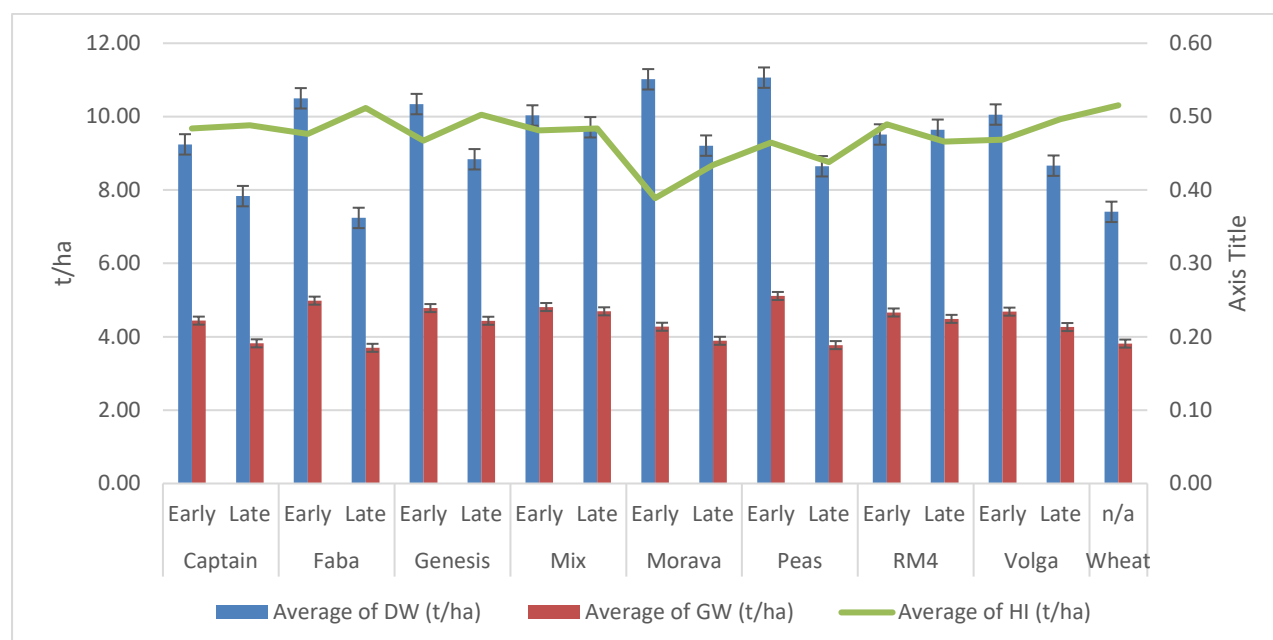


Figure 8. Average biomass, yield, and harvest index (HI) by grain legume and time of sowing.

No significant differences were found by grain legume, however general trends can be noted. The highest grain weight was higher in early-sown field peas (Twilight) led with 5.1 t/ha, closely followed by faba beans at 5.0 t/ha. Among the early-sown plots, field peas (Twilight) and vetch (Morava) achieved the highest biomass dry weights (DW), reaching 11 t/ha. The Harvest Index (HI) indicated that wheat-on-wheat rotations had the highest grain-to-yield ratio at 0.52, followed by plots of late-sown faba beans at 0.51 and chickpeas (Genesis) at 0.50 (Figure 8).

Economic Analysis 2022-2023

Table 4. Estimated yield gap for wheat following chickpea, faba beans, field peas and vetch varieties in Wickopin.

2023	2022 Rotation							
Wheat Yields Potential 4.2t/ha	Chickpea Genesis	Chickpea Captain	Faba bean	Field peas	Vetch RM4	Vetch Morava	Vetch Volga	Wheat
Wheat	4.5	3.9	4.6	5.0	4.8	4.6	4.9	3.7
Yield gap (t/ha)	-0.3	0.3	-0.4	-0.8	-0.6	-0.4	-0.7	0.5

Table 4 showcases the yield gap potential of the 2023 wheat rotation using the average of early and late sown yields. The wheat yield potential for that year was of 4.2 t/ha. The gap was exceeded by 0.3-0.8t/ha following all grain legume crops except for Captain chickpea. The yield potential of wheat was not reached that season.

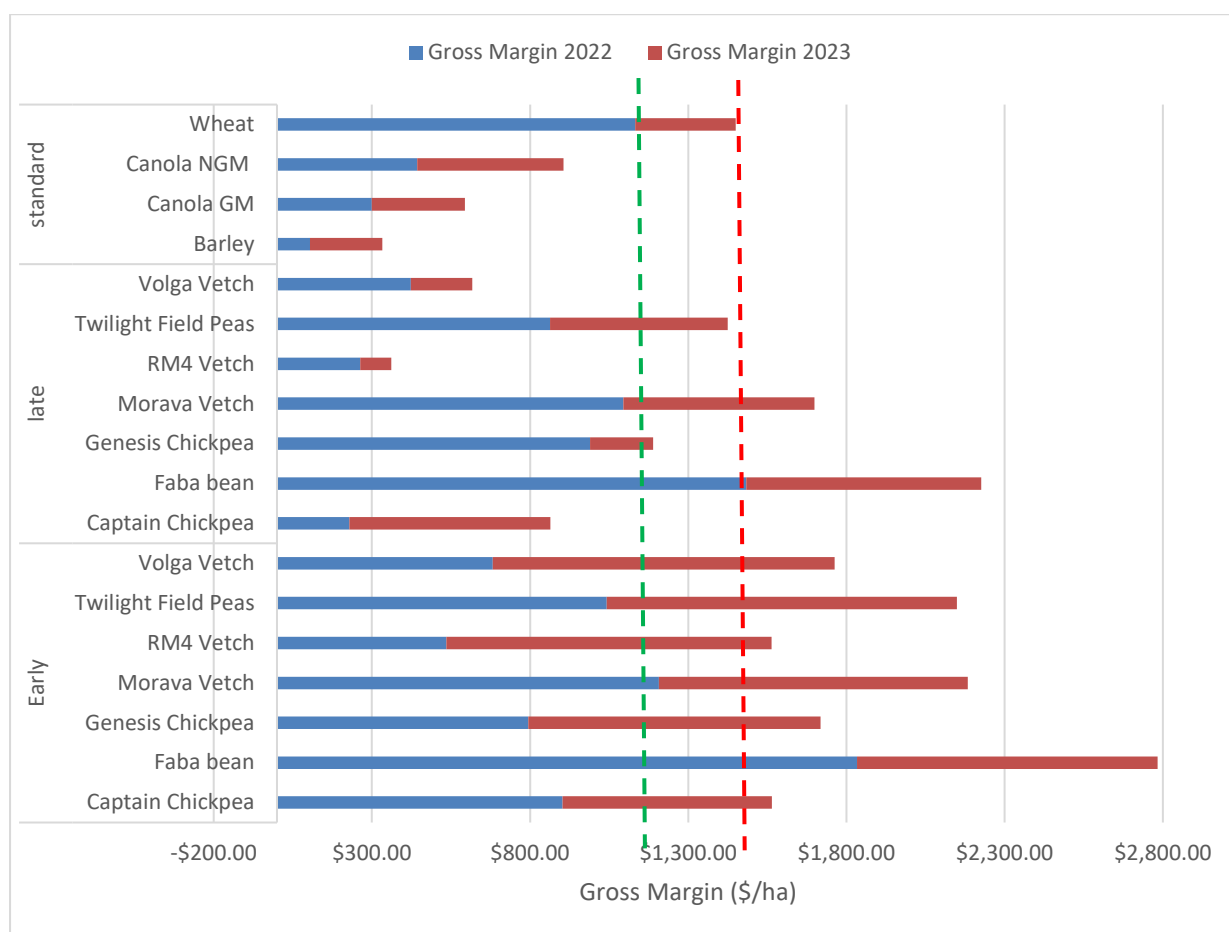


Figure 9. Two-year gross margin of the grain legume trial by grain legume and time of sowing – 2022 grain legume crops and 2023 wheat rotation.

The economic analysis indicated that in 2022 late sown (1483 \$/ha) and early sown (1833 \$/ha) faba beans, and early sown Morava vetch (1207 \$/ha) produced a higher gross margin than wheat. Almost all grain legume crops were more profitable than barley or canola in 2022, showcasing its economic benefits in that high rainfall season. This trend is consistent in the 2023 wheat rotation, except for the plots in late-sown RM4 and Volga vetch, Genesis and Captain chickpeas whose cumulative gross margin is below all the cash crops. Overall, faba beans (2783 \$/ha early sown and 2225 \$/ha late sown) presented the highest gross margin (Figure 9).

CONCLUSION

This trial has confirmed that the timing of legume sowing significantly impacts the yield of subsequent wheat rotations, with early sowing providing consistent agronomic advantages. The results align with those observed in the 2023 wheat rotation, where early sowing led to improved early canopy development, N uptake and grain weight, and this year's findings further reinforce the benefits. Early sowing of legumes enhances yield and offers extended benefits over two years, making it a reliable strategy for boosting productivity in wheat rotations (Mesfin et. al, 2023).

Additionally, the economic analysis of the first two rotations indicates that most legume-wheat rotations generate higher gross margins than wheat-wheat rotations, with early-sown legumes consistently outperforming cash crop rotations in profitability. These results highlight the dual agronomic and economic benefits of early legume sowing, making it a reliable strategy for improving productivity and profitability in wheat rotations

ACKNOWLEDGEMENTS

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