NGN OPTIMISING AND EXPANDING PULSE PRODUCTION IN COLD ENVIRONMENTS OF THE MID NORTH

2025 TRIAL RESULTS

Jordan Bruce, Stuart Sherriff, Ben Smith, Sam Trengove, Sarah Noack, Cameron Franklin and Luke Wheare

Trengove Consulting

GRDC project code: TGC2504-001RTX

The following report summarises the results from five field trials located near Koonoona, Mid North SA.

Contents

Acknowledgements

This research was funded by the GRDC as a part of project TGC2504-001RTX and this investment is gratefully acknowledged. Trengove Consulting acknowledges the Smith family for providing the site and assisting with trial management.

Why do the trials?

The research outlined in this project focuses on the eastern areas of the Mid North (Figure 1), which currently has a low pulse cropping intensity. The overall area comprises of approximately 300,000 hectares and is generally medium-high rainfall. It has a higher frequency of acidic soils and is colder compared to other subregions in the Mid North.

Legume production has historically been limited to lower value vetch pastures and lupins. Faba beans are also grown on a limited area. More commonly grown break crop options are oaten hay and canola, however, these both have limitations with high labour and machinery requirements for hay production and high financial risk for canola production.

Legume break crops are not widely adopted in the region due to several factors, including perceived production risk and historically inconsistent performance in terms of biomass and yield. Improving understanding of how and where high value lentil crops can be grown successfully could deliver significant economic benefits for growers in the region.

This project aims to quantify the relative performance of different pulse options and identify management options for lentils to optimise their performance. The project outcomes will provide growers with increased confidence around whether adopting pulses in their farming system is likely to be profitable, or not, and how best to achieve a profitable outcome.

Figure 1. Target area for the project on the eastern side of the Mid North, SA.

Site selection and soil properties

Five field trials were established within a single paddock near Koonoona in the Mid-North of SA. One trial (Trial 1) was located on a black clay loam soil within the paddock the remaining four trials (Trials 2 – 5) were located on a red silty loam soil.

Black soil (site 1)

These areas within the paddock are considered better performing. There are no chemical constraints within the top 30 cm. Root growth may begin to be impacted by sodicity in the 30-60 cm layer, otherwise there are no other constraints to 60 cm. Beyond 60 cm the sodicity level increases further which may begin to restrict root growth and the level of salinity increases. Boron also begins to increase at this depth. The level of boron that may be considered toxic for lentils is hard to determine as there is tolerance among varieties.

Site	**Black clay loam - Site 1**				
Depth	cm	0-10	10-30	30-60	60-100
pH	$CaCl_2$	7.57	7.8	8.09	8.22
	H_2O	8.12	8.69	9.14	9.17
Soil texture		Clay loam	Clay	Clay	Clay
Conductivity	EC1:5 dS/m	0.17	0.19	0.35	0.69
	ECe	1.4	1.1	2.0	4.0
Chloride	mg/kg	-	41	81	290
Boron	mg/kg	-	2.0	5.3	19.0
Exchangeable Cations (cmol/kg)	Al	<0.02	<0.02	<0.02	<0.02
	Ca	38.2	35.8	31.2	26.9
	Mg	3.9	8.3	11.1	11.2
	K	1.9	0.7	0.8	0.9
	Na	0.7	2.0	5.2	8.8
	ECEC	44.8	46.8	48.3	47.8
	ESP %	1.5	4.2	11	18

Red soil (site 2)

Generally, these areas of the paddock have more soil constraints for growing pulses compared to Site 1. The 0-10 cm pH is moderately acidic which can have potential implications for growing sensitive crops, such as legumes. It is important to note that the soil beyond 10 cm is alkaline which is the preferred soil pH range for growing legumes. Sodicity is an issue throughout the whole soil profile with low levels affecting 0-30 cm and high levels beyond 30 cm. However, it is possible that the level of sodicity is overestimated beyond 30 cm due to the presence of soluble salts (i.e. high ECe and chloride readings), therefore it is difficult to gauge the true level of soil sodicity at depth on this profile (Hughes et al., n.d.).

Site	**Red silty loam - Site 2**				
Depth	cm	0-10	10-30	30-60	60-100
pH	$CaCl_2$	5.37	7.47	7.87	8.33
	H_2O	6.12	8.23	8.68	9.44
Soil texture		Silty loam	Silty clay loam	Silty loam	Silty clay loam
Conductivity	EC1:5 dS/m	0.19	0.31	0.75	0.91
	ECe	1.8	2.7	7.1	7.9
Chloride	mg/kg	-	77	450	680
Boron	mg/kg	-	2.6	7.6	3.7
Exchangeable Cations (cmol/kg)	Al	<0.02	<0.02	<0.02	<0.02
	Ca	5.7	23.8	22.2	20.5
	Mg	1.1	5.2	6.7	5.7
	K	0.9	0.9	1.2	0.8
	Na	0.6	2.1	6.3	7.2
	ECEC	8.3	32.1	36.4	34.2
	ESP %	7.4	6.5	17	21

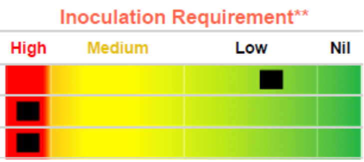
Predicta rNod

Both soils had a low inoculation requirement when sampled in late March 2025. Group E & F rhizobia were detected at a medium level, which was unexpected as faba beans were the last legume grown on this paddock back in 2016.

Group E & F – Lentil, faba bean, field pea and vetch
Group G & S – Lupin and Serradella
Group N – Chickpea

Site 1 – black soil

BENEFICAL ORGANISMS	RESULT	
Rhizobia Group E & F	3.5	log(rhizobia)/g sample
Rhizobia Group G & S	<2.3	log(rhizobia)/g sample
Rhizobia Group N	<2.3	log(rhizobia)/g sample



**Inoculation requirement categories may vary between regions and seasons, and may be revised over time.

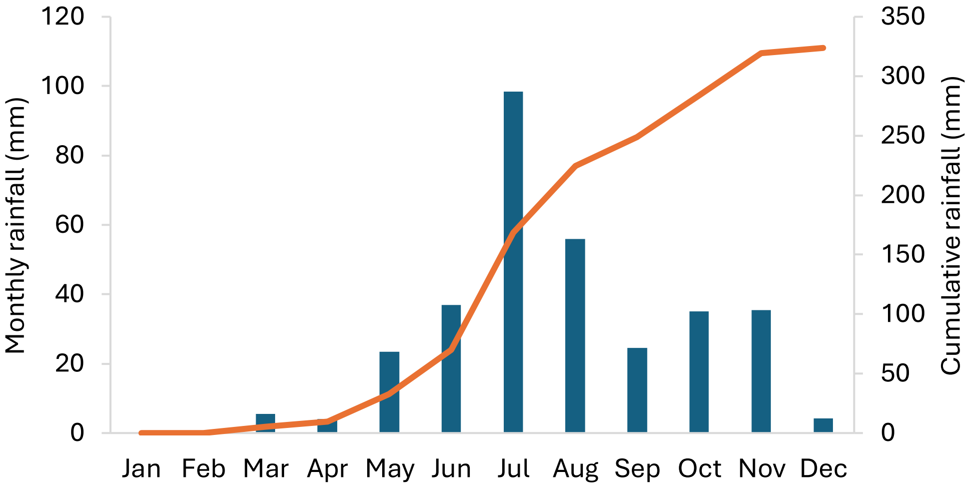
Site 2 – red soil

BENEFICAL ORGANISMS	RESULT		Inoculation Requirement** High	Medium	Low	Nil
Rhizobia Group E & F	3.4	log(rhizobia)/g sample			■	
Rhizobia Group G & S	<2.3	log(rhizobia)/g sample	■			
Rhizobia Group N	<2.3	log(rhizobia)/g sample	■			

**Inoculation requirement categories may vary between regions and seasons, and may be revised over time.

Rainfall

Figure 1. 2025 rainfall data supplied by a local farmer near Farrell Flat, SA.



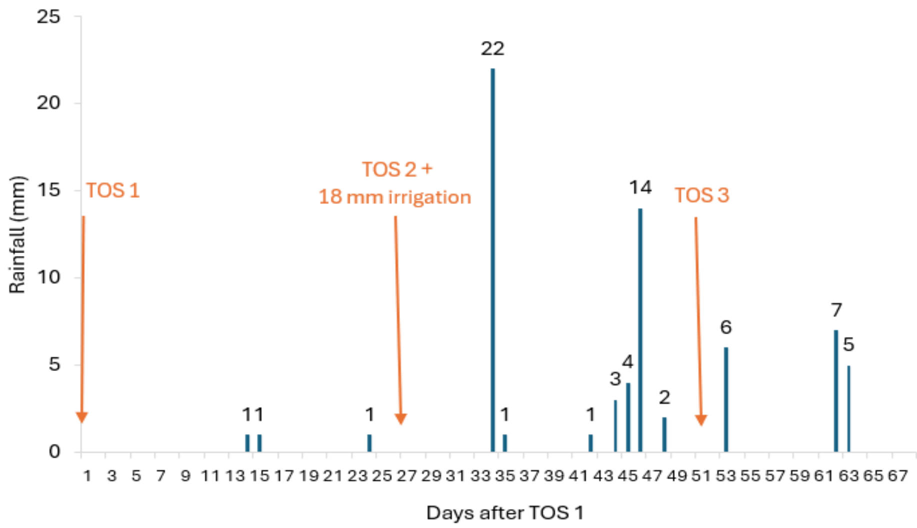


Figure 2. Time of sowing and daily rainfall for the trials at Koonoona, SA.

Trial 1. Lentil sowing time and variety performance on black clay loam

Key messages

- The productive clay loam soil (Site 1) yielded 610 kg/ha higher than the less productive silty loam site (Site 2) on average.
- Variety selection did not influence grain yield, despite differences in early vigour, biomass accumulation and maturity with the average yield of 2.48 t/ha.
- Time of sowing did not influence grain yield.
- Later sowing (TOS 3) delayed senescence. Crops maintained greener canopies longer, while TOS 1 and TOS 2 matured at similar rates despite different emergence times.

Aim

To investigate the influence of time of sowing on biomass production of different lentil varieties and how this impacts grain yield on a **productive soil type** (black soil – site 1) for pulse production.

Background

Spatial variation within paddocks is a common occurrence with productive and unproductive soils located within the same paddock. This trial is complemented by Trial 2, which is assessing time of sowing, lentil varieties and plant density on a less productive soil type.

This site was selected based on the characteristics of being a productive soil for growing legumes. This trial will investigate the relationship between crop biomass accumulation and grain yield, whilst optimising flowering time and grain fill. Sadras and Lake (2021) concluded that lentil yield correlated with biomass and growth rate in stressful conditions for lentils, but the relationship decoupled in more favourable, higher yielding conditions. This productive soil type should not be a biomass limited area of the paddock in most years, and it is hypothesised that biomass accumulation will not necessarily correlate with grain yield.

Methods

Rainfall 2025:	Annual 324 mm Growing season 279 mm	**Sowing date 1:** **Sowing date 2:** **Sowing date 3:**	24th April 2025 (dry) 21st May 2025 (+18 mm irrigation) 13th June 2025 (moist)
Varieties:	See Table 1.	**Fertiliser:**	MAP Zn @ 70 kg/ha
		Inoculant:	Alosca Group E (WSM4643) @ 10kg/ha

The trial was a factorial split plot design with three replicates, sowing time was the whole plot and variety was the subplot. Plots were 10 m x 1.5 m, sown on 2 m centres.

The trial consisted of three times of sowing (TOS); TOS 1 was sown dry, conditions prior to sowing TOS 2 were still dry and it was likely that both TOS would emerge when the first germinating rain fell. As a result, irrigation was applied to TOS 2 treatments to ensure full and complete emergence. The final TOS was sown into moist soil. While we still refer to TOS 1, 2 and 3 in the report the actual field experience saw TOS 2 emerge first due to irrigation. TOS 1 received 22 mm of rainfall seven days after TOS 2 was irrigated, therefore there is approximately a week's difference in emergence. TOS 3 emerged a lot later in late June.

Measurements throughout the season included crop establishment, growth stages, NDVI, dry matter and grain yield. Trial analysis was performed using linear mixed models with the ASReml package in R. Data presented as "Pred." are treatment means predicted from the ASReml mixed model, which accounts for spatial variation and random effects within the experimental design.

Lentil varieties were selected to cover a range of plant types and maturities. Table 1 describes the relative amount of vegetative growth and maturity timings for the six varieties.

Table 1. Comparison of lentil varieties in terms of crop growth and developmental characteristics.

Variety	Canopy/biomass	Maturity timing
PBA Kelpie XT	Moderate/high	Early
PBA Highland XT	Low/moderate	Early/mid
GIA Thunder	Moderate	Mid
GIA Colombo	Moderate/high	Mid
ALB Terrier	High	Mid
GIA Lightning	High	Mid/late

Results and discussion

Among the different management strategies there were few significant interactions between TOS and lentil varieties for any of the assessments. As a result, the discussion is based around the individual management factors.

Time of sowing

Despite differences in soil moisture and the use of irrigation for TOS 2, the final plant establishment was similar for all TOS. Final plant counts on 2 July averaged 122 plants/m^2 across the three TOS (data not shown), which is close to initial target planting density of 120 plants/m^2.

The effect of TOS and lentil variety on peak dry matter at mid podding was assessed. TOS 1 produced the lowest dry matter (Table 2), while TOS 2 and TOS 3 were similar. Generally, earlier emergence would be expected to result in greater dry matter production. In this trial, TOS2 emerged first and produced the highest dry matter. However, this relationship was not seen when comparing TOS 1 and TOS 3.

The average grain yield for the trial was 2.48 t/ha, which was higher than the average yield at the red soil site (Site 2) where productivity was lower and the average yield was 1.87 t/ha. Time of sowing did not affect grain yield at this site (Table 2).

Table 2. Average NDVI, pea dry matter and grain yield for each time of sowing (TOS) at the black soil TOS × variety trial at Koonoona, SA in 2025.

TOS	NDVI 1st Aug		Dry matter (kg/m^2)	
1	0.216	b	5294	b
2 (+18mm)	0.315	a	6020	a
3	0.160	c	5806	a
Pr(>F)	<0.001		0.0019	

Varietal selection
In general, lentil early vigour does not always correlate to peak dry matter. This was evident in the trial, where PBA Highland and PBA Kelpie had the greatest early vigour but this has not translated into the highest peak dry matter (Table 3). ALB Terrier had the highest peak biomass, which was greater than PBA Kelpie and GIA Thunder.

The two varieties known for high biomass canopies (Table 1) ALB Terrier and GIA Lightning, generally produced more biomass. As expected, based on the variety growth characteristics, the remaining varieties had lower biomass. However, in this trial there was no difference between the varieties despite ranging from low/moderate to moderate/high for biomass.

Grain yields across the varieties and times of sowing averaged 2.48 t/ha, with no differences observed between varieties.

Table 3. GreenSeeker NDVI and peak biomass results for all varieties averaged for the times of sowing at Koonoona, SA 2025.

Variety	NDVI 1 August		Peak dry matter (kg/ha)		Grain yield (t/ha)
ALB Terrier	0.233	abc	6290	a	2.57
Lightning	0.214	d	5978	ab	2.50
Colombo	0.224	bcd	5556	ab	2.47
Highland	0.248	a	5514	ab	2.48
Kelpie	0.241	ab	5465	b	2.39
Thunder	0.222	cd	5436	b	2.50
Pr(>F)	<0.001		0.016		0.118

Effect of TOS ×Variety on senescence
There was a significant interaction between TOS and variety on crop senescence. The two senescence scores were taken 8 days apart and illustrate how rapidly lentil crops can progress to maturity (Table 4).

Table 4. Senescence scores (0-100) based on changes in canopy colour from green to yellow/brown with a score of zero indicating a green canopy with no senescence at Koonoona, SA 2025.

Variety	TOS	Senescence	Senescence

		27th Oct		4th Nov	
ALB Terrier	1	7	ef	53	cd
Colombo	1	9	ef	78	abc
Highland	1	38	bc	97	a
Kelpie	1	35	bcd	97	a
Lightning	1	2	ef	58	bc
Thunder	1	6	ef	70	abc
ALB Terrier	2 (+18 mm)	31	bcd	80	abc
Colombo	2 (+18 mm)	10	ef	88	ab
Highland	2 (+18 mm)	47	ab	100	a
Kelpie	2 (+18 mm)	60	a	100	a
Lightning	2 (+18 mm)	15	def	85	abc
Thunder	2 (+18 mm)	23	cde	93	a
ALB Terrier	3	0	f	22	de
Colombo	3	1	f	20	e
Highland	3	0	f	77	abc
Kelpie	3	0	f	53	cd
Lightning	3	0	f	13	e
Thunder	3	0	f	12	e
Pr(>F)		<0.001		0.003	

The effect of sowing time was evident across all varieties, although the magnitude of the response differed between varieties. Earlier sowing allowed varieties such as Highland and Kelpie to senesce more rapidly, whereas later sowing delayed their development (Table 4). Mid and later maturing varieties, including ALB Terrier, Colombo, Thunder and Lightning, maintained greener canopies for longer, particularly under later sowing. Interestingly, GIA Lightning matured at a similar rate to the mid maturing varieties at all TOS, despite being classified as a later maturing variety.

Conclusions

Grain yield at the productive black soil (clay loam) site averaged 2.48 t/ha, which was 610 kg/ha greater than the less productive red soil (silty loam) site. This indicates that lentil production on these clay loam soil types is less constrained and capable of achieving higher yields.

Time of sowing did not influence grain yield.

Varietal selection did not affect grain yield, despite differences in early vigour, biomass accumulation and maturity. This indicates that under favourable conditions on this soil type, lentil yield was likely not limited by biomass production, and varieties with differing canopy structures produced similar yields.

Time of sowing influenced crop development, with later sowing delaying senescence, while earlier sowings matured at similar rates despite differences in emergence timing. This highlights the strong influence of seasonal conditions on crop maturity.

Trial 2: Lentil sowing time, seeding rate and variety performance on red silty loam

Key messages

- Despite lower early vigour at the standard plant density (120 plants/m^2), canopies in TOS 1 and TOS 2 had largely converged with the higher density (180 plants/m^2) by late September. In contrast, TOS 3 did not fully compensate, with the 120 plants/m^2 treatment maintaining lower NDVI values at the later assessment.
- Plant density did not affect grain yield at the two earlier times of sowing.
- Increasing plant density to 180 plants/m^2 for TOS 3 (mid-June) increased grain yields of PBA Highland XT by 220kg/ha (14%).
- Thunder generally had high and stable yields (average 1.95t/ha) and was less sensitive to late sowing and was overall higher yielding.
- GIA Colombo had intermediate yields (average 1.86t/ha) with a yield declining at TOS 3.
- PBA Highland XT was more variable and had the overall lowest average yield (1.79t/ha) with a clear yield penalty seen when sowing at TOS 3, especially with the standard seeding rate.

Aim

To investigate the influence of time of sowing and plant density (i.e. seeding rate) on biomass production of different lentil varieties and how this impacts grain yield on a minorly/moderately constrained **less productive soil** for pulse production.

Background

Spatial variation within paddocks is a common occurrence with productive and unproductive soils located within the same paddock. This trial is complemented by Trial 1, which is a similarly designed trial to investigate the difference of growth and yield but on a more productive soil type. This site was selected based on it fitting the characteristics of being a less productive soil for growing pulses.

This trial will investigate the relationship between crop biomass accumulation and grain yield, whilst optimising flowering time and grain fill. Sadras and Lake (2021) concluded that lentil yield correlated with biomass and growth rate in stressful conditions for lentils, but the relationship decoupled in more favourable, higher yielding conditions. This less productive soil type is likely to be more constrained, and biomass limited when growing lentils and it is hypothesised that biomass and yield will be correlated.

The three factors of time of sowing (TOS), variety selection and plant density should all have an influence on biomass accumulation of lentils.

Methods

Rainfall 2025:	Annual 324 mm Growing season 279 mm	**Sowing date 1:** **Sowing date 2:** **Sowing date 3:**	24th April 2025 (dry) 21st May 2025 (+18 mm irrigation) 13th June 2025 (moist)
Varieties by plant density:	GIA Colombo @ 120 plants/m^2 GIA Colombo @ 180 plants/m^2 PBA Highland XT @ 120 plants/m^2 PBA Highland XT @ 180 plants/m^2 GIA Thunder @ 120 plants/m^2 GIA Thunder @ 180 plants/m^2	**Fertiliser:** **Inoculant:**	MAP Zn @ 70 kg/ha Alosca Group E (WSM4643) @ 10 kg/ha

The trial was established in a lentil paddock near Koonoona, SA. It was a full factorial split plot design with three replicates, TOS is the whole plot and variety by plant density is the subplot. Plots were 10m x 1.5m on 2m centres.

The trial consisted of three times of sowing (TOS); TOS 1 was sown dry, conditions prior to sowing TOS 2 were still dry and it was likely that both TOS would emerge when the first germinating rain fell. As a result, irrigation was applied to TOS 2 treatments to ensure full and complete emergence. The final TOS was sown into moist soil. While we still refer to TOS 1, 2 and 3 in the report the actual field experience saw TOS 2 emerge first due to irrigation. TOS 1 received 22 mm of rainfall seven days after TOS 2 was irrigated, therefore there is approximately a week's difference in emergence. TOS 3 emerged a lot later in late June.

Measurements throughout the season included crop establishment, growth stages, NDVI, dry matter and grain yield. Trial analysis was performed using linear mixed models with the ASReml package in R. Data presented as "Pred." are treatment means predicted from the ASReml mixed model, which accounts for spatial variation and random effects within the experimental design.

Results and discussion

Plant density

The higher target plant density had greater crop establishment as expected. However, the percent of the target density was different between the two. Targeting 120 plants/m^2 achieved 104% of the target, while aiming for 180 plants/m^2 resulted in only 93% establishment. This effect has been seen in previous lentil trials, where higher seeding rates often results in a lower percentage of establishment once a certain plant density is exceeded. Time of sowing or variety selection had no effect on crop establishment.

Table 1. Average plant establishment for Site 2 at Koonoona, SA 2025.

Plant density (plants/m^2)	**Crop establishment (plants/m^2)**
120	125 b
180	167 a
Pr(>F)	<0.001

NDVI
TOS 2 had the greatest NDVI levels throughout the season, as it received 18mm irrigation to allow for earlier establishment. The NDVI levels were influenced by the crop establishment timing.

In general, increasing plant density resulted in an increase in NDVI. Earlier in the season on 1st August, an increase in NDVI was seen for all TOS. However, by 29th September, the effect of NDVI change was less for the earlier TOS but the effect was very pronounced for the later TOS 3. The earlier TOS were able to catch up to produce a similar size canopy between the two plant densities. However, TOS 3 could not catch up with its smaller canopy size throughout winter showing reduced NDVI at the lower plant density.

Table 2. GreenSeeker NDVI at two timings for TOS and plant density at Site 2 at Koonoona, SA 2025.

TOS	Target plant density/m^2	NDVI 1 Aug		NDVI 29 Sept	
1	120	0.228	d	0.773	c
1	180	0.259	c	0.786	bc
2 (+18 mm)	120	0.276	b	0.813	ab
2 (+18 mm)	180	0.317	a	0.824	a
3	120	0.191	f	0.663	e
3	180	0.204	e	0.712	d
Pr(>F)		<0.001		0.014	

When looking at varietal differences for early NDVI on 1st August, it can be seen that GIA Thunder had the greatest early vigour on this soil type compared to GIA Colombo and PBA Highland XT but only by 4%.

By the 29th September, GIA Thunder still had the greatest NDVI, inferring the largest canopy, followed by GIA Colombo and then PBA Highland XT. This contrasts Site 1, where all three of these varieties produced the same level of peak biomass in spring.

In general, GIA Thunder has performed better than expected in terms of early vigour and overall biomass. At Site 1, PBA Highland XT had greater early vigour than both GIA Thunder and GIA Colombo, which is generally expected. However, it is possible that GIA Thunder is more tolerant to some of the soil constraints that are influence growth on this red silty loam.

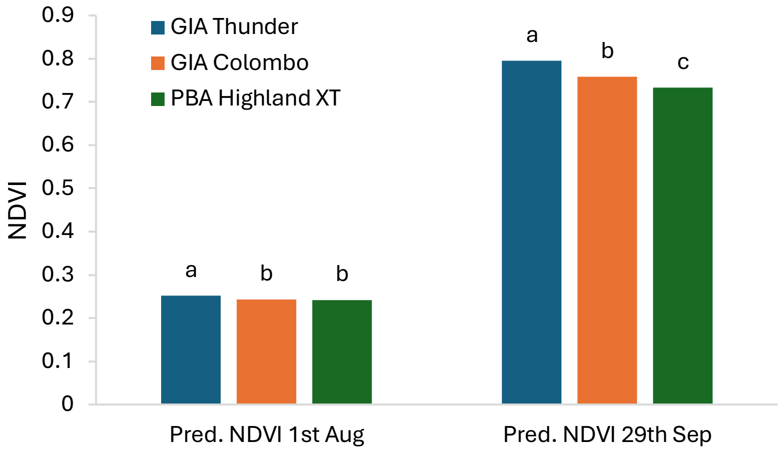


Figure 1. GreenSeeker NDVI at two timings for varieties at Site 2 at Koonoona, SA 2025.

Grain yield

Grain yield differed significantly among treatments, ranging from 1.54 to 2.15 t/ha. There was a three-way interaction where TOS, variety and plant density all had an influence on grain yield.

Thunder generally produced the highest yields, particularly at TOS 2, where yields exceeded 2.1 t/ha at the 120 plant density. Highland showed reduced yield under TOS 3, with the lowest yield recorded at the 120 plant density. This is expected, as Highland has a smaller canopy structure and was unable to compensate as well as compared to Thunder and Colombo. Colombo had intermediate performance, with yield declining under TOS 3 relative to earlier sowing opportunities.

Increasing plant density from 120 to 180 did not consistently improve grain yield across varieties or TOS. This is not surprising, as there was no NDVI difference for plant density for TOS 1 and TOS 2 by 29/09/25 for all varieties, however, plant density 120 had clearly lower NDVI compared to seeding rate 180 at TOS 3.

Table 3. Grain yield for TOS * Variety * plant density trial for Site 2 at Koonoona, SA 2025.

Variety	TOS	Target plant density	Grain yield (t/ha)	
GIA Colombo	1	120	1.90	abc
	2		1.96	abc
	3		1.67	ab
	1	180	1.80	abc
	2		2.15	c
	3		1.73	abc
GIA Thunder	1	120	1.88	abc
	2		2.13	c
	3		1.80	abc
	1	180	1.99	bc
	2		1.97	abc
	3		1.82	abc
PBA Highland XT	1	120	1.82	abc
	2		1.86	abc
	3		1.54	a
	1	180	1.71	abc
	2		1.91	abc
	3		1.76	abc
Pr(>F)			0.0104	

Senescence

There is no clear evidence that increasing plant density influenced the rate of senescence of any variety.

Highland sown at TOS 1 or TOS 2 had the highest level of senescence as of 27th October, averaging 79%. By 4th November, Thunder and Colombo sown TOS 1 or TOS 2 had all reached the same level of maturity as Highland averaging 93%.

On 4th November the senescence differences, which can be used to infer maturity, could be picked between the three varieties when sown later at TOS 3 with Highland having the earliest maturity, Thunder having mid maturity and Colombo having the slowest maturity. This contrasts Site 1, where Thunder and Colombo senesced and matured at the same rate.

Table 4. Senescence scores at two timings (8 days apart) for TOS * variety Koonoona, SA 2025.

Variety	TOS	Pred. Senescence score 27th Oct		Pred. senescence score 4th Nov	
GIA Colombo	1	21	c	79	bc
PBA Highland XT	1	71	a	97	ab
GIA Thunder	1	23	c	100	a
GIA Colombo	2 (+18mm)	33	bc	90	ab
PBA Highland XT	2 (+18mm)	86	a	95	ab
GIA Thunder	2 (+18mm)	44	b	99	ab
GIA Colombo	3	4	d	21	d
PBA Highland XT	3	27	c	93	ab
GIA Thunder	3	3	d	65	c
Pr(>F)		<0.001		<0.001	

Conclusion

Grain yield on the red silty loam soil averaged 1.86 t/ha, which was lower than the clay loam soil (Site 1), confirming that this soil type was more constrained for lentil production. Yield was influenced by the interaction between time of sowing, variety and plant density.

Time of sowing had a strong influence on crop growth and yield. The mid-May sowing plus irrigation (TOS 2) generally produced the highest NDVI and grain yields, while the later sowing (TOS 3) reduced biomass accumulation and yield potential.

Increasing plant density from 120 to 180 plants/m^2 increased canopy size (NDVI), particularly for the late sowing (TOS 3), where the lower density crop was unable to fully compensate for reduced establishment time. This increase in canopy size translated into a yield benefit for PBA Highland XT under late sowing, where grain yield increased by approximately 220 kg/ha.

Varietal performance differed across the trial. GIA Thunder produced the highest and most stable yields, particularly under earlier sowing opportunities, while GIA Colombo produced intermediate yields. PBA Highland XT was more sensitive to late sowing, particularly at the lower plant density where canopy development was limited.

Trial 3. Crop species performance on red silty loam

Key messages

- Field peas and hybrid canola were the highest yielding crops, averaging 2.70 t/ha.
- Lentils and hybrid canola provided the highest gross margin with an average of $1083/ha when using 5-year average commodity prices.
- Lupins and faba beans were less profitable at this site (5-year average price), with gross margins below $400/ha, and PBA Jurien lupin produced the lowest return.
- Variety selection within crop species did not significantly influence yield, with varieties within each crop type performing similarly in this season (excluding canola).

Aim
To investigate the most profitable pulse or non-cereal break crop on soils with minor/moderate soil constraints for pulse production.

Background
It is well known some pulse crops have a greater tolerance to soil constraints than others. For example, lupins are more suited to acidic soils, and faba bean are more tolerant to water logging on sodic soils. Lentils have previously shown poor tolerance to soil acidity and waterlogging on sodic soils. This trial will evaluate the profitability of legumes (pulses and non-pulses) and canola on constrained soils. Crop species include lentils, faba beans, lupins, vetch (hay/brown manure), field peas and canola.

Methods

Rainfall 2025:	Annual 324 mm Growing season 279 mm	**Sowing date:**	21st May 2025
Crop species	Lentil, vetch, canola, faba bean, field pea and lupin. See Table 1 for specific varieties.	**Fertiliser:**	MAP Zn @ 70 kg/ha Urea @ 100kg/ha (canola only) SoA @ 200kg/ha (canola only)
		Inoculant (sown with seed):	Lentil, vetch, field pea, faba beans: Alosca Group E (WSM4643) @ 10kg/ha Lupins: Nodulator granular Group G @ 4.2kg/ha

The trial was established in a lentil paddock (Site 2 – red soil) near Koonoona, SA. It was a split plot design with three replicates. Plots were 10m x 1.5m on 2m centres.

Measurements throughout the season included plant density, growth stages, NDVI, dry matter and grain yield. The trial was harvested on 27th November 2025. Trial analysis was performed using linear mixed models with the ASReml package in R.

Results and discussion

Grain yields

Across all crop types trialled, both field pea varieties and the hybrid canola were the highest yielding, averaging 2.70 t/ha (Table 1). Lentils, faba beans, PBA Bateman lupins and Bidgee TT OP canola yielded the next highest with an average grain yield of 2.05 t/ha. PBA Jurien lupins yielded the least with an average grain yield of 1.73 t/ha. The two vetch varieties were cut for hay and yielded 4.03 t/ha on average.

Variety selection within pulse crops did not impact outcomes this season, as all varieties of each crop species performed similarly. Harvesting across different maturities was managed as well as practicable. It is worth noting that yield cuts for Bidgee TT canola were taken slightly earlier for this variety, and actual yields may have been slightly higher than what is presented (Table 1).

Economic analysis

The total variable costs per hectare are based on figures provided in the 2024 Farm Gross Margin and Enterprise Planning Guide for South Australia (Ag Excellence Alliance 2024). The numbers displayed in Table 1 are an average of the medium and high rainfall zone costs per hectare, as this environment sits between the two.

The 5-year average commodity grain price was used to take the seasonal sensitivity out for this analysis (Table 1). The prices can similarly be found in the 2024 Farm Gross Margin Guide (Ag Excellence Alliance 2024). In comparison Table 2. uses 2025/26 pricing. The vetch price was estimated on local experience.

Gross margin

5-year average commodity pricing

Lentils and hybrid canola provided the highest gross margin with an average of $1083/ha. Vetch hay, field peas and OP canola provided the next highest gross margins with an average of $741/ha. Both faba bean varieties and lupins resulted in the lowest gross margins ranging from $263 - $425/ha.

Table 1. Grain yield and 5-year average economic results for the crop species trial at Koonoona, SA 2025.

Crop	Variety	Yield (t/ha)		5 yr ave price ($/t)	Gross income ($/ha)		Cost ($/ha)	Gross margin ($/ha)	
Lentil	PBA Highland	2.03	bc	$769	$1,561	b	$519	$1,043	a
Lentil	GIA Thunder	2.17	b	$769	$1,665	ab	$519	$1,146	a
Faba bean	PBA Bendoc	2.06	b	$475	$977	e	$552	$425	c
Faba bean	PBA Amberley	2.00	bc	$475	$948	e	$552	$396	c
Vetch	Timok	*3.86**	-	$350	$1,352	cd	$690	$662	b
Vetch	Popany	*4.20**	-	$350	$1,470	bc	$690	$780	b
Field pea	PBA Butler	2.59	a	$458	$1,184	d	$481	$703	b
Field pea	APB Bondi	2.72	a	$458	$1,245	d	$481	$764	b
Lupin	PBA Bateman	1.89	bc	$392	$739	f	$415	$324	c
Lupin	PBA Jurien	1.73	c	$392	$656	f	$415	$263	c
Canola	Regiment XC	2.79	a	$642	$1,789	a	$728	$1,061	a
Canola	Bidgee TT**	2.14	b	$690	$1,479	bc	$683	$797	b
	Pr(>F)	<0.001			<0.001			<0.001	

**Estimated hay yield*
***Timing of yields cuts were slightly early therefore yield is slightly lower than expected*

2025/26 seasonal pricing

Some of the gross margin outcomes differ from the five-year average when using current pricing due to changes in commodity prices (Table 2). Field pea, lupin, and vetch are currently priced higher than their long-term average, while lentil and faba bean prices are lower. Hybrid canola prices remain similar to average, with OP canola showing an increase. Under current pricing, field pea, canola, and vetch hay offer the highest gross margins (Table 2), whereas faba bean remains the least profitable option.

Table 2. Grain yield and 2025/26 pricing economic results for the crop species trial at Koonoona, SA 2025.

Crop	**Variety**	**Yield (t/ha)**		**Current price ($/t)**	**Gross income ($/ha)**		**Cost ($/ha)**	**Gross margin ($/ha)**	
Lentil	PBA Highland	2.03	bc	$600	$1,218	e	$519	$700	d
Lentil	GIA Thunder	2.17	b	$600	$1,299	de	$519	$781	cd
Faba bean	PBA Bendoc	2.06	bc	$430	$884	f	$552	$332	e
Faba bean	PBA Amberley	2.00	bc	$430	$858	f	$552	$306	e
Vetch	Timok	*3.86**	-	$400	$1,546	bc	$690	$856	bcd
Vetch	Popany	*4.20**	-	$400	$1,680	ab	$690	$990	abc
Field pea	PBA Butler	2.59	a	$570	$1,473	cd	$481	$993	abc
Field pea	APB Bondi	2.72	a	$570	$1,549	bc	$481	$1,069	a
Lupin	PBA Bateman	1.89	cd	$650	$1,225	e	$415	$811	cd
Lupin	PBA Jurien	1.68	d	$650	$1,090	e	$415	$675	d
Canola	Regiment XC	2.79	a	$635	$1,770	a	$728	$1,043	ab
Canola	Bidgee TT**	2.14	b	$740	$1,586	abc	$683	$904	abcd
	Pr(>F)	<0.001			<0.001			<0.001	

This trial will be sown back to wheat plots in 2026 to measure the moisture and nitrogen legacy effects.

Trial 4. Lentil herbicide tolerance trial

Key messages

- Despite some early season vigour differences by spring there were no NDVI differences leading to no yield losses from any herbicide treatment.
- Herbicide applications providing residual soil activity into spring were highly effective at controlling broadleaf weeds. These included treatments containing Reflex, which has a relatively long soil residual period, or PSPE, EPE or POST herbicide applications which provided residual activity later into the season.

Background

Lentils are a high value break crop in southern Australian farming systems but their adoption in colder areas of the eastern Mid North has been limited due to perceived production risk and limited local research. Effective weed control is critical for successful lentil production, yet the crop is sensitive to many herbicides, particularly pre-emergent products.

Crop damage from herbicides can be greater on soils with lower cation exchange capacity or other soil constraints, which are common in the region. As growers consider expanding lentil production into these environments, there is a need to better understand the crop safety of commonly used herbicides. This trial evaluates lentil tolerance to a range of herbicide options to identify safer weed management strategies for growers.

Methods

Soil type:	Red silty loam (Site 2)	**Sowing date:**	21st May 2025
Rainfall 2025:	Annual 324 mm Growing season 279 mm	**Inoculant:**	Alosca Group E (WSM4643) @ 10kg/ha
Fertiliser:	MAP Zn @ 70 kg/ha	**Herbicide application timings:**	IBS treatments were applied immediately prior to sowing. PSPE treatments were applied onto moist soil on 30th May EPE Brodal was applied at the 7-node stage on 18th July. POST Intercept was applied on 5th August.
Variety:	Thunder lentil @ 47 kg/ha		

The trial was a randomised complete block design (RCBD) consisting of 18 treatments with three replicates. Plots were 10 m x 1.5 m on 2 m centres. The full herbicide treatments are listed in Table 1.

Measurements throughout the season included crop establishment, vigour scores, NDVI, weed counts and grain yield. Weed counts were conducted one week prior to harvest. Trial analysis was performed using linear mixed models with the ASReml package in R.

Results and discussion

Crop establishment

Herbicide treatments did not affect crop establishment compared to the untreated control. Lentil establishment across the trial ranged from 105 – 147 plants/m^2 with an average of 126 plants/m^2 (Table 1).

Weed control

The broadleaf weeds (BLW) at the site were generally late to germinate in 2025. Prior to August there were minimal BLW that had germinated. Throughout spring low levels of common sowthistle, marshmallow, prickly lettuce, skeleton weed and wireweed began to germinate. This germination timing favours herbicides with longer residual periods.

Due to low levels of the five weed species present, the data for each species was summed together to calculate total BLW per plot (Table 1). The untreated control had a total of 6.3 BLW per plot on average. Group 5 herbicides applied IBS were providing no or very little BLW control. Applying metribuzin PSPE at 280 g/ha provided 63% BLW control, whilst using the lower 180 g/ha rate did not provide sufficient weed control.

Effective BLW weed control was achieved by either mixing two products together or applying two products in split application timings. The treatments providing the highest level of control were treatments 11, 12, 14, 15, 17 and 18, which provided 97% BLW control on average. These treatments either contained Reflex, which has a relatively long soil residual period, or had a PSPE, EPE or POST herbicide which provided residual activity later into the season.

NDVI

The only treatments to reduce NDVI compared to other treatments on the 1st August were Terrain Flow and Diuron IBS fb Metribuzin (Table 1). By late September these treatments had grown out of any herbicide damage symptoms and all treatments had similar NDVI.

Grain yield

Due to lack of herbicide damage symptoms in spring and very low weed competition there were no grain yield differences. The average lentil grain yield was 2.11 t/ha.

Table 1. Plant establishment, Greenseeker NDVI, weed counts and grain yield results for the lentil herbicide tolerance trial at Koonoona, SA in 2025.

Treatment	Herbicide/s	Plants/m^2	Pred. NDVI 1 Aug		Pred. NDVI 29 Sep	Total broad leaf weeds/plot*		Pred. grain yield (t/ha)
1	Nil (control)	105	0.237	abc	0.822	6.3	a	2.1
2	Diuron 415 g/ha IBS	134	0.236	abc	0.831	4.3	abcde	2.0
3	Diuron 830 g/ha IBS	123	0.227	abc	0.823	6.0	ab	2.1
4	Terbyne750 500 g/ha IBS	130	0.243	a	0.828	1.3	cdef	2.2
5	Terbyne750 1000 g/ha IBS	132	0.234	abc	0.831	5.0	abc	2.1
6	Metribuzin 180 g/ha PSPE	128	0.236	abc	0.832	5.3	abc	2.3
7	Metribuzin 280 g/ha PSPE	129	0.222	bc	0.830	2.0	bcdef	2.2
8	Reflex 750 mL/ha IBS	128	0.245	a	0.821	4.7	abcd	2.1
9	Reflex 1000 mL/ha IBS	119	0.233	abc	0.828	1.3	cdef	2.2
10	Terrain Flow 125 mL/ha IBS	116	0.221	c	0.810	3.7	abcdef	2.1
11	Diuron 415 g/ha IBS fb Brodal 150 mL/ha EPE	131	0.227	abc	0.825	0.0	f	2.1
12	Diuron 415 g/ha IBS fb Intercept 600 mL/ha POST	147	0.241	abc	0.840	0.3	ef	2.1
13	Diuron 415 g/ha IBS fb Metribuzin 180 g/ha PSPE	118	0.222	c	0.839	2.3	abcdef	2.2
14	Diuron 415 g/ha IBS fb Metribuzin 180 g/ha PSPE fb Intercept 600 mL/ha POST	127	0.231	abc	0.830	0.3	ef	2.1
15	Reflex 750 mL/ha IBS fb Intercept 600 mL/ha POST	116	0.239	abc	0.837	0.0	f	2.2
16	Diuron 415 g/ha + Reflex 750 mL/ha IBS	131	0.241	abc	0.828	1.3	cdef	2.2
17	Diuron 415 g/ha + Reflex 750 mL/ha IBS fb Intercept 600 mL/ha POST	143	0.243	ab	0.832	0.7	def	2.2
18	Reflex 750 mL/ha IBS fb Metribuzin 180 g/ha PSPE	113	0.235	abc	0.827	0.0	f	2.0
	Pr(>F)	0.44	<0.001		0.614	0.016		0.131
	LSD(0.05)	ns			ns	4.19		ns

*Sum of common sowthistle, marshmallow, prickly lettuce, skeleton weed and wireweed

Trial 5. Evaluating rhizobia inoculation in vetch and lentil

Key messages

- Adequate background levels of rhizobia for Group E & F indicated that a response to inoculation was unlikely.
- No differences in nodulation, NDVI or grain yield were observed for any application (peat or granular) of Group E (WSM4643) acid tolerant rhizobia compared to the untreated lentil and vetch.
- Vetch had more consistent and greater nodulation with an average of 40-45 nodules per plant compared to lentils which averaged 25-30 nodules per plant.

Background

Red silty soils are very common in colder environments east of Clare and Spalding in Mid North, SA. These soils are inherently acidic by nature, which has detrimental effects on soil rhizobia bacteria. Soil rhizobia are crucial for forming a symbiotic relation with legumes which is mutually beneficial for both the rhizobia bacteria and the legume plants. This symbiosis results in the production of root nodules which allows for biological nitrogen fixation. Acid soils reduce the survival and longevity of rhizobia populations within the soil.

Along with acid soils, the area in question often has long breaks between legume crops traditionally due to impeded growth and overall poor production. However, liming of acid soils has increased greatly on these soils over the past 10 years which has increased soil pH and allowed for increased productivity of legumes.

Methods

Rainfall 2025:	Annual 324 mm Growing season 279 mm	**Sowing date:**	21st May 2025
Fertiliser:	MAP Zn @ 70 kg/ha	**Inoculant:**	As per treatment in Table 1
Crops:	Timok vetch @ 50 plants/m^2 GIA Thunder lentil @ 120 plants/m^2		

Two legume crop species were selected: lentil, a high value pulse crop and vetch a commonly grown legume break crop in the area. All inoculant treatments were applied to both vetch and lentil. Both peat and granular inoculants contained the Group E WSM4643 acid tolerant rhizobia strain.

Table 1. Treatments for the inoculation trial at Koonoona, SA 2025.

Treatment	Variety	Inoculant description	Inoculant rate
1	Timok	Nil	-
2	Timok	Peat x1	NoduleN – 250 g/100kg seed
3	Timok	Peat x2	NoduleN – 500 g/100kg seed
4	Timok	Granular x1	ALOSCA -10 kg/ha
5	Timok	Granular x2	ALOSCA – 20 kg/ha
6	GIA Thunder	Nil	-
7	GIA Thunder	Peat x1	NoduleN – 500 g/100kg seed
8	GIA Thunder	Peat x2	NoduleN – 1000 g/100kg seed
9	GIA Thunder	Granular x1	ALOSCA – 10 kg/ha
10	GIA Thunder	Granular x2	ALOSCA – 20 kg/ha

The trial design was a split-plot trial with four replicates with inoculant as whole-plot and crop species as sub-plot.

All data was analysed by ASREML meaning treatment means are predicted values.

Results and discussion

Rhizobia levels for Group E & F were greater than expected, as the last legume crop of this group was back in 2016 when it was sown to faba beans. As a result, the requirement for inoculation was predicted to be low and it was unlikely that there would be any response to inoculation.

Table 2. Rhizobia levels and resulting inoculation requirement for the red silty loam at Koonoona, SA 2025.

			Inoculation Requirement**			
BENEFICAL ORGANISMS	RESULT		High	Medium	Low	Nil
Rhizobia Group E & F	3.4	log(rhizobia)/g sample			■	
Rhizobia Group G & S	<2.3	log(rhizobia)/g sample	■			
Rhizobia Group N	<2.3	log(rhizobia)/g sample	■			

**Inoculation requirement categories may vary between regions and seasons, and may be revised over time.

There was no NDVI, nodulation or grain yield response for either vetch or lentil to the addition of any inoculant (Table 3). This is not surprising given the starting population of Group E & F rhizobia in the soil would be considered adequate based on results from the Predicta rNod test.

Figure 2. Similar levels of nodulation on Timok vetch roots in the untreated control (left) and granular inoculant x2 (right).

Table 3. Nodule score, NDVI and grain yield for lentil and vetch inoculation trial, 2025.

Species	Inoculant	Pred. Nodule score	Pred. NDVI 29 Sept	Pred. grain yield (t/ha)
Lentil	Nil	5.6	0.817	2.05
	Peat x1	5.7	0.798	1.96
	Peat x2	5.7	0.817	1.94
	Granular x1	6.2	0.819	1.94
	Granular x2	6.0	0.832	1.99
Vetch	Nil	7.5	0.894	2.03
	Peat x1	7.6	0.887	2.02
	Peat x2	7.7	0.893	1.94
	Granular x1	8.2	0.894	1.93
	Granular x2	8.0	0.894	1.96
	Pr(>F)	0.523	0.507	0.97
		ns	ns	ns

There were however NDVI and nodulation differences between the two crop species (Table 4). Vetch had greater overall nodulation with an average score of 7.9 compared to lentils average score of 5.8. Based on the nodulation scoring scale, vetch averaged approximately 40–45 nodules per plant, while lentil averaged approximately 25–30 nodules per plant. Visually vetch plants also had a larger root system compared to lentil at this timing. The number of nodules per plant is likely to be proportional to the size of the root system. Vetch also had a lower coefficient of variation (CV) indicating the number of nodules per plant was more consistent when compared to lentil. As a result, vetch is likely to have fixed more nitrogen and provide greater residual nitrogen for the following crop.

Vetch had greater NDVI compared to lentil in early August and maintained greater biomass into later September (Table 4). Despite the differences in nodulation and growth there was no grain yield differences between the two crop species.

Table 4. In-season and harvest data for the inoculant trial at Koonoona, SA in 2025.

Species	**Nodule score**		**CV nodule score**		**NDVI 1 Aug**		**NDVI 29 Sept**		**Grain yield (t/ha)**
Lentil	5.8	b	0.21	a	0.231	b	0.817	b	1.98
Vetch	7.9	a	0.12	b	0.317	a	0.892	a	1.98
Pr(>F)	<0.001		<0.001		<0.001		<0.001		0.955

References

Ag Ex Alliance (2024) Farm Gross Margin and Enterprise Planning Guide for South Australia https://sagit.com.au/wp-content/uploads/2024/02/24210.03.01-Gross-Margins-Guide-2024_WEB.pdf

Hughes B, Davenport D and Dohle L (n.d) Standard soil test methods & guidelines for interpretation of soil results https://cdn.environment.sa.gov.au/landscape/docs/lc/140916-standard-tests-and-interpretation-guidelines-fact.pdf

Lake L, Sadras V (2021) Lentil yield and crop growth rate are coupled under stress but uncoupled under favourable conditions. European Journal of Agronomy