Nutrition management: Do soil nutrient levels constrain production in the Victorian high rainfall zone?

JADE KILLORAN[1], MALCOLM MCCASKILL[2], PENNY RIFFKIN[2], JAMIE SMITH[2] AND IRMA GRIMMER[2]

[1]Southern Farming Systems (SFS)
[2]Department of Economic Development, Jobs, Training and Resources (DEDJTR)

Key messages

- The omission (absence) of nitrogen and phosphorus fertiliser inputs at the Inverleigh canola trial site caused a statistically significant reduction in canola grain yield.
- Visual biomass differences at the Glenthompson wheat site were noted during the season, but did not translate to yield.
- Low rainfall and high temperatures in the 2015 spring reduced the response of crops to the presence or absence of nutrients.

INTRODUCTION

The high rainfall zones (HRZ) of Victoria and South Australia were traditionally classed as grazing areas unsuitable for cropping until CSIRO agronomist, Jim Davidson, began trialing winter wheats that were suited to the cool, long season 'European' environment of the HRZ. By 1993, Davidson had released a winter cultivar, Lawson, specifically bred as a dual purpose winter wheat, and with the introduction of high yielding cultivars suitable to the HRZ, cropping areas within the zones steadily increased.

However, although crop yields have improved due to adapted farming techniques and cultivars, the theoretical yields possible based on available sunlight, moisture and temperature are still higher than actual yields obtained in the HRZ.

One theory which could explain the margin is that maximum crop yields in the high rainfall zones are constrained by nutrition, because current soil test interpretation guidelines are calculated from yield responses obtained in the medium and low rainfall cropping zones. In the HRZ, in years of above average rainfall, high yielding crops may require much greater levels of nutrients than currently expected in order to reach maximum yields.

As part of a four-year national project led by DEDJTR, SFS established two farm trial sites in 2015 to determine crop response to soil nutrition levels, to discover whether these levels are adequate to produce maximum, economically viable yields in the high rainfall zone.

The final outcome of the project will be the formulation of tools which predict the production, economic response and risk of applying inputs to wheat and canola crops within the south-eastern high rainfall zones.

METHODOLOGY

Soil sampling prior to sowing

The topsoil (0-10 cm) of potential sites was tested to determine nutrition level, with two sites selected, a canola site at Inverleigh and a wheat site at Glenthompson (Table 1).

Table 1. Soil nutrient levels from topsoil (0-10 cm) sampled from the Inverleigh and Glenthompson omission trial sites, 2015.

Site	Colwell P (mg/kg)	Colwell K (mg/kg)	KCl-extractable S (mg/kg)
Inverleigh	58	254	6.8†
Glenthompson	54	112*	29.5

†Glenthompson site marginal in potassium.

**Inverleigh site marginal in phosphorus*

After the selection of the sites, comprehensive soil samples were taken to determine exact soil nutrition, water content and bulk density and to provide interpretation of crop growth during the season.

OMISSION TRIAL TREATMENTS

The trial was a randomised complete block design with 14 treatments replicated 4 times (table 2).

Table 2. Omission trial treatments conducted at both sites, 2015.

Treatment number	Nitrogen rate	Nutrient Level
1	Full	No nutrient omitted (All)
2	Full	All nutrients omitted (Nil)
3	Full	Phosphorus omitted (-P)
4	Full	Potassium omitted (-K)
5	Full	Sulphur omitted (-S)
6	Full	Cu and Zn omitted (-m)
7	Half	No nutrient omitted (All)
8	Half	All nutrients omitted (Nil)
9	Half	Phosphorus omitted (-P)
10	Half	Potassium omitted (-K)
11	Half	Sulphur omitted (-S)
12	Half	Cu and Zn omitted (-m)
13	0 N	No nutrients omitted (All)
14	0 N	All nutrients omitted (Nil)

The trials were sown in May at both sites, with sowing fertiliser applied in conjunction with the seed (table 3).
In early September a further 57 kg N/ha (half rate) and 106 kg N/ ha (full rate) was applied to the canola at Inverleigh and a further 39 kg N/ha (full rate) to the wheat at Glenthompson.

Table 3. Site and sowing details.

Site	Sowing date	Sowing fertiliser	0 rate (kg/ha	Half rate (kg/ha)	Full rate (kg/ha)	Crop	Variety	Harvest date
Inverleigh	15.5.15	N	0	18	30	Canola	Archer	16/11/15
Glenthompson	26.5.15	P	0		25	Wheat	Beaufort	23/12/15
		K	0		50			
		S	0		20			
		Cu	0		2			
		Zn	0		1.1			

In-season sampling and monitoring

At the 5-7 leaf stage of each crop, 120 of the youngest fully expanded leaves per plot were harvested and sent to the laboratory for analysis. The date of GS30, or bud visible growth stage, was recorded.

At flowering, biomass cuts were taken from each plot, dried at 60° C and subsampled for tissue nutrient status. At maturity, biomass cuts were taken to determine biomass production, grain content/quality and harvest index.

Statistical analysis

Data for grain yield and biomass at harvest were analysed firstly for the main effect of each nutrient (e.g. nil P versus plus P) and secondly for their interaction between each nutrient and N rate. The first analysis is more sensitive. Analyses were undertaken using the REML algorithm of Genstat 17.

Growing season rainfall

Rainfall during the season at both sites was nearly 40% below the long term average since 1960, and the year was classified as a decile 1 for rainfall, meaning the annual total was within the lowest 10% of recorded rainfall seasons (table 4).

Table 4. Growing season rainfall (April to November) in the 2015 growing season relative to the long-term average.

Location	2015 (mm)	Long term average (mm)(1960-2015)	2015 relative to average	2015 decile
Winchelsea	262	425	62%	1
Glenthompson	291	456	64%	1

2015 RESULTS

Inverleigh canola

Visually, at harvest there was a noticeable difference between the "Nil all" and "+ all" nutrient treatments, with "+ all" treatments showing higher levels of biomass (figure 1). Additional P produced a further 0.3 t/ha of canola, or a 22% increase in yield.

Figure 1. Visual differences in biomass vigour occurred between "Nil all" and "+ all" treatment at the canola omission trial site at Inverleigh, 2015.

Figure 2 shows the yield of the canola plots at Inverleigh was affected by the absence of nitrogen and phosphorus, but not affected by the absence of other nutrients. Canola yields increased when phosphorus and nitrogen fertilisers were applied.

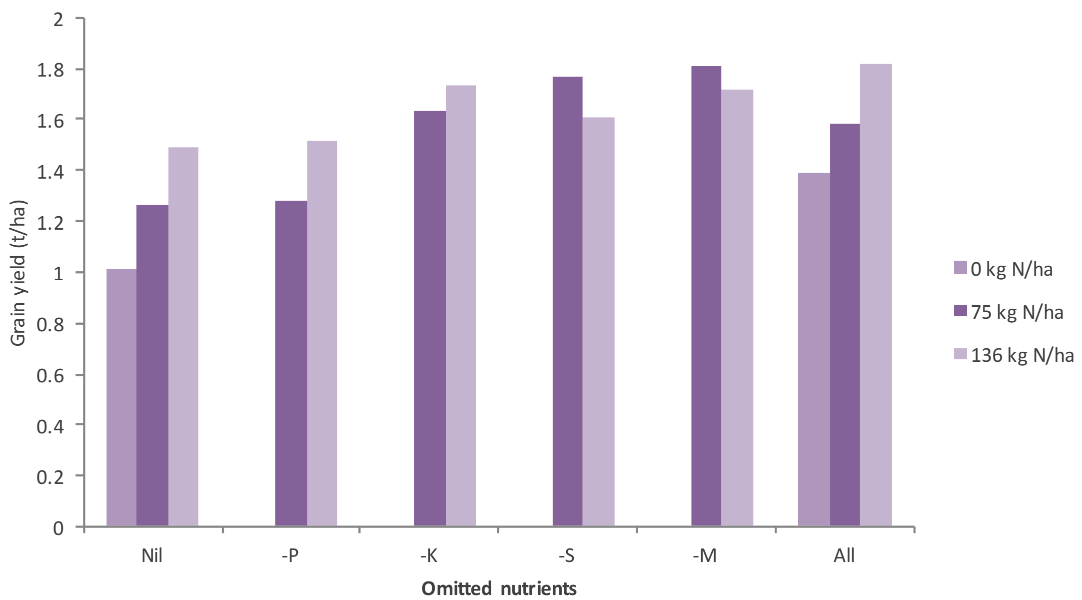

Figure 2. Canola grain yield (t/ha) in response to nitrogen rate/ha, at the Inverleigh omission trial site,

The main effect analysis showed significant positive grain yield responses to the addition of N and P, but not to K, S or micronutrients (table 5).

Table 5. Analysis of main effects of each nutrient on grain yield (tonne/ha).

Nutrient	Level			5% LSD	Significance
	Nil (t/ha)	Half (t/ha)	Full (t/ha)		
N	1.34	1.60	1.69	0.226	S
P	1.38		1.69	0.196	S
K	1.62		1.64	0.196	ns
S	1.62		1.64	0.196	ns
Cu, Zn	1.69		1.62	0.196	ns

The hypothesis of this trial suggests that crops will respond to the absence, or omission, of nutrients. The summary of Inverleigh site responses to soil nutrients supports this hypothesis (table 6). However, while a response to the omission of nutrients was observed, this was not the response to the marginal sulphur level (table 1) which was expected. Instead, the crop responded to the addition of P, which was not thought to be deficient according to the accepted critical levels detailed in table 1.

Table 6. Soil test values present at the omission trial sites in 2015, correlated to the accepted critical values in mg/kg.

Site	Nutrient	Soil test (mg/kg)	Accepted critical value (mg/kg)	Response expected	Response observed
Inverleigh	P	58	22	No	Yes
(canola)	K	254	46	No	No
	S	6.8	7.1	Yes	No

Glenthompson wheat

In contrast to the canola site at Inverleigh, the wheat site at Glenthompson showed no significant responses to the presence or absence of nutrients at harvest (figure 3). The largest response to nutrient omission can be seen in the "+ all" treatment, in which omitting nitrogen while supplying all other nutrients reduces yield, although not in a statistically significant manner. Earlier in the season, it was possible to note biomass differences but these did not translate to significant yield differences. Although the wheat did not respond to nutrient treatments, it did yield well in a difficult season, between 3.7 t/ha and 5 t/ha.

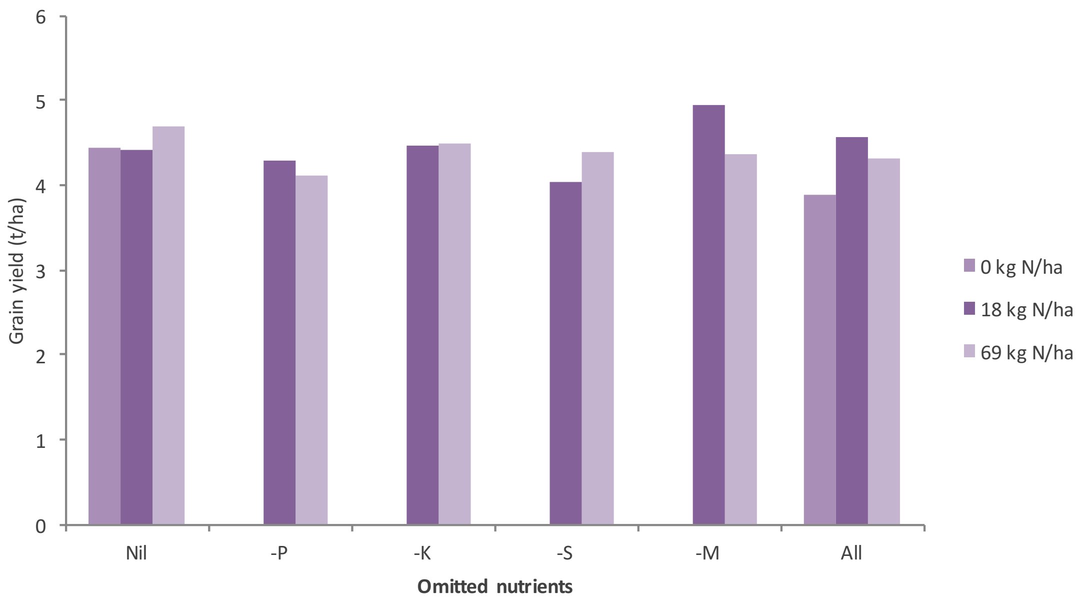

Figure 3. Wheat grain yield (t/ha) in response to nitrogen rate/ha at the Glenthompson farm trial site, 2015.

DISCUSSION

The 2015 omission trial did show responses to the omission of nitrogen and phosphorus at the canola site in Inverleigh, despite soil P levels which would normally be accepted as non-limiting. Additional P at this site increased grain yields by 0.3 t/ha under both nil and high-N treatments.

While there were significant responses to nutrient omission within the trial, there were several factors at both sites which reduced the ability of the crops to respond to soil nutrition level. Firstly, soil nutrient levels at each site were marginal, rather than severely deficient, reducing potential crop responses. Secondly, weather conditions during the 2015 growing season prevented crops from reaching their maximum yield potential. Growing season rainfall was affected by a strong El Nino, with all months excepting May, in the growing season, recording below average rainfall. Spring rainfall, which Western District crops depend on to reach yield potential, was a decile 1 at both sites. In addition, October was on average 5°C warmer for the month compared to the long term average, with November also recording below average rainfall and high winds which damaged flower and head retention in maturing crops.

CONCLUSIONS

A significant yield response was observed at the Inverleigh trial site in response to the omission of nutrients, in 2015. However, 2015 weather conditions, particularly low spring rainfall and high spring temperatures reduced crop response to treatments within the trial. In addition, the yield response to the omission of phosphorus were unexpected, as this was not a nutrient which was considered limited in the soil test analysis. Therefore, further testing of responses is required; particularly using canola crops, to determine the repeatability of the 2015 results. To maximise crop response to the omission of nutrients, trials should preferably take at sites with lower soil nutrient test values, and in seasons of higher rainfall.

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