Improved crop nutrition for disease management and reduced fungicide dependency

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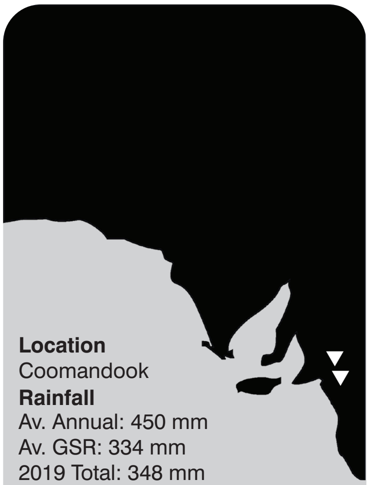

Location
Coomandook
Rainfall
Av. Annual: 450 mm
Av. GSR: 334 mm
2019 Total: 348 mm
2019 GSR: 294 mm
Yield
Potential: 4.1 t/ha
Actual: 3.5 t/ha
Paddock history
2019: Wheat
2018: Lupin
2017: Barley
Soil type
Deep (>50 cm) coarse sand over clay
Plot size
2 m x 10 m x 5 reps
Trial design
Split-split-plot
Yield limiting factor
Nil

Location
Palmer
Rainfall
Av. Annual: 325 mm
Av. GSR: 235 mm
2019 Total: 131 mm
2019 GSR: 120 mm
Yield
Potential: 0.6 t/ha
Actual: 0.7 t/ha
Paddock history
2019: Wheat
2018: Pea
2017: Barley
Soil type
Clay loam
Plot size
2 m x 10 m x 4 reps
Trial design
Split-split-plot
Yield limiting factor
Drought, possible herbicide damage in furrow due to furrow collapse

Key messages

- **Foliar and root diseases reduced yield by 0-20% over four cereal trials conducted form 2018-2019.**
- **Improving crop nutrition did not reduce Rhizoctonia disease severity.**
- **• Sulfur reduced spot form net blotch severity on barley in 2018, but did not influence yield.**
- **Yield responses to P and Cu in barley were greater under high Rhizoctonia disease pressure in 2018, indicating correct nutrition may be more important under high disease pressure.**

Why do the trial?

Disease is a significant cost issue for South Australian growers, causing yield loss and increasing management inputs such as fungicides. At the same time, many crops grown on in SA also have nutrient deficiencies, particularly copper, zinc and potassium. Previous research has demonstrated that these nutrient deficiencies not only reduce growth and yield directly, but can also affect the capacity of plants to resist or tolerate disease.

While the benefits of addressing nutritional requirements are becoming better understood and adoption by growers has increased, most research is carried out under low disease ('controlled') conditions. It is possible that the yield response to improved crop nutrition will be greater under moderate disease conditions. Addressing an underlying nutrient problem may reduce the need for some fungicide applications. A two-year project scoping the disease management benefits of improving crop nutrition has been established with funding from South Australian Grains Industry Trust (SAGIT).

How was it done?

Four field trials were conducted over two years. Field experiments were established at Stokes and Wangary on the lower Eyre Peninsula in 2018 and at Coomandook (upper South East) and Palmer (Murray Mallee) in 2019. Details of the 2018 trials were published in the Eyre Peninsula Farming Systems Summary 2018 p78.

In 2019, the Coomandook site had low-marginal phosphorous (13-15 mg/kg) and marginal potassium (42-90 mg/kg), whilst the Palmer site had low phosphorous (10 mg/kg) and marginal copper (0.29 mg/kg). Both sites were sown to Planet barley, Palmer on 14 May and Coomandook on 21 May. At each site, six nutrient treatments were applied at seeding either with or without fungicide to manage disease. Treatments sown without fungicide were also artificially inoculated with Rhizoctonia to ensure an even and significant amount of this root disease. The experiments were of a randomised, complete block design with 5-6 replicates of each of the 12 treatment combinations (Table 1).

Table 1. Treatment details at Palmer and Coomandook in 2019.

Palmer			Coomandook		
P (kg/ha as DAP)	K (kg/ha as MOP)	Disease	P (kg/ha as DAP)	Cu (kg/ha as CuSO4)	Disease
0	0	Low	0	0	Low
10	40	High	10	5	High
20			20		

In 'low disease' plots, Uniform was applied to fertiliser and soil and Vibrance was applied to the seed and Prosaro applied to foliage from late tillering stage, all at the highest label rate, to achieve relatively low levels of disease. In the 'high disease' plots, soil was inoculated with Rhizoctonia and foliar disease was allowed to develop from naturally-infected stubble present in the paddock. Weed and nitrogen management throughout the year were representative of district practice.

Tissue tests were conducted on above-ground biomass ('whole tops') sampled at late tillering to confirm any response to nutrients. Approximately forty plants were collected from each plot, with tests conducted on a single sample per treatment, bulked across replicates.

Root disease (predominately Rhizoctonia due to inoculation) was assessed visually for all plots at 'late-tillering' and 'full head emergence'. Forty plants per plot were assessed by collecting four 10 cm lengths of row dug from both ends of each plot to a depth of 20 cm, the roots were washed and disease severity scored on a 0-5 scale (0=no disease, 5=all roots totally rotted). Foliar disease was assessed at 'booting' and 'early dough' growth stages by randomly sampling 20 leaves per plot and recording percentage leaf area affected.

Plots were harvested on 13 November at Palmer and 18 November at Coomandook. Data were analysed in R (Version 3.6.1) and the R package 'asreml' to estimate treatment variability and adjust for spatial trends in the trials.

What happened?

Both sites received acceptable early rainfall, allowing crop establishment in both trials in the preferred seeding window. However, follow up rainfall at Palmer was poor, with the trial remaining drought-affected throughout the season. Growing season rainfall at Coomandook was approximately 285 mm.

Tissue nutrient status

Tissue tests conducted on whole above-ground biomass at Coomandook suggested marginal phosphorous status in nil phosphorous treatments, whereas all other treatments had sufficient phosphorous. Differences in potassium confirmed a response to the applied potassium treatments, however all samples were above the critical threshold. At Palmer, phosphorous deficiency was evident in nil phosphorous treatments and a consistent response to both phosphorous and disease was evident. Copper was sufficient for all samples.

Root disease

As can be expected, disease level (inoculated vs. fungicide treated) had a highly significant effect on both seminal and crown root disease for all sites, at all timings of assessment. This demonstrates that the method was effective at setting up different levels of disease. Disease could not be completely minimised in the 'control' plots, meaning the two disease levels are better defined as 'low' and 'high'.

There were minor effects of nutrition on root disease at Coomandook. Nutrient treatments did not affect root disease score in seminal roots at the first assessment (late tiller stage). However, effects were observed in the crown roots, where differences were observed across phosphorus treatments (Table 2). The effect of phosphorous was different for low and high disease pressures. Under low disease pressure, only the 20 kg/ha rate of phosphorous reduced disease. Under high disease pressure 10 kg/ha of phosphorous reduced crown root disease score from 3.46 to 3.11, while the addition of 20 kg/ha phosphorous resulted in average crown root score of 3.33, intermediate between 0 and 10 kg/ha phosphorous and not different from either.

Table 2. Average crown root disease score at early assessment (late tiller stage) for Phosphorous and Disease level treatments at Coomandook in 2019.

Disease	Phosphorous (kg/ha)	Disease score (0=none, 5=all)
Low	0	0.87
	10	0.94
	20	0.62
High	0	3.46
	10	3.11
	20	3.33
LSD		*0.25*

Under low disease pressure the addition of 20 kg/ha reduced crown root disease score from 0.87 down to 0.62.

At the second assessment (head emergence timing), phosphorous had an overall effect on seminal root disease only, reducing seminal root disease score on average (across disease levels) from 2.7 down to 2.4 with the addition of either 10 or 20 kg/ha of phosphorous. This same effect was not observed on the crown roots.

At Palmer, neither phosphorous nor copper had an effect on seminal or crown root disease score under low or high disease pressure, at either sampling time.

Leaf disease

Leaf disease was not assessed at Palmer, due to low rainfall throughout the year limiting any development of leaf disease.

At Coomandook, spot form net blotch developed in high disease plots (13.3% leaf area) and was limited in 'low' disease plots (0.015%) leaf area. However, nutrition had no effect on leaf disease at the first assessment (mid-tiller stage).

Disease continued to develop in high disease plots and was present at 33.0% leaf area at head emergence, while low disease plots remained controlled (0.02%). Again, nutrition did not have an effect.

Yield

At Coomandook, potassium did not influence yield. Both Phosphorous and Disease Level did affect yield (Table 4). Response to phosphorous and potassium was the same under low and high disease pressure. The addition of phosphorous increased yield by approximately 0.5 t/ha. There was no difference between the two levels of additional phosphorous (10 and 20 kg P/ha), suggesting the site was responsive to phosphorous but not highly so. High disease pressure reduced yield by 0.35 t/ha.

At Palmer, barley yielded approximately 0.7 t/ha. There was no response to disease level, indicating that the effect of Rhizoctonia was not limiting, likely due to the water limited (drought) conditions. There were no other effects.

What does this mean?

Disease, both root and foliar, was a significant limitation at Coomandook in 2019, reducing yield by around 10%. Yields at Palmer were unaffected by disease, despite root disease symptoms being more severe and the difference between low and high root disease symptoms being greater. These two sites demonstrate that the relationship between disease presence and yield loss is dependent on environmental factors i.e. rainfall or plant available water.

Nutrient inputs influenced yield at Coomandook, but not at Palmer. At Coomandook, increasing potassium did not improve yield under marginal soil potassium conditions, including in the diseased treatments where roots may have been expected to struggle to source potassium. This suggests that either the root systems can continue to function despite moderate-high damage, or that potassium was still sufficiently available at this site in this season.

Table 3. Average root disease scores (0=no disease, 5=all roots totally rotted) for low and high Rhizoctonia treatments on seminal and crown roots at late tillering and full head emergence stages at Coomandook and Palmer in 2019.

Site	Late tillering				Full head emergence			
	Seminal		Crown		Seminal		Crown	
	Low	High	Low	High	Low	High	Low	High
Coomandook	1.41	2.48	0.81	3.30	1.71	3.28	1.36	3.76
Palmer	1.85	2.74	1.24	3.90	1.94	3.50	1.45	4.60

Table 4. Yield at Coomandook considering Disease level and Phosphorous amount.

Phosphorous level (kg/ha)	Disease level	Yield (t/ha)
0	High	2.97[a]
0	Low	3.25[ab]
10	High	3.30[ab]
10	Low	3.79[c]
20	High	3.53[bc]
20	Low	3.82[c]

Disease

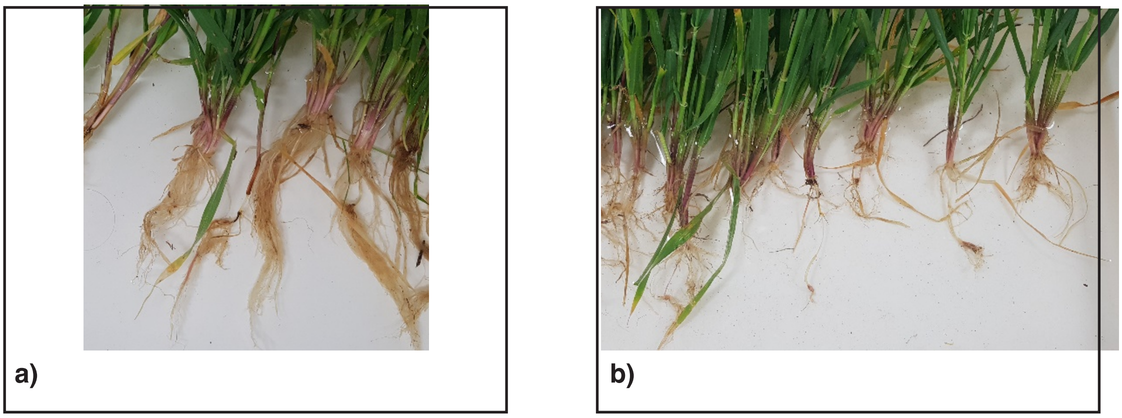

Figure 1. Palmer nutrition by disease trial 2019. a) low disease plots b) high disease plots. No yield differences were found between these treatments.

Phosphorous improved yield, but did so similarly in both low and high disease situations. Adding extra phosphorus (20 kg/ha) did not increase yield further (above the 10 kg/ha treatment), even in the treatments where roots were compromised by Rhizoctonia.

There were no clear benefits of nutrient inputs on actual root disease at either site. Root disease scores were high in inoculated plots, with generally all seminal and crown roots in all treatments at both sites displaying some disease. The responses did not show clear patterns i.e. the addition of 10 kg/ha phosphorous reduced disease score in crown roots under high disease pressure at Coomandook, whilst 20 kg/ha did not. Furthermore, the effects of phosphorous were visible in crown roots only at the early assessment, and seminal roots only at the second assessment. This may suggest subtle relationships between stage of root development, Rhizoctonia development and plant phosphorous requirement or it may simply be a chance effect.

It is important to note that no root disease response was particularly substantial. Small reductions in root or foliar disease, although statistically significant, are unlikely to influence yield or profit. Disease level treatment (low or high) had the greatest impact on root disease, which suggests established methods of managing Rhizoctonia (rotation to reduce inoculum, fungicides) are likely to have far greater impact on disease development than nutrient inputs.

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