SILICON FERTILISER FOR DROUGHT RESILIENCE IN BROADACRE CROPPING

KEY MESSAGES

- **Previous trial work under controlled experimental conditions has shown that silicon (Si) fertiliser application can improve tolerance to abiotic stress, including drought, via various plant physiological processes, leading to increased water uptake, reduced water loss from the leaves and improved plant growth**
- **While silicon application in this project has yet to show significant differences in grain yield or quality of the evaluated crops, positive trends for plant growth traits for various crop types were observed**
- **Further work is required to determine the potential yield effects of applying silicon on a commercial scale and the potential for economic returns to farmers.**

BACKGROUND

In Australia, climatic events have challenged the resilience and profitability of farming businesses. The occurrence and severity of climatic events such as drought, heat and frost, require more resilient approaches to sustain farm productivity, especially in the face of a changing climate. On-farm diversification can be a strategy to help farming communities prepare for, cope with, and recover from stressors, like drought.

The project *Whole-system redesign of broadacre farming of southeast Australia*, explores how the agricultural industry can build resilience by promoting diversity in farming systems while taking into consideration changing future climate scenarios. Drought is a major climate challenge, and this project is trialing the use of silicon fertiliser in broadacre systems as a primary drought mitigation strategy. The project also considers overall farm diversity enhancement, with the inclusion of legumes in a predominately wheat-canola production system, as well as dual purpose crops for grazing and grain production and native vegetation cover on non-farming areas of the farm.

AIM

To provide evidence-based innovative research for diversified farms in south-eastern Australia and allow farmers in the Riverine Plains region to consider options outside of the typical inputs, to build resilience to more frequent droughts.

METHOD

SILICON TRIAL

To test the effects of silicon on crop performance, a replicated trial was sown at the Riverine Plains and Uncle Tobys trial site in Wahgunyah, Victoria, during the 2022 and 2023 winter cropping seasons. The second year of the trial was established on 24 May 2023, with 24 small plots (three treatments with eight replicates) of each crop type. Crop types included faba beans, spring wheat and dual-purpose winter wheat, with further details on site set-up shown in Table 1. Treatments included a control (no silicon), granular silicon and foliar silicon application. Granular silicon was applied alongside MAP as an additional fertiliser at sowing, at a rate of 200 kg/ha for wheat and 300 kg/ha for faba beans. Foliar silicon was applied five times throughout the season, at a rate of 300 ml/ha. The first spray was applied at tillering, with follow-up sprays taking place every 2-3 weeks thereafter, and the final spray was applied at anthesis.

A large-scale demonstration site was also included as a part of this project and was sown to wheat on 27 April 2023 at Bundalong South, Victoria. This site was managed by the host farmer, in-line with their management strategy for the overall paddock. A foliar silicon fertiliser spray was applied to half of the selected area, to allow a comparison between treated and untreated areas. The commercially available silicon fertiliser was applied at the rate of 300 ml/ ha, using a water rate of 150L/ha, four times throughout the season. The first spray was applied using the Riverine Plains six-metre boom trial sprayer, in mid-July. Each spray was applied 2-3 weeks thereafter, finishing in mid-September. The product used was acidic in nature and it was important to check the pH of the water to ensure the spray solution did not crystallise and cause a blockage in the lines.

Prior to sowing, 0-10cm soil cores were taken for soil testing across both the replicated and demonstration sites, to allow comparison with post-harvest results. Soil test results are presented in Table 2.

Table 1 Site and treatment details for the replicated trial site at Wahgunyah and the demonstration site at Bundalong South, Victoria.

	REPLICATED TRIAL	DEMONSTRATION TRIAL
Location	Wahgunyah	Bundalong South
Sowing date	24 May 2023	27 April 2023
Varieties	**Spring wheat:** Scepter **Dual-purpose wheat:** Kittyhawk **Faba bean**: Samira	Scepter sown @ 90kg/ha
Starter fertiliser	80 kg/ha MAP	60 kg/ha MAP, 5 t/ha cow manure
In season fertiliser	120 kg/ha urea (wheat only)	300kg/ha urea
Average GSR (April-Oct)	347 mm	353 mm
Actual GSR rainfall	247 mm	273 mm

The impacts of grazing were assessed for the dual-purpose wheat plots by mowing half the plots area (to represent grazing) when the crop was at mid tillering (GS25). Biomass cuts were taken for all plots when the wheat was at mid-flowering (GS65), while harvest index was calculated at crop maturity. Plots were harvested for grain yield and sub-samples were taken to test for protein and nutrient content. The dual-purpose wheat plots were harvested separately in the grazed and non-grazed areas. Grain protein and moisture were analysed using near infrared spectroscopy (NIRS), and seed silicon content was analysed using the CaCl2 method.

NATIVE CORRIDOR

As part of the overall project, the impact of a native corridor in adjacent paddocks was assessed. Experienced ecologist, Meredith Mitchell assisted in marking and identifying native grasses for continuous monitoring. For assessment of soil chemical properties and microbial communities, The University of Melbourne team collected and analysed 0-10cm cores from no-cover and native grass cover areas of the native corridor.

RESULTS

SILICON TRIALS

Soil sampling results showed pH and other soil parameters to be in acceptable ranges for the type of crops being grown. The Wahgunyah site had lower nitrogen and phosphorus reserves than the demonstration trial site at Bundalong. This is the second year of the demonstration trial at Bundalong, and the faba beans sown at the site in 2022 likely contributed to the higher nutrient content observed in this soil.

Table 2 Soil chemical properties (0-10 cm) from samples collected pre-sowing at the replicated trial site at Wahgunyah and the demonstration site at Bundalong South, Victoria.

	REPLICATED TRIAL			DEMONSTRATION TRIAL	
Location	**Wahgunyah**			**Bundalong South**	
Soil chemical properties	**Faba beans**	**Dual purpose wheat**	**Wheat**	**Control**	**Silicon treated**
pH (CaCl2)	5.9	5.5	5.3	6.4	5.9
EC (dS/m)	0.1	0.1	0.1	0.2	0.17
Nitrate N (mg/kg)	2.8	2.8	3.4	67.8	57.5
Ammonium N (mg/kg)	2.8	2.0	2.3	5.8	3.7
Colwell P (mg/kg)	42.6	39.4	33.8	63.4	51.1
PBI	85.5	89.9	88.9	48.0	49.9
CEC (cmol(+)/kg)	8.4	7.2	7.3	8.7	7.1
Organic carbon %	1.6	1.6	1.6	1.2	1.2
Silicon(mg/kg)	46.1	40.3	47.8	47.4	45.6

RESULTS

Tables 3, 4 and 5 show biomass, harvest index, grain yield and grain traits, averaged across all replicates and crop types. The demonstration site was not replicated and thus acts to show the effects of silicon application in a scaled-up format.

Across all crop types at the replicated trial site, some positive trends were detected when silicon treatments were applied, such as increased in-season biomass production in spring wheat. However, there were no significant effects of silicon treatment (either granular or foliar applied) on final biomass, harvest index or grain yield (Tables 3 and 4). Silicon application also did not markedly increase yield over the control at the demonstration site, though statistical comparisons are not possible due to the nature of this trial. Silicon is understood to improve plant response to stress, and while the season was exceptionally dry during September, the remainder of the growing season was conducive to crop growth. Different results may have been seen in a more challenging, or drier, season.

The faba bean crop did not perform well due to heavy rain during crop establishment, resulting in significantly reduced biomass and lower-than-average yield. Significant damage from birds was also seen across multiple plots, resulting in decreased yield in spring wheat, however the dual-purpose wheat did not suffer the same level of pest damage. It is important to consider that these compounding effects may have affected the observations of silicon treatment effects.

Applying silicon did not affect the grain protein of dual-purpose and spring wheat or faba bean, and silicon was not detected above threshold levels in the grain (Table 5).

Table 3 In-season biomass production during mid October for the replicated trial site at Wahgunyah and the demonstration site at Bundalong South

	BIOMASS PRODUCTION (MID OCTOBER)		
Crop type	**Control**	**Foliar silicon**	**Granular silicon**
	DM t/ha	**DM t/ha**	**DM t/ha**
Wheat	7.1	7.3	7.3
Ungrazed dual purpose wheat	6.9	6.6	6.9
Faba beans	6.1	5.2	5.1
Wheat – demonstration Site	16.5	17.6	N/A

Table 4 Harvest traits for the replicated trial site at Wahgunyah and the demonstration site at Bundalong South.

CROP TYPE	HARVEST INDEX			GRAIN YIELD (T/HA)		
	Control	**Foliar silicon**	**Granular silicon**	**Control**	**Foliar silicon**	**Granular silicon**
Wheat	0.4	0.4	0.5	3.3	2.9	3.4
Grazed dual purpose wheat	0.4	0.4	0.4	2.4	2.4	2.4
Ungrazed dual purpose wheat	0.4	0.4	0.4	3.0	3.1	3.1
Faba beans	0.5	0.5	0.5	2.9	2.8	2.4
Wheat – demonstration site	0.5	0.5	N/A	10.6	10.8	N/A

Table 5 Grain quality characteristics for the replicated trial site at Wahgunyah

CROP TYPE	GRAIN PROTEIN %			MOISTURE %		
	Control	Foliar silicon	Granular silicon	Control	Foliar Silicon	Granular silicon
Wheat	8.0	7.2	7.4	10.6	10.5	10.5
Grazed dual-purpose wheat	9.3	9.1	9.0	11.3	11.3	11.3
Ungrazed dual purpose wheat	8.9	9.5	9.2	11.1	11.1	11.1
Faba Beans	20.8	20.7	20.6	7.8	7.7	7.7

NATIVE CORRIDOR

The native corridor area has been monitored throughout the project to understand the effect of native vegetation on the soil biodiversity and nearby cropping systems. Nine species were identified as native grass species as part of this work; tall speargrass (Austrostipa aristiglumis), spear grass (Austrostipa scabra), red grass (Bothriochloa macra), windmill grass (Chloris truncate), curly windmill grass (Enteropogon acicularis), common wallaby grass (Rytidosperma caespitosum), Brown-back Wallaby-grass (Rytidosperma duttonianum), wallaby grass (Rytidosperma erianthum), bristle wallaby grass (Rytidosperma setaceum). Over the two years of monitoring, Brown-back Wallaby-grass has been the dominant species with the highest plant density seen at each visit.

CONCLUSION

Long-term sustainability of broadacre farming under changing climatic conditions requires testing and trialling of old practices, as well as new and innovative ones. This project trials the innovative use of silicon fertiliser and the inclusion of legumes in a typical wheat-canola crop rotation to show how it can enhance soil health and productivity. The inclusion of native corridors on non-farm land could also be a long-term strategy for improved above and below ground biodiversity.

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