Australian Grains Free Air CO_2 Enrichment (AGFACE) program

Below ground Soil:Plant Processes

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Why B/G processes are important

To understand atmospheric * aboveground physiological processes, you must also know what is occurring belowground!

Background Issues

- Greater biomass: Increased demand for nutrients
- Increased transpiration efficiency
- Australian cropping environment
  - Large variety of soil types (pH, %N, %C, texture)
  - Chemical/nutritional and physical constraints common
  - Rainfall use efficiency often as low as 50%
  - Fertilisers are the single largest variable cost input

Approach: SoilFACE

	0-10 cm	0-10 cm	80-100 cm	80-100 cm
	Total N(%)	pH ($CaCl_2$)	pH ($CaCl_2$)	EC (dS/m)
Hamilton	0.403	4.5	6.8	0.16
Horsham	0.083	7.7	8.3	1.85
Walpeup	0.052	5.9	8.6	0.53

Mallee Calcarosol (MP4)

Wimmera Vertosol

Hamilton Chromosol (PV13)

Key findings: Nitrogen

- Increased amount of N fixed by pulses
- Strong effect of background soil type (Min N) on N_{fix} but no eCO_2 interaction.

CO_2 treatment	Dry matter (g/core)	N uptake (g/core)	Ndfa (%)	N fixed (g/core)
		(i) Walpeup		
Ambient	32.6	0.71	49.9	0.379
eCO_2	28.1	0.58	58.9	0.334
		(ii) Horsham		
Ambient	60.1	1.33	55.0	0.451
eCO_2	96.0	1.95	64.6	0.995
		(iii) Hamilton		
Ambient	47.1	1.02	9.1	0.081
eCO_2	57.7	0.96	10.7	0.063
		ANOVA		
CO_2	0.06	n.s.	n.s.	n.s.
Soil type	< 0.001	< 0.001	<0.001	0.001
CO_2 x soil	0.039	0.06	n.s.	0.038

Nitrogen (cont).

- eCO2 increases demand for N (> 20%) but no effect on N utilisation or recovery in soil (^{15}N) : need more Nfert or legume N
- Nfert recovery under eCO_2 depends on residue management
  - No residue >8% ; With residue no effect
- Increased microbial activity
- eCO_2 doubled N_2O emissions (but limited data)
- Response of canola yield to eCO_2 depends on variety and soil type (**N status**) in SoilFACE (but not in G/H)
- Significant interaction between wheat cultivar (putative NUE), N supply and eCO_2 on root mass (distribution).

Interaction between eCO_2 , soil type and canola variety

CO_2 treatment	Variety	Dry matter (g/core)	Seed yield (g/core)	N uptake (g/core)
		Hamilton		
Ambient	Hyola-50	67.6	18.4	2.15
	Thumper	52.5	11.4	1.44
eCO_2	Hyola-50	76.2	18.7	2.15
	Thumper	66.6	16.0	1.83
		Horsham		
Ambient	Hyola-50	41.8	11.7	1.64
	Thumper	17.8	4.7	0.58
eCO_2	Hyola-50	30.0	8.7	1.03
	Thumper	16.6	4.6	0.54
		Walpeup		
Ambient	Hyola-50	16.9	5.2	0.75
	Thumper	11.7	2.2	0.80
eCO_2	Hyola-50	17.9	5.0	0.67
	Thumper	13.3	3.8	0.40
		ANOVA		
CO_2		n.s.	n.s.	*
Soil		***	***	*
Variety		***	***	*
CO_2 * Soil		***	*	n.s.
CO_2 * Variety		n.s.	*	n.s.
Soil * Variety		*	n.s.	n.s.
CO_2 * Soil *Variety		n.s.	n.s.	n.s.

Key findings: Phosphorus

- 'CO_2 fertilisation effect' strongly dependent on adequate P nutrition
- Applies equally to both cereals and legumes
- Greater root mass (16%) and length (14%) under eCO_2, leading to better access to water and P (and N)
- Greater depletion of plant available soil P under eCO_2 but large increases in soil organic P (62%) & microbial biomass C (by 21%)
- No effect of eCO_2 on crop access to sparingly soluble sources of soil P (mineral or organic)
- No significant interaction between eCO_2 and B tolerance in lentils – other crops & SSC's?

Summary

- eCO_2 affects key soil properties (via plant); conversely soil properties alter plant response to eCO_2 e.g. Nfix
- Adequate nutrition (N & P; T.E's?) is critical to realise 'CO_2 fertilisation effect'
- Increase in N demand (due to greater biomass) is not compensated by greater N use efficiency (in short term)
- Strong interaction between soil type, variety and eCO_2
  - via soil chemical, physical and biological fertility

Research gaps

- Lack of long-term ‘system’ assessment

- Does the short term increase in N (and P) demand persist?

- Mineralisation of N_{org} and P_{org} pools?

- Soil biology (increased substrate; composition) , soil borne diseases?

- Pastures and crops other than wheat?

- N supply: what are the management options ?

- Effect on soil C sequestration (ARC application)?

- Interactions between Climate Change Factors:

  eCO_2 * water supply * temperature * genetics

More information

www.piccc.org.au/agface

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