Varietal differences in responses to manganese and zinc

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Why do the trial?

Aim: To examine the ability of genotypes of wheat and barley to produce high yields on micronutrient deficient soils.

There are large areas of micronutrient deficient soils in SA, including the Eyre Peninsula. Not only will micronutrient deficiency reduce growth and grain yield directly, but it can also affect a crop's ability to tolerate drought, heat stress and some diseases. In deficient soils there is a need for regular applications of micronutrient fertiliser, but there are also differences between varieties in their ability to grow in soils where micronutrient availability is low. This is measured in terms of 'micronutrient efficiency' and it is estimated as the relative yield of a variety grown under adequate and deficient conditions. An efficient variety will still yield well when the availability of a micronutrient is low, while an inefficient variety will yield poorly when the availability of a micronutrient is low. The Plant Nutrition Group at the Waite Institute regularly screens varieties, breeding lines and doubled haploid populations for manganese (Mn) and zinc (Zn) efficiency and this paper summarises some of the most recent results from this work.

How was it done?

Field evaluation of responsiveness has been conducted at Marion Bay on Yorke Peninsula (for Mn), and at Birchip in the Victorian Mallee (for Zn) each year since 1997. Commercial varieties and advanced breeding lines from the wheat and barley breeding programs of South Australia and Victoria were grown in the field as replicated paired plots (- trace element and + trace element treatments, side-by-side). Seed for the trials was obtained from the same site wherever possible to reduce the effect of seed nutrient content on yield. The plots were 6 rows (15 cm spacing) by 5m with a seeding rate of 180-190 seeds/m^2. At sowing 25kg N/ha and 28kg P/ha were applied. In the Mn trials, the fertilizer was coated with 2.2kg S/ha, 2.0kg Zn/ha, 2.0kg Cu/ha, 0.25kg Co/ha, 0.25kg Mo/ha and in the Zn trials the Zn coating was replaced by 5.1kg Mn/ha. This was done to eliminate other possible nutrient deficiencies. To compare responses to Mn, one of the paired plots was sown with manganese oxysulphate (20kg Mn/ha) and to compare Zn responses, zinc oxysulphate (7kg Zn/ha) was applied to one of the paired plots. Foliar sprays of either Mangasol ™ at 1.12kg Mn/ha or Zincsol ™ at 0.35kg Zn/ha were applied 8-9 weeks and at 16-17 weeks after sowing. Grain yield and grain nutrient content were measured each year.

What happened?

Manganese efficiency

Severe manganese deficiency was observed in all trials grown at Marion Bay and the genotype rankings correlate strongly from year to year. The most inefficient barley varieties consistently show 4 or 5-fold yield increases (responses of 2-3 t/ha), while the most inefficient wheat varieties show 2 or 3-fold increases (responses of 0.8-1 t/ha) (Tables 1,2). Yields of the most efficient varieties grown without additional Mn can often be similar to the yields of the most inefficient varieties with additional Mn.

Among the barley varieties, the breeding lines WI2986, WA73S276 and a Japanese variety Amagi Nijo, have the highest Mn efficiencies, Sloop and Chebec are moderately efficient while Skiff, Barque, Gairdner and Galleon are inefficient. The most Mn efficient bread wheat varieties are Janz, Stylet, and WI94091, while Frame, Yitpi, Halberd, Wilgoyne and Brookton have moderate to low efficiency. Most of the durum wheats that have been tested are sensitive to Mn deficiency and the most Mn efficient durum wheats are only within the lower range of the bread wheats

Zinc efficiency

Zinc deficiency symptoms have been evident at Birchip over the past three years. In general, barley shows a higher level of Zn efficiency than bread wheat (Tables 1,2). The most efficient barley varieties have shown little or no response to applied Zn, while the least efficient genotypes show responses of 10-25% (0.3-0.5 t/ha). Grain yields for efficient genotypes of wheat increase by 0-10% (<0.25 t/ha) while the yield responses in the inefficient varieties are often between 25-40% (0.4-0.8 t/ha) (Table 2). As occurred with Mn, a Zn efficient variety grown without additional Zn often produced a yield similar to that of an inefficient variety with Zn applied.

The most sensitive barley varieties are Fitzgerald, Sloop and the Japanese line SBWI-1, while Gairdner has moderate to low efficiency. The most inefficient varieties of bread wheat are Kukri, Silverstar and Westonia, while RAC 891, Stylet, Trident, Camm, Worrakatta and Krichauff show relatively high efficiencies. Durum wheat generally shows poor Zn efficiency.

What does this mean?

The micronutrient efficiency of a variety will affect its yield in soils where Mn or Zn deficiency occurs. Growing an efficient variety provides insurance against yield losses caused by Mn or Zn deficiency. With a very inefficient variety adding a micronutrient fertiliser may not be sufficient to overcome the micronutrient deficiency.

Table 1. Grain yields (t/ha) and micronutrient efficiencies of barley at Marion Bay (Mn response) and Birchip (Zn response) over two years.

Efficiency = (-micronutrient/+micronutrient) x 100%

	Manganese response							Zinc response						
	1999			2000				1999			2000			
Variety	-Mn	+Mn	Eff (%)	-Mn	+Mn	Eff (%)	Variety	-Zn	+Zn	Effic (%)	-Zn	+Zn	Ef fic
WA 73S276	2.93	3.29	89	2.09	2.84	74	Arapiles	2.95	2.9	102	2.58	2.6	99
WI 2986	2.94	3.38	87	2.25	2.78	81	Stirling	2.75	2.73	101			
Amagi Nijo	1.58	1.96	81	1.62	1.78	91	Galleon	3.3	3.26	101			
SloopBC2-1	2.48	3.37	74	1.61	2.15	75	Schooner	2.89	2.86	101	2.52	2.83	89
WA 0563	2.26	3.65	62	1.51	2.69	56	Keel	3.32	3.29	101	2.51	2.83	89
Stirling	1.96	3.19	61	1.65	2.54	65	Franklin	2.27	2.34	97	2.82	3.05	92
Chebec	1.92	3.65	53				Gairdner	3.09	3.22	96	2.42	2.82	86
Sloop	1.77	3.41	52	0.68	2.15	32	Barque	2.98	3.17	94	3.26	3.35	97
SBWI-1	1.26	3.03	42	0.82	2.41	34	Skiff	3.04	3.31	92			
Schooner	1.25	3.04	41	0.44	2.12	21	Sloop	3.06	3.43	89	2.62	2.93	89
Galleon	1.31	3.24	40	0.76	2.54	30	Fitzgerald	2.46	2.98	83			
Gairdner	1.24	3.13	40				SBWI-1	2.15	2.85	75	1.94	2.43	80
Fitzgerald	1.27	3.67	35										
Barque	1.11	3.73	30	0.59	2.29	26							
Skiff	0.67	3.56	19	0.39	1.99	20							
WI 2585	0.53	3.14	17	0.68	2.56	27							
LSD (5%)					0.36				0.33			0.23	

Table 2. Grain yields (t/ha) and micronutrient efficiencies of wheat at Marion Bay (Mn response) and Birchip (Zn response) over two years.
Efficiency = (-micronutrient/+micronutrient) x 100%

	Manganese response							Zinc response						
	1999			2000				1999			2000			
Variety	-Mn	+Mn	Eff (%)	-Mn	+Mn	Eff (%)	Variety	-Zn	+Zn	Effic (%)	-Zn	+Zn	Effic (%)
RAC 891	1.98	2.41	82	1.68	2.1	80	Stylet	3.44	3.62	95	2.80	3.09	91
Stylet	1.62	2.10	77	1.54	1.80	86	RAC 891	3.50	3.69	95	2.91	2.85	102
WI 94091	1.59	2.23	71	1.02	1.25	82	Worrakatta	3.13	3.40	92			
Janz	0.98	1.48	66	0.93	1.13	82	Krichauff	3.00	3.29	91	2.29	2.46	93
Worrakatta	1.03	1.63	63	1.22	1.78	69	Trident	3.19	3.51	91	2.23	2.37	94
Yitpi	1.35	2.38	57	0.92	1.57	59	Camm	3.09	3.44	90	2.66	2.72	98
Frame	1.12	1.96	57	0.79	1.53	52	Yitpi	3.17	3.56	89	2.01	2.28	88
Wilgoyne	1.17	2.10	56	0.83	1.48	56	Frame	3.18	3.59	89	2.15	2.36	91
Chara	0.89	1.64	54	0.87	1.36	64	Janz	2.78	3.22	86			
Brookton	1.09	2.12	51	0.69	1.43	48	Silverstar	3.03	3.53	86			
Yanac	0.50	1.55	32	0.53	1.21	44	Kukuri	2.51	3.19	79	1.32	1.83	72
							Yallaroi	2.22	2.86	78	1.68	2.12	79
							Westonia	2.83	3.68	77			
							VM 506	2.50	3.37	74	1.89	2.20	86
LSD (5%)	0.33			0.24				0.21			0.17		

Special attention needs to be given to the micronutrient requirements of durum wheat. This is particularly the case when high rates of N and P fertiliser are used as these can induce micronutrient imbalances.

In very general terms, the relative sensitivity to Mn deficiency (from least sensitive to most sensitive) is bread wheat, barley, durum wheat , while the relative sensitivity to Zn deficiency (from least sensitive to most sensitive) is barley, bread wheat, durum wheat. However, there is considerable overlap between the three species in terms of their sensitivity.

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Location:

Closest town: Mn: Marion Bay, SA
Zn: Birchip, Victoria

Cooperator: Marion Bay Damien and John McEvoy
Birchip: Gordon Braine

Rainfall

Av. Annual total: Marion Bay: 448 mm (decile 1=328 mm; decile 9 = 593mm)
Birchip 374mm (decile 1=228 mm; decile 9 = 494 mm)

Av. Growing season: Marion Bay: 362mm
Birchip 256 mm

Soils: Marion Bay – deep calcareous sand
Birchip – brown mallee soil