Grain Nutrient Concentrations – Report on a survey from 70 NVT wheat sites.

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Summary:

Grain nutrient concentrations for macronutrients and micronutrients were analysed from more than 70 NVT sites across southeastern Australia. All nutrients tested showed significant differences among regions. Values for the macro nutrient P were the most variable (3329±661 mg/kg) and was more than the commonly used value of 2900 mg/kg. The variation in grain P content could not be related to soil P test, fertilizer application or grain yield although values varied among regions and states. Sulphur and potassium levels also varied showed significant differences among regions, while grain zinc levels seemed lowest in regions characterized by alkaline soils.

These data suggest that regional or even paddock based nutrient concentrations may be required when construction nutrient balances. It may also be useful to use grain micronutrient content as a monitoring tool to indicate the need for fertilizer additions.

An understanding of the nutrient concentrations of grains such as wheat is important in developing nutrient budgets, and they can also be used diagnostically to assess particular nutrient deficiencies or toxicities for the crop from which the grain was derived. There have been several studies undertaken on grain nutrient densities in Australia and much of that information has been collated and published in "Plant Analysis – An Interpretation Manual" (Reuter and Robinson 2006). The values published there are considered as benchmarks and were used in developing regional nutrient budgets as part of the National Land and Water Resources Audit (2001) (Table 1).

*Table 1 Macronutrient wheat grain concentrations (kg/t) from Reuter as used in the National Land and Water Resources Audit (2001). * N values were estimated on a regional basis and values are presented as both 11% moisture content and on a dry grain basis.*

Species	N	P	K	S	Ca	Mg
Wheat (11%)	*	2.6	3.6	1.4	0.38	1.2
Wheat (0%)	*	2.9	4.0	1.6	0.43	1.4

However, regional, cultivar and annual changes in grain nutrient concentrations give a degree of uncertainty to possible long term nutrient balances calculated as the product of grain yield and nutrient density. This preliminary report aims to report values for nutrient densities for wheat, particularly in south-eastern Australia so that there can be confidence in the values used in nutrient budgets. It also provides a data set which can be used to test the amount of genetic, temporal and spatial variability in grain nutrient densities.

Materials and Methods

Wheat grain samples were obtained from site managers involved in the National Variety Testing (NVT) system which operates across the Australian grain production region to compare crop cultivars and then to provide that information to growers. A single sample of each of two varieties, Yitpi and Gladius, were collected from each site in southeastern Australia where they were grown in 2009. There were eight sites from New South Wales, 21 sites from South Australia and 17 from Victoria and these were in 12 agroecological regions across southeastern Australia. Samples from 23 sites from South Australian in 2008 were also provided and these were also included. So, a total of 70 sites across two years were analysed for grain nutrient concentration.

The NVT sites are managed using commercial best practice which includes regional fertilizer products and rates, as well as normal establishment and crop protection operations. Details of these practices are available as well as soil tests for most sites. All sites had top 10 cm Colwell P, as well as pH (water and $CaCl_2$), exchangeable cations (Ca, Mg, Na, K), EC and organic carbon values reported, as well as exchangeable cations in the subsoil (10-60 cm). Sulphur levels in the top 10 cm were reported for 24 sites and Zinc for 12 sites. Appendix Tables 1, 2 and 3 give a list of the sites, soil test values and their locations on Figures 1, 2 or 3.

Grain yield and grain protein (N) content were taken from the NVT reports published in 2008 and 2009 along with soil test values. Grain protein content was assessed using NIR calibrated against the Dumas method (AACC 46-30) and grain protein is expressed as %N x 5.7 on a fixed moisture basis (11% wheat). These values were then converted back to a dry grain (0% moisture) basis.

Between 18 and 30 grains of each line (approx. 0.8 g) from each site were randomly selected from the harvested grain, dried, weighed and processed for nutrient analysis by ICP-OES. Grain was digested with 11 ml of nitric acid (HNO_3)/perchloric acid ($HClO_4$) mixture (10:1 v/v), boiled down to approx. 1 ml of $HClO_4$ and made to 25 ml final volume using de-ionised water. This final solution was then analysed for nutrients on Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES; ARL 3580 B, Appl. Res Lab. SA, Ecublens, Switzerland) and results are reported on a dry grain basis). Analytes reported from this analysis are Al, B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, Se, Ti and Zn.

Because the data set developed was not balanced, nor were there replicated samples for each cultivar from each site in each year, the data were assessed using a one-way analysis of variance to compare nutrient densities using either state (Victoria, New South Wales, South Australia), region (70 site years), varieties (Gladius and Yitpi). In addition, the data set from South Australia was used to compare annual nutrient densities in 2008 and 2009.

Results

Table 2 provides a summary of the nutrient densities for the 13 nutrients assessed, giving the mean and standard deviation for each region and then aggregated data for states and then for the complete data set. The values are presented on a dry weight basis except for N, which is given on 11% moisture content. Levels of other analytes assessed under ICPOES were generally low, at the lower limits of detection for that instrument. These values were Ni<0.4 mg/kg, Co<0.4 mg/kg, Mo<0.4 mg/kg, Se<4.0 mg/kg, Pb<1 mg/kg and Cd<0.1 mg/kg. In addition, Ti and Cr were reported to determine in the samples may have been contaminated by soils or during grinding. Three samples were found with high Ti and Cr levels and these were not further reported.

Table 2. Mean and standard deviations of macronutrients (N, P, K,S, Mg, Ca and Na) and micronutrients (Fe, Mn, B, Cu, Zn and Al) for wheat samples from the 2008 and 2009 NVT sites for Yitpi and Gladius. All values are for dry grain (0% moisture content).

	Sites /Years	Number of values	Region	N %	P mg/kg	K mg/kg	S mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	Fe mg/kg	Mn mg/kg	B mg/kg	Cu mg/kg	Zn mg/kg	Al mg/kg
NSW	**4**	**8**	**South East**	3.13 ±0.15	3613 ±202	5075 ±217	1963 ±70	466 ±29	1261 ±37	7.1 ±6.0	42.1 ±2.2	57.6 ±3.6	1.6 ±0.3	3.9 ±0.4	23.0 ±2.4	3.5 ±1.3
	4	**8**	**South West**	2.52 ±0.15	2678 ±202	4238 ±217	1709 ±70	408 ±29	1173 ±37	7.6 ±6.0	39.5 ±2.2	54.4 ±3.6	1.7 ±0.3	4.1 ±0.4	23.5 ±2.4	5.1 ±1.3
		16	***Mean***	*2.83 ±0.12*	*3145 ±168*	*4656 ±161*	*1836 ±55*	*437 ±22*	*1217 ±30*	*7.3 ±4.6*	*40.8* ±1.7	*56.0* ±3.3	*1.7* ±0.3	*4.0* ±0.3	*23.3* ±1.8	*4.3* ±1.0
SA	6	12	**Lower EP**	2.17 ±0.12	3075 ±165	4533 ±177	1492 ±57	343 ±24	1223 ±30	38.7 ±4.9	30.3 ±1.8	25.3 ±3.0	2.3 ±0.3	4.4 ±0.3	18.7 ±2.0	1.6 ±1.1
	7	**14**	**Mid North**	2.67 ±0.11	3900 ±153	4686 ±164	1803 ±53	460 ±22	1359 ±28	21.0 ±4.5	39.1 ±1.6	51.1 ±2.7	1.3 ±0.3	5.6 ±0.3	25.4 ±1.8	3.1 ±1.0
	9	**18**	**Murray Mallee**	2.79 ±0.10	3467 ±135	4533 ±145	1789 ±47	424 ±19	1349 ±25	23.7 ±4.0	40.1 ±1.4	38.9 ±2.4	1.9 ±0.2	5.2 ±0.2	19.2 ±1.6	7.6 ±0.9
	5	**10**	**South East**	2.45 ±0.12	3620 ±181	4870 ±194	1780 ±63	488 ±26	1295 ±33	29.3 ±5.3	35.9 ±1.9	26.8 ±3.2	1.5 ±0.3	3.5 ±0.3	24.5 ±2.2	1.1 ±1.2
	12	**24**	**Upper EP**	2.78 ±0.08	3117 ±117	4758 ±125	1778 ±41	419 ±17	1237 ±22	47.6 ±3.4	35.9 ±1.2	49.3 ±2.1	2.4 ±0.2	4.9 ±0.2	26.0 ±1.4	5.5 ±0.8
	6	**12**	**Yorke Penn.**	2.40 ±0.12	3083 ±165	4433 ±177	1650 ±57	411 ±24	1202 ±30	35.0 ±4.9	31.3 ±1.8	41.8 ±3.0	1.8 ±0.3	5.6 ±0.3	22.2 ±2.0	3.0 ±1.1
		90	***Mean***	*2.63 ±0.04*	*3354 ±71*	*4641 ±68*	*1729 ±23*	*423 ±9*	*1278 ±13*	*33.8 ±1.9*	*35.9* ±0.7	*40.8* ±1.4	*1.9* ±0.1	*4.9* ±0.1	*22.9* ±0.8	*4.2* ±0.4
Vic	**8**	**16**	**Mallee**	2.42 ±0.10	3088 ±143	4256 ±154	1662 ±50	396 ±21	1291 ±26	12.5 ±4.2	34.9 ±1.5	36.8 ±2.6	3.4 ±0.2	5.1 ±0.3	18.9 ±1.7	4.5 ±1.0
	2	**4**	**North Central**	2.42 ±0.21	2900 ±286	4250 ±307	1793 ±99	348 ±41	1293 ±53	9.6 ±8.4	41.0 ±3.0	55.8 ±5.1	1.7 ±0.5	4.7 ±0.5	25.5 ±3.4	3.4 ±1.9
	2	**4**	**North East**	2.75 ±0.21	2950 ±286	4275 ±307	1933 ±99	380 ±41	1230 ±53	6.3 ±8.4	44.3 ±3.0	53.3 ±5.1	1.4 ±0.5	5.1 ±0.5	28.8 ±3.4	5.1 ±1.9
	5	**10**	**Wimmera**	2.60 ±0.13	4110 ±181	5040 ±194	1733 ±63	470 ±26	1424 ±33	21.7 ±5.3	36.2 ±1.9	49.2 ±3.2	4.6 ±0.3	4.8 ±0.3	27.3 ±2.2	4.6 ±1.2
		34	***Mean***	*2.51 ±0.08*	*3350 ±115*	*4488 ±111*	*1730 ±38*	*410 ±15*	*1323 ±20*	*14.2 ±3.2*	*37.1* ±1.2	*44.6* ±2.2	*3.3* ±0.2	*4.9* ±0.2	*23.3* ±1.3	*4.5* ±0.7
Total		**140**	**Mean**	**2.62 ±0.46**	**3329 ±671**	**4606 ±645**	**1742 ±220**	**421 ±89**	**1282 ±122**	**26.0 ±21.2**	**36.8** ±6.9	**43.5** ±13.8	**2.2** ±1.3	**4.8** ±1.2	**23.0** ±7.3	**4.3** ±4.1

The values reported show considerable regional differences, with N, P, K and S showing coefficients of variation (CV) of 18%, 20%, 14% and 13% (see Appendix Table 4) respectively although within each region, the CV's for N, P, K and S were usually less than 5%. There were some important exceptions to this, with P in southern New South Wales and P, K and S CV's for the North East and North Central regions of Victoria, although these values were derived from the smallest subsets within the data.

Figures 1 and 2 show the frequency of grain N from the data set, and Figure 2 shows P, K and S contents and this reflects the distributions and CV's for these nutrients discussed previously. The distribution of S contents is relatively consistent when compared to the three other nutrients. Table 2 gives the P value of the F statistic from the one-way analyses of variance for each of the main factors tested. shows that nutrient concentration for the macronutrients did not differ among the three sets of state means for N, P, K, S and Ca, although there were significant regional differences for these nutrients. N, P and S contents were not different between the two cultivars compared. Grain micronutrient concentration did differ between states and regions, except for state level Zn and Al contents. The data set analysed does have a strong weighting to data from South Australia so the "national" mean values presented in Table 2 are not indicative of the values across each agroecological zone. For all the nutrients tested, regional values differed significantly (Table 3), suggesting that there is no universal value that can be used for a nutrient budget at regional or sub-regional (ie farm) level, rather that values should be based on data from that region. Cultivar and annual differences were not significant for P, S, Mg or Na so that a single regional value would seem appropriate for these nutrients. If the level of interest is in a national scale measure of nutrient balance, then the values in table 2 would appear to be appropriate as there is no significant difference between the values at the state levels for the macronutrients.

Table 3. P values for the F test in one-way analyses of variance for states, regions or cultivars from the NVT data set analyzed. Highlighted cells show a significant effect of the factor on a particular wheat grain nutrient concentration.

	N	P	K	S	Ca	Mg	Na
States	0.071	0.509	0.476	0.191	0.597	0.014	0.000
Regions	0.000	0.000	0.014	0.000	0.002	0.000	0.000
Culitvars	0.998	0.017	0.001	0.236	0.000	0.090	0.872
Year (SA only)	0.000	0.864	0.001	0.116	0.000	0.000	0.382
	Fe	**Mn**	**B**	**Cu**	**Zn**	**Al**	
States	0.027	0.000	0.000	0.011	0.950	0.941	
Regions	0.000	0.000	0.000	0.000	0.003	0.001	
Cultivars	0.695	0.568	0.661	0.565	0.001	0.007	
Year (SA only)	0.700	0.007	0.000	0.041	0.049	0.651	

Grain N concentration

Figure 1 shows the distribution of grain N concentrations for the whole data set and there were significant differenced among the regions, with the Lower Eyre Pennisular showing the lowest value (2.17%) while the highest value was from the southeast of New South Wales (3.13%) was 44% more than the lowest value. It is also clearly understood that grain N contents vary with seasonal conditions, soil nutrient status and variety so that adopting a single value for N would give very large errors to a nutrient budget unless the value was corrected for a regional grain protein (N) content. There was a

weak relationship between grain yield and grain N content (r^2 = 0.26) but it would seem more appropriate to use regional grain N contents rather than a state or national value.

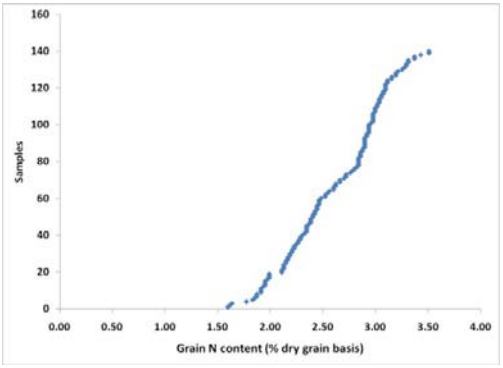

Figure 1. Grain N contents.

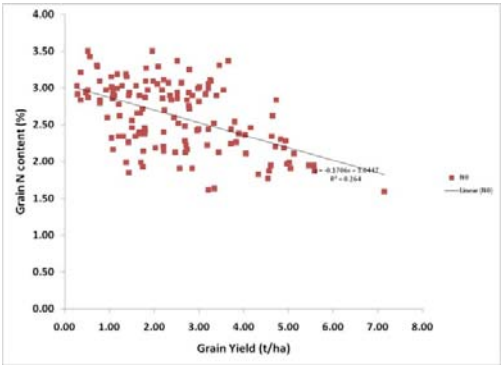

Figure 2. Grain N content versus grain yield.

Appropriate grain N contents for wheat (and other crops) could be taken from NVT site means or from marketing data collected through grain recieval points. Niether is a perfect value, but such an approach should provide a better estimate than taking a mean value for the state, particularly if the objective is to develop regional or farm gate nutrient balances. Table 4 gives the values taken from the mean grain N contents from the NVT database for the same sites and years reported here from South Australia.

Table 4. Regional and site mean wheat grain N contents for South Australia 2008 and 2009 from the NVT database. N values are on a dry grain basis.

Region	2008	N%	2009	N%
LEP	Cummins	1.7	Cummins	1.9
LEP	Ungarra	3.0	Ungarra	1.9
MM	Minnipa	3.2		
MM	Nangari	2.8		
MM	Palmer	2.8	Palmer	2.9
MM	Pinaroo	3.0	Pinaroo	2.0
MM	Wanbi	2.4	Wanbi	2.8
MM	Wunkar	2.9	Wunkar	3.0
MN			Booloroo	2.6
MN	Mintaro	3.0	Mintaro	2.3
MN	Spalding	2.7	Spalding	2.1
MN	Turretfiled	3.2	Turretfield	2.3
SE	Keith	2.8		
SE	Sherwood	2.7	Sherwood	1.9
SE	Woolsely	3.0	Woolsely	3.1
UEP	Kimba	3.1	Kimba	3.1
UEP	Mitchellville	2.9	Minnipa	2.2
UEP	Nunjikompita	2.8	Mitchellville	3.0
UEP	Penong	3.0	Nunjikompita	2.2
UEP	Rudall	2.0	Piednippie	2.1
UEP	Streaky Bay	2.3	Rudall	2.4
UEP	Warramboo	3.3	Warramboo	2.5

YP	Paskerville	2.2	Paskerville	1.9
YP	Urania	2.7	Urania	2.3
YP	Wokurna	3.0	Wokurna	2.1

Grain P contents

Figure 3 gives a distribution of grain P contents for the data set analysed. P concentration ranged from under 2000 mg/kg to over 4000 mg/kg, with a mean of 3329 mg/kg which is around 400 mg/kg, 15% more than the value reported by Reuter. There was no relationship between grain yield and P content (Figure 4) and soil pH or soil P test value (Colwell P) appeared to have no effect on grain P (Figures 5 and 6 respectively). P removal, the product of grain yield and grain P content was not well related to soil P test value or soil pH (data not shown). All the experiments received P fertilizers at sowing, at least 10 kg P/ha and it was a little surprising that grain P was so variable within this data set. Similar results have been reported by Mike Bell from the northern grains zone, and no driving variable could be proposed for large differences noted.

For an aggregate measure, it would appear that 3300 mg/kg is a reasonable estimate, but if state or regional nutrient balances are required, then the values need to be more closely

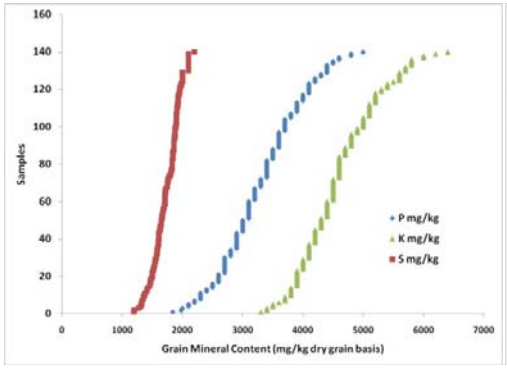

Figure 3. Grain P, K and S contents.

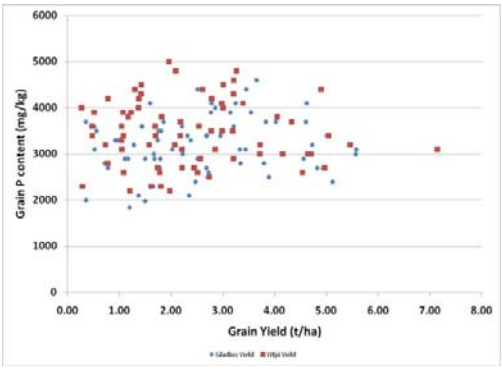

Figure 4 Grain P content versus grain yield.

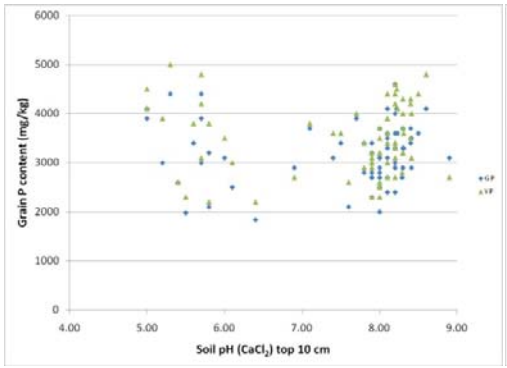

Figure 5. Grain P content and soil pH.

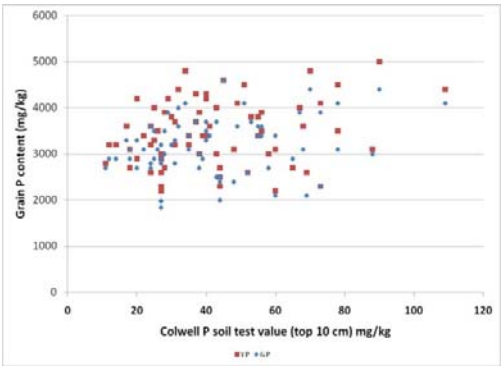

Figure 6. Grain P content and Colwell P values.

Grain K contents

Figure 3 and Table 2 give grain K contents for the samples analysed. The distribution of K values has a lower CV than the values for N (Appendix Table 4) and the values within each region generally have CV's less than 5%. As with N, there was little relationship with grain yield (Figure 7). Further, grain K values

showed littel relationship to soil test K values for the sites evaluated, although it appeared that the two varieties evaluated did show differences, specifically Gladius had about 10% lower grain K contents than Yitpi (4415 versus 4718 mg/kg). Aside from the NSW SE and the Victorian Wimmera, most K contents were around 4400 mg/kg, which is 10% higher than the values given by Reuter. The values for the SE NSW and Victorian Wimmera are both about 5000 mg/kg.

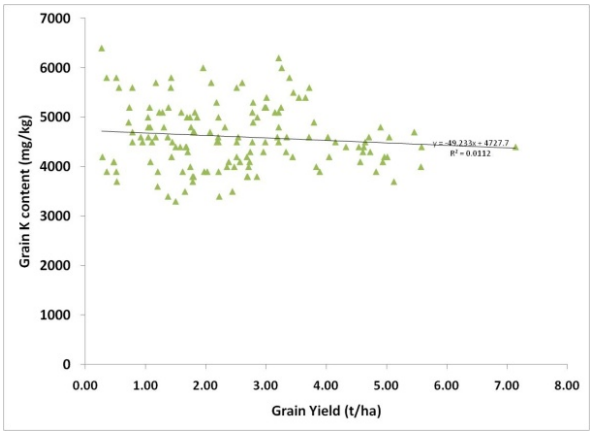

Figure 7. Grain K content versus grain yield.

Grain N:S ratios

Grain protein quality can be related to the relative proportions of N and S in the grain (Randall et al., 1981) and this can expressed as the N:S ratio. Those authors proposed that seed analysis may be a useful method for diagnosing the sulphur status of cereal crops. From their work, the critical grain S content was reported as 0.12% and also where the N:S ratio was more than 17 (Figure 8). The data from the NVT trials only showed one low S grain S value, and a few sites where N:S ratios were more than 17. The high N:S values when grain S is more than 0.12% indicate a high N supply or a limitation on yield by factor other than S. The low S grain came from the experiment at Willbriggie (Southern NSW) and from Cummins (Lower EP). The Cumminsr site no sulphur soil test, but the KCl40 soil test from Willbriggie was high (18 mg/kg) which should indicate no S response.

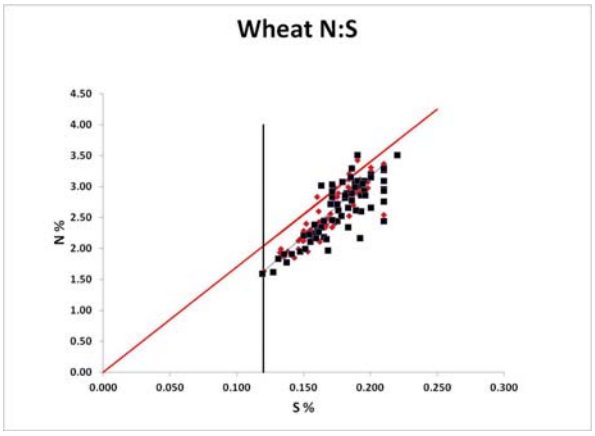

Figure 8 Grain N content (%) versus grain S content (%) on a dry grain basis. Critical values for S are less than 0.12% and where the N:S ratio is more than 17) (Randall et al., 1981).

Grain Zn content

It has been recognized for a long time that much of the Australian grain zone is low in soil zinc with the consequence that grain zinc levels are also low. As part of an International Plant Nutrition Institute global wheat project, grain micronutrient levels – including zinc – were analysed from grain taken from 70 sites used in the National Variety Trials for the GRDC southern region in 2008 and 2009. Most of these sites, especially on alkaline soils, received zinc supplements with the fertilizer applied at sowing.

A summary of these results is given in table 5, which shows the mean grain zinc content in mg/kg (or parts per million) for the various production regions. Also shown is the sort of normal range, or standard error (±)) for zinc for each region.

Table 5 Mean and standard error of grain zinc contents from National Variety Trial sites in New South Wales (2009), South Australia (2008 & 2009) and Victoria (2009).

State	Region	Zn (mg/kg)
NSW	**South East**	23.0±2.4
	South West	23.5±2.4
SA	**Lower EP**	18.7±2.0
	Mid North	25.4±1.8
	Murray Mallee	19.2±1.6
	South East	24.5±2.2
	Upper EP	26.0±1.4
	Yorke Penn.	22.2±2.0
Vic	**Mallee**	18.9±1.7
	North Central	25.5±3.4
	North East	28.8±3.4
	Wimmera	27.3±2.2
Total	**Mean**	23.0±7.3

In all regions, mean grain zinc levels are less than the 33 mg/kg target suggested as part of the Harvest Plus Zinc biofortification program, and in the Lower Eyre Peninsula, and the Victorian and South Australia Mallee mean levels are around half the Harvest Plus target. IPNI also analysed grain from other countries and Australian values were at the lower limits of grain from other countries such as Canada (48 mg/kg), Russia (27 mg/kg) and India (48 mg/kg).

The use of zinc fortified fertilizers at sowing is an effective way to raise grain zinc levels. Research over the past has shown that grain yield responses can be seen, although it is much more likely to get increases in grain zinc. Peck et al. (2008) for example reported grain yield responses on 3 of 6 sites to 7.5 kg Zn at seeding, but saw grain zinc increase on 5 of the 6 sites. Soil testing for zinc using the DTPA extraction has limited diagnostic value, but it is likely to identify extremely deficient soils. Plant tissue testing may be of some value, and advice from an Fertcare accredited advisor is important to collect and interpret this test.

For germinating seedlings, a supply of zinc from the seed is important for good seedling vigour. Seed zinc content and zinc concentration are often, but not necessarily, related (Figure 9). For example, one seed sample from Kimba (Upper Eyre Peninsula) had a grain Zn of 27 mg/kg, but the relatively small seed meant that there was 520 ng/seed. Seed with less than around 500 ng/seed are likely to have slow

establishment unless supplementary zinc is available at seeding. From the NVT data set, the mean seed zinc content was 770 ng/seed, which should be adequate. There were samples that had levels less than 500 ng/seed, and the lowest was 285 ng/seed, and most low values were from areas with alkaline, calcareous soils. Application of zinc to crops to be kept for seed will ensure good quality for the next season.

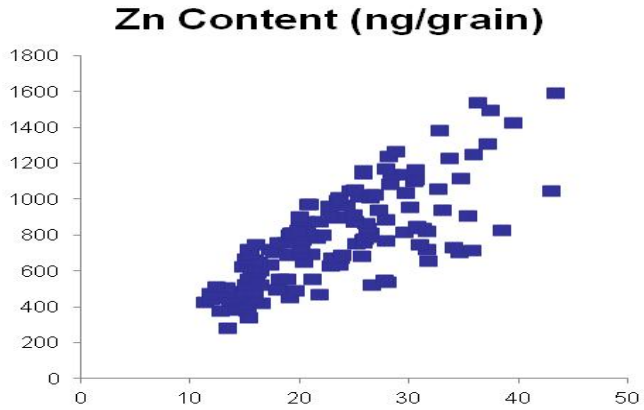

Figure 9 Grain zinc content (ng/kernel) versus grain zinc (mg/kg) for grain samples from the NVT sites 2008 and 2009.

Other grain micronutrient levels

There were significant regional differences within the data set analysed for Fe, Mn, B and Cu (Figure 10). The Cu levels were lowest in the New South Wales samples and higher in samples from Victoria and South Australia, which probably reflects the difference in soil acidity among the regions sampled. For the same reason, Mn levels were higher in New South Wales than samples from the other states. Despite some general trends, there were no statistically significant relationships between soil pH (surface) and grain micronutrient content.

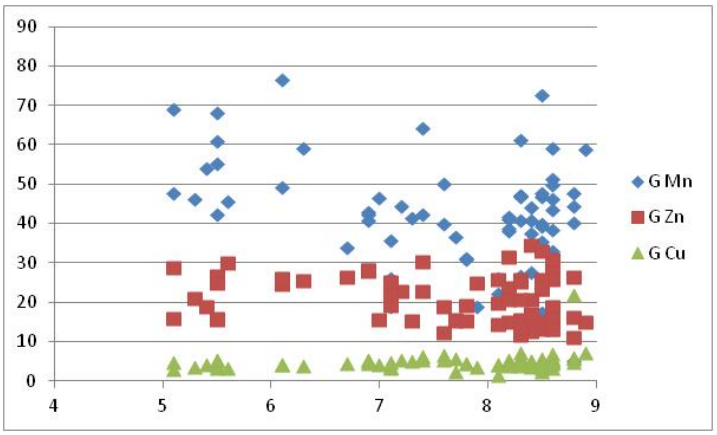

Figure 10 Grain Mn, Zn and Cu versus soil pH (1:5 soil:water, top 10 cm).

Grain B levels were also quite variable, which probably reflected soil B contents. No subsoil B levels were analysed from the New South Wales sites, but for the Victorian and South Australian data, grain B from a single variety tended to follow subsoil B content (Hot water soluble, 10-60 cm). However, the data seemed to separate into two groups and the reason for this is unclear (Figure 11).

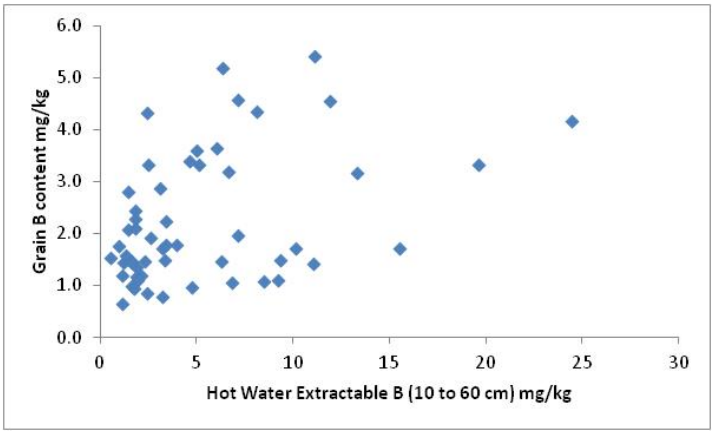

Figure 11 Grain boron content for Gladius wheat versus hot water extractable B content from 10-60 cm.

Conclusions:

Macro and micro nutrient densities are regionally dependant, and it may also differ among cultivars. To complete reliable nutrient removals for the macro nutrients, regionally or paddock determined grain P, S and K values should be used, although for aggregation of data at larger scales – such as for state level nutrient removals, nominal values could be used although they are also likely to have temporal differences may be related to grain yield.

Grain micronutrient densities should relate to soil conditions, and while the generalities of these relationships with soil pH can be seen, there are sufficient deviations to suggest that – like the macro nutrients, particular values could be appropriate for local regions.

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Appendix Table 1: NVT Site locations and map references (See Appendix Figures 1 to 4).

Year	State	Region Name	Nearest Town	Site Number on Figure 1	Year	State	Region Name	Nearest Town	Site Number on Figure 2	Year	State	Region Name	Nearest Town	Site Number on Figure 3	Site Number on Figure 4
2008	SA	Lower EP	Cummins	2	2009	SA	Lower EP	Cummins	2	2009	NSW	S/E	Canowindra	4	
2008	SA	Lower EP	Rudall	15	2009	SA	Lower EP	Rudall	16	2009	NSW	S/E	Galong	12	
2008	SA	Lower EP	Ungarra	20	2009	SA	Lower EP	Ungarra	20	2009	NSW	S/E	Gerogery	13	
2008	SA	Mid North	Mintaro	7	2009	SA	Mid North	Booleroo	1	2009	NSW	S/E	Quandialla	23	
2008	SA	Mid North	Spalding	17	2009	SA	Mid North	Mintaro	7	2009	NSW	S/W	Beckom	1	
2008	SA	Mid North	Turretfield	19	2009	SA	Mid North	Spalding	18	2009	NSW	S/W	Lockhart	17	
2008	SA	Murray Mallee	Nangari	9	2009	SA	Mid North	Turretfield	19	2009	NSW	S/W	Oaklands	22	
2008	SA	Murray Mallee	Palmer	11	2009	SA	Murray Mallee	Palmer	11	2009	NSW	S/W	Willbriggie	29	
2008	SA	Murray Mallee	Pinnaroo	14	2009	SA	Murray Mallee	Pinnaroo	15	2009	VIC	Mallee	Birchip		1
2008	SA	Murray Mallee	Wanbi	22	2009	SA	Murray Mallee	Wanbi	22	2009	VIC	Mallee	Hopetoun		7
2008	SA	Murray Mallee	Wunkar	26	2009	SA	Murray Mallee	Wunkar	26	2009	VIC	Mallee	Manangatang		11
2008	SA	South East	Keith	4	2009	SA	South East	Sherwood	17	2009	VIC	Mallee	Merrinee		12
2008	SA	South East	Sherwood	16	2009	SA	South East	Wolseley	25	2009	VIC	Mallee	Murrayville		15
2008	SA	South East	Wolseley	25	2009	SA	Upper EP	Kimba	5	2009	VIC	Mallee	Ultima		19
2008	SA	Upper EP	Kimba	5	2009	SA	Upper EP	Minnipa	6	2009	VIC	Mallee	Walpeup		20
2008	SA	Upper EP	Minnipa	6	2009	SA	Upper EP	Mitchelville	8	2009	VIC	Mallee	Woomelang		21
2008	SA	Upper EP	Mitchelville	8	2009	SA	Upper EP	Nunjikompita	10	2009	VIC	North Central	Diggora		4
2008	SA	Upper EP	Nunjikompita	10	2009	SA	Upper EP	Piednippie	14	2009	VIC	North Central	Mitiamo		14
2008	SA	Upper EP	Streaky Bay	18	2009	SA	Upper EP	Warramboo	23	2009	VIC	North East	Dookie		5
2008	SA	Upper EP	Warramboo	23	2009	SA	Yorke P	Paskeville	12	2009	VIC	North East	Yarrawonga		23
2008	SA	Yorke P	Paskeville	12	2009	SA	Yorke P	Urania	21	2009	VIC	Wimmera	Brim		2
2008	SA	Yorke P	Urania	21	2009	SA	Yorke P	Wokurna	24	2009	VIC	Wimmera	Corack		3
2008	SA	Yorke P	Wokurna	24						2009	VIC	Wimmera	Horsham		8
										2009	VIC	Wimmera	Kaniva		10
										2009	VIC	Wimmera	Minyip		13

Appendix Table 1 – Site Locations and top soil test values (0-10 cm)

Year	State	Region Name	Nearest Town	Top 10 cm Colwell Phosphorous mg/kg	Top 10 cm Colwell Potassium (K) (mg/kg)	Top 10 cm Organic Carbon %	Top 10 cm pH (CaCl2)	Top 10 cm pH (water)	Top 10 cm Conductivity (EC)	Top 10 cm Exchangeable Ca	Top 10 cm Exchangeable K	Top 10 cm Exchangeable Mg	Top 10 cm Exchangeable Na	Top 10 cm KCl40 Sulphur mg/kg	Top 10 cm DTPA Zinc mg/kg
2008	SA	Lower EP	Cummins	27	920	1.8	7.6	8.4	0.281	25.2	2.5	3.0	0.4		
2008	SA	Lower EP	Rudall	48	412	1.1	7.6	8.5	0.205	10.8	1.1	1.5	0.2		
2008	SA	Lower EP	Ungarra	55	800	1.9	7.6	8.3	0.356	23.4	2.1	4.3	0.7		
2008	SA	Mid North	Mintaro	78	685	2.3	6.5	7.2	0.305	19.3	1.7	4.1	0.3		
2008	SA	Mid North	Spalding	29	827	2.1	6.8	7.4	0.421	20.0	2.1	5.9	0.4		
2008	SA	Mid North	Turretfield	70	633	1.6	6.9	7.6	0.243	9.2	1.6	1.7	0.2		
2008	SA	Murray Mallee	Nangari	11	426	0.2	7.4	8.6	0.117	8.3	1.0	1.1	0.1		
2008	SA	Murray Mallee	Palmer	51	596	0.6	6.2	6.7	0.128	7.6	1.4	2.5	0.3		
2008	SA	Murray Mallee	Pinnaroo	25	534	0.2	7.5	8.2	0.139	12.2	1.2	2.8	0.2		
2008	SA	Murray Mallee	Wanbi	17	256	0.6	7.1	7.7	0.114	2.8	0.5	0.6	0.1		
2008	SA	Murray Mallee	Wunkar	18	355	0.5	7.5	8.4	0.098	7.5	0.9	0.8	0.0		
2008	SA	South East	Keith	67	361	2.1	7.4	8.1	0.190	16.3	0.8	3.9	0.2	8	
2008	SA	South East	Sherwood	27	235	1.8	6.5	7.1	0.130	9.1	0.7	0.7	0.2	1	
2008	SA	South East	Wolseley	14	435	1.3	7.7	8.1	0.270	21.8	1.1	3.4	0.7	11	
2008	SA	Upper EP	Kimba	43	818	1.4	7.8	8.8	0.275	16.5	2.1	3.4	0.8		
2008	SA	Upper EP	Minnipa	24	688	1.1	7.7	8.6	0.140	13.6	1.8	1.7	0.2		
2008	SA	Upper EP	Mitchelville	25	628	1.0	7.7	8.6	0.169	11.8	1.6	1.9	0.2		
2008	SA	Upper EP	Nunjikompita	44	677	1.2	7.6	8.3	0.489	15.1	1.8	1.3	1.2		
2008	SA	Upper EP	Streaky Bay	73	562	1.7	7.6	8.6	0.196	16.8	1.5	1.5	0.3		
2008	SA	Upper EP	Warramboo	28	526	1.1	7.7	8.6	0.126	12.2	1.4	1.1	0.1		
2008	SA	Yorke P	Paskeville	43	523	1.9	7.5	8.3	0.233	20.2	1.4	2.3	0.3		

Year	State	Region Name	Nearest Town	Top 10 cm Colwell Phosphorous mg/kg	Top 10 cm Colwell Potassium (K) (mg/kg)	Top 10 cm Organic Carbon %	Top 10 cm pH (CaCl2)	Top 10 cm pH (water)	Top 10 cm Conductivity (EC)	Top 10 cm Exchangeable Ca	Top 10 cm Exchangeable K	Top 10 cm Exchangeable Mg	Top 10 cm Exchangeable Na	Top 10 cm KCl40 Sulphur mg/kg	Top 10 cm DTPA Zinc mg/kg
2008	SA	Yorke P	Urania	65	962	3.2	7.5	8.2	0.281	27.2	2.7	2.6	0.5		
2008	SA	Yorke P	Wokurna	49	344	2.0	7.8	8.5	0.162	16.2	0.8	2.1	0.2		
2009	NSW	S/E	Canowindra	55	460	0.8	4.9	5.5	0.140	3.1	1.0	0.4	0.0	16	0.5
2009	NSW	S/E	Galong	90	840	1.5	5.7	6.3	0.170	4.6	1.7	0.4	0.0	16	1.0
2009	NSW	S/E	Gerogery	73	320	1.2	6.3	7	0.080	5.5	0.7	0.4	0.1	5	0.5
2009	NSW	S/E	Quandialla	60	450	0.7	4.4	5.1	0.090	2.6	1.0	0.7	0.1	14	0.3
2009	NSW	S/W	Beckom	27	460	0.9	4.8	5.5	0.150	4.3	0.9	2.0	0.3	17	0.3
2009	NSW	S/W	Lockhart	30	560	0.9	4.7	5.3	0.120	3.7	1.1	0.7	0.1	19	0.4
2009	NSW	S/W	Oaklands	27	390	1.0	4.7	5.4	0.150	5.0	1.0	3.5	0.5	9	0.3
2009	NSW	S/W	Willbriggie	88	450	1.4	4.5	5.1	0.270	7.5	1.2	5.8	1.1	18	0.2
2009	SA	Lower EP	Cummins	35	916	1.5	7.2	7.9	0.229	31.2	2.3	5.5	0.5		
2009	SA	Lower EP	Rudall	56	580	1.1	7.3	7.7	0.459	13.5	1.5	1.3	0.2		
2009	SA	Lower EP	Ungarra	27	725	1.9	7.4	8.1	0.172	23.9	1.9	4.9	0.6		
2009	SA	Mid North	Booleroo Centre	28	575	1.2	7.8	8.6	0.135	21.2	1.9	6.0	0.2		
2009	SA	Mid North	Mintaro	109	463	2.5	7.1	7.4	0.245	13.1	1.5	1.7	0.4		
2009	SA	Mid North	Spalding	53	725	2.1	5.5	6.1	0.224	8.0	1.8	2.4	0.2		
2009	SA	Mid North	Turretfield	41	601	1.6	7.6	8.2	0.165	20.7	1.6	2.4	0.3		
2009	SA	Murray Mallee	Palmer	56	473	1.5	6.3	6.9	0.186	9.7	2.4	2.5	0.3		
2009	SA	Murray Mallee	Pinnaroo	40	491	1.3	8	8.6	0.119	13.5	1.3	4.5	0.1		
2009	SA	Murray Mallee	Wanbi	22	403	1.2	8.1	8.8	0.175	14.5	1.1	1.5	0.4		
2009	SA	Murray Mallee	Wunkar	24	382	0.9	8	8.9	0.084	11.9	1.0	1.1	0.1		
2009	SA	South East	Sherwood	35	269	1.6	6.7	7.1	0.102					4	

Year	State	Region Name	Nearest Town	Top 10 cm Colwell Phosphorous mg/kg	Top 10 cm Colwell Potassium (K) (mg/kg)	Top 10 cm Organic Carbon %	Top 10 cm pH (CaCl2)	Top 10 cm pH (water)	Top 10 cm Conductivity (EC)	Top 10 cm Exchangeable Ca	Top 10 cm Exchangeable K	Top 10 cm Exchangeable Mg	Top 10 cm Exchangeable Na	Top 10 cm KCl40 Sulphur mg/kg	Top 10 cm DTPA Zinc mg/kg
2009	SA	South East	Wolseley	45	470	1.3	7.5	8.4	0.191					11	
2009	SA	Upper EP	Kimba	40	989	1.5	7.6	8.3	0.206	19.6	2.6	1.9	0.2		
2009	SA	Upper EP	Minnipa	38	823	1.3	7.7	8.5	0.158	18.4	2.3	1.9	0.3		
2009	SA	Upper EP	Mitchelville	20	594	1.0	6.4	6.9	0.091	6.5	1.6	2.1	0.2		
2009	SA	Upper EP	Nunjikompita	44	476	1.0	7.8	8.6	0.163	15.6	1.3	1.2	0.1		
2009	SA	Upper EP	Piednippie	60	764	1.5	7.5	8.4	0.149	20.7	2.1	1.8	0.3		
2009	SA	Upper EP	Warramboo	31	702	1.4	7.7	8.5	0.105	19.6	1.8	1.7	0.2		
2009	SA	Yorke P	Paskeville	37	701	2.1	7.7	8.3	0.153	32.8	2.5	7.5	0.5		
2009	SA	Yorke P	Urania	58	1056	2.4	7.9	8.5	0.177	26.4	3.4	2.3	0.4		
2009	SA	Yorke P	Wokurna	44	290	1.2	7.9	8.8	0.104	12.8	0.8	1.3	0.1		
2009	VIC	Mallee	Birchip	68	415	0.8	6.8	7.1	0.260	14.5	1.1	5.8	1.3		
2009	VIC	Mallee	Hopetoun	18	215	0.6	7.7	8.4	0.265	8.2	0.6	1.2	0.2	15	
2009	VIC	Mallee	Manangatang	31	400	0.7	6.7	7.3	0.087	3.7	0.9	1.1	0.2		
2009	VIC	Mallee	Merrinee	24	272	0.5	7.6	8.6	0.058	5.4	0.7	0.8	0.1		
2009	VIC	Mallee	Murrayville	12	241	0.6	7.1	7.8	0.068	4.2	0.6	0.8	0.1		
2009	VIC	Mallee	Ultima	20	198	0.3	7.3	7.8	0.101	2.2	0.5	0.7	0.1		
2009	VIC	Mallee	Walpeup	26	260	0.6	6.9	7.6	0.064	2.0	0.6	0.7	0.1		
2009	VIC	Mallee	Woomelang	39	582	1.5	7.9	8.5	0.149	21.0	0.9	5.2	0.3		
2009	VIC	North Central	Diggora	38	320	1.3	5.4	5.6	0.890	9.0	0.8	1.0	0.3	*	0.7
2009	VIC	North Central	Mitiamo	69	420	1.3	4.8	5.5	0.200	3.0	1.1	4.0	0.8	27	0.6
2009	VIC	North East	Dookie	52	400	2.0	4.9	5.5	0.150	5.5	1.0	1.3	0.1	12	0.6
2009	VIC	North East	Yarrawonga	78	390	2.2	5.5	6.1	0.190	7.5	1.0	2.9	0.4	27	0.7
2009	VIC	Wimmera	Brim	40	602	1.0	7.5	8.3	0.123	14.7	1.5	6.4	0.7	5	

Year	State	Region Name	Nearest Town	Top 10 cm Colwell Phosphorous mg/kg	Top 10 cm Colwell Potassium (K) (mg/kg)	Top 10 cm Organic Carbon %	Top 10 cm pH (CaCl2)	Top 10 cm pH (water)	Top 10 cm Conductivity (EC)	Top 10 cm Exchangeable Ca	Top 10 cm Exchangeable K	Top 10 cm Exchangeable Mg	Top 10 cm Exchangeable Na	Top 10 cm KCl40 Sulphur mg/kg	Top 10 cm DTPA Zinc mg/kg
2009	VIC	Wimmera	Corack	32	290	1.4	6.1	6.9	0.075	7.7	0.8	3.9	0.4	5	
2009	VIC	Wimmera	Horsham	37	647	1.4	7.8	8.5	0.135	29.7	1.8	7.0	0.5	3	
2009	VIC	Wimmera	Kaniva	32	585	2.1	7.7	8.2	0.157	31.3	1.5	3.5	0.4	7	
2009	VIC	Wimmera	Minyip	34	568	1.1	8	8.8	0.139	30.4	1.6	5.4	1.3	4	

Appendix Table 3 – Site locations, subsoil test values (10-60 cm), sowing times and fertilizers used.

Year	State	Region Name	Nearest Town	10-60 cm HWS Extractable Boron mg/kg	10-60 cm pH (CaCl2)	10-60 cm pH (water)	10-60 cm Conductivity (EC)	10-60 cm Exchangeable Ca	10-60 cm Exchangeable K	10-60 cm Exchangeable Mg	10-60 cm Exchangeable Na	SowingDate	N kg/ha	P kg/ha	K kg/ha	Zn Applied (Yes or No)
2008	SA	Lower EP	Cummins	3	7.8	8.8	0.225	19.3	1.1	6.6	1.7	30-May-08	51	19	1	Y
2008	SA	Lower EP	Rudall	8	8.2	9.2	0.314	13.4	0.8	7.6	2.3	22-May-08	11	12	1	N
2008	SA	Lower EP	Ungarra	13	8.2	9.2	0.387	15.8	1.5	10.6	4.4	28-May-08	14	18	2	N
2008	SA	Mid North	Mintaro	1	5	5.8	0.031	2.4	0.1	0.5	0.1	26-May-08	63	19	1	y
2008	SA	Mid North	Spalding	2	5.7	6.7	0.026	1.0	0.0	0.3	0.1	09-May-08	40	19	1	Y
2008	SA	Mid North	Turretfield	4	5.7	6.5	0.026	1.6	0.3	0.5	0.1	06-Jun-08	14	15	1	Y
2008	SA	Murray Mallee	Nangari	2	8.29	9.02	0.109	13.8	0.7	4.8	0.4	28-May-08	17	19	1	Y

Year	State	Region Name	Nearest Town	10-60 cm HWS Extractable Boron mg/kg	10-60 cm pH (CaCl2)	10-60 cm pH (water)	10-60 cm Conductivity (EC)	10-60 cm Exchangeable Ca	10-60 cm Exchangeable K	10-60 cm Exchangeable Mg	10-60 cm Exchangeable Na	SowingDate	N kg/ha	P kg/ha	K kg/ha	Zn Applied (Yes or No)
2008	SA	Murray Mallee	Palmer	3	8.22	8.87	0.184	15.9	1.5	7.5	1.4	01-Jun-08	17	19	1	Y
2008	SA	Murray Mallee	Pinnaroo	5	8.41	9.25	0.244	18.0	0.7	10.8	2.4	26-May-08	17	19	1	Y
2008	SA	Murray Mallee	Wanbi	1	8.31	8.99	0.066	2.3	0.2	0.4	0.1	29-May-08	17	19	1	Y
2008	SA	Murray Mallee	Wunkar	1	8.41	9.14	0.083	10.6	0.6	1.8	0.4	29-May-08	17	19	1	Y
2008	SA	South East	Keith	1	7.7	8.4	0.190	19.0	0.4	4.1	0.3	03-Jun-08	55	18	1	y
2008	SA	South East	Sherwood	2	7.9	8.6	0.180	20.0	0.4	2.5	1.1	03-Jun-08	55	18	1	Y
2008	SA	South East	Wolseley	7	8.3	9.3	0.350	17.4	0.8	9.0	4.8	04-Jun-08	55	18	1	Y
2008	SA	Upper EP	Kimba	24	8.3	9.3	0.820	12.7	1.2	7.1	6.7	20-May-08	11	12	1	N
2008	SA	Upper EP	Minnipa		8	8.7	0.657	14.1	0.7	4.2	1.3	22-May-08	9	10	1	N
2008	SA	Upper EP	Mitchelville	5	8.2	9.2	0.389	10.5	1.1	5.0	2.5	20-May-08	9	10	1	N
2008	SA	Upper EP	Nunjikompita		8	8.9	0.907	12.8	1.1	2.8	4.2	26-May-08	9	10	1	N
2008	SA	Upper EP	Streaky Bay		7.9	8.9	0.194	17.1	0.8	2.3	0.4	29-May-08	9	10	1	N
2008	SA	Upper EP	Warramboo	3	8.1	9.1	0.347	12.2	0.6	3.6	1.7	19-May-08	11	12	1	N
2008	SA	Yorke P	Paskeville	3	6.1	6.8	0.028	3.0	0.1	1.0	0.1	21-May-08	45	19	1	Y
2008	SA	Yorke P	Urania	1	6.9	7.3	0.045	1.4	0.2	0.5	0.1	08-May-08	17	19	1	Y
2008	SA	Yorke P	Wokurna	2	8.23	8.86	0.149	19.1	0.3	6.8	0.3	28-May-08	15	17	1	Y
2009	NSW	S/E	Canowindra		5.6	6.3	0.090	3.3	0.7	0.5	0.0	30-May-09	20	22	2	N
2009	NSW	S/E	Galong		5.3	5.9	0.180	2.9	1.5	0.4	0.0	31-May-09	50	20	2	N

Year	State	Region Name	Nearest Town	10-60 cm HWS Extractable Boron mg/kg	10-60 cm pH (CaCl2)	10-60 cm pH (water)	10-60 cm Conductivity (EC)	10-60 cm Exchangeable Ca	10-60 cm Exchangeable K	10-60 cm Exchangeable Mg	10-60 cm Exchangeable Na	SowingDate	N kg/ha	P kg/ha	K kg/ha	Zn Applied (Yes or No)
2009	NSW	S/E	Gerogery		5	5.5	0.110	4.1	0.3	1.2	0.1	02-Jun-09	20	22	2	N
2009	NSW	S/E	Quandialla		5.8	6.5	0.090	2.8	0.7	1.2	0.2	22-May-09	10	22	12	N
2009	NSW	S/W	Beckom		6.4	7.5	0.150	4.8	0.6	8.0	2.3	12-Jun-09	14	12	10	N
2009	NSW	S/W	Lockhart		5.8	6.6	0.060	3.7	0.6	2.1	0.2	05-Jun-09	14	12	10	N
2009	NSW	S/W	Oaklands		5.5	6.6	0.100	5.5	0.8	4.9	1.0	16-Jun-09	14	12	10	N
2009	NSW	S/W	Willbriggie		5.7	6.3	0.220	13.0	1.0	9.1	0.7	13-May-09	79	18	15	N
2009	SA	Lower EP	Cummins	8	8	8.7	0.258	24.6	1.8	11.3	3.4	20-May-09	64	20	2	N
2009	SA	Lower EP	Rudall	10	8.4	9.2	0.312	15.0	1.2	9.4	2.6	28-May-09	11	12	1	N
2009	SA	Lower EP	Ungarra	3	8	9	0.209	19.9	0.4	6.4	1.9	26-May-09	60	16	2	N
2009	SA	Mid North	Booleroo Centre	7	8.2	9	0.287	19.2	0.9	7.6	2.5	08-May-09	13	14	1	Y
2009	SA	Mid North	Mintaro	9	8.1	8.9	0.449	14.3	1.1	12.7	5.3	20-May-09	17	19	1	Y
2009	SA	Mid North	Spalding	1	7.1	7.7	0.072	10.4	0.8	8.9	0.6	09-May-09	13	14	1	Y
2009	SA	Mid North	Turretfield	2	7.5	8.3	0.171	28.2	1.3	8.8	1.2	04-Jun-09	25	28	2	Y
2009	SA	Murray Mallee	Palmer	5	8.1	8.8	0.397	16.2	1.4	8.6	2.7	11-May-09	17	19	1	Y
2009	SA	Murray Mallee	Pinnaroo	2	8.1	8.9	0.192	16.2	0.9	7.3	0.8	13-May-09	17	19	1	Y
2009	SA	Murray Mallee	Wanbi	2	8.1	8.9	0.165	15.4	0.9	2.2	0.8	08-May-09	17	19	1	Y
2009	SA	Murray Mallee	Wunkar	2	8.1	8.8	0.136	14.4	0.9	2.0	0.6	09-Jun-09	17	19	1	Y
2009	SA	South East	Sherwood	3	7.8	8.5	0.184	18.8	1.0	10.5	1.0	20-May-09	17	19	1	Y

Year	State	Region Name	Nearest Town	10-60 cm HWS Extractable Boron mg/kg	10-60 cm pH (CaCl2)	10-60 cm pH (water)	10-60 cm Conductivity (EC)	10-60 cm Exchangeable Ca	10-60 cm Exchangeable K	10-60 cm Exchangeable Mg	10-60 cm Exchangeable Na	SowingDate	N kg/ha	P kg/ha	K kg/ha	Zn Applied (Yes or No)
2009	SA	South East	Wolseley	16	8.2	9	0.719	15.1	0.8	12.2	7.7	20-May-09	65	18	14	Y
2009	SA	Upper EP	Kimba	11	8.4	9.2	0.893	11.2	1.4	7.8	5.0	27-May-09	11	12	1	N
2009	SA	Upper EP	Minnipa	7	8.1	8.9	0.408	19.4	1.2	6.4	3.0	08-May-09	13	14	1	N
2009	SA	Upper EP	Mitchelville	2	8.2	8.9	0.123	11.1	0.6	5.5	0.4	27-May-09	9	10	1	N
2009	SA	Upper EP	Nunjikompita	6	8	9	0.465	13.2	1.1	7.2	2.3	25-May-09	13	14	1	N
2009	SA	Upper EP	Piednippie	2	7.9	8.7	0.221	16.3	1.0	5.2	1.1	11-May-09	13	14	1	N
2009	SA	Upper EP	Warramboo	3	7.9	8.4	0.421	21.0	0.8	6.1	1.7	26-May-09	11	12	1	N
2009	SA	Yorke P	Paskeville	2	8	9	0.189	27.8	1.2	10.5	2.2	18-May-09	17	19	1	Y
2009	SA	Yorke P	Urania	2	7.9	8.6	0.268	19.4	1.2	6.4	1.0	20-May-09	15	17	1	Y
2009	SA	Yorke P	Wokurna	2	8.1	8.9	0.127	17.2	0.4	6.1	0.3	14-May-09	43	17	1	Y
2009	VIC	Mallee	Birchip	12	7.4	8.4	0.820	11.1	1.1	10.3	9.0	28-May-09	14	16	2	N
2009	VIC	Mallee	Hopetoun	11	8.9	9.8	0.254	11.0	0.8	7.4	2.4	28-May-09	10	32	8	Y
2009	VIC	Mallee	Manangatang		8.3	9.3	0.280	9.2	0.8	3.8	2.5	12-May-09	52	23	4	Y
2009	VIC	Mallee	Merrinee		8	9	0.111	7.8	0.5	1.6	0.4	08-May-09	14	16	2	N
2009	VIC	Mallee	Murrayville		8.3	9.2	0.408	11.5	0.6	4.0	3.3	11-May-09	14	16	2	N
2009	VIC	Mallee	Ultima	2	7.9	8.7	0.182	9.2	0.9	6.8	1.3	12-May-09	14	16	2	N
2009	VIC	Mallee	Walpeup		8	8.9	0.419	7.7	0.8	4.7	4.3	06-May-09	14	16	2	N
2009	VIC	Mallee	Woomelang	20	8.2	9.1	0.765	12.7	0.9	10.2	8.5	29-May-09	14	16	2	N

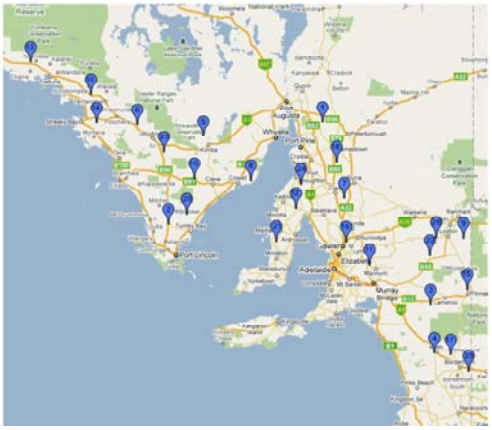
Year	State	Region Name	Nearest Town	10-60 cm HWS Extractable Boron mg/kg	10-60 cm pH (CaCl2)	10-60 cm pH (water)	10-60 cm Conductivity (EC)	10-60 cm Exchangeable Ca	10-60 cm Exchangeable K	10-60 cm Exchangeable Mg	10-60 cm Exchangeable Na	SowingDate	N kg/ha	P kg/ha	K kg/ha	Zn Applied (Yes or No)
2009	VIC	North Central	Diggora	1	5.2	5.8	0.180					26-May-09	10	22	2	N
2009	VIC	North Central	Mitiamo	9	7.6	8.2	0.690					26-May-09	10	22	2	Y
2009	VIC	North East	Dookie	1	5.4	6	0.120					07-May-09	10	22	2	N
2009	VIC	North East	Yarrawonga	2	6	6.9	0.220					01-May-09	56	22	2	N
2009	VIC	Wimmera	Brim	7	8.4	9.3	0.245	15.7	0.9	12.0	5.2	17-Jun-09	6	11	2	Y
2009	VIC	Wimmera	Corack	5	8.5	9.4	0.349	17.8	0.6	9.6	4.6	27-May-09	10	17	3	Y
2009	VIC	Wimmera	Horsham	6	8.3	9.3	0.315	24.7	1.0	10.6	4.9	19-Jun-09	11	19	4	Y
2009	VIC	Wimmera	Kaniva	2	8.2	9.2	0.220	25.2	0.5	7.9	2.2	11-Jun-09	11	19	4	Y
2009	VIC	Wimmera	Minyip	6	8.6	9.6	0.584	21.1	1.2	9.9	10.2	18-Jun-09	9	16	3	Y

Appendix Table 4. The coefficient of variation for regional, state and total wheat grain macronutrient and micronutrient concentrations.

CV's	N	P	K	S	Ca	Mg	Na	Fe	Mn	B	Cu	Zn
South East	5%	6%	4%	4%	6%	3%	84%	5%	6%	21%	9%	11%
South West	6%	8%	5%	4%	7%	3%	79%	5%	7%	20%	9%	10%
New South Wales	*4%*	*5%*	*3%*	*3%*	*5%*	*2%*	*63%*	*4%*	*6%*	*17%*	*7%*	*8%*
Lower EP	6%	5%	4%	4%	7%	2%	13%	6%	12%	12%	7%	11%
Mid North	4%	4%	4%	3%	5%	2%	21%	4%	5%	21%	5%	7%
Murray Mallee	4%	4%	3%	3%	5%	2%	17%	4%	6%	12%	5%	8%
South East	5%	5%	4%	4%	5%	3%	18%	5%	12%	21%	9%	9%
Upper EP	3%	4%	3%	2%	4%	2%	7%	3%	4%	8%	4%	5%
Yorke Penn.	5%	5%	4%	3%	6%	3%	14%	6%	7%	16%	5%	9%
South Australia	*2%*	*2%*	*1%*	*1%*	*2%*	*1%*	*6%*	*2%*	*3%*	*6%*	*2%*	*3%*
Mallee	4%	5%	4%	3%	5%	2%	34%	4%	7%	7%	5%	9%
North Central	9%	10%	7%	6%	12%	4%	88%	7%	9%	29%	11%	13%
North East	8%	10%	7%	5%	11%	4%	134%	7%	10%	36%	10%	12%
Wimmera	5%	4%	4%	4%	6%	2%	25%	5%	7%	7%	7%	8%
Victoria	*3%*	*3%*	*2%*	*2%*	*4%*	*2%*	*22%*	*3%*	*5%*	*6%*	*4%*	*5%*
Mean	**18%**	**20%**	**14%**	**13%**	**21%**	**10%**	**81%**	**19%**	**32%**	**58%**	**24%**	**32%**

Appendix Figure 1. Location of NVT Wheat sites in South Australia, 2008 (A) and 2009 (B) (NVT On-line).

A 

B. 

Appendix Figure 2. Location of NVT Wheat sites in New South Wales, 2009 (NVT On-line)

Figure 3. Location of NVT Wheat sites in Victoria, 2009 (NVT On-line)