Canola seed nutrient concentrations for southern Australia

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ABSTRACT

The nutrient concentrations of 290 canola grain samples were analyzed from more than 54 NVT sites across southern Australia. All nutrients tested showed significant differences among regions and states, while within region coefficients of variation were general <3%. Values for the macronutrient P were the most variable (5672±1125 mg/kg) and these values were consisted with commonly used values. The seed N (42±6 kg N/t) were 30% higher than accepted values, while grain S contents (4063±670 mg/kg) were nearly 30% lower than commonly published values. So, regional removal values will provide more accurate removal values for use in nutrient budgets than national values.

While canola seed nutrient concentrations varied with different herbicide tolerance types, glyphosate tolerant types tested showed significantly higher N, K, S, B, Cu and Zn concentrations than conventional canola. There were no significant differences in Mn concentration among conventional, RR and TT types of canola.

Only one seed sample showed seed Cd concentrations above 0.10 mg/kg and although up to 5% samples could approach this value in defatted meal. Levles require ongoing monitoring to ensure compliance with proposed food standards.

Key Words: macronutrients, micronutrients, manganese, herbicide tolerance, cadmium.

INTRODUCTION

An understanding of the nutrient concentrations of grains such as canola is important in developing field scale nutrient budgets for both macronutrients and micronutrients. The values can also be used diagnostically to retrospectively assess particular nutrient deficiencies or toxicities for the paddock from which the grain was derived. There have been several studies undertaken on cereal grain nutrient densities in Australia (e.g. Schultz and French 1978, Norton 2012) and much of the earlier information has been collated and published in “Plant Analysis – An Interpretation Manual” (Reuter et al. 1997). These published values (Table 1) 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. Nutrient canola grain concentrations (0% moisture) from Reuter as used in the National Land and Water Resources Audit (2001) and critical values are taken from Reuter et al. (1997).

Nutrient	N %	P mg/kg	K mg/kg	S mg/kg	B mg/kg	Cu mg/kg	Mn mg/kg	Zn mg/kg
Canola	3.4	5600	8100	5500	-	-	-	-
Critical Values	<1.9	<3500	-	<3600	<1	<1.5	<10	<15

There is, however, little information concerning values for current canola varieties, including differences among herbicide resistance groups or variation with regions, states or nationally. Uncertainty in grain nutrient concentrations gives a degree of uncertainty to possible long-term nutrient balances calculated as the product of grain yield and nutrient concentration. The research reported here summarises nutrient densities for canola grown across in southern Australia and so give confidence to the values used in nutrient budgets.

MATERIALS AND METHODS

Canola seed samples were obtained from site managers involved in the National Variety Testing (NVT) system. A single sample per site of selected varieties was collected from the 2012 season. There were 69 samples from 12 sites in New South Wales, 66 samples from 12 sites in South Australia, 66 samples from 10 sites in Victoria and 89 samples from 21 sites in Western Australia. Cultivars selected were conventional types (AV Garnet, Hyola50), imidiazolinine tolerant (IT; Hyola 474CL, Pioneer 44Y84), triazine tolerant (TT; ATR Cobbler, CB Junee) and glyphosate tolerant (RR; GT Cobra, Pioneer 45Y33). Cultivars were chosen to maximize the geographic spread for the test materials. Each herbicide tolerance group was grown at its own location.

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. Crop management practices, soil test values and grain yields are available in the NVT reports published in 2012.

Approximately 25 seeds of each cultivar (approx. 0.3 g) from each site were randomly selected from the harvested grain sub-sample, 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 here B, Cu, K, Mn, P, S, and Zn and all are given on a dry grain basis. This extractant was also analysed for Cd using ICP-MS.

Grain N concentrations were derived from the NVT seed or meal protein contents, adjusted for moisture content to 0%. The analysis of protein (N) in NVT is done using Kjeldahl or Dumas methods (Reference AOCS-Ai 4-91) or using NIR.

Because the data set developed was not balanced, nor were there replicates of each cultivar from each site, the data were assessed using a one-way analysis of variance to compare nutrient densities using either state (New South Wales, South Australia, Victoria, Western Australia), region or herbicide tolerance group (conventional, IT, TT and RR). The regions were Agzone (AZ) 1–6 in Western Australia; northeast (NENSW), northwest (NWNSW), southeast (SENSW), southwest (SWNSW) (New South Wales); lower Eyre Penninsular (LEP), mid-North (MNSA), southeast (SESA), upper Eyre Pennisula (UEP), Yorke Pennisula (YP) (South Australia); and Mallee (MAV), north central (NCV), north east (NEV), south west (SWV) and the Wimmera (WIV). With these data, because they are unbalanced, it was not possible to assess the interactions among state, region, or herbicide tolerance group.

RESULTS AND DISCUSSION

For all nutrients, there were significant differences among the regions in which the canola was grown. For all except P and B, state values were significantly different to each other.

Macronutrients, regional differences

Table 2 provides a summary of the nutrient concentrations for eight nutrients showing the mean values for each region, for each of the four states and a national value. Within a region, the coefficient of variation (CV) of the means was generally less than 5%, and the state means showed CV less than 3%. Even so, the national values did show a large range, with values for N (CV 14%), P (CV 20%), K (CV 15%), and S (CV 16%) indicating that regional or state values would be better to use than a national value for nutrient budgets. In the budgets undertaken as part of the National Land and Water Resources Audit (2001), the values for N concentration were around 80% of these measured values, while the S concentrations used were used were 25% more than these measured values. It has even been common for agronomists to use 10 kg S/t as the S removal, when the measured values here are 3.5 kg S/t at 8.5% moisture.

Seed P concentration was not related to soil Colwell P (r^2=0.02) and only weakly related to soil pH (r^2=0.12), while seed S concentrations were showed no relationship to either parameter. Using multiple linear regression seed micronutrient concentrations for Cu (R^2=0.238) and Zn (R^2=0.237) could be predicted from soil test value, soil pH, organic C and soil ED, but no relationship could be derived for Mn or B. Precise clay concentrations were not available in the soil test database but may may have assisted with improving the predictions.

Micronutrients, regional differences.

Seed micronutrient concentrations showed a similar pattern to the macronutrients, with relatively small within region differences, but significant differences between regions and states. It is also seen that the regional mean values for micronutrient concentrations are all above the critical values (Table 1) and indeed there were no individual concentrations for B, Cu, Mn or Zn below those critical values. This suggests the micronutrient nutrition of canola in these experiments was adequate, although the use of critical seed nutrient concentrations is not a reliable diagnostic indicator of nutrient supply (Norton 2013).

Grain micronutrient concentration could be related to soil type, as expressed by the Australian Soil Classification (ASC, Isbell 2002). did differ between states and regions, except for state level Zn. These data shows a 6 fold higher B concentration in canola compared to wheat (Norton 2013) and there were few soil classes where there was low grain B in canola. Grain Cu was lower in canola than wheat (Norton 2013) even though it is known that canola is able to access Cu more efficiently than wheat (Brennan and Bolland 2004). Canola grain Cu levels tended to be lower on alkaline Calcarosols and Vertosols, while wheat grain Cu levels tended to be higher on those soils (Norton 2013), although the significance of this is not clear.

The canola grain Mn concentrations were significantly lower than wheat (Norton 2013), although these levels were relatively high in both species. Grain Zn concentrations in canola were almost twice the concentrations in wheat, and it is recognised that canola is more efficient than wheat at accessing soil Zn (Brennan and Bolland 2006). Those authors indicated that because canola has more Zn than wheat, although Cu levels are similar, the drawdown of soil Zn would occur more rapidly under canola than wheat, so that the residual value of applied Zn would be less for canola than for wheat.

Table 2. Mean concentrations of macronutrients (N, P, K, S) and micronutrients (B, Cu, Mn, Zn) for canola samples from selected 2012 NVT sites by site and state. All values are for dry grain (0% moisture content).

Region & State	N %	P mg/kg	K mg/kg	S mg/kg	B mg/kg	Cu mg/kg	Mn mg/kg	Zn mg/kg
NENSW	4.94	4890	6106	4334	12.0	3.2	39.9	39.5
NWNSW	5.09	6575	6789	4438	13.0	3.4	38.9	31.9
SENSW	4.30	3943	6227	4818	12.3	3.1	36.8	42.3
SWNSW	5.40	5484	6318	3677	11.4	2.9	44.3	33.8
NSW	*4.81*	*5433*	*6396*	*4150*	*12.0*	*3.1*	*41.0*	*35.4*
LEP	4.09	6317	7140	3252	11.3	2.4	38.0	35.3
MNSA	4.96	5767	7191	4101	12.1	2.6	32.4	34.8
SESA	4.52	5076	7048	3923	11.9	2.6	29.7	32.2
UEP	3.69	7809	7407	3127	11.9	3.1	27.6	29.7
YP	4.57	6170	7496	3734	12.0	2.6	30.7	25.6
SA	*4.46*	*5868*	*7204*	*3725*	*11.9*	*2.6*	*31.7*	*32.0*
MAV	4.25	6544	6906	4338	12.6	2.9	38.5	44.4
NCV	3.94	5355	6654	3961	12.1	2.7	39.7	36.1
NEV	3.51	5499	6613	3572	10.7	2.6	40.7	35.8
SWV	3.27	5151	6782	3297	10.7	2.7	41.1	30.0
WIV	3.80	5804	6657	3663	12.2	2.5	32.7	38.3
VIC	*3.83*	*5711*	*6720*	*3801*	*11.7*	*2.7*	*38.8*	*37.4*
AG1	4.90	6825	7945	4664	11.2	4.0	41.6	43.2
AG2	4.07	5819	7675	4166	11.9	2.8	37.2	41.9
AG3	3.69	4707	6871	4063	11.3	2.6	41.6	44.1
AG4	4.18	6272	7627	5004	12.5	2.9	42.8	47.7
AG5	4.03	5542	7181	4347	12.1	2.7	38.4	40.4
AG6	3.77	4970	7125	3741	10.8	2.9	39.2	37.8
WA	*4.09*	*5492*	*7374*	*4166*	*11.6*	*2.9*	*39.2*	*41.8*
Mean	**4.28** **±0.62**	**5672** **±1125**	**6863** **±1015**	**4063** **±670**	**12.0** **±1.2**	**2.9** **±0.5**	**38.0** **±6.9**	**37.9** **±7.7**
LSD * (p<0.05)	**0.24**	**637**	**561**	**372**	**0.8**	**0.1**	**1.7**	**1.8**

** LSD is the mean least significant difference between means for each region.*

Herbicide Tolerance responses

There have been particular claims over the use of glyphosate on glyphosate-tolerant (RoundUp Ready®) crops and its theoretical involvement in reducing the access to some micronutrients, especially Mn although there is no substantive literature supporting this assertion. The data set presented here has modern varieties from the four herbicide tolerance types (Conv, IT, TT and RR) grown in Australia. Table 3 gives the means for the four macronutrients and four micronutrient seed concentrations by herbicide tolerance type.

Table 3 shows that while there are significant differences among some groups, the RR types tested showed significantly higher N, K, S, B, Cu and Zn concentrations than conventional canola. There were no significant differences in Mn concentration among conventional, RR and TT types of canola.

Table 3. The nutrient concentrations of the seed of different herbicide tolerance groups of canola, from the 2012 NVT experiments.

	N %	P mg/kg	K mg/kg	S mg/kg	B mg/kg	Cu mg/kg	Mn mg/kg	Zn mg/kg
Con	4.05	5421	7027	3765	11.2	2.7	36.2	33.6
IT	4.34	6176	6379	4071	11.4	3.1	40.8	39.6
RR	4.21	5653	7808	3893	12.1	2.9	36.4	36.7
TT	4.40	5654	6738	4315	12.5	2.8	37.0	39.0
LSD ($p<0.05$)	0.11	285	251	166	0.4	0.1	1.7	1.8

Cadmium concentrations

Food Standards Australia New Zealand is reviewing acceptable grain Cd concentrations, and even though canola seed or meal are not mentioned, wheat seed has a proposed maximum level of 0.1 mg/kg (FSANZ, 2014). Canola is reported to take up more Cd than wheat (Brennan and Bolland, 2005) and higher uptakes are also seen where soils are with high chloride availability, zinc deficiency and low pH (Smolders 2001). Trace metals like Cd in the seed are almost exclusively transferred to the meal (Durracq et al.b 2004), and so the values for seed concentration could be doubled for protein meals, albiet on a 0% moisture content.

Mean Cd concentrations were below the 0.1 wheat seed standard, except for two samples grown on vertosols. There were no specific issues of high salinity, low acidity or high soil P on these two sites, he the probability of exceedance curve for canola seed Cd concentration (n=286) taken from this data set. One sample exceeded 0.1 mg Cd/kg and 13 samples (5%) exceeded 0.06 mg Cd/kg which would approximate to 0.1 mg Cd/kg in the defatted meal.

Overall, these data show that macronutrient and micronutrient seed concentrations in canola show significant regional variation, and also differ in some cases among herbicide tolerance types. To complete reliable nutrient removals for the macronutrients, regionally or paddock determined seed P, S and K values should be used. For aggregation of data at larger scales – such as for state level nutrient removals; nominal values could be used although they may also have temporal differences, which differ due to grain yield. Aggregated values for P and S removal were 5.6 kg P/t and 4.1 kg S/t of seed respectively.

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 macronutrients, particular values could be appropriate for local regions.

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