Analysis of phosphorus, sulphur and growth stage in wheat shoots

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Introduction

Near infrared (NIR)-based tissue testing services assess the nitrogen and energy status of cereal crops and now operate in all the wheat-growing states of Australia.[1] There are reports of deficiencies of P and S in winter cereals. These deficiencies are attributed to the removal of P and S from soil in crop products exceeding inputs. To halt decreases in yield and grain quality, there is a need to increase the efficiency of use of fertilisers. This is becoming more important because of the high cost and a call for more environmentally responsible use of fertilisers.

The critical N concentration in plant shoots declines as the crop ages. If the growth stage of the crop is not correctly identified an incorrect fertiliser recommendation can be given to a farmer. Our experience indicates that describing the physiological age of plants in a crop is difficult. We believe that an NIR-based estimate of growth stage would improve the accuracy of predictions of crop yield, grain protein and the amount of remedial fertiliser to apply.

The ability to determine shoot P and S concentrations and growth stage, in addition to nitrogen and fructan concentrations, would greatly enhance the value of NIR analysis as a crop diagnosis and management tool. Earlier work on forages[5] suggested the great potential of using NIR to predict percent P and other elements. This paper reports useful calibrations for P, S and days after sowing for wheat crops.

Methods and materials

Wheat shoot samples were collected over two seasons and the growth stage recorded as the number of days after sowing. Samples were taken each week from both trial plots and commercial crops between early leaf development and harvest from sites which offered a wide range of wheat genotypes, sowing dates, soil types, temperature and rainfall.

The samples were dried in a microwave oven and ground, to pass a 0.5 mm screen in a cyclone mill.[2] The ground samples were analysed for a range of elements by ICP spectroscopy, after digestion in nitric acid, and scanned on an NIR monochrometer (model 6500 NIRSystems, Silver Spring, MD, USA). NIR calibrations were then developed using NSAS software (NIRSystems).

Results

Table 1 summarises the calibrations developed for P, S and days after sowing. The *SEP* values indicate that analyses of wheat shoots for P and S would provide valuable data to cereal producers. The P calibration selected used 11 factors. This supports the suggestion that a calibration for total P relies on the sum of numerous weak absorbances by P-compounds present in low concentrations.

Table 1. Summary of calibrations for P, S and age of wheat shoots.

	Calibration					Verification				
	N	Range	PLS Factors	*R*	*SEC*	*N*	*R*	*SEP*	Slope	Intercept
P (%)	87	.126–.638	11	.9698	.036	42	.932	.0446	.82	.0528
S (%)	75	.10–1-.450	3	.9712	.0235	38	.906	.0336	1.03	–.0151
Age (days)	177	19-173	13	.972	8.6	57	.97	8.7	1.02	–2.01

The correlation (R^2) between shoot N and S was 0.79. As this is significantly lower than the S-calibration R^2 value of 0.94, we conclude that the determination of S in cereal shoots is not entirely reliant on the N : S ratio of protein.

The calibration for days after sowing will be a valuable check on plant age when making a fertiliser recommendation. In a previous study [3] we reported a lower *SEP* of 6.1 days for days after sowing. In that study, only one variety of wheat, grown at one site, was sampled, whereas here samples were collected over two years from several varieties, soil types and sowing dates. The *SEP* value for S in wheat

Table 2. Operation of the expanded NIR wheat tissue testing system.

Farmers watch their crops for growth stage.
⇓
During tillering and stem elongation, farmers cut plants from three 1 metre drill rows and count the tillers.
⇓
Farmers dry samples as soon possible in a microwave oven.
⇓
Farmers post or deliver samples to a commercial testing laboratory
⇓
Laboratory staff check and number samples and record details in a data base.
⇓
Laboratory staff grind samples to pass a 0.5 mm screen.
⇓
Laboratory staff analyse samples for N, fructan, P, S and age using NIR spectroscopy.
⇓
A fertiliser recommendation is calculated using the NIR results and other information provided on the crop.
⇓
The N, fructan, P and S data, and the fertiliser recommendation are sent by phone, fax or post to the farmer.

shoots here was also slightly higher than the value reported for rice in Australia,[4] again indicating the wider range in plant age, variety and environments in the present set of wheat crop samples.

Some commercial laboratories still use filter NIR instruments. A comparison of *SEP* values revealed a satisfactory calibration for S (*SEP* = 0.05% S), but not for P (*SEP* = 0.08% P), could be obtained when using a filter-NIR instrument.

Conclusions

A wider range of constituents can now be determined on each sample of winter cereal shoots submitted for analysis by NIR (Table 2). For the same outlay, in terms of time to collect, dry and grind a sample, more information can be presented to cereal producers, to consider when deciding the yield and protein potential of a crop and what, if any, is the appropriate fertiliser to apply.

For some commercial laboratories to make full use of the new calibrations they will need to upgrade from filter to scanning NIR instruments if they are to determine phosphorus.

References

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