Genotypic variability in wheat for differential preference of NH_4^+ and NO_3^-

Cathryn O'Sullivan[1], Jairo Palta [1], Mark Farrell[2], Karen Treble[1], Greg Rebetzke[3]. CSIRO Agriculture and Food Perth[1], Adelaide[2], Canberra[3].

CSIRO AGRICULTURE AND FOOD
www.csiro.au

Conclusions: The data produced in this screening experiment show biomass accumulation and N content varies among tested wheat genotypes with some preferring NO_3^-, others NH_4^+ while others grow better on a mix of the two N forms. This information could be used to develop strategies to improve Nitrogen Uptake Efficiency (NUpE) by using genotypes with differing N preferences in target soil types where a particular N form is likely to dominate.

Introduction

Wheat crops in most agricultural regions of Australia are inefficient users of soil N (McDonald 1989; Fillery & McIness 1992; Angus 2001; Sadras & Angus 2006). Nitrogen Uptake Efficiency (NUpE) is the primary component of the Nitrogen Use Efficiency equation, and N uptake is the process that sets the capital of N through which a cereal crop generates yield and grain protein (Palta and Yang, 2014).

Surprisingly there has been little previous research investigating genotypic variation in wheat for preference of different forms of N. Capture of N by root systems is often correlated with root and shoot biomass. However, recent studies by Pang et al (2014) showed some wheat cultivars, such as Janz, with less root and above-ground biomass than vigorous genotypes, had a similar uptake of N due to a higher affinity for NO_3^- (Pang et al 2015). Independent studies of wheat overseas showed that the spring cultivar Star not only favoured NH_4^+ over NO_3^- as source of soil N but its root and shoot growth was greater under NH_4^+ than under NO_3^- (Feil 1994). Soils are known to vary in their relative amounts of NH_4^+ and NO_3^-.

These findings indicate that the next generation of studies for improving the NUpE in wheat should focus on identifying and exploiting genotypic variation for affinity to NO_3^- and NH_4^+ in the root system. This experiment screened a range of wheat cultivars and landraces for their ability to uptake N and produce biomass on NH_4^+, NO_3^- and a mixture of NH_4NO_3. The overall aim of this study was to improve wheat NUpE in contrasting soil types, by tailoring genotypes to soils that tend to be dominated by NO_3^- or NH_4^+.

Materials Methods

A random sample of 21 wheat cultivars and landraces, known to have high affinity for NO_3^-, preference for NH_4^+, and/or early vigorous growth, were chosen for the initial screening, along with a population of eight F1 crosses of cv. Star with elite Australian cultivars.

The wheat genotypes were grown hydroponically on three different nutrient solutions providing N as NH_4^+, NO_3^- or NH_4NO_3. The nutrient solutions were all supplemented with a nitrification inhibitor, well aerated and pH controlled. Plant N content was measured using a handheld N-tester at seven weeks. At 8 weeks after sowing (post-tillering for all lines) the shoots were harvested and leaf area, shoot biomass and N content measured.

Figure 1: The hydroponics set up used to assess biomass accumulation and N uptake in young wheat plants grown under glasshouse conditions.

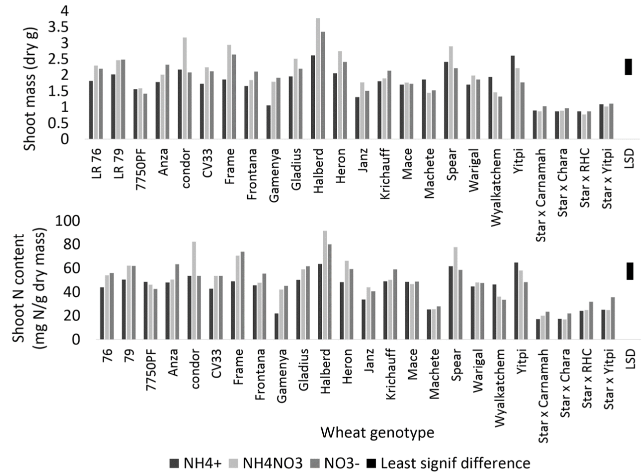

Figure 2: Shoot dry mass production and N content in a variety of wheat genotypes and crosses when grown on hydroponics solutions with N supplied as NO_3^-, NH_4^+ or NH_4NO_3. LSD indicates the least significant difference at P= 0.05 from ANOVA (eight replicates for each genotype).

Results

There was genotypic variation in the growth and N uptake among the tested genotypes on the different N forms. Some cultivars, like Frontana and Krichauff, accumulated more shoot biomass and N growing on NO_3^-. Others, such as Wyalkatchem and Yitpi, accumulated more biomass on NH_4^+ while Condor, Halberd and Spear, performed better on NH_4NO_3 (Fig 1 and 2).

Figure 3 shows a comparison of shoot dry weight of genotypes grown on NH_4^+ versus NO_3^- indicating several genotypes (e.g. Wyalkatchem and Yitpi) grew significantly better on NH_4^+ than NO_3^- while many varieties (especially Halberd, Frame and Gamenya) grew significantly better on NO_3^- than NH_4^+, and several genotypes showed no preference (e.g. Mace, Warigal, Janz, Condor). The crosses based on cv. Star grew slightly better on NH4+ than NO3- but did not show a strong preference for one N form over another (Figs 2 and 3). A comparison of leaf N content using this approach gave very similar results (data not shown).

Similar comparisons of shoot weights and leaf N contents of plants grown on NH_4NO_3 versus NO_3^- gave a more linear response ($r^2 = 0.62$) (data not shown), indicating that most varieties tested show no preference between NH_4NO_3 and NO_3^-. However, a handful of varieties, including Condor and Spear grew significantly better on a mix of NH_4NO_3 than on either NH_4^+ or NO_3^-.

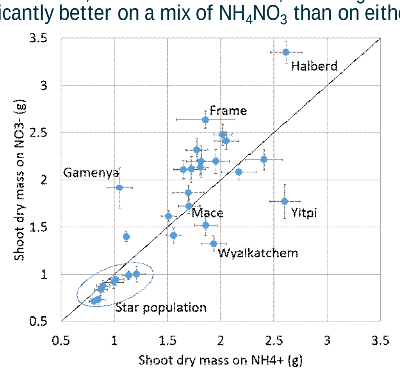

Figure 3: Comparison of shoot dry weight of plants grown on NH_4^+ versus NO_3^-. Genotypes falling below the 1:1 line produced more biomass on NH_4^+ while those above the line produced more biomass on NO_3^-. Error bars represent the standard error of the mean from eight replicates. Selected genotypes are indicated with labels.

FOR FURTHER INFORMATION
Dr Cathryn O'Sullivan
e Cathryn.osullivan@csiro.au
w www.csiro.au/ Agriculture and Food

REFERENCES
Fillery IRP, McInnes KJ (1992). *Australian Journal of Experimental Agriculture* 32, 887–899
Feil B (1994) *J. Plant Nutr*. 17, 717-728.
McDonald GK (1989) *Australian Journal of Experimental Agriculture*. 29: 455–481.
Palta JA, Yang J (2014) *Field Crops Research*. 165:1–4
Pang J, Palta JA, Rebetzke GJ, Milroy SP (2014) *Functional Plant Biology*. 41, 215-222.
Pang J, Milroy SP, Rebetzke GJ, Palta JA (2015) *Functional Plant Biology*, 2015, 42, 1179–1189
Sadras VO, Angus JF (2006) *Crop and Pasture Science*. 57: 847-856

ACKNOWLEDGEMENTS
[This work was funded by the CSIRO Agriculture and Food Strategic Investment Project program