Early vigor wheat genotypes have better N uptake

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Abstract

The extent and importance of differences in the efficiency of N uptake among wheat genotypes differing in early vigor were investigated in three experiments. Vigor 18, a wheat line with early vigor, and the current wheat cultivars Westonia, Tincurrin, Camm, and Janz were included in the studies. Shoot biomass and N uptake of Vigor 18 were higher than the other wheat cultivars regardless the level of N application. When plants were at tillering, Vigor 18 had higher root dry matter, root length, and root surface area. This early root growth of Vigor 18 resulted in higher N uptake. When Vigor 18 and Janz were grown in 0.5 and 1.5 mM NO_3^- nutrient solutions, differences in N uptake were apparent from tillering to booting. The specific absorption rates of nitrate of Vigor 18 were higher than those of Janz. The specific absorption rates of nitrate were correlated to the relative growth rate of shoots. The role of early vigor in improving N uptake efficiency in wheat is discussed.

Keywords

Root proliferation, vigorous growth, relative growth rate, root specific absorption rate.

Introduction

Genotypic differences in N uptake have been shown in wheat (1). These differences have typically been determined at final harvest in studies on the response of grain protein to soil N and fertiliser N. Whether these differences are determined by distinct genetic characteristics of the N uptake systems themselves or are consequences of differences in growth is an important agronomic question to be answered. The aim of this study was to determine the extent and importance of differences in the N uptake among wheat genotypes differing in early growth. Vigor 18, an experimental wheat genotype with early vigor, and the current wheat cultivars Westonia, Camm, Tincurrin and Janz were used in this study.

Methods

Experiment 1

A field trial was conducted over the May-November growing season of 2000 near Konnongorring, Western Australia. The soil is a sandy soil with the initial N level of 60 kg N/ha. A split-plot design with the wheat genotypes Vigor 18, Westonia, Camm, Tincurrin and Janz as main plots, and nitrogen application levels of 0 and 50 kg N/ha as sub-plots was used. Measurement of shoot biomass and total N were conducted at late tillering, 60 days after sowing (DAS) and at booting (90 DAS).

Experiment 2

An out-door lysimeter system study was conducted at CSIRO Floreat Park, Western Australia. Vigor 18 and Janz were grown in 1-m long PVC columns (0.24 m in diameter) filled with 0.1-m of topsoil from Moora field site and yellow sand. Water and KNO_3 were added to soil layers to match the NO_3^- concentration and the water content in a soil profile in the field site at Moora (2). Plants were sampled at tillering (35 DAS) to determine shoot biomass and N uptake. Soil was then sampled by sections of 0-0.1, 0.1-0.2, 0.2-0.4, 0.4-0.6, 0.6-0.8 and 0.8-1.0 m. Roots in each soil sample were recovered (3), root length and surface area were measured.

Experiment 3

In a nutrient solution study, wheat Vigor 18 and Janz were grown in a nutrient film technique system (NFT) in which the recycled nutrient solutions continuously flow over root systems under controlled conditions (4). A factorial design with 2 genotypes, and 2 NO_3^- concentrations (0.5 and 1.5 *mM* NO_3^-) was used. Plant shoot, root biomass, and N content were measured at transplanting, tillering, stem elongation and booting.

Results

The application of 50 kg N/ha, in the field trial, increased shoot biomass and N uptake in all genotypes by late tillering and booting. Differences in shoot biomass and N uptake were found among the genotypes, and there was a significant N ? genotype interaction in shoot biomass and N uptake. Vigor 18 had significantly higher (P=0.05) shoot biomass and N uptake than the other cultivars at a given N application and plant stage

In a lysimeter study, Vigor 18 had 115% more shoot biomass, 110% more root biomass and 91.3% higher root length than Janz at tillering. Root length density for Vigor 18 was greater than Janz in soil down to 0.6 m depth (Fig. 1). Nitrogen uptake by Vigor 18 was more than 2-fold higher than obtained for Janz.

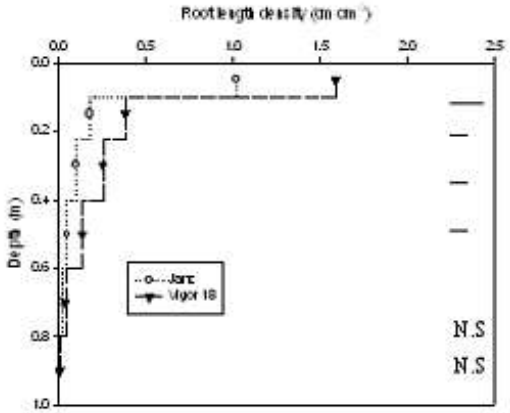

Fig. 1 Root proliferation within columns of soil for Vigor 18 and Janz at tillering. Outdoor lysimeter study.

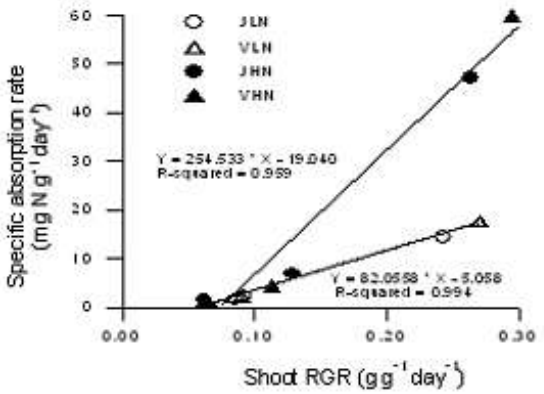

Fig. 2 The specific absorption rate of NO_3^- by roots of Vigor and Janz as determined using NFT system. J = Janz, V = Vigor 18, LN = 0.5 mM NO_3^-, HN = 1.5 mM NO_3^-.

Vigor 18 had higher biomass than Janz at tillering, stem elongation and booting, irrespective of the concentration of NO_3^- in nutrient solutions. The relative shoot growth rate of Vigor 18 was faster than that of Janz at tillering, but no differences were detected at later stages. Total NO_3^- uptake by Vigor 18 was higher than Janz at any given plant growth stage and irrespective of solution NO_3^- concentrations. The specific absorption rate (SAR) of NO_3^- by roots of Vigor 18 at tillering was higher than Janz and was closely related to shoot RGR at tillering (Fig. 2). The SAR of NO_3^- by roots of Vigor 18 was higher than those of Janz at tillering under the external NO_3^- concentrations where both the low affinity and high affinity NO_3^- transporter systems operate, suggesting that roots of Vigor 18 have higher NO_3^- absorption capacity than Janz.

Conclusion

It is concluded that early vigor in wheat is associated with early root growth which in turn leads to a higher NO_3^- uptake.

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References

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