Management effects on cumulative dry matter production and nitrogen uptake in wheat

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ABSTRACT

During the 1997 cropping season at Wagga Wagga, the effects of tillage, nitrogen fertiliser addition, and rotation, on the cumulative dry matter production and N uptake of wheat were investigated. Direct drilling in a wheat-lupin rotation resulted in rapid early growth and N uptake, compared with conventional cultivation. After early tillering, tillage method had little effect on dry matter yields and N uptake. Both nitrogen fertiliser, and inclusion of a legume in an annual wheat cropping system significantly increased dry matter yields and N uptake. While wheat grown in rotation with subterranean clover increased the uptake of N, compared with wheat grown after lupins, this did not lead to higher dry matter yields.

KEY WORDS

Crop rotation, nitrogen benefits, direct drilling.

INTRODUCTION

Nitrogen deficiency is common in NSW cropping systems. This leads to yield losses and protein reductions in wheat. To redress this, wheat is grown in rotation with other crops such as pulses (lupins, peas and faba beans) and pastures (usually based on subterranean clover), cultivation is minimised, and nitrogen fertilisers are used (1, 2). Many studies have investigated the effect of tillage, nitrogen fertiliser, and rotation, on nitrogen cycling and crop growth. Much of the research has focussed on nitrogen uptake and crop dry matter production at maturity. However there has been little data collected on the nitrogen uptake, or the accumulation of dry matter during the growing season. The objective of this study was to investigate the effect of these influences on the cumulative uptake of nitrogen and consequent dry matter production during the growing season of wheat.

MATERIALS AND METHODS

Treatments were selected from the SATWAGL (Sustainable Agriculture Through Wheat And Good Legumes) trial site located on a red kandosol at the Wagga Agricultural Institute. Each plot was 4.3 m wide and 50 m long. The treatments were replicated three times, and they were randomly assigned to each block. In 1997, all treatments were sown with wheat (*Triticum aestivum* var. Dollarbird) at 90 kg ha^{-1}. The stubble was retained on the tillage and rotation treatments, and burnt on the continuous wheat treatments. For the tillage comparisons of direct drill versus conventional cultivation, wheat was grown in rotation with lupins. Conventional cultivation within the latter rotation was compared with a wheat-clover system in which the clover was mown and mulched. The conventional cultivation treatment, the nitrogen fertiliser comparisons, and the wheat-clover rotation received three cultivations to a depth of 10 cm with a scarifier. The nitrogen fertilised treatment received a total of 100 kg N ha^{-1} as urea, which was broadcast at three times during growth. Wheat tops were cut at regular intervals, from the 2 leaf stage to final harvest. An area of 0.34 m^2 was cut from each plot at each sampling. The samples were dried and weighed to determine dry matter yield (DMY). The entire plant sample was ground and total nitrogen was determined using MicroKjeldahl digestion. The digest was analysed for NH^+_4 by a Bran and Leubbe TRAACS 800 continuous-flow analyser. One-way analysis of variance for each sampling time was used for the statistical analysis of the data using Genstat IV.

RESULTS

Growing season rainfall (April to October) at 281 mm was 14% lower than the long-term average, and the annual rainfall was characterised by a marked variability in monthly totals. Direct drilling (DD) significantly increased DMY of wheat at 29 and 63 days after sowing (DAS) (respective increases of 80% and 65%), exceeding conventional cultivation (CC) by 34 kg DM ha^{-1} at 29 DAS, and 219 kg DM ha^{-1} at 63 DAS (Figure 1a). From 63 DAS there was no significant tillage effect. Up to 63 DAS, DD wheat took up significantly more N than CC wheat, but from then on, the differences were not significant (Figure 1b).

Significant differences in DMY between zero N (-N) and plus N (+N) did not appear until 152 DAS, and they remained significant through to maturity (Figure 1a). At 190 DAS, plus N yielded 6,500 kg DM ha^{-1} more than the zero N treatment. Significant differences in N yield occurred from 119 DAS, at which stage plus N had taken up 73 kg N ha^{-1} and zero N had taken up 31 kg N ha^{-1} (Figure 1b). By final harvest, zero N had taken up 40 kg N ha^{-1}, whereas plus N had taken up 105 kg N ha^{-1}, an apparent recovery of 65% of the applied fertiliser.

There were no significant differences in DMY between wheat that was grown after sub-clover, and wheat grown after lupins, at any stage (Figure 1a). However, wheat grown after sub-clover took up significantly more N than wheat after lupins from 95 DAS to maturity (Figure 1b). At 181 DAS, wheat following sub-clover had taken up 136 kg N ha^{-1}, and wheat after lupins had taken up 94 kg N ha^{-1}. Both these treatments took up significantly more N than unfertilised continuous wheat.

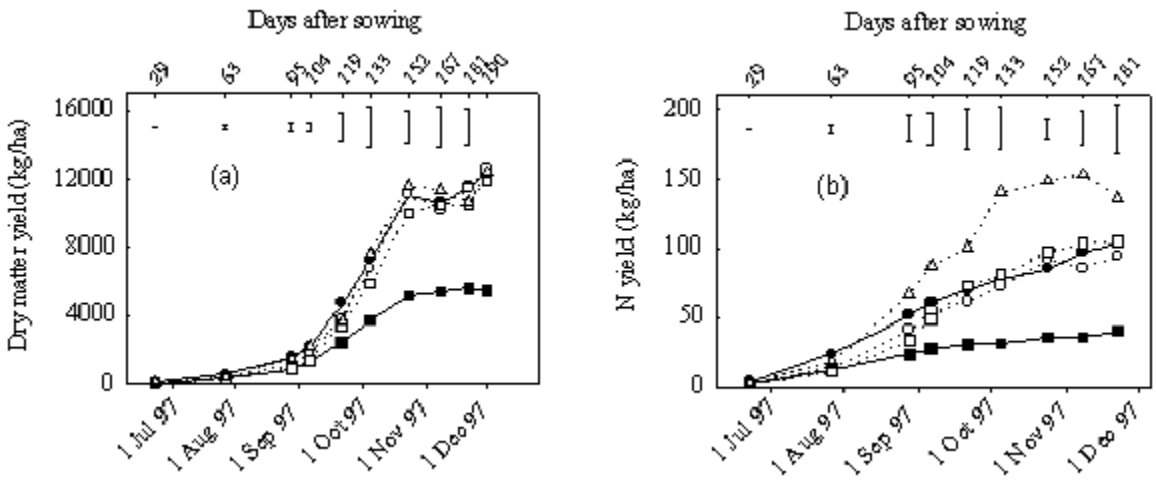

Figure 1. The effect of tillage, nitrogen fertiliser, and rotation on (a) cumulative dry matter yield and (b) cumulative nitrogen yield. (○) conventional cultivation lupin-wheat (●) direct drilled lupin-wheat (Δ) sub clover-wheat (■) wheat-wheat -N (□) wheat-wheat +N. Bars are LSD P=0.05.

DISCUSSION

Direct drilling significantly increased N uptake and DMY early in the crop's growth despite conventionally cultivated wheat having marginally higher levels of inorganic N in the 0–20 cm layer. The differences between the treatments at this stage were attributed to factors other than N supply. It is likely that more favourable moisture conditions occurred in the DD treatment.

The addition of N fertiliser in a three-way split allowed wheat to take up N for a longer period of time, compared with the unfertilised crop. Little N uptake occurred in the –N treatment after late tillering, suggesting that the soil N supply had been utilised.

The lack of any significant difference in DMY between wheat grown after lupins and wheat grown after sub-clover, even though the latter rotation significantly increased nitrogen supply, indicates that lupins improved the growing conditions for the following wheat crop in other ways. It is likely that lupins

increased the following wheat crops ability to utilise subsoil moisture due to its deeper tap rooting system and provision of old root channels (3). Additionally, the drier than average spring resulted in some “haying-off” in the sub-clover treatment (4).

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