The Impact of Late Applications of Nitrogen Fertilizer on the Yield and Grain Protein Content of Wheat in the Mediterranean-type Environment of Western Australia

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ABSTRACT
The efficacy of applying post-tillering fertilizer nitrogen on the yield and grain protein content in wheat was investigated in two successive seasons in the Mediterranean-type Environment of Western Australia. Maximum increases in grain yield of 0.6 t ha^{-1} and grain protein content of 1.7% occurred with uptake efficiencies of about 55% for the nitrogen applied at stem elongation in the season when the nitrogen status of the crop was high. In the season when the nitrogen status of the crop was low uptake efficiencies of about 70% for the nitrogen applied at stem elongation were not conducive to maximum increases in either grain yield and grain protein content.

INTRODUCTION
Recent increases in payments for grain protein content have made decisions on the application of fertilizer nitrogen to wheat more critical for profits. Grain yield and protein content in wheat crops in the Mediterranean-type environment of Western Australia can be increased by pre-tillering applications of fertilizer nitrogen through an improved early vegetative growth (Palta and Fillery 1995a; 1995b). However, the loss of soil water by deep drainage below the root zone in early winter when vegetative growth and N uptake is slow, is not always conducive to nitrogen uptake (Anderson et al 1998). Consequently, strategies that allow delays in decisions and expenditure on nitrogen fertilizer applications until later in the season when climatic conditions, yield potential, and grain prices are clearer are essential for the management of grain protein in this Mediterranean-type environment. We evaluated the effectiveness of post-tillering applications of nitrogen fertilizer on the yield and grain protein content of wheat crops grown under dryland conditions in the Mediterranean climatic region of Western Australia.

MATERIALS AND METHODS
Field experiments were conducted over the June-November growing season of 1997 and 1998 at Wongan Hills in the central wheatbelt of Western Australia (116^{o} 54' E., 30^{o} 43' S.). The experimental site is located in an area with an average of 390 mm of rainfall and the soil is a deep yellow earthy sand (UC 5.22, Northcote 1979; USDA Typic Xeric Psamment). In each year of the study the experimental site had been planted to wheat in the previous season. Wheat (*Triticum aestivum* L.) cv. Amery was sown on 4 June 1997 and cv. Kalannie on 10 June 1998 to a final density of 110 plants m^{-2}. At seeding superphosphate at 16 kg P ha^{-1} was drilled with the seed and two rates of nitrogen were applied in a randomized block design in four replicate plots. The nitrogen rates were Nil and 50 kg N ha^{-1} applied as topdressed urea. Post-tillering nitrogen at 30 kg N ha^{-1} was applied to these plots when the crop was at stem elongation (DC 25) booting (DC 42) and flowering (DC 61). Microplots (0.045 m^2, 5 plants) were established after sowing within each experimental plot and post-tillering nitrogen was applied as N^{15}-urea in order to quantify precisely the uptake and efficacy of late applications of nitrogen in increasing grain protein content.

RESULTS AND DISCUSSION
Rainfall during the 1997 growing season (Jun.-Nov.) at Wongan Hills was 217 mm, 40 mm less than the long-term average (Fig 1a). Under these conditions, maximum uptake efficiencies for the late applied nitrogen of about 55% occurred when nitrogen fertilizer was applied at stem elongation. The benefit from this application was an increase in grain yield and grain protein of 0.6 t ha^{-1} and 1.7% respectively, when nitrogen was applied at seeding and 1.6% in grain protein when nitrogen was not applied at seeding (Fig. 1b, c). Uptake efficiencies for the fertilizer nitrogen applied at booting was 32-

37% and the benefit from this application was an increase in grain protein content of 1.2% regardless of the nitrogen applied at seeding. Uptake efficiencies for the fertilizer nitrogen applied at flowering was about 7% and there were not benefits in grain yield or grain protein.

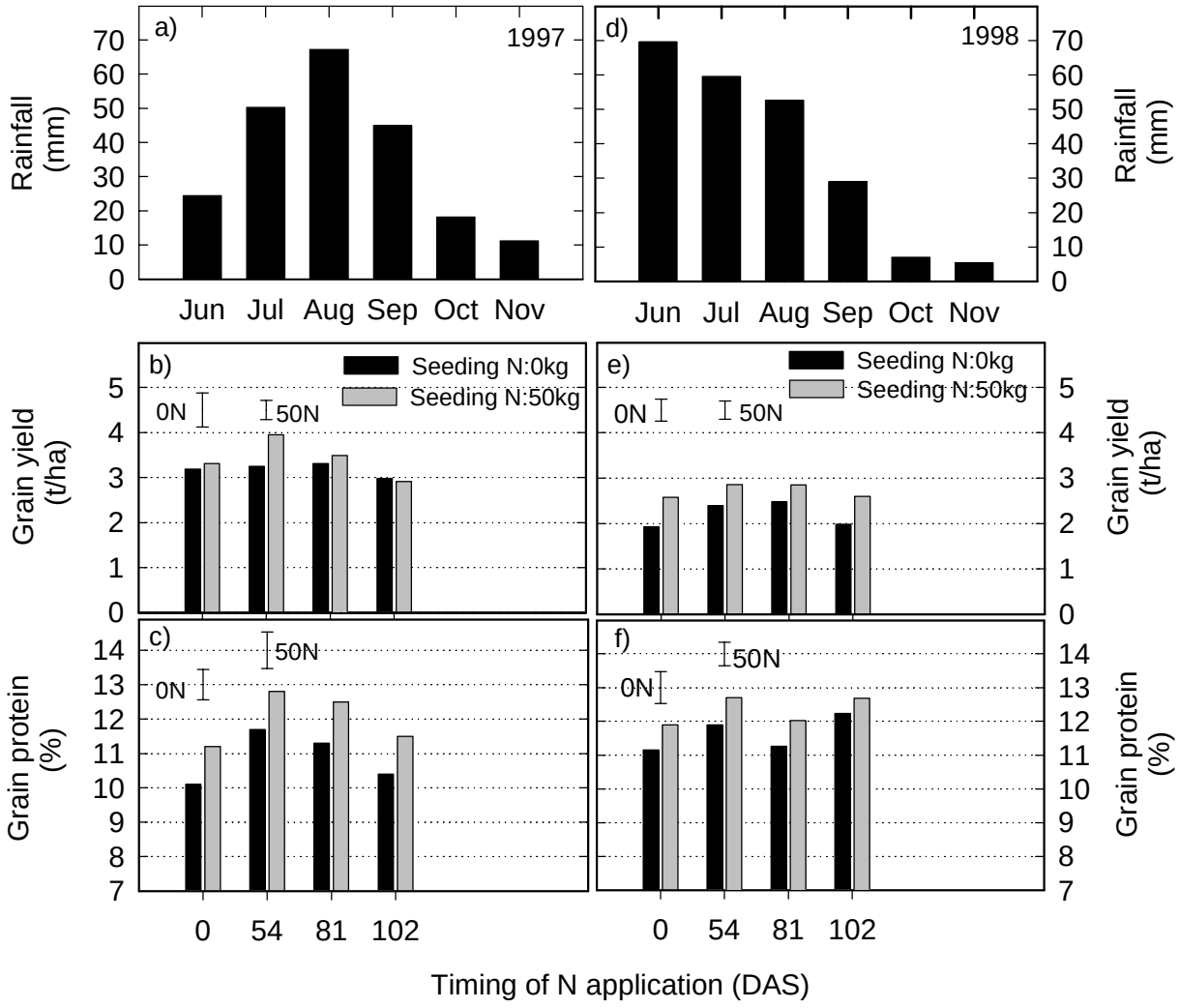

Fig.1. Monthly rainfall at Wongan Hills during the growing season of 1997 (a) and 1998 (b), and the impact of applications of fertilizer nitrogen at stem elongation (54 DAS), booting (81 DAS) and flowering (102 DAS) on the grain yield (b, c) and grain protein content (d, f) of wheat that received at seeding no nitrogen (black bars) or 50 kg N ha^{-1} (grey bars).

Rainfall during the 1998 growing season of 220 mm was similar to that in 1997, but the 50 mm extra that fell in the first 15 days after seeding (Fig 1d), presumably caused water and nitrogen losses by deep drainage (Fillery 2001). Under these conditions, maximum uptake efficiencies for the late applied nitrogen of about 69% occurred when nitrogen fertilizer was applied at stem elongation. The benefit from this application was an increase in grain yield of 0.4 t/ha^{-1} and grain protein of 0.8% regardless of the nitrogen applied at seeding (Fig.1e, f). Uptake efficiencies for the fertilizer nitrogen applied at booting was 30% and the benefit from this application was an increase in grain yield of 0.5 t ha^{-1} when nitrogen was not applied. Uptake efficiencies for the fertilizer nitrogen applied at flowering was about 16% and the advantage from this application was 1% increase in grain protein.

CONCLUSION

Increases in wheat grain yield and grain protein content from post-tillering applications of fertilizer nitrogen can be achieve in seasons when water and nitrogen losses by deep drainage after seeding are

minimum and when significant rains after stem elongation are capable to keep the soil surface moist for long enough to allow the fertilizer nitrogen to be taken up by the crop.

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