Response of wheat to split application of nitrogen on a leaching sandy soil

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Abstract

Light sandy soils prevalent throughout the Western Australian wheatbelt suffer from nitrogen (N) leaching , particularly in the high rainfall zone. We evaluated the benefits of N splitting under local conditions and compared N splitting strategies namely, all at seeding vs splitting according to age, phenological development or tactical (application after 20 mm of rainfall events) using the commonly grown bread wheat varieties , Carnamah, EGA Bonnie Rock, GBA Ruby and Wyalkatchem over two years at Muresk in the central wheatbelt of Western Australia.

In 2004, despite visual differences during early crop growth, split application did not show any benefit and we attribute the lack of grain yield response to the heavy rains (25ml over two days) that followed tactical application at tillering. In 2005, splitting 120 kg N/ha according to phenological stages (30 kg applied at seeding, Z-20, Z-30, Z-50 stages) was the best splitting strategy, but its comparison with the potentially promising tactical splitting (30 kg at seeding followed by 30 kg doses after 25ml rainfall events) remained untested as the latter received only 90 kg since there were only two rainfall events that met the application criterion. The economic efficiency was evident for the tactical treatment however, as cost savings on N quantity (30 kg of N/ha) or higher gross income (about $100/ha) through greater grain yield and/or higher protein.

Based on these two years results and grower feedback, we conclude that split applications have a merit on leaching soils; splitting may be done according to age, development stage or rainfall intensity, but apparently a criterion combining tactical and crop development needs to be further investigated.

Key Words

wheat, nitrogen leaching, sandy soils, N-fertiliser, split application, waterlogging,

Introduction

Managing timing of N application in wheat growing on soils with leaching conditions is a worldwide problem especially on light textured sandy soils in medium-high rainfall areas where rainfall events >20mm over two days are frequent. Evidence suggests that when intensity of leaching is only light (small rainfall events, clay/loamy soils, good soil structure, high organic carbon), roots can generally keep pace with the moving nitrate (Halse et al. 1969), but such conditions are not common in Western Australia, especially in the high rainfall areas.

It is understood that when N moves down the profile faster than root growth, its availability later in the season depends on soil depth. In deep sandy soils, the N gets washed out of the effective root zone, while on shallow duplex soils transient waterlogging above the clay layer can affect N uptake. Splitting N applications has been practiced worldwide to tackle such situations and this splitting is generally done according to time after sowing or development stage of the crop. Recent work in WA (N. Simpson, unpublished) has indicated that alternative splitting strategies might have merit and further research is needed.

The experiments reported here were aimed at increasing grower profits through strategic application of N in wheat. As such, the planned objectives were: (a) to evaluate the benefits of N splitting under local conditions, (b) to compare different N splitting strategies and c) to investigate if wheat cultivars differed for N response so as to evaluate if variety specific research will be needed should the strategy prove its economic merit.

Methods

Four wheat varieties Carnamah (Australian Hard), EGA Bonnie Rock (AH), GBA Ruby (Australian Standard White) and Wyalkatchem (Australian Premium White), were sown in a randomised split block design with N treatments as main plots and varieties as subplots in two experiments on a sandy duplex (grey sand over clay at 30-60cm depth) soil at Muresk (116.68^{o}E, 31.75^{o}S) in 2004 and 2005. The previous crop in the two years was barley and wheat, respectively.

The N treatments differed slightly in the two years, but overall comparisons of splitting vs. no splitting and among different strategies were possible. In 2004, treatments were based on variation of N dose at growth stages while in 2005 a comparison of strategies was made. In 2004, the growth stages were: Z-0 (at seeding), Z-14 (four leaves emerged) and Z-65 (mid anthesis). Calender dates for the three timings were 10 June, 5 July and 14 October, respectively. The Z-0 and Z-14 applications were made with urea while flexi-N was used for the last application. In 2005, the treatments were: i) nil nitrogen; ii) 120 kg N applied at seeding; (iii) 30 kg at seeding followed by 3 doses of 30 kg each at 3 weeks intervals; (iv) 30 kg at seeding followed by 30 kg applied at each of the Z-20, Z-30 and Z-50 phenological stages; and, (v) 30kg applied at seeding followed by 30kg applied after each rainfall event that exceeded 25ml (a total of 90 kg/ha of N).

Both experiments were sown using a cone seeder. Plot size was (20 m x 1.44m) 28.8 m^2. Standard crop management practices including district average phosphorous and potassium fertiliser levels were applied. Grain yield, yield components and small grain screenings were recorded as detailed elsewhere (Sharma and Anderson 2004) while grain protein percentage was estimated using NIR reflectance.

Results

In 2004, the N dose applied at Z-14 was followed by heavy rains (25 ml) within a week. The application at Z-65 was followed by dry weather. Treatments wherein N application was deferred (especially 0-50-0) appeared relatively greener and healthier until ear emergence in comparison to treatments where the same amount was applied at seeding (50-0-0), but all such visible differences disappeared later in the season. The results suggested that the total pre-anthesis application was most important; and among treatments with the same level of total pre-anthesis application, the treatments with the greater application at seeding rather than those with deferred application, yielded the most (Figure 1).

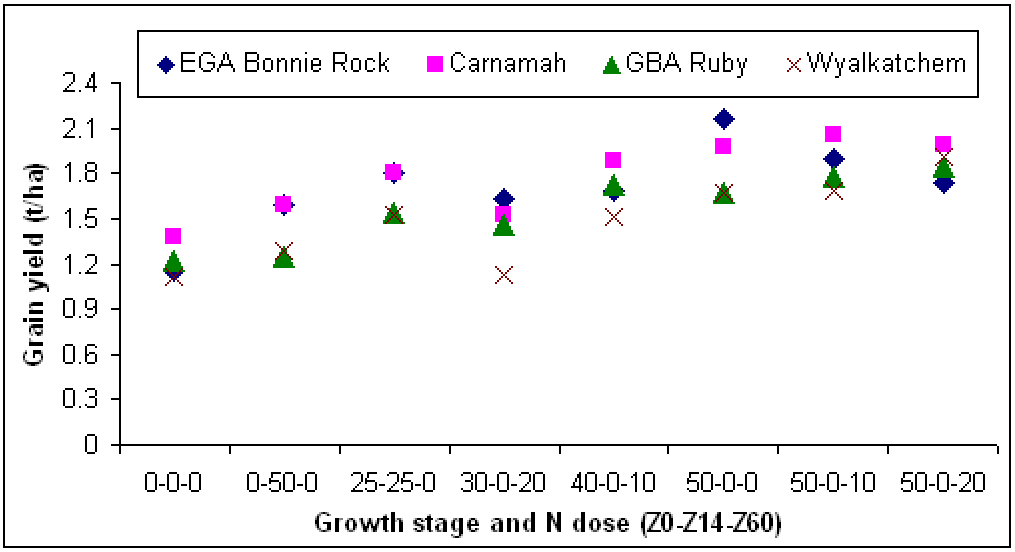

Figure 1. Grain yield of four wheat varieties with eight strategies of N application at Muresk in 2004. The three numbers separated by hyphens in the figure represent the kilograms of N applied at the three growth stages, Z0 (at seeding), Z14 (four leaves emerged) & Z60 (anthesis)

In 2005, the average grain yield and grain protein improved with split application (Figure 2). Compared to the nil treatment, a yield response of at least 70% was evident, which is not surprising given that cereal crops were grown in that paddock for the third consecutive year. However, the yields were not statistically different between the two N-splitting strategies that received 120kg N/ha. Economic differences were also consistent when gross income was compared following 'Golden Rewards' matrices from the Australian Wheat Board 2005. Splitting 120 kg N/ha according to phenological stages (30 kg at seeding, Z-20, Z-30, Z-50 stages) was the best splitting tactic, but its comparison with the potentially promising tactical splitting (30kg at seeding followed by 30kg doses after 25ml rain events) remained untested as the latter received only 90kg since there were only two rainfall events that met the criterion. The economic efficiency was hence evident for the tactical treatment, as cost savings on N quantity (30 kg of N/ha) or higher gross income (about $100/ha) through greater grain yield and/or higher protein.

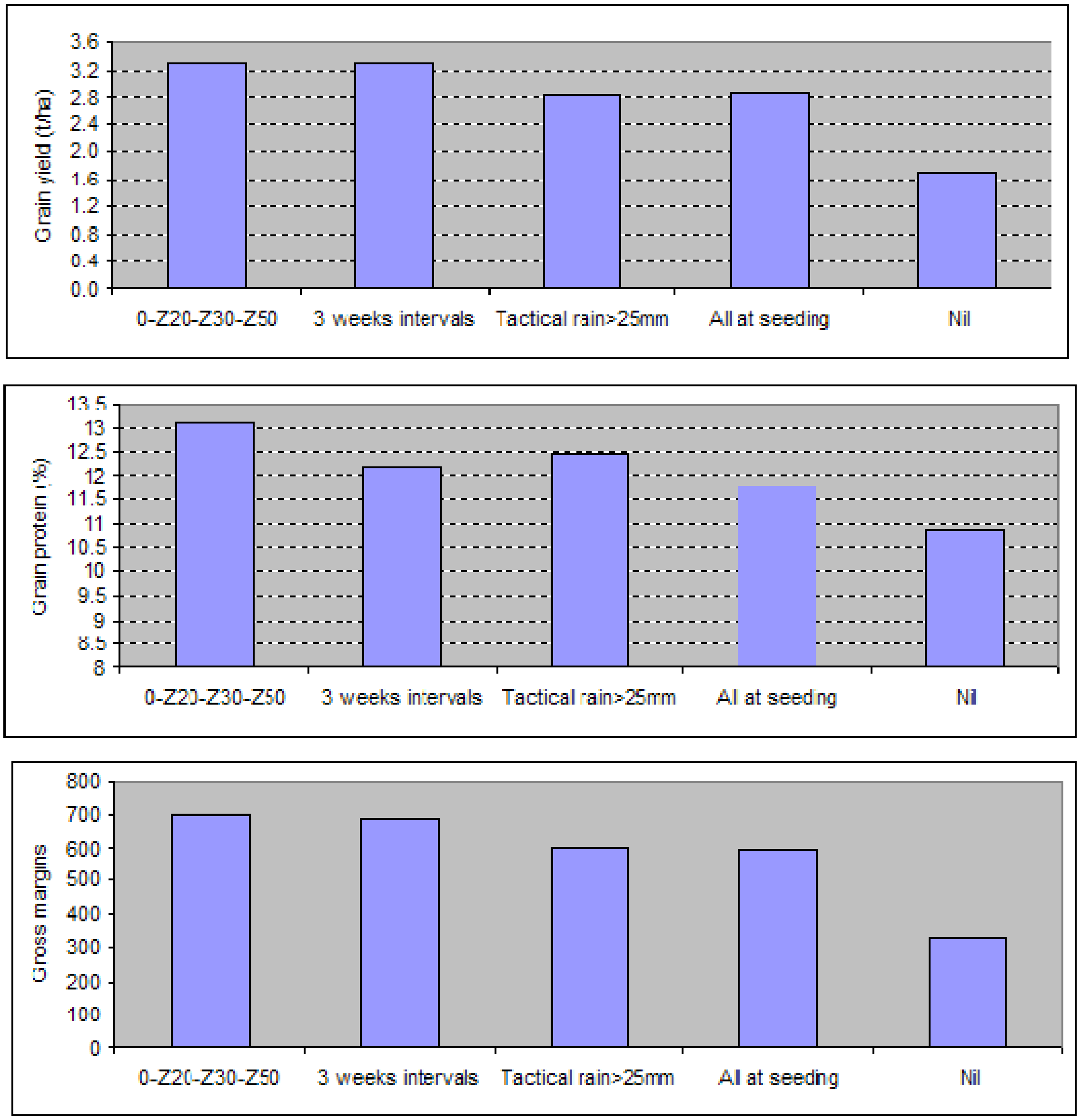

Figure 2. Average grain yield, protein and gross margins of wheat following different N application strategies in 2005. Dashed lines are one lsd apart.

Conclusion

The results confirm that economic efficiency of N fertilization of wheat crops grown under leaching conditions can be enhanced by split applications. However, the grower feedback suggests that the number of splits could be an issue of feasibility and needs further research. Secondly, given the retrospective nature of conclusions drawn here, a splitting guidance tool that can be proactively used to manage seasonal risk and opportunities under local conditions needs to be developed. We anticipate that a criterion combining tactical and crop development will provide an answer to such situations in WA.

References

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