# Strategic nitrogen application for weed suppression in wheat

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**Summary** The need to improve nitrogen use efficiency and increase wheat yield and quality has recently lead to an examination by growers and agronomists of alternatives to pre-sowing applications of nitrogen for wheat crops. These studies have generally been done in the absence of weeds. These days herbicide-resistant *Lolium rigidum* (annual ryegrass) cv. Guad, is a widespread problem and maintaining weed-numbers below critical thresholds may not be possible. *L. rigidum* is known to be strongly nitrophyllic, and changes in the availability of nitrogen are likely to alter the weed/crop competition interaction. In this study, a comparison was made of a range of different application methods and timings of nitrogen to both weed-free and wheat infested with *L. rigidum*. The aim of the study was to determine the potential of strategic placement and timing of nitrogen applications to enhance the competitive ability of the crop to suppress weeds. In the absence of weeds, the method of application did not significantly affect yield. Even though weeds reduced yield, the reduction varied depending on the nitrogen application method and timing. In 2000, in the presence of weeds when nitrogen was broadcast pre-sowing there was a yield loss of 1.85 t $ha^{-1}$, compared with a loss of only 0.66 t $ha^{-1}$ when nitrogen was banded below the seed at planting. Weed seed production increased correspondingly with crop yield loss. The reliability of this technique needs to be evaluated under a wider range of environments, combined with different split-applications, and with changing agronomic practices (e.g. higher seeding rates). The experiments need to be extended to study a wider range of weed species.

**Keywords** Nitrogen application and timing, weed competition, weeds, herbicide resistance.

## INTRODUCTION

With the onset of herbicide resistance, more integrated methods for weed control are required to reduce the impact of weeds on crop yields and economic returns. *L. rigidum* has developed resistance to six mode of action groups and has been the main contributor to Australia's herbicide resistance problem (Preston *et al*. 1999). The development of herbicide resistance, high herbicide costs (approximately $1.2 billion per annum in annual cropping systems) and environmental concerns require a more targeted approach to reduce our current high reliance on herbicides. Approximately 90% of farmers regard weeds as the major problem in annual cropping systems (Almseged *et al*. 1999)

Annual weeds, particularly *L. rigidum* have continued to flourish in annual cropping systems, due in part to the development of herbicide resistance. Integrated Weed Management (IWM) can reduce the weed seedbank, as well as reducing the reliance on herbicides (Walker *et al*. 1999). Selecting for more competitive wheat varieties is another method for reducing seed production from *L. rigidum* (Lemerle *et al*. 2001). The way nitrogen is applied to crops is another tactic that can lessen weed competition and improve crop yields. *L. rigidum* is an excellent scavenger for nutrients and has the capacity to compete strongly for nitrogen, reducing the amount available to wheat during grain filling, thereby reducing yield. In a mixed sward some annual weed species (*Chenopodium album*, *Sinapis arvensis*) improve their competitive ability when additional nitrogen is applied (Iqbal and Wright 1997). *L. rigidum* was found to compete well for late nitrogen when sown with barley. This coincided with competition during ear formation, producing reduced grain yields in comparison to non weedy controls (Ponce 1998). By manipulating where fertiliser is placed, crop competitiveness can be enhanced and weeds disadvantaged. The timing of nitrogen application can have a detrimental effect on crop yield. Early or pre-sowing applications can promote weed germination and growth, and suppress crop biomass (Liebman and Davis 2000). This paper reports on the response of *L. rigidum* production and wheat yield to different types of nitrogen placement and timing at two field sites in the Wagga Wagga region, NSW in 2000 and 2001.

## MATERIALS AND METHODS

Two experimental sites were established, one in 2000 at the Wagga Wagga Agricultural Research Institute (WWAI), and the second at Ganmain 25 km west of Wagga Wagga in 2001. In-crop rainfall in season 2000 at WWAI was 422 mm, compared to the long-term average (103 years) of 336 mm. The soil is a red brown earth, pH of 4.9 in $CaCl_2$. A pre-sowing soil test showed mineral nitrogen levels of 155 kg $ha^{-1}$ 0–90 cm. At Ganmain, in-crop rainfall for season 2001 was

221 mm. The soil is a clay loam, pH 4.7 ($CaCl_2$) with 90 kg ha$^{-1}$ of mineral nitrogen in 0–90 cm.

The experiments were established in fields following a canola crop in an attempt to limit soil nitrogen levels and to minimise the impact of cereal root diseases. The WWAI site contained a medium density of *L. rigidum* with group A herbicide resistance. The experimental area at both sites was sprayed with 2 L ha$^{-1}$ of Touchdown BA® (a.i. glyphosate-trimesium) pre-sowing.

**Experimental design** The experiments were a split-split plot design with three replications sown in paired plots, with and without *L. rigidum*. Main plots, nitrogen application (N1–N8), sub-plots, weed treatment (W1–W2), sub-sub plots, harvest areas (H1–H2). Nitrogen treatments were N1 broadcast, Incorporate by Sowing (IBS), N2 banded under row, N3 banded mid-row, N4 banded slow release, N5 top-dress Decimal Code (DC) 31, N6 half rate broadcast + half top-dress, N7 half mid-row banded + half top-dress, N8 zero nitrogen.

**Plot husbandry** Weed free treatments (W1) were sprayed with a post-sowing, pre-emergent application of 20 g ha$^{-1}$ Logran® (a.i. triasulfuron) and 1 L ha$^{-1}$ of Stomp® (a.i. pendamethalin), weedy plots were sown with *L. rigidum* cv. Guad to achieve a target population of 250 plants m$^{-2}$. Sub-sub plots were harvest areas H1 (destructive plant harvests) and H2 grain harvest.

Plots were 20 m long and 1.85 m (8 rows × 22.5 cm) wide. Wheat cultivar Diamondbird was sown at 80 kg ha$^{-1}$, with 150 kg ha$^{-1}$ of triple superphosphate banded under the row. Nitrogen treatments were applied as 174 kg ha$^{-1}$ of urea. At WWAI all treatments were sprayed with 2,4-D amine 500 at 2 L ha$^{-1}$ (a.i. dimethyl amine salt) for wild radish (*Raphanus raphanistrum* (L) control on 18 August 2000. At Ganmain, a mixture of 1 L ha$^{-1}$ Tigrex® (a.i. ethyl hexyl ester + diflufenican) and 5 g ha$^{-1}$ Ally® (a.i. metsulfuron-methyl) was used to control *R. raphanistrum* and shepherds purse (*Capsella bursa-pastoris* (L.Medikus) on 11 September 2000.

**Crop measurements** Crop establishment at both sites was measured by counting two rows × 50 cm rods in ten random locations at approximately the 3-leaf stage of the crop. *L. rigidum* numbers were measured using ten 0.1 m$^2$ quadrats per plot. In 2000, destructive harvests at DC24 (Zadoks *et al*. 1974) were taken for N content of leaf tissue (10 plants per plot). At DC33 area harvests of 50 cm × four internal rows of each plot from H1 sub-sub plots were taken with biomass, N content and tiller numbers recorded at both sites. A harvest at DC42 at WWAI and DC 52 at Ganmain from internal four rows × 50 cm measured N content and crop biomass. Height measurements were taken at DC 55 at WWAI in 2000 recording differences between weedy and weed free plots. Crop anthesis occurred on 11 October 2000 at WWAI and 15 October 2001 at Ganmain. Crop and weed material was cut to ground level in 50 cm × four internal rows of each plot for separation to calculate weed and crop biomass production and nitrogen uptake of the crop.

Grain yield at both sites was measured using a Kingaroy plot harvester to harvest whole plots, and the grain sub sampled for grain quality measurements, i.e. screenings and protein.

## RESULTS

Crop and *L. rigidum* establishment values for WWAI in 2000 are shown in Table 1. Crop establishment in the weed free plots was impacted by herbicide tolerance, resulting in up to a 25% reduction in seedling establishment.

**Table 1.** Establishment plants m$^{-2}$ crop and *L. rigidum* WWAI 2000.

| Nitrogen application | Wheat - ARG | Wheat + ARG | *L. rigidum* |
|---|---|---|---|
| N1 | 140 | 175 | 434 |
| N2 | 131 | 154 | 346 |
| N3 | 151 | 169 | 329 |
| N4 | 150 | 167 | 318 |
| N5 | 141 | 187 | 331 |
| N6 | 150 | 184 | 383 |
| N7 | 148 | 185 | 346 |
| N8 | 151 | 165 | 396 |

ARG = annual ryegrass.

**Table 2**. Establishment numbers for crop and *L. rigidum*, Ganmain 2001.

| Nitrogen application | Wheat - ARG | Wheat + ARG | *L. rigidum* |
|---|---|---|---|
| N1 | 128 | 126 | 139 |
| N2 | 130 | 137 | 133 |
| N3 | 132 | 129 | 126 |
| N4 | 129 | 140 | 112 |
| N5 | 128 | 125 | 139 |
| N6 | 122 | 130 | 125 |
| N7 | 125 | 123 | 136 |
| N8 | 131 | 120 | 124 |

The dry autumn and late season break, and marginal moisture at sowing (Table 2) resulted in reduced crop and *L. rigidum* establishment at Ganmain in 2001. Figure 1 shows the effects of nitrogen application on the grain yields of wheat plus and minus *L. rigidum* at WWAI in 2000. The combined effect of nitrogen placement and presence of weeds reduced yields (Figure 1). Damage to weed free crops from Logran® was evident at stem elongation (DC30) and early booting (DC43) but did not result in yield loss. However, the dry spring reduced the moisture available to the crop during grain fill. This was especially evident in crops with high biomass and increased tiller numbers. Crops that produced large amounts of early biomass yielded less than crops that accessed nitrogen later in the season.

The pressure from weeds during grain filling reduced yield in comparison to weed-free plots by as much as 28% at WWAI in 2000 (Table 3).

In the presence of weeds higher yields were achieved by banding under crop row or half broadcast + half top-dress. Yield loss caused by weeds was influenced by how nitrogen was applied (Table 3). Nitrogen was more available to weeds when broadcast or banded mid-row, resulting in increased competition between weeds and crop reducing grain yield (Figure 1).

## DISCUSSION

Yields at Ganmain in 2001 were reduced due to the below average rainfall. The largest reduction in yield in the presence of weeds occurred in treatments N5 (18%), N6 (23%) and N1 (11%), respectively (Figure 2). Banding nitrogen under the crop had a positive impact on yield, as did splitting the application between mid row banding and topdressing at DC 31. In season 2001, crops that produced large amounts of early biomass had insufficient resources left to fill grain. In the absence of weeds, a tactical application of nitrogen (top-dress DC31) produced the best yields. These trends are similar to 2000 results suggesting nitrogen application plays a major role in competition between weeds and crop.

Results from this experiment suggest that nitrogen placement can be used as a tool in an IWM plan. If weed seed production can be limited, seed banks will decline quickly over time in an integrated approach to weed control. The best way to apply nitrogen will vary depending on seasonal conditions, soil nitrogen levels, disease and whether weeds are absent or present. In

**Table 3**. Percentage reduction in wheat yield when *L. rigidum* is present.

| Nitrogen application | Treatment | Reduction % |
|---|---|---|
| Broadcast (IBS) | N1 | 28 |
| Banded under row | N2 | 10 |
| Banded mid-row | N3 | 14 |
| Banded slow release | N4 | 16 |
| Top-dress DC31 | N5 | 19 |
| Half rate broadcast + half rate top-dress | N6 | 20 |
| Half rate mid-row banded + half rate top-dress | N7 | 16 |
| Zero nitrogen | N8 | 17 |

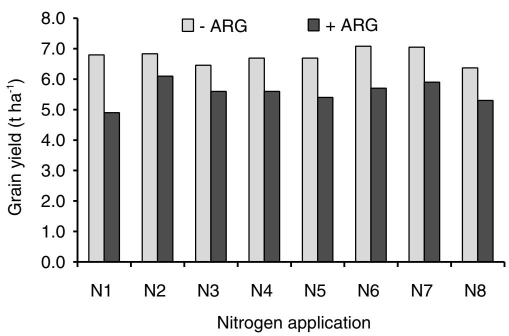


**Figure 1.** Effect of nitrogen placement and weeds on wheat yield (t ha$^{-1}$), WWAI 2000 (N1 broadcast IBS, N2 banded under row, N3 banded mid-row, N4 banded slow release, N5 top-dress DC31, N6 half broadcast + half top-dress, N7 half mid-row banded + half top-dress, N8 zero nitrogen). ARG = annual ryegrass LSD = 0.73.

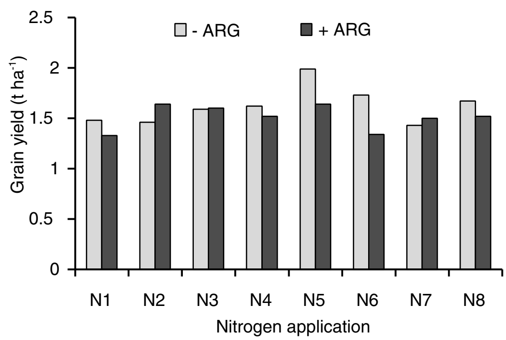


**Figure 2.** Effect of nitrogen placement and weeds on wheat yields, (t ha$^{-1}$) Ganmain 2001 (N1 broadcast IBS, N2 banded under row, N3 banded mid-row, N4 banded slow release, N5 top-dress DC31, N6 half broadcast + half top-dress, N7 half mid-row banded + half top-dress, N8 zero nitrogen). ARG = annual ryegrass LSD = 0.44.

the absence of weeds in season 2000, the method of application did not greatly affect yield. If high soil nitrogen levels are measured or high shoot densities recorded and weeds are a problem, delaying nitrogen application and top-dressing at DC31 will be beneficial to yield. When soil nitrogen levels and shoot densities are high it is possible in the eastern Riverina to delay nitrogen applications as late as flowering if suitable crop moisture is available. A tactical approach to nitrogen application as part of an IWM strategy will reduce the production of excessive weed biomass and limit replenishment of the weed seedbank. This has repercussions for herbicide use and delaying the onset of herbicide resistance. If a pre-sowing soil test shows high levels of nitrogen, then delaying the application of nitrogenous fertiliser will be beneficial to wheat yield if weeds are a problem. When dealing with herbicide resistant weeds, fertiliser application can play a role in reducing weed vigour and seed production. This provides farmers with another option in managing problem weeds. Further studies are required over a wider range of environments to fully understand the relationship between nitrogen placement in an IWM strategy.

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