Is splitting N fertiliser a more efficient strategy?

More Profit from Nitrogen (MPfN): enhancing the nitrogen use efficiency of intensive cropping and pasture systems is a four year partnership between Australia's four major intensive users of nitrogenous fertilisers: cotton, dairy, sugar and horticulture. For each of these industries, nitrogen (N) is a significant input cost to producers and a substantial contributor to environmental footprints. Collectively, the program aims to bring about increased farm profitability and reduced environmental impact by increasing nitrogen use efficiency (NUE), resulting in a reduction of the amount of N required in producing each unit of product.

To achieve improved NUE, the program is striving to deliver three major outcomes:

- Greater knowledge and understanding of the interplay of soil, weather, climatic and farm management factors to optimise N formulation, rate and timing across industries, farming regions and irrigated/ non-irrigated situations;
- Greater knowledge and understanding of the contribution (quantifying rate and timing) of mineralisation to a crop or pasture's nitrogen budget; and
- Greater knowledge and understanding of how enhanced efficiency fertiliser (EEF) formulations can better match a crop or pasture's specific N requirements.

MPfN is supported by $5.9 million funding from the Australian Government's Rural Research and Development (R&D) for Profit program over four years, with a further $9.8 million cash and in-kind contribution from each of the industry sectors, research organisations and collaborating partners.

The **NSW irrigated cotton** phase of the project is being led by Dr Graeme Schwenke (NSW Department of Primary Industries) with Dr Guna Nachimuthu and Jon Baird, -in partnership with CSIRO (Dr Ben Macdonald) and University of Melbourne (Dr Helen Suter).

The NSW MPfN Cotton Project recently conducted a core-site field experiment at the Australian Cotton Research Institute (2017–2018 summer). The experiment aimed to test a variety of irrigation and N fertiliser management treatments for their impacts on cotton lint yield, fertiliser N use efficiency and N losses. After soil testing to determine the pre-trial soil nitrate levels, a fertiliser rate (112 kg/ha) was chosen to make the total N available to the crop just below the optimum amount, so that the benefits of reduced N loss might be seen in the agronomic results. Some of the treatments were repeated under two different irrigation deficit regimes, 50 mm and 70 mm. Some of the key findings are summarized below.

Irrigation deficit x Nitrogen application timing.

The timing of N fertiliser application affected maximum plant height, with the 100% upfront N application resulting in taller plants (94 cm – averaged across the two deficits) compared to the 100% in-crop applied N treatment (86 cm). The two split N application treatments (70:30 and 30:70) were in between. These results show that applying all the required fertiliser N before the growing season resulted in more vegetative plant growth, while a late application management strategy reduced vegetative plant growth.

Interestingly, there was an interaction between the timing of N fertiliser application and the irrigation deficit. The number of bolls retained on the 1st fruiting position within the 5th and 15th node range were greater on the earlier N timing applications (100:0 pre-plant and 70:30 split) for the 70 mm irrigation deficit. Conversely the 50 mm irrigation deficit had higher 1st position boll numbers with the higher amount of in crop N application (0:100 in-crop and 30:70 split).

Yield-wise, both deficit and N application timing main effects were significant, with 50 mm > 70 mm, and 30:70 = 70:30 = 0:100 > 100:0 but there was no interaction between deficit and N timing (Figure 1). As the total N added was the same, the fNUE results followed the same pattern as the yields. Leaf N% was affected by N treatment with the 100:0 and 70:30 showing higher %N than 0:100 and 30:70 in mid-December, but there were no treatment differences found in leaves sampled later in the season.

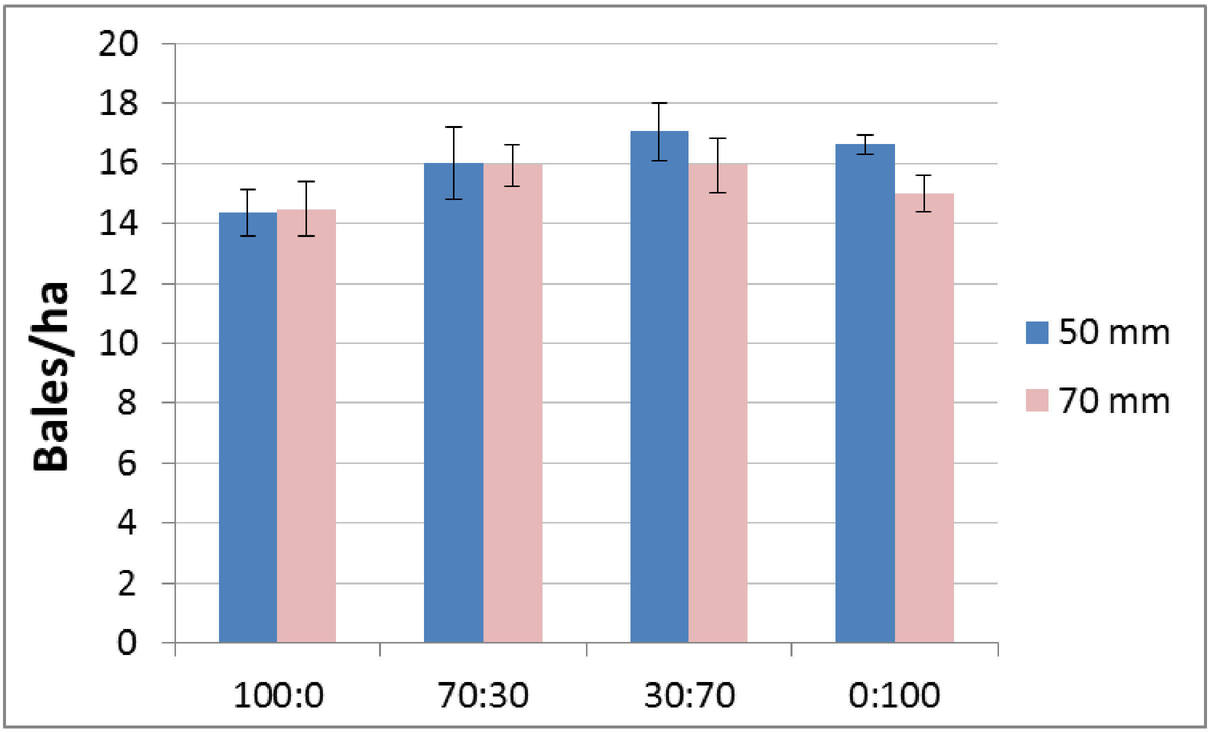

Figure 1. Irrigation deficit (50mm, 70mm) and N split timing (100:0, 70:30, 30:70, 0:100). Pre-plant was in September and in-crop N was applied in early December, late December and early January.

Modifying the N application timing also affected the amount of N in runoff water, with greater net loss of N (predominantly as nitrate-N) coming from the 100:0 treatment, then the 70:30 treatment, then the other two timing treatments (Table 1). After accounting for N losses from nil-N plots, these losses totalled up to 24% of all the N applied as fertiliser. At the end of the season, the earlier-applied treatments had less residual mineral N in the soil than those where more or all N fertiliser was applied in-crop.

Table 1. Net nitrate N loss in runoff water (kg N/ha) was affected by N application timing.

Deficit / timing	0:100	30:70	70:30	100:0	LSD (least significant difference)
50 mm	7.3	11.9	20.5	34.0	4.6 (N treatment)
70 mm	11.3	15.8	32.6	35.6	

In crop applications at 30:70 split

The method of in-crop N application significantly increased dry matter production, with the direct-drilled side-dress application resulting in 14.3 t/ha of dry matter, while the surface-broadcast method resulted in 11.6 t/ha (2.6 t/ha lower). There was no treatment difference between the three water-run N products of UAN, N26(urea) and Ammonia (12.7, 13.4, and 12.7 t/ha, respectively). When comparing the broadcast urea treatments of urea and NV-coated urea (urease inhibitor), we found no difference in plant matter production, but both produced less biomass than the side-dress urea treatment (Figure 2).

The various in-crop N products did not have any impact on cotton plant growth measurements, nor on lint yield (Figure 3), turnout, or fNUE. Leaf N% was affected on 18th January, with the water-run ammonia plots lower in N than all others.

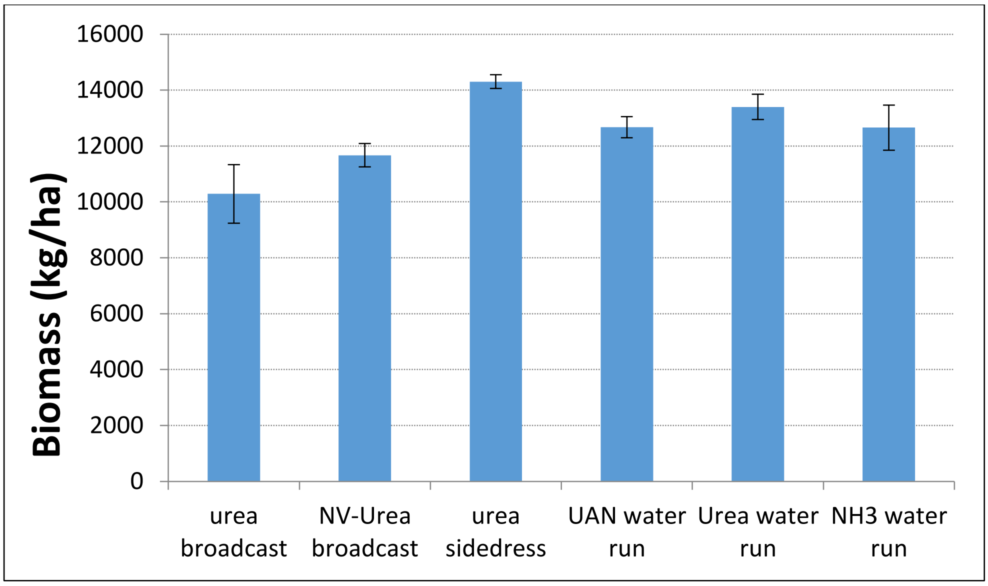

Figure 2. Biomass (kg/ha) for the deficit irrigation by product/application experiment .

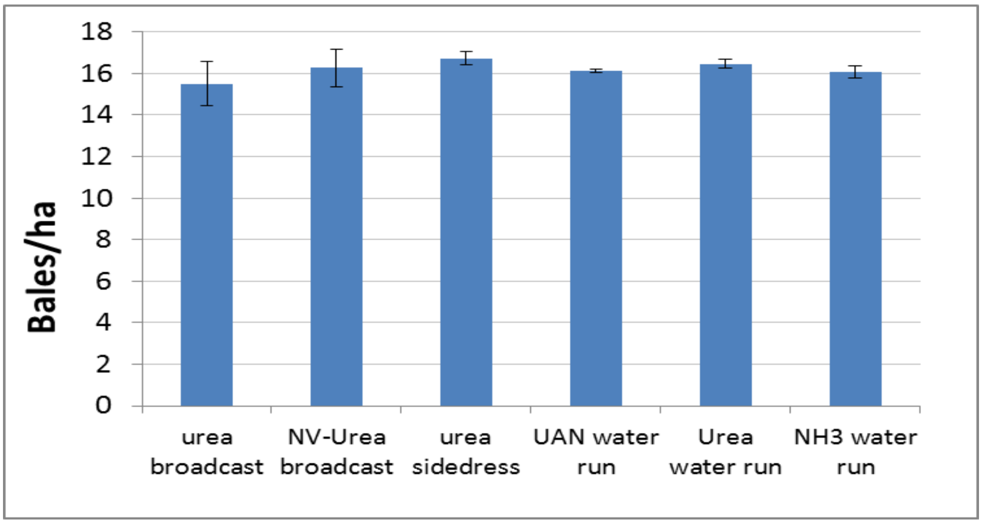

Figure 3. Biomass (kg/ha) for the deficit irrigation by product/application experiment.

In terms of net N runoff from the field, broadcast urea was lowest (14.7% of applied N), sidedress N slightly more (20.5%), and the three water-run treatments much greater, with ammonia (25.5%), UAN (30.9%) and water-run urea (34.8%). The N in the runoff water included nitrate (nitrified from pre-crop urea then mobilised during initial irrigations, also significant from water-run UAN), ammonia (main N loss from water-run ammonia but also significant from water-run UAN), and urea (main N loss from water-run urea, but also significant from water-run UAN). Not measured was the additional N loss via ammonia volatilisation during the water-run ammonia application, which would also have been significant given the strong smell of ammonia in the tail drain water during N application.

Conclusions

The results from the 2017–18 core site experiment indicated that 100% pre-plant N application accelerated vegetative plant growth at the expense of cotton lint yield at the end of the season. Pre-plant N application also led to significant N losses through runoff of nitrate produced from the pre-applied urea. Splitting the N applied into pre-plant and in-crop reduced vegetative growth but gave better yields. The greater the proportion applied in-crop, the lower the total N lost through runoff.

While the in-crop N method/product did not affect cotton lint yields, there were significant effects of both method and product on N losses in runoff. N losses during water-run irrigations are linked to the efficiency of water application, so reduced irrigation periods should keep more N in the paddock. We also recommend growers soil test for mineral N and reduce N application rates where pre-crop stocks of soil nitrate are high.