FAR

Cropping Strategies

Nitrogen in Perennial Ryegrass Seed Crops

Canopy Management Strategy for Autumn Sown Oilseed Rape

Issue 2 - Spring 2011

Nitrogen in Perennial Ryegrass Seed Crops

Summary

Principle

Nitrogen is applied to perennial ryegrass in spring to increase ear numbers, canopy size and/or to produce dry matter for livestock production. In effect all of the above can be classed as promoting growth. In perennial ryegrass seed production the promotion of shoot growth leads to potential problems later in the season associated with lodging.

Application rate

The target total N should be 180 kg N/ha in irrigated seed crops. This is made up of soil mineral N (0 - 30 cm) plus applied N i.e. nitrogen application rate (kg N/ha) = 180 – soil mineral N. Application rates for dryland crops should be similar to ensure optimum head numbers are achieved.

Application timing

In ryegrass the timing of application is not critical as long as greater than 1800 heads/m^2 are achieved and periods of intense N stress are avoided. Generally a small amount of N is applied in August (this may be before the soil mineral N test result is known) with the main N applications split between closing (early stem extension, GS30 - 31) and approximately 2 - 3 weeks later. However N can be delayed through until head emergence, as long as head numbers are not reduced and there is moisture (rain or irrigation) to incorporate the N with no detrimental effect on seed yield.

Lodging considerations

The application of N should include consideration of the effects of N on lodging. Too much early N and lodging will increase, too little early N and head numbers will be reduced. Consider N timing and application rate, grazing potential, plant growth regulator (PGR) programme and water availability when considering lodging control.

The same considerations should be given to all perennial ryegrass crops (e.g. late sown turf ryegrass), flowering date, tetraploid or diploid, irrigated or dryland.

Application rate

FAR has coordinated 23 nitrogen trials in perennial ryegrass since 2003/04, the average optimum application rate from these trials has been 138 kg N/ha, with the range being 60 up to 240 kg N/ha. It has become evident that an understanding of soil mineral N is important. Therefore growers should soil test in late winter to determine the application rate for the following spring. On average a target total N (soil and applied) of 178 kg N/ha will increase seed yield by 662 kg/ha above the untreated control (Table 1). Growers should also be aware that above the optimum application rate, yield reductions can occur through problems associated with early lodging, e.g. the production of less seeds/spikelet. Higher than optimum application rates do not necessarily mean a yield reduction, but any excess application will be stored in the straw at harvest and lost when/if the straw is transported off farm (Figure 2).

FIGURE 1

Visual differences in response to N application rate in perennial ryegrass, Methven 2006/07.

TABLE 1

Summary of six years of N rate response trials, trial number, year, cultivar, mineral soil N (0 - 30 cm), applied and total available N rate for the optimum seed yield response, the zero N (N0) and N optimum (N opt) seed yield response and the N response.

Trial no	Year	Cultivar	0-30 cm Min N (kg/ha)	N opt Applied (kg/ha)	N opt Total (kg/ha)	Seed Yield (kg/ha) N0	Seed Yield (kg/ha) N opt	Response seed/ kg N
1	2003/04	Banquet	46	154	200	1010	1710	4.5
2	2003/04	Bronsyn	50	150	200	1440	1820	2.5
3	2004/05	Bronsyn	71	129	200	1600	1970	2.9
4	2004/05	Aries	29	171	200	1870	2030	0.9
5	2005/06	Impact	36	214	250	1210	2050	3.9
6	2005/06	Hillary	122	104	226	1170	1790	6.0
7	2006/07	Bealey	36	164	200	2170	2630	2.8
8	2006/07	Bealey[1]	36	114	150	1420	2230	7.1
9	2006/07	Bronsyn	10	140	150	1610	2510	6.4
10	2006/07	Bronsyn[1]	10	240	250	1100	1880	3.3
11	2006/07	Hillary	33	167	200	1340	2240	5.4
12	2006/07	Hillary	33	117	150	1520	2240	6.2
13	2006/07	Commando	30	70	100	2510	2790	4.0
14	2007/08	Hillary	36	114	150	1590	2250	5.8
15	2007/08	Commando	54	144	200	1810	2250	3.1
16	2007/08	Arrow	30	120	150	1910	2340	3.6
17	2007/08	Arrow[1]	30	120	150	1810	2230	3.5
18	2008/09	Alto	25	120	145	1240	2340	9.2
19	2008/09	Samson	50	200	250	1010	1850	4.2
20	2008/09	Samson	35	110	145	1010	1920	8.3
21	2009/10	Samson	40	60	100	2390	3010	10.3
22	2009/10	Arrow	46	104	150	1480	2700	11.7
23	2010/11	Samson	30	150	180	1060	2550	9.9
	Average		40	138	178	1534	2232	5.1

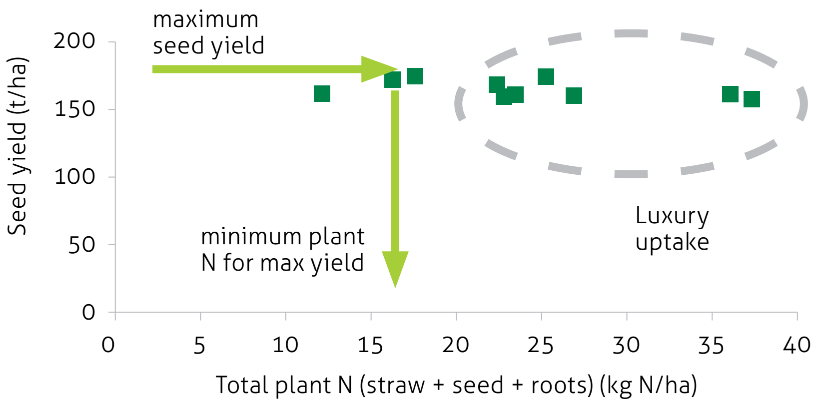
[1] Trials closed by mowing, all others grazed

The inconsistent seed yields of the zero N treatments presented in Table 1 (range 1010 - 2390 kg/ha) can, to a certain extent, be explained though differences in mineralisable N measured in the top 30 cm of the soil profile. For a number of seasons FAR has collected data on mineralisable N which varies between sites, often in relation to the previous crop history but not always. The amount of mineralisable N has varied from approx. 100 kg N/ha up to 238 kg N/ha. The relationship between mineralisable N and seed yield on the zero N treatments is not strong, suggesting limitations on the use of this test in ryegrass seed crops. However sites where mineralisable N values are above 200 kg N/ha generally require less fertiliser N to achieve optimum seed yield. FAR is currently trying to understand plant responses to nitrogen mineralisation in more detail so that growers can make better use of N that may become available throughout the season.

Why do zero N plots yield well?

In most cases the zero N treatments are very efficient at converting set seed into salable seed, a result of less lodging and better light use during seed filling. For example, at Greendale in 2008/09 the zero N plots converted approximately 70 % of set seed into saleable seed compared to approximately 50 % for the higher N application rates (above 160 kg N/ha).

FIGURE 2



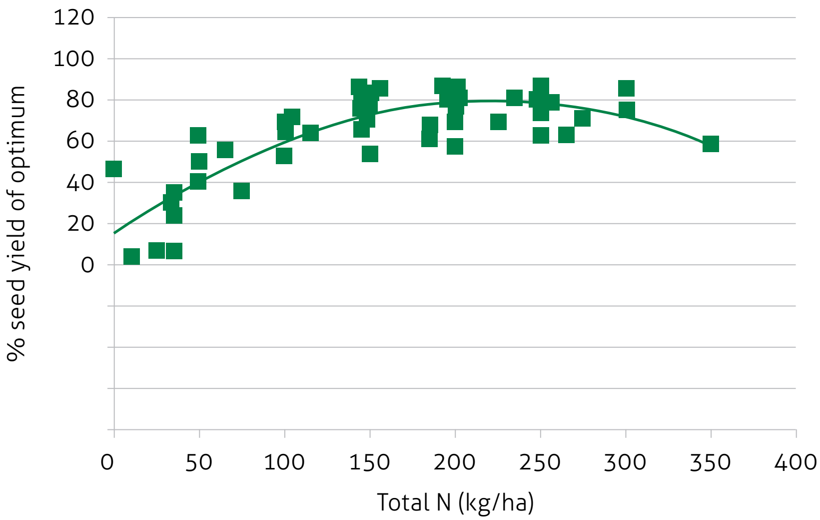
Relationship between seed yield of perennial ryegrass and the minimum plant N required to achieve maximum yield, also showing luxury uptake.

What is the risk of running short on Nitrogen?

It is important to remember that the mineral N test is not an 'exact science'. Differences in methodology during sampling and/or storage of samples and/or interpretation of the laboratory data, can all lead to variation in the mineral N value. Therefore a target total N rate of 178 kg N/ha is approximate.

In most cases the risk of the 'crop running short of N' is low due to the relatively flat nature of the response curve near where the optimum is located. There was no consistent yield reduction until under approximately 150 kg total N/ha (Figure 3.)

FIGURE 3

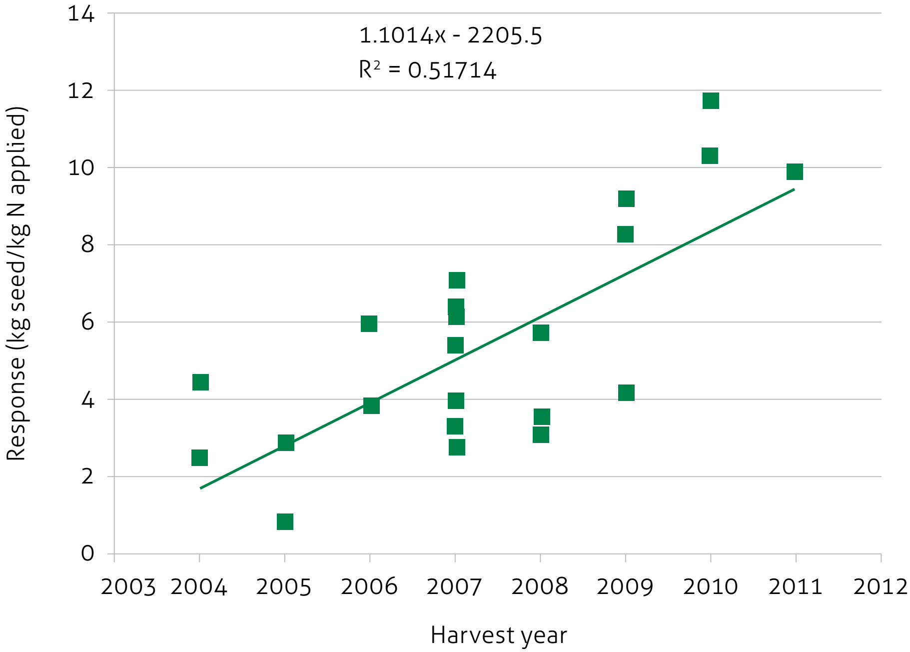


Percentage yield of optimum (100%) expressed for individual treatments compared to total nitrogen (applied + soil mineral), average of nine trials.

Kg seed/kg applied N response over time
(average during the 'responsive phase' i.e. 0 up to optimum N rate)

In general the seed yield response (defined as kgs seed/kg N) to the optimum rate has increased over the past seven years (figure 4). It is expected that this is a result of other agronomic changes outside of the nitrogen response i.e. delayed closing, appropriate PGR rates and overall reduced lodging.

FIGURE 4



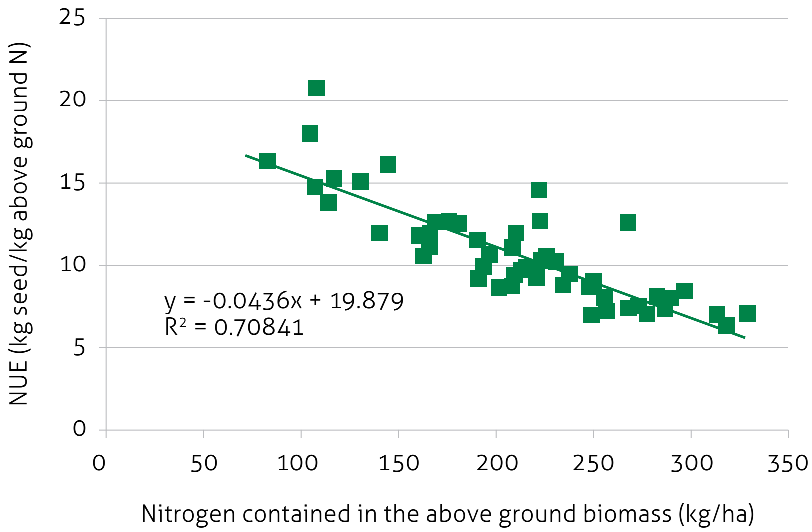
Nitrogen response to the optimum N rate of individual trials over seven years.

Nitrogen Use Efficiency

As nitrogen is applied the efficiency of producing seed per unit of applied N reduces from approximately 50 kg seed/kg N in the untreated plots down to 14 kg seed/kg total N (applied + soil mineral N) in the optimum seed yielding plots. However this does not take into account the nitrogen which is mineralised and/or used during the growing season.

When expressed as kg seed/kg nitrogen in the above ground biomass, a similar reducing trend occurs. The NUE for the untreated plots is, on average, 16 kg seed/kg above ground N. The untreated plots on average contained 99 kg N/ha in the above ground mass (compared to the long term soil N average of 40 kg N/ha). The optimum yielding treatments had a NUE of 9 kg seed/kg above ground N, and contained approximately 250 kg N/ha above ground (Figure 5). Since seed N is approximately 2%, at optimum N rates N in the seed accounts for approximately 45 kg N/ha. Therefore approximately 200 kg N/ha is in the straw at harvest. This should be accounted for when removed from the system.

FIGURE 5



Relationship between the nitrogen use efficiency (kg of seed produced per unit of above ground nitrogen at harvest) and the nitrogen located in above ground biomass (straw and seed combined) at harvest.

Delayed Nitrogen application

Following one experiment during the 2010/11 season at an irrigated site, it appears that the final nitrogen application can be delayed until early ear emergence with no detrimental effects on seed yield, and potential advantages through reduced lodging and the ability to reduce the risk of nitrate leaching. The experimental site had a high mineralisable N fraction, which may have helped the crop 'hold on' for longer before N stress became apparent. However the improvements in yield can be explained through reduced lodging and therefore should be repeatable across sites and seasons. For example, treatments where nitrogen was not limited which reached 50% lodging 14 days after flowering yielded below 2000 kg/ha, compared to 2500 kg/ha for those where lodging was delayed until approximately 25 days after flowering.

Notes:

Canopy Management Strategy for Autumn Sown Oilseed Rape

All canopy management research is in conjunction with Biodiesel New Zealand and FAR.

Summary

Nitrogen Rate

- Apply 200 - 300 kg/ha of nitrogen (N) split between green bud (100 - 150 kg N/ha at GS51) and yellow bud (100 - 150 kg N/ha at GS59). This optimum range was derived from trials with yields of 4 - 5 t/ha (three years of trials 2008 - 2010).
- Where crop canopies are thicker as a result of excessively high plant populations (over 70 plants/m^2) and lodging risk is higher, 200 kg N/ha may be more appropriate than 300 kg N/ha.
- Exact nitrogen rates will vary depending on the soil nitrogen available, the canopy size and site yield potential. Targeted applied N rates outlined above were based on seasons when the early spring soil nitrogen reserve was between 48 - 81 kg N/ha at a depth of 0 - 60 cm. Previous crop history and soil mineral nitrogen tests taken in early spring will give a better understanding of overall N requirement for the crop.

Nitrogen Timing

- Apply in two applications as a 50:50 split of the total nitrogen dose timed at Green bud (GS51) and Yellow bud (GS59). The later dose can be subject to drier conditions but in trials there has been no disadvantage to this split approach as opposed to applying all N at green bud.
- Data shows that this split timing resulted in no significant advantage for either seed yield or margin over that of single doses of N being applied at green and yellow bud (GS51 and GS59). However splitting N applications does allow greater risk management (dry periods, heavy rainfall events) than single dose applications.
- Applying N prior to green bud should only be considered where soil N results indicate very low soil N reserves, below 40 kg N/ha (0 - 60 cm) and then only if the crop is actively growing. Where oilseed rape follows crops that failed to utilise N, for example as a result of drought, early crop growth may be more vigorous than would have been expected, thus reducing the need and amount of N at the first dose timing.

- Crop ground cover in early spring, just prior to first N application, can be an excellent guide to fertility. In the UK it has been calculated that for every unit of GAI (green area index - amount of green surface area of crop on 1 m^2 of ground) the crop contains approximately 50 kg N/ha; thus the more ground cover in early spring the greater N uptake already in the crop.
- In 2010 the green bud timing of N application (in the hybrid Flash) resulted in higher harvest dry matter than yellow bud N timings, however there was no increase in seed yield. As a consequence nitrogen off-takes in the seed at harvest were the same but there was 60 kg/ha more N in the crop canopy with the earlier green bud timing.
- The extra N off-take in the crop canopy with green bud N application was un-productive in terms of seed yield and was returned to the soil at harvest as a higher stubble loading.

Seed Rate

- Current data suggests that for hybrid cultivars the optimum sowing rate is in the range of 1.5 - 3 kg/ha (which has given established plant populations in the range of 20 - 45 plants/m^2). This follows three years of data looking at a range of sowing rates for hybrids and conventional cultivars. The conventional cultivars should be sown at a slightly higher seeding rate of 3 - 4.5 kg/ha, which in trials has established plant populations in the range of 30 - 55 plants/m^2.
- Yield data has shown no difference due to plant population with the hybrid cultivar Flash (trialled in 2010) when populations ranged from 24 - 54 plants/m^2 (1.5 - 4.5 kg/ha seed sown), however with the conventional cultivar Lioness tested in 2008 and 2009, there was a significant yield increase in both seasons associated with increased seeding rates in the 1.5 - 4.5 kg/ha range.
- A confounding factor with lower plant population is the influence of weed competition. In 2008, under high shepherds purse pressure, increasing seeding rate from 1.5 kg/ha (25 plants/m^2) to 4.5 kg/ha (55 plants/m^2) increased yields or productivity by 1 t/ha. In 2009 with lower crop establishment and in the absence of weeds the same gain in productivity was secured by increasing plant population from 8 plants/m^2 to 31 plants/m^2.
- Where plant populations for conventional cultivars fall below 30 plants/m^2 they become vulnerable to weed competition, so where target populations are sub optimal, good weed control is essential.

Plant Growth Regulators (PGRs)

- There have been no significant benefits of PGR application in three years of trials in NZ. UK data suggests greater benefits have been observed where thick crop canopies predispose the crop to lodging.
- The use of the foliar fungicide tebuconazole as a growth regulator both overseas and in NZ trials means that benefits from disease control cannot be ruled out as the cause of any small yield responses. Small seed yield increases were observed in 2010 NZ trials, but they were not statistically significant.

Nitrogen removed (N off-take) at harvest

In 2010, using the hybrid cultivar Flash, the amount of nitrogen in the seed and the rest of the above ground dry matter (leaf, stems and pods) was compared at harvest under different nitrogen strategies. This data revealed that the nitrogen content of the seed and the rest of the plant were lower where no nitrogen was applied. When N was applied at different timings, there was no significant difference in N content (%N) of either seed or above ground dry matter from application of nitrogen at green bud or yellow bud. If the % N content data was combined with dry matter data taken at harvest it is possible to calculate nitrogen removed (off-take) at harvest (Figure 2). Although there was no difference in seed yield between green bud and yellow bud N application timing, the N removed with green bud was 60 kg N/ha higher than the yellow bud timing; this was the result of higher dry matter produced with the earlier timing which did not increase seed yield. This extra N accumulated in the crop canopy would have been returned to the system as a higher stubble loading at harvest. In the zero N plots, despite only 48 kg N/ha (0 - 60 cm) being available in the soil, 165 kg N/ha was present in the zero N plots compared to a total of 250 - 300 kg N/ha present in the 200 kg N/ha plots at harvest. Since N in the crop canopy that is not harvested as seed is returned to the soil, the data shows that when 200 kg N/ha was applied to the crop, between 110 – 176 kg N/ha was returned to the soil, this was dependant upon application timing of that nitrogen.

Nitrogen rate for hybrid cultivars

Less work has been conducted on nitrogen rates than nitrogen timing. In the 2009/10 season there was a significant yield response from increasing the nitrogen application rate from 200 kg N/ha to 300 kg N/ha when applied as a split between green bud and yellow bud (4.40 t/ha vs 4.63 t/ha, mean of three plant populations with PGR) (Figure 3). Split application timings (two applications rather than one) have a better environmental profile, reducing the risk of leaching and run-off losses of N if there is excessive rainfall and/or N not being available or volatilised in dry conditions.

FIGURE 1

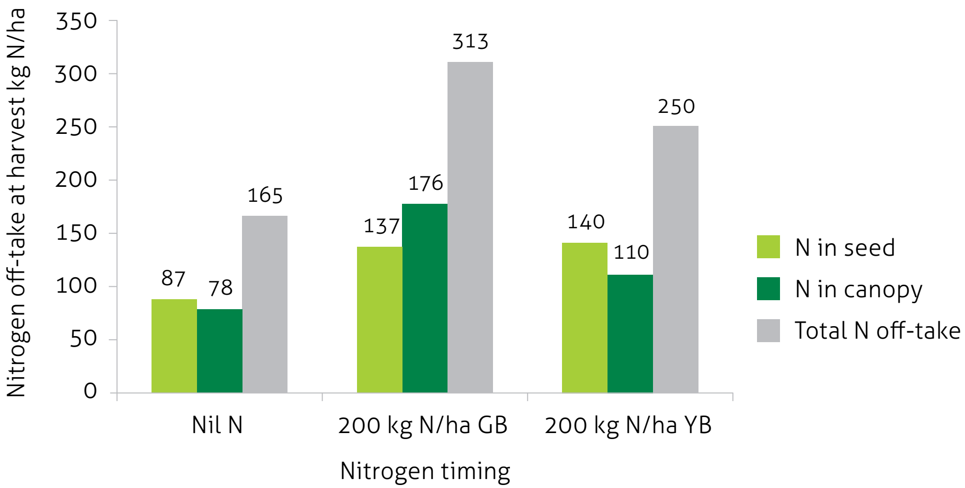
Seed rate of 3 kg - nil vs 200 kg N applied at Green Bud

Green bud 50:50 Yellow bud

Influence of nitrogen timing on canopy structure

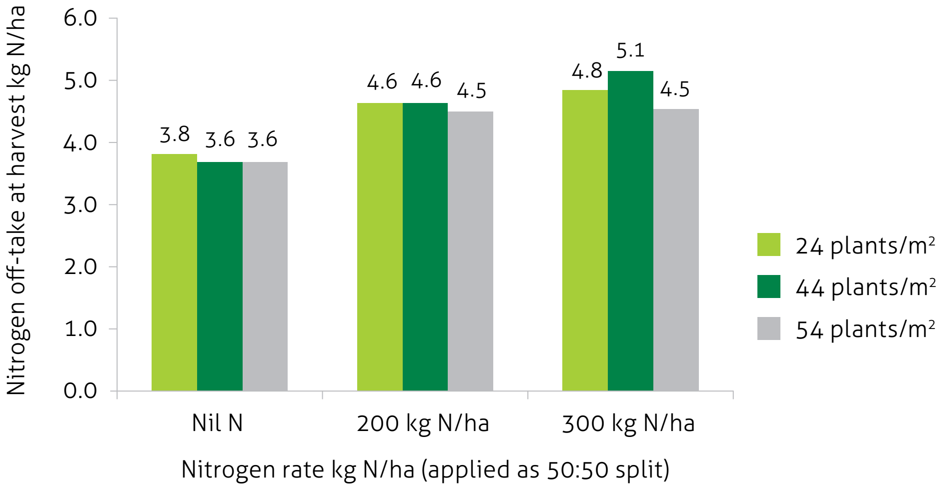
Note: the lower level of branching at the base of the plant where N was applied at yellow bud.

FIGURE 2



Effect of nitrogen application (200 kg N/ha) and timing (GB - green bud and YB - yellow bud) on nitrogen removed (off-take) in the seed and dry matter at harvest - average of three different sowing rates (1.5, 3 and 4.5 kg/ha) cv Flash, South Canterbury, 2010 (Soil Nitrogen reserve taken prior to N application in spring was 48 kg N/ha).

FIGURE 3



Effect of nitrogen rate on seed yield at three different sowing rates (1.5, 3 and 4.5 kg/ha) cv Flash 2010.

Influence of Plant Growth Regulator (PGR) on yield

The foliar fungicide Folicur (active ingredient tebuconazole) is used in Europe as both a fungicide and a growth regulator in oilseed rape. In the last three years of NZ research tebuconazole has been applied at the yellow bud stage at 440 ml/ha to examine the plant growth regulator response in reducing plant height and lodging.

There have been small height differences observed due to PGR application, however the 2 - 5 cm shortening of the crop with these applications have not been significant. There was no yield response from PGR application to the conventional cultivar Lioness in 2008 and 2009 (Figure 5), however there was a trend (not significant) towards a yield increase when PGR was applied in the hybrid cultivar Flash in 2010 (Figures 6 and 7).

It is important to note that Folicur is a fungicide, thus the small yield trend could be the result of disease control from the yellow bud application timing rather than a PGR effect.

Data from Europe would suggest that PGR applications have greater effect in thicker crops that are more predisposed to lodging. There was no evidence from our data over the three years to support this overseas observation at the higher plant populations; however growers should be aware that fungicides with PGR properties may be beneficial in crops predisposed to lodging, but these conditions have never been encountered in our trials.

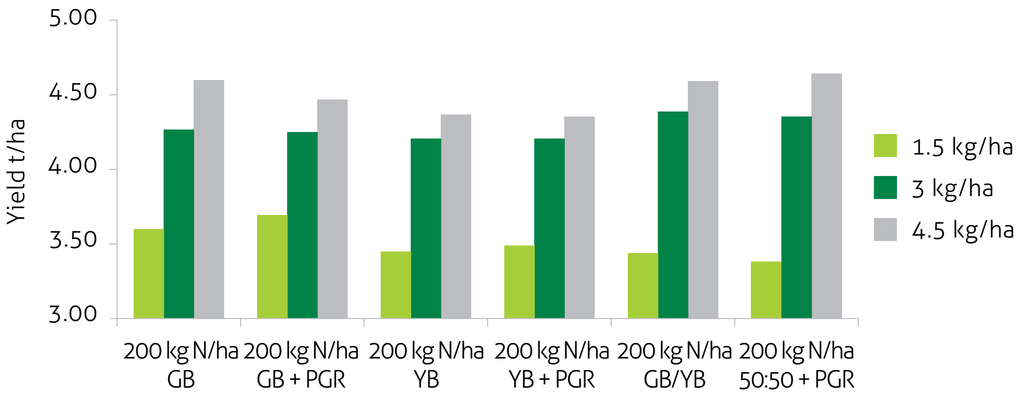
FIGURE 4

PGR applied

Nil PGR

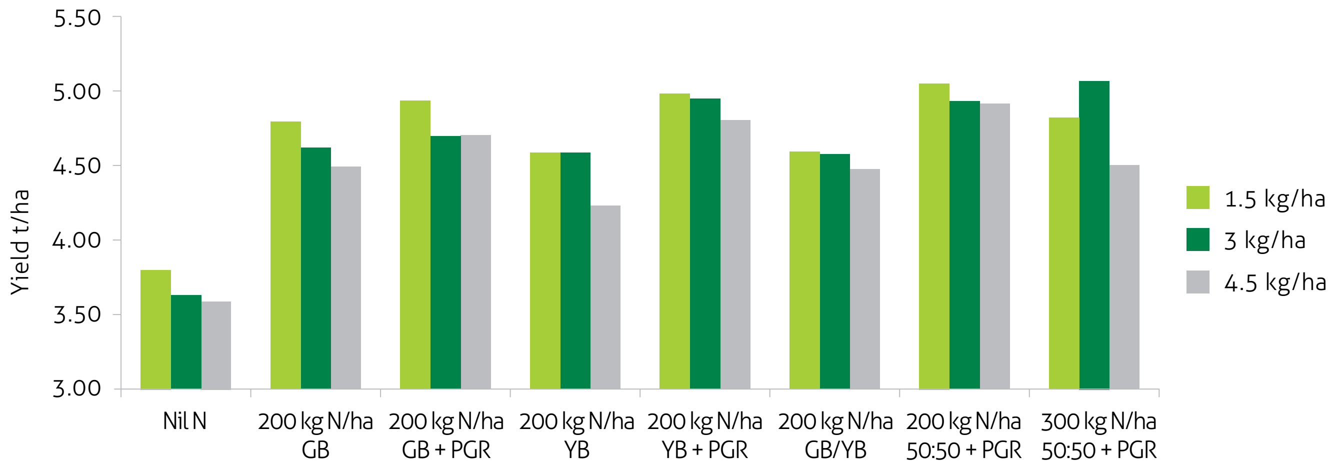
Influence of Plant Growth Regulators (PGRs) on canopy height.
Note: the PGR treatment with a lower canopy height then nil treatment

FIGURE 5



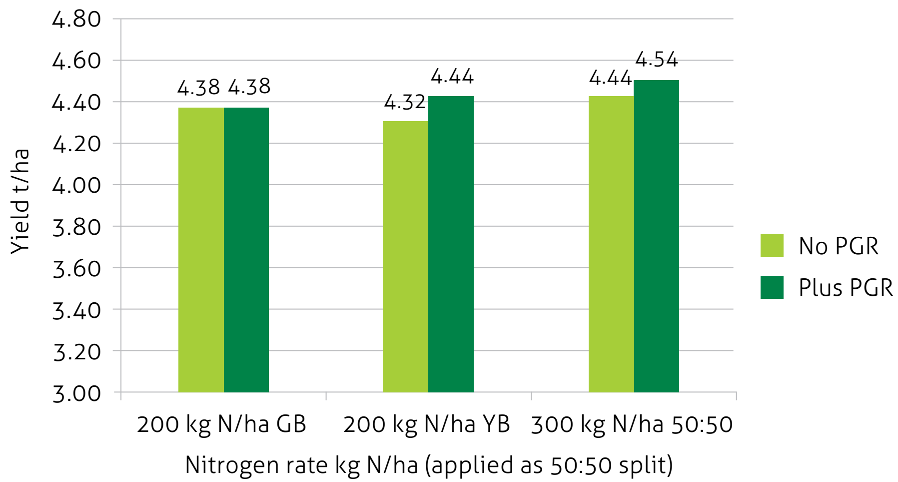
Effect of nitrogen timing with and without Plant Growth Regulator (PGR) on seed yield of a conventional cultivar at three different sowing rates (1.5, 3 and 4.5 kg/ha) averaged over two years of data (cv Lioness 2008 and 2009). GB - Green bud GS51, YB - Yellow bud GS59 and PGR - Folicur 440 ml/ha

FIGURE 6



Effect of nitrogen timing with and without Plant Growth Regulator (PGR) on seed yield of a hybrid cultivar at three different sowing rates (1.5, 3 and 4.5 kg/ha) over one year of data (cv Flash 2010). GB - Green bud GS51, YB - Yellow bud GS59 and PGR - Folicur 440 ml/ha.

FIGURE 7



Effect of Plant Growth Regulator (PGR) (Folicur at 440 ml/ha) on harvested seed yield (seeding rate of 3 kg/ha) averaged over three years of data.

Hybrid versus conventional cultivar - influence on biomass accumulation on final yield

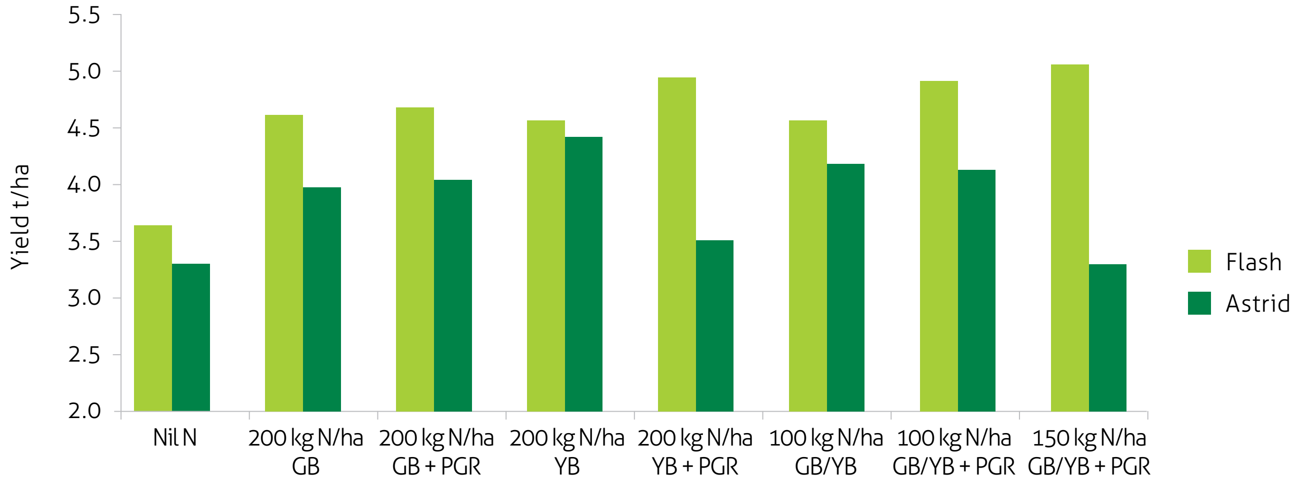
The hybrid Flash was higher yielding than the conventional cultivar Astrid at all three nitrogen timings tested (Figure 7). Flash had a mean seed yield of 4.6 t/ha compared to 3.9 t/ha with the conventional cultivar Astrid.

This difference in seed yield also related to differences in above ground dry matter (DM) at the onset of stem elongation (Astrid 1466 kg/ha DM vs Flash 2407 kg/ha DM both at a seed rate of 3.0 kg/ha). The biomass difference was measured at harvest with Astrid producing 13187 kg/ha DM (including seed) vs Flash at 16572 kg/ha (both compared at a seed rate of 3.0 kg/ha). When comparing the cultivars for harvest index (i.e. how much biomass was converted into seed yield) the two cultivars were very similar; Astrid had a slightly higher harvest index with 25.1% vs 23.9% for Flash. However this small difference in harvest index was not great enough to make up for the much lower dry matter in the conventional cultivar. Therefore the bigger crop canopy of the hybrid was a key component of the seed yield advantage over the conventional cultivar.

Hybrid versus conventional cultivar - influence of plant population on final yield

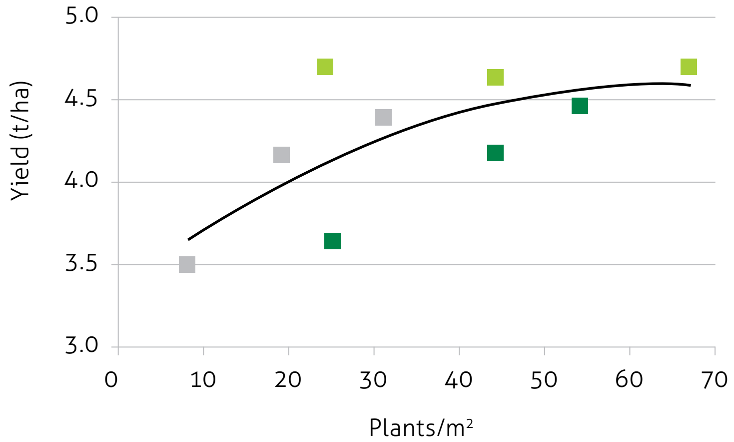
The optimum seed rate for seed yield has been shown to be different between the hybrid and conventional cultivars. With the conventional cultivar Lioness in 2008 and 2009, yield increased as plant population increased from 8 - 31 plants/m^2 in 2008 and from 25 - 55 plants/m^2 in 2009. In the hybrid cultivar Flash there was no significant difference in yield between 25 plants/m^2 and over 60 plants/m^2 (Figure 9). This is in line with overseas data that indicates that hybrids are more suited to lower plant populations than conventional cultivars. Weed populations are more competitive in low plant stands so thinner crops are more dependent on good weed control to fulfil their seed yield potential. The importance of weed control was observed in the 2008 trial when weed populations (Shepherds purse) were more competitive than in 2009; as a consequence it was noted that there was a higher optimum population in 2008 than in 2009.

FIGURE 8



Influence of nitrogen application, timing and PGR on a conventional (Astrid) and hybrid (Flash) cultivar on seed yield at a seed rate of 3 kg/ha.

FIGURE 9



Influence of plant population on harvested seed yield, (2008 - 2010). Green points Lioness (conventional) in 2008, grey points Lioness (conventional) in 2009 and light green points Flash (hybrid) in 2010.

Notes:

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