OILSEED RAPE VARIETY RESPONSES TO NITROGEN FERTILISER – A PILOT STUDY

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INTRODUCTION

A desk study (NIAB, 2004) identified the manufacture and application of nitrogen fertilizer as accounting for over 70% of the energy usage and greenhouse gas emissions associated with the production of winter oilseed rape crops. Identifying cultivars of oilseed rape capable of producing high yields but with reduced demand for nitrogen will have clear advantages in terms of sustainability and in limiting climate change. The key research into nitrogen responses by Chalmers (1989) demonstrated yield increases and oil content decreases with increasing nitrogen inputs but only small responses above application rates of 180 to 220kg/ha. Responses were generally greater at higher yielding sites. Since that time, nearly 2000 varieties have passed through the official National List testing scheme, introducing considerable improvement in genetic yield potential from numerous breeding programs and a considerable diversity of types. There has been no systematic approach to defining nitrogen requirements of modern varieties. The pilot study described here investigated the responses of a set of varieties, selected for their diverse genetic and morphological range, to reduced N applications, as part of a Defra-funded, Low Input Project, led by Warwick HRI.

METHODS

Trial design

A 3-replicate, split plot design was used, with three nitrogen treatments and eight varieties. Plots were established using a border row drill, giving a harvest plot area of 10m in length and 2m in width but with 2 rows of the plot variety sown outside the harvested area making up half of a ‘border plot’ in order to minimize inter-plot competition. Seed rates reflected the current practice in National List trials, with hybrids sown at 70 seeds/m^2 and line varieties sown at 100 seeds/m^2.

Agrochemical inputs

In early spring, sulphur (30kg/ha) was applied to all treatments as magnesium sulphate (kieserite) in order to simplify subsequent nitrogen fertiliser applications. In addition to a zero-N, baseline treatment, nitrogen was applied in two equal doses, as ammonium sulphate, to provide treatments 100 and 200kg/ha. It should be noted that a soil test, in February, gave an available nitrogen result of 50kg/ha. Fungicides were used to minimize the influence of disease on the trial, with sprays in late autumn, green bud and mid-flower.

Varieties

Eight varieties, including a mixture of open pollinated ‘line varieties’ and hybrids, were selected to express the current range of types used in commercial practice:

Castille – short, very early flowering line variety; **Catana** – medium height line variety with high oil content; **Es Astrid** – short, late flowering line variety, with low oil content; **Excalibur** – very early flowering, medium height hybrid; **Excel** – tall, weak-stemmed hybrid; **Hearty** – medium height, line variety with high erucic acid content in the oil; **PR45D03** – very short, late flowering semi-dwarf hybrid; **Winner** – tall, very early flowering, weak stemmed line variety

Plot recording

Subjective, 1-9 scales were used to record the onset of flowering and maturity and the degree of lodging and leaning in the plots just prior to harvest. Mean plot heights were recorded at the end of the vegetative growth phase. After desiccation with glyphosate, plots were harvested using a Sampo 2010 plot combine. Sub-samples from each plot were oven-dried for determination of moisture and oil content and the 1000 seed weight of the seed.

RESULTS

Seed yield and oil content

With the exception of anomalous results for the variety Es Astrid, clear, incremental responses to increased nitrogen applications were observed for yield, while oil content decreased with increasing nitrogen application rates. Overall yields were high, with the 200kg N treatment mean of 5.22t/ha comparing favourably with control mean yield for National List trials of 5.05t/ha for the same season.

All varieties, except Excel, showed a significant yield increase from the zero-N to the 200kg N treatment. Four varieties showed significant yield increases over zero N in the 100kg N treatment, (Excalibur, Es Astrid, PR45D03, Hearty) while only one variety (Catana) showed a significant yield increase going from the 100kg N to the 200kg N treatment. The anomalous response pattern shown by Es Astrid is almost certainly explained as experimental error, given the large LSD (Table 1).

Table 1. *Yield and oil content responses to nitrogen inputs. Varieties ranked in order of descending yield in the zero-N treatment – corrected to 9% moisture content*

Variety	Seed yield (t/ha)				Oil content (%)			
	Nitrogen application (kg/ha)							
	0	100	200	MEAN	0	100	200	MEAN
Excel	4.57	4.92	5.30	4.93	47.4	46.3	43.9	45.8
Excalibur	4.22	5.25	5.53	5.00	48.7	46.1	44.3	46.4
Catana	4.17	4.29	5.35	4.60	47.7	47.7	45.1	46.8
Castille	4.11	4.80	5.49	4.80	46.7	45.9	43.7	45.4
Es Astrid	4.05	5.42	5.18	4.88	47.5	45.4	43.9	45.6
PR45DO3	3.88	4.94	5.43	4.75	48.1	45.3	43.8	45.8
Winner	3.83	4.29	4.81	4.31	46.7	45.7	43.7	45.4
Hearty	3.74	4.60	4.70	4.35	49.9	48.3	46.1	48.1
Mean	4.07	4.81	5.22	4.70	47.8	46.3	44.3	46.2
LSD	0.84	0.84	0.84	0.48	1.84	1.84	1.84	1.07
(LSD treatments)				0.30				0.65
CV%	*	*	*	10.8	*	*	*	2.4

Oil content of rapeseed shows a characteristic decrease with increasing N application and this was confirmed here. Treatment mean differences were highly significant, given the LSD of 0.65, but once again variety LSDs, within and between treatments, were considerably larger (1.84). With only one anomaly (Catana) varieties showed a stepped decrease in oil content with increasing N. This was significant between zero-N and 100kg N for Excalibur, Es Astrid and PR45D03, and between 100kg N and 200kg N for all varieties except Es Astrid and PR45DO3.

Plant growth responses

While some measure of plant growth showed response to the different N treatment, there were no clear variety interactions. The period of full flower was short, compared with some seasons and this was attributed to the very low rainfall and lack of nitrogen up-take until rain fell late in the flowering period. Flowering commenced and finished marginally earliest in the zero-N treatment while the 100 and 200kg/ha N treatments showed no differentiation.

Plant height showed only a small and variable response to N, again reflecting the very dry period during vegetative growth. This failed to capture the real differences in biomass between the treatments and, with hindsight, it would have been useful to make an assessment of the 'bushiness' or branching of the canopies. There were strong visual differences between treatments, with the zero-N plots having thin, sparsely branched canopies and the 200kgN treatment producing dense, prolifically branched plants. While lodging would normally become a risk with increasing rates of N application, the season was not marked by conditions that tend to promote lodging and leaning in oilseed rape. Two varieties regarded as relatively weak-strawed, Excel and Winner, showed low levels of lodging but there was no indication of a treatment effect.

Maturity assessments showed a strong relationship with N application rate. The thin, low yielding canopies produced by the zero-N treatment senesced quickly, while the higher biomass and canopies associated with increasing N supply showed predictable trends of delayed maturity. But here again, all varieties behaved similarly and it was the same story looking at seed size. Seed size of the sown-seed lots varied greatly, from 7.7g/1000 seeds for Excalibur, down to 3.3 g/1000 for PR45D03. Seed collected from the plots showed very little variation between varieties, with a grand mean of 5g/1000and no discernable variation associated with the nitrogen input treatments.

DISCUSSION

The results presented here are from a single trial and must be treated with great caution given the very variable nature of oilseed rape performance in trials. The season itself was marked by very dry conditions leading up to, and persisting for, much of the flowering period. This will have restricted the availability of N during the vegetative growth period but will have conserved more available N for the pod-fill period than would normally occur.

Meaned over all varieties, treatments gave predictable patterns of increasing seed yield and decreasing oil content in response to increasing nitrogen fertiliser application rates. The extreme overall yield responses, comparing zero-N with 200kg/ha N ha, were from the tallest variety in trial, the hybrid, Excel, with a yield increase of only 0.73t/ha, and the short, semi-dwarf hybrid, PR45D03, with a response of 1.55t/ha. This could be taken to indicate that the tall vigorous, varieties such as Excel, effectively waste nitrogen by generating surplus stem growth and are more limited in their ability to increase seed yield in response to N, either because of self shading during pod-fill, or nutrient limitation during this phase. Looking at the whole variety set, no clear relationship between crop height and yield response was observed however. It should be noted that it was beyond the resources of this pilot experiment to undertake a detailed investigation of components of yield or, perhaps more importantly, rooting characteristics of the varieties included.

Looking at a more plausible scenario for reduced inputs, the comparison of the 100kg and 200kg N treatments, the mean yield reduction was 0.41t/ha or, expressed as gross output (yield adjusted for oil content value) of 0.34t/ha. Economic impact has been indicated in Table 2, basing calculations on a UK autumn 2010 crop price of £310/t, and a nitrogen fertiliser cost £630/t N. In this experiment, reducing N by 100kg/ha resulted in a crop value reduction of £105/ha, offset by a fertiliser saving of £63/ha, and a consequent net loss of £42/ha to growers. There was no clear pattern of variety type interaction but the range, even omitting the possibly anomalous results for Es Astrid, was large. The greatest penalty was shown by Catana, with a net loss of income of £256/ha, while the high erucic variety, Hearty, indicated an improved margin of £60/ha associated with the saving of 100kg/ha N. If corroborated by further investigations, this range of responses indicates a clear need for a systematic approach to identifying the source of variation and classifying the nitrogen sensitivity of commercial varieties of oilseed rape.

Table 2. *Economic assessment of yield penalty associated with reducing nitrogen inputs from 200kg to 100 and 0 kg/ha N, based on crop prices of £310/t and fertiliser costs of £630/t N.*

Variety	Plant height (cm)	Crop loss, adjusted for nitrogen cost saving (£/ha)	
		0 kg/ha N	100 kg/ha N
PR45D03	122	-330	-77
Castille	143	-286	-129
Excalibur	156	-246	4
Catana	152	-234	-256
Es Astrid	142	(-200)	(168)
Winner	157	-159	-83
Hearty	153	-150	60
Excel	166	-66	-27
Mean		-209 (-195)*	-42 (-77.2)*

* *Bracketed means exclude the anomalous data for Es Astrid*

CONCLUSIONS

The findings of this pilot study indicate that there is a range of yield and economic responses to reducing N inputs, displayed by different varieties, that the current trials programs fail to identify, based, as they are, on application rates in the order of 200kg/ha. Identifying nitrogen sensitivity traits and classifying varieties for their tolerance to reduced N will have important consequences, for growers and plant breeders, if new restrictions on N use are introduced to lessen the environmental impact of oilseed rape production in the UK. A more detailed experimental series, conducted over a range of geographical locations and examining components of yield and rooting characteristic of varieties, would be required to explore this.

REFERENCES

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