Crop management strategies to improve forage rape seed yield

J.A.K. Trethewey
AgResearch Limited, Private Bag 4749, Christchurch 8140, New Zealand

Abstract

In New Zealand, forage rape (*Brassica napus* L.) is an important supplementary feed crop in animal production systems. Detailed investigations on seed production are limited and strategies for maximising seed production are not well understood. The objective was to increase seed yield of forage rape by manipulating crop architecture using combinations of mechanical topping, plant growth regulators (difenoconazole and paclobutrazol) and sowing date. Data were collected for components of yield, including dissection of plants into four seed fractions. Topping at yellow bud or delaying sowing until April significantly ($P<0.05$) increased seed yield by 40-60% compared with control treatments. On average, 85% of seed was from secondary racemes with 60% coming from middle and lower racemes. Plant height was significantly ($P<0.05$) different among treatments. Seed yield of forage rape can be influenced by manipulation of crop architecture through mechanical topping and sowing date. There is therefore scope for forage seed growers to improve seed yield of forage rape through adoption of simple improvements in practice.

Additional keywords: *Brassica napus*, defoliation, light interception, secondary raceme

Introduction

Information about forage rape (*Brassica napus* L.) seed production in New Zealand is limited. In New Zealand, forage rape is typically grown for green feed to fill gaps in the feed supply of pasture-based animal production systems. Despite its value as a feed source there is little information on best practice for seed production and detailed investigations on the growth and reproductive development of forage rape grown for seed in New Zealand are not available. The production of forage rape seed from in New Zealand is primarily based in Canterbury. Seed yield potential is determined by the ability of a plant to produce biomass and the partitioning of biomass within the plant to the seed. Biomass accumulation is dependent on crop architecture and the ability of the canopy to intercept photosynthetically active radiation (PAR) (Sinclair and Muchow, 1999). In some brassica species, including forage rape, biomass accumulation continues through to reproductive maturity (Rose *et al.*, 2007). This suggests crop architecture for light interception throughout the season may be important for optimum seed yield.

Crop canopy architecture can be influenced through grazing or mechanical defoliation, or using chemical plant growth regulators (PGR), and may increase seed yield. Chlormequat-chloride (Cycocel®) and the triazole-type compound tebuconazole (Folicur®) are currently used on oilseed rape grown in New Zealand for both their fungicidal and growth regulatory properties. Plant growth regulators such as Toprex® (a combination of difenoconazole and paclobutrazol), have also been used on oilseed rape seed crops. Plant growth regulators may improve other aspects of crop growth, including lodging resistance and the number of seeds per unit area by restricting canopy growth (Armstrong and Nicol, 1991).

Defoliation at certain growth stages alters crop architecture and source sink relationships. The indeterminate growth of forage rape means that leaves, stems, flowers and pods are competing for resources simultaneously. Therefore any reduction in green leaf area during reproductive development will strengthen the leaf demand for resources and constrain the delivery of resources to the seed. Defoliation of forage rape during reproductive development has been shown to decrease seed yield depending on the timing and severity of defoliation (Khan *et al*., 2007a; 2007b). The objective of the present research was to investigate the effect of different management strategies on crop architecture and seed yield in forage rape in Canterbury New Zealand.

Methods

A trial comparing management strategies to increase seed yield of forage rape was established in 2011 at the AgResearch farm, Lincoln, Canterbury (43° 38’ S, 172° 28’ E). The trial was a randomized block design with four replicates, using the cultivar ‘Greenland’, a late flowering type grown for seed and fodder in New Zealand. Plots were 10 m × 2.7 m, with 15 cm rows. Plots were sown at 3 kg/ha at a depth of 2 cm with a tractor drawn precision cone-seeder drill. Treatments included combinations of early (25 March 2011) and late (13 April 2011) sowing dates, spring defoliation by mechanical topping at green bud (early) and yellow bud (late) growth stages, and application of the plant growth regulator (PGR) Toprex (a.i. difenoconazole 250 g/l and paclobutrazol 125 g/l) (Table 1).

Table 1: Trial sowing date, topping and plant growth regulator timing of application.

Treatment	Timing
Early Sowing (25 March 2011)	
Control	
Toprex early	17 October 2011
Toprex late	01 November 2011
Topping early	14 October 2011
Topping late	28 October 2011
Topping early + Toprex	14 October 2011
Topping late + Toprex	28 October 2011
Late Sowing (13 April 2011)	
Control	
Topping early	26 October 2011
Topping late	04 November 2011

The trial was fertilised with 150 kg/ha N as urea applied in two equal applications on 21 August 2011and 5 September 2011. A soil test (Hill Laboratories, Hamilton, New Zealand) indicated approximately 23 kg/ha available N prior to sowing. The trial was irrigated as required when water deficit was approximately 100 mm. Water deficit was estimated using Penman evapotranspiration data from local weather station (43°37´S, 172°28´S). Toprex was applied with a plot sprayer at 220 l/ha. Defoliation treatments were applied manually with hand shears, with the top 10% of the plant including the apical bud of the primary raceme removed. Netting was erected to cover the entire trial site to minimize seed loss from birds. Plots were harvested between 16 January 2012 and 30 January 2012 when seed was approximately 40% seed moisture content. At each harvest date a 2 m × 2 m quadrat was hand harvested, dissected into 4 plant fractions (Figure 1), air dried and hand thrashed. Seed fractions were cleaned using an air column separator.

Data analysis

GenStat (version 13, VSN International Ltd, UK) was used for statistical analysis using a general analysis of variance (ANOVA) model. Means were separated using the least significant difference (LSD) procedure. Individual and combined plots were designated as treatments and replicates designated as blocks.

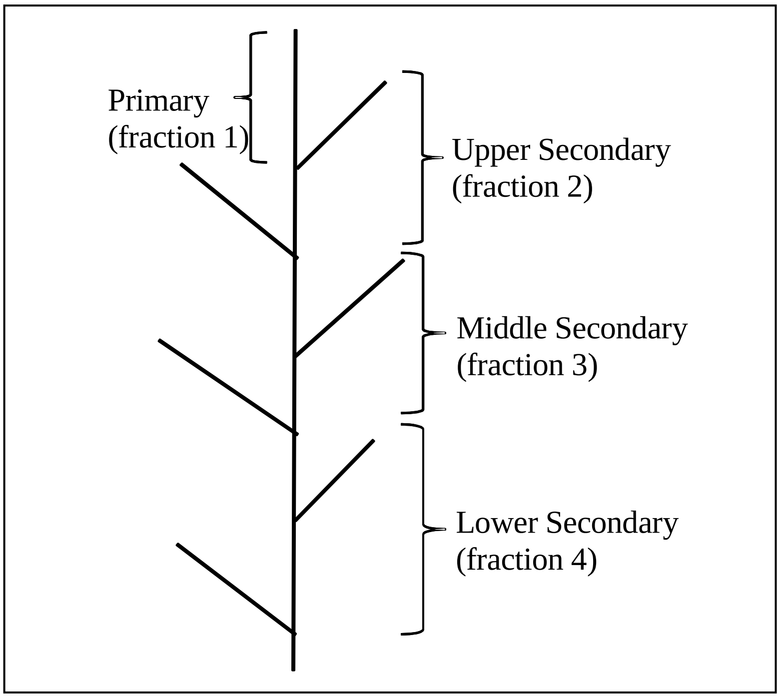

Figure 1: Diagrammatic representation of where seed fractions were obtained from. Plants were dissected into 4 fractions based on their position on the plant. Fraction 1 = primary raceme; fraction 2 = upper secondary racemes; fraction 3 = middle secondary racemes; fraction 4 = lower secondary racemes.

Results

Average seed yields from all treatments are shown in Figure 2. The April sown, late defoliation treatment produced the highest seed yield. In March and April sown plots the highest yielding treatments were the late (yellow bud) defoliation treatments. These treatments had 30% more seed than the corresponding controls (Figure 2). For all treatments, April sown plant were approximately 50% higher yielding than March sown treatments. Plant growth regulators had no effect on seed yield compared with controls in this experiment.

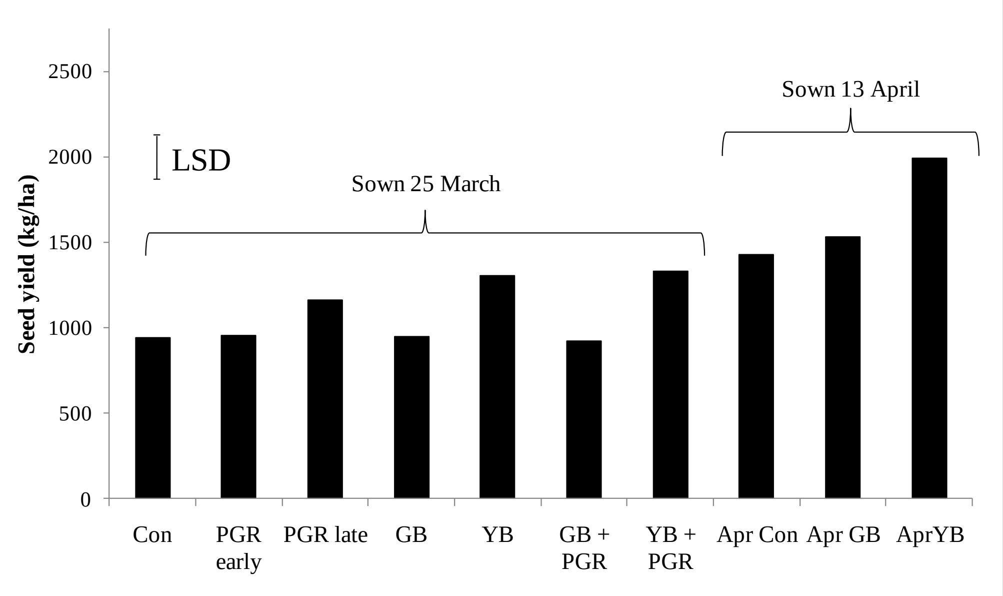

Figure 2: Average seed yield (kg/ha) for all treatments of forage rape, Lincoln, 2011-2012. Con = control; PGR = Toprex; GB = topping early; YB = topping late; Apr Con = April control. $LSD_{(0.05)}$=323.

The percentage of seed from different parts of the canopy varied significantly among treatments (Figure 3). In PGR treatments and the March and April sown control treatments almost 30% of the seed came from the primary raceme, (fraction 1) (Figure 3a). All other treatments had significantly less seed (9%) contributed by the primary raceme. On average among treatments, seed from the upper secondary racemes, fraction 2, accounted for 23% of all seed (Figure 3b). Late (yellow bud) defoliation treatments contributed the most seed from these fractions (27%). Seed from middle secondary racemes, fraction 3 contributed, on average, 28% of all seed (Figure 3c). Defoliation treatments contributed the most seed from these fractions whereas control treatments and PGR treatments contributed the least (Figure 3c). Lower secondary racemes (fraction 4), contributed, on average the largest percentage of seed with 31% of all seed (Figure 3d). Lower secondary racemes were less sensitive to defoliation, sowing date and PGR treatments when compared with other seed fractions. April early (green bud) defoliation gave the highest amount of seed from these fractions (38%) whereas the April control and March late PGR application gave the least (25%).

Crop height at treatment application and harvest are shown in Figure 4. Plant height was significantly reduced in early (green bud) defoliation treatments. At harvest early defoliation treatments were approximately 25% shorter than all other treatments.

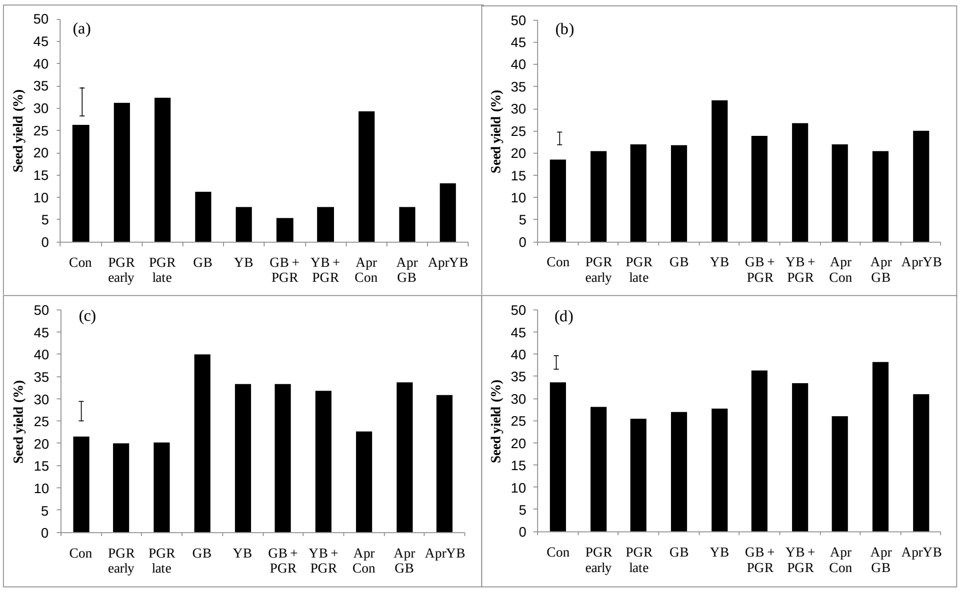

Figure 3: Seed yield as a % of total seed yield for (a) primary raceme, fraction 1, (b) upper secondary racemes, fraction 2, (c) middle secondary racemes, fraction 3, (d) lower secondary racemes fraction 4. $LSD_{(0.05)}$ for fractions were as follows: (a) = 7.9; (b) = 3.1; (c) = 6.8; (d) = 5.2. Con = control; PGR = Toprex; GB = topping early; YB = topping late; Apr Con = April control.

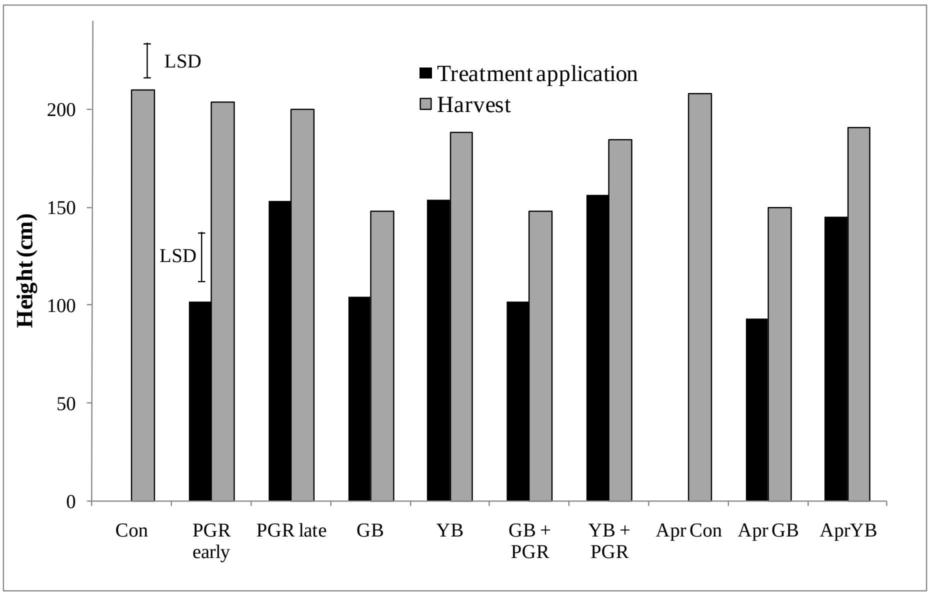

Figure 4: Crop heights at treatment application and at harvest. Bars = $LSD_{(0.05)}$. Con = control; PGR = Toprex; GB = topping early; YB = topping late; Apr Con = April control.

Discussion

In New Zealand, detailed investigations on the growth and reproductive development of forage rape grown for seed are limited. The present study has shown that mechanical defoliation and sowing date significantly alter crop architecture and seed yield. Late defoliation at yellow bud growth stage increased seed yield by 30% over the controls. Defoliation at yellow bud resulted in more even reproductive development with a higher proportion of seed being contributed by the upper secondary racemes. Previous defoliation trials have not resulted in seed yield increases (Khan *et al*., 2007a; 2007 b). In the trials of Khan *et al*. (1997) defoliation was extensive with two thirds of the growth removed, in contrast to this study where only 10% of plant height was removed. In the present study, defoliation at green bud growth stage did not affect seed yield. These plants were 25% shorter than other treatments and had fewer secondary racemes. The reduction in light interception may have affected source sink relationships (Diepenbrock, 2000) as these plants had a smaller proportion of seed contributed by the upper secondary racemes compared with yellow bud defoliation. Application of PGR had no affect on plant height or seed yield in this experiment. The first application of PGR in the present study was in the middle of October when the crop was approximately 1 m tall. Earlier applications might have reduced crop height and altered crop architecture.

April sown treatments yielded 50% more seed than comparable March sown treatments. Crop establishment in April sown treatments was slower than March sown treatments through autumn. During spring growth, April sown treatments had a more uniform distribution of plants and reached canopy closure later allowing better penetration of light through the canopy in late spring. Summer temperatures during the study were lower than average. The effect of cooler temperature during seed fill will require further investigation. Huehn (1998) showed that irregular sowing and germination, as well as abiotic and biotic effects, lead to non-uniform distribution of plants in the canopy resulting in reduced seed yields. The cultivar Greenland is a late flowering forage rape cultivar, and a later sowing date might benefit later flowering cultivars.

Conclusions

This study has shown that increases in seed yield can be achieved through cost effective management practices. However, innovations to minimise crop damage during defoliation are needed. Future detailed studies investigating flowering time, plant density, source sink relationships and stand uniformity will offer further insights into understanding and improving seed yield management practices in forage rape.

Acknowledgements

This research was funded by the Foundation for Research, Science and Technology (FRST) “Advanced seed production” contract number LINX0803. Thanks to Maria Duter, Lee Sutherland, Alec Maunsel, Angela Ravagnani and Alexandra Shearer for technical assistance.

References

Armstrong, E.L and Nicol, H.I. 1991. Reducing height and lodging in rapeseed with growth regulators. *Australian Journal of Experimental Agriculture* 31: 245-250.

Diepenbrock, W. 2000. Yield analysis of

winter oilseed rape (*Brassica napus* L.): a review. *Field Crops Research* 67: 35-49.

Huehn, M. 1998. A general approach to determine the effect of accuracy of sowing technique on yield per area. *Journal of Agronomy and Crop Science* 181, 249-255.

Khan, R.U., Rahid, A., Khan, M. and Khan, M.S. 2007a. Impact of topping rapeseed (*Brassica napus* L.) on the economic returns under Rhod Kohi conditions. *Pakistan Journal of Biological Sciences* 10: 2740-2743.

Khan, R.U., Muendel, H-H. and Chaudhry, F. 2007b. Ratooning rapeseed (*Brassica napus* L.): effect on yield components and seed yield under rain fed conditions. *Pakistan Journal of Agricultural Research* 20: 124-129.

Rose, T.J., Rengel, Z., Bowden, J. and Ma, Q. 2007. Differential accumulation of phosphorus and potassium by canola cultivars compared to wheat. *Journal of Soil Science and Plant Nutrition* 170: 404-411.

Sinclair, T.R. and Muchow, R.C. 1999. Radiation use efficiency. *Advances in Agronomy* 65: 215-265.