# Effect of sowing date on forage rape seed quality

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## Abstract

New Zealand produced forage rape (*Brassica napus* L.) seed lots usually have a germination of ≥ 90% but can differ markedly in seed vigour. Abiotic stress during seed development can reduce seed vigour, and changing sowing date has been proposed as a means of reducing the impact of this stress. Seeds of forage rape cv. Greenland were sown on 25 March and 11 April 2011 at Lincoln, Canterbury. Plant reproductive growth was monitored and a seed development study conducted. Seeds were hand harvested at 50% seed moisture content (SMC), 25% SMC and 14% SMC and their germination, seed vigour and thousand seed weight (TSW) determined. Seeds reached physiological maturity (PM) at 48% SMC after the plants had accumulated a total of 1279 (March) and 1229 (April) growing degree days (Tbase = 5$^{o}$C). Seed development was similar for both sowing dates. Sowing date had no effect on germination, but both seed vigour and TSW were lower for the March than the April sowing. In the three weeks between PM and harvest maturity (14% SMC), seed quality was reduced significantly for both sowing dates. Because climate data were obtained from a weather station one kilometre from the trial site, it was not possible to directly relate seed quality differences between sowing dates to abiotic stress during seed development, and this requires a further study. For this late flowering forage rape cultivar, Greenland, an April rather than a March sowing is likely to produce a greater yield of higher quality seed.

***Additional keywords:*** abiotic stress, germination, growing degree days, harvest maturity, physiological maturity, seed development, seed vigour, thousand seed weight

## Introduction

In New Zealand, forage rape (*Brassica napus* L.) is an important supplementary feed crop in animal production systems (Trethewey, 2009). Forage rape seed production is based in Canterbury, with between 2000-2500 tonnes of certified seed produced annually (AsureQuality, 2016). While seed of the same cultivar produced in the same season generally has a germination of 90% or greater, seed vigour can differ markedly among seed lots. This can cause establishment problems for forage rape seed crops (Leeks, 2006).

The developing seed can encounter abiotic stresses involving temperature, photoperiod and humidity which affect both seed germination and seed vigour (Wang *et al*., 2012). Hampton *et al*. (2013) suggested changing sowing date as a mitigation strategy for reducing such seed quality losses, Trethewey (2012) reported that seed yield was 50% greater for an April than a March sowing of forage rape, but did not report on seed quality. Brassica seeds attain physiological maturity (PM) at around 50-55% seed moisture content (SMC) and harvest maturity at around 14% SMC (Kimber and McGregor, 1995).This paper reports results from an experiment designed to investigate the effect of sowing date on forage rape seed development and seed quality in Canterbury.

## Materials and Methods

The experiment was carried out at the AgResearch Lincoln farm ($43^o$ 38'S, $172^o$ 28'E) on a Templeton silt loam soil type. Trethewey (2012) presented crop management strategies to improve forage rape seed yield, and the data reported in this paper were taken from the control (untreated) plots of Trethewey (2012). Briefly treatments were two sowing dates, 25 March and 13 April 2011, each replicated four times in a randomised complete block design. Soil preparation consisted of conventional cultivation after deep ploughing. Seeds of forage rape cv. Greenland were drilled at 3 kg/ha using a precision seeder in 15 cm rows at 2 cm depth. Plots were 2.7 m wide by 10 m long.

Weeds were controlled by a pre-emergence application of 1.71/ha$^{-1}$ of Treflan (ai 480 g/1 trifluralin EC) in 200 l water. A total of 150 kg nitrogen/ha (as urea) was applied in two split applications on 21 August and 5 September 2011. Plots were irrigated when water deficit was approximately 100 mm, as estimated using Penman evapotranspiration data from the Lincoln Broadfield weather station ($43^o$ 37'S, $172^o$ 28'E). Netting was erected after flowering to protect the developing seeds from bird damage.

Plant reproductive growth was monitored weekly and the following dates were recorded for each treatment: start of flowering (the date when 5% of plants in each plot had one open flower), peak flowering (the date when there were no further increases in flower numbers – Kirkegaard *et al*., 2008), first pod appearance (the date when 5% of the plants in each plot had one pod), seed physiological maturity (PM, the date when no further increase in seed dry weight occurred), and seed harvest maturity (HM, the date when seeds reached 14% SMC).

Three randomly selected plants from the middle rows of each plot were tagged. Every five days from the start of seed development 20 pods from the mid-section of a primary raceme were hand harvested and the seeds removed and weighed (fresh weight). Seed moisture content was assessed using the low constant temperature oven method (ISTA, 2016) of $103^oC$ for 17h. The weight of these seeds after the moisture test was the dry weight.

When seeds had reached 50% SMC (PM), 25% SMC (pre-final desiccation) and 14% SMC (HM), five plants from each plot were selected at random and all seeds hand harvested. The seeds were then ambient air dried to between 8-10% SMC and placed in moisture proof sealed zip-lock plastic bags and stored at $5^oC$ for one month until seed quality testing could be conducted. Samples drawn from the bulked seeds from each plot were assessed for standard germination and thousand seed weight (TSW) using internationally agreed methodology (ISTA, 2016). Seed vigour was assessed using (i) the method for the conductivity test for *Pisum sativum* (ISTA, 2016) but adapted for brassicas by reducing the seed soaking time at 20°C to 16h (Leeks, 2006), and (ii) The accelerated ageing test as described for *Glycine max* (ISTA, 2016) i.e. ageing seeds at 41°C for 72h.

Climate data (mean daily, daily maximum and minimum temperature, relative humidity and daily and monthly rainfall) were obtained from the Lincoln Broadfield weather station. Growing degree days (GDD) were calculated using a Tbase of 5°C.

### Data analysis

Seed quality test data were analysed by analysis of variance using Genstat Software (16th edition, VSN International Ltd, Hemel Hempstead, UK). An analysis of variance was used to establish relationships between the GDD accumulated during each seed development stage and seed quality attributes. The common slope was used to test the statistical significance of any relationship at P<0.05.

## Results

In the 2011/12 season the ambient air tempertaure was between 0.2 to 0.8°C cooler than the 30 year average from the Lincoln Broadfield site but total rainfall was higher by 50 mm. During the periods from flowering to seed harvest maturity, daily mean maximum temperature was from 0.6 to 1.6°C higher for the April compared with the March sowing, but daily minimum temperature differences were not consistent between the two sowings (Table 1). In the three months from November to January daily maximum temperature exceeded 25°C several times, but only in January did this occur on consecutive days. Mean daily rainfall ranged from zero to 3 mm, with the greatest number of days when rainfall exceeded 1 mm occurring between flowering and PM (Table 1). April sown plots received no rain in the week before harvest.

April sown plants took five days longer than March sown plants to reach 80% SMC, three days less to reach PM, and two days less to reach HM (Table 1). The April sown plants required 73 more GDD to reach 80% SMC then the March ones, but required 27 fewer GDD to move from 25% SMC to HM. Total GDD from sowing to HM were 1551 for the March sowing and 1479 for the April sowing (Table 1).

Seed development did not differ markedly between the two sowing dates (Figure 1). Seed dry weight increase ceased at just under 50% SMC for both sowings, signalling the achievement of PM. From this point SMC continued to reduce until the seeds were harvested at 14% SMC (Figure 1).

For all three seed harvest times, standard germination and seed vigour as assessed by the accelerated ageing test did not differ between the two sowing dates (Table 2). However, TSW was significantly (P<0.05, 0.01) greater for the April than the March sowing at all three harvests. At PM, seed vigour as assessed by the conductivity test did not differ between the sowing dates, but was lower for March than the April sowing at the two post-PM harvests (Table 2). As the GDD increased after PM, seed quality decreased (Figure 2). There were no significant differences between sowing dates for germination and vigour, but there was for TSW (P<0.04). The relationship between GDD and germination, accelerated ageing vigour, conductivity vigour and TSW was significant (P<0.01, P<0.01, P<0.01, P<0.05 respectively) (Figure 2).

**Table 1:** Environmental conditions during four seed development periods of forage rape for two sowing dates, duration of each period and growing degree days accumulated.

| Period[1] and Sowing date[2] | | Period Date | Period Duration (days) | Rainfall mean (mm day$^{-1}$) | Number of wet days (>1 mm) | Relative humidity mean (%) | Daily Temperature mean (°C) maximum | Daily Temperature mean (°C) minimum | Growing Degree Days Accumulated Per period | Growing Degree Days (Tb = 5°C) Total[3] |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | March | 16 Oct-2 Dec | 58 | 2.3 | 14 | 77.1 | 17.0 | 7.5 | 421 | 1104 |
| | April | 14 Oct-13 Dec | 63 | 2.8 | 13 | 77.0 | 17.6 | 8.5 | 493 | 1068 |
| 2 | March | 3-21 Dec | 19 | 3.0 | 5 | 81.4 | 17.7 | 10.8 | 175 | 1279 |
| | April | 14-29 Dec | 16 | 1.5 | 3 | 79.0 | 19.3 | 10.9 | 161 | 1279 |
| 3 | March | 22 Dec-4 Jan | 14 | 0.1 | 1 | 78.0 | 20.7 | 11.6 | 156 | 1435 |
| | April | 30 Dec-12 Jan | 14 | 0.6 | 3 | 79.3 | 21.0 | 12.3 | 161 | 1390 |
| 4 | March | 5 Jan-13 Jan | 9 | 0.8 | 2 | 82.0 | 22.5 | 13.3 | 116 | 1551 |
| | April | 13 Jan-19 Jan | 7 | 0.0 | 0 | 68.0 | 24.1 | 11.0 | 89 | 1479 |

[1]1 = flowering to 80% SMC; 2 = 80% SMC to 50% SMC; 3 = 50% to 25% SMC; 4 = 25% SMC to 14% SMC

[2]March 25 and April 11, 2011

[3]from sowing

(a)

(b)

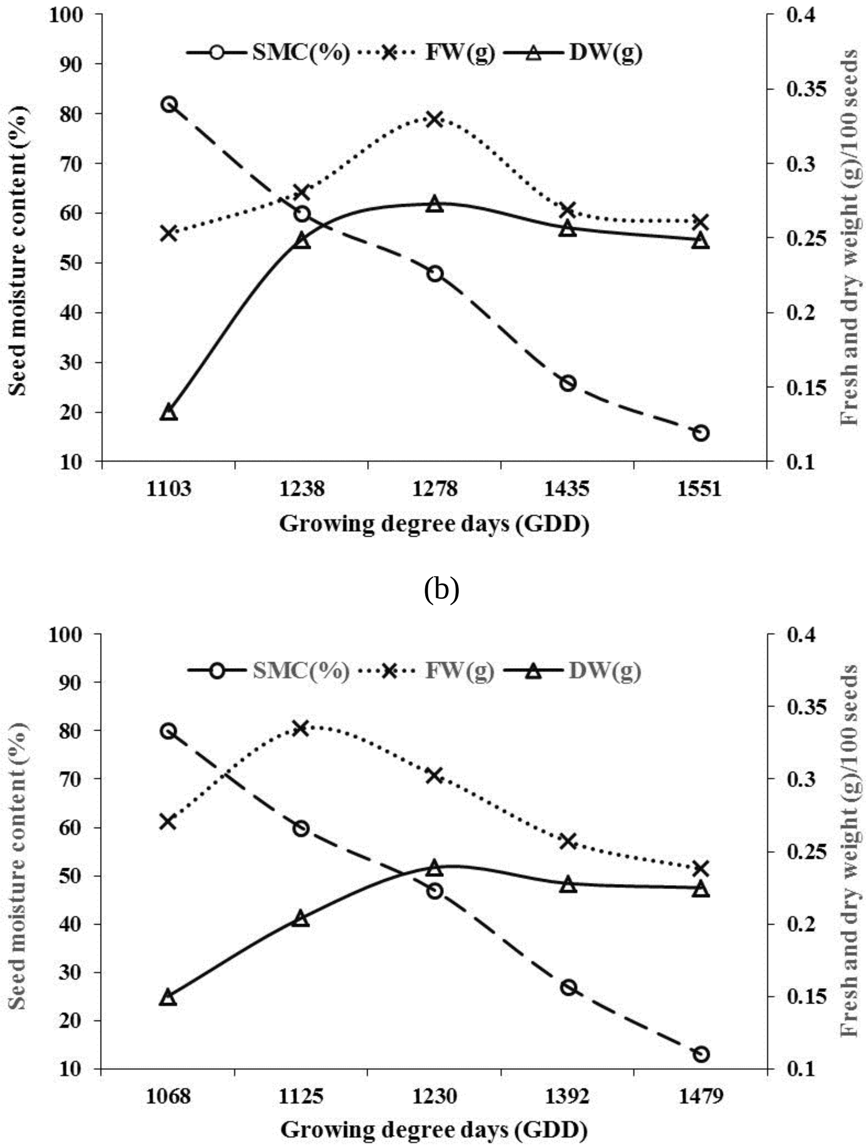


**Figure 1:** Seed development of forage rape cv. Greenland following a March (a) and April (b) sowing. Each data point is the mean of three independent measurements.

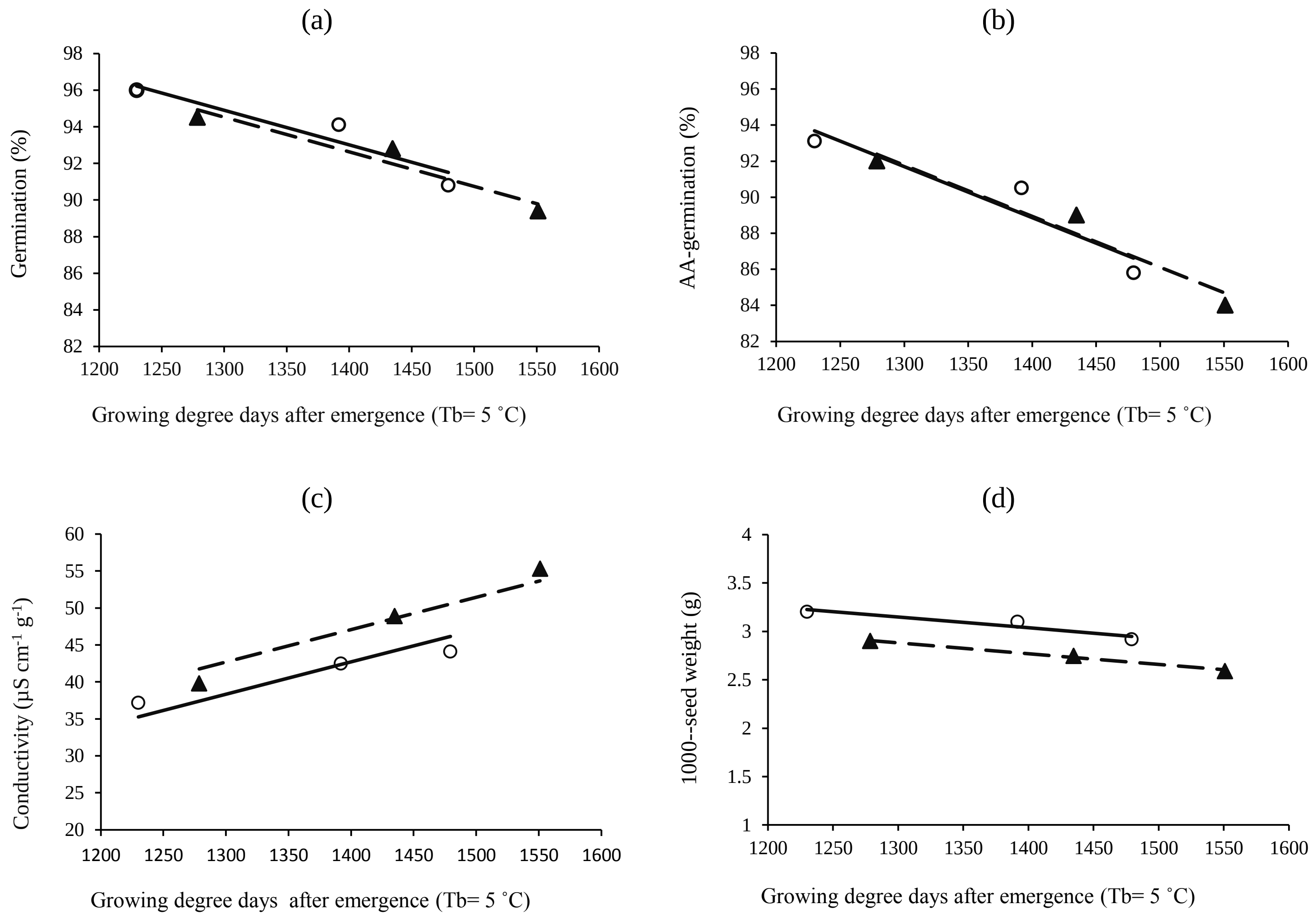


**Figure 2:** Relationship between growing degree days (GDD) accumulated after seed physiological maturity (PM) and seed quality, for the March (▲, — —) and April (○, ——) sowings.

**Table 2:** Effect of sowing date on forage rape seed quality when hand harvested at 50%, 25% and 14% seed moisture content (SMC).

| Sowing date | SMC[1] at harvest | Germination (%) | Vigour AA[2] (%) | conductivity[3] (μs cm$^{-1}$) | TSW[4] (g) |
|---|---|---|---|---|---|
| 25 March | 50 | 95 | 92 | 39.81 | 2.90 |
| 11 April | 50 | 96 | 93 | 37.19 | 3.20 |
| LSD P<0.05 | | 3.7 | 2.6 | 5.3 | 0.12 |
| Significance of difference | | ns | ns | ns | ** |
| 25 March | 25 | 93 | 89 | 48.91 | 2.74 |
| 11 April | 25 | 94 | 91 | 42.48 | 3.10 |
| LSD P<0.05 | | 3.0 | 4.3 | 4.6 | 0.13 |
| Significance of difference | | ns | ns | * | ** |
| 25 March | 14 | 89 | 84 | 55.32 | 2.59 |
| 11 April | 14 | 91 | 86 | 44.13 | 2.92 |
| LSD P<0.05 | | 2.7 | 4.4 | 10.7 | 0.22 |
| Significance of difference | | ns | ns | * | * |

[1]seed moisture content; [2]accelerated ageing vigour test; [3] conductivity seed vigour test; [4]thousand seed weight;
ns = not significant; *significant at P<0.05; ** significant at P<0.01

## Discussion

A knowledge of seed development stages can assist with the decision on when to harvest the crop to obtain the highest seed yield and quality. Harvesting too early may result in a lower yield and reduced quality because of lower TSW (Linton *et al*., 2016) or from immature seeds that will need to be removed during seed cleaning. Seeds may also be physically damaged during the harvesting process. Harvesting too late may reduce yield because of pod shatter and bird damage, and reduce seed quality due to weathering damage (Elias and Copeland, 2001). Days after flowering has often been used as an indicator of seed development stage, but is an inaccurate method as the environment during the time in which seed development is occurring affects the rate of seed development and maturation (Hampton *et al*., 2013). Seed moisture content is a better indicator of seed development stages, as it can be better correlated with seed physiological stage (Fraser *et al*., 1982).

For both sowing dates, seeds reached PM at around 48% SMC. This took 77 days after first flowering and the accumulation of 596 GDD for the March sowing, and 78 days and the accumulation of 654 GDD for the April sowing. These results are in agreement with two previous New Zealand studies of seed development in *B. napus* (Ali, 1984) and *B. oleracea* (Komba, 2003), and international studies on *B. napus* (Ghasemi-Golezani *et al.*, 2011), *B. oleracea* (Still, 1999) and *B. rapa (*Ren and

Bewley, 1998). There is a consistent pattern of physiological seed development among *Brassica* species (Still, 1999), although GDD required for seed development will differ among different environments (Still and Bradford, 1998).

PM is generally considered to be the time when seeds attain maximum quality (Hampton, 2000), although PM can occur after maximum seed dry weight has been attained (Finch-Savage and Bassel, 2016). It is also known that seed quality may decrease after PM, with the extent depending on environmental factors (Ellis and Hong, 1994). Environmental stress during this time accelerates the physiological deterioration of seeds, and seed germination and vigour can decline rapidly (Hampton *et al*., 2013). In this study as GDD accumulated after PM, seed vigour and TSW declined significantly.

New Zealand forage brassica seed crops are usually cut at around 40-45% SMC (Trethewey, 2012) and left in the swath for around two weeks for SMC to reduce to 14-20% before threshing (Komba, 2003). In *B. oleracea*, Komba (2003) reported that both the germination and vigour of seed did not begin to decline until after three weeks in the swath, but in the present study in the three weeks between PM and HM (14% SMC), seed quality had declined. Because of the differences in species, harvesting method and season, a direct comparison is not valid, but the present seed quality results do support the practice of cutting the seed crop soon after PM, and not waiting until SMC has reduced to <20% before direct combining. The latter method is also likely to produce a lower seed yield because of increased pod shattering (Komba, 2003).

Differences in environmental conditions resulting from different sowing dates may result in differences in seed quality (Hampton *et al.*, 2013). The 17-day difference in sowing date for the present trial did not affect germination, but there was a small reduction in seed vigour for the March sowing indicated by the conductivity test. The March sown crop took 22.2 GDD more to move from PM to HM, and in the week prior to HM encountered a higher relative humidity and rainfall than the April sowing, possibly resulting in the reduced cell membrane integrity recorded by the conductivity test (Wang *et al*., 2012). However, it was not possible to directly relate seed quality differences to different abiotic stresses experienced by March and April established plants as the climate data recorded were not directly from the trial site. While the conductivity test indicated a significant difference in seed vigour between the sowing dates, the accelerated ageing test did not. However Rashid (2016), in further experiments involving a greater number of seed lots reported a significant negative relationship between conductivity and accelerated ageing vigour test results ($r = 0.981$, $P<0.05$).

TSW was significantly greater for the April than the March sowing. This result differs from that of Chakwizira *et al.* (2010) who reported that sowing date had no effect on TSW. Trethewey (2012) reported that seed yield was significantly greater for the April sowing than the March sowing, and attributed this to the fact that the former had a more uniform distribution of plants allowing a higher interception of light and a greater net assimilation rate in the crop (Mandal and Sinha, 2004).

## Conclusions

In this season seed development was similar for both sowing dates. Seeds reached PM at just under 50% SMC. Sowing date had no effect on germination, but seed vigour and TSW were lower for the March sowing than for the April sowing. For both sowings seed quality declined significantly between PM and HM. For the late flowering cultivar Greenland, an April rather than a March sowing is likely to produce a greater yield of higher quality seed. Whether this also applies to other forage rape cultivars requires further investigation.

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