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Research Note

Seed loss as a result of pod shatter in spring rape and spring turnip rape in Finland

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The aims of this study were to evaluate seed shedding in spring turnip rape (*Brassica rapa* L.) and spring rape (*B. napus* L.) and to assess the effect of delayed harvesting on seed yield loss. Experiments on spring turnip rape (cv. Emma) were conducted in 1988–1990 and on spring rape (cv. Topas) in 1989–1990 in Jokioinen (60°49'N, 23°28'E). Rimmed tin boxes were used to collect seed from shattered pods. They were placed between the continuous rows before pods started to shatter. The shed seeds were collected two to three times a week. Susceptibility and timing of pod shattering varies between spring turnip rape and rape. However, before optimal harvest date spring rape does not shatter significantly more than spring turnip rape. Spring rape starts to shatter more compared with spring turnip rape after its optimal harvest date. It is also more sensitive to weather conditions than spring turnip rape. Furthermore, pod shattering after optimal harvest time differs among years. Weather conditions are discussed as one possible cause of pod shattering.

Key words: *Brassica napus* L., *Brassica rapa* L., delayed harvest, pod shattering, weather

Introduction

The principal oilseed crops in Finland are spring turnip rape (*Brassica rapa* L.) and spring rape (*B. napus* L.). In 2000 51300 ha and 1200 ha were respectively sown to each. Oil seed crops have proved to be advantageous in breaking cereal monocultures when cultivated every fourth or fifth year. Pods of *Brassica* species shatter during maturity and harvest resulting in marked losses of seed. Moreover, the shed seeds may remain viable during several years and germinate to produce volunteer plants, which represent weeds in the following crops. Average annual seed losses for rape can reach 20% and are

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much higher than for any other major arable crop (Child et al. 1998). Most previous studies have focused on pod shattering in *B. napus*.

Seed loss is generally divided into two periods, shattering before harvest and shattering during harvesting. Factors in the field that influence the level of shattering include weather conditions prior to and during harvesting. Contacts among pods and other canopy components during windy conditions have also been assumed to contribute to shattering in the field. Furthermore, pest and disease damage can result in accelerated ripening and pod shattering (Josefsson 1968, Kadkol et al. 1984, Child et al. 1998). Finally, the mechanism of pod opening involves changes in phyto-hormone balance (Child et al. 1998).

This experiment was a part of a larger study, the specific objective of which was to determine the weed potential of volunteer oil seed plants under field conditions, including assessment of viability and dormancy of the shed seeds. In this experiment pod shattering in spring rape and spring turnip rape stands was recorded, to evaluate the natural seed losses in the field and the number of seeds that can become weeds in the next crop.

Material and methods

Experiments on spring turnip rape (cv. Emma) were conducted in 1988–1990 and on spring rape (cv. Topas) in 1989–1990 in Jokioinen (60°49'N, 23°28'E). The crops were sown using a combine sowing machine (Tume 2000, Nokka-Tume Oy, Finland). Because of the properties of the sowing machine the theoretical row spacing of 12.5 cm resulted in the actual row spaces at 10 and 15 cm in the field. The size of the experimental field was 40 m × 40 m in 1988 for spring turnip rape, and 25 m × 50 m in 1989 and 1990 for both *Brassica* species. Six replicates of 1 m^2 (in 1988) and 0.7 m^2 (in 1989 and 1990) were located in the fields so that each was randomly assigned in relation to length and width of the field. A 0.5 m × 1 m buffer zone of intact plants was left in front of each replicate. Rimmed tin boxes of two different sizes, 5 cm × 100 cm and 10 cm × 100 cm, were used to collect seed from shattered pods. They were placed between the continuous rows before pods started to shatter. The shed seeds were collected two to three times a week. To avoid inducing shattering during collection the boxes were moved by pushing them slowly along the soil surface through the buffer zone. All measured values given in this study have been adjusted to correspond to a collection area of 1 m^2. Seed weights, g m^{-2} and kg ha^{-1}, are given at 9% moisture content. Both weight and number of shed seeds per unit area were evaluated and presented on a daily basis by dividing the values by the number of days between the collection dates. For *B. rapa* the yield at optimal harvesting time was determined by randomly harvesting from four plots of 1.25 m × 8 m (in 1988), and for both *Brassica* species by harvesting three plots of 1.25 m × 23 m (in 1989 and 1990). Favorable harvesting time was determined as being when the green colour had disappeared from all plant parts except the stem base, and seeds were black (rape) or dark brown (turnip rape). The growth stage at optimal harvesting time is 5.5 using the scale of Harper and Berkenkamp (1975). The description is modified for Finnish conditions according to official procedures for field trials at MTT. Agricultural details are given in Table 1 and weather conditions during the collection in Fig. 1.

Flea beetles (*Meligethes aeneus*) were controlled during both years by using deltamethrin (0.06 kg ha^{-1}) one to three times before anthesis, when the threshold level of the control (one to three beetles on a plant) was exceeded. Annual weeds were sprayed using metazachlor (1.3 kg ha^{-1}) at the three leaf stage of the crop, and *Agropyron* was controlled using fluazifop-P-butyl (0.3 kg ha^{-1}) in 1988. In 1989 and 1990 trifluralin (0.96 kg ha^{-1}), applied before sowing, was used for weed control.

After graphic examination the data for both *Brassica* species strongly suggested the presence

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Table 1. Agricultural details for pod shattering experiments in 1988–1990.

	Spring turnip rape			Spring rape	
	1988	1989	1990	1989	1990
Sowing date	27 May	19 May	8 May	19 May	8 May
Seeding rate, viable seeds m^{-2}	350	350	350	300	300
Nitrogen fertilizer, kg ha^{-1}	110	110	110	110	110
Field size, m^2	1600	1250	1250	1250	1250
Plant density m^{-2} in June	420	370	237	318	301
Optimal harvest time	26 Aug	11 Sep	17 Sep	5 Oct	5 Oct
Seed yield, kg ha^{-1}	1920	2110	1810	2130	1280

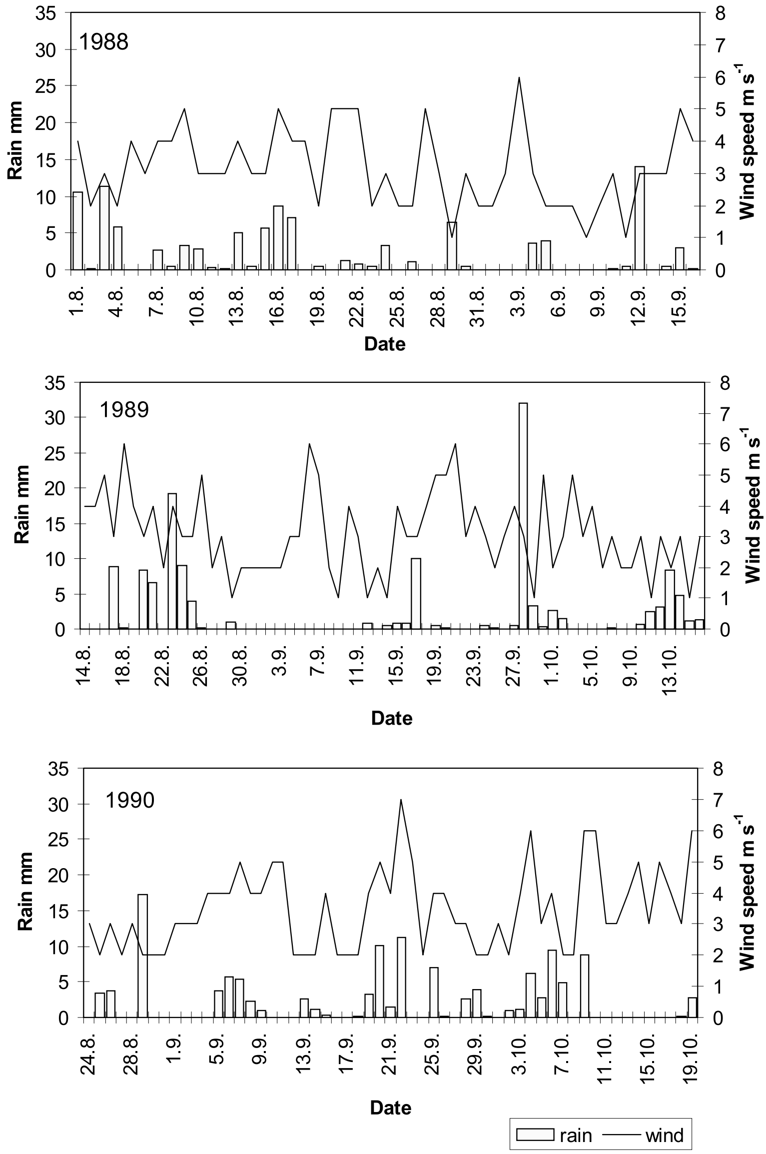

Fig. 1. Precipitation (mm day^{-1}) and average wind speed (m s^{-1} day^{-1}) during seed collection in 1988, 1989 and 1990 measured at Jokioinen Observatory.

of a skewness. Daily pod shattering releasing five to ten seeds was very common, but there was an unexpectedly large shattering of up to 300 seeds m^{-2}. The phenomenon was so clear that descriptive statistical terms of median value, 25th percentile (first quartile, i.e. value greater than 25 per cent of the values measured) and 75th percentile (third quartile) were used in analysing the data separately for each of the three years. The difference between species was so clear (Figs. 2–3) that statistical analysis was not appropriate.

Results and discussion

Spring turnip rape

The number of shed seeds m^{-2} day^{-1} around normal harvest time varied depending on the year and the crop species. There was only a slight connection between number of shed seeds (Fig. 2) and weather conditions (Fig. 1). The greatest number of spring turnip rape seeds was shed in 1988. Shedding peaks of about 40 seeds m^{-2} day^{-1} were recorded between 3 and 7 August (three weeks before normal harvest time) and between 2 and 4 September (one week after optimal harvest) (Fig. 2). According to the Finnish Meteorological Institute, Jokioinen Observatory, there was neither exceptionally high precipitation nor high wind speed during the period of these two peaks. However, rainfall of 11 mm on both 1 and 3 August and a wind speed of 6–7 m s^{-1} on 3 September together may have had a slight effect on the high number of shed seeds. By the optimal harvest date, 26 August, 8 kg of seeds ha^{-1} (median) had been shed. This was 0.4% of the total yield of 1920 kg ha^{-1} harvested at the optimal time. Pod shattering clearly increased after the optimal harvest date, and after three weeks the cumulative median weight of the shattered seeds was 1.59 g m^{-2}, corresponding to 16 kg ha^{-1} (0.8% of seed yield harvested at optimal date) (median). Hence, in 1988, harvest on the optimal harvesting date resulted in an amount of shed seeds equivalent to that sown in the spring, while a harvest delay of three weeks resulted in twice the amount of shed seeds in comparison with the amount of seed used in sowing. In order to achieve a seedling density of 180–250 plants m^{-2} the optimum seeding rate of spring turnip rape is 6.5–8 kg ha^{-1} (Sankari and Pahkala 1994). The currently recommended seeding rate for spring turnip rape in Finland is 6–10 kg ha^{-1} (Franssila 2001).

In 1989, only 3.1 kg turnip rape seeds ha^{-1} (0.1% of total seed yield of 2110 kg ha^{-1}) was lost before the optimal harvest date (11 September) (Fig. 2). The daily amount of shed seeds exceeded 10 seeds m^{-2} about two weeks later and delayed harvest resulted in a total amount of 6 kg ha^{-1} of shed seeds. No clear connection with weather conditions was established even though two heavy rains were recorded between 23 August and 17 September (Fig. 1). A slight effect of wind on increased shedding was established during the subsequent days as wind speeds were 6 m s^{-1} and 8 m s^{-1} on 21 September.

In 1990, several shedding peaks of about 20 seeds m^{-2} day^{-1} were recorded for spring turnip rape (Fig. 2). The first peak appeared about one week before the optimal harvest date. At that time, again, no extreme weather conditions were recorded (Fig. 1). The next peak appeared on the optimal harvest date and thereafter shattering clearly increased in comparison with the period before the optimal harvest date. By the optimal harvest date (17 September) only 1.8 kg seeds ha^{-1} had been lost, and at the end of the observation period, i.e. three weeks after optimal harvest, the cumulative median seed weight was 1.04 g m^{-2}, which corresponds to 10.4 kg seeds ha^{-1}. This represented 0.6% of the total seed yield of 1810 kg ha^{-1}.

In 1988, when the sowing date for spring turnip rape was latest in comparison with other years, the pod shattering started two weeks earlier than in 1989 and three weeks earlier than in 1990. The highest plant density was achieved in 1988. A higher number of plants per unit area results in a higher numbers of pods and branches (Pahkala et al. 1994) that can touch each oth-

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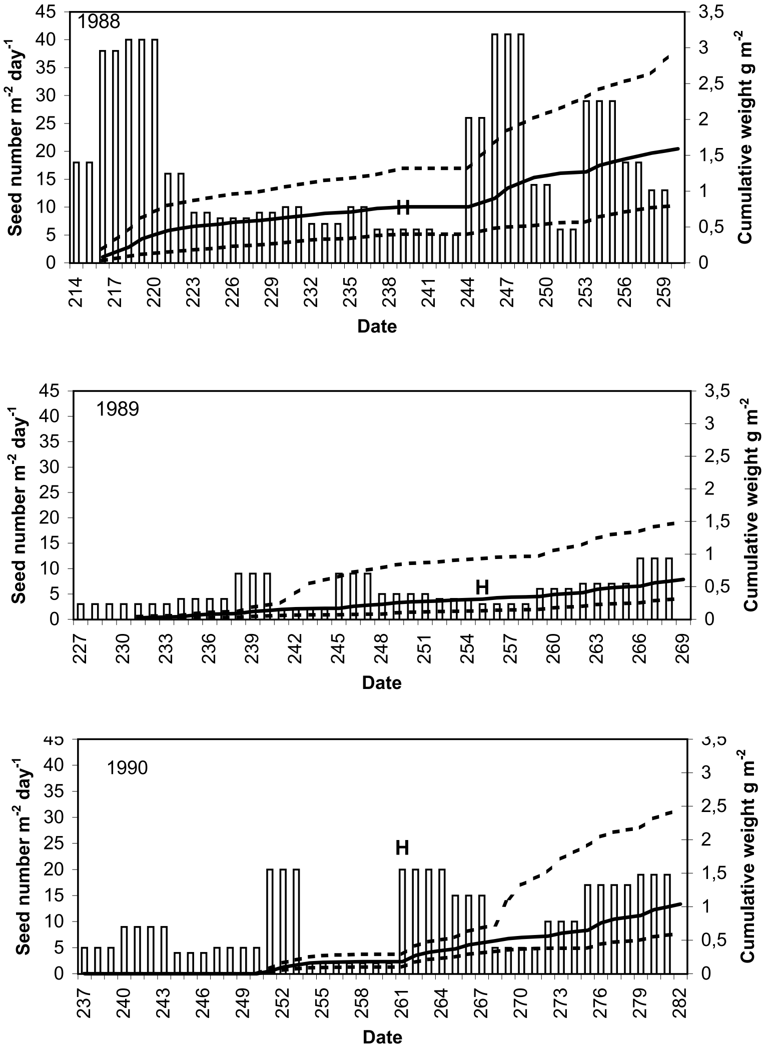


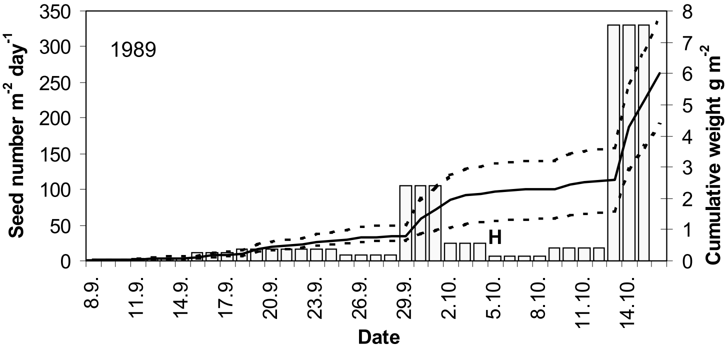
Fig. 2. Field shattering of spring turnip rape seed. Columns represent the daily number of shed seeds m^{-2}. The line represents the median of the cumulative weight of the shed seeds m^{-2} day^{-1}. The broken line under the median line is the 25th percentile and above the median line the 75th percentile of the cumulative weight. Optimal harvesting dates, marked with H, were 26 August 1988, 11 September 1989 and 17 September 1990.

er during windy conditions and accelerate pod shatter and seed loss. Dense stands characterised the whole observation period in 1988. However, pod and branch numbers were not measured in this study.

For spring turnip rape, the highest number of shed seeds m^{-2} day^{-1} was about 40 seeds. However, if the 75th percentile is studied, for example in 1988, seed loss of up to 30 kg ha^{-1} at late harvest was possible. Only few shattering peaks were associated with the weather conditions. Spring turnip rape is partially resistant to changing weather conditions and pod shattering seems to be more or less a sum of the various effects that it was not possible to analyse more accurately in this study.

Spring rape

In 1989 the optimal harvest date for spring rape was on 5 October. By that time, only one peak of shed seeds higher than 100 shed seeds m^{-2} day^{-1} was recorded (Fig. 3). One day earlier, on



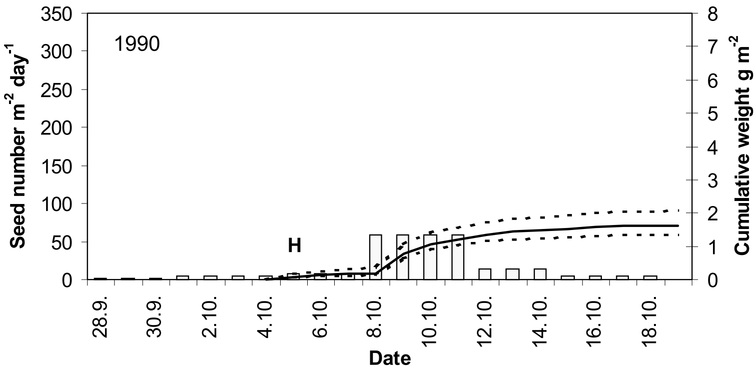


Fig. 3. Field shattering of spring rape. Columns represent the daily number of shed seeds m^{-2} day^{-1}. The line represents the median of the cumulative weight of the shed seeds m^{-2}. The broken line under the median line is the 25th percentile and above the median line the 75th percentile of the cumulative weight. Optimal harvesting date, marked with H, was 5 October in the both 1989 and 1990.

28 September, 32.1 mm of rain fell. Moreover, an average wind speed of 5 m s^{-1} (Fig. 1), reaching 8 m s^{-1} at 14.00 (data not shown) was recorded on 30 September. These conditions could explain this shattering peak. By the optimal harvest date, the yield loss of spring rape was 22.2 kg seeds ha^{-1} (median) i.e. 1% of total harvested yield of 2130 kg ha^{-1}. The second peak occurred 10 days after optimal harvest, resulting in about 300 shed seeds m^{-2} day^{-1}. In this case, however, shattering was not explained by extreme weather conditions (Fig. 1). The cumulative weight of the seeds ha^{-1} surviving the winter indicates that spring rape can be a harmful weed in subsequent years and would require controlling with herbicide.

In 1990, spring rape shattered clearly less than in 1989 (Fig. 3). The highest daily peaks, of about 60 shed seeds m^{-2}, were observed on 8–11 October, only a few days after optimal harvest date. Weather conditions could explain the shattering on 10–11 October, as the average wind speed was 6 m s^{-1} on both days (Fig. 1), but neither the wind speed nor the precipitation explained the start of the higher shattering on 8 October. In 1990, spring rape shattered at only 0.8 kg ha^{-1} by the optimal harvest date. This represented only 0.1% of the total harvested yield of 1280 kg ha^{-1}. Even if the harvest was delayed two weeks it finally resulted in only 16 kg shed seeds ha^{-1} (1.3% of harvested seed yield) (median) and was then much less than the loss in previous year.

Susceptibility to shattering differs between spring turnip rape and spring rape. Spring rape does not seem to shatter significantly more than spring turnip rape before the optimal harvest date. By that date, seed loss varied between 0.1 and 1% of total harvested seed yield for both species. These figures are far smaller than those

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reported by Child et al. (1998). Pod shattering after optimal harvest varies among years. The highest number of shed seeds per unit area and per day was about 300 for spring rape, which is 7.5 times more than for spring turnip rape. Spring rape also seemed to be more sensitive to extreme weather conditions than spring turnip rape. The cultivars used in this study are no longer commercially cultivated in Finland. However, the results remain relevant since little variation in resistance to shattering has been observed among genetic resources of these oilseed cultivars (Josefsson 1968, Child et al. 1998, Morgan et al. 2000). In field shattering the influence of plant morphological characteristics, including number and stiffness of the branches, the angle between the shoot and the siliqua and the tendency of the plants to form a mat-like canopy are important (Kadkol et al. 1984). The canopy structure of *Brassica* oilseed crops, including number of branches and pods, is highly dependent on the number of emerged plants (Pahkala et al. 1994).

The results of the study focused on pre-harvest seed losses. More studies are needed to evaluate seed losses attributable to machinery during harvest. Determination of weed potential of volunteer plants includes also study of the viability and dormancy of the shed seeds at various soil depths.

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SELOSTUS

Öljykasvien siementen variseminen ennen puintia

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Tutkimuksen tarkoituksena oli määrittää ennen korjuuta varisevien kevätrypsin ja -rapsin siementen määrä. Varisemisen seuranta aloitettiin ennen optimikorjuupäivää ja sitä jatkettiin useita viikkoja sen jälkeen (myöhästetty korjuu). Tutkimuksessa määritettiin luonnollisen varisemisen seurauksena aiheutuneet satotappiot ja arvioitiin öljykasvien viljelyn aiheuttamaa rikkakasvipainetta viljelykierrossa.

Rypsin ja rapsin varisemisherkkyys oli erilainen. Ennen tuleentumista ero kasvilajien välillä ei ollut merkityksellinen, mutta korjuun myöhästyessä rapsin variseminen lisääntyi selvästi rypsin varisemiseen verrattuna. Kasvuston varisemisen aiheuttama satotappio vaihteli vuosittain. Säätekijät kuten sademäärä ja tuulennopeus eivät kuitenkaan selvästi lisänneet varisemista.