The biology and non-chemical control of Volunteer Oilseed Rape (*Brassica napus* L.)

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Volunteer oilseed rape
(Oil-seed rape)
***Brassica napus* L. ssp. *oleifera* (DC). Metzg.**

Occurrence
Volunteer oilseed rape infestations result from the massive seed losses that occur in both spring and winter oilseed rape due to natural shedding and crop disturbance during harvesting (Price *et al.,* 1996). The seed bearing pods mature in sequence and the earliest become fragile and are easily split open as the seed ripens. However, the crop is harvested at a relatively late stage because there are problems with the drying and storage of immature seeds. Seed losses of 8-12% during crop harvest can mean several thousand seeds per m^2 being shed onto the soil. In adverse conditions losses can exceed 20%. Shed seed numbers often reach 10,000 per m^2 (Lutman, 1993). This is equivalent to 200-500 g/ha of seed. Feral oilseed rape seed was not detected in arable seedbanks before the 1970s but became common as the crop area increased in the 1970s and 1980s (Squire *et al.,* 2003).

Volunteer seedlings can emerge in any crop that follows oilseed rape. It has been suggested that up to 25% of winter wheat crops are contaminated with volunteer oilseed rape (Orson, 1994). Where soft fruit is grown in an arable rotation volunteer oilseed rape can be a problem even when the rape crop was grown 3 years earlier (Lawson, 1984). It is a particular problem in strawberries.

Feral or volunteer oilseed rape can cause quality problems in any subsequent oilseed rape crops that are grown (Squire *et al.,* 2003). The volunteers may reduce oil quality where glucosinolate levels are affected. Volunteers from genetically-modified (GM) oilseed rape are a particular problem and may cause a non-GM crop to exceed the EU threshold for the allowed level of GM contamination. GM and non-GM cultivars differ little in seed shedding, dormancy and persistence. Only rigorous management would meet an impurity threshold of 1% even with a 5-year gap between crops. Out-crossing of herbicide tolerant (HT) oilseed rape into non-HT crops grown in close proximity has been reported in Canada (Beckie *et al.,* 2001). Volunteer oilseed rape is a common weed there and occurs in 11% of fields in western Canada (Devine & Buth, 2001). Where reduced or zero tillage is practiced there is an immediate opportunity for gene flow to occur (Gruber *et al.,* 2005). Ploughing delays the risk of gene flow to the future by preserving the seeds deep in the soil until inversion returns them to the soil surface. The likelihood of outcrossing of volunteers with a rape crop depends on when the volunteers flower in relation to the drilled crop.

Flowering feral oilseed rape is a feature of roadside verges and field margins from early spring through to late autumn (Wilkinson *et al.,* 1995). Non-flowering plants can be found throughout the year. Stands can vary from isolated plants to populations containing more than 3,000 individuals.

Volunteer oilseed rape can form a 'green bridge for plant pathogens such as dark leaf spot (*Alternaria brassicae*), powdery mildew (*Erysiphe cruciferarum*) and light leaf spot (*Pyrenopeziza brassicae*) (Yarham & Gladders, 1993). Volunteers facilitate the survival of diseases that do not form resting bodies. Pests that can be carried over include cabbage seed weevil (*Ceutorrhynchus assimilis*), bladder pod midge (*Dasyneura brassicae*) and mealy cabbage aphid (*Brevicoryne brassicae*) (Bray, 1976). Volunteer oilseed rape can also perpetuate the beet cyst eelworm and could cause serious problems in rotations containing sugar beet by allowing populations of the pest to build up in the soil.

Biology

Seeds buried in soil require light for germination and will respond to just a short flash (Pekrun *et al*., 1997a). Germination levels are also related to the amplitude of temperature alternations.

Seedlings are able to emerge successfully from 50 to 75 mm deep in soil but fewer emerge from 100 mm or deeper (Lutman, 1993).

Persistence and Spread

Shed oilseed rape seed can remain viable in soil for several years. In burial experiments seed has persisted for at least 5 years. Volunteer seedlings have emerged 9 years after the original rape crop was harvested.

Light and temperature are thought to affect seed persistence (Pekrun *et al*., 1997a). It may also be linked to the potential for the development of secondary seed dormancy. The seeds do not exhibit dormancy at the time of seed shed and only develop secondary dormancy after exposure to certain environmental conditions. Laboratory studies have shown that the induction of secondary dormancy is influenced by the light and temperature regime, water stress and genotype (Pekrun *et al.*, 1998). Field studies have confirmed that freshly shed seeds exposed to dry, dark conditions after an early cultivation showed the greatest persistence. Seeds left on the soil surface for 4 weeks before cultivation do not build up into a large seedbank. If the soil is left uncultivated rape seeds rarely persist.

Experiments have clearly demonstrated that genotype is the principle factor controlling secondary seed dormancy (Gulden *et al.,* 2004). The development of secondary dormancy under osmotic stress varied considerably between and within genotypes (Momoh *et al.,* 2002). Dormancy ranged from almost zero up to 60% for winter genotypes and up to 85% for spring types. Within genotypes, variation occurred between seed lots and years of harvest. It appears that genotypes that are slow to germinate have a higher potential for developing secondary dormancy. The level of secondary dormancy ranged from below 2% in the spring cultivars Acrobat and Industry and the winter cultivars Falcon and Rapier, to over 50% in the spring rape Nimbus and the winter rape Apex, (Pekrun *et al.*, 1997b).

In set-aside land in Scotland, some volunteer oilseed rape was recorded in the first year but this gave way to other species in later years (Fisher, *et al.*, 1992). In Canada, a high number of volunteer oilseed rape seedlings emerged in the year after crop production (Légère *et al.*, 2001). Small numbers of seedlings were still emerging five years after the original crop was grown.

Pig slurry containing weed seeds may be dried to aid transport. The effect of duration and level of drying temperature on the viability of volunteer oilseed rape seeds was tested in the laboratory (Bloemhard *et al.*, 1992). Seeds were imbibed in pig manure and heated in an oven at different temperatures. Seed survived up to 9 minutes at 50^{o}C but did not survive even 3 minutes at 75 or 100^{o}C.

Management

The choice of a low shedding cultivar and the prevention or reduction of seed losses from harvesting machinery will limit the volunteer problem (Bray, 1976). In row crops, volunteer seedlings in the inter-row can be controlled by mechanical cultivations.

Timely harvest will reduce but not eliminate seed shed (Lutman, 1993). The optimum stage for oilseed rape harvest is when seeds in the bottom pods are dark brown, those in the middle pods are reddish brown and seeds in the top pods are green but starting to turn brown (Price *et al.*, 1996). Rape may be harvested by direct cutting and combining when ripe, the alternative is to swath the crop at an earlier stage of ripening and combine from the swathe after 7-14 days. Shorter cultivars are usually direct cut while taller ones are swathed. Overall losses in winter rape were 11% overall in a direct cut crop of which around half was due to natural shedding. In the swathed crop, losses ranged from 10.7 to 24.8% of which less than 2% was due to natural shedding. The later the swathing the greater the losses. In spring rape, direct cutting losses were up to 5% for both the direct cut and the swathed crop.

Freshly shed seed is not dormant and exposure of seeds on the soil surface does not induce dormancy (Lutman, 1993). Experiments suggest that the germination of volunteer rape seed can be maximised by keeping seeds in the light and exposing them to alternating temperatures (Pekrun *et al.*, 1997a). Cultivations that bury seeds deeply in soil will only increase the risk of inducing dormancy and hence persistence. Therefore, to avoid persistence in soil, freshly shed seed should be retained at the soil surface (López-Granados & Lutman, 1998; Pekrun & Lutman, 1998). Incorporation by tillage should be avoided or delayed as long as possible. A two-week delay in cultivation should be enough if conditions are wet after harvest.

When the stubble was cultivated immediately after an oilseed rape crop, 4-29% of the seed lost during harvest entered the soil seedbank (Gruber *et al.*, 2005). If tillage was delayed, 0-3% of seed entered the seedbank. Zero tillage or cultivation with a rigid tine cultivator distributes seeds in the upper layers of soil whereas ploughing moves seeds into the deeper soil layers. A high number of volunteers are likely to emerge in the following crop when the seed is located near the soil surface. The build up of a large seedbank over several years can lead to the emergence of numerous volunteers when annual ploughing is practiced.

A model has been developed that can predict how different management strategies will affect the seedbank of OSR (Rasmussen *et al.*, 2003). The model can be used to estimate how long it would take to deplete the seedbank in rotations with crops having different management practices.

In laboratory studies, OSR seed mixed with soil was killed by steaming at 75^{o}C (Melander *et al.*, 2002).

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