The biology and non-chemical control of Perennial Sow-thistle (*Sonchus arvensis* L.)

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Perennial sow-thistle
(corn sow-thistle, creeping sow-thistle, dindle, field milk-thistle, field sow-thistle, gutweed, swine thistle)
***Sonchus arvensis* L.**

Occurrence

The perennial sow-thistle occurs widely on arable land and waste ground and is common throughout the UK. It is native by stream sides on banks, waysides, dunes and shingle (Clapham *et al.*, 1987; Stace, 1997). It can be a problem garden weed (Copson & Roberts, 1991). It thrives best in moist fertile soil (Frankton & Mulligan, 1970). Perennial sow-thistle is recorded up to 1,500 ft in the UK (Salisbury, 1961). Remains have been found in prehistoric deposits and there is evidence that it was a pioneer species in the late-glacial period in Britain (Holzner & Immonen, 1982).

In an early survey of weeds in Bedfordshire and Hertfordshire, Brenchley (1911) considered the perennial sow-thistle to be universal in its distribution on different soils. In a further survey of Norfolk and Bedfordshire it was found to be especially associated with heavy loam and clay soils (Brenchley, 1913). Perennial sow-thistle has a preference for level, poorly-drained, stone-free soils rich in organic matter with a pH from 7.4 to 7.8 (Dale *et al.*, 1965). It is common in abandoned sites such as recently abandoned pasture. Perennial sow-thistle prefers slightly alkaline to neutral soils and does not thrive in acid or highly alkaline soils (Lemna & Messersmith, 1990). In greenhouse studies the optimum pH was between 6.2 and 7.2 (Zollinger & Kells, 1991). At pH 5.2, plant dry weight was reduced by 30%. Plants grow better with increasing levels of soil moisture up to the point of saturation. Growth and flowering suffer in dry conditions. Flowering and growth are greater at high light intensities.

In early studies it occurred as often among one type of arable crop as another (Brenchley, 1920). In a survey of weeds in conventional cereals in central southern England in 1982, perennial sow-thistle was found in 1% of winter wheat, 2% of spring barley but not at all in winter barley (Chancellor & Froud-Williams, 1984).

In the Netherlands, 2 ecotypes are found that differ in leaf morphology (Pegtel, 1973). One is found on the coast the other inland on arable sites. The arable form does not germinate readily or survive in the dune habitat. It is not able to develop the extensive root system needed to exploit the poor nutrient and moisture reserves. The coastal ecotype does not tolerate the disturbance that occurs in the arable situation.

Perennial sow-thistle is a host of several important pests and diseases (Lemna & Messersmith, 1990). The potato tuber rot nematode, *Ditylenchus destructor,* can infest the roots (Franklin, 1970). The plant is eaten by foraging animals including rabbits (Rowan, 1913). The abundant latex suggests that the plant has potential for hydrocarbon or oil production.

Biology

Flowering takes place from late July until early October. The flowers are monoecious, insect pollinated and more or less self-sterile (Derscheid & Schultz, 1960). Hover flies, bumble and honey bees visit the flowers. The few seeds (achenes) produced by self-pollination rarely germinate. The time from flowering to full seed maturity is 10 days but 16% of seeds are viable after just 4 days, 25% after 7 days and 83% after 8 days. Viable seeds were able to develop when sow-thistle stems were cut down and left to dry 9 days after flowering. A few seeds matured even when the plants were cut down 4 days after flowering and left in the field. Up to 80 seeds are produced per flower head with an average of 46. Stevens (1932) quotes a figure of 9,750 seeds for a flowering stem with 62 heads. Salisbury (1961) gives the average number of seeds per plant as 13,000. The average seed number per plant is 2,716 according to Pawlowski *et al.* (1970). Other authors have given seed numbers per plant of 6,400 and 13,300 (Stevens, 1957). In cereal crops the average seed number per plant ranged from 475 to 731 and in root crops from 1,377 to 1,510 (Pawlowski, 1966). The 1,000 seed weight ranged between 0.38 and 0.50 g (Stevens, 1932).

Diurnal fluctuations in temperature with an amplitude of 7.5°C promote germination in the light (Thompson *et al.*, 1977). Seed germination is comparatively rapid when day temperatures are high and night temperatures low (Salisbury, 1962). The level of seed germination increased from 0 to 72% following a period of moist storage at 5°C (Grime *et al.*, 1981). In laboratory tests, seed in the light germinated only to 3% at a constant 18-20°C, up to 57% at alternating 20 to 30°C and up to 60% with cycles of 20 to 30 to 8°C (Cross, 1930-33). When seed was sown soon after shedding in August around 80% had germinated within 26 days. Brenchley & Warington (1930) found the pattern of germination to be somewhat irregular. The seeds exhibited only a short period of dormancy and readily germinated whenever conditions were favourable. Few seeds remained after 3 years. Salisbury (1961), however, states that seeds may remain dormant for at least 6 years.

With freshly shed seed mixed into the top 75 mm of soil under field conditions the main emergence period was March to May with a peak in April (Roberts & Neilson, 1981). The soil was cultivated three times a year and seedling emergence recorded at monthly intervals over 5 years. Most seeds germinated in the first year after sowing, however, odd seedlings continued to emerge over the next 4 years. Seed viability was generally poor and only 30% of seeds germinated and emerged over the 5 year period. In greenhouse studies, seeds at or near the soil surface emerged better when soil was at field capacity (Boyd & Van Acker, 2003). At field capacity 44% of seeds germinated on the soil surface and none germinated when buried. Most germination occurs at 5 to 30 mm deep in soil (Hanf, 1970). Seeds do not require light for germination but light may enhance it (Lemna & Messersmith, 1990). In the USA, seed sown in the field began to germinate in May and continued to emerge through to July (Chepil, 1946). Mosts seed germinated in year 1 with only odd seedlings emerging in year 4.

Laboratory studies with two ecotypes, one arable and one maritime, showed differences in germination response (Pegtel, 1972). The coastal form germinated faster at lower temperatures and moisture levels. Both germinated well at 25 or 30°C. The arable form appeared to require a relatively high temperature for germination.

In Sweden, perennial sowthistle seeds mixed with soil in the autumn, put in frames in the field, exhumed at intervals and put to germinate at alternating temperatures showed the seeds to have the lowest dormancy and greatest tendency to germinate from April to November (Håkansson, 1979). Peak germination occurred in April/May. Some seedlings emerged in the autumn after sowing. Seedlings flower in the first year only in favourable conditions (Lemna & Messersmith, 1990).

The vegetative spread of perennial sow-thistle is due to the development of stems from below ground but these arise from roots not rhizomes. Clapham *et al*. (1987), however, refer to them as underground stolons. The radial extension of the roots is commonly from 1 to 2 m per year, even 5 m has been recorded (Salisbury, 1962). New shoots arise from any part of the roots where these are within 15-30 cm of the surface. The roots are found mainly in the top 15 cm of soil (Salisbury, 1961). Aerial shoots do not survive the winter, foliage and fine roots die in September and plants overwinter as thickened roots and as the underground stems of aerial shoots (Håkansson, 1982). Thickened roots appear to live for at least two years. Stems begin to elongate in mid-June and flower buds are visible by the end of the month. Flowering begins in late-July and there is then continuous flower and fruit production until early-September.

Cut pieces of thickened roots, 3-5 mm thick, planted in November, developed new roots and shoots the following April (Håkansson, 1969). When the shoots had developed 5-7 leaves some of the new roots began to thicken. In the summer, new shoots developed from these thickened roots. The underground stem of aerial shoots also had considerable reproductive capacity when cut into pieces. Thickened roots that had reached 1-1.5 mm in thickness were able to regenerate when cut into segments. Shoot regeneration from buried root sections was much less from late-May to early-June when food reserves were low (Håkansson, 2003). Few shoots emerged immediately from roots buried after the end of August, but shoot development began again the following spring. In the autumn the roots develop a strong innate dormancy that is not broken by tillage. New shoots develop from buds that overwinter on vertical and spreading roots or on the basal portions of aerial stems (Lemna & Messersmith, 1990). This occurs as soils warm up in late-April.

Perennial sow-thistle grows more rapidly at day/night temperatures of 20/15^{o}C than at 30/25 or 10/5^{o}C (Zollinger & Kells, 1991). The foliage leaves are frost sensitive. The plant overwinters as underground buds on the creeping roots (Zimdahl, 1993). When the freezing resistance of overwintering root buds was evaluated in the laboratory, the temperature required to reduce survival by 50% was –17^{o}C. (Schimming & Messersmith, 1988). However, freezing resistance is often greater in the field than under artificial conditions.

Persistence and spread

Salisbury (1961) states that seeds may remain dormant in soil for at least 6 years. Seeds survive for up to 5 years in cultivated soil (Roberts & Neilson, 1981).

Perennial sow-thistle reproduces by seed, vertical thickened roots and cylindrical horizontal roots (Lemna & Messersmith, 1990). Seed production by isolated plants is poor due to self-incompatability. The plumed seeds are wind-borne. Laboratory tests suggest maximum dispersal distances of 6.7 and 10 metres at wind speeds of 10.9 and 16.4 km/hour respectively but this would be affected by plant height (Sheldon & Burrows, 1973). Hooked cells at the tips of the pappus hairs enable the seeds to be carried on clothes and animal fur as a further aid to dispersal. Viable seeds have been recovered from irrigation water (Kelley & Bruns, 1975). However, seeds of perennial sow-thistle were found to have rotted within 3 months, after submergence in water (Bruns, 1965).

In a survey of cereal seed drilled in 1970 on UK farms perennial sow-thistle seed was found in 6% of samples from home saved seed but none was found in merchants seed (Tonkin & Phillipson, 1973). Sow-thistle seeds ingested by earthworms have been recovered intact and viable in worm casts (McRill, 1974). While not an effective method of dispersal, seeds brought on to the soil surface may find conditions more favourable for germination.

The roots are the main means of vegetative spread and persistence in soil (Lemna & Messersmith, 1990). Root sections less than 2.5 cm long with well-developed buds can produce new plants.

Management

Control is by frequent cultivations (MAFF, 1976; Morse & Palmer, 1925). The aim is to destroy or exhaust the roots by repeated destruction of the regenerating shoots and to prevent seeding. Thorough cultivations and the inclusion of successive root crops in the rotation will help to destroy the weed. Laying badly infested land down to grass will crowd out perennial sow-thistle. A dense crop of lucerne, vetch or maize will tend to shade the weed out (Long, 1938). Winter cereals favour perennial sow-thistle giving it the winter, spring and summer to become established and allowing it to flower before crop harvest. Perennial sow-thistle will increase most in winter wheat where zero-tillage is practiced (Streit *et al.*, 2003).

Perennial sow-thistle is susceptible to repeated tillage in the early part of the growing season (Håkansson, 1982). Fragmentation induces more buds on the root pieces to grow, using up the plant's food reserves. Burial at the 5 to 7 leaf stage when food reserves were low was likely to result in the least regeneration. Burial at the 4 to 6-leaf stage and again at the 4 to 6-leaf stage after further regeneration killed plants completely. Plants buried at the 8-leaf stage or later generally survived to a greater or lesser extent (Håkansson, 1969). There was little difference between burial at 5, 7.5 and 10 cm depth. Repeated defoliation of plants at the 4 to 6 leaf stage killed plants before the end of the growing season. After defoliation, new aerial shoots regenerated mainly as lateral shoots from the basal underground parts of the cut stems. Repeated shoot removal over a period of 80 days is said to exhaust the underground organs (Salisbury, 1961). A single shallow stubble cultivation immediately after cereal harvest followed by deep ploughing later in the autumn helps to contain populations of perennial sowthistle in an arable rotation (Pekrun & Claupein, 2006).

Mechanical control of perennial sow-thistle is greater with increased fragmentation and deeper burial of the roots in the autumn (Vanhala & Salonen, 2007). The longer the fragment, the greater the potential for shoot regrowth. During the winter, decay and predation increase more with shorter fragments than with longer ones. Burial depth influences regrowth but not survival. On a clay soil heavily infested with perennial sow-thistle, bare fallowing reduced the weed more than other treatments but is costly and could destroy soil structure (Vanhala *et al.*, 2004; 2003; Lötjönen & Vanhala 2003). One year after a bare fallow just 1% of perennial sow-thistle remained in the subsequent oat crop. Inter-row hoeing in cereal and fibre hemp crops also reduced the weed by about 53% but not within the crop row. The crops themselves did little to reduce weed abundance but the sow-thistle plants remained small.

In the USA, land infested with perennial sow-thistle was ploughed in April and followed between June and September with cultivations at 2, 3, or 4 week intervals with overlapping sweeps and one way disks operating at 10 cm depth (Derscheid *et al.*, 1961). Cultivations at 3-4 week intervals gave 99% control of the sow-thistle. In other studies, 4 cultivations at 3-week intervals reduced perennial sow-thistle by 85% and when seeded to alfalfa or bromegrass had eliminated the thistle after 2 years of cropping. In Canada, large infestations have been controlled with a summer fallow (McRostie *et al.*, 1932). The land is ploughed in early July and regular surface cultivations are made till the end of the growing season. Alternatively the land is ploughed after crop harvest followed by surface tillage. Hoeing to prevent top growth and the digging out of the roots can give control in small areas. A sheeted mulch can also give control of perennial sow-thistle.

Fallowing for one year reduced seed numbers in soil by 60%, a two year fallow reduced numbers by 80% (Brenchley & Warington, 1933). Seed numbers increased on land cropped with winter wheat for the same period. The seed numbers remained low even after the land was cropped again (Brenchley & Warington, 1936). A cycle of fallowing every 5 years over a 15 year period also kept the weed seed numbers low (Brenchley & Warrington, 1945)

Seeds in the flower head may be eaten by beetle larvae (Salisbury, 1961; Lemna & Messersmith, 1990). The plant itself is palatable to both cattle and sheep

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References

Boyd N S & Van Acker R C (2003). The effects of depth and fluctuating soil moisture on the emergence of eight annual and six perennial plant species. *Weed Science* **51**, 725-730.

Brenchley W E (1911). The weeds of arable land in relation to the soils on which they grow. *Annals of Botany* **25**, 155-165.

Brenchley W E (1913). The weeds of arable soil III. *Annals of Botany* **27**, 141-166.

Brenchley W E (1920). *Weeds of Farm Land*, Longmans, Green & Co, London, UK.

Brenchley W E & Warington K (1930). The weed population of arable soil. I. Numerical estimation of viable seeds and observations on their natural dormancy. The *Journal of Ecology* **18** (2), 235-272.

Brenchley W E & Warington K (1933). The weed seed population of arable soil. II. Influence of crop, soil and method of cultivation upon the relative abundance of viable seeds. *The Journal of Ecology* **21** (1), 103-127.

Brenchley W E & Warington K (1936). The weed seed population of arable soil. III. The re-establishment of weed species after reduction by fallowing. *The Journal of Ecology* **24** (2), 479-501.

Brenchley W E & Warington K (1945). The influence of periodic fallowing on the prevalence of viable weed seeds in arable soil. *Annals of Applied Biology* **32** (4), 285-296.

Bruns V F (1965). The effects of fresh water storage on the germination of certain weed seeds. *Weeds* **13** (1), 38-40.

Chancellor R J & Froud-Williams R J (1984). A second survey of cereal weeds in central southern England. *Weed Research* **24**, 29-36.

Chepil W S (1946). Germination of weed seeds 1. Longevity, periodicity of germination and vitality of seeds in cultivated soil. *Scientific Agriculture* **26** (7), 307-346.

Clapham A R, Tutin T G, Moore D M (1987). *Flora of the British Isles*, 3rd edition, Cambridge University Press, Cambridge, UK.

Copson P J & Roberts H A (1991). Garden weeds – a survey in Warwickshire. *Professional Horticulture* **5**, 71-73.

Cross H (1930-33). Laboratory germination of weed seeds. *Proceedings of the Association of Official Seed Analysts of North America* **24**, 125-128

Dale H M, Harrison P J, Thomson G W (1965). Weeds as indicators of physical characteristics in abandoned pastures. *Canadian Journal of Botany* **43**, 1319-1327.

Derscheid L A, Nash R L, Wicks G A (1961). Thistle control with cultivation, cropping and chemicals. *Weeds* **9**, 90-102.

Derscheid L A & Schultz R E (1960). Achene development of Canada thistle and perennial sow-thistle. *Weeds* **8**, 55-62.

Franklin M T (1970). Interrelationships of nematodes, weeds, herbicides and crops. *Proceedings of the 10th British Weed Control Conference*, Brighton, UK, 927-933.

Frankton C & Mulligan G A (1970). *Weeds of Canada.* Publication 948, Canada Department of Agriculture.

Grime J P, Mason G, Curtis A V, Rodman J, Band S R, Mowforth M A G, Neal A M, Shaw S (1981). A comparative study of germination characteristics in a local flora. *Journal of Ecology* **69**, 1017-1059.

Håkansson S (1969). Experiments with *Sonchus arvensis* L. I Development and growth, and the response to burial and defoliation in different developmental stages. *Lantbrukshugskolans Annaler* **35**, 989-1030.

Håkansson S (1979). Seasonal influence on germination of weed seeds. *Proceedings of the EWRS Symposium: The influence of different factors on the development and control of weeds*, 73-80.

Håkansson S (1982). Multiplication, growth and persistence of perennial weeds. In: *Biology and Ecology of Weeds* (eds) W Holzner & N Numata. Dr W Junk Publishers, The Hague, 123-135.

Håkansson S (2003). *Weeds and weed management on arable land. An ecological approach.* CABI Publishing, Cambridge, UK.

Hanf M (1970). *Weeds and their seedlings.* BASF UK Ltd.

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Holzner W & Immonen R (1982). Europe: an overview. In: *Biology and ecology of weeds* (Eds. W Holzner & N Numata), Dr W Junk Publishers, The Hague, 203-226.

Kelley A D & Bruns V F (1975). Dissemination of weed seeds by irrigation water. *Weed Science* **23** (6), 486-493.

Lemna W K & Messersmith C G (1990). The biology of Canadian weeds. 94. *Sonchus arvensis* L. *Canadian Journal of Plant Science* **70**, 509-532.

Long H C (1938). Weeds of arable land. *MAFF Bulletin* **108**, 2nd edition. HMSO, London, UK.

Lötjönen T & Vanhala P (2003). Does mechanical control take effect on *Sonchus arvensis*. *Proceedings of the NJF's 22nd congress 'Nordic agriculture in global perspective'*, Turku, Finland. Online at http://www.orgprints.org/11141/

MAFF (1976). Weed Control – Thistles. *MAFF Advisory Leaflet* **51**, HMSO Press, Edinburgh, UK.

McRill M (1974). The ingestion of weed seeds by earthworms. *Proceedings 12th British Weed Control Conference, Brighton*, UK, 519-524.

McRostie G P, Kirk L E, Godel G, Smith W G, Manson J M (1932). Weeds and their control. *Dominion of Canada, National Research Council, Report No.* **27**, 15 pp.

Morse R & Palmer R (1925). *British weeds their identification and control*. Ernest Benn Ltd, London.

Pawlowski F (1966). Prolificacy, height and ability of producing shoots on some weed species growing among crop plants. *Annales Universitatis Mariae Curie-Sklodowska Lublin-Polonia*, **21** (9), 175-189.

Pawlowski F, Kapeluszny J, Kolasa A, Lecyk Z (1970). The prolificacy of weeds in various habitats. *Annales Universitatis Mariae Curie-Sklodowska Lublin-Polonia*, **25** (5), 61-75.

Pegtel D M (1972). Effects of temperature and moisture on the germination of two ecotypes of Sonchus arvensis L. *Acta Bot. Neerl*. **21** (1), 48-53.

Pegtel D M (1973). Aspects of ecotypic differentiation in the perennial sow-thistle. *Technical Communications of the International Society for Horticultural Science* **32**, 55-71 (*Acta Horticulturae*).

Pekrun C & Claupein W (2004). The effect of stubble tillage and primary tillage on population dynamics of Canada thistle (*Cirsium arvense*) in organic farming. *Journal of Plant Diseases and Protection Special Issue* **XIX**, 483-490.

Roberts H A & Neilson J E (1981). Seed survival and periodicity of seedling emergence in twelve weedy species of Compositae. *Annals of Applied Biology* **97**, 325-334.

Rowan W (1913). Notes on the food plants of rabbits on Blakeney Point, Norfolk. *Journal of Ecology* **1** (4), 273-274.

Salisbury E J (1961). *Weeds & Aliens*. New Naturalist Series, Collins, London.

Salisbury E (1962). The biology of garden weeds. Part II Biological features of the perennial weed flora of the garden. *Journal of the Royal Horticultural Society* **87**, 458-470.

Schimming W K & Messersmith C G (1988). Freezing resistance of overwintering buds of four perennial weeds. *Weed Science* **36**, 568-573.

Sheldon J C & Burrows F M (1973). The dispersal effectiveness of the achene-pappus units of selected Compositae in steady winds with convection. *New Phytologist* **72**, 665-675.

Stace C (1997). *New Flora of the British Isles*. 2nd edition. Cambridge University Press, Cambridge, UK.

Stevens O A (1932). The number and weight of seeds produced by weeds. *American Journal of Botany* **19**, 784-794.

Stevens O A (1957). Weights of seeds and numbers per plant. *Weeds* **5**, 46-55.

Streit B, Rieger S B, Stamp P, Richner W (2003). Weed populations in winter wheat as affected by crop sequence, intensity of tillage and time of herbicide application in a cool and humid climate. *Weed Research* **43**, 20-32.

Thompson K, Grime J P, Mason G (1977). Seed germination in response to diurnal fluctuations of temperature. *Nature* **267** (5607), 147-149.

Tonkin J H B & Phillipson A (1973). The presence of weed seeds in cereal seed drills in England and Wales during spring 1970. *The Journal of the National Institute of Agricultural Botany* **13**, 1-8.

Vanhala P, Lötjönen T, Salonen J (2003). Effect of crop species and management practices on perennial weeds in organic farming. *Proceedings of the NJF's 22nd congress 'Nordic agriculture in global perspective'*, Turku, Finland. Online at http://www.orgprints.org/11140/

Vanhala P, Lötjönen T, Salonen J (2004). Response of *Sonchus arvensis* to mechanical and cultural weed control. *Proceedings of the 6th EWRS Workshop on physical and cultural weed control*, Lillehammer, Norway, 25.

Vanhala P & Salonen J (2007). Overwintering and regrowth of *Sonchus arvensis* roots in Finland as affected by fragmentation and burial in three different soil types. *Proceedings 7th EWRS Workshop on Physical and Cultural weed control*, Salem, Germany, 135.

Zimdahl R L (1993). *Fundamentals of Weed Science*. Academic Press, Inc.

Zollinger R K & Kells J J (1991). Effect of soil pH, soil water, light intensity, and temperature on perennial sowthistle (*Sonchus arvensis* L.). *Weed Science* **39**, 376-384.