

## **The biology and non-chemical control Spear Thistle (*Cirsium vulgare*).**

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### **Spear thistle**

(bull thistle)

#### ***Cirsium vulgare* (Savi) Ten.**

(*Cirsium lanceolatum*, *Carduus lanceolatum*, *Carduus vulgare*, *Cnicus lanceolatum*)

### **Occurrence**

Spear thistle is a robust biennial or monocarpic perennial that can be a serious problem in grassland and waste and cultivated ground (Stace, 1997). It also occurs on roadside verges, coastal dunes and in woodland clearings. It is common throughout the UK (Clapham et al., 1987). Spear thistle prefers calcareous soils and is rarely found on pure clays. The distribution appears to be indifferent to soil fertility but optimal growth occurs at high nutrient levels (Sindel, 1991). It is largely absent from deeply shaded and waterlogged habitats (Klinkhamer & de Jong, 1993). Seedlings and young rosettes are susceptible to drought.

In a survey of conventional winter oilseed rape in central southern England in 1985 spear thistle was found in 6% of fields (Froud-Williams & Chancellor, 1987). It was associated with temporary grass and clover grown for seed (Brenchley, 1920). A study of changes in the weed flora of southern England between the 1960s and 1997 suggests that spear thistle has become more common (Marshall *et al.*, 2003). Spear thistle numbers increased in the first year of set aside in fields managed under the permanent fallow option in England (Poulton & Swash, 1992). In unsown set-aside land in Scotland, spear thistle was one of the most frequently recorded species (Fisher *et al.*, 1992). It occupied 20% of the ground cover after 2 years of set-aside (Lawson *et al.*, 1992).

Spear thistle has a relatively high content of copper (Salisbury, 1961). Goldfinches and linnets feed on the seeds (Klinkhamer & de Jong, 1993, Moorcroft *et al.*, 1997).

### **Biology**

Spear thistle flowers in June and July but the leaf rosettes can survive for up to 4 years without flowering (Soil Association, 2002). The rosettes need to reach a threshold size (Grime *et al.*, 1988). In Holland, spear thistle rosettes require vernalization by winter cold before flowering is initiated. Bees and other insects pollinate the flowers. The first ripe seeds are formed by the end of July. Plants cut down at flowering produced just a few seeds on the cut stems and, although they appeared normal, none contained a viable embryo (Gill, 1938). The average number of seeds per flower head is given as 100 but there can be up to 340 (Salisbury, 1961). Seed production may vary from 1,600 to 8,400 seeds per plant (Sindel, 1991). Klinkhamer *et al.* (1988) reported mean seed numbers per plant of 258, 647 and 2,080 in three consecutive years. Seed numbers appeared to be related to rainfall levels during seed production. Seeds are dispersed during August and September (Klinkhamer & de Jong, 1993).

Spear thistle seeds have little dormancy and germinate rapidly in moist conditions at favourable temperatures in the light. Germination is increased by a period of dry storage (Grime *et al.*, 1988). When freshly shed seed was mixed into the top 75 mm of soil under field conditions, the main period of seedling emergence was March to April (Roberts & Chancellor, 1979). The soil was stirred occasionally and seedling emergence recorded at monthly intervals. There was some emergence in the autumn following sowing. Around 60% of seeds germinated in the first year after sowing, however, odd seedlings continued to emerge over the next 4 years. Emergence was stimulated by rainfall but there was high seedling mortality if dry conditions followed and no additional water was applied (Jong & Klinkhamer, 1988). Seed was stimulated to germinate when sown in a humus rich soil (Van Leeuwen, 1981). Soil micro-organisms may also affect the germination of spear thistle seeds.

Disturbance of the soil and vegetation has been shown to advance the germination of spear thistle (Sindel, 1991). Seeds may germinate and become established in thinner parts of a grass sward. Less than 1% of seedlings develop as rosettes (Klinkhamer & de Jong, 1993). Rosette mortality varies between 10 and 69% and is highest during May-July. In pasture and other areas of vegetation, seedlings emerge from small areas of disturbance like rabbit scrapings or bare patches such as those left when a parent plant dies (Klinkhamer & Jong, 1988). As the leaf rosette develops it physically suppresses the growth of the surrounding grass. In the second year most plants bolt and the rosette elongates to form the flowering stem (Mitich, 1998). The stout taproot is up to 70 cm in length (Klinkhamer & de Jong, 1993).

### **Persistence and Spread**

The seed has little innate dormancy and is generally thought not to form a persistent seedbank (Doucet & Cavers, 1995). Seedlings may only emerge after fresh seed has been shed. Fewer than 10 seedlings are likely to result from the seeds shed by an individual thistle plant. Only 1% of seeds buried at 2 cm deep in soil remained viable after 3 years while 55% remained after burial at 15 cm (Van Breemen & Van Leeuwen, 1983). Some seeds had germinated others had died. Seeds in dry storage do not germinate after 3 years (Klinkhamer & de Jong, 1993). In light soils the seeds do not persist for longer than a year on the surface or in shallow layers of soil. In heavier soils, however, a small number of seeds may remain viable for 3 years or more. In both types of soil, 40-60% of seeds buried at 15 cm deep remain firm and viable for at least 3 years. Burial excludes light, reduces temperature fluctuations and possibly induces seed dormancy. The buried seeds do not germinate without major soil disturbance but could allow the thistle to re-establish after cultivation.

Seed submerged in water gave 1% germination after 3 months and after 4 years but no seeds germinated after 5 years (Comes *et al.*, 1978).

Seeds are dispersed by the wind and unlike creeping thistle (*C. arvensis*) the white, feathery pappus of spear thistle remains attached firmly to the seed. Nevertheless, in tests, 50% of seeds were dispersed less than 1 metre from the parent, 66% were dispersed less than 2 metres and only 10% travelled more than 32 metres having reached higher air levels (Klinkhamer *et al.*, 1988). The seeds have an elaiosome in the form of a peg of tissue inside the collar-like distal end of the fruit (Pemberton & Irving, 1990). This is attractive to ants that may further disperse the fallen seeds.

Another important means of spread is in fodder such as baled hay (Anon, 1983; Mitich, 1998). At the Official Seed Testing Station for Scotland, spear thistle was present in 0.06% of certified barley seed samples tested in 1996/97 (Don, 1997). In clover and grass seed samples tested in Denmark for the period 1966-69, 1955-57, 1939 and 1927-28, spear thistle seed was a contaminant in 0.4, 1.5, 1.6 and 0.6% of samples respectively (Olesen & Jensen, 1969).

### **Management**

Spear thistle spreads only by seed and it is essential to prevent mature plants seeding. Young plants should be spudded out at the rosette stage or cut down when in bud (MAFF, 1976). Seedlings will establish in thin areas of sward and management should aim to encourage a dense grass cover. Spear thistle is not able to withstand regular cultivation (Frankton & Mulligan, 1970). In arable crops, the seedlings are destroyed by surface cultivations in spring, and by hoeing or spudding as necessary (Morse & Palmer, 1925). Older plants should be spudded out in June and again in August to prevent seeding.

At the rosette stage the taproot may be cut below ground using a thistle hoe. Spear thistles can be pulled out manually when in flower or pulled mechanically using an Eco-puller set low (Soil Association, 2002). The time taken to extract the plant with hand tools depends on the growth stage, the terrain, the density of the spear thistle population, the density of other vegetation and the level of soil moisture. Removal is easier on flat sites in well-grazed vegetation. Plants are pulled out more readily from moist soil in spring and autumn and are best removed as soon as the rosettes become visible. Rosettes at 5 to 8 cm across are more readily lifted and disposed of than large plants. An experienced worker should have a work-rate of 400 rosettes per man-hour. Spear thistle at a low density may take around 2 to 6 man-hours per ha to clear while older, established plants at a high density could take over 27 man-hours per ha to clear (Trevelyan, 2001). In permanent pastures the plant may be killed by mowing just as it starts to blossom (Buchholtz & Briggs, 1953).

Spear thistle seedlings are often out-competed by tall grasses and the weed may disappear from areas where rabbits and other grazing animals are excluded (Klinkhamer & de Jong, 1993). Less than 1% of thistle seedlings are likely to survive in a grazed pasture but as the seedlings are very susceptible to competition even fewer survive in an ungrazed pasture (Sindel, 1991). In pasture in Australia it was found that spear thistle grew better in grazed than ungrazed pasture (Forcella & Wood, 1986). In ungrazed it suffered from competition by the surrounding herbage. In grazed it was avoided by the sheep and took advantage of the reduced competition from neighbouring plants. Flowering and seed production were improved and seedling survival was greater in grazed pasture. The number of seedlings that developed into rosettes also increased. Spring grazing in particular increased seedling emergence and rosette numbers (Bourdôt, 1996). But winter grazing and heavy summer grazing also increased thistle numbers. Emergence was greatest where there were gaps in the vegetation. The bigger the gap, the more successful the establishment of seedlings. In ungrazed swards, the grasses seem to reduce the growth of spear thistle more than the legumes. In the UK, spear thistle increased in abundance in response to tight grazing by sheep in summer, winter or spring (NERC, 2006).

Spear thistle is unpalatable to most stock but some sheep breeds will graze it when young. Dorset Horn sheep have been seen to eat it and dig for the roots (Klinkhamer & de Jong, 1993). Grazing by ponies or cattle may have some effect on young plants, and goats will eat thistles even when more palatable pasture is available (Sindel, 1991). Pheasants graze on the seedlings, rabbits may eat the rosette leaves in winter and early spring but plants recover. Rabbits may also bite off the flower stems but do not destroy the plant (Tansley, 1949).

Seeds in the flower head suffer predation by insect larvae and small rodents prior to dispersal (Klinkhamer *et al.*, 1988). Finches have been seen eating seeds from the flower heads. Spear thistle is attacked by stem boring insects including: *Cheilisia grossa* (Fallén) (*Syrphidae*, Diptera); *Epiblema scutulana* (Den. & Schiff.) (*Tortricidae*, Lepidoptera); *Myelois cribrella* (Hübner) (*Pyralidae*, Lepidoptera). Stem boring insects are unlikely to have much effect on flowerhead production (Klinkhamer *et al.*, 1988). In Europe, the gall forming *Urophora stylata* F. (Tephritidae) is a widely distributed phytophagous insect that attacks spear thistle (Zwölfer, 1969). It can cause seed losses of 80% in the flower heads. It is highly specific to the plant and has been released as a biological control agent in Canada. It was also released in South Africa with the seed feeding weevil, *Rhinocyllus conicus* (Froelich) (*Curculionidae*), to control spear thistle. The gall fly population did not persist and the effectiveness of the weevil has yet to be demonstrated (Zimmermann, 1991). In Australia, the weevil has proved difficult to rear and has not established in the field (McLaren, 1993). After dispersal, most seed predation is by mice and voles, birds and insects are less important. Around 40% of shed seeds were taken after 1 week and 60% after 3 weeks.

### Legislation

The Minister has powers under the Weeds Act 1959 to require an occupier of land to prevent the spread of spear thistle (*Cirsium vulgare*) and creeping thistle (*C. arvense*).

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