The biology and non-chemical control of Corn Spurrey (*Spergula arvensis* L.)

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Corn spurrey
(beggar-weed, bottle brush, cowquake, dother, farmer's ruin, franke, granyagh, lousy grass, makebeg, make-beggar, mountain flax, pick pocket, pickpurse, poverty weed, sand-grass, sandweed, spurry, yarr, yarrel, yawr, yur)
Spergula arvensis **L.**

Occurrence
Corn spurrey is a native summer annual weed of arable fields and gardens. It is also found on roadsides and other open habitats throughout the UK (Clapham *et al*., 1987; Stace, 1997). It is recorded up to 1500 ft (Salisbury, 1961). Corn spurrey occurs primarily on arable land where it has been so plentiful as to cause crop failure (MAFF, 1949). On light acid soils it can form a vast seedbank from which seedlings emerge in great numbers (Brenchley, 1920). It is most frequent on light sandy soils and on peat (New, 1961). In early surveys of Bedfordshire, Hertfordshire and Norfolk, corn spurrey was confined to sandy and light soils of a non-calcareous character (Brenchley, 1911; 1913). It is symptomatic of acidic sands and disappears when soil is limed. It usually absent from alkaline soils and is considered to be an indicator of the absence of lime (Long, 1938). It is also considered to be an indicator of acid soils (Hanf, 1970). Corn spurrey occurs mainly in soils between pH 5.0 and 6.0 (Grime *et al.,* 1988). On light land there is a strong correlation between soil pH and the presence of corn spurrey.

Corn spurrey was a common weed of flax during the Iron Age (Grime *et al.,* 1988; New, 1961) and was considered a problem weed over 150 years ago (Long, 1938). It has a wide climatic tolerance and may be found in many root crops. It was common in cereals but was most plentiful in spring barley (Brenchley & Warrington, 1930). In a study of seedbanks in some arable soils in the English Midlands sampled in 1972-3, corn spurrey was not recorded in any of the fields sampled in Oxfordshire and Warwickshire (Roberts & Chancellor, 1986). Corn spurrey was one of the main dicotyledonous weeds prior to herbicide application in cereals in NE Scotland in 1973 but was less frequent in 1985 possibly due to liming (Simpson & Carnegie, 1989). Corn spurrey seed was found in 42% of arable soils in a survey in Scotland in 1972-1978 (Warwick, 1984). It accounted for 27% of the seeds in the soil seedbanks. It was also one of the most abundant weeds in a seedbank survey in swede turnip fields in Scotland in 1982 (Lawson *et al.,* 1982). It was found in 87% of fields sampled. In a comparison of the ranking of arable weed species in unsprayed crop edges in the Netherlands in 1956 and in 1993, corn spurrey had moved up from 18th to 8th place (Joenje & Kleijn, 1994). In a seedbank survey of arable fields in Denmark in 1964, corn spurrey was one of the most frequent species recorded with an average of 1,784 viable seeds per m[2] (Jensen, 1969). Corn spurrey was described as vulnerable in the BSBI species status list 2005.

Corn spurrey is phenotypically plastic and genotypically variable (Grime *et al.,* 1988). Crop morphology can affect the weed's growth habit. Plants vary in seed and flower

characters and in hairiness (New, 1961). The form with the papillate seedcoat is sometimes described as var. *vulgaris* and the tuberculed as var. *sativa*. The papillate form is more frequent in southern Britain. A third variety var. *nana* is restricted to the Channel Islands. In flax fields in Europe, unique forms of corn spurrey developed that were specially adapted to the crop (Hjelmqvist, 1950). Tricotyledonous seedlings occur in a ratio of 1:7000 (Brenchley & Warrington, 1936).

Corn spurrey can become infected with cucumber mosaic virus which is transmitted by the aphid *Myzus persicae* (Tomlinson & Carter, 1970). Studies have shown that the virus can also be seed borne and around 2% of seeds may carry the virus in infected plants.

Corn spurrey is eaten avidly by many animals particularly sheep and has been included in seed mixtures (Derrick *et al.,* 1993). It is high in sodium, phosphate and magnesium but lower in calcium and potassium (Wilman & Riley, 1993; Wilman & Derrick, 1994). It has a relatively high fibrosity index similar to that of ryegrass (Wilman *et al.,* 1997).

Biology
Corn spurrey flowers from June to August or May to September. The flowers are 97% self-pollinated but there is some insect pollination (Grime *et al.,* 1988). Corn spurrey produces seeds in summer and early autumn (MAFF, 1949). Seed is set around 2 weeks after flowering (Grime *et al.,* 1988). Corn spurrey continues to produce seeds until killed by harvesting operations or frosts (New, 1958). It can be found in fruit for 4 months of the year (Salisbury, 1962). To determine when the seeds become viable, seed was collected from plants at different periods after flowering, stored for a short period then tested for germination (Chakravarti & Pershad, 1953). Seed collected 5, 10 and 15 days after flowering gave 4, 8 and 12% germination respectively.

There are 25 seeds per seed capsule (Grime *et al.,* 1988). The average seed number per plant is 491 according to Pawlowski *et al.* (1970). Corn spurrey has an average of 1,300 seeds per plant but a large plant may produce 22,000 seeds according to Salisbury (1961). Guyot *et al.* (1962) give the seed number per plant as 10,000 to 12,000, while Hanf (1970) gives it as 1,000 to 10,000 with an average of 3,200. Seeds can be produced just 10 weeks after seedling emergence and two generations may occur in a year (Grime *et al.,* 1988). In other studies, the time from germination to fruiting is given as 100 days (Guyot *et al.,* 1962) and eight weeks (Salisbury, 1961). Corn spurrey can live for 5 months and continues to produce seeds during this time (New, 1961). Plants normally die in early autumn but can withstand some frost and may remain alive until December.

Two main types of seed are produced that differ in the presence or absence of papillae on the surface of the seedcoat (New, 1958; New, 1961). Individual plants bear only one type of seed. Hybrids with variable amounts of papillae sometimes occur although the species is predominantly self-fertilising (New, 1959). The variation appears to be due to environmental not genetic factors. In the UK, the non-papillate form has a northern and westerly distribution, the papillate form is found further south and east (New & Herriot, 1981). The non-papillate seeds germinate more readily at lower temperatures while at higher temperatures the papillate seeds germinate best.

At 21°C papillate seeds germinate rapidly compared with non-papillate seeds while at 13°C the reverse is true (New, 1961). Corn spurrey seeds do not have a light requirement for germination. When weed seeds extracted from field soil were put to germinate, corn spurrey was one of the few that germinated in darkness (Wesson & Wareing, 1969). There was a marked reduction in the germination of non-papillate seeds at higher water tensions. Poorer germination under drier conditions may account for the differences in UK distribution. In the USA, germination studies did not show a consistent response from the different seed types, neither was there evidence of a pattern of distribution in the Californian population associated with climate (Wagner, 1988).

Freshly harvested seed is dormant. Dry-stored seed was still dormant after 6 months at 5°C. Dormancy studies under laboratory conditions demonstrated that high temperatures alleviate dormancy and seed will then germinate over a broad temperature range (Thompson & Whatley, 1983). Low temperature treatments induced germination only at high temperatures. Seed stored at 20°C began to lose dormancy after 2 months and gave 60% germination in the light or in darkness after 5 months (Hall & Waring, 1972). When seeds were put to germinate under a leaf canopy or in diffuse white light there was 32% germination under the canopy and 50% in the light (Górski et al., 1977). In Petri-dish tests with seed given alternating or constant temperatures in diffuse light, maximum germination was achieved at a constant temperature in the light (Vincent & Roberts, 1977). Alternating temperatures appeared to inhibit germination, as did chilling. Increasing the amplitude of temperature fluctuations did not increase germination in either the light or dark up to an amplitude of 25°C (Thompson & Whatley, 1983). Carbon dioxide has been shown to promote germination in the light (Hall et al., 1978). Ethylene, which can occur naturally in soil, also stimulates germination in the light and dark. Studies have show that the seeds are able to produce ethylene when imbibed, particularly after a period of dry-storage. The effects of CO_2 and ethylene are additive.

Experimental evidence suggests that in spring dormancy is broken by rising temperatures and does not depend on exposure to cold winter temperatures (Karssen et al., 1988). There is an increase in field emergence in spring that continues into the summer. Light, nitrate and desiccation following imbibition all stimulated germination. Desiccation can even stimulate germination in the dark. It was therefore predicted that germination would be restricted to autumn in moist, nitrate poor soils. In disturbed nitrate rich soils germination was likely from early spring to late autumn. Germination of seed buried in the field and exhumed at regular intervals was tested over a range of conditions (Bouwmeester & Karssen, 1993). Dormancy was broken by rising temperatures in spring and re-induced by falling temperatures in the autumn. Seeds kept outdoors in moist soil overwinter, exhumed in darkness and put to germinate in 12 hours per day light, in darkness following a 5 second light flash or in complete darkness gave 34%, 35% and 2% germination respectively (Andersson et al., 1997).

Dry-stored seed buried outside in pots in the autumn and exhumed at monthly intervals for germination tests, germinated from March to November if seeds received light, even a short flash (Milberg & Andersson, 1997, Andersson & Milberg, 1996). Germination levels increased from March to May then remained high into the autumn.

There was no germination in complete darkness. Bouwmeester & Karssen (1989) demonstrated that a 24 hour desiccation treatment eliminated the light requirement. Nitrate also improved germination. Seed mixed into a 15 cm layer of soil in cylinders sunk in the field and stirred periodically, emerged from February to October with most emergence from March to July (Roberts & Feast, 1970). Seeds germinate mainly between mid and late April (New, 1961). Seedling emergence in Scotland recorded in field plots dug at monthly intervals began in April and continued through until October with peaks in May and August (Lawson *et al.,* 1974).

In Sweden, corn spurrey is considered a summer annual (Håkansson, 1979). 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. Peaks of germination occurred in April/May and August/September. Many seedlings emerged in the autumn after sowing.

Seeds germinate in the upper 5 to 30 mm of soil (Hanf, 1970). In a sandy loam soil, field seedlings emerged from the top 30 mm of soil with the majority, 66%, coming from the top 10mm (Unpublished information).

Persistence and spread
Seeds can remain viable for at least 5 years (New, 1958). Thompson *et al.* (1993) suggest that based on seed characters, corn spurrey seed should persist for longer than 5 years in soil. Seeds mixed with soil and left undisturbed had declined by 87% after 6 years but in cultivated soil the decline was 98% (Roberts & Feast, 1973). Seeds are said to exhibit a long period of seed dormancy (Chepil, 1946). Seed in pans of field soil showed irregular flushes of emergence that continued for at least 3 years (Brenchley & Warrington, 1930). Seed buried in soil in subarctic conditions had 35, 18 and <1% viability after 2.7, 6.7 and 9.7 years respectively (Conn & Deck, 1995). Corn spurrey seed has been found to persist for 22 years under grassland (New, 1961). Seed recovered from excavations and dated at 30 years old was found to germinate (Ødum, 1974). Seed longevity in dry storage is over 15 years and in soil is 4 to 5 years (Guyot *et al.,* 1962).

Corn spurrey has been a common contaminant in crop seeds. In cereal seed samples tested in 1961-68, corn spurrey was found in up to 1.1% of rye, 3.2% of oats, 0.8% of barley and 0.3% of wheat samples tested (Tonkin, 1968). In a survey of weed seed contamination in cereal seed in drills ready for sowing on farm in spring 1970, it was found in 9% of samples (Tonkin & Phillipson, 1973). Most of this was home saved seed. In the period 1978-1981, it was found in 2-3% of barley seed samples tested but not at all in wheat (Tonkin, 1982). Seed has sometimes been found in samples of clover and grass seed (Long, 1938).

Apparently-viable seeds were found in samples of manure from dairy farms (Pleasant & Schlather, 1994). Seed has been found in cattle, horse and pig droppings, it has also been found in red and fallow deer droppings (New, 1961). Seedlings have been raised from the excreta of various birds (Salisbury, 1961). Short distance seed dispersal is possible in mud on the tyres of farm machinery (New, 1961).

Management
Control is by thorough liming or chalking (MAFF, 1949; Long, 1938; Morse & Palmer, 1925). Frequent surface cultivations should be undertaken whenever possible. It may be necessary to avoid growing cereals for several seasons and choose open crops that allow easy cleaning. To allow more time for spring cultivations, late-sown, quick-growing crops can be grown. Corn spurrey is discouraged by smother crops. It does not tolerate trampling.

Corn spurrey is common in cereals but is most frequent in oats (Brenchley, 1920). Over an 11 year period of cereal cropping, from1962 to 1973, in one particular field, corn spurrey declined from being 1.9% of the weed population at 5 plants /m^2 to being just 0.1% at 0.2 plant/m^2 (Chancellor, 1976). This was due to a combination of herbicide use and fallowing that prevented seeding together with liming of the soil at 5 t/ha that raised the pH from 6.0 to 6.8.

In set-aside fields in north-east Scotland, corn spurrey made up a significant proportion of the seed rain (Jones & Naylor, 1992). Seed was shed from July to October. Cutting time influenced the amount of seed returned to the soil. If defoliated in active growth, corn spurrey can produce new shoots from the base (Grime *et al.,* 1988). Plants cut off at 2-3 nodes from the ground can regenerate from axillary buds (New, 1961).

Small seedlings are susceptible to flame weeding (Ivens, 1966).

Corn spurrey is palatable to sheep, cattle and poultry (New, 1961). Badly infested crops may be grazed with sheep. Grazing before seed set prevents reproduction. The seeds have been found in the crops of pigeons and sparrows. Corn spurrey is attacked by a limited number of insect species and pathogens. Exposure to an arbuscular-mycorrhizal fungal inoculum has been shown to cause a a reduction in the biomass of corn spurrey, a non-host weed species (Jordan *et al.,* 2000).

Acknowledgement

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