The biology and non-chemical control of Greater Plantain (*Plantago major* L.)

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Greater plantain

(birdseed, bird's-meat, great waybrede, broad-leaved plantain, slanlas, waber-leaf, wayfron, way-bread, wibrow, wybrow)
***Plantago major* L.**

Occurrence

Greater plantain is a native perennial of disturbed habitats, farmyards, roadsides and cultivated ground. It is generally distributed throughout the UK (Clapham *et al.*, 1987). Greater plantain is recorded up to 1,500 ft in the UK and has been found in prehistoric deposits. It occurs on a wide range of soils and is almost always associated with the activities of man. In early surveys of Bedfordshire, Hertfordshire and Norfolk it was universally distributed on all soils (Brenchley, 1911; 1913). Greater plantain has a preference for level, moderately fine texture soils with the plant cover reduced by cutting or grazing (Dale *et al.*, 1965). It prefers heavy clay soils (Hanf, 1970). Greater plantain is common on trackways being very resistant to treading and it is also tolerant of drought and waterlogging. It can become established on compacted soil. Greater plantain is a very frequent bird seed alien (Hanson & Mason, 1985).

Greater plantain is sometimes troublesome on arable land and can be a problem in clover and grass grown for seed (Long, 1938). It is common in old pasture, meadows, lawns and waste places (Chepil, 1946). It is often associated with heavily grazed grassland (Gibson, 1997). Greater plantain is a common garden weed (Copson & Roberts, 1991). It is prevalent in well-cropped grassland and short turf (Salisbury, 1961). It appears to be discouraged by root crops but is frequent in cereals (Brenchley, 1920).

In a study of seedbanks in some arable soils in the English midlands sampled in 1972-3, greater plantain was recorded in 50% of the fields sampled in Oxfordshire and 47% of those in Warwickshire but only in low numbers (Roberts & Chancellor, 1986). Greater plantain seed was found in less than 1% of arable soils in a seedbank survey in Scotland in 1972-1978 (Warwick, 1984). In studies of the soil seedbank of arable fields in France, greater plantain was well represented in the seedbank but less frequent in the emerged vegetation (Barralis & Chadoeuf, 1987). In a survey of seeds in pasture soils in the Netherlands in 1966, greater plantain was common in the sward and in the soil seedbank (Van Altena & Minderhoud, 1972). It is one of the most frequent arable weeds in soil seedbanks in Denmark (Streibig, 1988). In a seedbank survey of arable fields in Denmark in 1964, greater plantain was one of the most frequent species recorded with an average of 2,030 viable seeds per m^2 (Jensen, 1969).

Greater plantain is a very variable perennial of which many varieties have been recorded (Sagar & Harper, 1964). Subspecies *major* is found in open, cultivated and rough ground and in grassy places, ssp. *intermedia* is found near the sea (Stace, 1997).

In closed vegetation, greater plantain leaves are more erect but leaf habit is also under genetic control (Grime *et al.*, 1988). Plants grown from the seed of prostrate lawn plants maintained this habit (Warwick & Briggs, 1980). Plants raised from the seed of roadside plants were larger and more erect. Variants have been recorded that are tolerant to heavy metals (Warwick & Briggs, 1979). The plant does not form hybrids with related species.

Greater plantain has reasonable palatability and is eaten by livestock (Sagar & Harper, 1964). It contains only a low level of oxalic acid and has a moderate calcium content (Guil *et al.*, 1996). The young leaves have been cooked like spinach (Mitich, 1987). The dried leaves have been brewed to make plantain tea. Greater plantain has been applied to wounds in the past and has other medicinal uses (Barker, 2001). The leaves contain a soothing mucilaginous sap that is used to treat sore feet (Mitich, 1987). Greater plantain pollen can cause hayfever in sensitive individuals (Frankton & Mulligan, 1970).

The potato tuber rot nematode, *Ditylenchus destructor*, can infest the roots of greater plantain (Franklin, 1970).

Biology

Greater plantain flowers from May to September (Long, 1938). The flowers are wind pollinated and capable of self-fertilization. Seed is set rapidly within 3 weeks of fertilization but is often not dispersed until the following spring, the seed being retained on the dead flower spike (Grime *et al.*, 1988). The flower spike is not usually consumed by grazing animals. There are 9-10 seeds per capsule and 23-26 capsules per cm length of flower spike (Warwick & Briggs, 1980). Ruderal plants usually have longer flower spikes and hence more seeds than lawn plants. A single plant may produce 14,000 seeds per year but a large plant may have 30,000 seeds. The average number of seeds per plant is given as 21,500 (Stevens, 1957), 36,150 (Stevens, 1932), 13,000 to 15,000 (Salisbury, 1961). The average seed number per plant in ruderal situations is given as 23,685 (Pawlowski *et al.*, 1967). The 1,000 seed weight is 0.20 g (Stevens, 1932). Plants may flower and set seed just 6 weeks after germination (Sagar & Harper, 1964). Normally the time to first flowering is approximately 90 days but seedlings in lawns can flower up to 23 days earlier than roadside seedlings (Warwick & Briggs, 1980). Plants generally flower 14 days later in tall than in short grass.

Under alternating temperatures, increasing the amplitude of temperature fluctuations increased seed germination in both the light and dark up to an amplitude of 25^{o}C (Thompson & Whatley, 1983). In laboratory studies, an alternating temperature of 20/30^{o}C increased the germination of plantain seed compared with a constant 20^{o}C (Deschênes & Moineau, 1972). Germination was more complete under light conditions than in the dark. Seed scarification slightly increased germination levels and, in alternating temperatures following imbibition, it reduced the light requirement. In the laboratory, dry-stored seed did not germinate in complete darkness but some germination occurred under a 'safe' green light. When seeds were put to germinate under a leaf canopy or in diffuse white light there was just 2% germination under the canopy and 68% in the light (Górski *et al.*, 1977). In petri-dish tests with dry-stored seed imbibed in polyethylene glycol (PEG) solution to prevent germination, the greater plantain seeds were kept in darkness or exposed to red and/or far-red light

before being rinsed and put to germinate at 27°C (Pons, 1991). Few seeds germinated in the dark but exposure to 10 minutes of red light resulted in over 90% germination. Seeds exposed to 10 minutes of far-red light alone gave 37% germination and far-red light partially reversed the effect of a short period of red light. The germination of freshly-collected seeds was promoted by red light (Froud-Williams *et al.*, 1984b). After a period of burial, germination was greater in seeds irradiated with far-red light. At a constant 18-20°C germination was around 40%, at alternating temperatures of 20-30°C germination increased to over 90% (Cross, 1930-33).

Seed dormancy is broken by chilling (Grime *et al.*, 1988). The level of seed germination increased from 31 to 100% following a 3-month period of moist storage at 5°C (Grime *et al.*, 1981). Freshly shed seed does not germinate until the following spring. Germination may then occur sporadically throughout the growing season (Sagar & Harper, 1964). Seed germinates best near the soil surface in open areas resulting from soil disturbance. The seed coat is mucilaginous which helps to absorb moisture from soil under drier conditions (Harper & Benton, 1966). Nevertheless germination levels are reduced by up to 40% as soil begins to dry out. Seeds germinate and emerge well on soil that has been compressed, by light trampling for example (Harper *et al.*, 1965; Blom, 1978).

In the field, seeds began to germinate in early spring and continued to emerge through the year (Chepil, 1946). Seed sown in trays of soil in the field emerged mainly in year 1 but odd seedlings continued to emerge until year 5. Seed sown in a 75 mm layer of soil in cylinders sunk in the field and stirred periodically, emerged from April to August, with few seedlings at other times (Roberts & Boddrell, 1984). Some viable seeds still remained after 5 years and it appears that seeds can survive long periods of burial in soil. Seed sown in soil at different depths, with and without cultivation, in pots and boxes sunk in the field, emerged primarily in the spring with some emergence in summer when sown on the surface (Froud-Williams *et al.*, 1984a). Seed sown at 75 mm depth and cultivated in February emerged in large numbers in spring with some in summer. Cultivation in June gave few seedlings. The optimum emergence depth was 0 to 5 mm, the maximum was 10 mm.

Plants form a short, thick rootstock with many strong roots that anchor the plant down (Frankton & Mulligan, 1970). On paths across grassed areas, greater plantain has smaller prostrate leaves and its growing point is below soil level (cryptophyte) (Bates, 1935). In untrodden areas the leaves are semi-erect and the growing point is at soil level (hemicryptophyte). In open areas, greater plantain overwinters underground but in grassland it overwinters as a small above-ground rosette of leaves (Grime *et al.*, 1988). Root and shoot growth commence in spring and new growth ceases by August. Lawn plants that flower and set seed often die afterwards (Warwick & Briggs, 1980). In grass there is a rapid turnover in the greater plantain population and a high rate of seedling mortality (Warwick & Briggs, 1979).

Persistence and Spread

Seeds can remain viable in soil for 50-60 years (Sagar & Harper, 1964). Seeds have been recorded in enormous numbers in the soil beneath pastures even though the plant may be poorly represented in the vegetation (Chippindale & Milton, 1934). Seed recovered from excavations and dated at 30 years old was reported to have germinated (Ødum, 1974). Seed buried in soil for 5 years retained 30% viability. In

Duvel's burial experiment, seed buried at 8, 22 and 42 inches gave 40, 44 and 47% germination respectively after 1 year, 53, 32 and 41% after 10 years, 6, 14 and 84% after 21 years but less than 1% after 30 years (Toole, 1946; Goss, 1924). Buried seed remained viable after 2 years but surface sown seed did not (Froud-Williams *et al.*, 1984a). The annual percent decline of seeds in cultivated soil was 38% (Popay et al., 1994). In studies with seeds buried at 2.5, 10.0 or 17.8 cm deep in soils with different water tables, seeds of ribwort plantain did not deteriorate as quickly in wetter soils (Lewis, 1961). In laboratory tests, the highest germination levels came from seeds that were immediately above the water level. Seed has given 10% germination after 40 years burial in soil but the life span of dry-stored seed was less than 10 years (Crocker, 1938). After 1 year of dry storage seed gave 96% germination but none was viable after 5 years (Kjaer, 1940).

Although a perennial, reproduction and spread of greater plantain is primarily by seed and it does not reproduce freely by vegetative means. Daughter rosettes may be produced from lateral buds and a greater plantain plant can form a small clump.

In samples of wheat, barley, oats and rye seed tested by the Official Seed Testing Station from 1961 to 1968, greater plantain seeds were found in 0.4, 0.9, 1.0 and 1.5% of samples respectively (Tonkin, 1968). In cereal seed sampled in the period 1978 to 1981, greater plantain seed was found in up to 3% of wheat and barley samples tested (Tonkin, 1982). In a survey of weed seed contamination in cereal seed in drills ready for sowing on farm in spring 1970, it was found in 3% of samples (Tonkin & Phillipson, 1973). All of this was home saved seed. In a survey of grass and clover seed contamination in 1960-61, greater plantain seed was found in 13.6, 22.2 and 12.7% of Timothy seed samples tested of English, Scottish and Swedish origin respectively (Gooch, 1963). It occurred in 16 and 23% of white clover samples tested of English and Danish origin, and 5% of red clover seed of English origin. In clover and grass seed samples tested in Denmark for the period 1966-69, 1955-57, 1939 and 1927-28, greater plantain seed was a contaminant in 7.6, 24.4, 17.8 and 8.3% of samples respectively (Olesen & Jensen, 1969). In Timothy seed there was an average of 217 and a maximum of 1,600 greater plantain seeds per kg of grass seed.

The seeds become mucilaginous and adhesive when wet and this assists with dispersal on animals, mowing implements, and in mud on tyres and boots (Young & Evans, 1973). Seed has been found in cattle, horse and goat droppings. Seedlings have been raised from the excreta of various birds (Salisbury, 1961). Apparently-viable seed has been found in samples of cow manure (Pleasant & Schlather, 1994). Earthworms ingest the seed and undamaged seed has been recovered from worm casts (McRill, 1974).

Management

The plant possesses a shallow perennial taproot that is readily destroyed by cultivation (Chepil, 1946). Good cultivation, well-hoed root crops and the use of pure seed contribute to greater plantain control (Morse & Palmer, 1925; Long, 1938).

In roadside verges, increased cutting frequency increased the frequency of greater plantain (Parr & Way, 1984). Seedlings raised from roadside plants suffered greater damage from cutting at 2 cm height than seedlings raised from lawn plants (Warwick & Briggs, 1980). If anything, the growth of lawn plants was stimulated by clipping.

Under regular mowing regimes, lawn plants are still able to set and shed seeds. In grassland, trampling by livestock leads to soil compaction that favours greater plantain (Wells, 1985).

A large number of insects are found on greater plantain some of which may feed on it (Sagar & Harper, 1964).

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