The biology and non-chemical control of Groundsel (*Senecio vulgaris* L.)

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Groundsel

(birdseed, chickenweed, chinchone, grinsel, grinning swallow, grunsel, grundsel, grunnishule, sencion, simson, swichen)
***Senecio vulgaris* L.**

Occurrence

Groundsel is a summer annual, ephemeral or overwintering weed, native in open and rough ground (Clapham *et al.*, 1987). It is common throughout the UK in a wide range of habitats (Stace, 1997). It has been recorded up to 1,750 ft in Britain (Salisbury, 1961). It is present on almost all soils and is especially prolific on good land (Long, 1938). It may occur in vast numbers that can smother a young crop. Groundsel is a common garden weed (Copson & Roberts, 1991). It is abundant on rubbish heaps and on horticultural, arable and fallow land (Hanf, 1970). Groundsel prefers loose, sandy and sandy loam soils. In early surveys of Bedfordshire, Hertfordshire and Norfolk, groundsel was universally distributed on all soils and was often frequent (Brenchley, 1911; 1913).

Groundsel was found as often among one type of arable crop as another (Brenchley, 1920). It was one of the main weed species present in conventional sugar beet crops surveyed in East Anglia in autumn 1998 (Lainsbury *et al.,* 1999). It was also a common species in the field margins. In a study of some arable soils in the English midlands sampled in 1972-3, seed was recorded in 38% of fields sampled in Oxfordshire and 28% in Warwickshire but only in low numbers (Roberts & Chancellor, 1986). Groundsel seed was found in less that 1% of arable soils in a seedbank survey in Scotland in 1972-1978 (Warwick, 1984). In a comparison of the ranking of arable weed species in unsprayed crop edges in the Netherlands in 1956 and in 1993, groundsel remained in 14-15th place (Joenje & Kleijn, 1994).

Groundsel is very variable in habit, leaf shape and flower form (Clapham *et al.*, 1987). Ligulate florets are usually absent but forms do exist with 7-11 ligulate florets in the flower head, some are var. *denticulatus*. The level of variability in populations depends on the amount of soil disturbance (Bosbach *et al.*, 1982). In frequently disturbed soils there is a greater number of genotypes. In a less disturbed habitat the population will be more stable and less variable. This applies both to the above ground population and eventually to the seedbank too. It is essentially an in-breeding species and ecotypes have developed with tolerance to saline conditions, acid rain and to particular groups of herbicide (Grime *et al.*, 1988). Herbicide resistant forms have evolved where triazine herbicides have been used extensively (Mitich, 1995; Putwain & Mortimer, 1989). Natural hybrids occur with Oxford ragwort (*S. squalidus*).

The plant has diuretic properties and has been used medicinally in the past both internally and externally (Mitich, 1995). In Europe it has been grown as green food for cage birds and poultry. Consumption of large quantities by livestock can cause liver damage. The leaves are the most toxic part of the plant. The alkaloids

responsible are not destroyed by drying or by fermentation in silage. The plant is more toxic to horses, cattle and pigs than to sheep.

Groundsel acts as a host for the fungus that causes black root rot in peas and for another responsible for Cinerarea leaf rust (Morse & Palmer 1925). Other fungi, various insects and several nematode species that attack important crops also infest it (Thurston, 1970). The stem nematode, *Ditylenchus dipsaci*, can infest it (Franklin, 1970). It can carry seed transmitted virus diseases that attack some economically important crops (Heathcote, 1970; Moore & Thurston, 1970).

Biology

Groundsel flowers throughout the year, and a plant may continue to flower and set seed for several months (Long, 1938). Plants have been observed in flower in early January. The main flowering period is April to October and most seed is set from May to October (Grime *et al.*, 1988). The flowers are usually self-fertilized. Guyot *et al.* (1962) give the seed number per plant as 1,500 to 10,000. The average seed number per plant is 1,000 to 1,200 (Salisbury, 1961). Plants cut down in bud did not ripen viable seed but seed from plants cut in flower had germination levels of 35% (Gill, 1938). Groundsel plants can be found in fruit all the year round. The time from germination to fruiting is around 100 days (Guyot *et al.*, 1962). Groundsel can complete its life cycle in 5-6 weeks (Salisbury, 1962). The cycle tends to take longer in richer soils. Under conditions of moderate stress, flowering may be precocious but under greater stress flowering becomes irregular and plants may remain vegetative (Harper & Ogden, 1970). Under conditions of medium to low stress there may be a 7-fold difference in plant size but net reproductive effort (Total seed production/Total net production x 100) remains at around 21%.

In the UK, most seeds are capable of germinating at once and more than 80% can emerge within a few days of shedding. Seed from a Mediterranean population of groundsel was far more dormant than UK seed (Mitich, 1995). In Petri dish tests with seed kept under high or low light intensity or in darkness, seed gave 100% and 79% germination in low and high light respectively but there was no germination in the dark (Grime & Jarvis, 1976). After a 50 week period of soil burial, seeds germinated only when the soil was disturbed in the light not in darkness (Wesson & Wareing, 1969). Seed stratified outdoors in soil overwinter was exhumed and tested for germination in the light, in the dark and in the dark with a 5 second flash of light (Andersson *et al.*, 1997). Seed gave almost complete germination in the light, 93% germination in the dark with a short flash of light and 65% germination in darkness. When seeds were put to germinate under a leaf canopy or in diffuse white light there was no germination under the leaf canopy and 60% in the diffuse light (Górski *et al.*, 1977). Freshly shed seeds usually require light but not stratification for germination to take place (Popay & Roberts, 1970a). However, it was noted that seed produced in spring was generally more dormant than seed produced in summer or autumn. High summer temperatures may have an effect on the seeds. Seed germination was better at lower (10-15^{o}C) than higher (20-30^{o}C) temperatures. Seeds buried for 6 months in soil under natural conditions germinated readily on exposure to light. Germination in the dark was much less than in the light (Popay & Roberts, 1970b). At 4^{o}C there was still some germination in the light but none in the dark. Dry stored seed gave a low level of germination in darkness at 20^{o}C (Hilton, 1983). Exposure to white or red light for 8 hours per day resulted in maximum germination after 4-5 days. Just 10

minutes of red light had a positive effect on germination. Red light stimulates germination, far-red light is inhibitory. A relatively high concentration of KNO_3 replaced the light requirement.

Groundsel seeds do not have a particular chilling requirement but germination in the dark is somewhat better after stratification. Increased levels of carbon dioxide inhibit seed germination (Karssen, 1980/81b). Low oxygen, high carbon dioxide, darkness and low temperature combine to reduce germination of buried seeds even when soil cover is just 20 mm. Little germination occurs in winter until the temperature rises. Vegetation cover also suppresses germination (Long, 1938). Following soil burial in autumn and early winter, freshly shed seeds were able to germinate in late-winter and early spring. Seed that did not germinate by early summer developed secondary dormancy (Karssen, 1980/81a). The pattern was repeated in the following year. Seed buried 10 cm deep in soil in June and tested for germinability at monthly intervals over 2 years exhibited high germination initially but the potential for germination was reduced as winter approached (Figueroa *et al.*, 2007). The ability to germinate increased in the following spring/summer then decreased again towards the winter. Germination is increased by a period of dry storage (Grime *et al.*, 1988).

Germination and seedling establishment is better in conditions of high humidity (Sheldon, 1974). In dry conditions the seed's hairy pappus holds the seed above the soil surface. In moist or humid conditions the pappus collapses permanently and the seed lays on the soil surface.

Seeds sown in May germinated in a few days (Long, 1938). Seed sown in pans of field soil exhibited a very short period of natural dormancy and most seeds germinated within 12 months (Brenchley & Warington, 1930). There was no real periodicity of emergence but some preference for spring emergence. Field emergence in plots cultivated at monthly, 3 monthly or yearly intervals or not at all, extended from March to December with most emergence from June to October (Chancellor, 1964a). Seedling emergence was similar whatever the cultivation treatment. Flushes of emergence occurred in February and May-June (Long, 1938). Seed sown in a 75 mm layer of soil in pots sunk in the field and stirred periodically emerged from February to November with peaks in May and September (Roberts, 1964). Seedling emergence in Scotland recorded in field plots dug at monthly intervals began in May/June and continued through until August/September with peaks in June or August (Lawson *et al.*, 1974). Groundsel does not have very exacting germination requirements and flushes of emergence may be associated with rainfall events that follow cultivation or seed shedding. Seedlings are frost tolerant.

In the field, 64 to 100% of seedlings emerged from the surface 40 mm of sandy and peat soils with the odd seedling from down to 40 mm (Chancellor, 1964b). In a sandy loam soil, field seedlings emerged from the top 30 mm of soil with up to 80% from the upper 5 mm (Unpublished information).

At high levels of soil moisture the horizontal spread of groundsel roots increases (Berntson & Woodward, 1992). Elevated CO_2 levels also result in increased branching and horizontal spread of the root system. The greater overall length of the roots increases their ability to forage through the soil under drought conditions.

Persistence and Spread

Groundsel seed does not survive long even in undisturbed soil (Roberts & Feast, 1972). In the first autumn after seed was mixed into the surface 25 mm of soil, 85% germinated and over the 5-year study 100% of seeds germinated in cultivated soil. Seeds mixed with soil and left undisturbed had declined by 87% after 6 years but in cultivated soil just the odd seed survived (Roberts & Feast, 1973). During 2 years burial in soil at 10 cm deep, 94% of seeds germinated or died (Figueroa *et al.,* 2007). Seeds buried in nylon mesh packets at a depth of 70 mm in undisturbed and cultivated soil, persisted longer over an 18-month period than seed buried at 10 mm depth (Watson *et al.,* 1987). There was an annual loss of around 40% at 10 mm and less than 20% loss at 70 mm. Losses were due to *in situ* death and germination in equal amounts. At the 70 mm depth, the rate of loss of seeds from triazine resistant biotypes was consistently lower than that of normal seeds. However, triazine resistant seedlings that emerged in the field had a lower probability of survival and those that reached maturity produced fewer seeds than normal biotypes.

The seeds have a hairy pappus and are widely dispersed by the wind (Long, 1938). Laboratory tests suggest maximum seed dispersal distances of 1.9 and 2.9 metres at wind speeds of 10.9 and 16.4 km/hour respectively but this would be affected by plant height (Sheldon & Burrows, 1973). Floating seeds of groundsel have been observed to travel by wind power across water (MacNaeidhe & Curran, 1982). The pappus also adheres to clothes and to animal fur, which further aids dispersal (Grime *et al.,* 1988).

In a survey of weed seed contamination in cereal seed in drills ready for sowing on farm in spring 1970, groundsel seed was found in 1% of samples (Tonkin & Phillipson, 1973). In seed samples from a range of grasses of UK and other origin, groundsel was not found in any grass or clover samples tested in 1960-61 but was found in trace amounts in some brassica and carrot seed (Gooch, 1963). However, it was found in 15% of celery seed samples. Seed has been found in sparrow droppings and seedlings have been raised from the excreta of various birds including sparrows (Salisbury, 1961). Apparently-viable seed has been found in samples of cow manure (Pleasant & Schlather, 1994).

Management

In the past, groundsel was controlled by cultivation with the hand or horse-hoe (Long, 1938). While stubble cleaning may not be appropriate for dealing with the shed seeds of some weed species it can be an effective way of controlling groundsel. The surface soil should be cultivated to a depth of not more than 2 inches and this operation is repeated at 14 day intervals. Every opportunity for cleaning agricultural land must be taken including fallowing and root crops (Morse & Palmer, 1925). Continual hoeing and hand pulling should be practiced. The areas around manure heaps and similar sites where groundsel often occurs in abundance should be cleaned up to prevent seed spreading into cropped areas.

Being a wind dispersed species, common groundsel is generally associated with zero tillage systems (Derksen *et al.,* 1993).

Seedlings with 2-6 leaves are tolerant of flame weeding (Ascard, 1998). Although the growing point is exposed, the leaves are resistant to damage. Groundsel seed is susceptible to soil solarization. Preliminary studies of soil steaming in the field

indicated that seeds of groundsel were controlled by treatment (Hansson & Svensson, 2004). Imbibed seeds in trays of moist soil held at 75 or 100°C for 12 hours lost viability but at 56°C the results were variable and a few seeds retained viability after 16 days (Thompson *et al.*, 1997). Seed held at 155°C for 7.5 minutes or at 204 or 262°C for 5 minutes was killed.

Seed numbers in soil were reduced by 70% following a 1-year fallow and by over 90% if this was extended for a second year (Brenchley & Warrington, 1933). The land was ploughed, disked and harrowed during this time. Seed numbers were reduced but to a lesser extent by cropping with winter wheat for the same period. Seed numbers increased again in the first crop after fallowing (Brenchley & Warington, 1936). There may have been periods during cropping when seeding occurred and groundsel is able to emerge and develop rapidly to flower and set seed in the autumn after crop harvest. Fallowing every 5th year over a 15-year period reduced seed numbers in soil by 65% at the first fallowing and by over 95% at the second. The same level of seed numbers was found after the 3rd fallow period (Brenchley & Warington, 1945). In the intervening cropped years seed numbers may have increased slightly.

In a 2-year set-aside in Scotland groundsel seed numbers in the soil increased when the set-aside was left fallow but not when there was a sown grass cover (Lawson *et al.*, 1992). Crop competition reduces seed production in groundsel by shading the weed (Baumann & Bastiaans, 1999). Groundsel cannot exploit grazed, trampled or mown sites (Grime *et al.*, 1988).

Biological control of groundsel with the naturalised rust fungus *Puccinia lagenophorae* Cooke has been the subject of much research (Müller-Schärer & Frantzen, 1996). The rust was first recorded in England in 1961 and spread rapidly. The fungus now occurs widely in the UK and may cause considerable damage to groundsel plants but there is no guarantee of an attack by the pathogen. Different lines of the weed vary in susceptibility and different stains of the fungus vary in the level of aggression (Wyss & Müller-Schärer, 1999). The leaves of groundsel become increasingly more susceptible to infection as they get older. Environmental factors also affect the aggressiveness of the pathogen. Groundsel (*Senecio vulgaris*) infected with the rust fungus *Puccinia lagenophorae* was less competitive in field grown lettuce and had little effect on yield unless the weed was at a high density (Paul & Ayres, 1987). However, when uninfected groundsel plants were also present these were able to take advantage of the reduced competition. Prior to 1960, the common rust that affected groundsel was *Colesporium tusillaginis* which has pine as an alternative host (Moore & Thurston, 1970).

Caterpillars of the cinnabar moth (*Tyria jacobaeae*) feed on groundsel in June-July and may weaken or even kill a plant before it can set seed. The cinnabar moth caterpillars themselves are attacked by several different predator insects that can have a drastic effect on their numbers and hence effectiveness.

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