The biology and non-chemical control of Dandelion (*Taraxacum* Spp.).

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***Taraxacum* spp.**
(*Taraxacum officinale, T. vulgare*)
Dandelion
(common dandelion, dent-de-lion, lion's tooth, one-o-clocks, pissenlit)

Occurrence

Dandelion is a perennial with a stout taproot (Stace, 1997). It is abundant everywhere but prefers chalky soils (Morse & Palmer, 1925). It also favours nutrient-rich loamy soils with a moderate humus content (Hanf, 1970). It is mostly found on soils above pH 7.0 (Grime *et al.,* 1988). It has been identified in prehistoric deposits, and is recorded up to 2,700 ft in Britain (Salisbury, 1961).

Dandelion is common in pastures, lawns, orchards, hay fields, waste ground and roadsides. Dandelion can be both a pioneer plant colonizing freshly disturbed land and a longer-term constituent of the stabilised vegetation cover that develops. It is able to become a more dominant component of the sward when grassland suffers disturbance (Burke & Grime, 1996). It is often associated with heavily grazed grassland (Gibson, 1997). It is also a common garden weed (Copson & Roberts, 1991). In urban situations it often occurs in shaded areas (Benvenuti, 2004). It is a weed of perennial horticultural crops and may also be a problem in some annual crops, particularly where reduced tillage is practiced (Stewart-Wade *et al.*, 2002). In a survey of seeds in pasture soils in the Netherlands in 1966, dandelion was common in the sward and in the soil seedbank (Van Altena & Minderhoud, 1972).

The taxonomy of the dandelion is very complex (McNeill, 1976). The flowers of most of the aggregate are apomictic and hence local strains tend to develop. 132 micro-species were recognised in 1972 (Clapham *et al.*, 1987) and in 1997, 229 were recognised and grouped into 9 sections (Stace, 1997). Approximately 90% of these are polyploids that reproduce asexually by obligate agamospermy (Stewart-Wade *et al.*, 2002). The rest are diploids that reproduce sexually and are obligate out-crossers. Hybridization may occur between the sexual forms and the apomictic pollen bearing types (Grime *et al.,* 1988). Although patches of genetically identical individuals may occur the plants exhibit sufficient phenotypic plasticity to adapt to a changing environment. Ecotypes in pasture are resilient to treading and recover rapidly from defoliation. Other ecotypes are adapted to dry, wet or montane habitats.

Dandelion has some nutritive value in pasture and is relatively high in copper and iron (Salisbury, 1961). It is also high in calcium and nitrogen (Wilman & Derrick, 1994) and in potassium (Wilman & Riley, 1993). It is eaten readily by sheep but is relatively low yielding (Derrick *et al.,* 1993). The fibrosity index is consistently low compared with ryegrass (Wilman *et al.,* 1997). The protein and mineral content of dandelion leaves have been shown to meet the nutritional needs of beef cattle (Bergen *et al.,* 1990). The flowers are a rich nectar source for insects and the leaves and seeds are eaten by many bird species including linnets (*Carduelis cannabina*) (Moorcroft *et* *al.*, 1997) and bullfinches (personal observation). Dandelion leaves provide winter food for pigeons. The roots are used in medicine, as a tonic and for their diuretic properties.

Dandelion possesses allelopathic ability and can inhibit the germination of seeds of other plant species (Stewart-Wade *et al.*, 2002). Dandelion plants release ethylene which can affect the growth of neighbouring plants. The dandelion can carry economically important viruses some of which are seed borne (Heathcote, 1970). The stem nematode, *Ditylenchus dipsaci*, can infest it too (Franklin, 1970).

Biology

Dandelion flowers profusely in May and June according to Listowski & Jackowska (1965). Barker (2001) suggests that flowering occurs from March to May and again from July to November. Grime *et al.* (1988) give the flowering period as May to October, but mainly from April to June. A period of low temperature seems to intensify flowering. Daylength does not appear to be a major influence on flowering under natural conditions. Plants that bloom in spring can flower again in autumn. Seedlings that emerge in spring may flower in the first year but many remain vegetative and the first flowers are produced in the spring of their second year. There is unlikely to be more than one generation per year. A plant may have 50 or more inflorescences on rich soil while only a single flower head may be produced at a poor site. The flowers are mostly apomictic but are visited by insects (Grime *et al.,* 1988). The fruiting period is from April to June (Bostock, 1978).

A flower head can produce up to 400 seeds but the average is 180. A plant may have a total of 2,000 to 12,000 seeds (Salisbury, 1961; Stevens, 1932), or even 23,456 seeds (Stewart-Wade *et al.*, 2002). The average seed number per plant is 2,720 (Pawlowski *et al.*, 1970). The 1,000 seed weight is given as 0.583 g (Bostock, 1978) and 0.620-0.640 g (Stevens, 1932). Seed weight may vary with the time of year it is produced. The time from flowering to seed ripening takes about 9-12 days. At least 7 days must elapse before seeds are likely to be viable. Ripe seed gave 90% germination but cut down flowering stems did not produce any viable seed (Gill, 1938).

Ripe seed is able to germinate immediately after shedding but the germination of seeds in close proximity to each other may be inhibited. In Petri dish test, seed in the light germinated up to 65% at a constant 18-20^{o}C and up to 76% at alternating temperatures of 20 to 30^{o}C (Cross, 1930-33). The maximum germination of fresh seed occurred at an alternating temperature of 10 to 20^{o}C (Mezynski & Cole, 1974). Seed stored for 30 days germinated best at an alternating temperature of 15 to 20^{o}C. Storage, especially at low temperatures, increased the level of seed dormancy. In the laboratory, germination was stimulated by light, nitrate and alternating temperatures (Bostock, 1978). Seed was killed by storage at 27^{o}C with 80% humidity. Seed that was tested after it had been stratified in soil overwinter gave almost complete germination in the light, in darkness with just a 5 second light flash and in complete darkness (Andersson *et al.,* 1997).

Seed sown in trays of soil in the field germinated from April to September but showed no marked periodicity of emergence (Chepil, 1946). Most seedlings emerged in year 1 but emergence continued into year 4. In greenhouse studies, seeds on or near the soil surface emerged better when soil was at field capacity (Boyd & Van Acker, 2003). There was 62% emergence of seeds from 0-2 cm deep and 7-11% from 3-4 or 6-7 cm deep. Seed sown in a 75 mm layer of soil in cylinders sunk in the field emerged mainly from March to July with most seedlings appearing in March-April with odd seedlings at other times (Roberts & Neilson, 1981). The majority of seedlings emerged in the first 2 years of the experiment and few viable seeds remained at the end of 5 years. Field emergence in plots cultivated monthly, 3 monthly, yearly or not at all extended throughout the year with most from May to October (Chancellor, 1964). The highest seedling numbers came from the least cultivated plots. Seeds germinate in the upper 50 mm of the soil (Hanf, 1970).

Germination and seedling establishment is better in conditions of high humidity (Sheldon, 1974). When conditions are dry the hairy pappus remains erect holding the seed with its scar of attachment in contact with the soil. Water uptake by the seed is mainly via the cells in this region. In moist conditions the pappus collapses and the seed lays on the soil surface. The position of the seed on a substrate has a significant effect on the level of germination. Seeds germinate best (80%) when upright or at an angle of 45^{o} with the scar of attachment partially buried. Germination is moderate (40-50%) when the seed is laying flat on the soil surface or buried at 5 mm. The poorest germination (20%) occurs when seeds are vertical but with the scar of attachment uppermost.

In an abandoned pasture, seedling emergence from shed seed was relatively high whether the vegetation cover was left intact or was removed as long as seed predation was prevented (Reader, 1993). If seeds were not protected from predation seedling numbers were much lower particularly where ground cover was left intact.

At the end of the growing season the taproot contracts to keep the growing point that is at the base of the leaf rosette, beneath the soil surface (Mitich, 1989). The plant overwinters as a taproot with a few leaves (Zimdahl, 1993). Dandelion also has a well-developed system of fibrous roots (Bostock & Benton, 1979).

Persistence and Spread

Dandelion overwinters as seed or as a basal rosette. Individual plants commonly survive for 10 to 13 years. Seed stored in soil had a half-life of 3 months (Bostock, 1978). Large populations of seeds can be found in soil in both grassland and arable fields (Stewart-Wade *et al.*, 2002). Dry stored seed had 83% viability after 12 months and 44% after 24 months. Seed submerged in water retained 7% viability for 3 months but little beyond this (Comes *et al.,* 1978).

Dandelion reproduces vegetatively and from seed (Listowski & Jackowska, 1965). In uncultivated soil, undamaged taproots show little capacity to divide and form large clumps (Bostock & Benton, 1979). However, a large taproot that may be 3 cm in diameter and reach a depth of 2 m in optimal soil conditions can be fragmented by cultivation. In greenhouse studies almost 100% of fragments will regenerate. Even the small fragments of root left after plants are pulled up may regenerate (Salisbury, 1961). In natural conditions, regeneration is much less certain (Mann & Cavers, 1979). The length of a root fragment that will regenerate depends on its diameter. The wider the diameter the shorter the length of root that is able to regenerate. For this reason, fragments from the upper parts of the root regenerated better than those from lower down. When the regeneration of upper and lower root pieces of the same diameter were compared, there was little difference in survival.

Less than 20% of root fragments regenerated and survived in May when most plants were in flower but weather condition could have been a factor in this too. Survival was much greater, 65% or more, when roots became fragmented between June and September. However, at this time there was there was little difference in regeneration between non-flowering plants and those with a few to moderate number of flowers. The orientation of the fragments also influences survival. Regeneration from fragments in the normal orientation is greater than from those that are inverted. Regeneration from horizontal fragments is intermediate. The fragments all retained their polarity.

New plants may emerge from root fragments buried 5-10 cm deep in soil (Stewart-Wade *et al.*, 2002). There was no consistent difference in survival of fragments at depths down to 10 cm except for a lower percentage survival of young root fragments near the soil surface (Mann & Cavers, 1979). However, regeneration took longer the deeper that fragments were buried but climate and time of year were also factors in this.

The seeds have a hairy pappus and are wind dispersed (Salisbury, 1961). Almost 100% of the seeds are dispersed in this way. As the seeds ripen, the stalk that carries the flower head elongates to increase the height from which the dispersal takes place. The wind carries seeds up to 500 m from the parent plant (Stewart-Wade *et al.*, 2002).

In determinations of seed contamination in grass and clover seeds in Denmark in 1966-69 and 1955-7, dandelion seeds were found in 7.1 and 0.7% of seed samples tested respectively but only in low numbers (Olesen & Jensen, 1969). Seedlings have been raised from the excreta of various birds, however, seed germination may be impaired. Seeds have been found in cattle and horse droppings. Apparently-viable seeds have been found in cow manure (Pleasant & Schlather, 1994). Seeds have also been recovered from irrigation water (Kelley & Bruns, 1975). Seeds can survive in water for up to 9 months.

Management

Every effort should be made to prevent dandelion flowering and seeding. The long taproot renders eradication by hoeing a slow and difficult process (Morse & Palmer, 1925). The deep taproot is difficult to extract manually. In the past a tool called a 'dandelion grubber' was used to remove the roots completely. Cutting individual plants below ground with a blade may not be successful because any portion of the root that remains can sprout and a cluster of new shoots often develops. Regeneration and survival of root fragments is lowest at the time of maximum flowering. Dandelion can survive tillage through regeneration of root fragments but ploughing may bury the roots deep enough to prevent emergence. As a wind dispersed species, dandelion is often associated with zero tillage systems (Derksen *et al.*, 1993).

Defoliation of dandelion alters the shoot-root ration in favour of root growth. Plants become smaller as the degree of defoliation increases but leaves can be replaced very rapidly once removal ceases. In roadside verges, increased cutting frequency increased the incidence of dandelion in the more open habitat that was created (Parr & Way, 1984; 1988). With increasing grass height the density of dandelion is likely to decrease due in part to the shading effect of the tall grasses. In closely mown grass the leaves spread flat against the ground, in taller vegetation the leaves stand more or less erect. In pasture, dandelion increases under tight spring grazing by sheep and decreases under lenient grazing (NERC, 2006).

In grassland, dandelion is favoured by an increased level of potassium (Williams, 1976). Dandelion has a high requirement for potassium and is likely to be less competitive on soils low in this nutrient (Stewart-Wade *et al.*, 2002).

Flame weeding is not effective and may favour dandelion growth by removing other vegetation (Stewart-Wade *et al.*, 2002). Microwave treatment of soil in a controlled environment has killed dandelion plants given a 16 second exposure.

In field studies, mulching the soil with residues of hairy vetch (*Vicia villosa*) and of rye (*Secale cereale*) reduced the emergence of dandelion (Mohler & Teasdale, 1993). Weed emergence declined with increasing rate of residue, however, the natural amount of residue that remained after the cover crop was killed was insufficient for good weed control. A low rate of residue could even encourage greater weed emergence.

In greenhouse tests, corn gluten meal (CGM) applied as surface and incorporated treatments to soil sown with dandelion seed has been shown to reduce plant development (Bingaman & Christians, 1995). Application rates of 324, 649 and 973g per m^2 reduced dandelion survival by 75, 90 and 100% respectively. Shoot and root length was reduced by up to 100%. Corn gluten hydrolysate (CGH), a water soluble material derived from CGM, was found to be more active than CGM in reducing root and shoot length and plant survival when applied at 100 g/m^2 to the surface of pots of soil sown with dandelion seed (Liu & Christians, 1997).

Seed predation by birds, insects and rodents can reduce seed numbers in soil. Some birds will take the whole seedhead (Bostock & Benton, 1979). Cattle do not avoid dandelion in pasture and may even favour it in longer grass when the leaves are more erect (Bergen *et al.*, 1990). Dandelion tends to recover more rapidly than grass following defoliation. Sheep and geese have been used for biological control of dandelion, with sheep being the more effective (Stewart-Wade *et al.*, 2002). Slugs find dandelion seedlings highly palatable. Although rabbits will eat dandelion, excluding rabbits from grassland did not result in an immediate increase in the dandelion population (Watt, 1981).

The soil-borne fungus *Sclerotinia sclerotiorum* has been investigated for the control of dandelion (TeBeest, 1996). The fungus has reduced populations by 80 to 85% but it has a wide host range that includes economically important crop plants such as lettuce. There are many other pest and disease organisms that show potential as biological control agents for dandelion (Stewart-Wade *et al.*, 2002).

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