# The biology and non-chemical control of Field Bindweed (*Convolvulus arvensis* L.)

**W. Bond, G Davies, R Turner**
HDRA, Ryton Organic Gardens, Coventry, CV8, 3LG, UK

## Field bindweed

(bearbine, bethbine, cornbine, field convolvulus, wild convolvulus)
***Convolvulus arvensis* L.**

## Occurrence

Field bindweed is native in cultivated land, roadsides, railways, grassy banks and in short turf (Clapham *et al.*, 1987; Stace, 1997). It is found throughout England, Wales and Ireland but is rarer in Scotland. Field bindweed is common on light basic soils as well as heavy land (Salisbury, 1961). It is not recorded above 1,000 ft in the UK. Field bindweed can survive long periods of drought due to the extensive root system.

Field bindweed is a perennial weed of cornfields and waste places on almost all soils (Long, 1938). Field bindweed is also a common garden weed (Copson & Roberts, 1991). It is a particular problem in cereals and in perennial horticultural crops like soft-fruit and asparagus (MAFF, 1957). Field bindweed trails over the ground and climbs among the crops pulling them down and hindering harvesting. In early surveys of Bedfordshire, Hertfordshire and Norfolk it was universally distributed on all soils often in association with creeping thistle (*Cirsium arvense*) (Brenchley, 1911; 1913). It was found as often among one type of arable crop as another (Brenchley, 1920). In a survey of weeds in conventional cereals in central southern England in 1982, field bindweed was found in 7, 2 and 0.8% of winter wheat, winter barley and spring barley respectively (Chancellor & Froud-Williams, 1984). In a survey of UK cereal field margins recorded as part of Countryside 2000, field bindweed was one of the most frequent species recorded (Firbank *et al.*, 2002). In a series of 4 national weed surveys made in Hungary between 1950 and 1997, it moved from 1$^{st}$ to 7$^{th}$ place in the rankings (Tóth *et al.*, 1997; 1999).

Populations differ in leaf shape and flowering habit but light and moisture levels can also affect plant morphology (Weaver & Riley, 1982). When 9 clones that differed in leaf shape and morphology in the field were grown under controlled conditions 5 of them became indistinguishable (DeGennaro & Weller, 1984a). Each of the distinct clones was incompatible and did not produce seed when self-pollinated. No seed was produced when the 5 identical clones were cross-pollinated with each other. The 4 distinct clones would successfully cross-pollinate with each other and with the identical clones. In the USA, biotypes of field bindweed differ widely in susceptibility to the herbicide glyphosate leading to variable control where the herbicide is used regularly (DeGennaro & Weller, 1984b).

Field bindweed has medicinal uses as a mild laxative and as a diuretic (Barker, 2001). In India, the root has been used as a purgative (Weaver & Riley, 1982). It is an alternate host of the virus that causes potato X disease.

## Biology

Field bindweed generally flowers from June to September but Hanf (1970) gives the flowering period as May to October. The flowers are insect pollinated and plants from the same clone are self-incompatible (Weaver & Riley, 1982; DeGennaro & Weller, 1984a). Clones may differ in the timing and capacity of flowering. Seed is set from August to October (Grime *et al.,* 1988). There are 1 to 4 seeds per fruit capsule. The average seed number per plant is 550-600 (Salisbury, 1961; Guyot *et al.*, 1962; Mitich, 1991). In cereal crops the average seed number per plant ranged from 31 to 98 and in root crops from 7 to 9 (Pawlowski, 1966). The flowers may fail to set seed in cultivated soils (Weaver & Riley, 1982). Most pollen is carried and deposited just 1 to 4 m from the source and this may restrict seed set in a single biotype population (Degennaro & Weller, 1984a). Seed production is greater in hot dry summers (Swain, 1983). Seeds can become viable 10-15 days after the flowers are pollinated. Seed coats become impermeable 23-25 days after pollination (Brown & Porter, 1942). Seeds from plants cut down after flowering have thin seed coats initially and may germinate at once. If the immature seeds are unable to germinate they gradually develop the thickened coats of ripe seeds. The hard, impermeable seed coats are responsible for seed dormancy (Grime *et al.,* 1988). Scarification of the seed coat results in rapid germination. Although field bindweed can seed prolifically, seedlings are rarely seen in the field (Chancellor, 1959).

Seeds germinate in autumn and spring (Salisbury, 1961; Swain, 1983). Timmons (1949) found that most seedlings emerged in spring but a few emerged at intervals through the year. Hanf (1970) considers that field bindweed germinates throughout the year. Seed mixed into the surface 25 mm of soil in boxes out of doors and stirred periodically, emerged from April to December (Chancellor, 1979). The main period of emergence was May to August. The minimum temperature for germination is 0.5$^{o}$C and the maximum is 40$^{o}$C (Brown & Porter, 1942). Seedlings emerge best from seeds near the soil surface (Mohler, 1993). Seeds that germinate in spring can achieve root penetration of 1.3 to 1.7 m by November (Weaver & Riley, 1982). A seedling may flower and fruit in the first year if conditions are favourable (Frazier, 1948). This may take just 13 weeks from seedling emergence.

After seed germination the vertical taproot grows directly down (Frazier, 1948). Six weeks after emergence the taproot has reached a depth of 45-62 cm and has 3 to 6 lateral roots (Weaver & Riley, 1982). Lateral roots develop mainly in the top 30 cm of soil and these grow out horizontally for 35 to 100 cm before turning down to form secondary vertical roots. These give rise to more laterals that again turn down to form verticals and so on. At the point where laterals turn down, rhizomes develop from adventitious root buds and grow upwards to emerge as new shoots. Less commonly, shoots form along the horizontal portion of the lateral roots. Apart from the initial aerial shoot, all other shoots originate from root borne stem buds which give rise to vertical underground stems or rhizomes (MAFF, 1957). At nodes along the rhizomes are buds that can develop into branch rhizomes. Roots may reach 1.2 m deep after 1 year and 4.2 to 4.8 m after 2.5 years. The majority of the root system (50-70%) remains in the upper 60 cm of soil (Weaver & Riley, 1982). Most rhizomes are produced in this layer of soil.

The above ground shoots appear in May and persist until the hard frosts. Shoots can reach 3 m in length (Frankton & Mulligan, 1970). Most lateral roots die back each year but a few persist and spread horizontally (Weaver & Riley, 1982). Field

bindweed overwinters by means of roots and rhizomes. The shoots are killed by frost, and the roots in the upper layers of soil may be damaged if temperatures fall below –8°C. New growths arise in spring from endogenous buds formed in the autumn on any lateral roots that survive the winter.

The rhizome is stout but brittle and is often spirally twisted (Clapham *et al*., 1987). Shoots form on fragments of underground stems and fleshy roots (Salisbury, 1962). A 5 cm length of vertical root can regenerate into a new plant (Mitich, 1991). Lateral roots do not regenerate as readily as vertical roots or rhizomes. New shoots arise within 7-14 days of stems being cut below ground level. A vigorously growing plant requires only a few days for buds to produce new rhizomes following injury and the new shoots soon appear above ground (Frazier, 1948). Bindweed often responds by producing more shoots than were originally cut back. The number of shoots formed from lateral root segments is greatest in early spring and least in early summer (Weaver & Riley, 1982).

**Persistence and spread**

Thompson *et al.* (1993) suggest that based on seed character, field bindweed seed is likely to persist for longer than 5 years. Impermeable seeds can retain viability for at least 4 years in soil (Brown & Porter, 1942). Over 95% of seeds are hard-coated and can lie dormant in soil for over 28 years. Seedlings continued to emerge for over 20 years after all the adult plants were removed from an area (Timmons, 1949). After 50 years in dry-storage, 8% of seeds were viable and a further 54% were viable but impermeable (Mitich, 1991). Field bindweed seed is relatively resistant to destruction in a manure heap. It has been suggested that seeds can remain viable for several months in dung and compost (Willis, 1954). Seeds gave 22% germination after 2 months in manure but none germinated after 3 months (Zimdahl, 1993). The seeds can survive in silage (Mitich, 1991). After 54 months storage in freshwater, seeds gave 55% germination (Zimdahl, 1993).

Seeds generally fall around the parent plant but ingestion by birds and other animals may disperse them further (Weaver & Riley, 1982). The seeds can remain viable in the stomachs of migrating birds for 144 hours. Field bindweed seed was not a common contaminant in wheat, barley, oat and rye seed samples tested by the Official Seed Testing Station each year between 1961 and 1968 (Tonkin, 1968). In general it was found in less than 0.1% of samples tested and never in more than 0.4%. However, it is considered to have spread worldwide as a contaminant in crop seed including within the USA (Mitich, 1991). The seeds were thought most likely to occur in cereal and bean seeds (Weaver & Riley, 1982).

Initial spread into a new area may be by seed but once established vegetative spread is more important (MAFF, 1957). A plant can spread radially by 3 m per year and can cover an area of 25 $m^2$ in a season (Mitich, 1991). Spread is mainly as fragments of rootstock that are able to produce new plants (Morse & Palmer, 1925). Biotypes differ in their capacity to develop new shoots from root segments (Degennaro & Weller, 1984a). Studies suggest that while root fragments readily produce new shoots they often fail to develop new roots and die as a result (Hill, 1977). Seed and rhizome fragments may be spread with soil (Grime *et al.*, 1988). Marshall (1989) in a study of the distribution of plants associated with the edges of arable fields found that field bindweed was common in the hedge bottom but did not spread far into the field.

**Management**
Avoid introducing seeds and rhizome pieces from contaminated fields into fields that are free of the weed.

In a perennial crop such as fruit the period before planting is the main opportunity to deal with perennial weeds like field bindweed using repeated cultivations (Bailey, 1978). Ploughing to 30 cm in March reduced subsequent field bindweed emergence for the following 6 months. Rotovation in March to a depth of 15 cm had some effect initially but regrowth soon occurred. Additional, shallow summer cultivations cleared the weed further for a short time but appeared to stimulate greater regrowth. The level of control by cultivation may depend on the vegetative reproductive capacity of the biotypes present (Degennaro & Weller, 1984a).

Control is based on exhaustion and removal of the rootstock and killing seedlings before they become established (Long, 1938; MAFF, 1957). Seeding should be prevented. A dense crop stand may out-compete bindweed seedlings and cultivations 10 cm deep at monthly intervals will control them (Swain, 1983). Seedlings over 6 weeks old are less likely to be killed by shallow cultivation. Most seedlings cut off just below the soil surface were able to regenerate after decapitation at 20 days old (4-leaf stage). Younger seedlings were less likely to regrow.

The depth of the underground root system makes complete removal difficult if not impossible. In field crops this entails short rotations with extra root crops and persistent hoeing. During tillage operations the rootstocks can be collected by harrows or by hand and these should be burnt (Morse & Palmer, 1925). Turning up the rootstocks to dry in the sun during summer fallowing will reduce the weed. Sometimes only the more drastic bare fallowing with regular cultivations will reduce field bindweed appreciably. A year of intensive fallowing can be followed by a cereal or some other competitive crop to keep the weed in check (Phillips & Timmons, 1954).

Repeated cultivations over a period of 2-3 years may eradicate the weed (Salisbury, 1961). Crop competition can help with this (Weaver & Riley, 1982). Phillips & Timmons (1954) found there was little advantage in cultivating deeper than 10-15 cm but it was important to cut all of the shoots each time a cultivation was performed. A duckfoot or sweep type implement seemed best. The optimum interval between repeated cultivations was 12 days after each emergence of regenerated shoots. Cultivating every 2 weeks initially and every 3 weeks later in the year was more practical and equally effective. Hand-hoeing is shallower and needs repeating at 10 day intervals to have the maximum effect. Elimination of the weed is likely to take 2 years (Timmons & Bruns, 1951). Ploughing at 20-30 cm before the shallow cultivations reduced the number of cultivations needed. Shallow ploughing or disking failed to eradicate the weed in 2 years.

Cutting the bindweed at ground level every 12-14 days eradicated the weed in 2 seasons, extending the interval to 16 or 20 days prolonged the time to eradication to 3 or 4 seasons (Bailey & Davison, 1984). Delaying the start of control or not continuing to the end of the growing period also lengthened the time to achieve complete control. It has been said that when shoots are cut back, food reserves are

used up during regeneration and it takes 14 days for reserves to be replenished by the newly emerged shoots (Frazier, 1948). Cultivations every 14 days should therefore prevent this and further deplete the remaining reserves. As the plant weakens, cultivations can be extended to every 21 days. Seedlings with 2-5 true leaves are easily killed by surface cultivations. Seedlings with 10-20 leaves may need up to 4 hoeing treatments to kill all the plants. Colonies established for just 2 years can be as difficult to eradicate as colonies that have been growing for many years. Sullivan (2004) describes a 5-year strategy for non-chemical control using tillage and crop rotation.

Field bindweed is not common in grassland and is unlikely to appear on closely grazed pasture (Morse & Palmer, 1925). Where it does occur, harrowing in spring may keep it down. Sheep and cattle eat the leaves and stems, pigs and chickens may unearth and consume underground stems and fleshy roots but it may cause digestive problems (Mitich, 1991). In grassland grazed by horses field bindweed often occurs in latrine areas (Gibson, 1996). In roadside verges, increased cutting frequency had no effect on the frequency of field bindweed (Parr & Way, 1988).

A sequence of autumn and spring-sown green-manure or cover crops and the associated cultivations are reported to give good results against field bindweed (Sullivan, 2004). A ground cover of common chickweed (*Stellaria media*) has been used to suppress field bindweed in vineyards (Turkington *et al.,* 1980). Entire or woven black plastic or other fabric sheeting will prevent field bindweed emerging but the cost can only be justified in long-term or high value crops. It can survive under black plastic mulch for at least 6 months (Personal experience). Field bindweed seed is moderately susceptible to soil solarization.

Biological control with fungal pathogens of the genus *Septoria* and of the genus *Phoma* has been investigated (Giannopolitis & Chrysayi, 1989). The species demonstrated sufficient pathogenicity and host specificity to be regarded as promising biocontrol agents. The host-specific fungus, *Erysiphe convolvuli*, has also been evaluated as a potential biocontrol agent of field bindweed (Abu-Irmaileh & Al-Raddad, 1999). Application of *Stagonospora convolvuli* to field bindweed caused extensive necrosis after 20 days and the severity increased over the next 20 days (Guntli *et al.,* 1998). However, there was no effect on the emergence of the weed in the year that followed.

An inoculum of the fungus *Phomopsis convolvulus* caused severe damage to field bindweed plants at all growth stages (El-Sayed *et al.,* 2001). The extent of the damage varied with plant age. Seedlings at early leaf stages were more sensitive than established plants. The fungus requires a long dew period to be effective but this can be overcome by formulation of the inoculum. Soil applications of a granular formulation were evaluated in field and glasshouse studies with seedlings and established plant (Vogelgsang *et al.,* 1998a). Application to pots of soil containing pre-germinated seeds of field bindweed reduced plant biomass by 87%. Application to pots of established but cut down plants reduced regrowth by 43%. In field studies, the biomass of both seedlings and regrowing plants was reduced by 98-100%. Pre-emergence applications within the dose range of 10 to 30 g per 0.25 $m^2$ were equally effective (Vogelgsang *et al.,* 1998b). In controlled conditions, incorporation was more effective than surface application of the granular formulation but the reverse

was true in the field. Timing is important as the fungal inoculum will lose viability if there is a long period between application and weed emergence. Incorporation should protect the inoculum from desiccation as well as increasing contact with the emerging bindweed.

In the USA, herbicides based on natural substances such as acetic acid, clove oil and thyme oil can be used in certified organic production for non-selective post-emergence control of weeds (Sullivan, 2004). They are intended for use as spot-treatments rather than overall sprays but acetic acid is a hazardous material at concentrations greater than 5%. Only plant foliage is killed and the roots are not affected.

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