The biology and non-chemical control of Field horsetail (*Equisetum arvense L.*)

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Field horsetail

(bottle-brush, cat's-tail, colt's-tail, frog pipes, horse pipes, mare's tail, scrub grass, shave grass, snake grass, snake pipes)
***Equisetum arvense* L.**

Occurrence

Field horsetail occurs throughout the world and is widely distributed in the UK (Marshall, 1984a; Holm *et al*., 1977). In early surveys of Bedfordshire, Hertfordshire and Norfolk, field horsetail was universally distributed on most types of soil (Brenchley 1911; 1913). It was frequently found in association with coltsfoot (*Tussilago farfara*). It was considered to be discouraged by competitive crops like cereals (Brenchley, 1920). In a survey of weeds in conventional cereals in central southern England in 1982, field horsetail was found in less than 1% of winter wheat and not at all in winter barley and spring barley (Chancellor & Froud-Williams, 1984). It is a weed of horticultural importance being a particular problem in fruit and other perennial crops and in nursery stock. It grows strongly in arable soils and grassland (Long, 1938). Horsetail is also found in meadows, hedgebanks and waste land (Clapham *et al*., 1987; Stace, 1997). It is a serious garden weed and flourishes on damp soils (Copson & Roberts, 1991). Field horsetail has a preference for stone free, abandoned sites (Dale *et al.,* 1965).

Field horsetail has the ability to accumulate gold in its tissues, 4.5 ounces per ton of fresh plant material have been recorded (Holm et al., 1977). It will also accumulate heavy metals such as cadmium, copper, lead and zinc (Cody & Wagner, 1981). Extracts of horsetail make an effective fungicide and have been used to treat blackspot on roses, rust on mint and mallow and mildew on many plants (Mitich, 1997). It has herbal uses for treating bladder disorders and skin inflammations. The silica rich sterile stems have been used to scour cooking pans, sand wood and polish metal.

Horsetail is toxic to sheep, cattle and horses. Horses are particularly sensitive (Forsyth, 1968). The plant is poisonous both in the green state and dried in hay due to an enzyme present in the tissues (Willis, 1954). Hay containing the weed is potentially more dangerous than horsetail growing in pasture (Frankton & Mulligan, 1970). The related marsh horsetail (*E. palustre*), a perennial weed of wet, low-lying grassland is also poisonous to livestock.

Biology

A rhizomatous perennial, field horsetail is dimorphic, producing non-photosynthetic spore-bearing fertile stems in March-April followed by green vegetative stems in late-spring. The cone bearing fertile stems develop from subterranean buds formed the previous summer and persist for about 10 days after emergence (Grime *et al.,* 1988).

The single cone on each fertile stem can produce 100,000 spores but these are very short lived (Salisbury, 1962). The spores remain viable for 48 hours after release

(Doll, 2001). Spores germinate quickly on moist substrates to produce male and female gametophytes that mature only within a narrow range of conditions. After fertilisation, cell division results in the formation of a shoot apex and roots (Marshall, 1984a). Once established, the sporelings soon become rhizomatous and quickly develop successive layers of horizontal rhizomes at 30 cm intervals as growth continues downwards (Holm *et al*., 1977). Spores that do not germinate after release lose viability rapidly (Cody & Wagner, 1981). The gametophytes too are susceptible to desiccation and few achieve fertilisation.

The vegetative stems have a rough texture due to deposits of silica. Maximum vegetative growth occurs in July (Marshall. 1986). Stored food reserves are depleted from late-April to mid-May, and the reserves are replenished from mid-May to August (Holm et al., 1977). Dry matter accumulation in the rhizomes may continue until October and then decline through the winter (Marshall. 1986).

The rhizome system can be extensive both horizontally and vertically and may reach over 1.5 m deep depending on substrate and water table level. More than half the rhizomes are found in the upper 25 cm of soil (Williams, 1979). In fallow soil and where there is little crop competition more rhizomes are found at shallower levels. The rhizomes grow rapidly in June-July and continue to elongate beyond October. The underground rhizome tips are covered with scale-like leaf sheaths. Roots arise at the nodes of the rhizomes. Tubers are also produced at the nodes of the rhizomes and may be present singly or in strings of two to four (Marshall, 1984a). Tubers are initiated in July and formation is thought to be influence by soil pH and soil type. Tuber formation is more frequent in sand rather than clay soil. Tubers initiated in August may continue to grow in size and number until November, well beyond the period of active shoot growth (Marshall. 1986). Rhizomes may produce numerous tubers (300-1000/m^3). Most of the tubers are found below 50 cm depth. Once detached, the tubers can grow into independent plants (Salisbury, 1962).

Persistence and Spread

Vegetative reproduction via rhizomes and tubers is probably the most important means of spread and perennation. It has been calculated that horsetail has the potential to infest a one hectare area within 6 years of introduction (Cloutier & Watson, 1985). The plant also reproduces by spores but the importance of sexual reproduction is unclear.

Vegetative reproduction and regeneration is by detached rhizome sections or tubers. Rhizome buds may remain dormant or develop into aerial shoots or new rhizomes (Marshall, 1984a). Regeneration of single node fragments is mainly in March-May and October-November. A 1.3 cm long segment planted 15 cm deep easily produces a new plant (Doll, 2001). Larger fragments have been shown to regenerate anytime except when high temperatures make the rhizome pieces susceptible to desiccation. In growth room tests, a 10 cm length of rhizome has produced a total of 64 m of rhizome in 1 year (Cody & Wagner, 1981). Tubers germinate when separated from the rhizome system and can remain viable for long periods in soil. Tubers immersed in water for 42 days remained viable but tubers kept dry in the laboratory for 14 days did not. Tubers that remained attached to the parent rhizome did not germinate (Williams, 1979).

Management

Field horsetail is difficult to control by cultivation because new stems regenerate from rhizome fragments and tubers. It is essential therefore to avoid introducing horsetail into clean fields. Field horsetail regrew equally well whether cut back once or sixteen times during the growing season (Cloutier & Watson, 1985). Keeping an area free of the weed for one year did little to reduce horsetail growth in the following year.

Field horsetail is adapted to sunny habitats. The vegetative shoots lack functional leaves and this is possibly the reason that horsetail cannot tolerate shading (Holm et al., 1977). At lower light levels the shoots become taller while at a high light intensity the shoots lie prostrate (Andersson & Lundergådh, 1999a). Tuber production increased at higher light levels. It seems that the weed is not always so competitive with crops (Cody & Wagner, 1981). Horsetail was only a serious weed in cereals growing on low fertility soil where the light penetrated to ground level in May when the horsetail shoots were emerging (Thurston, 1976). Cereals are better able to take advantage of increased nitrogen levels giving them a competitive advantage over field horsetail which does not respond as rapidly to increased soil fertility (Håkansson, 2003; Andersson & Lundergådh, 1999a). Rhizome tissues contain sufficient reserves of nitrogen and the plant has a relatively low requirement for soil nitrogen at least initially. The growth rate of field horsetail responds linearly to increasing levels of potassium but only at higher nitrogen levels (Andersson & Lundergådh, 1999b).

Annual cultivations and a herbicide regime that controls competitive broad-leaved weeds favour field horsetail which can become dominant (Andersson & Lundergådh, 1999a). Soil compaction and prolonged cereal rotations result in increased abundance. Field horsetail can be controlled by improved cultivation regimes and more competitive crops and cultivars.

Regular mowing over a period of years may eliminate horsetail (Marshal, 1984b; Allan, 2007). It is said to not persist in lawns that are mown regularly. Control in arable land includes draining, liming, deep cultivation, improvement in soil texture and persistent cutting of vegetative and spore bearing shoots (Long, 1938).

Black plastic sheeting has been found to kill rhizomes in the upper layers of soil (Cody & Wagner, 1981). However, the emerging vegetative stems can penetrate some woven polypropylene mulches (Personal experience). A biodegradable mulch of card and straw has had some effect in reducing horsetail after 1 year but would need to be renewed regularly (Allan, 2007).

It has been shown that horsetail can survive periods of flooding and burning but may be sensitive to water stress in drought conditions especially when growing in competition with other plants (Cloutier & Watson, 1985). Improved land drainage can also affect horsetail vigour and its competitive ability (Morse & Palmer, 1925). A good dressing of lime is helpful in reducing the weed.

No biological agents that are useful in the control of field horsetail have been found.

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