The biology and non-chemical control of Black Medick (*Medicago lupulina* L.)

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Black medick

(black hay, black medic, lupuline, nonsuch clover, yellow clover)
***Medicago lupulina* L.**

Occurrence

Black medick is a procumbent annual, biennial or short-lived perennial (Clapham *et al.*, 1987). It functions as a winter annual but may persist for 4 years on moist fertile sites (Grime *et al.*, 1988). Black medick is native in grassy places and rough ground (Stace, 1997). It is also prevalent in disturbed habitats and is a common weed in fields and gardens, including lawns (Turkington & Cavers, 1979). Black medick has a preference for fine textured, poorly-drained soils, low in organic matter with a pH from 6.5 to 7.8 and a low vegetation cover that is cut or grazed (Dale *et al.*, 1965). Black medick has a thin wiry taproot that penetrates deeply making the plant difficult to pull up. The plant can withstand summer drought (Grime *et al.*, 1988). Nodules containing nitrogen-fixing bacteria develop on the roots.

In the past, black medick was chiefly found in temporary leys where it came in as a contaminant of the grass and clover seed but it was only considered a problem on arable land (Morse & Palmer, 1925). It was thought to be a useful plant on dry chalky soils and was often deliberately included in seed mixtures, however, being relatively short-lived it soon dies out leaving bare patches. Black medick has been regarded as a valuable herbage plant and mixtures have been developed containing a high proportion but these were not popular in Britain. It has been cultivated as a green fodder for livestock, a green manure and as a hay crop. It has been introduced as a legume in sheep pasture. It is grazed by sheep but is less palatable to cattle. In dry prairie areas in Canada, black medick is used as a living mulch, green manure and fertility building crop that remains as part of the rotation for year after year (Wallace, 2001).

The species is morphologically very diverse and many varieties have been described (Turkington & Cavers, 1979). Black medick is occasionally found as a birdseed alien (Hanson & Mason, 1985).

Biology

Black medick flowers from April to August (Clapham *et al.*, 1987). Flowers may self- or cross-pollinate. Plants can flower within six weeks of emergence and new flowers are initiated throughout the growing season (Turkington & Cavers, 1979). Because of this, seeds can be at different stages of maturity on one plant throughout the season. Seeds are produced 9 weeks after flowering begins (Turkington & Cavers, 1978). Almost a third of plant biomass is allocated to seed production. The pods are single-seeded (Sidhu & Cavers, 1977). Seed number per plant may be up to 6,600 but the average number per plant is 2,350 (Stevens, 1932). The 1,000 seed weight is 1.26g (Stebbins, 1976).

Seed germinates in autumn or spring (Clapham *et al.*, 1987). Nearly mature seeds germinate readily and seedlings can emerge at any time of year (Turkington & Cavers, 1979). Seeds can remain non-dormant for around 10 days when almost mature whether attached to the parent plant or shed. The level of seed germination increases in the 16 days after flowering then decreases again as the seeds begin to ripen and the seed coat hardens (Sidhu & Cavers, 1977). In the growing season, seedlings may emerge from immature seeds that germinate beneath the parent plant. Premature germination allows black medick to produce more than one generation in a year. Mature seeds possess innate dormancy and with their impermeable seed coats can remain dormant for many years. Under natural conditions, seeds require a period of overwintering and as a result most germination occurs in spring. In laboratory tests, seed gave less than 10% germination at both a constant 18-20^{o}C and at alternating temperatures of 20 to 30^{o}C (Cross, 1930-33). Scarification promotes germination but light is not required. The level of germination increased from 13 to 98% following scarification (Grime *et al.*, 1981). Scarified seeds gave complete germination in the dark at constant and alternating temperatures and under a 'safe' green light.

Seed sown in pans of field soil emerged chiefly in winter but also in spring (Brenchley & Warington, 1930). Seed mixed in a 75 mm layer of soil in cylinders sunk in the field and stirred periodically, emerged mainly from March to May but odd seedlings emerged throughout the year (Roberts & Boddrell, 1985, Roberts & Feast, 1970). Seeds naturally-occurring in field soil, concentrated down by washing and put into dishes, germinated within a few days whether temperature fluctuations were wide or narrow (Warington, 1936).

In abandoned pasture, seedling emergence from shed seed was greatest when the vegetation cover was removed as long as seed predation was prevented (Reader, 1993). Emergence was still relatively high when the ground cover was left intact and predation prevented. If seeds were not protected from predation seedling numbers were moderately high in bare soil but were much lower where the ground cover was left intact. Ants rather than birds or rodents were responsible for most seed predation.

Persistence and Spread

Black medick seed can exhibit a period of dormancy in excess of 3 years (Chepil, 1946). Thompson *et al.* (1993) suggest that based on seed characters, black medick seed should persist for longer than 5 years in soil. Some seeds are hard-coated and can remain dormant for many years. Seeds mixed with soil and left undisturbed had declined by 87% after 6 years but in cultivated soil the decline was 93% (Roberts & Feast, 1973). Seeds were able to persist in soil for at least 10 years (Brenchley & Warington, 1936). Seed buried in soil had 1% viability after 1 year and still had 1% after 5 years (Kjaer, 1940). Seed buried in mineral soil at 13, 26 or 39 cm depth and left undisturbed retained 1-3% viability after 1 year, 1% after 4 years but the seed was no longer viable after 20 years (Lewis, 1973). Seed buried in a peat soil at 26 cm retained only trace viability after just 1 year. Seeds recovered from excavations and dated at 20, 25, 30 and 80 years old have been reported to germinate (Ødum, 1974; Ødum, 1978). In dry-storage, seeds gave 75% germination after 1 year and 55% after 5 years. Seed stored under granary conditions after 1, 4 and 20 years retained 58%, trace and nil viability respectively.

Seeds can be dispersed by birds and by sheep and other grazing animals (Turkington & Cavers, 1979). Seeds can float in water for up to 5 days. Seeds submerged in water for up to 9 months gave only 1-2% germination (Comes *et al.*, 1978).

Management

Control is by good surface cultivations and hoeing out the plant to prevent seeding (Morse & Palmer, 1925). In grassland, plants can tolerate frequent mowing but not competition from tall grass (Turkington & Cavers, 1979).

Seed numbers in soil were reduced by 75% after a 1-year fallow and by over 90% when the fallow was continued for a second year (Brenchley & Warington, 1933). The land was ploughed, disked and harrowed during the fallow period. Seed numbers in soil under cropping with winter wheat for the same period increased in year one then returned to the original level in year two. Fallowing at 5 year intervals over a 15 year period did not reduce seed numbers in soil (Brenchley & Warington, 1945). Numbers had risen to 158%, 952% and 539% of the original seedbank after the 1st, 2nd and 3rd fallow years respectively. In the intervening cropped years the trailing weed was able to set and shed seeds before and after crop harvest and before any post-harvest cultivations.

In greenhouse tests, corn gluten meal (CGM) applied as a surface and incorporated treatments to soil sown with black medick seed has been shown to reduce plant development (Bingaman & Christians, 1995). Application rates of 324, 649 and 973g per m^2 reduced black medick survival by 49, 63 and 63% respectively. Shoot and root length were reduced by up to 92 and 100% respectively. Corn gluten hydrolysate (CGH), a water soluble material derived from CGM, was found to be more active than CGM when applied to the surface of pots of soil sown with black medick seed (Liu & Christians, 1997). Wheat gluten meal (WGM) at 1 or 3 g.dm^{-2} dusted over seeds put to germinate on moist paper reduced germination by 6% (Gough & Carlstrom, 1999).

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References

Bingaman B R & Christians N E (1995). Greenhouse screening of corn gluten meal as a natural control product for broadleaf and grass weeds. *HortScience* **30** (6), 1256-1259.

Brenchley W E & Warington K (1930). The weed seed population of arable soil. I. Numerical estimation of viable seeds and observations on their natural dormancy. *The Journal of Ecology* **18** (2), 235-272.

Brenchley W E & Warington K (1933). The weed seed population of arable soil. II. Influence of crop, soil and method of cultivation upon the relative abundance of viable seeds. *The Journal of Ecology* **21** (1), 103-127.

Brenchley W E & Warington K (1936). The weed seed population of arable soil. III. The re-establishment of weed species after reduction by fallowing. *The Journal of Ecology* **24** (2), 479-501.

Brenchley W E & Warington K (1945). The influence of periodic fallowing on the prevalence of viable weed seeds in arable soil. *Annals of Applied Biology* **32** (4), 285-296.

Chepil W S (1946). Germination of weed seeds I. Longevity, periodicity of germination and vitality of seeds in cultivated soil. *Scientific Agriculture* **26** (7), 307-346.

Clapham A R, Tutin T G, Moore D M (1987). *Flora of the British Isles*, 3rd edition, Cambridge University Press, Cambridge, UK.

Comes R D, Bruns V F, Kelley A D (1978). Longevity of certain weed and crop seeds in fresh water. *Weed Science* **26** (4), 336-344.

Cross H (1930-33). Laboratory germination of weed seeds. *Proceedings of the Association of Official Seed Analysts of North America* **24**, 125-128

Dale H M, Harrison P J, Thomson G W (1965). Weeds as indicators of physical characteristics in abandoned pastures. *Canadian Journal of Botany* **43**, 1319-1327.

Gough R E & Carlstrom R (1999). Wheat gluten meal inhibits germination and growth of broadleaf and grassy weeds. *HortScience* **34** (2), 269-270.

Grime J P, Hodgson J G, Hunt R (1988). *Comparative Plant Ecology*, Unwin Hyman Ltd, London, UK.

Grime J P, Mason G, Curtis A V, Rodman J, Band S R, Mowforth M A G, Neal A M, Shaw S (1981). A comparative study of germination characteristics in a local flora. *Journal of Ecology* **69**, 1017-1059.

Hanson C G & Mason J L (1985). Bird seed aliens in Britain. *Watsonia* **15**, 237-252.

Kjaer A (1940). Germination of buried and dry stored seeds. I. 1934-1939. *Proceedings of the International Seed Testing Association* **12**, 167-190.

Lewis J (1973). Longevity of crop and weed seeds: survival after 20 years in soil. *Weed Research* **13**, 179-191.

Liu D L & Christians N E (1997). Inhibitory activity of corn gluten hydrolysate on monocotyledonous and dicotyledonous species. *HortScience* **32** (2), 243-245.

Morse R & Palmer R (1925). *British weeds their identification and control*. Ernest Benn Ltd, London, UK.

Ødum S (1974). Seeds in ruderal soils, their longevity and contribution to the flora of disturbed ground in Denmark. *Proceedings of the 12th British Weed Control Conference*, Brighton, UK, 1131-1144.

Ødum S (1978). *Dormant seeds in Danish ruderal soils.* The Royal Vet and Agriculture University, Hørsholm, Denmark.

Reader R J (1993). Control of seedling emergence by ground cover and seed predation in relation to seed size for some old-field species. *Journal of Ecology* **81**, 169-175.

Roberts H A & Boddrell J E (1985). Seed survival and seasonal pattern of seedling emergence in some Leguminosae. *Annals of Applied Biology* **106**, 125-132.

Roberts H A & Feast P M (1970). Seasonal distribution of emergence in some annual weeds. *Experimental Horticulture* **21**, 36-41.

Roberts H A & Feast P M (1973). Emergence and longevity of seeds of annual weeds in cultivated and undisturbed soil. *Journal of Ecology* **10**, 133-143.

Sidhu S S & Cavers P B (1977). Maturity-dormancy relationships in attached and detached seeds of *Medicago lupulina* L. (Black medick). *Botanical Gazette* **138** (2), 174-182.

Stace C (1997). *New Flora of the British Isles*. 2nd edition. Cambridge University Press, Cambridge, UK.

Stebbins G L (1976). Seed and seedling ecology in annual legumes. I. A comparison of seed size and seedling development in some annual species. *Oecologia Plantarum* **11** (4), 321-331.

Stevens O A (1932). The number and weight of seeds produced by weeds. *American Journal of Botany* **19**, 784-794.

Thompson K, Band S R, Hodgson J G (1993). Seed size and shape predict persistence in soil. *Functional Ecology* **7**, 236-241.

Turkington R & Cavers P B (1978). Reproductive strategies and growth patterns in four legumes. *Canadian Journal of Botany* **56** (4), 413-416.

Turkington R & Cavers P B (1979). The biology of Canadian weeds. 33. *Medicago lupulina* L. *Canadian Journal of Plant Sciences* **59**, 99-110.

Wallace J (2001). Black medic: a promising green manure for dryland areas. *Eco-Farm & Garden* **4** (2), 18-19.

Warington K (1936). The effect of constant and fluctuating temperature on the germination of the weed seeds in arable soil. *The Journal of Ecology* **24** (1), 185-204.