Annual Weed Management in Organic Systems

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Why are annual weeds a problem?

Charlock in cereal

- Annual weeds reduce crop yield and quality, delay maturity and hinder harvesting
- They may act as hosts for pests and diseases and can act as a 'green bridge' that maintains a disease when the normal crop host is absent
- However, are weeds really a 'problem'? Plants are only defined as a 'weed' by man and many species have beneficial aspects to offer the farmer - organic weed management is a balance (see page 8)

Where do they come from?

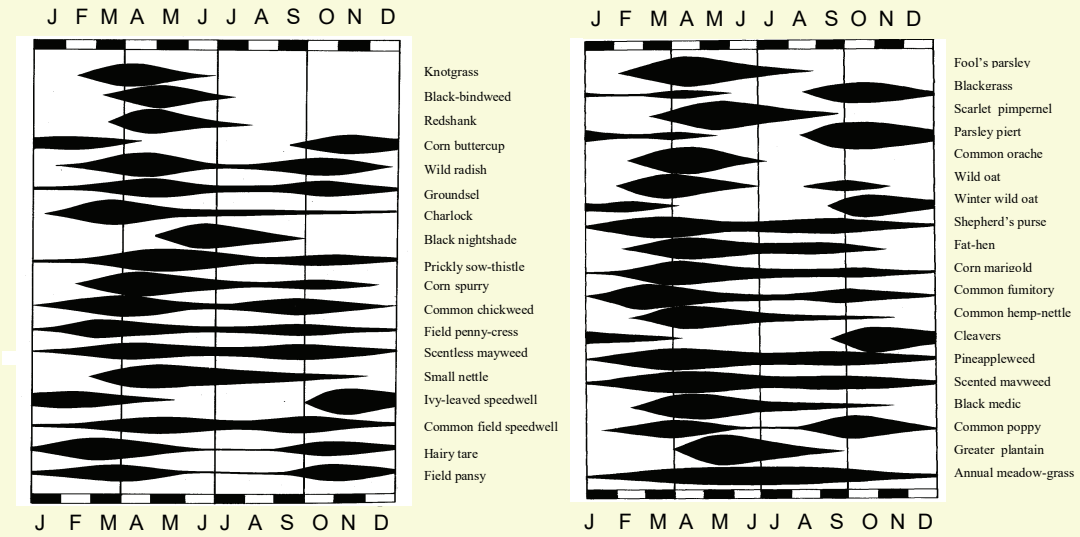
- Annual weeds originate from seed, the majority arise from seeds left in the soil after previous crops
- Cultivated land has an average seedbank of 10 000 seeds/m^2, capable of germinating if conditions are suitable
- The seeds of some weeds are blown in on the wind, dispersed with irrigation water, or carried by animals and spread in their droppings
- A few develop from seeds spread in soil amendments like slurry, farmyard manure and composted green waste. Seed can also be introduced in straw and other organic materials used such as mulches
- Weed seeds lodged on farm machinery can be spread from headlands into the field and from field to field
- Weed seed contamination of crop seed is now less of a problem except with home-saved seed

What is their biology?

- Some species tend to emerge in spring others in the summer and a few in the autumn and early winter, but many common weeds will emerge throughout the year (see the table below of germination times)
- Most seedlings emerge from the top 5 cm of soil, a few will only germinate in the top few mm of soil while weeds with large seeds can emerge from below 10 cm
- Earlier emerging plants grow bigger before flowering and have more seeds. Later emerging plants are smaller having less time to grow before flowering
- Some plants produce seeds with different germination strategies. Most are dormant but others germinate more readily. To break dormancy weed seeds typically require either warm temperatures during the summer (e.g. ivy-leaved speedwell) or winter chilling (e.g. knotgrass)
- Position in the soil profile, soil moisture and temperature are the main determinants of seed germination patterns
- Under normal cropping soils lose 3-6% of the seedbank annually through seedling emergence. Predation, attack by pathogens and micro-organisms and natural ageing also contribute to losses

Germination periods of some common annual weeds

Source: Naylor (2002)



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How can annual weed problems be prevented?

Rotation

- Planning weed management into a rotation is the primary cultural control tool. A rotation should be designed to include annual and perennial crops, spring and winter sown crops, crops with different habits and aim to use different machinery types through its course
- The more exploitative a rotation, i.e. the greater the ratio of cash cropping to fertility building, the more difficult it will be to manage weeds. Simple, extensive systems work best. Systems that include livestock can give more weed management options, e.g. sheep can be very useful to graze newly establishing leys or taking whole crop silage can save a weedy crop
- The crop rotation and duration of the ley should be designed around the farms specific weed problems e.g. wild oats are best controlled with a longer ley period
- The market often influences cropping, for example oats and triticale are good competitors with weeds but their market is limited. Where there are options avoid crops which need to be drilled at the same time as problem weed flushes e.g. black nightshade may hamper maize and pea growth
- For any system, planning, organisation and having a range of options available are the key to success

Fertility building

- A ley phase will help suppress weed emergence and give control of some weeds e.g. black grass
- Short-term green manures will cover the land and prevent weed growth, others such as rye will reduce the subsequent germination of weeds
- Undersowing with a low growing species, possibly leguminous, can prevent weed germination

Mowing a grass/clover ley

Transplanting sweetcorn

Variety choice and spacing

- Variety choice can be important, ideally use rapidly emerging, vigorous varieties with dense foliage or good height to cover and shade the soil surface
- Crops can be sown more densely in rows or transplanted closer together to stop weeds emerging
- Spacing can be altered to allow mechanical weeders to work more effectively
- Some species/varieties seem able to suppress weeds allelopathically and may be useful in the future once the process is better understood (see our leaflet on allelopathy)

Advancing the crop

- A competitive crop is very important; ensure optimum soil nutrients and avoid compaction to give good growing conditions
- It is useful to advance the crop as far forward as possible compared with the weeds so it is at a later growth stage when weeded
- Later spring sowings and plantings can establish quicker and compete better than early ones
- Ideally keep soil disturbance to a minimum during seedbed preparation, weed seedling numbers are related to the depth and frequency of cultivations
- Methods to advance the crop include; transplanting, using primed seed, thermally removing weeds that have emerged before the crop, 'blind' weeding (typically performed with a harrow through cereals) or flushing out weeds with a stale seedbed technique
- A weed strike or stale seedbed can be achieved by preparing the land 2-4 weeks before planting. If there is sufficient moisture this cultivation will stimulate the first, and worst flush of weeds from the soil. These can be removed by a shallow cultivation prior to planting or with a flame weeder
- A glass plate or plastic sheet laid on drilled rows will cause the crop to germinate a little time ahead of the rest of the field allowing a flaming operation to be performed just before crop emergence

A plastic sheet laid over a parsnip bed

A cabbage transplant grown in modular trays

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Use of livestock for weed management

- A mixed system will be able to make use of livestock in the weed management programme
- Sheep can be used to graze establishing leys and permanent pastures and remove annual weeds seedlings, they can also clear weeds after cropping of, for example brassicas
- Light grazing of cereals can encourage tillering and hence a more competitive crop
- Goats will eat most weeds (and crops)
- Pigs, if managed carefully can help control annual as well as perennial weeds
- Geese can be useful to control grass weeds e.g. in orchards

Sheep grazing a ley

Mulches

- Mulches provide a physical barrier over the soil through which light cannot penetrate, preventing germination. These can be sheeted, particle or living

Lettuce grown through black plastic

- **Sheeted mulches** are commonly used in horticultural systems e.g. the use of black polythene to grow onion transplants. Disposal of these mulches can be costly to the farmer and the environment. Paper or starch based mulches will break down naturally and may be suitable for short term horticultural crops. Sheeted mulches can also be used in the long term to clear vegetation prior to planting a crop or in the short term to prevent weed emergence

Raspberries grown through straw

- **Particle mulches** e.g. straw are common in fruit systems where crops are in the ground for more than one season. Weed control improves with depth of mulch. At least 3 cm of compost is needed to prevent annual weed emergence. Fine green waste compost can be used for baby leaf production
- **Living mulches** are most widely used in arable systems e.g. the undersowing of clover leys in cereals. Crop or cover crop residues can be left to form a mulch for the next crop. They can also aid soil structure, prevent nutrient leaching or help prevent pest attack. Management may be needed to prevent competition and hence yield loss of the cash crop. They can also be suitable for tall growing vegetable crops such as sweetcorn or runner beans
- The high cost of mulches means that they are only economic in high value crops or those in the ground for many seasons

White clover a common living mulch

What can I do in the field before planting the crop?

Tillage

- The most effective way to deplete the soil reserves is to stimulate weed emergence and then remove seedlings by mechanical or thermal means
- Cultivation typically causes around 10% of the seedbank to germinate, these weeds need to be killed before they get a chance to set seed
- Most farming systems in the UK are tillage based, i.e. operate some method of turning or cultivating the soil
- The plough is the most effective and widely used machine for weed control
    - It will bury and kill established weeds on the surface
    - Shed weed seeds can buried to a depth below which they are unable to germinate
    - Soil which tends to have a lower number of viable weed seeds is brought up

Ploughing in cereal stubble

- Disadvantages of ploughing include soil compaction issues and potentially enhancing dormancy in some species (e.g. wild oats)
- Some farmers are trying minimum tillage i.e. not inverting the top 20 cm's of soil, these systems have specific weed issues associated and are the topic of another leaflet in this series

What are the direct control options once the crop has been planted?

- The main methods used to kill weeds are by cutting, uprooting or burial. Stripping of leaves can also be fatal in annual weeds. When weeds are small (cotyledon-4 true leaves), burial is extremely effective on all annual weeds.
- If weeds have grown larger, their habit will be important in determining which machinery is best for removal (see below)
- Adjustment of machinery to specific field conditions can be more important than choice of weeder. A fine flat seedbed and straight crop rows will help weeding operations
- Soil conditions during weeding will affect efficacy, hard dry soil will be difficult to penetrate or weeds will remain alive in lifted clods. Wet soil will encourage weed survival
- Weather conditions after weeding are critical, the drier it is, the greater the weed kill

What are the common annual weed types?

- Annuals are commonly grouped by when they germinate, here we are referring to their habit which will influence the most appropriate control methods

Fat-hen seedlings

Tap rooted weeds

- Examples of these are fat hen, poppy, redshank, shepherd's purse and mayweed. Slicing through the main tap-root is a very effective removal technique if the weeds have become established. Any kind of hoe will be appropriate

Fibrous rooted weeds

- Examples of these are chickweed, cleavers and speedwells. Even if weeds are not removed at a small size then the prostrate habit of their foliage can be used to aid removal as it easily catches on weeding implements, particularly something like a harrow comb

Cleavers flowering

Wild oats in vetch

Grass weeds

- Examples of these are annual meadow grass, wild oats, black grass and barren brome. These can be the most difficult annual weeds to control. They have the advantage of a basal growing points, which can re-grow vigorously if leaves are lost and a strong anchorage system difficult to remove mechanically or manually. They are best controlled at very early growth stages by burying, for example with a harrow comb

To weed or not to weed?

- Every farmer has to make the decision whether or not to weed in each crop they grow. Knowledge of the weed flora, the crop being grown and previous weed management experience will help find the answers
- Four basic questions to ask are;
    1) Is weeding necessary? Is the population of weeds such that they will cause a loss of crop yield or the seed shed from mature weeds will cause problems in the future? (see References on page 8)
    2) If so, when is weeding needed? (see Timing below)
    3) Where are the weeds? Does the whole field need work, or are the weeds between the rows, in the rows or in patches?
    4) Finally which method of control is appropriate? Mechanical, thermal, manual or a combination of approaches (see pages 5-7)

How many cornflowers can wheat tolerate before they affect yield?

Timing

- If soil conditions allow, annual weed control is most effective when recently germinated weed seedlings are at the 'white thread' stage before emergence. Very light harrowing in dry conditions readily kills the seedlings
- Crops can often tolerate weeds for the first few weeks, competition for resources (mainly light) and hence yield losses will begin when resources become limiting
- The aim is to wait and let as many weeds germinate as possible but remove them before they have any effect on the crop, generally this is around 4 weeks after crop emergence

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Mechanical weeding options

- There is a range of machinery available that can be divided into 3 categories depending on where in the crop it is designed to operate; broad-spectrum, inter-row or intra-row

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Broad-spectrum

A comb harrow going through beans

- Weeding action is across the whole width of the machine, examples of these are, spring or flexi tines, chain or drag harrows, mowers or toppers
- **Spring or flexi tines** are coiled loop or spring mounted tines of 6-8 mm diameter mounted on bars. The aggressiveness of the weeding action can be adjusted and tines can be raised to allow weeding between crop rows. Wide usage including cereals, beans, maize, some horticultural crops. Works best on small broad leaved annuals
- **Chain or drag harrows** have a more rigid construction with steel spikes that stir the soil. They are commonly used for knocking down potato ridges and can be more damaging to the crop than flexi tines
- A general purpose **topper** can be used to control tall weeds in a short crop, e.g. fat hen in beetroot or fodder brassicas. Home built toppers with weed seed collectors have been used successfully to prevent wild oats dropping seeds in cereal crops

Inter-row

- There are many types of machine designed to work between the crop rows. Some are static others are powered. Costs vary widely from second-hand hoes or scuffles purchased at farm sales to large precision guided inter-row hoes. Machines can be front or rear mounted and can have a second operator to steer closer to the crop rows. Row protectors can be fitted to protect the crop from damage, these can be removed when the crop is better established to allow some soil to be thrown into the crop row and bury weed seedlings

Steerage hoe through onions

- There are various designs of **hoe** (sweep) blades to work between the crop rows. Common types are 'A' or 'L' shaped in plan view
  - Blades are often attached to the machine via a spring tine to allow independent movement

A powered rotary hoe

- The **powered rotary hoe** is PTO driven and has rotating 'L' shaped blades on a horizontal axis
  - This is a more aggressive weeding action and can deal with larger weeds but is more damaging to the soil

- **Brush weeders** have a series of rotating polypropylene brushes that are PTO driven, the most common ones rotate on a horizontal axis
  - Best used in friable soil conditions, can cope with wetter soil than hoes
  - Narrow crop protection tunnels (6 cm) allow work very close to the crop rows
  - Mainly used on horticultural holdings

Eight row brush weeder going through carrots

- **Cage (or basket) weeders** are a non-powered inter-row cultivator
  - The machine has two horizontal axis on which rotating baskets are mounted
  - These are fairly cheap machines but require a flat working bed and small weed sizes to be effective
  - Mainly used on horticultural holdings

A cage weeder

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Inter-row (continued)

Rotary cultivator on potato ridges

- **Rotary cultivator** (star/spider hoe) can be used across the whole soil surface, but more commonly adjusted between the crop rows in the UK
  - Ground-driven with an aggressive weeding action and fast working speed
  - Works best on light stone-free soil
  - Main use in large scale arable crops, e.g. maize or soyabeans

Close-up of a precision-guided 24 m hoe

- **Automatic vision-guided systems** are now replacing the manual second operator steerage systems
  - A higher speed for longer time periods, with a greater soil area worked (around 80% of the bed) can be achieved
  - Soil throw with speed can be a problem and machines are expensive
  - Can be used in any row crop

Intra-row

- Machinery is now available to work in the crop row

Finger weeder in leeks

Close–up of one head

- **Finger weeders**, ground driven rotating discs of rubber finger-like protrusions angled down and placed either side of the row
  - These can uproot small weeds in the crop row
  - The intensity of work can be varied by altering the distance between the two discs
  - It is essential that there is a difference between crop and weed size

Close-up of tines

- **Torsion weeders**, two spring tines angled downwards and backwards to the crop row vibrate around the crop uprooting and burying small weeds
- Again position of tines can be altered depending on the level of aggression required
- Both machines are mainly used in horticultural systems

A front mounted torsion weeder

Summary of mechanical weeding equipment commercially available

Device	Speed (km h^{-1})	Depth (mm)	Mode of action	Weed size (mm)	Inter-row effect	Intra-row effect
Basket weeder	8	25	Uprooting/scrubbing	<20	Y	
Brush weeder	<3.5	15-45	Uprooting/burial	<50	Y	Y
Ducksfoot	6	20-40	Uprooting/burial/cutting	Large	Y	
Harrow	7	20-30	Uprooting/burial	<50	Y	Y
Hoe ridger	7	25-40	Uprooting/burial/cutting	Large	Y	Y
Finger weeder	10	12-19	Uprooting	<25		Y
Powered rotary	6	120	Uprooting/burial/cutting	<150	Y	
Split hoe	3	50	Uprooting/burial	<50	Y	
Subsurface tiller	8	100	Cutting	Large	Y	
Sweep	6	20-40	Uprooting/burial/cutting	Large	Y	
Torsion weeder	<10	25	Uprooting/burial			Y

Source: Welsh *et al*, (2002)

Thermal

- Two main types of thermal weeder are available, the **flame weeder** and the **infra-red burner**
- The flame weeder applies heat directly to the soil surface, usually from the combustion of LPG, the infra-red burner heats a metal/ceramic surface which then radiates that heat towards the ground
- An intense wave of heat cause plant cells to boil, burst and desiccate
- The temperature must reach 100°C for about one tenth of a second
- Weed seedlings of some species will be easily killed whereas others are more tolerant
- Waxy leaves, creeping habit and protected growing points give plants such as annual meadow grass or shepherd's purse some tolerance

Flame weeder

Infra-red burner

- Thermal weeders are multipurpose tools, they can be used; to prepare a stale seedbed, pre-emergence in slow germinating crops, post-emergence broad-spectrum in tolerant crops and selectively post-emergence between row crops or in patches
- Choice of machine will depend on the size of operation, type of cropping and capital available

Manual

- **Hand weeding** in high value crops is still economically viable and essential for crops such as bunching carrots or baby leaf salads which have a zero weed tolerance at harvest
- **Rogueing** mature plants present in low numbers is recommended to prevent seed shedding and keep seedbank levels low in all systems
- On horticultural holdings **flat bed machines** which attach to the back of the tractor are used. These typically hold 4-8 people who lie prostrate to the ground and weed specifically in the crop row. These machines often follow an inter-row hoe so the entire area is covered with the minimum possible area hand weeded

Six person flat bed weeder

- **Hand held hoes** with different designs for specific crops are available, although there has been little research in the UK into the design and efficacy of hand held implements for a commercial scale
    - Wheeled or push hoes are useful for small scale horticultural enterprises

Wheel hoe

- Managing and sourcing labour for hand weeding can be difficult
    - Farmers are increasingly sourcing labour from expanded Europe and beyond using the Seasonal Agricultural Workers Scheme (SAWS)
    - Larger farms could benefit from recruiting harvest managers to oversee labour
    - On a smaller scale World Wide Opportunities on Organic Farms 'WWOOF' can be a useful source of labour

Post harvest options

- The most practical step to reduce future annual weed problems is to stop weeds seeding. Weed seed collected at cereal harvest should be retained and denatured rather than dropped back on the field
- Post harvest operations to reduce the spread of weed seeds depend on the weed species involved. For example shed oil seed rape should be left on the soil surface to germinate while barren brome should be buried as soon as possible to prevent it becoming dormant
- Weed seeds left over winter will provide food for seed eating birds

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Biodiversity benefits of weeds

- In organic systems weed management rather than complete control is always the aim
- At low densities weeds can provide many benefits for the farmer
    - They can help conserve soil moisture and prevent soil erosion
    - A ground cover of weeds can reduce leaching of nutrients, particularly nitrogen
    - Weeds can provide shelter for natural enemies of pests or even act as alternative food sources or decoys for crop pests
    - Weeds provide food for many seed-eating birds e.g. knotgrass or fat hen
    - Weeds also host a number of useful insects e.g. groundsel
    - Certain weeds can be indicators of growing conditions in a field, for example corn spurrey can

Most organic farmers would be happy to see this Yellow rattle in red clover

References and useful reading

- Bowman G (1997). Steel in the field: a farmer's guide to weed management tools. Sustainable Agriculture Network Handbook Series Book 2. National Agricultural Library, Beltsville, Maryland 20705-2351
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- Welsh JP, Tillet N, Home M, King JA (2002). A review of knowledge inter-row hoeing and its associated agronomy in organic cereal and pulse crops. DEFRA project OF0312.
- Mechanical weeding in organic arable production systems. Opico Ltd, South Road, Bourne, Lincolnshire, PE10 9LG
- Rothamsted Research website 'Weeds or wild plants?' http://www.rothamsted.bbsrc.ac.uk/pie/PeterGrp/bcpc/bcpc1.htm

For further information on weed management go to www.gardenorganic.org.uk/weed-management. There you will find the following:

- Advice on over 130 individual weeds, from Black Grass to Yarrow www.gardenorganic.org.uk/weeds-list
- Advice on cultivation controls, such as crop rotation, tillage and hygiene www.gardenorganic.org.uk/cultural-weed-controls
- Direct control methods, such as mulching and mechanical control www.gardenorganic.org.uk/direct-weed-controls
- Crop weeding strategies, in field vegetables, fruits and grasslands www.gardenorganic.org.uk/crop-weed-management-strategies
- Further reading in research papers.

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the national charity for organic growing

Formerly HDRA.

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