Weed Management Outline for Beet Crops

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These outlines are intended to give an overview of non-chemical weed control opportunities and developments in beet crops. These include historical information and summaries of more recent research. Although many aspects of crop production that have some bearing on weed control may be covered here, the outlines are not meant to form a crop management protocol as such. The outlines will be regularly updated as further information from publications or grower experience is received. Further reading and references are given to allow the reader to follow up any items that are of particular interest.

Beet crops

Three cultural types of *Beta vulgaris* are commonly grown in the UK for their roots:

Sugar beet grown as a field crop, for the high sucrose content of its roots. After sugar extraction, the by-products (molasses and pulp) may be used for raw or processed animal feed, or as fertilizer. Foliage may be used as fodder.

Fodder beet grown as a field crop for its roots and foliage for animal consumption.

Beetroot, red or table beet grown as a vegetable crop outdoors or under protected conditions for the edible roots.

Sugar beet

Sugar beet is a biennial grown as an annual crop in the UK and northern and central Europe. The crop is sown usually in March or April, but sometimes from February to early May. Sugar beet should be grown under good cultural conditions and within an appropriate crop rotation, ideally with 3-4 years between beet crops. In conventional farming rotations this usually includes potatoes and cereals. Production aims at ensuring a good qualitative and quantitative yield of roots. In the past, beet seeds were sown in their natural multi-seeded clusters (polygerm seed) and were later thinned to a stand. The extra seedlings were used to replace those that were destroyed by soil pests or early thinning. Currently, crops are grown mainly from pelleted ‘monogerm’ seed, which is drilled at the desired final spacing. Any seedling subsequently destroyed leads therefore to a missing plant, with consequent yield loss.

Sugar beet will grow on a range of soils but good structure is important to allow rooting to 1 metre depth. Conventional primary and secondary cultivations are used for crop establishment and to remove weeds. The land is ploughed in autumn and allowed to settle naturally during the winter with the frost helping to produce the fine, firm, moist tilth that is required. Spring cultivations are kept to a minimum to prevent moisture loss. Sugar beet usually follows a grass/legume leys or a cereal in the rotation and precedes a cereal or some other crop that will benefit from the residues of any manure application. Sufficient nitrogen from manure or compost application is

important to ensure rapid the leaf development that will provide a dense leaf canopy and shade out the weeds.

Survey data show that over 90% of sugar beet crops follow a winter or spring sown cereal (Allison *et al.*, 1996). The data also reveal that 50% of the crops are grown on sandy or sandy loam soils with low water holding capacity. During the winter prior to sowing, the land could benefit from an autumn sown cover crop established after cereal harvest. Cover crops evaluated for this have included barley, rye, phacelia, mustard, oil radish, fodder radish, buckwheat as well as naturally regenerated mixtures of volunteer cereals and weeds. The cover crops may be broadcast over the stubble and lightly incorporated or drilled following a shallow cultivation. The sowing date will depend on the time of cereal harvest but establishment during August ensures a better ground cover over winter. Trefoil (*Medicago lupulina*) or ryegrass undersown in barley, or fodder radish broadcast after barley have been investigated as green manures grown before sugar beet (Last *et al.*, 1981). The green manures decreased the requirement for nitrogen fertilizer before sowing the crop and were particularly beneficial on very light soils.

The recommended good practice is to plough the soil then apply other methods of soil preparation, depending on the soil type and time of the year. The aim is to remove remnants of the preceding crop, destroy the weed population present and prepare a seedbed in optimal condition. Beet is normally grown in rows that allow mechanical weeding well after emergence of the crop. Sugar beet is slow to emerge and weeds may obscure the position of the crop rows. Improved inter- and intra-row mechanical weeding methods are being developed and superior guidance systems have become available that ensure more accurate steering along the crop row.

The primary and secondary cultivations required for seedbed preparation will have a considerable influence on the weeds. However, the nature and timing of these cultivations will vary with the previous crop, with soil type and with soil condition at the time of any operation. In general a level crumbly seedbed will give the crop the best start but growers may want to keep cultivations to a minimum. Weeds tend to emerge better and in greater numbers from a fine seedbed than a coarse one, but control measures are often more effective on a fine level seedbed.

In addition to being grown as an annual crop for their roots, sugar beet is also raised as a seed crop. Sugar beet grown as a seed crop occupies the land for up to 18 months (Budd *et al.*, 1982). In the second year, weed control is vital to prevent contamination of the seed crop with pollen from annual or weed beet. Early bolting plants should be removed along with any beet plants outside the drilled row to avoid possible contamination. Ripe seed shed by the mature crop before or during harvesting may exacerbate future volunteer beet problems. The seed is able to persist in soil for up to 15 years in some circumstances.

Weed control

The farmer should be familiar with the main weeds and monitor his fields regularly. The control of weeds, both annual and perennial, is of paramount importance in beet because the crop establishes in cool conditions, the plants are widely spaced and the leaf canopy takes time to develop (Scott & Wilcockson, 1976). However, leaf production by beet continues throughout the growing season and the crop is capable

of some recovery from an early check due to weeds. Crop emergence is protracted and can take 40-50 days. It will take longer if crops are sown too early and emerging seedlings may not thrive or may bolt and leave gaps in the row. It is important to achieve a good crop stand, as it is the dense leaf canopy that shades out emerged weeds and inhibits later flushes of seedling weeds. The weeds will exploit any gaps in the crop. The crop canopy does not close fully until mid-summer and tall growing weeds such as fat-hen and certain mayweeds may grow above the canopy before it closes. Sugar beet cultivars vary in their growth habit, some have an erect leaf rosette (cv. Carla) others have a more horizontal leaf arrangement (cv. Lucy) (Lotz et al., 1991). Weed seedling survival can be much less with the latter, demonstrating the importance of early ground cover establishment.

A stale seedbed may be prepared 10 days in advance of the drilling date and the weeds killed by shallow cultivation before drilling (Parker, 195-). There is a risk of the seedbed drying out resulting in erratic germination when the crop is sown. Light harrows may be used after drilling either on the flat or to level the ridges due to drilling, but this may reduce plant stand. Mechanical inter-row cultivation is important in early control of weeds. However, cultivation stimulates further weed seedlings to emerge. Using laser-guided implements to limit seedbed preparation to the narrow area of row due to be drilled and leave the inter-rows uncultivated has given little advantage in terms of reduced weed emergence (Van Zuydam *et al*., 1995). Also, when the inter-row was eventually hoed, the soil broke into clods that became lodged among the crop seedlings. Seedbed preparation in the dark made little difference to weed numbers, however, inter-row hoeing in darkness stimulated fewer new seedlings to emerge.

The important period for weed control is during the eight weeks after crop emergence and before the crop canopy develops. In the UK, the optimum weeding period is between 4 and 6 weeks after 50% crop emergence (Turner *et al*., 1999). The timing depends on crop sowing date, the weed population and the May/June rainfall (Scott & Wilcockson, 1976). In practice, weeding operations should commence at the 4-6 leaf stage and may cease at around the 10-12 leaf stage. Once the optimum weeding time has been reached yield may be depressed by 1.5% for each day the crop is left unweeded, although sugar beet has some ability to recover from an early check. In field experiments in Italy, the optimum period for weed removal varied between 48 and 60 days after crop emergence (Montemurro et al., 1999). Crop losses where weeds were not controlled ranged from 95% where tall weeds such as fat-hen (*C. album*) predominated to 50% when the lower growing chickweed (*Stellaria media*) and scentless mayweed (*T. inodorum*) were dominant (Scott *et al.*, 1979). For late March/early April sowings the optimum time for weed removal was between 4 and 6 weeks after crop emergence depending on prevailing conditions. In a late-sown crop with short weed species at low density, a single weeding at anytime between 2 and 8 weeks after crop emergence may be sufficient to avoid yield loss.

In Finland, weeds in sugar beet exhibit two peaks of emergence, the first in late May-early June the second in late June-early July (Erviö, 1981). Annual meadow-grass was the most frequent grass weed present in conventional sugar beet crops surveyed in East Anglia in autumn 1998 (Lainsbury *et al.*, 1998). Feral oilseed rape and groundkeeper potatoes are problem volunteer weeds (May, 1996). The perennial weed creeping thistle occurs in 40% of beet fields. Fat-hen (*Chenopodium album*),

scentless mayweed (*Tripleurospermum inodorum*) and knotgrass (*Polygonum* aviculare) are three annual broad-leaved weed species that often predominate in sugar beet crops. Fat-hen (*C. album*) exerts a competitive effect by shading the crop and when present at the same density as the crop reduced yield by around 40% (Longden, 1989). A fat-hen population of 23 plants/ha can reduce yields by over 95% (May, 1996). Models have been developed for the population dynamics of fat-hen in a sugar beet (Freckleton & Watkinson, 1998; Watkinson & Freckleton, 2001). They are based on existing published data and are intended to be used to demonstrate the effect of a change in the level of crop and weed density, weed fecundity, seedling emergence and mortality, and seed persistence in the soil seedbank, and how this relates to weed management. Spring temperatures and rainfall are important in determining the emergence of fat-hen but weather conditions during the main period of crop growth have little impact on the weed.

Weed beets are a particular weed problem and may occur in 25% or more of sugar beet fields. A density of one weed beet per m^2 can reduce sugar beet yield by up to 15% (Longden, 1989). They differ from the normally biennial sugar beet by flowering in the first year and setting seed without producing a storage root. They may result from seed shed by ordinary bolters in a previous beet crop, by sugar beet groundkeepers growing in other crops or by feral weed beet. The seedlings are identical to sown beet. The introduction of weed beet in contaminated crop seed should be avoided. Seed shedding by weed beet and crop bolters must be prevented by removing whole plants or cutting off the flower spike. Cutting may need to begin in July to catch the first bolters and be repeated 3 weeks later and possibly again in September. Bolters and other tall weeds may be cut back in late summer, before seeding, using a flail cutter or mower. Groundkeeper beet and weed beet should be controlled in other crops in the rotation, and in field margins and elsewhere on the farm. If seed is shed, it is best to leave it on the surface for as long as possible to encourage germination, and predation. Minimal cultivation after seed shedding is preferable to ploughing to avoid deep burial, and hence long-term persistence of the seed.

Spring-tine weeders can be effective in sugar beet at low weed densities when the soil is drying and weeds are unlikely to re-root (Penny, 1994). The tines work at a shallow depth. If conditions are too wet soil clings to the tines and weeds can re-root. Weeds must be small, perennial or established tap rooted weeds like weed beet are not controlled. The crop must have at least 6-leaves to withstand the tine weeder but must not be so large that the leaves catch on the tines and pull the crop out. Tine weeders can be run at right angles to the crop rows as well as parallel with them. Some damage is done to the crop but it recovers rapidly.

Inter-row cultivation is an established technique in sugar beet, and the crops are usually tractor hoed at least once, often to control weed beet (Wiltshire et al., 2003). Intra-row weeds are more difficult to deal with. Using a computer-vision guided hoe it is possible to get in closer to the crop row. In addition, soil flow from the cultivation can provide some within-row weed control due to soil covering. The hoe has been used at the 2 to 10-leaf crop stages but at early stages side guards are needed to prevent excessive soil throw covering the crop. The hoe did not reduce crop vigour or cause plant or yield loss.

Even with guidance systems there is a limit to how close a hoe can get to the crop row. A torsion weeder attached to an ordinary hoe can improve weed control in the row (Hallefält *et al*., 1998). The torsion weeder at low intensity has proved to be relatively gentle on the sugar beet crop from the 4–leaf stage. Altering the distance between the tines and increasing the driving speed to give higher intensity weeding caused more damage to the crop but gave good weed control. The working depth of the tines was 1-2 cm. Dry weather is required before and after cultivation, and weeds must be smaller than the crop.

In tests of intra-row weeding, the Einbock spring-tine harrow was used at the 0-2, 6-8 and 8-12 leaf stages of the crop (Ascard & Bellinder, 1996). Cultivations were made at 3 km/hr at a depth of 0-4 cm or at 6 km/hr at a depth of 2-4 cm. The crop was cultivated between the rows twice. Early cultivations caused severe damage. At later crop stages, plant stand was not significantly reduced but some larger beet were uprooted by the tines. Treatments reduced weed numbers and weed weight by 44% and 3% respectively at low speed and by 80 and 47% respectively at high speed. Accurate steerage was important.

Intra-row brush weeding with brushes on a vertical axis did not reduce beet yield or cause any visible damage (Fogelberg & Johansson, 1993). The driving speeds used were 0.5 to 3.0 km/h, the working depth was 1.5 cm and the brushes rotated backwards. The sugar beets had about 18 leaves and were 20-25 cm high.

The effectiveness of direct weed control operations depends in part on the density and size of the weeds. The fewer the weeds and usually, but not always, the smaller the weeds the better the level of control. It is important to keep weeds at a manageable level using a mixture of indirect control strategies and ‘good housekeeping’. It may be possible to adapt weed detection systems developed for limiting herbicide use through patch spraying of weeds to identify areas of crop that need more intense weed management. One method uses online digital image analysis and global positioning systems (GPS) to identify weed patches (Gerhards & Christensen, 2003).

Among the more unusual weed control techniques evaluated is an electric discharge system to kill tall growing weeds in sugar beet (Wilson & Anderson, 1981). An electrical charge vaporises the plant sap causing considerable tissue damage. Some weeds are more susceptible than others. The system has achieved 30-50% control of the weeds after up to 3 treatments with only minor damage to the sugar beet leaves. It is unlikely that however that the system will ever be commercially available due to safety issues.

It has been reported that the growing beet crop excretes a substance that inhibits the germination of corncockle seeds (Evenari, 1949).

Beetroot, Red beet, Table beet

Beetroot can be grown on most soils but quality is better on sandy and heath soils. Harvesting is easier on soils that do not cling to the crop at lifting. Excessively dry soils should be avoided, as germination may be erratic. The pH value of soil should not exceed 7.0 otherwise manganese deficiency may occur. Beetroot responds well to

potash but is susceptible to boron deficiency. Beetroot usually follows a cereal or another vegetable crop in the rotation. It should be grown only 1 year in 4 to help in controlling pests, diseases and weeds, and not within 2 years of land being ploughed out from grass to avoid wireworm damage.

Beetroot is generally drilled from late-April to early-July, the main crop is drilled in mid-May. Harvesting takes place from August onwards, however, beetroot is often not harvested till October-November. Early beet for bunching is drilled in late-March or sown in modules in late-February in a heated greenhouse for subsequent transplanting at the 2-leaf stage. The modules are multi-seeded, the aim being to achieve 5 seedlings per block. Bolting resistant cultivars are required for early sowings. Plastic covers may be used to protect early crops from late-March until late-April.

The average yield is 30-37 tonnes/ha but could be higher if uniformity of roots could be improved. Within any chosen sowing density, much of the variation in root size at harvest is due to the spread of seedling emergence (Benjamin, 1987). Drilling and growing the crop under uniform and optimum conditions will reduce variation and increase the marketable yield. Crop plant spacing depends on market requirements. Higher density sowings produce small beet suitable for bottling. For the fresh market, row spacing may be 45 cm with 50-70 plants per running metre giving 30-40 marketable roots at harvest. Seed within the row may be scattered in a 4-5 cm band at drilling. Seed is in multi-germ clusters but rubbed seed is available. Rubbing of seed clusters reduces both seed numbers in the cluster and the natural inhibitor in the corky tissue. Cultivars may be flat, long, globular or cylindrical. Globe is the main shape grown for processing and fresh market. At harvest the beet may be machine pulled with the leaves intact, or topped and lifted with a potato lifter.

Weed control

Conventional primary and secondary cultivations are used to establish the crop. Land should be free of perennial weeds. False or stale seedbeds will reduce weed numbers in the growing crop. As with sugar beet, once the crop has emerged, regular inter-row cultivations with brush weeders, ridgers, steerage hoes, finger-tines etc will deal with weeds between the rows. There will be some effect on intra-row weeds but hand weeding may be required.

The presence of weeds for up to 4 weeks after 50% crop emergence did not affect crop yield if the crop was subsequently weed-free (Hewson & Roberts, 1973). Conversely it was only necessary to keep the crop weeded for 2-4 weeks after 50% crop emergence. Hence the optimum time for weed removal is around 3-4 weeks after 50% crop emergence (Turner *et al.*, 1999). Once the weeds have been removed the crop has some capacity for recovery from a check to growth due to the weeds.

Fodder Beet

Fodder beet may be drilled or broadcast.

Weed control

Punch planting makes use of the stale seedbed technique but minimises soil disturbance even further by dropping the seed into holes made by a dibber

(Rasmussen, 2003). After autumn ploughing the area is harrowed in April just before sowing and worked down again to achieve a fine tilth, if this is required. Delayed sowing extends the stale seedbed effect. Forage beet seed was dropped into the holes and left uncovered. The area was flame weeded just before crop emergence. The crop was tractor hoed several times leaving a 10 cm untilled strip along the crop rows. The technique reduced weed density by 30% compared with a normal drilled crop.

In fodder beet, pre-emergence flaming reduced weed numbers by 34 to 44 % (Nemming, 1993). However, in relatively low value arable crops such as fodder beet that are grown on a large scale the cost of flame weeding may not be justified.

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