Minimum tillage

SAC

Technical Note

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Key points to success with minimum tillage are:

- Minimum tillage is not an easy option, it demands commitment, time and patience.
- Assess the experience of others in your area before starting on minimum tillage.
- Drier and more stable structured soils are best suited to minimum tillage.
- Aim to operate one main system to reduce costs but be prepared to be flexible throughout – it may be necessary to change the tillage system or even cropping at short notice.
- Consider sharing with neighbours or contracting in labour and machinery.
- Ensure that machinery is available and used properly, with minimum compaction, particularly at harvest.
- Pay special attention to soil conditions and grass weeds.
- Visit SAC demonstrations comparing minimum tillage with ploughing.

The information provided in this note is based on research and on experience of a wide range of specialists within SAC. Further advice and ideas based on future experience with minimum tillage are likely to be forthcoming. This technical note was funded by SEERAD as part of a minimum tillage campaign in the crop health advisory activity and as part of an advisory activity on land uses that impact on soil quality and protection.

Interest in non-ploughing tillage systems has increased in Europe because of the need to reduce costs, to establish winter crops timeously and because of perceived environmental benefits. However, the main objective of the use of non-ploughing tillage is to reduce the costs of production whilst maintaining or increasing yields. Reduced costs take the form of savings of time and machinery. Thus there should be fewer or faster cultivation passes at a shallower depth than under normal ploughing, giving a **minimum tillage** system. Alternatively, cultivations can be avoided altogether by **direct drilling**. Environmental benefits of these systems include reductions in soil erosion, nitrate leaching and fuel use, increased soil organic matter and improved soil structure. Interest in minimum tillage has been heightened in England by the publication of detailed guidelines by the Soil Management Initiative[1]. However, these guidelines are not necessarily applicable in Scotland where the higher proportion of spring barley, the greater use of rotational cropping, the smaller scale of farm enterprise and the wetter climate can mitigate against the success of minimum tillage or direct drilling. The objective of this note is to identify opportunities for use of minimum tillage and direct drilling in Scotland and to make suggestions for their successful application with minimum risk.

Winter barley establishment after direct drilling

Opportunities for different scales of enterprise

Experience has shown that the use of minimum tillage is generally more reliable than direct drilling mainly because it allows for better broad-leaved weed control and clearing the surface of straw and wheel ruts. Most of the emphasis of this note is thus on minimum tillage. Minimum tillage can be used either as the main system on a farm or on an opportunistic basis. As a main system it tends to be

more successful on larger farms, particularly those with a high proportion of winter cereals and oilseed rape. Rotation of crops, however, helps by providing opportunities for weed control. Large farms can bear the costs of the equipment required to make the best use of labour and reduced cultivation techniques. Smaller farms are more likely to use reduced tillage on an opportunistic basis (i.e. for just one or two crops in the rotation as the opportunity arises) using whatever equipment is available[2]. Winter crops have traditionally been more favourable for minimum tillage than spring because seedbed quality is less important and because the faster work rate is more relevant than for spring crops. The most suitable crops are:

1) Winter wheat after potatoes – where the land is loose, weed free and not compacted or rutted by wheeling during the potato harvest.

2) Winter wheat after winter oilseed rape – where quick establishment is vital and weeds are readily controlled.

3) Winter oilseed rape after winter barley – where quick establishment is vital and weeds are readily controlled.

4) Winter wheat after peas – where quick establishment is vital, weeds are readily controlled and where the land should be loose.

Reduced tillage can also be used for specific conservation aspects. For example, on land surrounding sources of fresh water, the risk of soil and phosphorus loss due to erosion can be decreased by the use of minimum tillage. This is important on sloping land where runoff can pose a pollution hazard[3]. It is important to bury phosphorus fertiliser in this situation. Erodible soils are also compactible so that the use of minimum tillage may require special measures for compaction control (see below).

On very light soils direct drilling can reduce the likelihood of low pHs (<6) and associated magnesium deficiency causing N starvation and delaying the onset of tillering. However, it is important that pH is not too high or manganese deficiency may occur. Also on light soils e.g. in the Inverness district, barley stunt caused by *Rhizoctonia* may be reduced by direct drilling. On very stony soils, where ploughing is time consuming and expensive, machinery wear and tear can be reduced by direct drilling.

In deciding whether to try minimum tillage, careful consideration of the availability of labour and machinery and the possible need to share these is required. These factors, along with soil and weather factors need to be taken into consideration and are outlined below. Also explained below are aspects of weed, disease and pest control which need special consideration with minimum tillage. Overall, **achieving success with minimum tillage demands greater management skill and patience from the farmer and his staff than does plough-based crop establishment.**

Yield and economics

Direct drilled spring barley

Lower cost establishment systems do not justify acceptance of lower yields. Experience throughout the UK has shown that there is no real link between tillage system and crop yield if it is done under appropriate conditions and grass weeds can be controlled. If the site is appropriate and conditions are suitable, then yield under minimum tillage should be no different to that using conventional crop establishment. However, any significant drop in yield with minimum tillage is likely to offset savings in establishment costs, though these are notoriously difficult to estimate. Savings accrued by minimum tillage generally result from the reduction of labour and the greater area capacity for the remaining inputs of labour and fuel. This normally

increases the chances of establishing the crop at the optimum time – the timeliness factor. These benefits can outweigh extra herbicide costs unless grass weeds such as herbicide-resistant black-grass and rye grasses become very serious.

Soil and climate

It is important to till the soil only when it is moist, friable and workable. If the soil is worked when it is too wet and is plastic (when it can be moulded like putty) compaction and smearing damage will result. Timely cultivation is probably more important for minimum tillage than for ploughing because compaction and wheel rut damage can persist closer to the soil surface. For this reason, soils have been classified according to their suitability for minimum tillage and direct drilling[4] using a combination of soil texture and drainage. Climate influences the number of days when the soil is workable and the likelihood of waterlogging of the crop. Weather also has an influence – even well-drained soils can remain unworkable for long periods in a wet year.

Soil structure after long-term direct drilling

Basically, **the drier and more stable-structured soils are then the more suitable they are for minimum tillage.** Although many sandy soils are dry and workable, these can have low structural stability and care has to be taken to avoid compaction damage. However, the flexibility of minimum tillage, particularly in depth of working, means that there is some scope for a reduction in tillage at all sites[2]. The more favourable the site conditions then the shallower the depth of minimum tillage. However, depth of tillage is also determined by the presence of weeds and straw – factors related to the previous crop. The most important aspect of application of minimum tillage, according to the Soil Management Initiative, is timeliness. Correct timing creates a suitable growing medium, incorrect timing gives smearing and compaction. The latter is often not obvious with minimum tillage and is best checked by digging after cultivation to ensure that the soil is friable both above and below the seedbed. Compaction damage can be reduced by using special measures for compaction control (see below). Locating tramlines in the same place every year also helps to minimise the area of soil regularly compacted.

Inevitably the situation will arise where the harvest is wet and the harvest machinery creates ruts and soil damage. In this case it is necessary to be flexible and to till deeper, possibly using the plough, to regain a smooth surface and rectify any compaction. Another difficult situation arises where conditions are waterlogged shortly after drilling in the autumn and the crop survival over winter is poor. In such cases, it may be necessary to re-drill with a spring crop.

Machinery Systems

Management of machinery and traffic starts with the previous crop. **Compaction control** is important, particularly during harvesting because compaction from grain trailer wheels can penetrate to below the proposed depth of cultivation. This may demand that trailers sit on the headlands during emptying of grain or seed, the use of small trailers or that trailers are kept to the tramlines. One advantage of direct drilling or shallow minimum tillage is that tramlines can be located in the same place every year. The other vulnerable period is when recently cultivated

land is wheeled e.g. during sowing. The use of dual or wide tyres and reduction in wheel loading is particularly important at this stage. Where used, low ground pressure tyres should be adjusted to the minimum inflation pressure for the task.

Low ground pressure tyre tracks

Minimum tillage equipment is specialised and expensive. Some machinery and herbicide manufacturers offer complete tillage system 'packages'. Before investing in these, a discussion with your SAC adviser is recommended. Although single pass drill systems are available e.g. Simba Horsch, Vaderstad, some earlier cultivation is often required to allow weed germination and control (stale seedbeds – see below), though time constraints may prevent this. Cultivators are either discs or tines with discs that are preferable for straw burial – though compaction and achieving a level finish can be problems. Choice of cultivator will depend on power requirement, flexibility of use for other purposes and cost. It can be difficult to find a machine which works shallow enough. A possible option is to use a reliable contractor or machinery rings. However, availability of minimum tillage equipment may be restricted. Sharing equipment with a neighbour is another option.

Minimum-tillage drill

Whichever system is used, it is important to check correct use of the equipment – particularly in regard to depth of sowing, firmness and leveling of seedbed – these tend to vary more under minimum tillage.

Ploughing systems also offer limited opportunities for making savings. Ploughing width and depth should be adjusted to suit the crop. For example, it should be possible to plough shallower between cereals. Whichever system is used, it is essential to be able to gain rapid access to machinery in order to capitalise on the timeliness benefits of tillage.

Weeds and straw

Weed control generally requires more careful management under minimum tillage; in particular, grass weeds and volunteer cereals can become more of a problem. They are generally encouraged by minimum tillage or direct drilling if seed has been shed in the previous crop. Opportunities for using autumn stale seedbeds to control grass weeds and volunteer crops, as practiced in England, are more limited in Scotland because of the smaller window between harvesting the previous crop and drilling the next cereal crop. Under minimum tillage, weeds need to be controlled before sowing cereal crops to prevent a build-up of grass weeds, such as bromes, meadow-grasses, rye-grasses and potentially black-grass, which has appeared in south-east Scotland. Volunteer cereals also need to be controlled as it is impossible, for example, to control volunteer wheat in a barley crop, or wheat and barley in oats. Where stale seedbeds can be used, it is best to till the soil to about 5cm depth immediately after harvest in order to encourage weed seed germination thereby depleting the available surface weed seedbank. This can then be sprayed off with a non-selective herbicide such as glyphosate or paraquat, shortly before sowing.

Some weeds such as cleavers and wild-oats are relatively unaffected by tillage, although the stale seedbed approach can assist in wild-oat control. However, many broad-leaved weeds are discouraged by minimum tillage. Where stale seedbeds are not possible, and crops are sown early, early control of grass weeds should be a priority in the establishing crop.

Minimum tillage

To help weed control and crop establishment, straw removal is recommended. Burning of stubble and straw residues is advantageous in destroying cereal grain and seed of grass shed in that season. Build up of organic matter in the soil at the surface, and burnt organic matter on the surface can reduce the activity of many residual herbicides. Such layers may need occasional cultivation in the rotation to disperse them. Depth of tillage may also need to be adjusted to suit burial of certain herbicides prior to sowing the crop. Otherwise, most herbicides can be used in minimum tillage or direct drilled situations, provided that the seed is not exposed to the herbicide; that is, the seed and/or the seedling root system are buried. Further details on the management of weeds in cereals are given in a recent note [5].

Straw may lock up nitrogen as it decomposes. Thus where straw is incorporated it will probably be worthwhile adding some nitrogen to autumn-sown crops. Trashy seedbeds are unlikely to affect seed germination so long as the drill has operated correctly.

Diseases

Minimum tillage can influence disease severity compared to ploughing, but it is not necessarily worse for all diseases. Minimum tillage crops tend to be sown early and this can result in carry over of some diseases from the previous crop. Wheat diseases including powdery mildew and yellow rust have a greater chance of survival where the gap between crops is short or where cereal volunteers are common. This effect is known as the green bridge effect. If crop canopies under minimum tillage differ from those under ploughing, this could influence the spread of rain-splash diseases, including *Septoria tritici*. Recent SAC research has shown that the stem base disease eyespot and the root disease takeall are not necessarily worse in minimum tillage situations. Trash plays a part in spreading eyespot, but inverted trash in a ploughed situation may protect the fungus better than exposed trash in a minimum tillage crop. The takeall fungus survives best in loose seedbeds, so may survive better in a ploughed crop.

Pests

One of the benefits from minimum tillage is the increase in populations of beneficial insects such as predatory ground beetles and parasitic wasps over several seasons' use. Ploughing tends to kill a proportion of beneficial insects that overwinter in the soil, whereas adoption of minimum tillage allows a greater degree of survival, and leads to a higher level of natural control of pests such as slugs and aphids. Recent research at SAC and elsewhere in the UK has demonstrated significant benefits in pest management by natural enemies, with long term adoption of minimum tillage techniques in conjunction with targeted insecticide use (Integrated Crop Management, ICM).

One potential downside of minimum tillage is a tendency for slug populations to increase due to the presence of trash at the surface and because ploughing often kills slugs and slug eggs to some extent. However, the increase in slug populations is overcome to varying degrees by the build up of ground beetle populations that will prey on slugs, and by the provision of alternative food sources such as weeds and volunteers. Use of slug traps to gauge slug populations is recommended, coupled with the use of metaldehyde slug pellets where necessary to ensure that the newly sown crop is not checked by slugs.

Aphids, and particularly the threat of barley yellow dwarf virus (BYDV) in cereals, may be increased if volunteer cereals and grass weeds are left unchecked, as these will harbour aphids (and possibly BYDV), and provide a 'green bridge' between the previous crop and the next. Consequently weed control either prior to sowing, or early post-emergence may be necessary to reduce the risk of aphids and BYDV in cereals. In some circumstances, an aphicide application in the autumn, through the use of treated seed or a spray may be necessary depending on the level of weeds/ volunteers expected, aphid presence on the newly emerging crop, and the migration of flying aphids into the crop.

Once crops have established in minimum tillage systems, pest pressure is comparable to that of

Minimum tillage

conventional cropping, although continual minimum tillage within a field over several seasons may lead to a reduction in some pests through an increase in natural control.

Examples of successful use

(We the authors are grateful to the three farmers who shared their ideas and experiences which are summarised below)

Case study 1.

Minimum tillage with tine cultivator

Location: South Fife on mainly sloping land with a mixture of medium loam, imperfectly drained soils and freely drained sandy loams.

Cropping: Winter wheat (500 ha), winter oil seed rape (500 ha), winter oats (300 ha) and spring barley (300 ha). Rotation is crucial to successful control of weeds and volunteers.

Equipment: On the heavier soils, 4 m tine cultivator operating up to 15 cm depth and Vaderstad Rapid drill. On the lighter soils, Horsch A-tine stubble cultivator operated up to 8 cm depth and Simba-Horsch Airseeder with band sowing through wing coulters. The Airseeder is also used for direct drilling. 250 hp and 150 hp tractors are used.

Cultivation policy: The target is to get level seedbeds for fast and effective machinery use. The choice of system and depth of tillage depends on soil conditions and on previous crop. The presence of wheel tracks at harvest, for example, demands deeper tillage. Machinery is kept simple to reduce costs and compaction. Autumn tillage is essential before spring barley.

Work rate: In the autumn, the aim is to establish 400 ha per member of staff. Hiring seasonal labour is essential.

Reason for change from plough: To improve soil husbandry by recycling weed and crop residues near the surface and encouraging earthworm development.

Benefits: Reduced labour and fuel costs, quicker crop establishment, improved soil structure and other environmental benefits such as providing shelter for birds in the winter.

Problems: Management demands are greater – particularly at the tractor driver level. Where straw is to be incorporated, straw choppers are inadequate at giving either a uniform chop length or distribution.

Will the system continue?: Yes. The aim is to increase the proportion of cropping that is direct drilled. If more straw is to be incorporated then straw handling needs to be improved. Reduction in nitrogen fertiliser use is expected due to improved cycling and more timely release by mineralisation of soil organic matter.

Secrets of success: Choosing the correct rotation, ensuring level fields and early drilling.

Case study 2.

Direct drilling of light soils

Location: Fife coast on flat and sloping land with mainly sandy loam, well drained soils.

Cropping: Winter wheat (60 ha), spring barley (80 ha), oil seed rape (100 ha) and spring oats (30 ha).

Equipment: Krause 3m direct drill with double disc coulters, Horsch A-tine stubble cultivator.

Cultivation policy: Stale seedbeds are made immediately after harvest, crops are all direct drilled after spraying glyphosate.

Work rate: Direct drilling is up to 60 ha/day, with a tractor speed of up to 15 km/h.

Reason for change from plough: Minimise labour requirement (farmer plus casual staff only) and cost savings.

Benefits: Improved soil structure, drainage and trafficability. Flatter fields allow quicker and more accurate cultivation and drilling. Allows timely establishment of crops when soil conditions are favourable.

Problems: Grass weeds – these demand the careful use of rotational cropping and may require the use of 10 m wide sterile strips around field edges to prevent weeds coming in from field edges. Keeping cultivations shallow enough (5 cm depth). Lack of information on soil and crop management.

Will the system continue?: Yes, the farmer reckons that nothing is irretrievable. He is considering the use of cover crops to overwinter land to be sown with spring barley. A cultivator drill may be needed if organic matter build up at the soil surface continues.

Secrets of success: Stale seedbeds, glyphosate and imaginative and flexible management.

Case study 3.

Minimum tillage with grubber

Location: Central Aberdeenshire on flat and sloping land with mainly sandy loams, well drained and imperfectly drained.

Cropping: Spring barley (210 ha), spring wheat (10 ha), winter wheat (30 ha), winter barley (30 ha), winter oil seed rape (30 ha) and lupins (20 ha).

Equipment: Simba-Horsch Airseeder with band sowing through wing coulters, Horsch A-tine stubble cultivator operated at 4 – 8 cm depth, two passes. The drill coulters are modified to allow combined application of a 'starter' fertiliser mixture below the seed. The Airseeder is used to direct drill oil seed rape.

Cultivation policy: This is a mixed dairy/arable farm. The emphasis is on holistic soil management, maintaining biological, chemical and physical soil fertility for soil, plant and animal health. Soil macro- and micro-nutrients are monitored and adjusted to optimum levels regularly on a field-by-field basis. Cation exchange capacity is also monitored. By reducing tillage depth, the volume of soil for main nutrient cycling is reduced. However, this volume is more biologically active, encouraging earthworm activity and allowing rapid mineralisation of nutrients from slurry and organic matter. This can allow savings in fertiliser inputs. Compaction damage is avoided at all times by minimising inflation pressures of low ground pressure tyres and using small trailers for receiving grain from moving combines.

Work rate: 30 ha/day for spring barley using 1.5 full-time equivalent men.

Reason for change from plough: Cost savings and improvement in timeliness of crop establishment.

Benefits: Increased soil quality due to greater worm activity and better usage of nutrients from cattle dung. Dung (over 1 year old) is used for spring-sown crops. It is spread in February and incorporated by minimum tillage just before sowing.

Problems: Weed control – use of stale seedbeds is not an option due to the short periods available after harvest of previous crop. Grass weeds – principally annual meadow grass for spring barley that needs control in the autumn. Keeping cultivations shallow (4 cm depth), maintaining even depth of sowing on slopes.

Will the system continue?: Yes, the farmer intends to use minimum tillage throughout the farm. Future emphasis will be on maintaining soil fertility.

Secrets of success: The need to consider minimum tillage as a complete system distinct from a ploughing system. As such the system has its own unique requirements.

Further information:

[1] Soil Management Initiative (2001). A guide to managing crop establishment. DEFRA, 51 pp.

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[3] Ball, B.C., Dickson, J.W. (1998). The potential for application of conservation tillage in the UK. In: *'Diffuse Pollution and Agriculture II'* (eds. Petchey, T., D'Arcy, B. and Frost, A.). SAC/SEPA, Aberdeen, 287 pp.

[4] Scottish Cultivations Working Group (1985). Cultivation requirements for winter barley. COSAC/SIAE/MISR Publication 154, 17 pp.

[5] SAC (2003). Winter wheat and barley: The integrated management of broad-leaved weeds and meadow-grass. Technical Note No. 540, 15 pp.

Authors: Bruce Ball, Ian Bingham