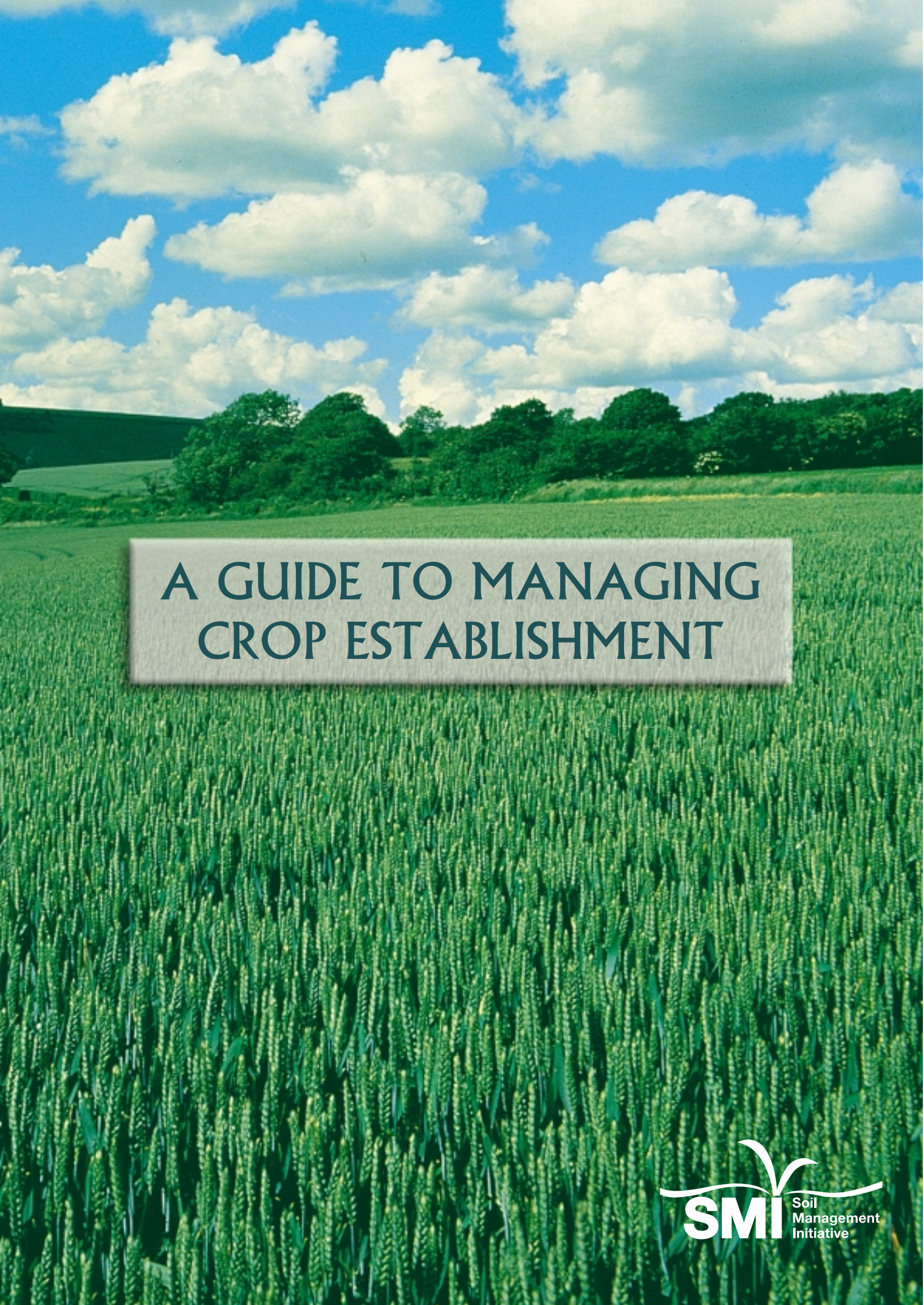


A GUIDE TO MANAGING CROP ESTABLISHMENT

SMI Soil Management Initiative

Contents

SMI Soil Management Initiative

INTRODUCTION

The recent sharp decline in agricultural income has led farmers to seek ways to reduce costs whilst maintaining profitable production. It is difficult to make savings in variable costs (agrochemical inputs) without affecting crop yields, but, savings can be made in crop establishment costs, through adopting more efficient cultivation techniques. These have the potential not only to reduce overall operating costs but also provide the opportunity to save time, which is especially valuable in weather-limited operational windows.

Intensive, poorly timed or inappropriate cultivations and reliance on inorganic fertilisers have contributed to soil degradation (loss of organic matter, compaction and capping) and a subsequent increase in runoff and erosion. The quality of soil, water and air have declined together with the diversity of wildlife. Recent research indicates that reduced cultivation practices can protect productivity,

profitability and the environment. However, plough-based soil management systems will continue and these guidelines also identify opportunities for developing better ploughing practice.

The most appropriate crop establishment method is open to debate, because of the complex interactions between market-driven demands, regional constraints, soil type and conditions, crop rotation and the weather. Reduced cultivation systems are becoming accepted in the UK as they can provide good soil conditions for crop growth, greater soil biological activity and a homogenous and stable soil structure less sensitive to capping, compaction and erosion.

Traditional Cultivation describes a sequence of operations commonly used to prepare a seedbed for a given crop. This is invariably plough-based and usually involves stubble cleaning down to 8cm depth, primary cultivation down to 25cm depth and secondary cultivation down to 10cm depth.
In the UK, *traditional cultivation* usually refers to crop establishment systems that bury or incorporate crop residues by complete soil inversion, usually accompanied by additional cultivation.

Reduced Cultivation refers to crop establishment systems that involve fewer passes than is the case for traditional cultivation and minimal soil disturbance during crop establishment. Usually crop residues are incorporated into the surface (upper 10cm) soil layers without soil inversion (*Non-Inversion Tillage, Lo-Till, or Minimum Tillage*) leaving a proportion on the soil surface. *No-Till/Direct Drilling* refers to a system of seed placement where the soil is left undisturbed from harvest until sowing with crop residues left on the surface. Seeds are delivered in a narrow slot created by discs, coulters or chisels.

DEFRA, amongst its objectives to support and sustain a financially healthy farming community, is putting environment at the heart of agriculture. There is now increased recognition of the need to protect the soil as a valuable resource, with DEFRA-funded research directed towards quality, structure and sustainability. More appropriate soil management is essential for the long-term productivity of land.

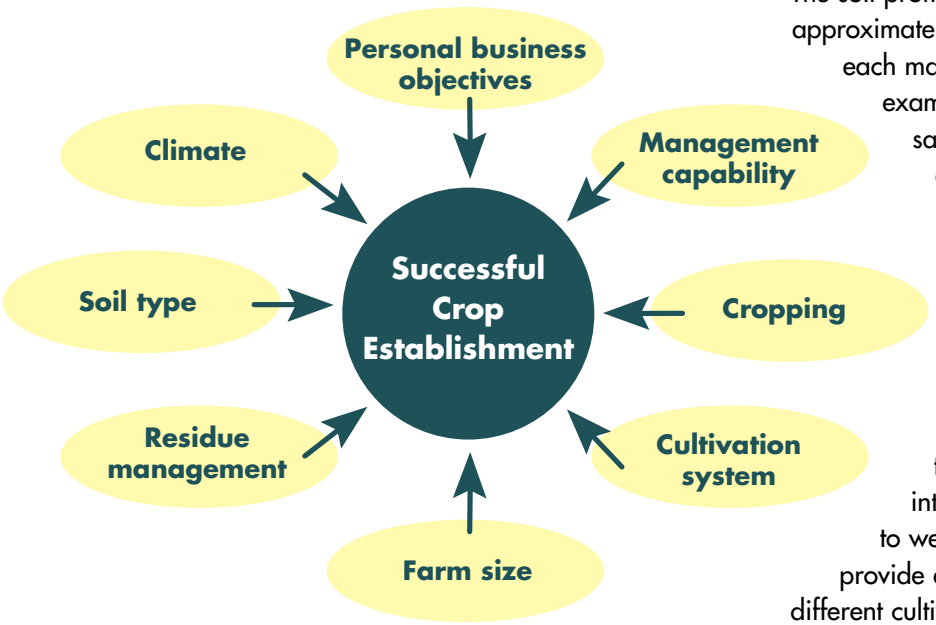
This document has been produced by the Soil Management Initiative and provides guidelines for the progressive adoption of improved cultivation practices whether plough-based or reduced cultivation. It aims to improve soil management, reduce input costs and protect both profitability and the environment. It is a practical, informed tool for farmers, advisors and the farming industry particularly where a transition from traditional methods to alternative cultivations systems is under review.

This guide will direct you towards the most appropriate cultivation system for your situation. Following the different sections of the guide, step by step, you will be able to make your own decisions on how to proceed. A number of case studies report the different experiences of farmers who practice different cultivation systems.

KNOW YOUR SYSTEM

Where am I now?

Look at the diagram and think about all the factors which influence the current crop establishment system. Understanding these factors will enable you to consider whether there are economic and other benefits to be gained from changing your system.



Farm size

Farm size need not be a limiting factor, commitment and financial status is the primary determinant. However, farm size and resources will affect the route taken in adopting new/revised systems.

Soil type

The soil profile should be assessed by digging a hole to approximately 60cm depth at representative sites for each main soil type. The profile needs to be examined to determine the soil texture i.e. sand, silt, light loam, medium loam or clay and whether it is predominantly organic or mineral in content. Assistance with soil assessment can be found in "A Guide to Better Soil Structure". Natural drainage of the profile should be considered – are there impeded layers? Does it need subsoiling or underdrainage? How long after rain does the land become traffickable? Appreciation of the interactions of soil with weather are crucial to well timed cultivations. It is difficult to provide a firm formula for soil suitability for different cultivations: it is based on observations and experience.

Personal Business Objectives

All farms start from a different point depending on farm size, soil type, cropping, machinery available and individual personal and business aims. Key factors to survival in the current economic climate are increases in efficiency, improved output and reduced costs. Many farmers hope for or anticipate expanding, but it is important that the existing farm is run efficiently and expansion is not viewed as the sole means of solving problems of scale, excess labour etc. Because of the competition for land and the prices being paid, not all farms will necessarily have the opportunity to expand.

Cropping

Combinable crops are most suitable for reduced cultivations. Systems are being developed for sugar beet but methods for potatoes are more difficult and still under development. Mixed farms with livestock, maize and fodder beet will maybe consider a range of options including partial adoption. Improved soil management benefits all cropping situations.

Soil Management

The companion booklet "A Guide to Better Soil Structure" is an in depth treatment of this issue In summary:

- Soils need to be managed
- Soils vary considerably
- Soils need to be in a friable state for successful cultivations.

Cultivation and the associated machinery movement, for example, vibration, shearing by powered wheels, cutting and breaking by moving tines and discs, must be carried out when the soil is friable and thoroughly workable. Compaction and smearing result if it is done when the soil is moist and plastic (plastic in the sense of being easily deformed or moulded, as with fresh putty). This provides an unsatisfactory rooting medium and, in addition, rainwater infiltration decreases, causing ponding, increased runoff and consequential environmental damage.

Soils vary considerably, particularly in how long they stay workable. Some, notably clayey soils, stay easily worked for only a few hours after rain, passing quickly from moist and plastic to rock hard within a day or two. This is particularly so if they have been compacted or worked too wet in previous, ill-timed operations. Others stay workable in all but the wettest weather. Few farms are on just one soil type.

Friable, workable soil is essential for success with all types of cultivation. Plough-based systems allow rapid weathering and drying of the soil during preparation of the seedbed through the roughness and openness of the surface. The easy tests described in the "A Guide to Better Soil Structure" are a good indication of success. But all this comes at a high price in time and effort. Plough-based cultivation is forgiving but expensive. Moreover good surface conditions are not necessarily indicative of the deeper soil condition, masking damage lower in the topsoil or in the subsoil caused by the cultivation passes being ill-timed, for example, subsoil compaction by tractor wheels running in the furrow during ploughing.

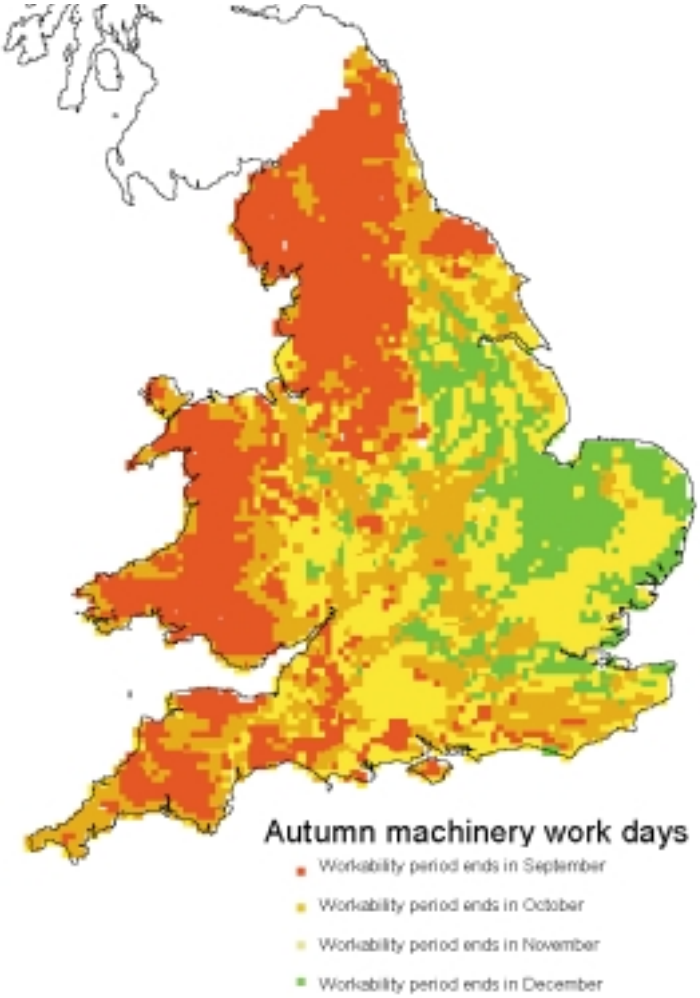
Working the soil when it is friable, not plastic, is just as essential to any reduced cultivation approach, not least direct drilling. Time it right and you create an amenable growing medium, time it wrong and you smear and compact. A lack of awareness of the importance of timeliness was one of the main reasons for the failure of direct drilling in the 1970's. Unlike plough-based seedbeds it is less obvious, without digging, whether the friability of the soil, both above and below the seedbed, has been achieved. So, use that spade, regularly!

Bearing in mind the wide ranges of workability across different soil types, the farmer needs to learn the the soil's responses to reduced cultivation on his land. Careful soil examination is crucial. It can then be followed by well-timed cultivation of friable, non-plastic soil. Cultivate when the soil is too moist and plastic and all the benefits from reduced tillage will be thrown away.

Reduced cultivation can save time and money, but it needs timeliness in working the soil. This demands greater skill and patience from the farmer than does plough-based crop establishment.

Climate and weather

Climate and weather exert a strong influence on the occurrence of waterlogging. The duration of field capacity (period when there is no soil moisture deficit) is a useful indicator. It generally begins in the autumn and ends in spring when transpiration by plants first exceeds rainfall and a soil moisture deficit develops. The field capacity period determines accessibility of machinery to land, provided allowance is made for soil properties. The cultivation of well drained coarse textured soils is often possible within the traditional field capacity period without harmful effects, whereas clayey and other slowly permeable soils are usually impassable and remain wet for longer periods. Dates for the safe access of machinery to well drained sandy land and surface wet clay land can differ by as much as 80 days in the autumn and 40 days in the spring, highlighting the importance of soil type and conditions. For those farming in wetter districts it is worth remembering that general caveats which relate to wet year practices, are applicable in most years.



Cultivation system

We have identified associated time requirements, costs, advantages and disadvantages for different crop establishment systems. A cost calculator is available on the Soil Management Initiative web site (www.smi.org.uk) to aid the decision process.

Cultivation type	Depth (cm)	Cost (£/ha)*	Time (min/ha)	Advantages	Disadvantages
Plough	15-35	85-120	150-220	• All soils • Buries trash/weed seeds • Creates fine seedbed • Uses existing equipment	• Low work rates • Many operations • High cost of establishment • Plough pans need subsoiling • Seedbeds created but subsurface damage caused by ill-timed cultivation can occur
Deep cultivation	10-20	60-100	80-150	• High output • Fast work rates • Few passes needed	• Perceived higher horse power need • Perceived more grass weeds

*2000 prices

Cultivation type	Depth (cm)	Cost (£/ha)*	Time (min/ha)	Advantages	Disadvantages
Reduced cultivation	5-10	40-70	60-100	• High output Fast work rates • Few passes • Low cost of establishment • Soil moisture and nutrient retention • Drill suitability	• Perceived higher horse power need • Perceived more grass weeds • Not suited to all soil types
Direct drill	0	30-45	25-40	• High output • Low cost of establishment • Moderate horse power needed compared to cultivator drills	• Extra horse power vs. Suffolk coulter drills • Grass weed problems • Specialist drill needed • Suitability for non direct drill crops

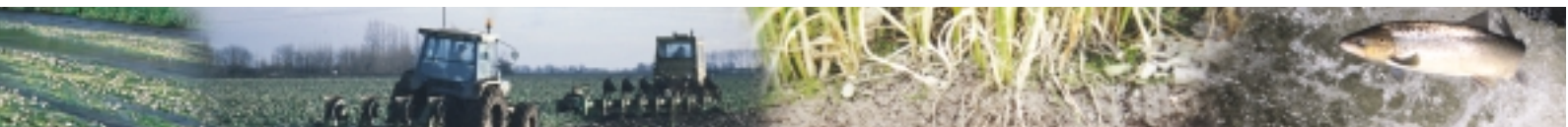
*2000 prices

Residue management

Poorly distributed straw and chaff is probably the most common reason for failure with reduced cultivations. As combine capacity, header width and crop yields have significantly increased so have straw and chaff volumes. Baling and selling may be one option but to chop and spread poorly can impede workability and affect crop establishment. Effective chaff spreading, redistribution of the crop residues and creation of a scratch tilth are essential requirements for successful crop establishment. Correct incorporation of crop residue can greatly benefit soil structure, water infiltration and workability and protect it from soil erosion and compaction damage.

Management capability

Management capability is the key to the successful adoption of improved crop establishment. The adoption of approaches to improve soil management requires greater levels of management skill and knowledge than for traditional practices. Commitment in terms of time and attention to detail are required especially when operational conditions are less than ideal when learning new techniques. Flexibility and willingness to confront change are important.



Integration of factors

None of these factors can be considered in isolation; ultimately they all integrate to form a strategy as to how you manage your cropping requirements. You need to identify how inter related these factors are and how they operate within your farming landscape, for example, why does soil erosion occur, is the timing of cultivation best suited to the soil type and crop, is your machinery capable of establishing crops in your soil type and climate? The relative importance of the factors will vary according to your specific circumstances.

Is your system organic?

Opportunities for reduced cultivations in organic production systems are limited. In the absence of chemical weed control options, physical destruction and burial assumes greater importance. Organic systems typically involve alternative husbandry between ley and arable periods with cover crops retaining nitrogen prior to spring cropping. The plough is used to destroy these fertility building crops and to mineralise nutrients to support the growing crop. In all-arable organic systems chisel plough, spring tine and disc options are feasible between crops but impractical in the destruction of bulky fertility building crops or green manures.

WHAT ARE THE OPTIONS?

The diagram overleaf takes you through a series of thought processes to help you evaluate your resources, preferences, needs and options. The options are not mutually exclusive and a decision cannot be made for you. The responses provided are the extremes to help decision making. The questions are to stimulate thought - if you feel the answer is in the middle that is just as important.

Use of the diagram

Start at the top and answer all questions. The balance of your answers will guide you to the best option. Sum your scores and assess your system fitness by looking at the total.

Scores of 60 or more

Reduced cultivation

Now consider the sections on "Progressive Adoption", "Suitability Tables", "Challenges" and "Questions And Answers" and the "Case Studies".

Scores of 40 to 60

Mixed

If your answers lead you to the "Mixed" option box, the choice of cultivation system is not straight forward and an in-depth analysis of costs, farm size and other factors such as machinery sharing, contracting out, cropping changes and progressive adoption need to be considered.

- Use old/depreciated equipment imaginatively, for example, an old tine cultivator can be used on light/medium soils for primary cultivations
- Seek expert advice to assist you
- Mixed cultivation systems bring the risk of unacceptable costs of retaining machinery which continues to depreciate, alongside the cost of financing new machinery.

Scores of less than 40

Deep/plough based cultivation

Those using deep cultivation systems (plough-based) need to consider whether current practices can be adapted to:

Reduce costs

- Shallow ploughing
- Reduce frequency and intensity of cultivation
- Switch from power harrow to cultivator press (see "Progressive Adoption"and "Suitability Tables")
- Adopt a cultivator drill to cultivate, drill and consolidate in one pass.

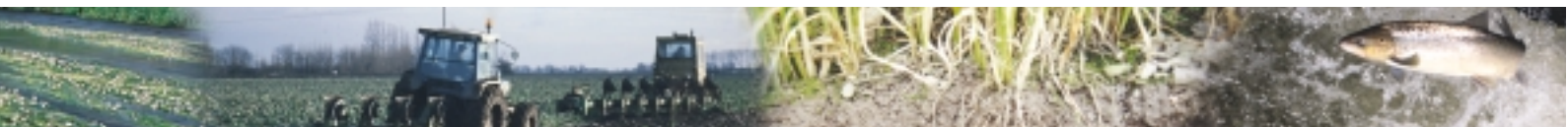
Increase water infiltration

- Subsoil/mole drain
- Leave seed bed coarser over winter. Use rough ploughing or chisel plough
- Surface profiling or ridging. Leave the surface ridged by pressing, or profiling with a roll. This aids water infiltration and provides vital structure to reduce movement off-site.

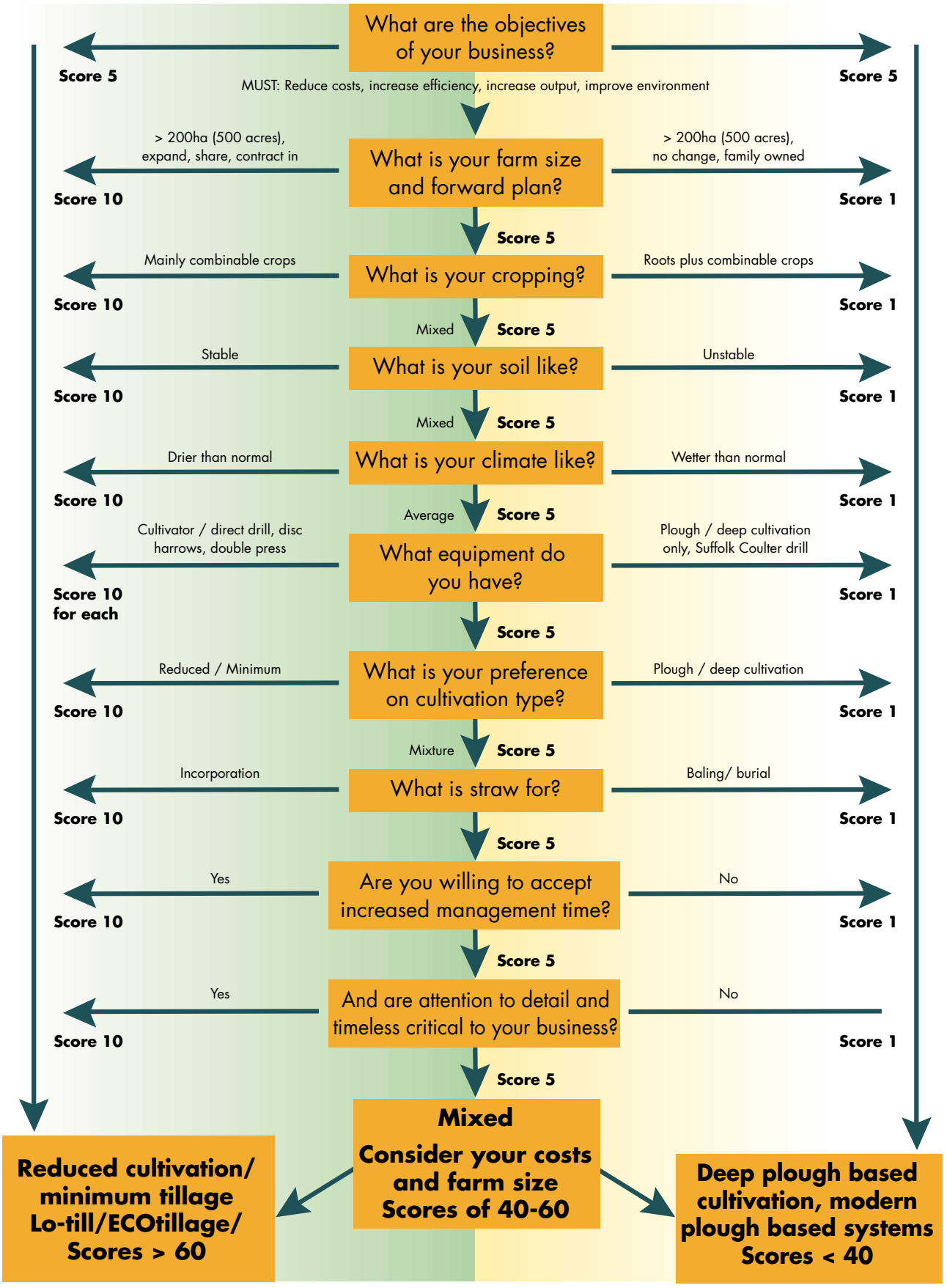
Reduce soil erosion

- Surface profiling or ridging
- Rough plough for over winter
- Retain or introduce grass breaks
- Consider the use of cover crops.

Consider relevant case studies.



Explore your Situation and Options



PROGRESSIVE ADOPTION – HOW TO DO IT

When starting progressive adoption or transition into reduced cultivation systems, consider the following:

- Gather accurate information
- Conduct cultivation trials on your farm and visit demonstrations off the farm
- Obtain information specific to your farm/soil type
- Discuss with/ observe near-neighbour/ practising/ leader farmer
- Assess soil, know how it helps or hinders cultivations, determine need for occasional/ regular sub soiling or deep cultivations
- Consider partial farm conversion initially
- Consider cropping options
- Examine current equipment (type, age, timeliness, costs, long-term goals)
- Seek professional advice/training courses
- Draw up a management plan for weed control and crop protection
- Consider adjustments to farm management and staff training where appropriate.

When all information is available follow these steps using the suitability tables:

STEP 1.

Select the most appropriate drilling system

- Currently the drill offers the main decision as an entry opportunity
- Combine and thus reduce the number of operations: for example, cultivating - drilling - rolling with a cultivator drill
- The drill must have the flexibility to work in a range of seedbeds
- The drill should be able to handle trash, sow into consolidated land, cultivate at time of drilling, and accurately place seed. It should ideally consolidate as the final operation, or alternatively the seedbed should be rolled after drilling
- Check the suitability tables for your soil type, cropping, depth of cultivation and trash levels.

STEP 2.

Replace or remove spring tine/ power harrow operations

- Combine and thus reduce the number of operations: for example, power-harrow cultivators by a double press
- Check the suitability tables for guidance by soil type
- Choose a system that provides flexibility for ploughed or reduced cultivation
- Create a consolidated stale seedbed
- Allow time for weed germination and spray out weeds prior to drilling
- Drill into the stale seedbed.

STEP 3.

Change the primary cultivation

- Ensure crop debris is chopped and spread well prior to incorporation
- Consider primary cultivation (tines/discs) to incorporate trash
- Check the suitability tables for guidance by soil type
- Choose a system that suits, on balance, your soil types, slopes, and horsepower availability
- Bear in mind that on most farms it is best to operate one main system in order to avoid increased costs, except where equipment is old and depreciated or farm size is large enough to carry such costs. A change to reduced cultivation can be accommodated, even if rotational ploughing is felt useful by contracting in the ploughing. Review overall farm business costings with a financial adviser.

STEP 4.

Determine the crop establishment system and then follow the Management Plan

CROP ESTABLISHMENT SYSTEM

Use these suitability tables to help decide which equipment is most suited to your needs.

Drills by cultivation depth

✔ good fit ✔ ✖ Use with care ✖ No/ poor fit

Drill	15-35cm Plough	10-20cm Deep cultivation	5-10cm Reduced cultivation	0cm Direct drill
Suffolk coulter drills	✔	✔	✖	✖
Disc cultivator drills	✔	✔	✔	✖ ✔
Tine cultivator drills	✔	✔	✔	✖ ✔
Direct drills	✖ ✔	✔	✔	✔

Drills by cropping

✔ good fit ✔ ✖ Use with care ✖ No/ poor fit

Straw baled or buried

Drill	Oilseed rape	Legumes	Linseed	Cereals	Sugar Beet	Potatoes
Suffolk coulter drills	✔	✔	✔	✔	✖	✖
Disc cultivator drills	✔	✔	✔	✔	✖	✖
Tine cultivator drills	✔	✔	✔	✔	✖	✖
Direct drills	✔	✔	✔	✔	✔	✖
Specialised planters	✖	✖	✖	✖	✔	✔

Disc cultivator drills offer superior establishment in vining peas.

Straw incorporated in top 10cm

Drill	Oilseed rape	Legumes	Linseed	Cereals	Sugar Beet	Potatoes
Suffolk coulter drills	✔ ✖	✔ ✖	✔ ✖	✔ ✖	✖	✖
Disc cultivator drills	✔	✔	✔	✔ ✖	✖	✖
Tine cultivator drills	✔	✔	✔	✔	✖	✖
Direct drills	✔	✔	✔	✔	✔	✖
Specialised planters	✖	✖	✖	✖	✔	✔

Drills by soil type

✔ good fit ✔ ✖ Use with care ✖ No/ poor fit

Soil types	Light unstable	Medium unstable	Light stable	Medium stable	Heavy stable
Drill types	**Sandy**	**Silty**	**Light loamy**	**Medium loamy**	**Clayey**
Suffolk coulter	✔	✔	✔	✔	✖
Disc cultivator drills	✖	✖	✔ ✖	✔	✔
Heavy Tine cultivator drills	✖	✖	✔ ✖	✔	✔
Light Tine cultivator drills	✔ ✖	✔ ✖	✔	✔	✔ ✖
Direct drills	✖	✖	✔	✔	✖

Consolidation by soil type

✔ good fit ✔✖ Use with care ✖ No/ poor fit

Soil types	Light unstable	Meduim unstable	Light stable	Medium stable	Heavy stable
Equipment	**Sandy**	**Silty**	**Light loamy**	**Medium loamy**	**Clayey**
Heavy double press	✖	✖	✔	✔	✔
Medium double press	✖	✔	✔	✔	✔✖
Single press	✖	✔✖	✔✖	✖	✖
Heavy Cambridge rolls	✖	✖	✔✖	✔	✔✖
Light Cambridge rolls	✖	✔✖	✔	✖	✖
Surface profiling rolls	✔	✔	✔✖	✔✖	✖

Cultivation by soil type

✔ good fit ✔✖ Use with care ✖ No/ poor fit

Soil types	Light unstable	Meduim unstable	Light stable	Medium stable	Heavy stable
Equipment	**Sandy**	**Silty**	**Light loamy**	**Medium loamy**	**Clayey**
Plough	✔	✔	✔	✔	✔✖
Chisel plough	✔	✔	✔	✔	✔✖
Tined cultivator	✔	✔	✔	✔	✔✖
Heavy disc harrows	✖	✖	✔✖	✔	✔
Disc+tine+consolidation	✔✖	✔	✔	✔	✔
Light disc harrows	✖	✔✖	✔	✖	✖

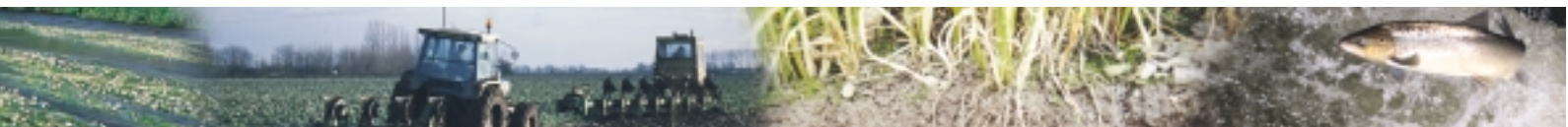
After you have reviewed the progressive steps and considered the suitability tables it is then necessary to decide how you can implement improved cultivation practices. Adoption should proceed progressively and can be in many different ways, for instance:

Typical implementation in a small business, for example, less than 400ha (1000acres)

Year	Activity
One	Decide to purchase or contract. Change drill learn best use. Benefit from initial cost savings.
Two	Change consolidation or primary cultivation as needed. Learn best use or fit. Continue to adapt agronomy.
Three	Ensure other components of total system are suitable for example, combine, tractors.

Typical implementation in a larger business, for example, more than 400ha (5000acres)

Year	Activity
One	Change drill/ consolidation or primary cultivation as needed. Learn best use. Benefit from initial cost savings.
Two	Ensure other components of total system are suitable: combine, tractors. Continue to adapt agronomy.
Three	Continue to adapt management/agronomy. Consider increasing machinery use by increasing land farmed provided it does not prejudice the timeliness of cultivations with regard to the protection of soil quality.



MANAGEMENT PLAN

Once the cultivation system is agreed it is essential to draw up a management plan well in advance of any intended changes.

Determine strategy for following years The range and extent of soil types will influence choice of crop, rotation, timing and method of cultivation and the time required to do the work. Consider which existing machinery will be appropriate and which may need to be acquired. Look carefully at options for machinery sharing, renting and purchase. Plan in spring, well ahead of harvest.

Assess soil condition and quality - take appropriate actions Dig down to below cultivation depth, using the spade as a probe to determine soil compaction. Look at soil structure and condition within the field and on headlands. Work out an action plan for dealing with any problems such as subsoiling or drainage. Prioritise which land needs to be cultivated first. For more details on how to assess your soil see "A Guide to Better Soil Structure".

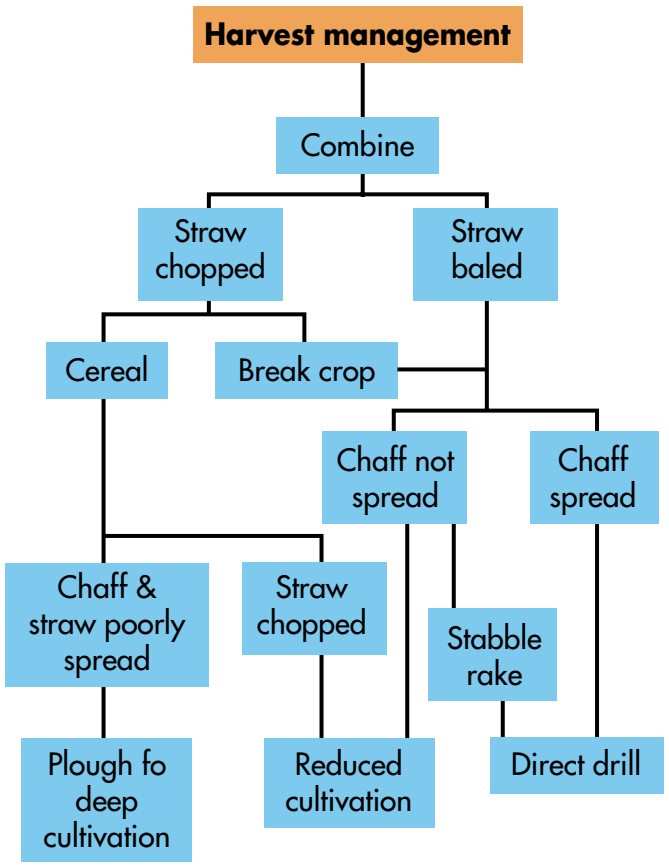
Manage current crop There are many options for crop management such as varying seed rates, nitrogen use, growth regulators, weed control, disease control (for example, take-all and eyespot in wheat), pest control (stem base pests for example, wheat bulb fly). It is important to ensure best agronomy to suit the situation the crop is grown in. In particular to ease crop residue management, shorter standing crops are a great help if you plan to reduce cultivations.

Harvest management Aim for a dry crop by using an appropriate desiccant to increase combine efficiency, bring harvest forward and ensure a good even crop and spread of straw to aid an early start to autumn cultivations.

Residue management Factors to consider are

- Does the straw have any value off the field and the nutrient losses if it is removed
- What is the effect on timeliness of baling operations, particularly if contracted for example, through waiting for baling and carting of the straw
- Can the straw and chaff be effectively chopped and spread.

To incorporate straw, the combine must be capable of chopping and spreading the straw and chaff to the full width of the header. This is vital if reduced cultivation options are being considered. Stubble height should be fairly low, but not so much to overwork the combine. Leaving a longer stubble can reduce the volume of straw through the chopper and in crops like direct drilled oilseed rape, provide some additional protection against pigeons.



Primary/secondary cultivation and consolidation for a stale seedbed

Cultivations should aim to

- Deal with surface trash,
- Create the stale seedbed, work progressively with 1-2 passes as needed
- Consolidate with a double press to promote straw breakdown and weed germination

WAIT!! Timing is perhaps the most critical factor in this process and it is important to leave enough time to allow weeds to germinate. Check that the majority of weeds have emerged before spraying with a non-selective herbicide like glyphosate; no more than 2 to 3 days before drilling in the case of grasses, and no less than 2 to 3 weeks in the case of volunteer oil seed rape. Where the inter-crop period is reduced for example, going from winter wheat to winter rape, waiting may not be an option, this is especially the situation in the north of England.

Timing is critical for management of the soil. Cultivate it too wet and you can undo all the benefits you've achieved!

Weed management Use a non-selective herbicide to kill weeds flushed prior to drilling; this will be a major opportunity to avoid problems later. In-crop weed control will focus on late germinators which would otherwise be in competition with the crop.

Drill The most important target to achieve is to surround the seed with a fine, firm tilth to encourage rapid, even germination and avoid slug damage. Depth of drilling can be an important factor, for example, the ideal depth for cereals being 4cm or 12cm for beans.

Roll This has many advantages, including reducing slug numbers and protecting the seed from them in the soil, assisting germination, and the development of good rooting systems which, in turn, improve subsequent growth. In dry conditions it helps to conserve moisture and makes it more difficult for birds to find and eat the seed. Rolling is not usually necessary after a cultivator drill with full width press wheels, but is often needed with other drills, except on slumping/fragile soils in wetter regions or in wet years. Where slot closure is incomplete behind a direct drill, rolling can also be beneficial.

Pest management Slugs can be a concern in low till husbandry where the seedbed is left loose or cloddy, seed is shallow drilled and weeds/volunteers have not been killed prior to drilling. They can be a particular hazard on wetter soils and in wetter districts. Control measures include treatment in the previous crop, or the incorporation of pellets with the seed at sowing, good soil structure, pre-harvest crop desiccation, firm seedbeds and in crop treatment if monitoring with bait traps indicates the need. Reduced cultivations and the presence of straw help preserve aphid predators for example, spiders and beetles. The presence of straw also confuses flying aphids by masking their recognition of newly emerged crops and so aphid colonisation is reduced, minimising the risk of Barley Yellow Dwarf Virus (BYDV).

Agronomic decisions Sustainable soil management requires a more flexible approach, but used properly, it will

- reduce cultivation and husbandry costs
- produce a healthier soil which is more robust than heavily cultivated soils with low organic matter
- protect against environmental damage.

WEED CONTROL

Grass weeds, especially black-grass, wild oats, Italian rye-grass, brome grass species, cereal volunteers, combined with herbicide resistance are of increasing concern in autumn planted arable systems. Cereal monoculture, early autumn sowing, reduced cultivation and high weed infestations encourage grass weed problems. They are perceived to be more of a problem and, hence, a major challenge, in reduced cultivation systems than in plough-based systems.

Ploughing, used on 70 to 80% of arable land, has been shown to reduce grass weed populations by up to approximately 80% in some trials by burying weed seed, but can also bring up seeds from the weed seed-bank. Reduced cultivations alone will increase grass weeds, but good management through knowledge of weed seed distribution in soils and weed germination periods are key to strategic decision-making for both weed control and minimising resistance development.

Weed control begins pre-harvest and inter-crop management is the key to success. Stale seedbeds are most effective when combined with some delay in drilling, crop rotation allows the use of different herbicide chemistry and can reduce weed levels by at least 60% in the crop being drilled.

Stale seedbeds are an effective method of weed control in all cultivation systems, but essential to prevent a build-up of grass weeds under reduced cultivation. For most species establishing a stale-seedbed immediately after harvest does this best.

To maximise the benefit from the stale-seedbed:

- To remove volunteer oilseed rape, early cultivation is effective so long as it is shallow, at 2 to 5cm
- Delay cultivation by one month if the summer was cool and moist, and wild oats/black-grass and cereal volunteers predominate to allow seed ripening on soil surface to germinate or if rye grass/soft/meadow brome species predominate
- Maximise emergence of weeds prior to drilling by consolidating after cultivation
- The wrong set-up of a stale seedbed or too early cultivation will ensure some species survive longer by encouraging dormancy
- Make sure all weeds emerged prior to spraying are removed by use of a non-selective spray like glyphosate
- Reduce soil disturbance at drilling, if seedbed is good enough, to reduce further flushes of weeds.

Rotational ploughing may be part of your strategy, and the plough can be a useful tool to bury major seed return in one year. To optimise its use:

- Leave the seed buried at a known depth and cultivate more shallowly afterwards
- For large seeded grass species ploughing depth should exceed 12 to 17cm
- Ideally plough no more frequently than one year in three
- Timing of ploughing should be adjusted according to species, as above, to allow seed to ripen and thus not to enforce dormancy
- Quality of ploughing is key if it is to be useful as a cultural weed control tool, otherwise it will merely prolong the problem through the rotation. Good set-up is vital to fully invert the soil, and to avoid flicking of seed across the soil surface during inversion.

A herbicide resistance management strategy is essential. Resistance in the UK occurs in black-grass, Italian rye-grass and wild oats. Assess risks and make

sure your plans minimise resistance risk; refer to the Weed Resistance Action Guidelines (WRAG) - HGCA, (1997). Such a strategy is built on combining herbicide chemistry (modes of action, mixtures and sequences) and cultural techniques (stale seedbeds, crop rotation, delayed drilling, rotational ploughing).
A resistance management strategy is extremely important in reduced cultivation systems and where very high weed levels exist.

In summary - planning and timeliness are essential to success

- Plan across the whole rotation – use of break-crops/spring crops (think rotationally)
- Weed control prior to crop establishment is essential – pre-harvest opportunity, stale seedbeds, non-selective herbicides
- Control weeds as early as feasible – weeds can be 10 times more competitive than the crop, timing and herbicide choice is vital
- Use a programmed approach stale seedbeds/ drilling date/ pre-emergence and mixtures or sequences with different herbicide chemistry.

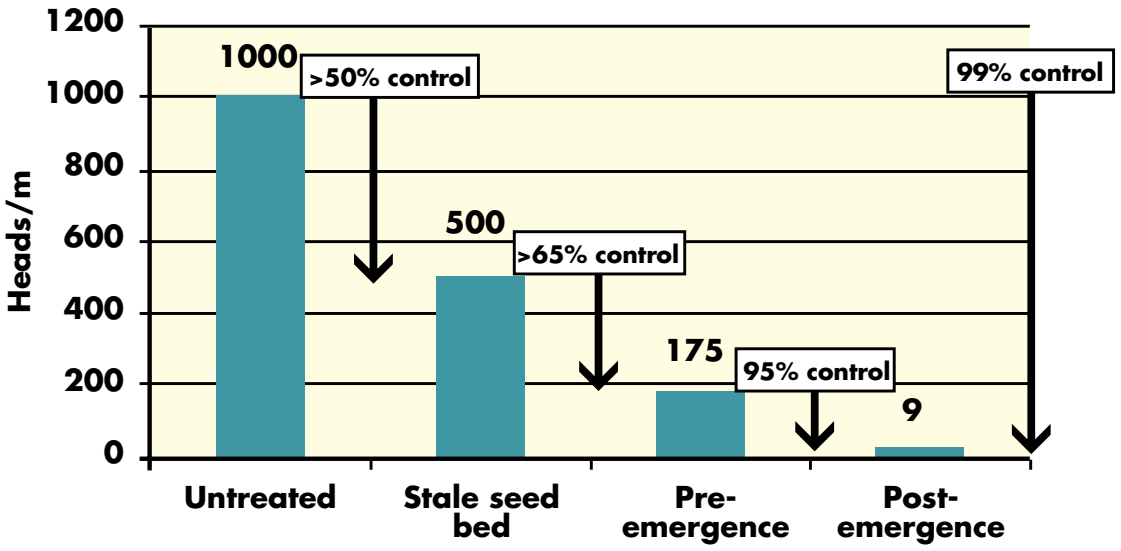
Stale Seedbed

- post harvest crop residue incorporation
- create a medium quality seedbed
- consolidate
- WAIT for weed germination
- spray a non-selective herbicide to control weeds
- drill within 2-3 days.

Sequential Strategy For Black-grass

- stale seedbed (>50%control) + pre-treatment (>65%control) + post treatment (95% control) gives a targeted 99% control.
- a resistance management strategy is essential: assess risks, ensure your plans minimise resistance risk; consult the WRAG Guidelines.
- rotational ploughing may be part of your strategy.

Sequential Strategy for Blackgrass Control



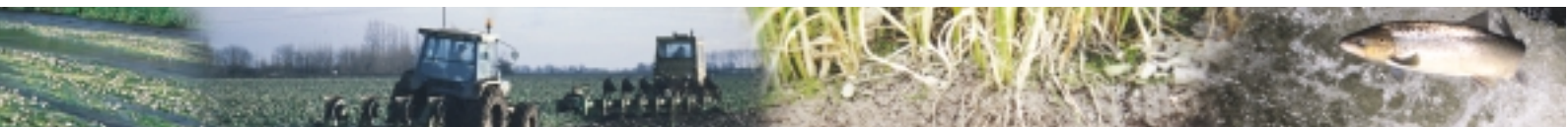
CASE STUDIES

This section describes 12 case studies which are summarised in the table. The experience of farmers in different soil, crop, and climate situations will assist your own decision. Each case study includes an assessment of the number of machinery work days (M.W.D. 🚜) available in both an normal and a wet year, for autumn and spring cultivations, for the predominant soil types on the farm. The available days can be compared with machinery work rates and man days required to highlight any advantages or disadvantages of the chosen cultivation system.

Case Study	Location	Predominant soils	Cropping	System	Efficiency hP/ha: tractors/man
1	Worcestershire	Clay loam over clay, variably affected by surface wetness	Combinable crops	Reduced cultivation with disc harrows or direct drill on 320ha	1.2 : 1.0
2	Rutland	Clay with surface wetness	Combinable crops	Reduced cultivation with disc harrows direct drill, with surplus horsepower on 400ha	1.5 : 1.2
3	Essex	Clay with surface wetness and well drained clay loam over gravel	Combinable crops, roots, sweet corn vining beans	Successful adoption of reduced cultivation, on 2000ha	0.4 : 1.3
4	Wiltshire	Clay with surface wetness plus clay loams over chalky gravel	Combinable crops, break crops	Progressive adoption of reduced cultivation on 352ha	1.0 : 2.0
5	Leicestershire	Clay with surface wetness plus well drained deep clay loams	Combinable crops	Progressive adoption of new system, sharing equipment on 617ha	1.7 : 2.0
6	Wiltshire	Shallow, flinty clay loam and silty clay loam over chalk	Combinable crops, set aside	Large business adopting tined and plough cultivations to suit soils and cropping on 1630ha	Contract hire
7	Leicestershire	Clay soils and some medium loams with surface wetness	Combinable crops, rotational leys	Environmentally-driven, reduced cultivation systems on 65ha	Experimental
8	Suffolk	Clay with surface wetness, locally well drained clay loam and sandy loam	Combinable crops and sugar beet	Simba Solo (discs/press/subsoil) /cultivator drill on 752ha	1.2 : 1.0
9	Cambridgeshire	Deep stoneless silts, occasionally over peat and locally with peaty topsoils	Combinable crops, roots and vegetables	Planned change from plough to reduced cultivation system on 1483ha	0.4 : under change
10	Devon	Stony, well drained clay loams over reddish sandstone plus clays with surface wetness	Maize/grass/ livestock	Plough/power harrow system on an arable livestock farm on 205ha	0.6 : 1.0 part contract
11	Suffolk	Clay loam over clayey soils with surface wetness	Combinable crops, sugar beet, vining peas	Plough and reduced cultivation systems on 928ha	1.5 : 1.8
12	Nottinghamshire	Well drained sandy soils locally affected by groundwater near water courses	Cereals, sugar beet, potatoes	Plough based system, sandy soils on 330ha	2.8 : 0.8 trials work

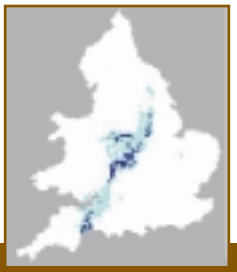
Efficiency of the system is assessed by determining the horsepower available per hectare (hp/ha) and the number of tractors per man (tractors/man). Each case study is illustrated by a map showing the location, extent and occurrence of similar soil types.

Key to Maps ■ Few ■ Common ■ Many



CASE STUDY 1

Reduced cultivation with disc harrows or direct drill



Location	Worcestershire
Size, average field size and spread	320ha; 6.4ha with land spread over 14.5km.
Soils and landscape	Heavy clay loam over dense slowly permeable red clay soils. Locally stony at the surface they are subject, in varying degrees, to seasonal surface wetness (Brockhurst and Whimple associations). Occasional steep banks are dominantly clay in texture (Worcester series).
Cropping	152ha winter wheat (milling varieties), 56ha winter oilseed rape, 72ha winter/spring beans and 40ha (permanent set aside/grass).
Workforce	Managed by family labour (father and two sons) and also employs a part-time secretary and an independent agronomist.
Equipment and cultivation machinery	Kuhn 4m discs; Weaving 3m 'Sub-lift' fitted with 5 legs; Bullock 6m Lo-Till rake; Marstig 6m folding rolls; Kuhn SD4000 4m folding direct drill; 150hp JCB Fastrac 2155 (2 years old); 130hp John Deere 6900 (3 years old); 90hp 2M-F 600 series (15 years old) tractor.

Cultivation Policy	
The basic policy is to obtain a good stale seedbed, then Spray ➨ Direct-Drill	
Wheat ➨ oilseed rape	Straw is baled ➨ Rake (x2);
Winter beans ➨ wheat	Disc ➨ Roll;
Spring beans ➨ wheat	Rake (x2);
Wheat ➨ wheat	Bale straw ➨ Rake
Wheat ➨ beans	Rake (?) ➨ Sub-soil (?) - Rake or sub-soiling only when necessary
Oilseed rape ➨ wheat	Either Disc (x2) ➨ Roll or Rake (x2) ➨ Direct-Drill

Costings and Work rates

Operation	Output (ha/hr)	Cost (£/ha)	Time taken (min/ha)
Discing	2.8	15.0	22
Raking	6.0	6.25	10
Rolling	4.0	7.50	15
Direct-Drilling	2.8	25.0	22
Sub-soiling	1.6	20.0	38
Spraying	10.0	7.50	6

Discussion	
Decision to change	Reduction in commodity prices and area aid; problems in achieving reasonable seed beds in wet autumns (short access window); difficulty moving large machinery on busy roads & into small fields; soil erosion was becoming more of a problem.
How	Change to reduced cultivations/direct drilling from a plough & power/ harrow-drill system phased in over three years (drills hired during first two seasons): a drill purchased (year 3) partly by sale of redundant equipment. Now the farm does not own a plough or power harrow.
Benefits	Yields maintained on a field for field basis; overall farm output increased due to better timeliness (cultivations/spray and fertiliser applications) and better land trafficability. Improved soil structure and significant increase in worms have added to overall fertility of the soil. With the change now complete, the farm shows an overall crop establishment cost saving of > 45% and 40% saving in time. This has allowed over 120ha of contract drilling to be done, which has helped to fund the change.
Problems	Most significant problem has been uneven spread of chaff and chopped straw behind the combine. This led to "hair pinning", toxins from rotting crop residues and increased slug problems in the early days resulting in poor crop establishment. Some drilling days have been lost waiting for suitable glyphosate spraying conditions in a difficult autumn.
Solutions found	Problems overcome by use of stubble rake; a more efficient combine will be purchased in the long term. The use of glyphosate eased "Harvest Management". Weed control has not been a problem - good stale seedbeds pre-drilling and the rotation allowed various strategies for grass weed control.

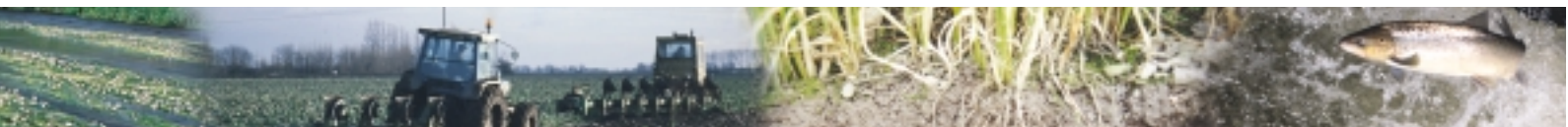
SMI Soil Management Initiative

SMI COMMENT

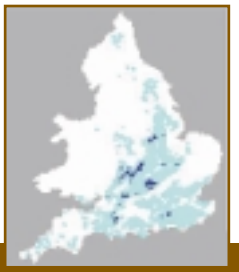
Well thought out and successful; at 52min/ha as low as one could expect; rake improves combine straw/chaff spread efficiency. Problems encountered in wet years have been alleviated by adoption of a mixture of reduced cultivation and direct drilling.

Soil Group	Type of Year	M.W.D.'s	AUTUMN: SEP	OCT	NOV	WINTER: DEC	JAN	FEB	SPRING: MAR	APR	M.W.D.'s
Brockhurst 70%	Normal	45									6
	Wet	17									0
Whimple 30%	Normal	60									11
	Wet	32									0

Man days required to complete autumn cultivation		Spring cultivations	
Wheat ➡ OSR	25	2	Wheat ➡ sp beans
OSR ➡ wheat	35	11	Conventional plough (35ha)
Farm average	32		
Conventional Plough system	60		



CASE STUDY 2



Reduced cultivation with disc harrows or direct drill, with surplus horsepower

Location	Lincolnshire-Leicestershire border
Size, average field size	400ha, 10ha
Soils and landscape	Largely on dense, slowly permeable seasonally waterlogged clay soils (Denchworth association) developed on Lias Clay. Locally, more permeable sandy clay loam soils are seasonally affected by groundwater (Wigton Moor association).
Cropping	180ha winter wheat and 180ha winter oilseed rape with 40ha part permanent/part rotational set aside.
Workforce	Managed by family labour (father and son) with a student at harvest.
Equipment and cultivation machinery	Galucho 5m discs; Simba 12m Cambridge rolls; 2-legged mole plough; Subsoiler; Kuhn SD4000 4m Direct-Drill; 285hp CAT Challenger (8 years old); 185hp John Deere 8100 (5 years old); 130hp Renault 110-54 (8 years old); Berthoud S/P Sprayer, 3000 l/28m boom.

Cultivation Policy	
After set aside land is moled, disced, roll/pressed then winter wheat direct-drilled. Sub-soiling only when necessary, usually on headlands where traffic has turned after wet harvest.	
Wheat ➡ OSR	Inter-crop is sprayed and oilseed rape direct-drilled
OSR ➡ wheat	Disced, rolled, sprayed, and wheat is direct-drilled

Costings and Work rates

Operation	Output (ha/hr)	Cost (£/ha)	Time taken (min/ha)
Discing	4.0	12.5	15
Rolling	8.0	9.0	7.5
Direct-Drilling	4.0	35.0	15
Sub-soiling/moling	1.0	30.0	60
Spraying	10.0	7.5	6

Discussion	
Decision to change	Cost saving and to conserve soil moisture and allow early September drilling of winter wheat (100 seeds/m^2 – 50kg/ha) to give greatest yield potential (10t/ha).
How	The Case rotary combine chops and evenly spreads both straw and chaff. Stubbles are left long (30-40cm) to improve combine output and reduce amount of straw to be chopped and re-distributed. Grass weeds are controlled in oilseed rape and broad-leaved weeds in cereals. Glyphosate is used pre-drilling. Compaction is avoided by travelling only when dry; all vehicles including combine and chaser bin are fitted with LGP tyres or tracks. Liquid fertiliser and sprays are applied down 28m tramlines to reduce wheelings.
Benefits	Cost-saving: on heavy land, achieving a satisfactory seedbed with a plough-based system was a problem (4 passes with power harrow) and cost equalled £134/ha (£94/ha-light land) compared with £58/ha for direct drilling system.
Problems	Slugs: due to oilseed rape grown close in rotation, the wetter weather and build up of surface trash. Slug pellets are not a solution to the problem.
Solutions found	Increasing the gap between rape crops by growing second wheat (now grass weeds controlled); establishing wheat after set-aside is a rotational change that will be made. Light discing or other suitable surface cultivation to incorporate crop residue and create a less slug-friendly environment. The use of gypsum is also an effective way to reduce slug numbers.

SMI Soil Management Initiative

SMI COMMENT

Improved rate of work; CAT challenger relevant to "old" system; low ground pressure tyres clearly advantageous. Insufficient machinery work days for a whole farm plough based system in a wet year, risks have been minimised by the adoption of reduced cultivation systems.

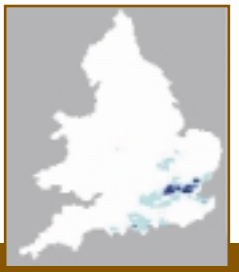
Soil Group	Type of Year	M.W.D.'s	AUTUMN SEP	OCT	NOV	WINTER DEC	JAN	FEB	SPRING MAR	APR	M.W.D.'s
Denchworth	Normal	56									12
	Wet	27									0
Wigton Moor	Normal	86									22
	Wet	57									0

Man days required to complete autumn cultivation

180ha Wheat ➡ OSR	7
180ha OSR ➡ wheat	13
Total Farm	21
Conventional Plough system	90

CASE STUDY 3

Successful adoption of reduced cultivation, large scale



Location	Essex
Size and spread	2,000ha; 30 different land owners within 32km
Soils and landscape	Mainly flat land. Dense, slowly permeable, seasonally waterlogged clayey soils (Windsor association) developed in London Clay predominate. Subsidiary areas of permeable well drained clay loams over gravel (Efford association) occur locally and the gravels are occasionally affected by groundwater.
Cropping	The land is primarily down to combinable crops with 50% winter wheat, plus oilseed rape, winter beans and spring peas or beans. Other crops grown include sugar beet and sweet corn and vining beans grown for a local marketing group. Pig enterprise.
Workforce	Run by two brothers with 6 arable staff employed, partly made up of further family labour plus extra help at harvest.
Equipment and cultivation machinery	Case Quadtrac (360 hp), JD 8400 (265 hp), Case 7250 (270 hp) plus a further 7 Fastracs from 145 to 170 hp. Tim Howard 9 legged subsurface cultivator (working about 300mm deep), 12m Horsch FG Stubble cultivator, 10 furrow plough, 5m Simba 2B Discs, 8m Horsch CO tined cultivator drill, old Vaderstad 8m drill, 12m rolls, 2 x 24 m sprayers, 2 x 24m pneumatic fertiliser spreaders 2 x Claas Lexion Combines.

Cultivation Policy

Over the last 2 to 3 years the farm has significantly reduced the hectarage ploughed to only about 20%. In 2000, this was mainly for sugar beet, sweetcorn, green beans and where there was muck to incorporate. The farm has experimented progressively and widely adopted a cultivation system based around two passes of the 12mm Horsch cultivator with wide "A" bladed tines followed by the roll in one pass. These are pulled by the Quadtrac working to a 75mm depth. In very hard or wet conditions the "A" blades are replaced by 75mm wide points. The aim, as far as possible, is to mix the straw into the top 75mm layer where the aerobic breakdown is at its greatest and to drill through and into this mixed surface layer. The 8m tined Horsch drill is pulled by the Case 7250 (270 hp). Sub-soiling is not routine, averaging once every 5 years, but is only done when necessary following advice from an independent soil scientist.

Costings and Work rates

Operation	Output (ha/hr)	Cost (£/ha)	Time taken (min/ha)
2 x 12m Horsch cultivator + roll	10	12	12
Spray	16	7.5	4
Horsch drill	5	20	12
Roll	8	10	8
Sub-soiling lifting	2.5	20	24

Discussion	
Decision to change	To help reduce costs and further significantly increase output on a rapidly expanding hectarage. The farm has a proven history of making brave decisions with its machinery and successfully adopting new machinery and working it hard and cost effectively. They fully appreciate the blackgrass problem but have predominantly first wheats (maximum 5 to 10% second wheats) and believe that with good spraying timeliness and the correct rotation they can keep it under control. The roll producing the correct consolidation is extremely important in keeping slugs under control.
How	The farm changed to an 8 m Vaderstad with front tines and levelling board in 1991. This could no longer cope by itself with the expanding hectarage. Drilling into disced land with surface straw had at times been a problem. In 2000 the Horsch drill covered two thirds of the hectarage and it is likely that the farm will replace both drills with a 12m Horsch drill in the near future. This type of drill has also proved effective drilling on ploughed and pressed land.
Benefits	It is too soon to judge the medium to long term effect on blackgrass but the farm feel they can keep on top of it, especially with the correct rotation and the low proportion of second wheat's. The overall establishment time for the operations described, excluding subsoiling, is about 36 minutes per hectare. The spray is not always used but it is generally just prior to drilling after the second pass of the cultivator. These times compare favourably with the farm's plough based system, which averages about 80 minutes per hectare, and a disc system at about 55 minutes per hectare. Compared to the original plough and cultivator drill system there is a time saving of over 1,000 hours per year. Yields have been maintained while output and timeliness have been improved. In the future yields are expected to increase due to better timeliness and soil conditions. In wet seasons the reduced cultivation land has a greater machinery carrying capacity than ploughed land.
Problems	Following the cultivator with a roll in the same pass helps to minimise the number of wheelings and also retains moisture in dry autumn. In wet conditions and in small fields it is not always possible to pull the roll as well. Occasionally laid fields of, for example, beans need to be disced to give a greater chopping action. Transport of machinery from farm to farm is costly and time consuming. The ease of folding within the legal limit is crucial to the success of such an operation.
Solutions found	Increased management and attention to detail is necessary, especially a greater use of the spade to decide on the need for lifting. The rewards for paying attention to the latter are enormous - 2 hours investigating work may save 2 weeks of autumn work. Each field needs to be treated on its own merits. The even straw spread behind the Lexion combines has been an important factor in enabling the system to be adopted.

SMI Soil Management Initiative

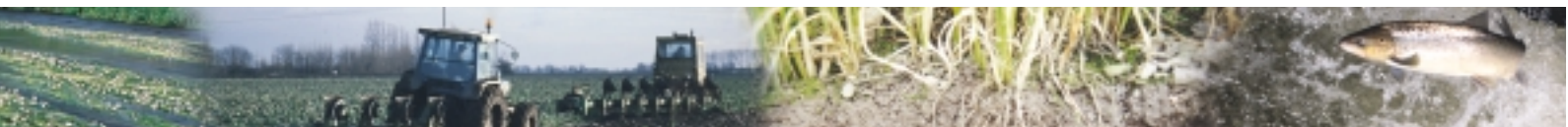
SMI COMMENT

Well thought out and progressively adopted; the large tractor allows wide cultivation which pulls a roll at the same time.At 28min/ha very good, but could be improved further with a 12m drill. If all land is ploughed, 400 man days would be required, whereas 69 man days are required using this reduced cultivation system.

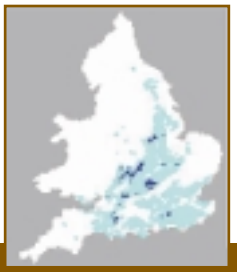
Soil Group	Type of Year	M.W.D.'s	AUTUMN SEP	OCT	NOV	WINTER DEC	JAN	FEB	SPRING MAR	APR	M.W.D.'s
Windsor	Normal	81									26
	Wet	60									5
Efford	Normal	121									46
	Wet	100									15

Man days required to complete autumn cultivation

1200ha with Spray ➡ Cultivator x 2 ➡ Drill	55
plus 400ha ploughed	100



CASE STUDY 4



Progressive adoption of reduced cultivation

Location	Wiltshire
Size, average field size and spread	352ha; 12ha; 6.4km
Soils and landscape	Predominantly flat land, largely on Gault Clay which here produces dense, slowly permeable clayey soils (Denchworth association), which suffer seasonal surface waterlogging. A small part of the farm has moderately permeable clay loam soils over chalky gravel, which is variably affected by groundwater (Block association). The farm has a few steep banks.
Cropping	200ha winter wheat (1st and 2nd wheats), 40ha winter oilseed rape and 64ha of other break crops.
Workforce	The farm is managed by family labour - farmer and father (part-time) plus extra help at harvest.
Equipment and cultivation machinery	Simba 2B Discs 3m; Simba 'Double-Disc' press; Paraplow; Cambridge rolls; Krause 3m No-Till drill; 150hp JCB Fastrac 2150 (new 2001); 110 hp Massey Ferguson 3080 (11 years old); 95hp Case 995 (8 years old); SprayCoup s/p Sprayer; Case 2188 Axial-Flow Combine.

Cultivation Policy

All crops are direct drilled following an inter-crop glyphosate spray, with the exception of oilseed rape, which is direct-drilled into chopped wheat straw and some beans which are broadcast and ploughed down. First wheats have a single pass of disc and press, second wheats have an additional disc and press prior to spraying. Sub-soiling is only done when necessary.

Costings and Work rates

Operation	Output (ha/hr)	Cost (£/ha)	Time taken (min/ha)
Discing & Pressing	2.8	25.0	22
Rolling	4.0	9.0	15
Direct-Drilling	2.8	5.0	22
Sub-soiling	1.4	40.0 (approx)	43
Spraying	16	7.5	3.75

Discussion	
Decision to change	To help control herbicide resistant blackgrass and slugs. Surface cultivation and stale seedbeds are additional tools for its control. Ploughing had not controlled black grass but simply rotated seeds annually and accentuated the problem.
How	The original plough, power harrow combi-drill system was progressively changed to a reduced cultivation system over 3 to 4 years. First the Amazone RPD drill was given disc coulters to allow it to work in trashy seedbeds. The old lightweight discs were replaced by Simba 2B discs and the single press by a heavier double press. This enabled a move away from ploughing. The following year the combine harvester was changed to a second hand Case Axial Flow to improve the ability to chop and spread straw/chaff and aid incorporation. In the third year the drill was changed to a 3m Krause triple disc drill capable of much higher work rates and able to direct-drill rape crops into undisturbed stubbles. Otherwise the stubbles are disced and pressed to create a stale seedbed, usually in one pass, but two passes are used when there is surface trash, and are left as long as possible to allow germination before spraying and drilling.
Benefits	The strategy has controlled black grass; the fine/firm seedbed has improved crop emergence and reduced slug activity; the system has created much local farmer interest and led to some contract work which has helped fund the purchase of new machinery. A dramatic reduction in establishment costs and an increase in work rate has been achieved.
Problems	Biggest problem is time to get a satisfactory stale seedbed. This may delay drilling of winter wheat until October- not ideal on the heavier land. Drilling output had to be increased in the reduced operational window. The Amazone combination, although effective, was slow (sometimes 4.8km/hr). The Krause drill does not leave such a good finish but at 12km/hr can cover far more land per day.
Solutions found	Delayed drilling can create problems in wet autumns, especially where stale seedbeds had been insufficiently re-consolidated. The Simba double disc press leaves a soil surface that will dry out unless conditions are intolerably wet.

SMI Soil Management Initiative

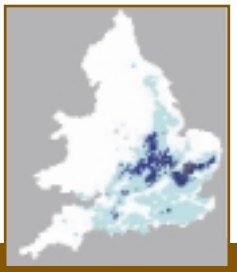
SMI Comment

Progressive adoption; the scheme has evolved in a sensible way. The time of 18min/ha is good for modest size equipment. There is ample time for timely crop establishment. A recent change to a Horsch cultivator drill has allowed the farmer to expand his operations to a further 280ha.

Soil Group	Type of Year	M.W.D.'s	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	M.W.D.'s
			AUTUMN			WINTER			SPRING		
Denchworth	Normal	40									5
	Wet	17									0
Block	Normal	90									15
	Wet	67									0
Man days required to complete autumn cultivation											
Culitivation plus D.D 240ha			25								
Man days required for traditionalo Cultivation											
(Plough, Harrow & Drill) 240ha			60								

CASE STUDY 5

Progressive adoption of new system, sharing equipment



Location	Leicestershire
Size, average field size and spread	310ha (shares labour and machinery with a neighbouring concern to give a total area of 607ha); 8ha; 3km.
Soils and landscape	Undulating land - the majority of soils suffer surface wetness caused by dense slowly permeable subsoils. Clay soils (Denchworth and Hanslope associations) predominate, the latter calcareous and developed on Chalky Boulder Clay. Small areas of well drained medium loamy soils (Banbury association) are included.
Cropping	65ha winter wheat (soft wheat varieties), 52ha winter barley, 28ha winter oats, 37ha winter oilseed rape, 39ha winter/spring beans and 50ha (permanent set aside).
Workforce	The manager and a tractor driver operate the farm.
Equipment and cultivation machinery	John Deere 7810, 180hp (3 years old); John Deere 6800, 120hp (6 years old); Fiat F140 140hp (6 years old); Ford 7840 100hp, (5 years old) (hired); Simba 4.4m 2b Discs, Simba 4.6m Cultipress, Simba 4m Freeflow Drill, 2 Accord 4m Air drills one as combination, 6 Furrow Dowdswell Plough, 5 Furrow Ransomes Plough, 4m Kuhn Powerharrow, Cousins 3m Flatlift.

Cultivation Policy

All the crops are established following a disc cultivation, flat-lift, cultipress, spray and drill with the exception of wheat after beans, which are drilled following a plough and power harrow, and beans which are broadcast, ploughed in and power harrowed.

Costings and Work rates

Operation	Cost (£/ha)
Discing	22
Cultipress	12
Freeflow drill	23
Ploughing	39
Power harrow	23

*Figures used for cultivation costs are taken from Central Association of Agricultual Values (2000) in order to compare with previous year's costings. As the farms' recording becomes more efficient they will be able to use actual costs.

Actual system costs 2000 (£/ha)	Winter Wheat	Winter Barley
Plough (Cultivations Early August)	120	
Non Inversion Cultivation (Cultivations Early August)	92	
Non Inversion Cultivation (Late Sept)		84
Plough (Cultivations Mid Sept onwards)	82	
Plough (Late Sept)		62
Average cereal cultivation costs 2000	92	
Average cereal cultivation costs 1999	113	
Average cereal cultivation costs 1998	111	

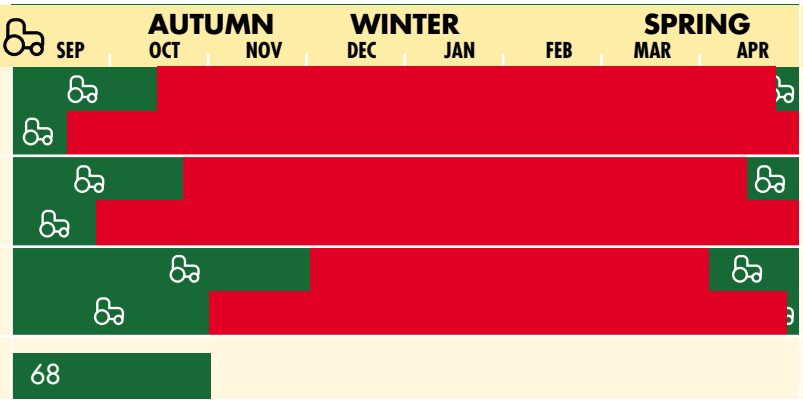
Discussion	
Decision to change	The need to reduce fixed costs has led to a joint venture with a neighbouring farmer, sharing both labour and cultivation equipment.
How	The plan to increase reduced cultivation saw the purchase of a 4m Simba Freeflow Drill and a 4.6m Simba Cultipress. This was to supplement some of the existing equipment in year one. In year two the addition of a larger traction unit and a disc cultivator means that more of the existing cultivation machinery will be sold.
Benefits	The farm has learnt a lot in autumn 2000 about over cultivating fields especially early on, when the weather was relatively dry. Two areas will need to be addressed in 2001. The first is the extra cosmetic discing, which was soon stopped, and the second, the separate subsoiling operation. These extra passes across the field have increased costs unnecessarily.
Problems	As the 2000 season progressed a number of factors beyond the farm's control further hampered efforts to drill winter crops. The progressively wet conditions reduced the amount of drilling able to be done with the Simba Drill - the combination was the best drill with which to continue.
Solutions found	Early autumn 2000 proved to be a relatively simple year to prepare seedbeds behind the plough (due to the abundant moisture) and some of the lower cultivation costs were achieved with this cultivation method. Costs shown give a comparison between early and late ploughing and show that some of the ploughed seedbeds cost significantly less than some of the reduced cultivation ones. Final yields will determine the success of the systems, for example, the wheat crop established early for £120/ha yielding 10 tonne/ha will give a better return than a crop established late behind the plough for £82/ha but yields only 8 tonne/ha. The comparison in yearly cultivation costs do not show the dramatic reduction hoped for but the aim is to reduce our total cultivation cost to about £72/ha or less next season without affecting yield.

SMI Soil Management Initiative

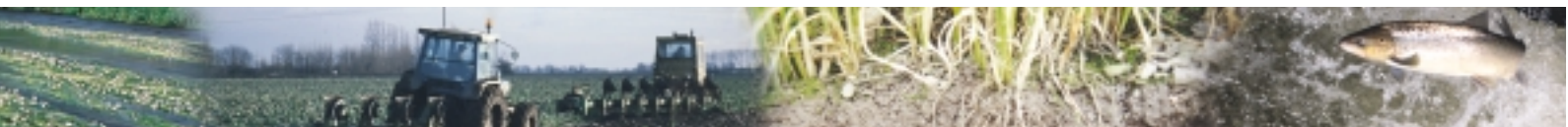
SMI Comment

Not unusual to accept a slower rate of work in the first year until a larger tractor can be purchased. Machinery workdays indicate there will be ample time to establish the crops in autumn, irrespective of cultivation system. However, over cultivation can be responsible for soil structural damage.

Soil Group	Type of Year	M.W.D.'s
Denchworth	Normal	43
	Wet	13
Hanslope	Normal	53
	Wet	23
Banbury	Normal	93
	Wet	63
Cultivation Plough system		68



M.W.D.'s
4
0
9
0
24
1



CASE STUDY 6

Large business adopting tined and plough cultivations to suit soils and cropping

Location	West of Salisbury
Size, average field size and spread	1630ha (four landowners)
Soils and landscape	The land, which is frequently steep, lies between 115 and 200m OD and is dominated by shallow flinty clay loam and silt clay loam soils over chalk (Upton and Andover associations). The highest land has deep well drained silty over clayey soils (Carstens association) formed in clay-with-flints which cap the hills.
Cropping	Cropping includes 480ha of winter wheat (mostly), 115ha winter barley, 280ha spring barley for malting, 220ha oilseed rape, 220ha peas, 85ha beans, 163ha set-aside, plus grass and an Environmentally Sensitive Area (ESA).
Workforce	A farm manager, with 2 full time staff, manages the farms on a flexible basis, bringing in self-employed and/or casual labour as needed.
Equipment and cultivation machinery	Case MX270 tractor on contract hire, with further tractors hired in for autumn cultivation and harvest. Case SP 3000 – 24m self-propelled sprayer on hire, with three Case 2388 combine harvesters. Five furrow plough + press, light weight Parmeter 3.25m discs and press, new 7.5m Horsch FG stubble cultivator, 7.6m Cambridge rolls, 6m Vaderstad NZ spring-tine cultivator, and a new 6m Vaderstad Rapide drill fitted with "system disc" replaced the existing Suffolk coulter drill.

Cultivation Policy

The established system, typical of Wiltshire, is plough and press, spring tine then drill. Reduced cultivation was used for the first time in autumn 2000 for the 1st wheat, 40% of winter barley, and all the oilseed rape. Spring barley was also established this way. A plough-based system is preferred to establish peas and beans at present, but the farm is experimenting with reduced cultivation on these crops.

Costings and Work rates

As the farm has only completed one autumn of reduced cultivation, costings are not available yet. Approximate work rates are as follows:

Operation	Output (ha/hr)	Cost (£/ha)	Time taken (min/ha)
Horsch FG cultivator	8.8	not available	7
Disc and press	3.8-5.0	not available	12-16
Vaderstad drill	6.3-7.5	not available	8-10
Sprayer	18.8	not available	7
Plough and press	1.5	not available	40
Vaderstad NZ spring-tine cultivator	5.0-6.3	not available	10-12
Suffolk Coulter drill	5.0	not available	12

Discussion	
Decision to change	The established system was relatively slow and expensive with a requirement for a highly trained workforce. Casual labour was employed to overcome peak workload, but the quality of ploughing was reduced. Plough maintenance was high on the flint soils with a need to replace plough metal twice a day under dry conditions and the existing Suffolk coulter drill had come to the end of it's useful life.
How	An immediate change to use of reduced cultivation for the most suitable parts of the rotation was brought in for autumn 2000. 80% of this is was carried out with two passes of the FG cultivator consolidated with Cambridge rolls, 20% with one pass of light discs and press, to establish seedbeds for wheat, barley and oilseed rape. The FG cultivator was brought as it was the ideal tool for the stony ground, and has a lower horsepower need than a disc and press on the slopes. Weeds are sprayed out and crops then drilled with the new Vaderstad Rapide drill. The drill was chosen as it provides a secondary cultivation, has a lower horsepower requirement than some other cultivator drills, can compensate to some extent for uneven slopes, and copes with straw unlike the old Accord. Meanwhile, the plough followed by Vaderstad spring tine cultivator is used to prepare seed beds for Peas and Beans drilled with the Vaderstad Rapide, as this system is felt to provide ideal drilling depth. 60% of the Barley is still established after ploughing. However, progressively more of the land will move to reduced cultivation as experience grows.
Benefits	Easier management of drilling process and increased drill outputs. Seedbeds are more level and are firmer providing better crop establishment. Reductions in cost are still to be quantified. Less soil erosion has been seen when comparing crops established by minimal and ploughed cultivation, particularly those that were established earlier and have good root structure.
Problems	The biggest problem is that the new cultivation and drilling equipment enables fast progress to be made, with the inevitable frustration when wet weather intervenes. Continuing to drill in poor conditions would not only bring poor crop establishment but also damage soil structure and must be resisted. Ensuring best establishment in difficult autumns. Do not be tempted to drill directly onto unpressed ploughed land. With the desire to increase the area under reduced cultivation there is still insufficient cultivation capacity as the current disc harrows are not wide enough.
Solutions found	Learning to be patient, and using the drill's higher output to drill more in better conditions! Ensure a good crop and spread of straw, cultivate and consolidate early, and do not cultivate too deep. Planned purchase of 6.5m Vaderstad Rexius C discs to replace current disc harrows in 2001.

SMI Soil Management Initiative

SMI Comment

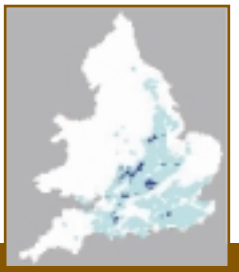
Good use of contract hire equipment – allows crops to be established in the machinery workdays available. No unexpected bills. Fewer working units easier for man management, but crop management more specialised. The reduced cultivation adopted allows twice the area to be established in the same number of man-days compared to the traditional 'Wiltshire' system.

Soil Group	Type of Year	M.W.D.'s	AUTUMN SEP OCT NOV	WINTER DEC JAN FEB	SPRING MAR APR	M.W.D.'s
Upto Andover	Normal	79				21
	Wet	57				0
Carstens	Normal	69				16
	Wet	47				0

Man days for minimum cultivation	Spring cultivations		
Cultivator; disc/press; spray; drill over 1000ha	66	20	280ha sp.barley
Established Wiltshire system plough/press; spring tine; drill over 1000ha	60	30	

CASE STUDY 7

Environmentally-driven, reduced cultivation systems



Location	Central Leicestershire
Size, average field size	2200ha; 10ha
Soils and landscape	The majority of soils suffer surface wetness caused by dense slowly permeable subsoils. Clay soils predominate (Denchworth and Hanslope associations), the latter calcareous and developed in Chalky Boulder Clay. Small areas of well drained, permeable medium loamy soils (Banbury association) are included.
Cropping	60ha are devoted to field-scale trials involving winter wheat, oilseed rape, winter beans, set-aside and rotational leys.
Workforce	Trials and farm team.
Equipment and cultivation machinery	The trial has the benefit of access to machinery used on the main estate as well as machines provided by manufacturers as part of the experiments. The seven fields used are around 10ha in size, but divided in half with one side adopting the cultivation practices typical of the main estate, while the other side adopts a policy of reduced cultivation or direct drilling wherever possible. 3.0m Rau Rotosem combined soil preparation and drilling. John Deere 750A No-Till drill, direct drill. 6.0m Vaderstad Rapide, combined cultivator drill. 3.0m Simba FreeFlow cultivator drill. Simba heavy discs. Cambridge rolls. Howard sub-soiler. 24m self-propelled sprayer.

Cultivation Policy

Traditionally the plough has been the main tool used in seedbed preparation on the estate, although there has been a move towards reduced cultivation with the purchase of a cultivator drill. The plough is still used exclusively going into and out of the ley phase and to establish beans. Rape after wheat is part- ploughed part reduced cultivation while wheat after rape is established with discs and a cultivator drill, as is wheat after beans. Current policy is to drill as much as possible with the cultivator drill until soils become to wet, finishing off with the plough. The reduced cultivation sides of the fields are only ploughed, on average, once per rotation (7 years). Wheat after rape and beans is done with a cultivator drill with a stale seedbed prepared in advance using heavy discs if the inter-crop period is sufficient. Rape after wheat is established with a direct drill into the stubble as is wheat after grass and grass after wheat. Beans after wheat are direct drilled into a previously disced and pressed seedbed, which has been sprayed out with glyphosate. This minimises soil disturbance during crop establishment and reduces subsequent weed emergence. Spring weed control is obtained using a harrowcomb weeder.

Costings and Work rates

Operation	Cost (£/ha)	Time taken (min/ha)
Ploughing	35	45
Power harrow combination	23	21
Sub soiler	32.6	67
Drill	43.2	13
Discs	22	12
Rolls	8.4	8
Direct Drill	43.2	13
Sprayer	4	7

Discussion	
Decision to change	The trial was established in 1993 to evaluate the economic performance, technical feasibility and environmental impact of a less intensive farming system. In contrast to other case studies, a strong environmental focus was a key objective of the trials development.
How	Different cultivation machinery was supplied by manufacturers to demonstrate the advantages and disadvantages of the various established methods.
Benefits	The benefits measured are wide-ranging. It is important to note that these have largely been achieved without financial disadvantage to the system. With less passes there has been less trafficking and lower compaction. This has led to lower fuel consumption and less implement wear. Conserving the organic matter at the surface and reducing the exposure of soil aggregates to oxygen has increased soil carbon and soil nitrogen levels. This has improved the environment for soil fauna, such as invertebrates and earthworms. In one field, which has not been ploughed since 1992, earthworm biomass has risen from 6g/m to over 1kg/m. This in turn reduces bulk density and improves structure and drainage. There is evidence of less sheet erosion because the organic matter provides a better-structured soil surface, particulate transport is reduced along with nitrate and phosphate losses to surrounding water courses. In the direct-drilled plot the presence of trash and stubble at the surface during the winter months has been shown to provide improved habitat for over wintering birds.
Problems	Drilled beans more accessible to rook predation. Direct-drilled crops on clay soil do not receive a well enough closed slot. Directly drilling small seeds after a trashy crop can be problematic. Reduced cultivation minimises the amount of N mineralised but this can lead to a poorly developing crop. Slugs.
Solutions found	Drill deeper (4cm), consolidate well. Protect seed using a seed dressing, mix pellets with the seed, roll after to close slot. Bale straw off, spread chaff well, roll after drilling to increase seed to soil contact. Apply autumn N, subject to SMN test, prevailing weather and conditions, and crop appearance. Consolidate, drill deeper.

SMI Soil Management Initiative

SMI Comment

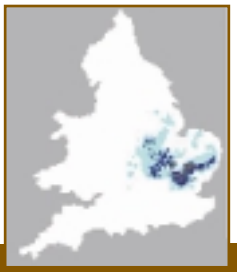
Range of equipment clearly applicable for an experimental and demonstration farm, whereas a single farm in a similar situation would need to decide the most appropriate set. Efficiency in crop establishment has been increased by approximately 60% using a reduced cultivation system.

Soil Group	Type of Year	M.W.D.'s	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	M.W.D.'s
Brockhurst 70%	Normal	47			AUTUMN		WINTER			SPRING	5
	Wet	18									0

Man days to complete autumn cultivation	
Beans ➡ wheat	4
OSR ➡ wheat	4
Wheat ➡ barley	4
Wheat ➡ OSR	1
Conventional Plough system 60ha	9

CASE STUDY 8

Simba Solo (discs/press/subsoil)/cultivator drill



Location	Suffolk
Size, average field size	752ha, 18ha
Soils and landscape	Farm is on relatively flat Chalky Boulder Clay. The land is dominated by dense, slowly permeable calcareous clayey soils (Hanslope association) with slight seasonal water logging. Locally, well-drained clay loam and sandy loam over clay with moderate permeability are typical (Melford Association).
Cropping	Crops comprise 327ha winter wheat (48% 1st, 52% 2nd) 101ha winter and 96ha spring barley, 57ha winter beans, 38ha winter oilseed rape and 67ha sugar beet.
Workforce	Three family members plus one employee manage the farm; there is no casual help over the harvest autumn period.
Equipment and cultivation machinery	Caterpillar 85 – 375 hp (3 years old bought second-hand 2000); John Deere 8400 – 260 hp; John Deere 6910 –140 hp; John Deere 6800 –120 hp; 24m pneumatic fertiliser spreader; Atlas Cleanacres Airtec sprayer; John Deere CTS combine new 2000; 10- and 6-furrow ploughs; 4.5m Simba Solo; 7m Toptilth; 8m Simba Double Press; 6m Vaderstad Rapide drill with front tines; 9m rolls.

Cultivation Policy

Seventy-four percent of 2nd winter wheat was established after ploughing and 26% established with the Solo after glyphosate has been applied to kill off any weed growth, whereas the 61% of winter barley after wheat was established with the Solo and 39% ploughed. Apart from Solo established oilseed rape, all other crops and sequences were established following the plough.

Crop Sequence	System	System Cost (£/ha)	Time taken (min/ha)
Winter wheat ➨ winter wheat	Plough (74%)	£96	94
Winter wheat ➨ winter wheat	Solo (26%)	£76	47
Winter wheat ➨ winter barley	Solo (61%)	£76	47
Winter wheat ➨ winter barley	Plough (39%)	£96	94
Winter barley ➨ oil seed rape	Solo (100%)	£76	47
Sugar beet ➨ winter wheat	Plough	£79	79
Winter wheat ➨ winter barley	Plough (60%)	£79	79
Winter barley ➨ sugar beet	Plough	£76	47

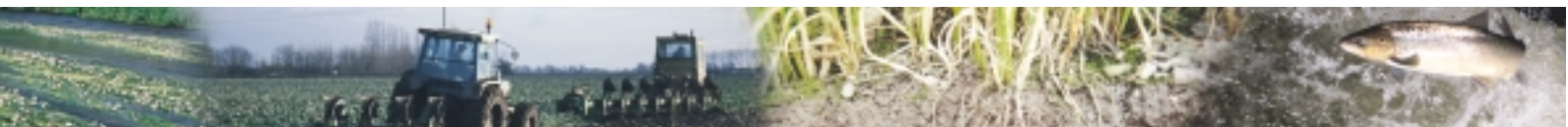
Discussion	
Decision to change	The farm has a good reputation for high yields, work and up to date machinery. It needs to have quicker and alternative establishment methods since realising the difficulty, the cost and timeliness of continuing to plough set against plans for expansion when land becomes available at a sensible price. Wheat yields are regularly more than 9.5 t/ha with high volumes of straw.
How	Part of the hectarage in rotation will be ploughed for the foreseeable future with the remainder established with the Solo system, which has shown undoubted promise.
Benefits	The advantages of taking out compaction during cultivation were well illustrated in some fields and this will result in fewer separate remedial operations overall. The farm is changing the 6m Rapide drill, bought second-hand and now 7 years old for an 8m System Disc version. They anticipate advantages of added mixing with more straw on the surface and enhanced opportunities for a much reduced scratch and drill cultivation, especially to establish the oilseed rape.
Problems	Following the very wet autumn in 2000 (860mm rainfall) and experiments with the new implement, fewer hectares were established with the Solo than had been expected. The Solo worked reasonably well with much promise but with the very high straw yields the soil/straw mix required another pass which limited the area in the autumn. Some 80ha were still to be drilled at the turn of the year (2000). Under the wet conditions the chop and straw spread from the CTS combine was not as good as expected.
Solutions found	Concerns about discing and smearing in wet conditions were allayed with the incorporation of subsoil tines in the Simba Solo. A small amount of base N was added to the P and K fertiliser applied by a contractor in the autumn to overcome the lock up of nitrogen found. Advantages for keeping the press separate from the Solo (24h later) were foreseen. The farm press needs upgrading with mixing tines and a levelling bar for best effect in tandem with the Solo, as a separate operation or working on ploughed land.

SMI Soil Management Initiative

SMI Comment

First year with the Solo; difficult year to start; family farm keen to expand but original plough too slow; therefore need to adopt some reduced cultivation approaches. Decision needed on most appropriate system. Insufficient machinery working days for use of plough to establish autumn crops without damaging soil.

Soil Group	Type of Year	M.W.D.'s	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	M.W.D.'s
			AUTUMN			WINTER			SPRING		
Hanslope	Normal	86									28
	Wet	65									7
Melford	Normal	122									43
	Wet	105									22
Man days required for use of plough on all autumn cultivations											
		520ha	82								



CASE STUDY 9

Planned change from plough to reduced cultivation system

Location	Cambridgeshire
Size	1483ha
Soils and landscape	The land is dominated by deep stoneless silt loam soils (Wisbech association) where groundwater levels are controlled by ditches and pumps. Towards the west, similar but clayey soils predominate (Wallasea association) and occasionally these overlie peat at depth (Dowels association). Locally, deep permeable sandy soils occur with peaty topsoils (Isleham association).
Cropping	Crops include winter wheat (646 ha), winter beans (191ha), spring beans (117ha), winter rape (67ha), Spring rape (69ha), sugar beet (110ha), potatoes (72ha), combinable peas (41ha), and set-aside (171ha). The farm usually grows vegetable crops, but this enterprise is being put on hold. Historically all the land was under the plough but the need to increase work rates with fewer staff has meant that reduced cultivation is now the preferred option for most of the combinable crops established in autumn.
Workforce	Workforce currently under change.
Equipment and cultivation machinery	The farm is in the process of re-equipping following the retirement of 2 CAT Challengers who have done most of the work on the estate when the plough was the primary tool. The proposed equipment is a single, new CAT Challenger or CASE Quadtrack which would be used for late summer/ autumn subsoiling operations and high-speed spring cultivations. This would also do winter ploughing in front of potatoes, sugar beet and other spring crops. A 270hp tractor will complete the draft equipment, capable of subsoiling, ploughing and pulling the triple bed former in front of potatoes. However its main use would be to pull a set of discs post-harvest for high speed crop establishment with a 6m Vaderstad Rapide drill.

Cultivation Policy

The farm is divided into two rotations based on the ability of the land to be irrigated. The rotation on this land is wheat/potatoes/peas/wheat/sugar beet/wheat/brassicas/brassicas. The non-irrigated land operates a rotation of wheat/rape/wheat/beans or set-aside.

Approximate work rates (costings not yet evaluated)

Operation	Output (ha/hr)	Time taken (min/ha)
Plough	1.2	50
Mono	1.2	50
Discs	3.0	20
Vaderstad drill	3.2	20
Rolls	6.0	10
Triple bed former	0.5	120

Discussion	
Decision to change	A re-appraisal was initiated because the Challengers were reaching the end of their life, the transfer of a Vaderstad drill from a sister farm and the suspension of vegetable production and low prices.
How	A move from ploughing to reduced cultivations in all crops where this can practically be achieved. Rape land going to wheat is now disced and pressed (once or twice depending on conditions), with tramlines subsoiled out if required. The stale seedbeds are sprayed off pre-drilling and direct- drilled with the Vaderstad Rapide. On wheat land going to rape the straw is baled off for sale to the local power station, with the rapeseed either broadcast with the pneumatic fertiliser spreader or direct-drilled with the Vaderstad Rapide. Wheat land going to beans is left post-harvest as a stubble with the beans broadcast on the surface and ploughed down to establish. Wheat going to second wheat is mostly ploughed to reduce trash borne diseases but increasingly non-inversion cultivation is used in conjunction with seed treatments. Root crop and spring sown break cropland is still ploughed.
Benefits	Increased output, timelier establishment, lower costs.
Problems	Vegetable crops leave much standing crop debris in the field and since many of these crops are harvested during the winter months the only effective method of disposal is the plough. Likewise trash from the sugar beet crop along with soil damage from the harvesting process means that intensive cultivations are required to restore soil structure.
Solutions found	Still building on experience before reducing the ploughed area.

SMI Soil Management Initiative

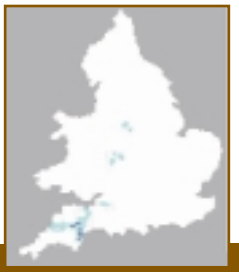
SMI Comment

The move away from brassicas and vining peas means that this farm can practice reduced cultivations across a wider hactarage, justifying the investment in new equipment. Ploughing will still need to be done for beet and potatoes, but at less than 200ha, contractors could do that in future. This system requires twice the machinery working days for crop establishment than is available in a normal year, therefore there is a need to increase the work rate especially for autumn establishment.

Soil Group	Type of Year	M.W.D.'s	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	M.W.D.'s
				AUTUMN		WINTER			SPRING		
Wisbech Isleham	Normal	122									46
	Wet	111									25
Wallasea Dowels	Normal	113									36
	Wet	91									15
Man days required to complete autumn establishment											
Traditional ploughing at 2½hr/ha		220									

CASE STUDY 10

Plough/power harrow system on an arable livestock farm



Location	Devon
Size	205ha (70ha redland 135 heavy Dunland over Culm Measures)
Soils and landscape	The red, gritty Crediton series soils are easily worked and do not poach, however they are droughty in dry summer weather. They contrast with the clayey Hallsworth and Halstow soils, which grow heavy grass crops, but which poach readily and are difficult as arable soils. Rainfall averages about 900mm a year, with autumn and winter typically the wettest seasons.
Cropping	Cropping involves 59ha of arable (all but 25ha on the Redland) given over to silage maize, 146ha of permanent grass and 52ha of leys. Slurries and manures from the 300 strong dairy herd, plus followers, are spread mainly on the Redland maize stubbles and grass fields on the Dunland, in accordance with the farm's waste management plan.
Workforce	Although run as a family farm, contractors carry out a proportion of the spring cultivations, all of the maize drilling and harvesting, and increasingly slurry application using umbilical spreading.
Equipment and cultivation machinery	Plough; 3m Kuhn power harrow; John Deere 120hp tractor. Contractors either 3 or 4m power harrow and 12 row combination drill. Harvesting by contractors.

Cultivation Policy

Procedures are tailored to the different soils. Maize harvest is followed by subsoiling, if ground conditions allow. Because maize harvest rarely takes place with dry soil conditions soil damage is to be expected. This can encourage runoff and is also a reason for the importance attached to subsoiling. On the Redland autumn ploughing follows immediately after slurry spreading on the maize stubbles, particularly on fields where winter runoff has been a problem. Any Redland unploughed in the autumn is left until March when slurry is applied prior to ploughing. All the maize land is then power harrowed, twice if needed, followed by drilling. Often autumn conditions rule out ploughing on the Dunland, although that is the preferred option. Spring ploughing of these difficult soils is commonly followed by Cambridge rolling, prior to power harrowing and drilling.

Costings and Work rates

Operation	Output (ha/hr)	Cost (£/ha)	Time taken (min/ha)
Ploughing	0.6	39	100
Rolling	3.5	7	17
Power harrowing	2.3	18	23
Drilling	2.5	23	24
Subsoiling	1.6	20	28

Discussion	
Decision to change	The cultivation systems remain largely unchanged as they suit the scale of operations on this mixed farm.
How	An important aspect is the use of maize stubbles for slurry and manure spreading in late winter and early spring. Slurry is not applied to maize stubble on the Dunland, only FYM.
Benefits	The farm has made maize silage for the last 20 years. In the last 2 years nearly all of the winter wheat hectarage has been converted to maize because of the farm's increasing forage needs and the fall in grain prices.
Problems	The Dunland is not ideal for maize growing. While ploughing is possible immediately after some harvests, in wet autumns it may have to be left, which then congests the workload in the following spring. Then maize yields are likely to be prejudiced by late sowing. Spring ploughing of this land rarely produces good conditions for forming seedbeds.
Solutions found	The easily worked, freely draining red soils are usually drilled at the optimal dates.

SMI Soil Management Initiative

SMI Comment

A plough is required on this soil type to take out old grass prior to reseeding. The success of the maize crop favours a plough-based system with the establishment of a good seedbed and nutrient release after frosting. A power harrow is required for spring cultivations, when autumn ploughing is not possible. Slurry disposal to stubble during winter and spring is a risky practice due to leaching and runoff and the soil compaction, which may occur. Application to top leys where available may be more appropriate. In a true mixed farm situation where cereals and break crops are grown, it is likely that the farm would continue to use same power harrow combination unless reduced cultivations were contracted out. Spring machinery workdays are very limited and soil damage in this system is more than likely to occur even in a normal year.

Soil Group	Type of Year	M.W.D.'s	AUTUMN SEP	OCT	NOV	WINTER DEC	JAN	FEB	SPRING MAR	APR	M.W.D.'s
Crediton	Normal	76									22
	Wet	52									0
Halstow Hallsworth	Normal	26									2
	Wet	2									0

Man days required to complete autumn cultivation

Plough 4

Spring cultivations

42 Harrow (+2) + drill for maize

CASE STUDY 11

Plough and reduced cultivation systems

Location	Suffolk
Size	938ha
Soils and landscape	On Chalky Boulder Clay with predominantly dense soils that are slowly permeable and seasonally waterlogged. Clay loam or sandy clay loam soils over clay (Beccles association) are widespread, mixed with better-structured calcareous clays (Hanslope association). This case study comprises several farms within a 12km (8 mile) radius. Fields are predominantly flat with some gradual slopes.
Cropping	Apart from 89ha of sugar beet, 51ha of vining peas and 128ha set aside, the crops are all combinable with 523ha winter wheat, 73ha winter oilseed rape, 37ha winter barley and 37ha spring barley.
Workforce	Two working partners and 2 full time tractor drivers' plus causal help at harvest manage the farm.
Equipment and cultivation machinery	2 x Caterpillar 55 - 270 hp, 400 hp 4 years old (second-hand 2000); 2 x 12 5 hp wheeled tractors; 100 hp runabout tractor; 80 hp runabout tractor; 24m Amazone pneumatic fertiliser spreader; 24 m Sands 2000l Self Propelled Sprayer with Airtec nozzles; Claas Lexion 480 combine with a Horsch trailer. For cultivation a 10- and 5-furrow plough, 8m Vaderstad Press, 8m Vaderstad cultivator with Crosskill rolls'; 6m Simba Solo, 6m Vaderstad Rapid drill with front tines, 12m rolls.

Cultivation Policy

Until recently the farm has almost exclusively ploughed, having reduced ploughing time and cost to a minimum with high output machinery. Part of the decision for further change was due to the expansion in the area farmed, often taking in land with a blackgrass weed problem. Ploughing is seen as a very complete operation, but the farm size is now such that alternatives to the plough on part of the hectarage needs to be and is being considered. The farm is changing the 6m Vaderstad Rapide drill, bought second-hand and now 7 years old, for an 8m System Disc version. The farm anticipates it will bring advantages of added mixing with more straw on the surface and open up enhanced opportunities for a much-reduced scratch and drill cultivation, especially to establish the oilseed rape.

Realising the increased cost and resulting times of continuing to plough set against the plans for expansion when land becomes available at a sensible price, the farm decided they needed to have a quicker and alternative establishment method. The wheat yields are regularly above 10 tonnes per ha with the resulting high volumes of straw. The concerns of discing and smearing in wet conditions were allayed with the incorporation of subsoil tines in the Simba Solo. Less hectares were established with the Solo in the wet autumn of 2000 than had been expected.

Previous crop	New crop (2001 season)	Plough or *Solo	Approximate cost (£/ha)	Approximate overall time (min/ha)
1st winter wheat	2nd winter wheat	Plough	£96	94
1st winter wheat	2nd winter wheat	Solo	£76	47
Winter wheat	Winter barley	Solo	£76	47
Winter wheat	Winter barley	Plough	£96	94
Winter barley	Oilseed rape	Solo	£76	47
Winter barley	Oilseed rape	Plough	£96	94
Sugar beet	Winter wheat	Plough	£79	79
Winter wheat	Winter beans	Plough	£79	79
Winter wheat	Sugar beet	Anticipated Solo, but will plough	£76	47

* No glyphosate spray has been used to date to kill off any weed growth. Where a second pass has been necessary behind the Solo a further 15 minutes per ha and a cost of £15 per ha needs to be added.

Discussion	
Decision to change	The farm has a good reputation in the area for producing high yields and generally doing the job well with up-to-date machinery. They are keen to expand when extra land can be acquired at the right price and they anticipate and need to have a proven cultivation system in place for this expansion.
How	They visualise continuing to plough at least part of the hectarage in rotation for the foreseeable future. The Solo has worked reasonably well showing undoubted promise but at times the very high straw yields has necessitated another pass and the wet autumn has limited the area that was anticipated for the Solo.
Benefits	The advantages of taking out compaction during cultivation were well illustrated in some fields and this will result in less separate remedial operations overall. Another cultivation pass is likely to be necessary in some fields. The owners see advantages in keeping the press separate from the Solo, perhaps 24 hours later.
Problems	Under the wet conditions the chop and straw spread resulting from the CTS combine was not as good as was hoped for, showing how critical this is to minimise the number of passes.
Solutions found	The farm press needs upgrading with a levelling bar for best effect in tandem with the Solo, as a separate operation or working on ploughed land. A small amount of base N is likely to be added to the P and K fertiliser applied by a contractor in the autumn to overcome the lock up of nitrogen which has been found.

SMI Soil Management Initiative

SMI Comment

Traditional and well respected farm; can just about manage with all-plough situation. With the intention to farm more land, alternatives to the plough must be sought. However, this reduced plough system saves 50min/ha, equivalent to 67 man-days in autumn and 19 man-days in spring. In future, weeds should be sprayed out before drilling.

Soil Group	Type of Year	M.W.D.'s	AUTUMN SEP OCT NOV	WINTER DEC JAN FEB	SPRING MAR APR	M.W.D.'s
Beccles Hanslope	Normal	77				24
	Wet	60				3

Man days required for current reduced cultivation

Plough/press/drill/roll = 1.67hr/ha approx 800ha (810)	133	36
Plough/harrow/drill = 2½hr/ha approx 800ha (810)	200	55

CASE STUDY 12

Plough based system, sandy soils

Location	Nottinghamshire
Size, average field size and spread	135ha
Soils and landscape	Soils are generally deep permeable well-drained and sandy (Cuckney association) with shallow soils over soft sandstone on steeper slopes (Bridgnorth series). Sandy soils suffering seasonal wetness flank the water courses (Blackwood association).
Cropping	The typical rotation is cereals (first wheat/barley followed by second cereal winter barley 60ha) followed by peas or a root break crop of potatoes (20 ha) or sugar beet (20ha). Approximately 10ha of the farm is in rotational or permanent set aside with Miscanthus, and approximately 10ha is rented to carrot and onion growers. Sixty beef cattle are kept on 15ha of permanent grassland and these are finished indoors.
Workforce	The farm is run by a manager and a staff of five who are also involved with experimental work.
Equipment and cultivation machinery	Four tractors 110hp, 95hp, two 85hp all approximately 5 years old. Doweswell 4 furrow plough, Furrow press and 4m Nordsten drill and Ransom subsoiler.

Cultivation Policy

The plough and press have traditionally been the main tools used in seedbed preparation. Drilling is directly into pressed land, which aids water conservation and minimises wind erosion. The number of machinery workdays is high in autumn and spring, with soils draining quickly enabling most operations to take place when soil is within a few days of field capacity following heavy rainfall. Land going into root crops is left in stubble and old tramlines are used to spray weeds off with glyphosate. Low-pressure tyres are used for spring spraying. Subsoiling is carried out on headlands and down tramlines before a root crop. Stubble is cut at approximately 10cm and all straw is baled for the farms' own use or sold for over wintering carrots. Slurries and manures from the livestock are spread onto cereal stubbles post-harvest or applied to land following sugar beet in January and February and ploughed in. Irrigation is necessary for potatoes, carrots both receiving 200 to 300mm (8 to 12'') per annum and sugar beet about 100mm (4'') per annum. Sugar beet drilling and harvesting is contracted out.

Combinable crops	Cost £/ha	Output ha/hr	Root crops	Cost £/ha	Output ha/hr
Subsoiler	35	1.3	Plough and press	39	1.0
Plough and press	39	1.0	Bedforming	30	0.8
Drill	19	2.0	Stone separator	130	0.4
Cambridge roll	9	4.0	Potato planting 2 row	50	0.4
Spraying	8	6.3	Spraying	8	3.8

Discussion	
Decision to change	Alternative systems of cultivation have not been considered on the farm.
How	Approximately one third of the farm has vegetation cover/stubble through the autumn, winter and early spring period.
Benefits	Costs are low and operations simple, vegetation cover provides protection from wind or water erosion and cover/food source for wildlife. Addition of manures assists nutrient supply and reincorporates some organic matter.
Problems	High wear and tear on cultivation equipment due to sandy texture and stone content. Potato cyst nematode (PCN) can cause a problem with potatoes. Wind and water erosion can be a problem on these light sandy soils. Potato volunteers cause a problem in following crops. Surface conditions in these very permeable soils can be misleading after wet weather and trafficking too soon after wet weather can cause subsoil damage.
Solutions found	Machinery fitter employed on the farm to maintain/repair equipment. Pressing after drilling reduces 'wind-blow' which can be a severe problem in this area and fields are left in stubble prior to cultivations for root crops. Rotations are being 'stretched' so that potatoes are now grown on a 5-7 year rotation to reduce PCN pressure. Aldicarb is applied where control problems persist. Rotation experiments are ongoing to assist control of potato volunteers, for example, potatoes, sugar beet, winter wheat, winter wheat.

SMI Soil Management Initiative

SMI Comment

Ploughing is the best option for maintaining structure, optimal cost for the size and type of the farming operation and use with potatoes and sugar beet. There are good returns from renting land to high value crop (carrots/onions) producers. There is higher than average manpower due to research/trials requirements. Surface profiling could reduce erosion risks further. Leaving ex-potato ground unploughed until late winter would reduce the volunteer problem.

There are adequate man-days for autumn establishment, irrespective of type of year but insufficient for spring crops in wet years. Localised damage can occur if soil is worked too soon after heavy rain.

Soil Group	Type of Year	M.W.D.'s	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	M.W.D.'s
Cuckney	Normal	114									40
	Wet	84									19
Blackwood	Normal	104									30
	Wet	74									9

AUTUMN WINTER SPRING

Man days required to complete autumn cultivation

Plough/press ➡ drill 125ha — 58

Spring cultivations

25 — Plough ➡ bedforming ➡ planting 40ha roots

SUMMARY OF CASE STUDIES.

These case studies were put together in order to demonstrate the range of options that can be used effectively and are dependent upon soil type, farm size and location, and crops grown. In many of the studies the cultivation practice is substantially different from what it was a decade previously, and in all cases is still evolving. In many cases the decision to change a robust, tried and tested set of cultivation practices has come about when a machine has reached the end of it's useful life. However, increasingly it is in response to economic pressure or linked to an increase in the size of farmed area. Successful cultivation strategies are based around forward planning, flexibility, the ability to respond to field conditions and attention to detail. There is not necessarily a right and a wrong way. That said, in all the case studies the practitioners highlighted parts of the system which challenged them and gave rise to problems which had to be tackled. A number of these were common to a range of soils and equipment while others were very specific.

Challenges

Coping with trash

There are a range of options to mitigate against problems including better straw chopping and chaff spreading, early post-harvest incorporation and, if necessary an additional pass either to spread the straw on the soil surface prior to incorporation or to facilitate further breakdown after initial incorporation. Extending the inter-crop period by changing the rotation or delaying drilling can also help, but this should be approached with caution because of the economic and practical consequences. Nitrogen can be applied in the autumn to both direct drilled and straw incorporated situations. In the former scenario nitrogen may be in short supply because none has been released while in the latter it has been locked up in the straw degradation process. N applications should be made with regard to the state of the crop, the level of mineral N in the soil and the prevailing weather conditions.

Slugs can be dealt with using both physical and chemical options. Creating a stale seedbed is hugely beneficial to reducing weed pressure which can occur in the crop post-drilling, but it also creates a green bridge which benefits slugs. Population monitoring can be targeted to high risk situations. In dry conditions it may be appropriate to mix pellets with seed as slugs are likely to be seeking refuge within the soil, while in wet conditions a surface application is likely to be more effective. The best solution is good seed placement in a good seedbed, with good consolidation with increased seed rates and seed dressings also being beneficial.

Where trash is in the form of green matter, for instance, the tops of sugar beet or the stems and leaves of brassica crops, the cultivations required to make a seed bed will depend on the time of year. However this is most likely to be in the late autumn or winter when soil conditions have deteriorated and more intensive cultivations are required to restore soil structure and dispose of trash.

Weeds

Dealing with weeds is intrinsically linked with cultivations. There are a number of options depending on the crop, time of sowing and crop rotation. Ideally the inter-crop period is good for reducing the seed bank but stubble cleaning sprays and pre-harvest desiccants also help. Non-inversion of potato land post harvest is the best way to reduce volunteer problems since a high proportion of discarded tubers become frosted.

Reduced cultivation techniques can give rise to another difficulty; the crop and the weeds are at similar developmental stages across the farm. This puts pressure on the herbicide sprays which the crops require during November, since there are insufficient spray days at this time to get all crops treated. As an option use a pre-emergence residual herbicide on a proportion of the drilled hectarage. Consider using a BYDV seed treatment to avoid additional spray treatments.

Soil erosion

In some cases extending the inter-crop period to enable stale seed beds to develop is not practical since early crop establishment is used to stabilise soil. Likewise, on some soil types the finer tilth developed by some reduced cultivation equipment increases erosion vulnerability compared to the more lumpy structure behind the plough. The incorporation of straw and other crop residues can help to reduce erosion and on some slopes and soil types. Direct drilling with the stubble left intact can work well.

Root crops

For most root crops the growing system demands the formation of beds and this means substantial soil upheaval. The cheapest and most effective way of achieving this is by deep ploughing with limited alternatives. Similarly maize grown on heavy land needs excellent soil conditions to establish and these are best achieved by ploughing during the winter to create a frost mould. The threat of erosion and loss of soil nitrogen can be reduced by delaying ploughing until February.

COMMON Q & A

Q Why will reduced cultivations succeed now, when it failed in the '70's?

A We are not only talking about direct drilling this time

A The system is flexible. We know the risks – grass weeds, herbicide resistance etc. You can still plough

A Cultivation technology has improved
- Heavier discs, sometimes in partnership with tines, which do not lead to smearing and panning are available
- Presses are better and more available to ensure that there is good consolidation
- Cultivator drills are available which work well in a range of conditions

A Herbicide technology has improved
- Grass weed herbicides for non-cereals crops
- Range of residual and foliage applied herbicides in cereals
- New herbicides in pipeline.

Q Surely the cheapest method of establishment is the one you already have? Any expenditure only benefits the machine manufacturers?

A Yes it might be. If you only have capacity for one system, then what you have might be right

A But make sure you know the costs of the current system. You may be able to use it more effectively
- Are all passes justified?
- Do you do recreational cultivation?
- An extra pass costs money – it is not free just because someone is available
- Is the current system increasing costs elsewhere – need for sub-soiling, loss of crop and nutrients due to erosion

A Often investing in larger capacity and reducing numbers of machines can save labour costs, establishment costs and growing costs

A May be harder for smaller farms to justify extra expense. Consider sharing with neighbours, or contracting the operation in, or offering your services as a contractor to others

A Progressive adoption of the technique is both practical and a way of reducing costs of adopting it – consider cultivator/press first to replace power harrow but to provide seedbed for a variety of drills; then replace drill and finally plough (or consider retaining it for rotational ploughing).

Q How do you control grass weeds such as barren (or sterile) brome and black-grass without a plough? What rotational changes are required in a reduced cultivation system?

A This is a big concern and major challenge for which you need to plan ahead. The answer is rotation, rotation, rotation, rotation

A Rotation of crops. Use crops in the rotation to maximum advantage. Good/excellent control of grass weeds can be achieved in oilseed rape for instance using specific graminicides (Fusilade, Falcon, Pilot, Laser)

A Rotation of herbicides. Rotation of crops allows easier rotation of herbicides – this helps minimise the risk of herbicide-resistance

A Rotation of drilling dates. Delay drilling in some seasons to allow maximum germination of weed seeds prior to drilling. Do not drill same fields first every year – rotate drilling dates in fields. Maximise germination of weed seed in stubble by cultivation, then consolidation then **whether or not drilling is delayed, use a non-selective herbicide to remove weeds**

A Rotational use of plough. It may be necessary to use the plough on a rotational basis. For barren brome quality of ploughing is important. Make sure you bury seeds, very few will survive burial for over one year.

Q Will reduced cultivation send my slug control bill sky high?

This is a potential risk. The key to minimising this is:
- A good straw chop
- Good spread of chaff
- Get a well structured seedbed by working from top down
- Consolidate the stale seedbed
- Remove green material pre-sowing with non-selective herbicide

- Try and make sure drilling is at 4cm
- Consolidate the seedbed maximise crop emergence and eliminate slug 'motorways'.

Q What is the long term impact on compaction and natural drainage?

A Check for and correct existing problems before you start with reduced cultivation. Only sub-soil when needed and ensure depth is correct for problem

A The undisturbed soil will begin to develop its own natural structure with pores and cracks through cycles of wetting and drying

A Soil fauna will increase and their activity will increase the natural structure and porosit.

A Incorporation of organic material will help to stabilise the structure and support the soil fauna

A Plough pans and smeared surfaces will begin to break up but rotational sub-soiling on less well structured soils or where required is vital

A Improved structure and porosity improves natural drainage

A Improved drainage reduces soil erosion, ponding and increases the loading strength of the soil.

Q Are there any soil types not suited to reduced cultivation methods? Should light and heavy soils be managed differently?

A It should be possible on most soils, but the machinery and management will be different

A Reduced cultivation is ideally suited to the well structured (especially clays) soils

- Greater choice of suitable equipment may already be available. Benefits from a drill with more cultivation capability which in turn gives flexibility to use more cultivator options
- Autumn cropping dominates and autumn cultivation will be the norm, even before spring crops.

A On less well structured soils (such as silts, sands) more care is required

- Correcting soil structure before you start is essential. Monitoring soil structure as you progress is also vital
- Lighter wider equipment (discs or tine cultivators) are required, also lighter wider presses. Ideally consider a drill which does less cultivation
- Before autumn sown crops, autumn cultivation is successful, especially in dry autumns when moisture conservation is important
- Leave seedbed coarser
- Prior to spring sown crops, spring cultivation is normally best. In a dry spring this conserves moisture over deeper cultivation.

Q How effective is reduced cultivation equipment at incorporating bulk organic matter products such as sewage sludge cake and paper waste?

A Growers are successfully incorporating large amounts of organic manure and sewage sludge

A You do not need to get rid of the organic matter, just to incorporate it and get good crop establishment

A Incorporating less than 8t/ha of chopped dry wheat straw has not been a problem.

Q Can you increase yields from a reduced cultivation system?

A Depends where you are starting from! If you are doing everything right now, possibly not Advantage may only be to reduce costs. Also remember that if costs are reduced more than yield that overall it will increase profit margin Aim to reduce costs of production whilst maintaining or increasing yield

A Yes there is potential to increase yields. Examples include:

- Dry years when moisture conservation increases establishment
- Increased crop area being established at the optimum time

A If you let grass weeds dominate, then as we all know yields may suffer. This risk increases as years go on and from early drilling

A It is very important to balance potential yield increases from early drilling with yield losses from increased grass weeds from early drilling. Also note that in high take all risk situations (such as second, third or fourth wheats) that later drilling will reduce take all and improve yields.

Q What are the pros and cons of different reduced cultivation drills? Which one is best for me?

A Tine cultivator drill:

- Good on cost and flexibility
- Does not leave slots
- Less wear
- Potentially very accurate depth of drilling control
- Can handle higher volumes of surface trash

A Disc cultivator drill:

- Minimal soil disturbance and therefore opportunity for further weed germination
- Most expensive
- Does not cope as well in wet, can leave slits which favours slugs and can push straw into the slit which leads to poor soil:seed contact and hence emergence

A Disc direct drill:

- Direct drill
- Cheaper that disc cultivator drill and as good with similar issues
- However, no soil movement or consolidation at all so can leave straw in slit giving very anaerobic conditions if wet which kills crops. Can also lead to greater compaction

A Normal coulter drill:

- Unsuitable in presence of a lot of straw or clods
- Disc coulters better way into a reduced cultivation system.

Q I want to keep my plough, can I still reduce costs and improve the environment?

A It many circumstances it will be appropriate to retain the plough, particularly during the transition period and when learning how best to manage the land, particularly when the plough has already depreciated. If it is not cost effective to keep the plough, consider using contractors or share farming. Alternatively the plough can be used more efficiently, on-going research indicates that shallow ploughing (15-20cm) can save time and energy and can cover more land area than deeper ploughing. The final results may not be so neat and tidy and there may be implications for weed control.

ENVIRONMENTAL CONSEQUENCES

Inappropriate soil management causes many environmental problems and is dependent on several interacting factors. Excessive run-off creates soil erosion leading to relocation of sediments to roads, property, rivers and lakes, flooding, disruption of water supplies and impacts on crop growth and productivity.

Guidelines assessing and reducing the risk of soil erosion are available from DEFRA.

- Soil type, structure and condition – sandy, silty and those with low organic matter are most vulnerable to water erosion: sandy and peaty soils are prone to wind erosion
- Crop cover – bare soil in winter encourages water movement across the soil surface
- Slope – erosion can occur on any slope
- Compaction – prevents infiltration of rain
- Type of cultivation – excessive cultivation creates greatest risk
- Type of seedbed – fine tilth and level seedbeds encouraging capping
- Weather - amount of rainfall and intensity
- Cropping – root crops, maize and vegetables can pose the greatest risk
- Straw disposal method – surface and incorporated crop residues help add stability and aid infiltration
- Field characteristics – long, unbroken slopes can encourage run-off: hedgerows, grassland, woodland strips and buffer strips halt the movement of water and soil
- Field drainage – effective drainage prevents water surface accumulation of water
- Livestock enterprises – grazing and trampling of river banks, poaching by stock and run-off from farm tracks are other causes of soil degradation.

Leaching of nutrients and pesticides into surface and ground water causes eutrophication and may pose a threat to aquatic organisms and impact on drinking water quality. Loss of soil and agrochemicals is not only a source of pollution but is also a waste of valuable resources.

- Soil type – sandy soils are the least retentive: drained, structured clay soils can rapidly transport pollutants
- Crop cover – bare ground over the winter is most vulnerable
- Capping and compaction – promotes soil run-off containing nutrients and pesticides
- Cultivation type – ploughing stimulates N mineralisation in the autumn
- Soil organic matter – binds nutrients and pesticides
- Fertiliser – type (inorganic, slurry, manures), rate and timing of application influence leaching or runoff.

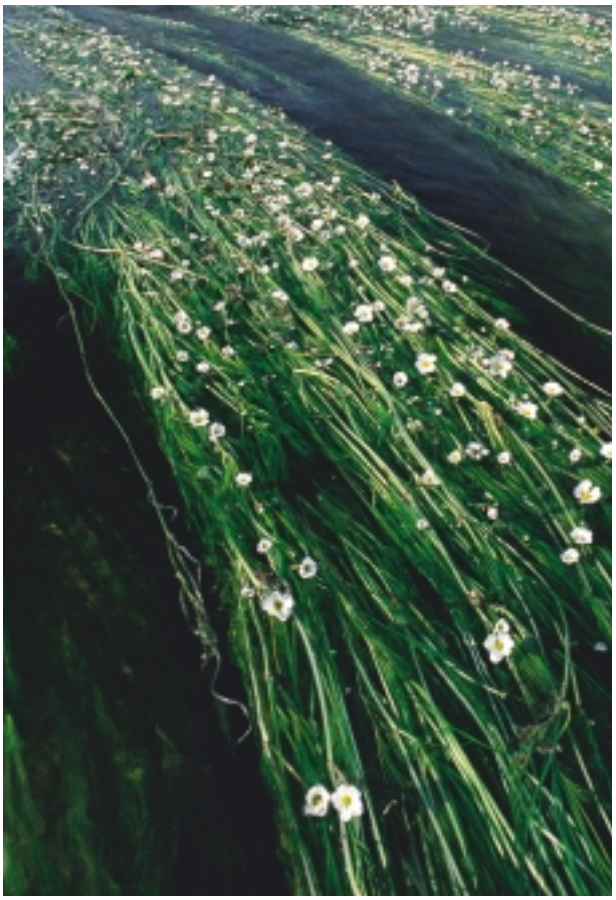
Agricultural systems both produce and consume carbon dioxide, 20% of the carbon dioxide released globally is estimated to come from soil processes or as a result of land-use change. Organic matter acts as the reservoir for organic carbon; this element is constantly alternating (sequestrating) from solid form in plants and soil, and gaseous form in the atmosphere (CO_2).

- Intensive and inappropriate cultivation depletes soil organic matter
- Total carbon loss (as CO_2) from ploughed land can be 5 times higher than from unploughed land
- Proposals for a carbon tax in the UK will require farmers to consider methods to reduce CO_2 emissions
- Future CO_2 trading may enable farmers to claim compensation with power generating companies for no-plough techniques, as already practised in the US mid-west.

ENVIRONMENTAL BENEFITS

Improved soil management can have many benefits.

- When crop residues are left on the surface or incorporated, a more stable soil habitat with a high organic matter content is created.



- Micro-organisms break down organic matter and perform many useful functions: they recycle crop residues making the nutrients available to the crop; a richer soil biota ensures pesticides are efficiently degraded and they promote good soil structure and quality
- Earthworms numbers increase and recycle organic material thus promoting soil health
- Soil fauna which over winter are better able to survive and contribute to both pest control and food sources for farmland birds
- Weed and crop seeds remaining on the surface are available for birds, mammals and insects
- Biodiversity and species richness is increased
- The presence of vegetation, soil organic matter and improved soil structure increases infiltration
- By creating a more healthy soil with better structure, crop rooting is improved, crop stress created by extremes is lower and consequently there may be less need for pesticides
- Nutrient and agrochemical losses are reduced
- Soil erosion and off site impacts are reduced for example, control of soil erosion reduces silt deposition in river beds protecting fish spawning and their food supply
- Reduced cultivations offer possibilities to lower CO_2 emissions and reduce energy use (fuel).

FURTHER READING

The following reports can provide further information

- You can obtain a copy of the WRAG Guidelines through your agronomist or agrochemical adviser. Alternatively copies are available free of charge from: Home-Grown Cereals Authority, Caledonia House, 223 Pentonville Road, King's Cross, London N1 9NG; Crop Protection Association, 4 Lincoln Court, Lincoln Road, Peterborough PE1 2RP or UKASTA, 3 Whitehall Court, London SW1A 2EQ. They are also accessible on **www.farmline.com/hgca/grassweedsguideline/**

- DEFRA and MAFF reports are available from DEFRA Publications, Admail 6000, London SW1A 2XX or telephone 08459 556000

Code of Good Agricultural Practice for the Protection of Soil. 1998. MAFF Publications, London

Controlling Soil Erosion - Advice for preventing erosion by water in lowland England. 1999. MAFF Publications, London

Main document:

A manual for the Assessment and Management of Agricultural Land at Risk of Water Erosion in Lowland England: PB4093

Three complimentary Leaflets:

A field guide for an erosion risk assessment for farmers and consultants: PB4092

An advisory booklet for the management of agricultural land: PB3280

An advisory leaflet for preventing erosion caused by grazing livestock in lowland England: PB4091

Folder for above: PB4262

- A Guide to Better Soil Structure: 2001. National Soil Resources Institute, Cranfield University, Silsoe, MK45 4DT Telephone 01525 863000

- Best Farming Practices: profitting from a good environment. 2001. Environment Agency, Bristol. Telephone 01454 624400. www.environment-agency.gov.uk

- SMI Leaflet: Improved Soil Management for Agronomic and Economic Gain ; www.smi.org.uk

- Changing Cultivation Practices. 2001, 25 minute video, SMI/ADAS, ADAS Boxworth, Cambridge, CB3 8NN. Telephone 01954 267666

Designed and produced by ADAS Marketing. Telephone 01902 693340

WHERE DO I GO FROM HERE?

The UK Soil Management Initiative

- Sustainable soil management
- Maximise arable production for profit
- Protect and enhance the Environment

This guideline has been compiled by members of the UK Soil Management Initiative Ltd (SMI). SMI is an independent organisation created to promote the adoption by UK farmers and advisers of systems designed to protect and enhance soil quality. Agronomic and economic benefits may then be accrued whilst also improving the environment for example, through reduced soil erosion and water pollution or increased habitats/food supply for wildlife. SMI achieves its objectives through information transfer and advice.

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