NSW DEPARTMENT OF
PRIMARY INDUSTRIES

SOILpak – cotton growers - Readers' Note

This document is part of a larger publication. The remaining parts and full version of the publication can be found at:

http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/soilpak/cotton

Updated versions of this document can also be found at the above web address.

PART B. QUICK HELP

B1. Trouble-shooting guide

As described in Chapter A2, the soil should supply plants with adequate water, oxygen, nutrients and support. When the soil does not furnish these needs, we say that there is a soil problem.

Common soil-related problems under cotton include:
- poor seedling emergence
- poor crop growth and disappointing yields
- excessive expenditure on land preparation and management
- too much soil loss by erosion.

A soil problem may be due to:
- recent management (for example, compaction, remoulding and smearing when `middle-busting' a soil that is too wet)
- a residual management problem (for example, deep subsoil compaction caused by heavy landforming equipment under moist conditions on soil with a poor self-regeneration potential).
- a 'natural' problem present at the time of European settlement (for example, sodicity caused by saline dust storms tens of thousands of years ago, or subsoil acidity created by brigalow forests).

Consider the needs of plants, examine the soil, and then deduce the problem. You will then be able to choose a management strategy to deal with the problem, keeping in mind that treatment costs should not exceed expected benefits.

The following figures will help you to determine the cause of a soil problem, and direct you to sections of the manual with more detailed information.

Figure B1-1. Soil-related problems under cotton—introductory flow diagram.
Figure B1-2. Soil problems associated with poor seedling emergence—possible causes and where to get help.
Figure B1-3. Soil problems associated with poor crop growth and yield—possible causes and where to get help.
Figure B1-4. Problems associated with excessive expenditure on land preparation and management—possible causes and where to get help.
Figure B1-5. Problems associated with too much soil loss by erosion—possible causes and where to get help.

Figure B1-1. Soil related problems under cotton—introductory flow diagram

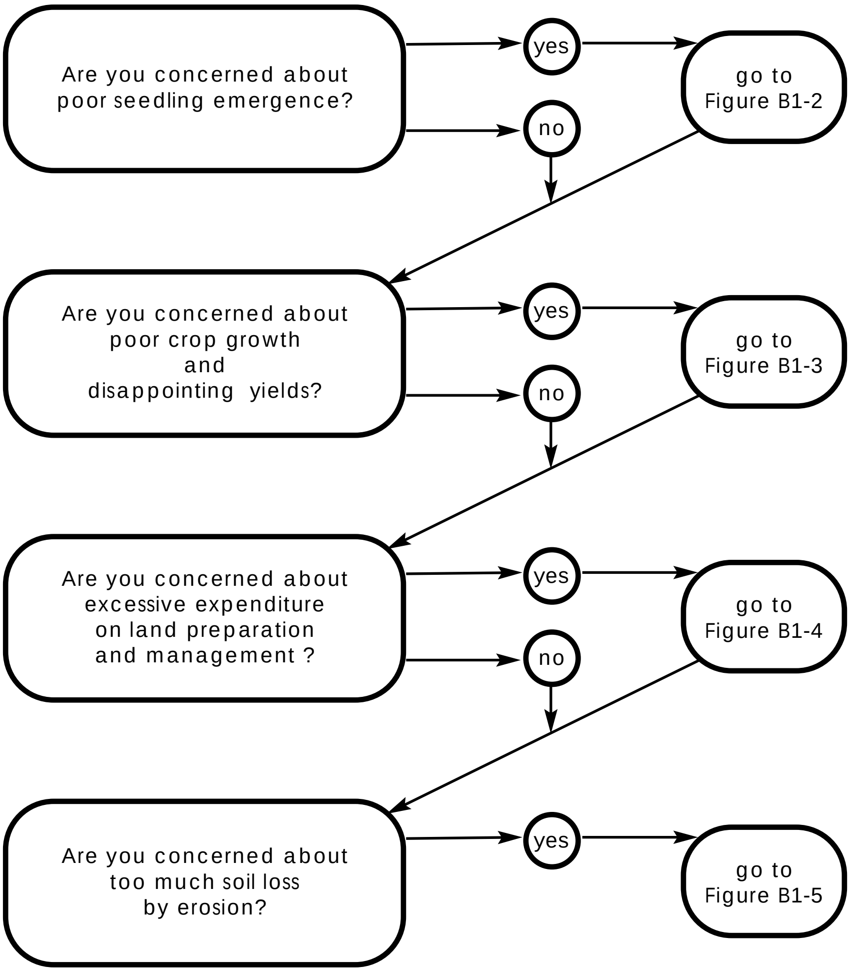


Figure B1-2. Soil problems associated with poor seedling emergence—possible causes and where to get help

PROBLEM	POSSIBLE SIGNS	POSSIBLE CAUSES	SEE CHAPT.
Poor seedling emergence	surface poorly drained after irrigation/rainfall	sodicity, compaction and/or land flat or depressed	C4, D2, E2, E3, E7
	dispersion*	sodicity	C4, D2, E3
	hard surface few cracks	hardsetting, sodicity	C4, D2, E2 E3
	too many large clods in seedbed ▼	hardsetting, sodicity, vehicle compaction and/or tillage equipment problems	C4, D2, E2, E3

* Dispersion shows as light coloured sand grains separated from the other soil components, with a skin of dispersed clay in the depressions.
▼ Excessive cloddiness also is associated with poor control of Heliothis pupae.

Figure B1-3. Soil problems associated with poor crop growth and yield—possible causes and where to get help

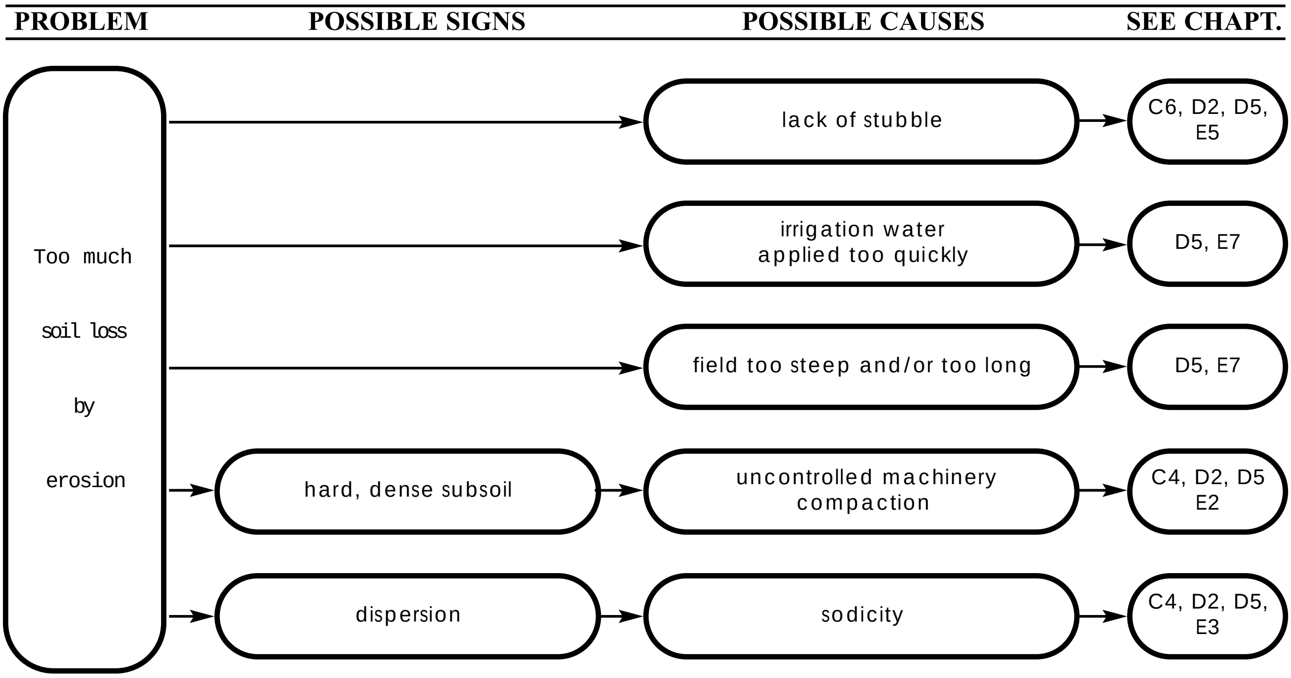
PROBLEM	POSSIBLE SIGNS	POSSIBLE CAUSES	SEE CHAPT.
Poor crop growth and yields	surface poorly drained after irrigation/rainfall	sodicity, machinery compaction, land flat or depressed	C4, D2, E2, E3, E7
	hard, dense subsoil	compaction and/or smearing by machinery, sodicity	C4, D2, E2, E3
	dispersion	sodicity	C4, D2, E3
	unusual leaf colour	poor nutrition	C8, D3
		waterlogging, aggravated N deficiency	C8, E7
		pH imbalance	C8, D7
		disease, herbicide damage	**
	salt-tolerant weeds, rising water levels in bores	salinity	C7, D4

** See an agronomist for help with disease or herbicide problems.

Figure B1-4. Problems associated with excessive expenditure on land preparation and management—possible causes and where to get help

PROBLEM	POSSIBLE SIGNS	POSSIBLE CAUSES	SEE CHAPT.
Too much money spent on tillage, nitrogen and/or irrigation	hard dense subsoil	uncontrolled machinery compaction	C4, D2, E2
	dispersion	sodicity	C4, D2, E3
	hard surface few cracks	hardsetting, sodicity	C4, D2, E2, E3
		failure to realise that the soil is well structured, and that some inputs are unnecessary	C4

Figure B1-5. Problems associated with too much soil loss by erosion—possible causes and where to get help



The soil related problems outlined in Figures B1-1 to B1-5 tend to be inter-related. Often, several limitations occur simultaneously.

Farmers should develop programs for soil management that deal with as many of these limitations as possible while land is being prepared for the next cotton crop.

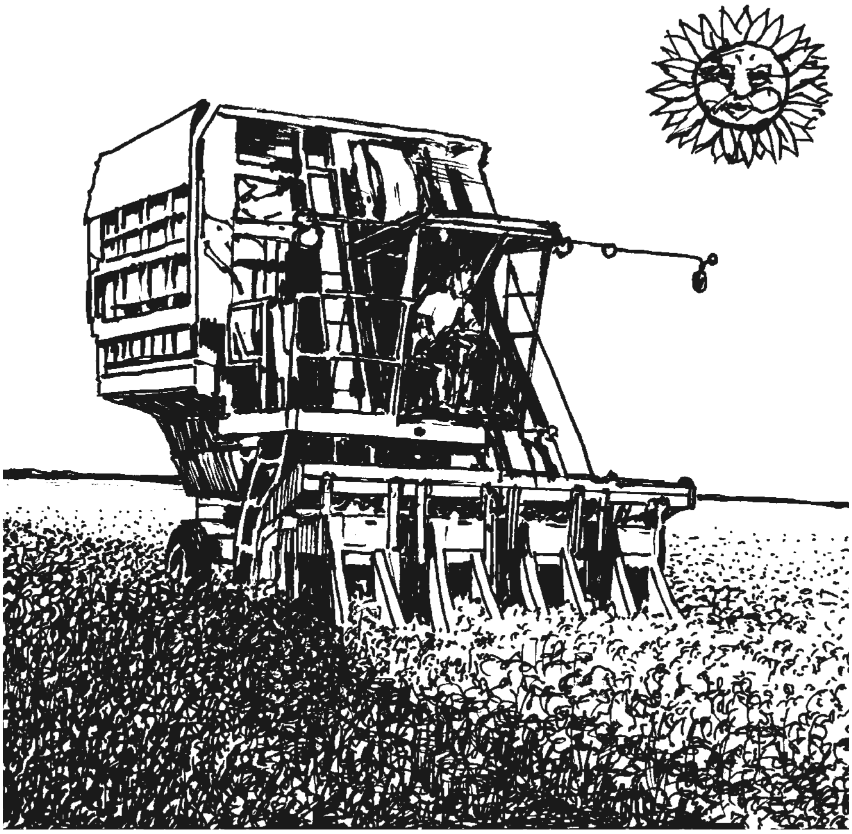
Failure to attend to just one of the many key factors influencing cotton growth may cause large declines in profitability.

The remaining chapters in Part B briefly describe practical options that can be ‘packaged’ to deal with soil-related problems at various stages of the cropping cycle under contrasting climatic conditions.

Topics include:

- soil preparation options after a wet cotton harvest (Chapter B4)
- managing variable fields; yield map interpretation (B8)
- soil survey for new developments (B9).

B2. Soil preparation options after a dry cotton harvest



PURPOSE OF THIS CHAPTER

This chapter outlines factors to consider following a dry harvest to maintain or improve soil structure. It takes into account the need to control over-wintering Helicoverpa (Heliothis) pupae, remove root growth restrictions and handle stubble efficiently.

CHAPTER OVERVIEW

This chapter covers the following points:

- pupae control
- checking compaction severity and subsoil moisture content
- choosing a tillage and/or rotation option
- stalk management.

Other chapters to refer to:

- Chapter C3: Soil moisture (before tillage), soil texture and available water
- Chapter C4: Structural condition
- Chapter C6: Stubble
- Chapter D2: Improving soil structure.

INTRODUCTION

When preparing soil after a dry harvest, the first priority is to deal with the over-wintering pupae of *Heliothis armigera* (also referred to as *Heliocoverpa armigera*). They are a major cause of increasing resistance to chemicals. A tillage strategy must be implemented to destroy the pupae by the end of August, while avoiding serious structural damage to the soil and minimising input costs.

Cotton pickers are very heavy, with front axle loads as great as 14 t. However, when the soil profile is dry at harvest, their impact on soil structure is not great. Wheel damage will not be nearly as severe as when the soil is moist, although wide tyres or dual front wheels may still compact loose beds.

It must be remembered, however, that serious soil compaction may have occurred earlier in the season (due to operations such as fertiliser application and weed control), or remain from previous seasons where the self-regeneration capacity of the soil is poor. Such damage may require treatment.

A big advantage of a dry harvest is that it gives you the widest possible range of options for preparation and improvement of cracking clay soils, provided that heavy rain does not follow soon afterwards. If you are contemplating using deep tillage, be aware that the previous cotton crop may not have had enough time to thoroughly dry the soil to an adequate depth before defoliation.

On non-swelling silty soil, however, excessive dust production may be a problem if it is heavily tilled when dry. When dusty soil is re-wetted rapidly, it will have very poor structure.

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See Chapter D9 for further information on red soil management.

PUPAE CONTROL

Tillage to a depth of at least 10 cm is most likely to kill over-wintering Heliothis pupae, if all of the very large clods (more than 50 mm wide) in the topsoil have been broken down and rearranged. However, be careful on silty soil where overly aggressive dry cultivation will create too much dust.

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See MACHINEpak for more information on which tillage equipment to use.

CHECKING COMPACTION DAMAGE AND MOISTURE

Go to the best yielding, average and worst yielding points within at least one representative field as soon as possible after picking. Dig at least one, preferably two or three, inspection holes at each of these points and assess soil structural condition. Look particularly at the zone directly below the plant lines next to and away from the main wheel tracks.

Determine the SOILpak score for the topsoil (0–10 cm), sub-surface (10–30 cm) and subsoil (30–100 cm). Enter the results onto the 'post-harvest' description sheet.

If the site has not been assessed previously, measure soil stability in water (ASWAT test). It is also advisable to collect soil samples from the SOILpak/ASWAT scoring sites and have them analysed in a laboratory for gypsum and/or lime requirement. An economically viable response to gypsum is likely where the ESI value is less than 0.05 (ASWAT score greater than 6). Soil salinity should also be assessed by measuring soil electrical conductivity.

Also, use clues such as plant symptoms and moisture probe data during the growing season, to indicate problem areas. Even after a dry harvest, check soil moisture at the depth, and slightly below the depth,

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See MACHINEpak for more information on pupae control.

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See Chapters C3 and C4 for further information on soil assessment.

at which you are going to till. This is important because although upper, easily examined layers of the soil are drier than the plastic limit (PL) and there has been no deep rutting of the soil by harvesting machinery, deeper levels of the soil may be wet enough to smear rather than fracture when tilled.

If your crop ripened in dry weather, there is a good chance that the soil is drier than permanent wilting point to an adequate depth. However, if defoliation took place when the crop was still active, there is a chance that soil moisture may still be moderate at the depth of tillage. Check the soil moisture.

COTTON STALK MANAGEMENT

Crop residues can carry disease, clog tail drains and/or interfere with herbicide incorporation or planting. However, stalk incorporation may improve the amount and quality of soil organic matter. Burning of cotton stalks should be avoided (wherever possible) because of loss of nutrients.

The stalks should be removed soon after harvest, and cut finely enough to avoid immediate management problems such as implement blockage. If the trash is broken down too finely, decomposition and nutrient release may occur too quickly—this can lead to loss of nutrients such as nitrogen. If fusarium wilt is a problem, it may be necessary to at least partially, disinfect the stalks by exposing them to UV light on the soil surface—burial is likely to aggravate the problem. Much remains to be learnt about fusarium wilt control.

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See Chapters D1, D2 and E5 for further information about cotton stalk management.

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See MACHINEpak for more information on trash-working equipment.

CHOOSING A TILLAGE AND/OR ROTATION OPTION

You may find that the crop you have just harvested has partly or wholly fixed the problem that had caused it to perform poorly. Cycles of wetting and drying during the growing cycle and deep drying by the crop after the last irrigation can crack the soil and improve structure to a point where deep tillage may not be necessary.

Other fields may not have had such good work done by the crop. Residual compaction may remain; and cracking by rotation crops, and/or deep tillage, may be required to improve yields and profits.

Four options should be considered. They are shown in Figure B2-1.

Option 1. Rotation crop and/or deep tillage

Full land preparation (ploughing the old hills and forming new ones) gives you the opportunity to ‘tidy up’ a field: removing hollows, straightening crooked rows, adjusting guess row spacing, and controlling weeds. Examine the soil structure using a spade or back-hoe pit. If the structure under the plant lines is poor (SOILpak score less than 0.5), consider deep tillage. Where the soil has moderate compaction damage (SOILpak score between 0.5 and 1.5) but does not have good shrink-swell potential (CEC less than 40), deep tillage is also likely to be beneficial, particularly where there is a great danger that new beds will lie over old wheel tracks with their associated compacted zones.

After examining the soil structure, assess soil moisture to determine to what depth tillage would be beneficial. The soil profile may not be at a uniform moisture content. It may be possible to till the upper, dry part of a compacted layer and leave the deeper, moist soil untouched (and unsmeared).

If a sodicity problem is identified, applications of gypsum and/or lime may be needed. Where the subsoil only is sodic, any deep tillage should loosen but not invert the soil profile.

Advantages:

- Good stubble incorporation for field hygiene.
- The opportunity to tidy up field architecture.
- Thorough control of Heliothis pupae
- Weed control.

Cautions:

- Reformed hills may lie over old compacted furrows, hence expensive deep working may be more necessary with this system.
- Deep ripped soil may become very boggy after heavy rain. Re-establish the main wheel tracks as soon as possible after ripping.

Instead of tilling the soil, it may be more economical to sow a rotation crop such as wheat or lucerne to improve soil structure by drying and cracking the soil. This option is particularly useful where there are problems with weeds and soil-borne cotton diseases, and where sufficient water is available to establish the crop satisfactorily.

A rotation crop will be particularly useful where compacted soil is not quite dry enough for deep tillage after a cotton crop. The soil can, if necessary, be deep tilled after growing the rotation crop to loosen the soil further.

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See Chapter D2 for further information about soil structure improvement.

Option II . Permanent beds with controlled traffic and middle busting

If moderate damage to soil structure is detected in the top 30 cm of soil under the plant lines (SOILpak score between 0.5 and 1.5), and the soil is drier than the plastic limit, you may be able to loosen it by middle busting without completely destroying the beds. Before this operation, the cotton stalks may need to be slashed, pulled and/or mulched.

Lightly chisel the furrow bottoms to create loose soil for reforming existing beds, and use gas knives to break up any serious bed-shoulder compaction. Reform the beds with soil from the furrows, using go-devils or sweeps. Ensure that all of the soil is disturbed to a depth of 10 cm; otherwise, some of the over-wintering pupae may survive.

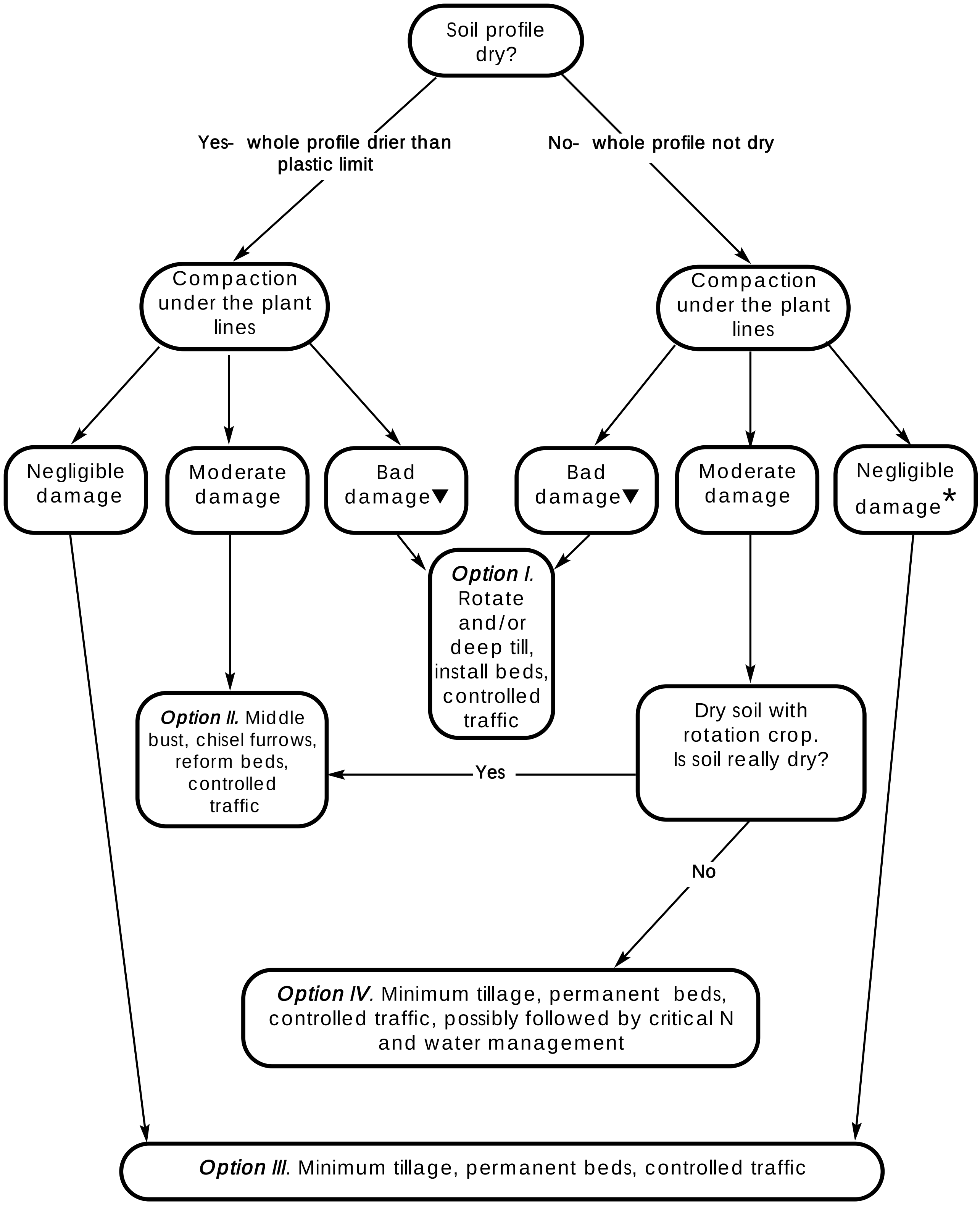
Advantages:

- Furrows are always present for surface drainage in the event of heavy rain.
- Leaves traffic lanes for vehicle support.

Cautions:

- Difficult to manage unless all the farm machinery has compatible wheel and/or track spacings.
- Weeds such as nutgrass may build up.

Figure B2-1. Tillage and rotation options after a dry harvest



* Bad damage = serious compaction in the bed subsoil, sub-surface and/or surface (SOILpak score less than 0.5).
Moderate damage = moderate compaction in the bed subsoil, sub-surface, and/or surface (SOILpak score between 0.5 and 1.5).
Negligible damage = absence of compaction problems (SOILpak score greater that 1.5)

▼ If economically necessary to grow cotton immediately, apply critical N and water management (see Chapter B6).

Option III. Permanent beds with controlled traffic and minimum tillage

If the soil structure under the plant lines has remained uncompacted (SOILpak score greater than 1.5) due to careful control of traffic, keep it that way by minimising soil disturbance below a depth of 10 cm. Slash, pull and/or mulch the cotton stalks.

Tillage of the topsoil may have to be repeated to ensure effective pupae control, particularly where the previous cotton crop was late. This operation should ensure good weed control.

Lightly chisel the furrow bottoms to create loose soil for reforming existing beds, and use gas knives to break up any serious bed-shoulder compaction. Reform the beds with soil from the furrows, using go-devils or sweeps. Ensure that all of the soil is disturbed to a depth of 10 cm; otherwise, some of the over-wintering pupae may survive.

Advantages:

- Fast and cheap.
- Maintains or improves soil structure and soil organic matter in the sub-surface and subsoil.
- Furrows are always present for drainage in the event of heavy rain.
- Leaves traffic lanes for vehicle support.

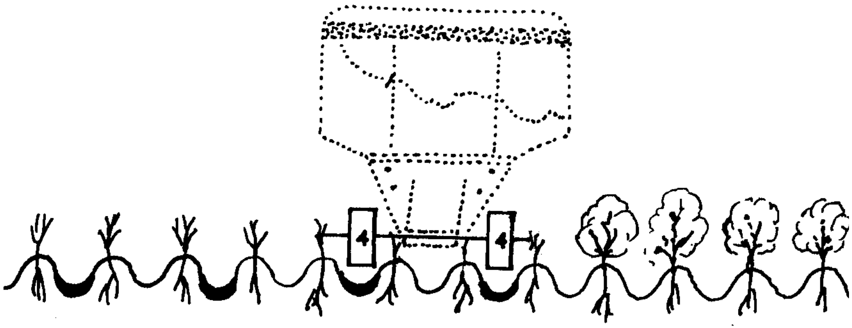
Cautions:

- Difficult to manage unless all the farm machinery has compatible wheel and/or track spacings.
- Weeds such as nutgrass may build up.

Option IV. Permanent beds with controlled traffic, minimum tillage and special nutrition and/or water management

The procedures described under Option III may also be used where there is moderate compaction under the plant lines (SOILpak score 0.5 to 1.5), but it is likely that critical management (extra N and more frequent irrigation) will be needed.

B3. Harvesting cotton on wet soil



PURPOSE OF THIS CHAPTER

This chapter gives you options for harvesting cotton when the soil is wet and soft, and suggests ways of minimising damage to soil structure.

CHAPTER OVERVIEW

This chapter covers the following points:

- improving the mobility of pickers
- minimising soil compaction.

Other chapters to refer to:

- Chapter B4: 'Soil preparation options after a wet cotton harvest'
- Chapter D1: 'Avoiding soil structure and waterlogging problems'.

TWO PROBLEMS: MOBILITY AND COMPACTION

There are two distinct problems involved with mechanised cotton picking on a wet soil—mobility of pickers and soil compaction.

If your major concern is getting the crop off, then you may have to accept a higher level of soil degradation. Once picking machinery is mobile in a wet field, think carefully about wheel patterns that provide the maximum number of unwheeled rows.

Pay particular attention to those fields in which you plan to grow cotton in the following season. The short period of time available before planting may not allow you to fully repair damaged soil. If possible, reserve the more damaging options suggested in this chapter for fields marked for rotation in the coming season.

As a guide to how damaging the harvesting operation is, watch a picker at work. If the wheels are producing deep ruts and are pushing plant rows sideways, the operation is probably causing severe damage to soil structure.

In general, fewer problems occur where there are permanent beds and unploughed wheel tracks.

INCREASING MOBILITY

Some of the methods suggested here to improve mobility of pickers will damage soil structure. These methods will help you to pick when the usual methods fail.

- Four-wheeled pickers are preferable to early-model three-wheeled pickers. Three-wheeled pickers are less mobile on soft soil and compact all the furrows and the middle of wide beds. The single rear wheel should be replaced by a pair of wheels in line with the front wheels.
- Rear wheel assisted drive increases mobility but does not, on its own, ensure that the picker heads stay out of the mud.
- Wider tyres help to prevent wheel sinkage. At the front of the machine, wide tyres help to keep the picker heads out of the mud. Twenty-four inch tyres improve flotation in very wet conditions. However, wide tyres compact the sides of the beds (see Figure B3-1)—this approach is a 'last resort' option. As the soil dries, convert back to narrower tyres to conserve tyres and to minimise compaction on the edges of cotton beds.

⚠ Risky option

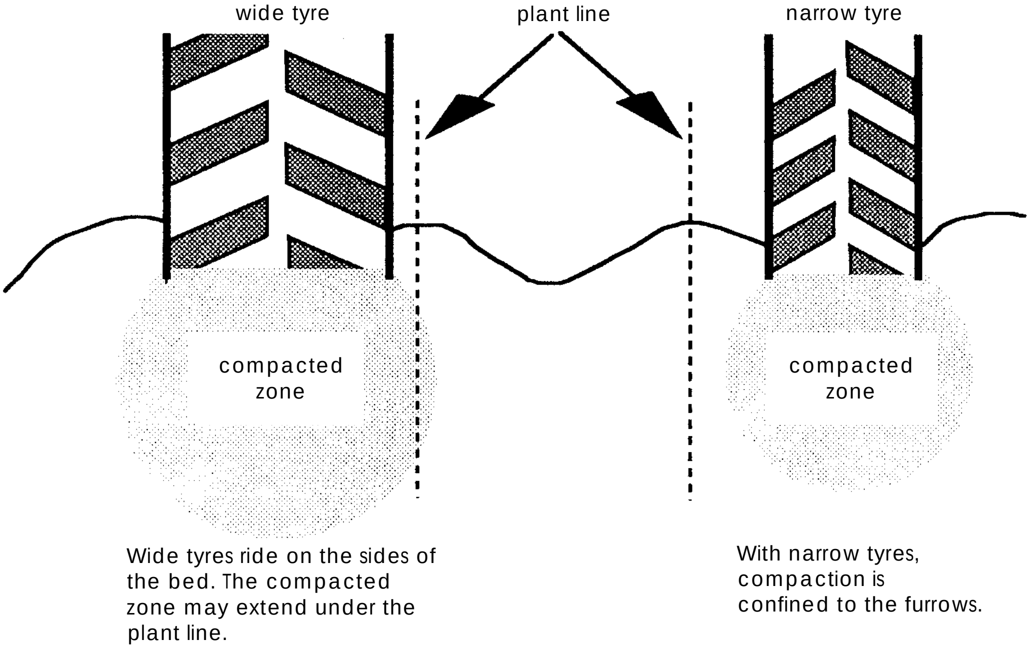
- Tracks increase mobility greatly, consequently allowing a much earlier entry into the field. This comes at a price because damage to the soil is great. Tracks, also, are usually not readily available.
- Uneven furrows do not help mobility. A picker may bog more easily if one wheel runs along an already-compacted cultivating wheel track, and the other wheel runs on a soft furrow.

Try either to:

- Stay wholly on or wholly off cultivating wheel tracks; this may involve straddling guess rows with associated problems of running over beds and missing cotton.
- Run the heavier side of the picker along the firmer furrow (cultivating wheel track).

⚠ Risky option

Figure B3-1. Compaction under wide and narrow tyres on wet soil.



Advantages:

- These methods will allow you to pick when the usual methods fail.

Cautions:

- There is a trade-off between soil damage and a quick harvest.
- Cotton lint may not have time to brighten following rain (causing dollar penalties).
- Uncertainty about the next fall of rain makes it difficult to develop a soil management plan.

MINIMISING COMPACTION

As the soil dries and mobility is no longer your major concern, consider methods of minimising compaction.

Look after the existing beds; their condition strongly influences the next crop.

Leave some furrows untrafficked so that plant roots from the next year's crop can grow into them.

Plan your picking pattern

Even before a wet harvest, there are compaction zones beneath the furrows used by tractors during the growing season. Harvesting on wet soil will compact more furrows, but careful planning will enable you to leave the maximum number of furrows untrafficked.

About 90% of the potential compaction that occurs under wheels happens in the first pass of the machinery. Make use of the already-compacted furrows rather than attempting to spread the compaction.

Figures B3-2 to B3-5 show how the pattern of picker tracks affects the potential compaction of a field. The diagrams assume that you are not picking across guess rows.

With a six-row tillage system it is best to use two-row pickers only, as they will leave 50% of the furrows untrafficked. Using a four-row picker and a two-row picker in the same set of six rows leaves only 17% (one in six) of the furrows untrafficked (see Figure B3-3).

With a tillage system that spans four rows or multiples of four rows (4, 8, 12, 24) it is best to use four-row pickers only, as they will leave 50% of the furrows untrafficked. If you use a four-row picker and a two-row picker in the same tillage set, plan the picking pattern carefully to leave the maximum number of untrafficked furrows (see Figures B3-4 and 5).

Figure B3-6 is provided for you to enter your own picking pattern.

Stay off beds

Soft soil within the beds is very prone to severe damage. Keep picker wheels within the furrows. This may mean converting to narrower tyres.

If the soil is so soft that you need to use wide tyres that cover part of the beds, use tyres that are lugless or very worn to minimise the severity of near-surface compaction.

Increase ground contact area

A large area of ground contact spreads the weight of the picker and helps trafficability when the soil is very soft. For example, wide tyres are less likely to exceed the critical ground pressure, but when they do, they cause a deep, wide zone of damaged soil. In addition, wide tyres will damage the soft beds even if the beds are dry.

- Lower tyre pressure makes the tyres wider, but there is not much scope for making use of lower pressures. Reducing tyre pressure from 240 kPa to 140 kPa (35 psi to 20 psi) results in only 5% tyre deflection—not a large benefit. Low tyre pressures can cause increased tyre failures and tyre roll-off when cornering. When a picker empties its load, much of the weight is thrown to one side and soft tyres may fail.
- Dual front wheels spread the load of heavy pickers, but may cause serious damage to the middle of wide beds. Dual wheels with spacings that do not match exactly with the furrow centres should not be used; otherwise much of the root zone will be severely compacted. Deep subsoil compaction only starts to be reduced by dual wheels if their spacing is greater than 1.5 m. Tandem wheels lined up with the furrows cause much less damage than the same wheels in a dual configuration.
- Experience with half tracks in Australia has shown they do improve picker mobility in much wetter conditions than could be expected with wheels. However, soil damage was also much greater simply because the soil was wetter. Compaction from tracks is greater than expected because there are ‘spikes’ of extra pressure as the track rollers pass over the soil.

Always remember that subsoil compaction is related more to the axle load of a vehicle than tyre pressure.

Decrease the weight of pickers

There are very few options for decreasing picker weight. Even frequent emptying of the basket will not make a large percentage

Figure B3-2: Key for diagrams B3-3 to B3-6

Key

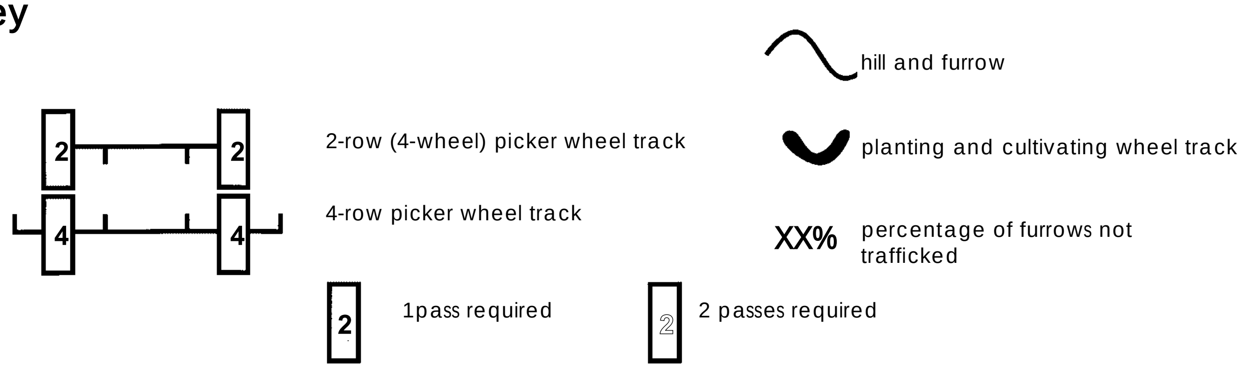
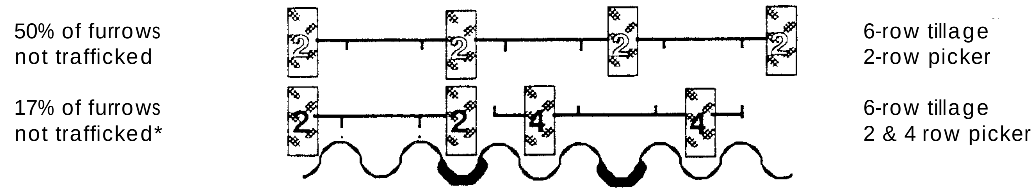
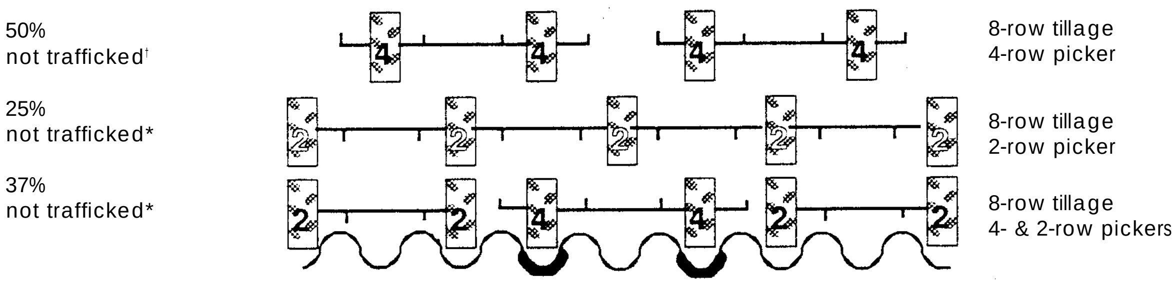


Figure B3-3. Potential compaction under the rarely used six-row tillage system



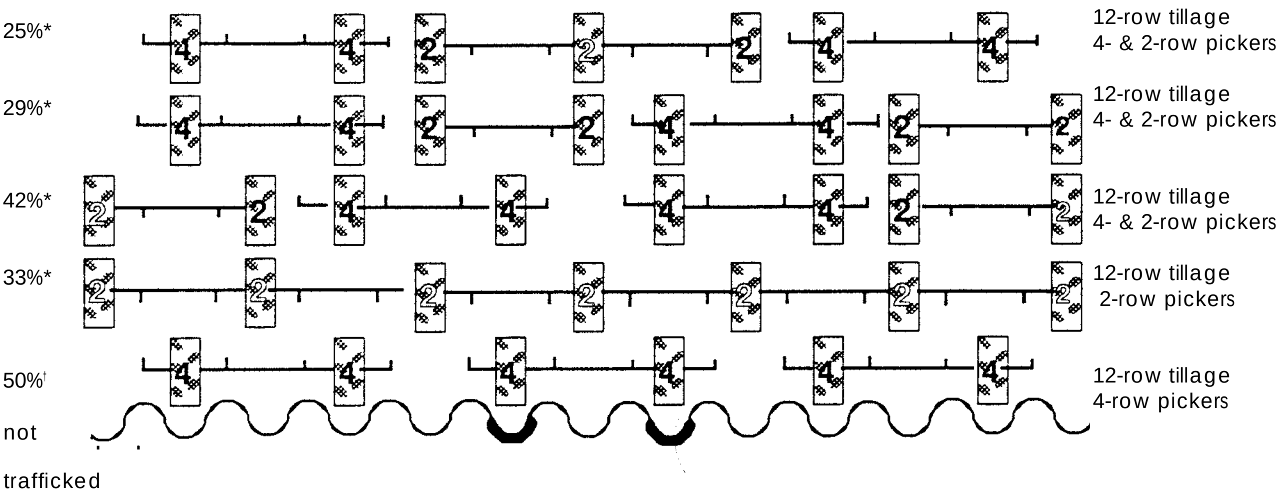
* not compatible with 2 m wide raised beds

Figure B3-4: Potential compaction under eight-row tillage system



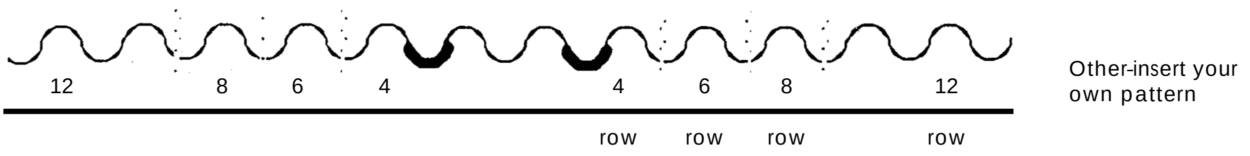
* not compatible with 2 m wide raised beds
† recommended

Figure B3-5: Potential compaction under twelve-row tillage system



* not compatible with 2 m wide raised beds
† recommended

Figure B3-6: Enter your own picking pattern



difference to the weight of the machine (roughly 10%). However, if a choice has to be made between the use of three four-row pickers and two (about to be released) six-row pickers, the first option would be preferable in terms of the lower axle load and more-shallow subsoil compaction.

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See Chapter E2 for more information on compaction processes.

SOIL DRYING

Soil drying improves trafficability (due to less sinkage and less wheel slip) but it will not lessen damage until the depth of dry surface soil exceeds half the tyre width (approximately). Transpiration ceases at defoliation, and little water will be lost by evaporation from a soil surface covered with leaves. Soil drying slows as autumn progresses.

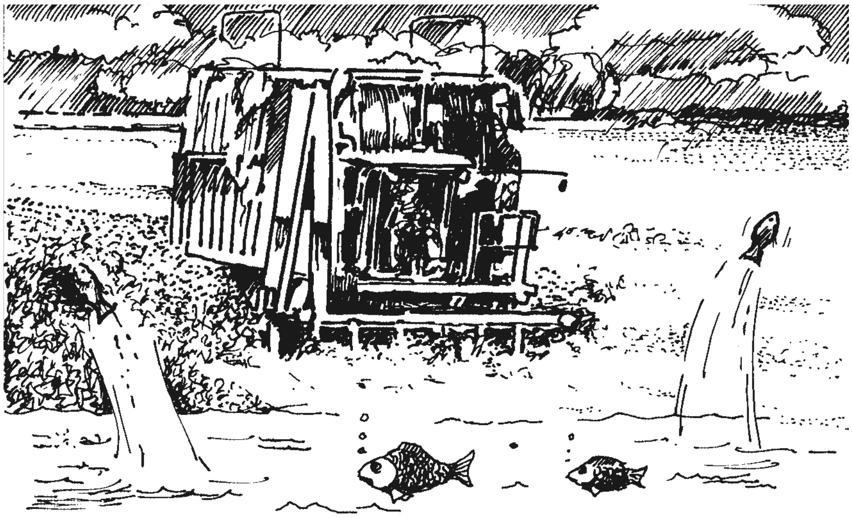
HARVESTING NARROW-ROW COTTON

The options given above refer to cotton grown with a row spacing of 1 m (40 inch).

Row spacing sometimes is reduced to 75 cm (30 inch) or less to minimise the time between planting and attainment of a full canopy cover. When this occurs, the wheel spacings of all row-cropping and harvesting equipment should be adjusted to:

- avoid breakage of rows of cotton plants by machinery wheels
- minimise percentage of the root zone compacted by wheels and tracks when the soil is moist.

B4. Soil preparation options after a wet cotton harvest



PURPOSE OF THIS CHAPTER

This chapter helps you to choose a tillage and rotation option when preparing land for the next cotton crop after a wet harvest. It takes into account the need to control over-wintering Heliothis pupae, deal with root growth restrictions and handle stubble efficiently.

Options vary. They depend on how badly the soil was compacted by pickers, how wet the soil is and how much time you have.

CHAPTER OVERVIEW

This chapter covers the following points:

- examining wheel ruts to assess the damage done by picking
- relating the appearance of wheel ruts to the actual damage beneath the soil surface
- deciding whether soil under the plant lines is badly, moderately or not compacted
- assessing soil moisture
- choosing a rotation/tillage option
- pupae control
- stalk management.

Other chapters to refer to:

- Chapter C3: ‘Soil moisture (before tillage), soil texture and available water’
- Chapter C4: ‘Structural condition’
- Chapter C6: ‘Stubble’
- Chapter D2: ‘Improving soil structure’.

INTRODUCTION

A wet harvest is referred to here as one where:

- rain prevents picking because the soil becomes too soft and sticky for pickers to work; and
- when you can start to pick again, the soil remains wet enough for the pickers to form ruts under the furrows.

THE SOIL PREPARATION PREDICAMENT

Picking on wet soil has, despite all your precautions, compacted the furrows and bed edges. Soil under the plant lines may be compacted too. The soil is still wet and you want to know how to prepare the land before planting another crop of cotton.

The two key points to remember are:

- Minimise wet soil disturbance; and
- Do what you have to do without undue delay. Delays may mean that you will miss the planting window in the coming season. Early land preparation often gives sufficient time for the surface soil to shrink, swell and mellow to form an acceptable seed bed.

Minimum disturbance

Current knowledge indicates that soil disturbance to kill over-wintering *Heliothis armigera* pupae must occur to a depth of 10 cm. If the top soil is wet, temporary structural damage may occur but this is unavoidable. Compaction and smearing due to deeper tillage under moist conditions will, however, create longer term problems and should be avoided.

Leave the existing beds in place—they will form the basis of next season's beds. With the beds still in place, the field can drain if rain continues. Be wary of discing, deep ripping or land planing. Any of these operations on wet soil will cause soil structural damage and reduce profitability.

Minimum delay

For most of the following options (where the soil is damaged) start to implement the recommendations as soon as conditions allow. Use a step-by-step approach as the soil dries.

You need to allow the maximum time for damaged soil to mellow under the action of the weather. An exception is when the soil is not damaged or is only slightly damaged (see Chapter B2, Options III and IV)—in this situation it is best to wait for the soil to dry before doing anything.

ASSESSING THE DAMAGE

Damage to soil structure caused by picking on wet soil can be assessed in three ways:

- examining the furrows
- digging into and under the beds with a spade
- examining the soil profile to a depth of 1.2 m in a backhoe pit.

Furrows

Examine each field and record notes on the following:

- In how many furrows is there a picker wheel track? Refer to the picker patterns sheet (see Chapter B3) to decide how well your various wheeled implements matched.
- How deep are the wheel ruts? Measure and record the depth of the furrow bottoms below the tops of the beds.
- Have the sides of the beds been squashed by wheels?
- Has the distance between plant lines been altered by harvest machinery? If so, it is likely that the soil was moderately or severely damaged.

Beds

Use a spade to examine the soil within and just under the beds/hills. The feel of the soil as you dig (easy or hard digging) will give you some idea of how far the compaction spreads into (or under) the beds. Note that clay soils become hard as they dry—if the soil has a dry layer that is hard to dig, don’t necessarily attribute this to compaction.

Look for and record signs of platiness in the soil structure, especially under hills. Platy structure is often found in the bottom of the furrow above a zone of compaction. Platiness under the hills is a much more serious problem because that is the main region of root exploration.

Backhoe pits

From your observations on the furrows and the beds, select a few fields to represent a range of conditions from the worst to the least compacted. These fields are the ones to examine more thoroughly using backhoe pits.

A backhoe pit is the best way to assess compaction. A backhoe pit shows signs of damage other than that caused by picker wheels. Such damage may be the residual effects of tillage, sowing, and/or nitrogen application.

Relate your observations on the furrows and beds to what you see in the pits. In this way, you can form an opinion about the severity of compaction in each field without necessarily examining a pit in each.

After ranking your fields into order of severity of compaction, go to the best yielding, average and worst yielding points within representative fields as soon as possible after picking. Dig at least one inspection hole at each of these points and assess soil structural condition, with emphasis on the zone directly below the plant lines next to and away from the main wheel tracks.

Determine the SOILpak score for the topsoil (0–10 cm), sub-surface (10–30 cm) and subsoil (30–100 cm). Enter the results onto the ‘post-harvest’ description sheet.

If the site has not been assessed previously, measure soil stability in water (ASWAT test). It is also advisable to collect soil samples from the SOILpak/ASWAT scoring sites and have them analysed in a laboratory for gypsum/lime requirement. An economically viable response to gypsum is likely where the ESI value is less than 0.05 (ASWAT score greater than 6). Soil salinity should also be assessed by measuring soil electrical conductivity.

Also use clues such as during-season plant symptoms and moisture probe data to point to areas that caused problems before harvest. Problems identified during post-harvest inspection may have occurred during the wet harvest; others may have been there longer.

Check soil moisture throughout the soil profile. Most of it is likely to be wetter than the plastic limit (PL). However, if—for example—only the subsoil is drier than the PL, and this soil underlies a compacted layer, deep tillage should not damage that subsoil.

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See Chapters C3 and C4 for further information about soil assessment.

DAMAGE CLASSES

After observing the extent and severity of damage, place the site in one of the following classes:

- Badly damaged. Compaction occurs under the furrows and beds, and appears severe enough to inhibit root development into the subsoil (SOILpak score under the plant lines 0.0 to 0.4).
- Moderately damaged. Compaction in the furrows does not spread completely under the beds, and there is a connection of reasonably well-structured soil between the tops of the beds and the better-structured subsoil. Roots can extend below the compacted or degraded zones (SOILpak score under the plant lines 0.5 to 1.5).
- Slightly or not damaged. A broad band of well-structured soil is present below the plant lines. There will be a concentrated zone of compaction under the wheel tracks, but it will be narrow. Roots will be unimpeded and will have a large soil volume to exploit at all depths (SOILpak score under the plant lines 1.6 to 2.0).

Decide which option to follow for each field. The following list and Figure B4-1 are a brief summary of the options that should be considered.

For each damage category there are:

- four options (A, B, C and D) for a moist field with badly compacted soil;
- two options (C and D) for a moist field with moderately compacted soil; and
- two options (D and E) for a moist field with no damage or slight damage.

The choice is yours; and it depends on your resources of labour, machinery, available land and finances.

OVERVIEW OF THE OPTIONS

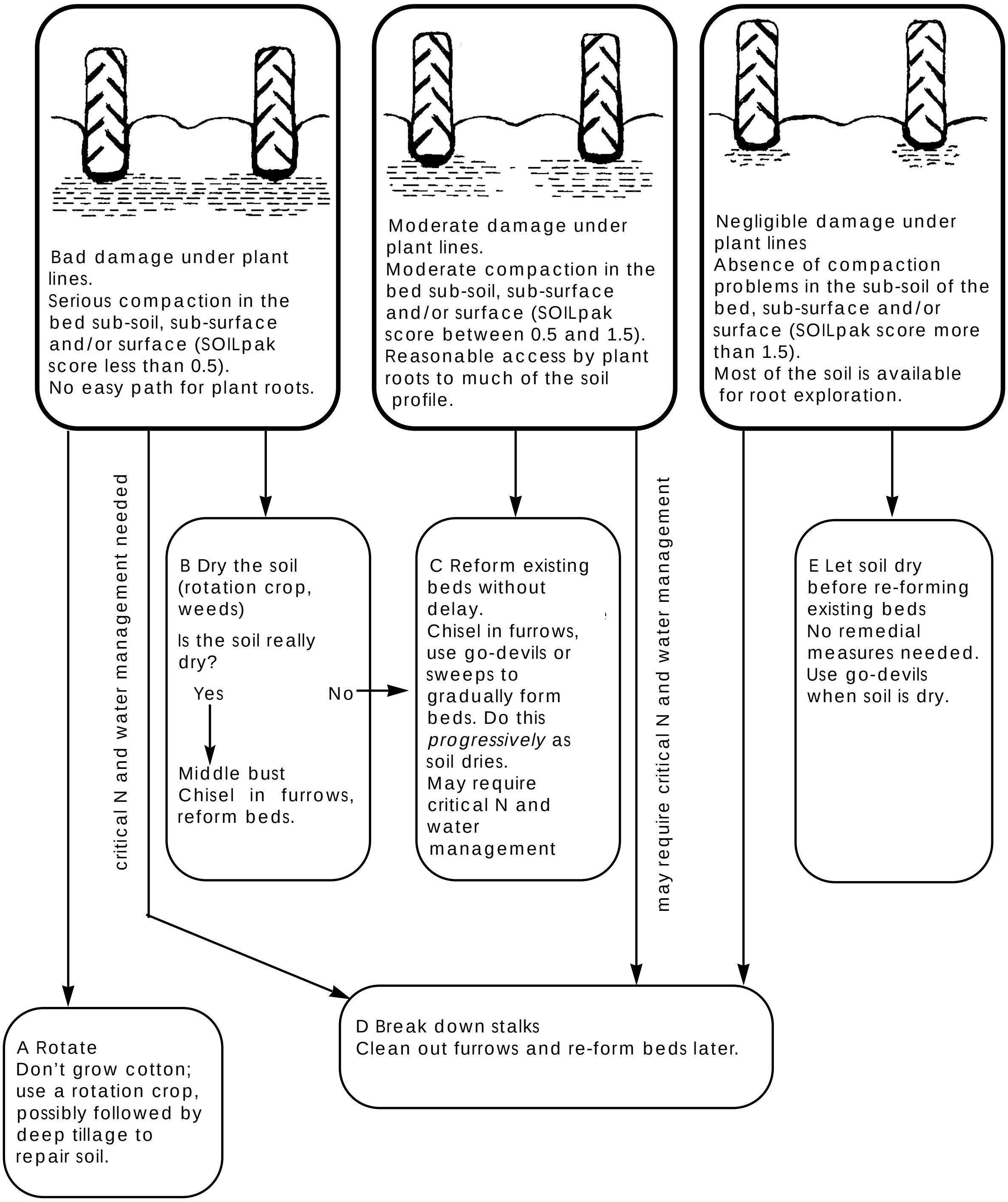
Option A. Repair damage using a full-season deep rooted dryland or irrigated rotation crop

Option A suits a field that did not yield well last season. The field may already have been compacted, and picking on wet soil has made it worse. Yield potential for the next season is not good, and it may be uneconomic to grow cotton before you fully repair existing damage. After a rotation crop has been used to dry and crack a soil, deep tillage may be necessary to further loosen it.

Option B. Quickly repair damage using a winter rotation crop

Option B attempts to repair damage quickly by drying the soil with plants (for example, using a winter cereal or legume that is killed with a herbicide before reaching maturity), but still aims to allow you to

Figure B4-1. Tillage strategies after a wet harvest



plant cotton in the coming season. If the drying is successful, this option has a good yield potential. If the drying is unsuccessful, you can fall back on an alternative strategy (option C).

Option C. Reform existing beds without delay

Option C, reforming existing beds without delay, has the disadvantage that picker wheel damage beneath the surface will not be repaired. Soil at such depth will not dry and crack before cotton planting without plant growth. Therefore, if the soil is badly damaged, yield potential is lower than for option B and management costs are likely to be greater. Choose option C if you are unsure that there is enough time for significant drying under option B.

Option D. Remove stalks and then plant

Option D involves minimal field operations and time. This is suitable for situations when the season remains wet after picking. Pull, slash and/or mulch the stalks, and clean out the furrows. Rebuild the beds after planting.

Option E. Allow soil to dry before reforming existing beds

Option E suits a field which received little damage during picking and which needs little work to be ready for replanting. However, because the soil is wet, you still need to take care. Wait as long as you can to allow the soil to dry before doing anything. The bed shoulders may need to be mechanically loosened if problems with water entry are anticipated.

FACTORS TO CONSIDER WHEN CHOOSING AN OPTION

Heliothis pupae

Heliothis armigera pupae spend the winter in the soil and emerge as moths in spring to mate and lay eggs. Control of such pupae is a vital part of pest management, particularly now that transgenic cotton varieties have been introduced. In cotton fields, pupae are likely to have a high survival rate (due to low numbers of predators and a high level of insecticide resistance). Clods that are at least 50 mm wide, and that remain after cultivation, may contain viable pupae.

These pupae must be destroyed before the end of August, by tillage to a depth of 10 cm. To be effective this operation may need to be repeated.

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See MACHINEpak for more information on what tillage equipment to use to control pupae.

Cotton stalks

Cotton stalks from the previous crop need to be slashed, pulled and/or mulched rather than being raked and burnt. This returns nutrients to the soil and boosts the reserves of soil organic matter. If fusarium wilt is present, it may be necessary to at least partially disinfect the stalks by exposing them to UV light on the soil surface—burial is likely to aggravate the problem.

Disc planters are better able to cope with cotton stalks. Boot planters may encounter difficulties if the stalk line is not removed.

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See Chapters D1, D2, E5 and MACHINEpak for more information on what equipment to use for management of cotton stalks.

Accepting yield loss and/or excessive land management costs

You may decide to grow cotton in a badly or moderately compacted field and accept penalties in yield and input costs. You will need to pay close attention to nitrogen nutrition and irrigation. Extra nitrogen fertiliser and more frequent watering will help, but will not fully compensate for poor soil structure.

Nitrogen application

The type of nitrogen-application machinery that you have will also affect your decision on a tillage option. An anhydrous ammonia shank running through the centre of a wet bed will damage the structure of soil in the planting line.

Leave the ruts

You may be concerned about the need to cultivate to remove wheel ruts, thus allowing irrigation water to run evenly down each furrow. Removing ruts is an operation that can wait—your top priority now is to choose and apply a tillage option for soil under the plant lines.

Match wheel tracks and introduce guidance systems

Matching wheel tracks helps you to avoid the compaction of a large proportion of a field. Do what you can with your existing machinery to match the working widths and re-use already-compacted furrows. Use guidance systems to steer machinery in a straight line.

FEATURES OF THE TILLAGE OPTIONS

Option A: Bad damage, repaired by a full-season dryland crop

The aim of Option A is to grow a crop such as wheat that can forage for moisture well, although irrigation may be necessary to ensure crop establishment. If the season is dry the crop can dry and crack the soil; if not, the small swelling and shrinking cycles between rainfalls can help soil structural improvement.

Conditions:

- Soil is badly compacted (serious compaction directly under the plant lines; SOILpak score less than 0.5).
- Soil is wet throughout the profile (water content greater than the 'plastic limit').
- You have decided not to plant cotton in this field next spring.

Procedure:

- Leave the existing beds in place.
- Sow a crop such as wheat, faba beans, field peas or safflower; and disturb the surface soil to effectively control Heliothis pupae.
- Ensure adequate soil nitrogen (if necessary apply fertiliser when the rotation crop is sown) to encourage vigorous root growth and rapid drying of the soil.
- You may need to irrigate to assist germination of the rotation crop seeds.
- Reassess soil condition as the crop dries the ground.
- Refer to Chapter B2 for information on preparing dry soil for your next cotton crop.
- If wheat is being grown and rain falls heavily before (or just after) harvest, consider growing a summer crop, e.g. a mix of forage sorghum and cowpeas, to re-dry the soil and further improve soil structure. However, in years with low water allocation it may be more profitable to conserve the moisture for the next cotton crop.

Advantages:

- Improved soil structure for the following year.
- Control of pests and weeds.

- More flexibility. You may decide not to harvest the winter crop, but to take advantage of dry soil and get on with preparing for your next cotton crop.

Cautions:

- Irrigate to achieve several extreme wetting and drying cycles, rather than aiming for high yield. Depending on the weather and availability of water, this may mean only one irrigation.
- Avoid late irrigation; allow the crop to dry and crack soil ready for the next land preparation.

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See Chapter D2 for more information on improving soil structure.

OPTION B. BAD DAMAGE, QUICKLY REPAIRED USING A WINTER ROTATION CROP

The aim of Option B is to dry the soil as much as possible (even only the top 10 cm) to repair some of the damage caused by picking, and to minimise further soil damage during seedbed preparation and pupae control.

Soil drying (to promote shrinkage cracks) and root growth (to perforate compacted soil) will, even if the soil is re-wet, bring about some repair of soil structure. A good cover of green plants can absorb light rains that would be a disaster on bare soil.

Option C is an alternative in situations where you are not convinced that there is enough time for significant drying. The yield of cotton expected for Option B is higher than for Option C because of improved soil structure through drying.

Conditions:

- The soil is badly compacted, through the beds (SOILpak score less than 0.5).
- The soil is wet.
- The time is soon after harvest.
- You are determined to grow back-to-back cotton.

Procedure:

- Leave the existing beds in place.
- Till the surface soil to control Heliothis pupae.
- Slash, pull and/or mulch the cotton stalks.
- Dry the soil by sowing winter cereals (e.g. wheat) or legumes (e.g. faba beans, field peas, vetch and sub. clover), with adequate fertiliser. When sowing, disturb the surface soil to effectively control Heliothis pupae. Weeds can also be used to dry the soil but remember that weeds can set seeds, can became large and difficult to handle and may be patchy in their distribution. If you used a rotation crop, you may decide not to harvest it.
- Reassess soil moisture as the crop dries the soil.
- If you chose this option and the soil dried out thoroughly to depth (at least as dry as the plastic limit, see Chapter C3) then consider the options outlined in Chapter B2. You have made good progress with your soil structure improvement!
- If you chose this option and the soil didn't dry out satisfactorily to depth then refer to Option C.

Advantages:

- Option B repairs some picker wheel damage.
- The soil will be drier than bare fallow if rain continues.
- Covering the surface with organic material protects it from raindrop impact.
- The use of winter legumes in rotation with back-to-back cotton, can supply large amounts of N for the following cotton crop.

Cautions:

- Remember that rain can occur at any time and may re-wet soil dried out by the crop.
- Time for significant soil drying is the deciding factor.
- Adjust nitrogen rates for the following crop if you plough in a crop or weeds; non-leguminous crops can tie-up nitrogen.
- Stubble management may be a problem.

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See Chapter D2 for further information on improving soil structure.

Option C: Reform existing beds without delay

The aim of Option C is to disturb the soil as little as possible in getting a seedbed ready for next season, and to do it as soon as possible so that the soil on the surface of the beds has time to mellow after shrinking and swelling cycles.

Do not be tempted to deep cultivate—the soil is too wet and will not benefit.

Conditions:

- The soil is moderately damaged (SOILpak score between 0.5 and 1.5) or badly damaged (SOILpak score less than 0.5).
- The soil is wet.
- The time is either soon after harvest, or close to planting time because Option B did not dry the soil satisfactorily.

Procedure:

- Leave the existing beds in place.
- Slash, pull and/or mulch the cotton stalks.
- Till the surface soil to control Heliothis pupae.
- Leave the field (for 2–3 weeks) until the soil surface is relatively dry.
- Loosen furrow bottoms (not the beds) by shallow chiselling to provide loose soil for bed building. Also loosen the bed edges with a gas knife to disrupt any compaction that is there.
- Reform beds with go-devils or sweeps. Do this progressively, as the furrows dry and the beds mulch, until a satisfactorily high bed is formed.
- When the surface is dry enough to avoid smearing, use a sled with Texas sweeps to work the top of the bed and remove any remaining stalks.

Advantages:

- Gives maximum time for damaged soil (thrown onto the beds) to mulch.

Cautions:

- Will not repair soil damage at depth. Yield potential may be limited if the damage is bad.

Option D. Remove stalks and then plant

The aim of Option D is to disturb the soil as little as possible in getting the next cotton crop planted. Choose this option when time has run out due to continuing rains, and planting on time is the most important factor. It is also an option if all is well—hills are in good shape and soil structure is suitable for unrestricted root growth (SOILpak score greater than 1.5).

Conditions:

- Any pre-existing soil structural form.

Procedure:

- Leave the existing beds in place.
- Slash/pull/mulch cotton stalks.
- Till the surface soil to control Heliothis pupae.
- Plant cotton.
- Clean out furrows and rebuild beds during crop cultivation to ensure good water flow and drainage.
- On badly damaged soil, watering intervals will need to be shorter and nitrogen rates should be higher (See Chapter B6). Do not expect crop yields and profitability to be as high as for crops grown on undamaged soil.

Advantages:

- Option D is fast and cheap. It may be the only option if rain continues.
- It leaves traffic lanes for vehicle support.
- It leaves old crack lines and root channels in place.

Cautions:

- Option D will not repair soil damage at depth. Yield potential may be limited if damage is bad.

Option E. Let the soil dry before reforming existing beds

The aim of Option E is to preserve the good soil structure by disturbing the wet soil as little as possible.

Conditions:

- Picking did no damage, or only slight damage to soil structure (SOILpak score greater than 1.5). Possibly you harvested before the rain.
- The soil is wet.
- The time is soon after harvest.

Procedure:

There is no need for remedial measures. You do not need tillage to loosen compacted soil—it is only needed for pupae control, and to assist with stalk incorporation. You do not need to reform beds from compacted soil in furrows. There is no need to allow the weather to mellow damaged soil. Wait for the soil to dry as much as possible (weeds will help, but can be a problem if they grow too large or are patchy) before reforming the beds and applying fertiliser.

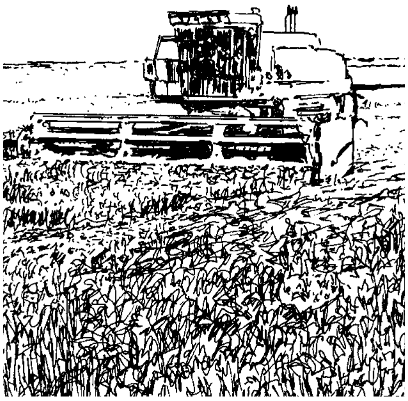
Advantages:

- Soil needs no remedial measures.

Cautions:

- Do not be tempted to spoil the good soil structure by thoughtless tillage or careless fertiliser application.

B5. Soil preparation options after a rotation crop



PURPOSE OF THIS CHAPTER

This chapter outlines factors to consider following harvest of a crop grown in rotation with cotton.

It takes into account the need to remove root growth restrictions before the next cotton crop, and to handle stubble efficiently.

CHAPTER OVERVIEW

This chapter covers the following points:

- checking compaction severity and soil moisture content
- choosing a tillage/rotation option
- stubble management.

Other chapters to refer to:

- Chapter C3: ‘Soil moisture (before tillage), soil texture and available water’
- Chapter C4: ‘Structural condition’
- Chapter C6: ‘Stubble’
- Chapter D2: ‘Improving soil structure’.

INTRODUCTION

Chapters B2 and B4 describe how rotation crops can be used to overcome compaction problems after cotton harvest. The shrink/swell cycles caused by soil water extraction and soil re-wetting loosen compacted layers.

Wheat is a popular choice. It is easy to establish and, when adequately fertilised, develops a vigorous fibrous root system that cracks the soil to a depth of about 80 cm.

Safflower is also used for ‘biological deep ripping’. It is more prone to diseases than wheat, but has taproots that penetrate to a depth of about 2 m. It extracts soil water later into the summer than wheat (if grown to maturity) and very deep shrinkage cracks may develop. An alternative to safflower is lucerne—it provides the extra benefit of adding nitrogen to the soil.

Winter legumes (e.g. faba beans, field peas, vetch and sub-clovers) provide the extra benefit of adding N to the soil, although some of their breakdown products may retard cotton growth.

Other benefits of rotation crops include:

- increase in soil organic matter content (often accompanied by a reduction in pH and sodicity)
- protection of the surface against erosion caused by raindrop impact and overland flow (cereals such as wheat provide the best cover)
- disruption of some disease cycles of cotton, e.g. wheat will decrease the incidence of seedling diseases and black root rot in subsequent cotton crops
- extraction of water and nutrients that otherwise may move below the cotton root zone.

This chapter describes the soil preparation options that are available after a rotation crop has been grown.

SOIL ASSESSMENT

If the soil was sampled before sowing of the rotation crop (as described in Chapters B2 and B4), return to the best and worst yielding points and dig an inspection hole. Re-assess soil structural condition, with emphasis on the zone directly below the old cotton plant lines next to and away from the main wheel tracks.

Determine the moisture status and SOILpak score for the topsoil (0–10 cm), sub-surface (10–30 cm) and subsoil (30–100 cm). Enter the results onto the ‘post-harvest’ description sheet.

If the site has not been assessed previously, follow the rest of the soil assessment procedure described in Chapter B2.

STUBBLE MANAGEMENT

Always attempt to maximise the amount of organic mulch on the soil surface, particularly on the siltier soils. Maximise the amount that is anchored to the soil. Herbicide options are reduced where stubble is retained, due to difficulties with the incorporation of products such as Treflan®. However, knockdown sprays such as Roundup® effectively control weeds in most situations. Weed control in cotton under a mulch will become easier when herbicide-resistant transgenic cotton cultivars become available.

The stubble can, however, cause problems by blocking tillage implements, unless the trash passing through harvesting equipment is chopped finely and spread evenly behind the combine harvester. Stubble burning should only occur as a last resort.

TILLAGE OPTIONS

The following four tillage options should be considered.

Option 1. Deep tillage, reforming of beds after thorough drying of the soil

Full land preparation (chisel ploughing and discing the old hills, and forming new ones) gives you the opportunity to 'tidy up' a field. Hollows can be removed, crooked rows straightened and guess row spacing adjusted. Weed problems, e.g. with nutgrass, can be eased by the mechanical disturbance, provided that the soil is dry enough to shatter.

If the soil structure under the proposed plant lines of the next cotton crop is poor (SOILpak score less than 0.5), consider deep tillage. Where the soil has moderate compaction damage (SOILpak score between 0.5 and 1.5), but does not have good shrink-swell potential (CEC less than 40), deep tillage is also likely to be beneficial. The soil profile may not be at a uniform moisture content. In situations where the rotation crop was unable to penetrate and dry the soil deeply, it may be possible to till the upper, dry part of a compacted layer and leave the deeper, moist soil untouched (and unsmeared).

Alternatively, if the soil was dried thoroughly by the rotation crop, but remained compacted and the surface was re-wet by rain, deep tillage can be carried out successfully if the ripping tines extend into the dry soil.

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For further information about improvement of soil structure, see Chapter D2.

If the rainfall is very great, however, and the whole profile is rewet, a follow-up summer rotation crop (e.g. a mixture of forage sorghum and cowpeas) may be required to re-dry the soil. This option will be particularly attractive if the soil compaction problem was aggravated by harvesting of the winter rotation crop using headers with wheel configurations that were incompatible with the cotton farming wheel tracks.

If a sodicity problem is identified, gypsum and/or lime may have to be applied. Where the subsoil only is sodic, any deep tillage should loosen but not invert the soil profile.

Option 2. 'Permanent beds– controlled traffic' with 'middle-busting'

If moderate damage to soil structure is detected in the top 30 cm of soil under the plant lines (SOILpak score in the range 0.5 to 1.5), and the soil is drier than the plastic limit, you may be able to loosen it by 'middle-busting' without completely destroying the beds.

Lightly chisel the furrow bottoms to create loose soil for reforming existing beds, and use gas knives to break up any serious bed-shoulder compaction. Reform the beds with soil from the furrows, using go-devils or sweeps.

Advantages:

- Furrows are always present for drainage in the event of heavy rain.

- Option 2 leaves traffic lanes for vehicle support.

Option 3. Permanent beds with controlled traffic and minimum tillage

If the soil structure under the plant lines is undamaged (SOILpak score greater than 1.5) keep it that way by minimising soil disturbance below a depth of 10 cm. Consider zonal tillage along the plant lines. Another option is to plant cotton between the rotation crop rows.

Lightly chisel the furrow bottoms to create loose soil for reforming existing beds, and use gas knives to break up any serious bed-shoulder compaction. Reform the beds with soil from the furrows, using go-devils or sweeps.

Advantages:

- Option 3 is fast and cheap.
- It maintains soil structure and soil organic matter.
- Furrows are always present for drainage in the event of heavy rain.
- Option 3 leaves traffic lanes for vehicle support.

Option 4. Permanent beds with controlled traffic, minimum tillage and special nutrition and/or water management

Alternatively, the procedures outlined in Option 3 may be used where there is moderate compaction under the plant lines (SOILpak score 0.5 to 1.5) following rotation, but the soil could not be kept dry. However, critical management (extra N and more-frequent irrigation) will be needed.

SPECIAL NOTES FOR COTTON PRODUCERS WITH COMPACTED NON-SWELLING SOIL

- Shrink/swell manipulation is not a strongly effective option, unless subsoil clay is brought to the surface.
- Chiselling usually is the only repair option (carried out at a water content near the ‘plastic limit’), followed by biopore encouragement. Biopores can be created by the action of rotation crop roots, earthworms and ants.

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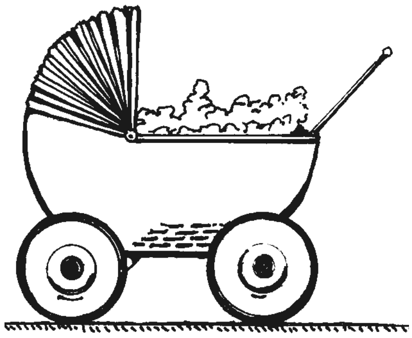
See Chapter D9 for more information on red soil management.

B6. Nursing a cotton crop in a damaged soil



PURPOSE OF THIS CHAPTER

This chapter explains how you can modify agronomic practices so that a cotton crop can grow better in a compacted soil.

This approach deals with symptoms rather than the actual problem and is not recommended as a long-term strategy.

Nevertheless, it may be necessary in situations where rain continues for several months after a wet harvest. It also is needed where cotton was harvested on dry soil, but subsequent heavy rain led to soil compaction problems whilst preparing for and planting the following cotton crop.

CHAPTER OVERVIEW

This chapter covers the following points:

- determining the severity of the problem before growing cotton
- changes to irrigation scheduling
- changes to nutrient needs
- structural improvement due to growth of the cotton (drying-wetting cycles).

Other chapters to refer to:

- Chapter B7: ‘Applying nutrients to the soil’
- Chapter C4: ‘Structural condition’.

INTRODUCTION

This chapter assumes that the crop will be planted into a compacted soil and that, because of soil moisture levels, tillage was not possible without causing further damage. Lack of time prevents the use of rotation crops to improve soil structure.

DEFINE THE PROBLEM

Defining the problem is an important step in managing your crop. Without a knowledge of the severity of soil compaction, you cannot make the best decisions for the crop. Look for clues and examine the soil following the previous harvest to assess severity of the problem.

Go to the best yielding, average and worst yielding points within at least one representative field as soon as possible after picking. Dig one inspection hole (preferably two or three) at each of these points and assess soil structural condition, with emphasis on the zone directly below the plant lines next to and away from the main wheel tracks.

Determine the SOILpak score for the topsoil (0–10 cm), sub-surface (10–30 cm) and subsoil (30–100 cm). Enter the results onto the 'post-harvest' description sheet.

If the site has not been assessed previously, measure soil stability in water (ASWAT test). It is also advisable to collect soil samples from the SOILpak/ASWAT scoring sites and have them analysed in a laboratory for gypsum/lime requirement. Soil salinity should also be assessed by measuring soil electrical conductivity.

Apart from clues such as deep ruts remaining after the last cotton harvest, also use clues such as during-season plant symptoms and moisture probe data to point to areas that caused problems before harvest. Problems identified during post-harvest inspection may have occurred during the wet harvest; others may have been there longer.

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See Chapter C4 for more information on soil structural assessment

As the severity of compaction increases, more care is needed to produce a crop. One of the problems with compaction is that the ability to supply adequate amounts of water and nutrients is restricted.

In a severely compacted soil (SOILpak score less than 0.5), the crop will have limitations which are impossible to overcome completely. However, careful attention to nitrogen and water will minimise plant stress and associated yield loss. Land management costs will be greater than for well-structured soil (SOILpak score more than 1.5) when this approach is used.

BEFORE PLANTING ON A COMPACTED SOIL

Do everything you can to improve soil conditions to ensure that the crop gets off to a good start.

Due to the increased chance of waterlogging in a compacted soil it is preferable before planting to pull up as high a bed as possible to allow good surface drainage. Well-formed furrows will also help drainage.

Pre-water beds and allow the soil to warm up before planting. Watering up after planting chills the soil and increases the risk of seedling disease.

Avoid using moisture-seekers if possible when sowing as they will flatten the beds—this will increase the chance of waterlogging.

COTTON VARIETIES

Unfortunately there is little difference between cotton varieties at this stage with regard to seedling disease. The effects of waterlogging and compaction may make the plant more susceptible to bacterial blight. Avoid blight susceptible varieties if possible.

Different varieties show no difference in water extraction in a compacted soil. This situation may change in the future if new transgenic cotton varieties are introduced with waterlogging tolerance.

IRRIGATION

The major effect of compaction is to limit the growth of plant roots. Due to lack of oxygen and mechanical impedance, the plant is forced to survive with its roots confined to a smaller volume of soil. This volume has less available water for the plant, so water must be added more frequently.

Be aware that the presence of soil moisture at depth may not give you a good indication of the need to irrigate. The potential store of water at depth may be blocked from the plants by the compacted layer.

Increase irrigation frequency for a crop on compacted soil and closely monitor water use (for example, with a neutron probe) and stress levels. A crop on a compacted soil will become stressed (reach the refill point) much more rapidly than one on a well structured soil. Moisture stress causes the plants to lose fruit.

Table B6-1 outlines some examples of how compaction can affect irrigation intervals and daily water use of a crop.

Although you may need to increase the frequency of watering, be very cautious not to waterlog the soil by irrigating for longer than is absolutely necessary. Excessive water application will only compound the problem of waterlogging caused by compaction.

Plants will eventually penetrate the compacted zone. Daily water use and available water may increase through the season as the plants gain access to previously unavailable water.

There would be no advantage in purposely under-watering cotton to force soil drying, as the sacrifice in yield would be too great to justify.

CHANGES IN CROP NUTRIENT REQUIREMENTS

Root entry to compacted regions of the soil is limited; so the plants have difficulty extracting nitrogen, other nutrients (particularly potassium) and water from these regions. If roots cannot penetrate the degraded layers, nutrients deeper in the soil will also be unavailable to the plants.

Because of the increased chance of waterlogging in a compacted soil, the risk of nitrogen loss by denitrification is greater.

The low availability of nitrogen in compacted soil can be overcome to some extent by increasing the rates of nitrogen applied by about 10% above the usual rate for moderately compacted soil (SOILpak score in the range of 0.5 to 1.5) and by about 20% for badly compacted soil (SOILpak score less than 0.5). If too much N is applied, the cotton growth regulator Pix™ can be used to prevent rank growth.

Foliar application of nitrogen before irrigations can help to overcome the symptoms of waterlogging, but do not expect it to overcome all compaction problems. Cloudy and cold weather will make foliar applications less effective.

Table B6-1. Examples of daily water use and irrigation interval for soil with contrasting compaction severity during the period of peak water use
For more details about this topic, see Chapter C9.

	Daily water use (mm/day)	Available water (mm)	Irrigation interval (days)	Notes
Well structured soil	7	90	13	Plant internodes gradually shorten from 7 cm maximum as refill point is reached.
Moderately compacted	5–6	76	13–15	
Severely compacted	5	40–65	8–13	Plant internodes rapidly shorten from 5 cm as refill point is reached.

WHAT GROWING A CROP CAN ACHIEVE

Growing a cotton crop on a compacted soil can start to improve soil structure as the soil goes through wetting and drying cycles between irrigations.

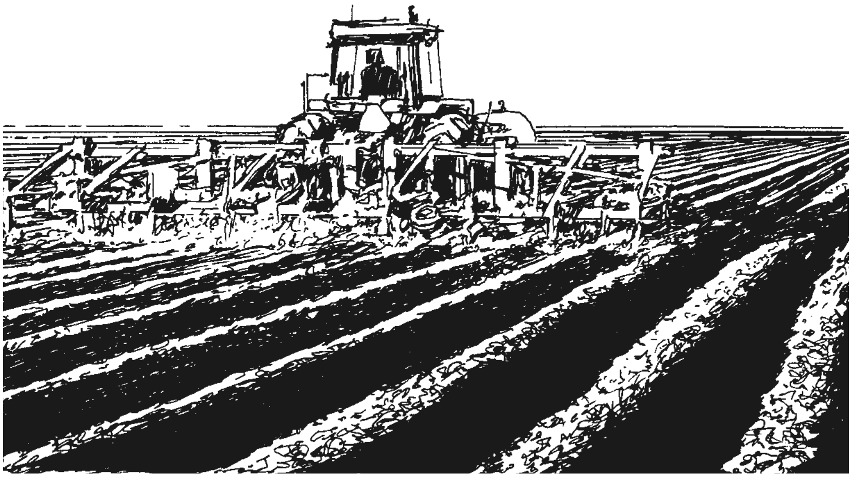
Advantages:

- Growing any sort of crop will assist in repairing soil structure for the next season.
- When cotton prices are high, cotton is more profitable than other crops, even with reduced yield and higher costs, on compacted soil.

Cautions:

- The inevitable penalty in yield for crops grown on compacted soils.
- Critical management is needed to obtain yields approaching (but not equalling) a crop on a well structured soil. Input costs are greater than for well-structured soil.

B7. Applying nutrients to the soil



PURPOSE OF THIS CHAPTER

This chapter discusses nutrient application in relation to soil structure management.

It should be read in conjunction with NUTRIpak, which gives details about how to determine the amount and form of nitrogen (N), potassium (K), phosphorus (P) and zinc (Zn) to apply to cotton and its rotation crops.

Nutrient inputs to the cotton farming system need to be matched with nutrient outputs, and nutrient losses to the atmosphere or into groundwater should be negligible.

CHAPTER OVERVIEW

This chapter covers the following points:

- selection of the best place to apply nutrients so that plant roots can extract them (based upon a knowledge of the structure and water content of the soil profile)
- the relationship between crop striping and soil compaction
- procedures to minimise structural damage when applying fertiliser to the soil.

Other chapters to refer to:

- Chapter B6: 'Nursing a cotton crop in a damaged soil'
- Chapter D3: 'Managing nutrients'.

WHERE TO APPLY NITROGEN

Before adding nitrogen to a compacted soil, first decide on the best place to apply it.

Observe where the soil is least compacted—this will be the zone which the roots can penetrate most easily. The centre of the bed is usually more accessible to roots than compacted furrows, which is the worst zone for placement of fertiliser.

Although an anhydrous ammonia shank will break up some of the compaction in furrows, roots will not easily grow into the fertiliser band because of rapid recompaction of the furrows by subsequent field operations.

If applying nitrogen near a compacted zone, keep the application relatively shallow. 'Cold-flow' anhydrous ammonia or solid fertilisers may help here.

N fertiliser placed in compact, waterlogged layers of soil may denitrify and be lost to the atmosphere as nitrous oxide gas.

If the soil is excessively cloddy, anhydrous ammonia may be lost directly to the atmosphere.

CROP STRIPING

When yellow striping (some rows of cotton more yellow than others) is evident, determine the cause. Is it from malfunctioning nitrogen application equipment or from compaction in some of the furrows and adjacent hills?

Adding extra nitrogen to the problem areas will help to alleviate the problem in both cases. However, if striping is apparent it already is too late to prevent all of the yield loss.

APPLYING FERTILISER WITHOUT DAMAGING SOIL STRUCTURE

Observe soil moisture. If the soil is wet, it may be better to apply fertiliser to the sides of the beds rather than smearing and compacting soil beneath the plant line with tines.

Fertiliser application to the sides of beds may cause smearing if the soil is wet, but the damage is away from the main lines of root growth. Also, it will be shallow enough to be quickly disrupted by shrink-swell cycles.

Dissolving nutrients in the irrigation water is a less-damaging way of transporting them to the root zone. Electrolyte concentration of the soil solution is increased by this option, which will reduce the risk of clay dispersion. Water-run urea can be applied well after the planting of a cotton crop.

There is uncertainty about the effects of anhydrous ammonia on soil structure. Ammonium ions do not persist for long in the soil before being converted to nitrate. However, while present they act in a similar fashion to exchangeable sodium ions and may make the soil more dispersive. The increase in pH that occurs when anhydrous ammonia is added also will make the clay particles more prone to dispersion (see Chapter E3 for an explanation). Further research is needed on this topic.

If the pH should be lowered, ammonium sulfate should be considered. It is a more expensive source of N than anhydrous ammonia or urea, but it is a useful option in situations where high pH appears to be destabilising the clay particles and inducing trace element deficiencies.

B8. Managing variable fields

PURPOSE OF THIS CHAPTER

All cotton farmers are aware of variations in soil condition and crop performance in at least some of their cotton fields.

This chapter provides some general guidelines about the management of obvious sources of soil-related crop variation. It also previews yield mapping technology, outlines how to sample the soil after studying a yield map, and describes how remote sensing data (for example, airborne thermal infra-red scanning) can assist.

CHAPTER OVERVIEW

This chapter covers the following points:

- sources of soil-related variation within fields
- production of within-field yield maps
- interpreting yield maps
- use of remote sensing data.

Other chapters to refer to:

- Chapter C4: 'Structural condition'.

SOURCES OF SOIL-RELATED VARIATION WITHIN COTTON FIELDS

Variations in crop performance within a field may be due to any one (or combination) of a large number of inter-related factors.

These include:

- different insect and disease pressures
- passage of narrow, intense rain and hail storms
- differences in field slope
- presence of gilgais
- management variations (for example, contrasting periods of inundation by flood irrigation water between one end of a field and another)
- machinery malfunction (for example, uneven anhydrous ammonia application)
- contrasting soil physical and chemical properties.

Soil factors responsible for crop variations include:

- degree of compaction by farm machinery (due, for example, to heavy rain on a field part-way through a harvesting or landforming operation)
- soil stability in water (related to sodicity, electrical conductivity, pH, organic matter, clay mineral type and water content)
- soil texture (which influences infiltration rate, water-holding capacity and ability to shrink and swell)
- salinity
- pH
- nutrient reserves.

PRODUCTION OF WITHIN-FIELD YIELD MAPS

Widespread introduction (hopefully by the 1999 harvest) of cotton yield monitors on pickers will allow farm managers to more easily identify poor yielding areas within fields. Soil sampling in the low- and high-yielding sections of a field will allow the design of much more precise soil management programs.

Until yield monitors are fully developed, yield variations can be mapped by hand-picking small sub-sections of fields. Another approach is to map the average yield of large sub-sections of fields by weighing each module that leaves a field.

Aerial photographs, satellite imagery and airborne video scans of crops and bare soil can help to show the location of problem areas.

Even just a walk through a cotton crop will provide a rough indication of the best and worst performing sections of a field.

Because the effect of soil properties on crop growth usually is strongly influenced by temperature and rainfall, yield monitoring needs to be repeated over several contrasting growing seasons.

INTERPRETING YIELD MAPS

Much can be learnt, even from the most basic of yield maps, by assessing soil condition at the best, worst and average points within a field. If the field contains obviously different soil units—for example, a mosaic of red and grey soil—the best average and worst yielding areas within each of these two soil groups should have their soil tested.

The 'post-harvest' soil description sheet should be filled out for each of these locations after digging inspection pits soon after harvest. The results can then be compared with the critical values presented in Chapter A2.

Soil compaction variations under the plant lines are becoming less of a problem due to the successful introduction of controlled traffic farming by most cotton growers. Yield limitations now are more likely to be due to soil instability in water, poor nutrition and/or inadequate field slope and bed height.

If a strong relationship is evident between the measured soil properties and cotton lint yield, these soil properties should then be mapped. The subsequent soil factor maps form the basis of soil management programs. For example, a soil stability map will indicate where gypsum or gypsum–lime mixes should be applied to the soil and at what rates. Remote sensing data may help to improve the accuracy of these soil factor maps (see the following section, `Use of remote sensing data').

Yield maps are also useful for ensuring that access tubes for soil moisture monitoring are located in representative positions within a field.

USE OF REMOTE SENSING DATA

Patterns of variation of soil properties

Where there is a strong relationship between key soil factors and patterns seen in aerial photographs or videos, accurate maps can be produced of that soil factor.

For example, on a field near Warren it was shown that airborne thermal infra-red scanning (which measures surface soil temperature) related strongly to surface soil sodicity. The sodic soil was more poorly drained, and therefore cooler, than nearby well-structured soil. This relationship allowed surface soil sodicity to be mapped (with a resolution of 4 m x 4 m), and the soil requiring gypsum application was drawn onto a map of the field.

It is possible to connect the gypsum spreader to a Global Positioning System (GPS), and an on-board computer containing the sodicity map, and spread gypsum semi-automatically exactly where it is needed (ASWAT score greater than 6) and at the appropriate rate.

However, this relationship between remote sensing pattern and soil stability in water cannot be transferred directly to other fields because of differences in other factors influencing crop yield, for example field slope, nutrient reserves.

Problems such as inadequate field slope, caused for example by the reforming of gilgais, are not fixed as easily and cheaply. Field re-levelling may be required.

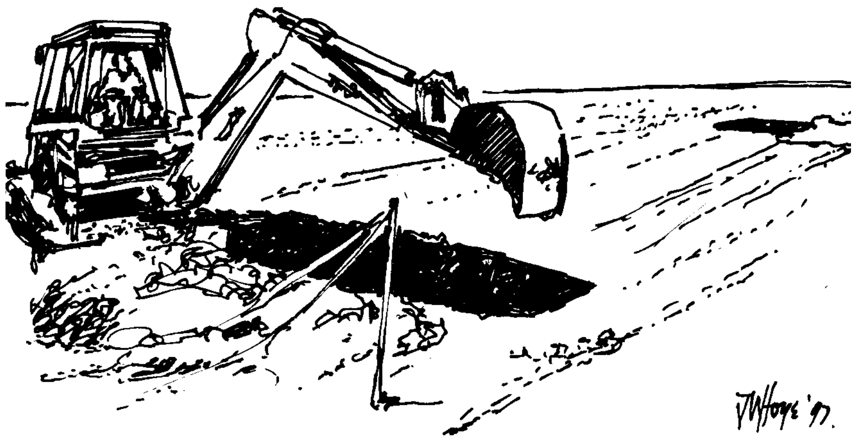
Patterns of variation of crop performance and lint yield

Airborne thermal infra-red scanning is being used commercially to indicate the relative performance of cotton within sub-sections of fields throughout the growing season. This procedure is based on the assumption that cotton with a high canopy temperature is under more stress (and therefore likely to have poorer lint yield) than cotton with a lower canopy temperature.

On a broader scale, ‘Landsat’ satellite imagery is being used commercially to give an approximate prediction of lint yield both between and within cotton fields.

Ideally, the remote sensing information described here should be used in conjunction with yield maps so that the reasons for variations in crop growth can be determined systematically. A Geographic Information System (GIS) on an office computer should be used to store the information.

B9. Soil survey for development or redevelopment



PURPOSE OF THIS CHAPTER

When planning a new cotton development, each management unit should have soil condition and slope as uniform as possible. To achieve this aim, the soil should be mapped before any irrigation design work is carried out.

In fields already under cotton, variability problems may be so severe that the field must be redeveloped. Again, soil surveys should be made before redesigning.

This chapter outlines how to carry out such surveys.

CHAPTER OVERVIEW

This chapter covers the following points:

- soil survey before new development for irrigated cotton
- soil survey before redevelopment of irrigated cotton fields
- 'available soil water' maps for drip irrigation design
- soil survey requirements for dryland cotton.

Other chapters to refer to:

- Chapter C3: 'Soil moisture (before tillage), soil texture and available water'
- Chapter C4: 'Structural condition'
- Chapter C7: 'Salinity'
- Chapter C8: 'Other tests'.

INTRODUCTION

When soil properties within a field are variable, it usually is impossible to deliver the required inputs to all sub-sections simultaneously when flood irrigation is used. Some parts of variable fields, therefore, will have lint yields that are lower than the field's potential, and product quality for the whole field will not be uniform.

In practice, it is unlikely to ever be economically feasible to completely remove across-field soil variability. However, if good quality soil survey information is available, the variation within each management unit can be minimised in a cost-effective fashion.

In locations where soil variability is considered excessive for all possible furrow irrigation layout designs, the feasibility of drip irrigation should be considered. Drip irrigation allows the required amounts of water to be added to sub-sections of a field when necessary, with minimal risk of losing water by deep drainage. Drip systems are much more expensive to develop than furrow irrigated fields, but deserve consideration in areas that have adequate water supplies and a suitable climate for cotton, but contain complex mosaics of soil with contrasting hydrological properties.

SOIL SURVEY BEFORE A NEW DEVELOPMENT FOR IRRIGATED COTTON

Money spent on a soil survey before development usually is repaid several times over because of the potential management problems that it highlights.

Soil survey information provides a benchmark that can be used to check progress with soil quality management as the cotton farming project proceeds.

In the Riverland district of South Australia, the Loxton Research Centre's 'Irrigated Crop Management Service' carries out soil surveys for landholders before land development for irrigated horticulture. This involves digging backhoe pits on a grid over a property at a spacing which varies from 50 m to 100 m.

The same procedure is recommended before land development for irrigated cotton, even though its value of production per hectare usually is less than for horticulture.

The best grid spacing to use for irrigated cotton developments is uncertain. However, as a first approximation a spacing of 100 m is recommended for land that obviously contains soil variation (for example, a mosaic of red and grey soil). For land with less-obvious variation, a spacing of 150 m is suggested. Further research is required to fine-tune these recommendations.

Using the 'SOILpak soil description sheet for cotton field development', assess the following features in the topsoil (0–10 cm), sub-surface (10–30 cm) and subsoil (30–100 cm):

- soil texture
- available water
- suitability of soil moisture for landforming
- aggregate stability in water
- natural regeneration potential
- salinity
- pH.

☞

See Chapters C3 and C4 for more information on soil assessment.

These soil factors should be mapped. Geographic Information Systems (GISs) are available for office computers—they allow the different layers of soil information for a field to be stored in an orderly fashion. Each of the soil factor maps can be converted to cost of repair maps.

Once all of the soil factors have been mapped in terms of the same unit ($/ha), they can be overlaid and added up to provide a 'total cost of soil improvement' map. Such a map will make the job of selecting suitable land for cotton development much more systematic, without making the process too complicated. The maps also allow soil with similar, difficult-to-modify, properties (for example; water holding capacity, shrink/swell potential) to be included within the same management units.

After design of the irrigation layout:

- landform each of the new fields (when dry if possible); try to avoid deep cuts into sodic subsoil
- create hills and/or beds; consider the use of guidance systems to make them very straight
- refer to Chapter B10 for suggestions about how to treat the soil before the first cotton crop is planted.

SOIL SURVEY BEFORE REDEVELOPMENT OF IRRIGATED COTTON FIELDS

Cotton fields are re-developed for a number of reasons, which include:

- subsided areas with poor surface drainage
- impractical field size or shape
- impractical mosaic of contrasting soil types
- inability to shed storm water in a controlled fashion.

Redevelopment provides an opportunity to properly assess, and if possible correct, soil problems that have been reducing farm profitability. It also allows soil with similar, difficult-to-modify properties (for example, water holding capacity) to be included within the same management units.

The procedures described above for 'new cotton developments' should be followed. The best grid spacing to use is uncertain. However, as a first approximation a spacing of 100 m is recommended for land that obviously contains soil variation (for example, a mosaic of red and grey soil). For land with less-obvious variation, a spacing of 150 m is suggested. Further research is required to fine-tune these recommendations.

Using the 'SOILpak soil description sheet for new cotton developments', assess the following features in the topsoil (0–10 cm), sub-surface (10–30 cm) and subsoil (30–100 cm):

- soil texture
- available water
- suitability of soil moisture for landforming
- aggregate stability in water
- natural regeneration potential

☞

See Chapters C3 and C4 for more information on soil assessment

- salinity
- pH.

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After design of the irrigation layout:

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- create hills and/or beds; and consider the use of guidance systems to make them very straight
- refer to Chapter B10 for suggestions about how to treat the soil before the first cotton crop.

‘AVAILABLE SOIL WATER’ MAPS FOR DRIP IRRIGATION DESIGN

Where it is impossible to devise management units that are large enough for furrow irrigated cotton—due to mosaics of soil with contrasting texture, infiltration characteristics and water holding capacity—consider the feasibility of installing drip irrigation.

Using ‘plant available water capacity’ (PAWC) maps, relatively-uniform drip irrigation management zones can be defined which receive neither too much nor too little water. This approach is used widely by the Australian wine industry to ensure that scarce water resources are used efficiently in vineyards with variable soil types.

SOIL SURVEY REQUIREMENTS FOR DRYLAND COTTON

Dryland cotton growers have fewer management options than irrigators when dealing with problem soil; their financial returns are lower.

Nevertheless, they should have a detailed knowledge of the soil on their farms. Degree of compaction at planting time, and soil water holding capacity, are particularly important.

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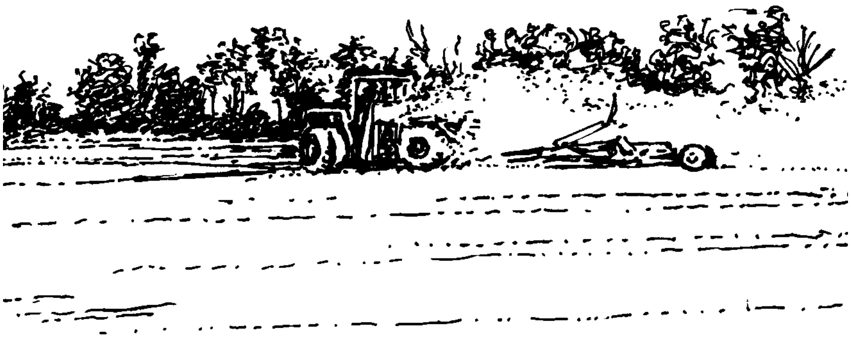
See Chapter D10 for more information on soil management for dryland cotton.

B10. Soil preparation after landforming



PURPOSE OF THIS CHAPTER

The aim of this chapter is to describe site assessment procedures that can be used after land development, and to outline the options that are available to deal with any problems that are identified.

CHAPTER OVERVIEW

This chapter covers the following points:

- soil management problems caused by land development
- available soil management options.

Other chapters to refer to:

- Chapter C3: ‘Soil moisture (before tillage), soil texture and available water’
- Chapter C4: ‘Structural condition’
- Chapter C8: ‘Other tests’
- Chapter D2: ‘Improving soil structure’.

INTRODUCTION

Landforming of cotton fields often creates soil problems that should be dealt with before cotton is grown. Issues include exposure and spreading of unstable subsoil, compaction, creation of abrupt texture-contrast boundaries and excessive dust production. These problems should be overcome before planting the next cotton crop.

Other soil problems (such as sodicity) that may have been identified during the pre-development soil survey can also be dealt with.

SOIL MANAGEMENT PROBLEMS THAT MAY OCCUR DURING AND AFTER LAND DEVELOPMENT

Exposure of unstable subsoil

Subsoil exposure usually is unavoidable because of the need to provide an even slope in irrigated fields. Even drip irrigated fields have to be landformed because of the need to quickly dispose of runoff water after heavy rain.

At best, the exposed subsoil will have inadequate organic matter. At worst, it will be sodic, depleted of mycorrhiza, have a high pH and perhaps be saline.

Where sodic subsoil is exposed, the scraped material also has poor physical properties. It may be spread thinly over low lying areas which previously had a favourable soil structure. Therefore it is desirable to stockpile the original topsoil, landform the subsoil, then replace the topsoil.

If stockpiling and replacement of the topsoil is not possible, the exposed sodic soil will have to be reclaimed by the use of gypsum, and perhaps by the growth of a well-fertilised barley crop. Zinc fertiliser may need to be added.

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See Chapter D2 for more information on improvement of sodic soil.

Compaction

Due to the tight schedules of landforming contractors, it is difficult to reshape fields at exactly the correct soil water content, particularly when there is a mix of grey and red soil. Nevertheless, a well-fertilised crop such as wheat should be grown just before landforming to maximise the chances of the soil being drier than the plastic limit (PL).

If, however, there is heavy rain before landforming and the contractors cannot be delayed, deep compaction may occur. In this situation, the soil needs to be carefully re-assessed.

Create beds and/or hills using a listing rig, preferably with a guidance system that ensures very straight furrows. Dig inspection pits close to at least three of the pre-development assessment sites, and use the soil inspection and interpretation procedures outlined in Part C. Fill out a ‘SOILpak soil description sheet for after landforming’ (see Chapter C2).

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See Chapters B4 and D2 for more information on overcoming soil compaction problems.

Creation of abrupt texture-contrast boundaries

Placement of scraped clay-rich subsoil over loamy topsoil may create a texture-contrast boundary that forms a perched water table. This may restrict cotton root growth due to waterlogging. Similar problems may arise when the buried topsoil has a thick layer of organic material that forms a wedge under the fill soil.

Once recognised, however, these impeding layers can be easily disrupted by deep tillage.

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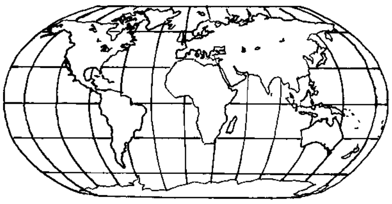
See Chapter D9 for more information on red soil management.

Excessive dust production

Silty soil is particularly difficult to landform because it compacts when it is wetter than the PL, but is reduced to fine dust when over-worked under dry conditions.

Generally the only option is to tolerate the dust problem until landforming has been completed, then take steps to improve soil structure as soon as possible afterwards. A cereal or forage crop should be grown promptly to protect the soil from wind erosion, boost soil organic matter content (to assist with re-aggregation of the surface soil) and permeate the potentially-hardsetting soil with stabilised root channels.

B11. Cotton soil management and the environment



PURPOSE OF THIS CHAPTER

Some cotton growers are gaining 'environmental accreditation' (for example, ISO 14000) for their farms. Such schemes commit participating growers to an ongoing improvement (or at least avoidance of a decline) in key environmental indicators (for example, soil fertility).

This chapter outlines the main soil related environmental issues that are relevant to cotton growers, and provides options for overcoming possible problems.

CHAPTER OVERVIEW

The following points are considered:

- soil and nutrient loss through water and wind erosion
- rising water tables and salinity
- greenhouse gas emissions
- pesticide and fertiliser residues.

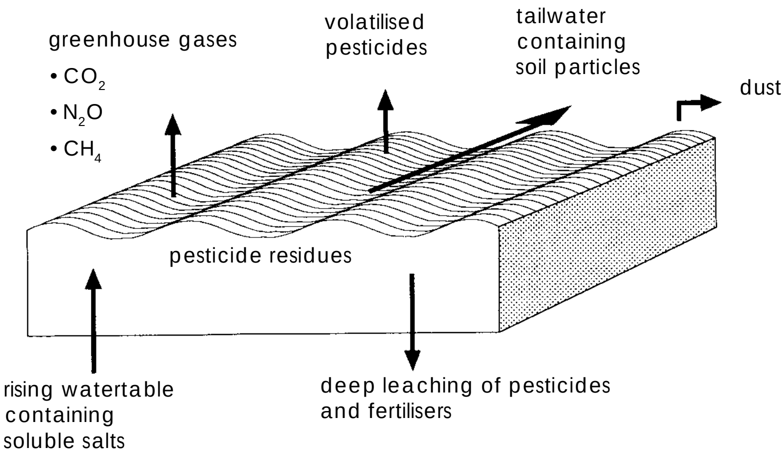
Other chapters to refer to:

- Chapter E3: 'Effects of sodicity and salinity on soil structure'
- Chapter E5: 'Organic matter and soil biota'
- Chapter E7: 'Water movement'.

INTRODUCTION

The Australian cotton industry is a pioneer amongst agricultural groups in Australia because of its attempts to define and minimise the adverse effects of its activities on our environment. The possible side-effects of insecticides have received detailed attention. However, there are several other issues, mainly associated with soil management, that deserve more consideration. Figure B11-1 summarises these issues.

Figure B11-1: Environmental issues that may be associated with soil management for cotton production



Whilst the exact impact of these problems remains unclear until further research is carried out, cotton growers can minimise them by making some simple and inexpensive modifications to their management procedures. This proactive approach should reduce the possibility of restrictive and expensive environmental legislation being imposed by government agencies. It is better to continue to responsibly address environmental issues as an industry, rather than being seen to be responding to pressure.

WATER AND WIND EROSION

Water erosion can move fertile topsoil, pesticides and dissolved nutrients. Most cotton farms now have tail water re-circulation systems, reducing losses off the farm. However, topsoil and nutrients may move to areas of the farm that are inaccessible to the growing crop—for example, the bottom of drainage ditches or storage dams.

The loss of topsoil and nutrients is likely to increase the need for fertiliser, and the regular excavation of drainage ditches is expensive. Eroded soil may carry adsorbed pesticides such as endosulfan. Also, increased concentrations of fine sand and silt in the furrows can reduce the soil infiltration rate.

Erosion usually occurs during heavy rain, although high-flow flood irrigation systems produce a similar effect.

Two metre wide raised beds are less prone to waterlogging than hills spaced 1 m apart; and this reduces the need for fast watering. Slowing the flow of water down the furrows will reduce soil erosion.

Organic mulches left on top of the beds, and on their steep sides will protect them from the erosive effects of raindrop impact during intense storms. Anchored straw is more useful than loose residue.

Wind erosion generally is a less serious problem than water erosion. However, dust blown from cotton fields may contain pesticide residues. Organic mulches will help to protect the soil surface from wind erosion within cotton fields, but pesticide drift onto dusty roads should be minimised.

RISING WATER TABLES AND SALINITY

Salinity is adversely affecting some small areas of cotton on silty soil in the Macquarie Valley. In most Australian soil types used for cotton, water movement beyond the root zone is considered by most authorities to have been negligible. However, on certain soil types deep drainage does add to the groundwater. The amount of pore space in the deep subsoil is very small, so 10 mm of water, for example, could raise the water table by as much as 300 mm.

As salt concentration in the subsoil increases, its ability to transmit water also increases (even in the heaviest clay soils). Therefore, all cotton soils can become leaky. Irrigation water contains dissolved salts that may accumulate over time.

Because the deep subsoil often has large amounts of sodium salts, it is crucial that the water table is never allowed to get within 2 m of the soil surface. Salinity is expensive to correct and it is difficult to dispose of saline drainage water.

To prevent the development of salinity in sensitive areas, the following management procedures are available:

- schedule irrigations to avoid over-watering
- monitor water movement to detect and then seal leaks in the system—for example from supply channels
- locate above-ground storages on the least-permeable parts of a farm
- grow vigorous rotation crops rather than leave fields in bare fallow
- plant trees and/or saltbush and lucerne to extract excess water.

Tree planting

Woodlots can occupy spare land, or trees can line fields provided there is no danger to aerial spraying operators. River red gum (*Eucalyptus camaldulensis*) is a suitable species. It is moderately tolerant of salinity and its roots can penetrate up to 10 m deep. It tolerates herbicide spray drift; but it requires good weed control over the first two years, and nitrogen fertiliser (70 kg/ha).

Inter-planting river red gum with saltbush (*Atriplex* species) or lucerne can increase water use. An established woodlot can remove 20–25 ML of water per hectare per year. Woodlots look good, reduce spray drift, absorb carbon dioxide, encourage wildlife, and provide timber for various uses.

A possible problem, however, is that the soluble salts in the groundwater may accumulate around the roots of trees and shrubs and adversely affect their growth. If this occurs, parts of the root zone should (if possible) be flushed with fresh water to translocate the harmful salts to other parts of the soil profile, or into drains and evaporation basins.

Alley cropping

In areas where lateral flow of near-surface groundwater is poor, the strips of vegetation for water table control need to be close together (about 70 m apart).

This form of farming is referred to as 'alley cropping'. It is becoming popular in parts of Western Australia. Optimal strip width and spacing for cotton soil needs to be determined by further research.

Lucerne strips for deep drainage control can also assist with insect management in cotton.

Deep-rooted winter rotation crops

Another option is to use a deep-rooted, well-fertilised rotation crop such as lucerne or safflower to dry all of the soil in a field to a depth of about 2 m. Because a flood irrigation usually will not wet the soil below a depth of about 0.8 m (at least for a few weeks after watering), the dry soil at 1–2 m depth acts as a buffer and absorbs any water leaking below the depth of rooting of cotton. Deep rooted rotation crops also help to overcome soil compaction problems—they create large cracks in the subsoil.

Persistent winter rain will recharge the deep subsoil, particularly if the land is fallowed. Under 'back-to-back' irrigated cotton, vigorous winter crops (for example wheat) reduce the risk of deep drainage losses. These winter crops are killed with herbicide just before the cotton is planted.

The decision about winter cropping is more difficult where dryland cotton is grown because of the need to conserve moisture for the next cotton crop. However, consider planting a crop such as wheat if plant available water is greater than 75% of capacity after cotton harvesting.

Salt inputs to cotton fields

Salt can move in from neighbouring areas—e.g. saline runoff from the Liverpool Plains enters the Namoi River and accumulates downstream in cotton fields at Wee Waa. Salinity control must involve the whole catchment, with detailed soil surveying to identify areas that are causing the problem, as well as areas under threat. Preventing the problem is likely to be much cheaper than finding a cure.

However, some salts are a lot more harmful than others. If the salt load in the irrigation water is dominated by calcium rather than by sodium, soil condition may actually be improved by the imported salt. Studies in the Macquarie Valley have shown, for example, that although about 1.5 t/ha of soluble salt accumulate in the soil for each cotton crop, through the irrigation water, the salt apparently consists mostly of calcium compounds.

GREENHOUSE GAS EMISSION

A build-up of greenhouse gases—mainly carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)—in the Earth's atmosphere apparently is causing temperatures to rise. A greenhouse gas is transparent to short-wave infra-red radiation, but is somewhat opaque to long-wave infra-red radiation. Thus heat from the sun (short-wave infra-red radiation) can pass through the atmosphere to warm the Earth's surface; heat re-transmitted by the ground (long-wave infra-red radiation) is absorbed by these gases instead of escaping. The result is a warmer Earth.

Since pre-industrial times, CO_2, CH_4 and N_2O levels have risen markedly (in order, 23%, 110% and 8% rises). The predicted rises over the next 50 years are 45–115% for CO_2, 200–500% for CH_4 and 25–60% for N_2O.

An increase in the concentration of CO_2 may make crops grow faster, and higher temperatures may allow the cotton industry to expand southwards. However, these benefits could be out-weighed by national problems such as sea-level rises and changes in rainfall patterns.

The CSIRO Division of Atmospheric Research has predicted that, in the Macquarie Valley, the temperature will increase between 0.4 and 1.7^{o}C by 2030. Average rainfall—particularly in winter—is expected to decline, but rain events are likely to be more extreme.

Nitrous oxide

Nitrous oxide (N_2O) has a greater ability to produce the greenhouse effect than the better known CO_2, so it is very important to control its emission. Another problem with N_2O is that when it eventually enters the stratosphere, it accelerates ozone breakdown, allowing extra input of ultra-violet radiation. This extra radiation increases the risk of skin cancer in humans and may have other, unknown environmental effects.

Man-made sources of N_2O include, in about equal proportions:

- fossil fuel combustion
- biomass burning
- losses from nitrogen fertiliser via the process of denitrification.

The total of these inputs is about 30% of that derived from natural sources.

Cotton farming, like other intensive forms of agriculture, may contribute substantial amounts of N_2O, although the actual amounts involved have not been measured. Experiments near Narrabri have shown that, if applied under less than ideal conditions, some of the nitrogen fertiliser is lost to the atmosphere as N_2O. Wet years and compacted soil increase the likelihood of loss.

Emission of N_2O from cotton farms can be minimised by management techniques such as:

- maintaining good soil structure
- avoiding unnecessarily early N application
- conserving crop residues
- using fuel efficiently.

Carbon dioxide

Burning organic residues releases carbon dioxide (CO_2) into the atmosphere. CO_2 is also released when soil organic matter decomposes. Decomposition is accelerated by tillage, and global warming is also likely to accelerate the process.

A study near Warren showed that the amount of organic matter in the upper 30 cm of the soil profile decreased by about 25% after 15 years of cotton farming, when compared with grazed natural pasture. If this loss has occurred in all Australian cotton soils (250,000 ha), approximately 6 million extra tonnes of carbon has entered the atmosphere.

This figure is very small when compared with the estimated world-wide totals of carbon (see Table B11-1).

Table B11-1. Amounts of naturally occurring carbon

Location of carbon	Estimated amount of carbon (billion tonnes)
Soil	1,456
Land plant biomass (about half of which is tropical rainforests):	827
The atmosphere:	725
Oceans:	
—shallow, exchangeable with the atmosphere	550
—deep, not easily exchanged with the atmosphere	36,450
Fossil fuels (coal, oil, gas)	7,243

The amount of carbon lost from our cotton soils is only a small proportion of the carbon that has been lost from cultivated soil in Australia—mainly used for dryland cereal production—over the period from 1860 to 1990 (an estimated 290 million tonnes of carbon). However, sown pastures and fertilised legumes in other parts of Australia have accumulated organic carbon that almost balances these losses.

Agriculture and forestry perhaps are the only enterprises that can counterbalance the huge increase in CO_2 emission from the burning of fossil fuels and from forest destruction in other parts of the world.

Any farming practices that encourage conservation or, if possible, accumulation of organic matter will help to reverse CO_2 build-up in the atmosphere. For example, reduced tillage conserves soil organic matter, and reduces the amount of CO_2 released by the burning of fuel in tractors.

Methane

Methane (CH_4) emission is not great under cotton, except where organic residues are burnt. Cattle grazing and rice production generate much greater quantities.

PESTICIDE AND FERTILISER RESIDUES

Pesticides

There is no clear evidence to show that pesticides (herbicides and insecticides) have an adverse effect upon the structure or biological activity of Australian cotton soils. Herbicides, in fact, can stimulate many of the organisms and biological processes in soil by providing them with an extra source of food. Anti-microbial chemicals—for example fungicides—generally have a greater inhibitory effect than other pesticides, but are not widely used for cotton production.

Toxic spills (for example, petroleum) have a much more serious effect on soil biological activity than properly-applied pesticides (Table B11-2). Pesticides are extensively screened for toxic effects upon the environment before their release, and are usually applied at low rates. Even if soil microbes are adversely affected by pesticides, populations return to their former levels within a few months unless there are unusually high concentrations of pesticides.

Table B11-2. The duration of the effects of people's activities on microbial communities or processes in soils

Activity	Duration
Crude oil spill	more than 10 years
Clear cutting of forests	300 years
Pesticide application	4–16 weeks
Strip mining	50–100 years

Some pesticides—for example DDT—may remain in the soil for many years, but can no longer be used. Modern pesticides used by the cotton industry are much more degradable. Before a pesticide can be registered for use, data on its persistence in the environment must be presented. For example, there is little carryover of either endosulfan or its decomposition products from one year to the next, although water and wind erosion has to be controlled to avoid off-site movement soon after application.

Soil compaction and depletion of soil organic matter may reduce the rate at which microbes can break down pesticide residues. Good soil structure and high biological activity should reduce the risk of pesticide residues building up. Organic matter in soil traps pesticides and reduces their volatile loss, allowing microbes to degrade the entrapped pesticides. Furthermore, repeated applications may even enhance microbial degradation of a particular pesticide.

Because most of the cotton pesticides are selective in their activity and do not persist for long periods in the soil, they are unlikely to adversely affect beneficial soil animals such as earthworms. It appears that earthworms are absent from most cotton fields because of disturbance by tillage, lack of food and excessive wetness and dryness of the soil, rather than because of pesticide residues.

Fertiliser impurities

Fertilisers and soil conditioners may contain toxic impurities. Some phosphate fertilisers and by-product gypsum contain traces of cadmium—a poisonous heavy metal that can accumulate in soil and be taken up by plants. Cadmium availability in soil decreases as pH becomes higher. High amounts of organic matter in soil help to limit cadmium uptake, but high chloride concentrations in the soil may increase cadmium uptake.

By-product gypsum may also contain fluorine impurities (up to 2%) but they become immobilised and unavailable to plants in clay soil. Mined gypsum generally has fewer toxic impurities than by-product gypsum.

Groundwater contamination by pesticides and fertilisers

In parts of the USA and Europe, pesticide residues are present in groundwater beneath cropping land, especially where the soil is light-textured. Australian cotton soil tends to be less permeable.

Nitrate salts can cause serious groundwater pollution, but the amounts involved are very low in most of the soil under cotton in Australia. Experimental work on a grey cracking clay near Narrabri has shown negligible leaching of nitrate below the root zone, but monitoring should continue.

Pollutants entering groundwater from normal application practices are said to come from non-point pollution sources; only very small amounts have the potential to enter the groundwater from any one location. However, point pollution sources (which include areas where empty drums have been buried, and places where spillage has occurred) can have much larger quantities of pesticides. The pollutants can move deeply and quickly if the point pollution source is close to an old bore.

Some early chemicals such as DDT were highly persistent, but not prone to leaching because of tight binding to soil particles. Now the trend is toward less persistent, but more highly mobile, chemicals that have a potential to pollute groundwater. Pesticides that normally break down quickly can remain active in groundwater because of low temperatures, and the lack of oxygen, ultra-violet light and biological activity. Table B11-3 compares the soil mobility of some of the chemicals used in cotton production.

The risk of groundwater contamination can be reduced by:

- following the recommended handling and application procedures
- accumulating soil organic matter, which encourages pesticide breakdown.
- careful application of irrigation water.

If there is no aquifer (sand or gravel layer) beneath the cotton field, or if the aquifer is very deep, risks are low. Where a problem is likely, use a pesticide from a lower mobility class (Table B11-3).

THE GOLDEN RULE OF ON-FARM ENVIRONMENT CONSERVATION

You can't be ***green*** when you're in the ***red***. A highly productive cotton enterprise is one of the few farming systems that is able to generate the wealth required to be environmentally constructive.

Table B11-3. Mobility of some of the chemicals used in cotton production.

Mobility Class **1** **very unlikely to leach**	**2** **slightly able to leach**	**3** **moderately able to leach**	**4** **easily able to leach**	**5** **highly likely to leach**
diquat disulfoton endosulfan glyphosate paraquat parathionphorate trifluralin	diuron prometryn	atrazine	amitrole dicamba endothal methomyl picloram	ethephon monocrotophos

B12. Case studies

PURPOSE OF THIS CHAPTER

The aim of this chapter is to present case studies involving soil diagnosis and management in a number of different situations.

YIELD MAP INTERPRETATION

Case study 1: Poor cotton yield in one corner of a field that had been heavily landformed

District: Gwydir Valley

Soil type: Grey cracking clay (Vertosol)

Soil diagnosis for high-yielding end of field

Field observations

Controlled traffic was used after precision deep tillage; there was evidence of hills having been moved sideways over old wheel tracks.

Soil test results

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay
Topsoil (0–0.1)	1.6	8.7	0.09	16	30	2.9	1.4	0.030	0.85	10	19	27	47
Subsurface (0.15–0.25)	1.6	8.5	0.16	48	29	4.0	1.5	0.039	0.75	11	18	27	47
Upper subsoil (0.4–0.5)	1.3	8.1	1.07	14	31	8.0	1.3	0.127	0.70	10	18	26	47
Mid subsoil (0.7–0.8)	1.2	8.0	1.80	26	34	11.3	1.3	0.158	0.60	7	17	30	50

KEY:
Spak score: SOILpak score (compaction severity under main plant lines); 0.0 = poor, 2.0 = excellent
pH: 1:5 soil:water
EC: dS/m; 1:5 soil:water
Cl: chloride in ppm; 1:5 soil:water
CEC: exchangeable cations in cmol(+)/kg, extracted using the Tucker method
ESP: exchangeable sodium percentage
Ca/Mg: calcium magnesium ratio (exchangeable cations)
ESI: electrochemical stability index (EC/ESP); values less than 0.05 indicate dispersion problems
OC: organic carbon (Walkley Black method)
Coarse sand (0.2–2 mm), fine sand (0.02–0.2 mm), silt (0.002–0.02 mm), clay (<0.002 mm), %

Interpretation of laboratory data

Slightly dispersive topsoil overlies a non-dispersive (ESI >0.05) but saline subsoil. Root growth by cotton is likely to be restricted below a depth of 0.7 m because of salinity. Structural regeneration potential is moderate (CEC = 20–40).

Management options to consider

Gypsum application (5 t/ha) is an option that should be assessed via the use of test strips. Improve the guidance of traffic so that furrows remain narrow and in the same position. Minimise deep drainage of water.

Soil diagnosis for low yielding end of field

Field observations

The observation pit was on a small sub-section of the field that had been heavily cut during field development. Controlled traffic was used after precision deep tillage; there was evidence of hills having been moved sideways over old wheel tracks.

Soil test results

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay
Topsoil (0–0.1)	1.0	9.3	0.24	8	31	12.7	1.8	0.018	0.65	16	19	16	51
Subsurface (0.15–0.25)	0.8	9.4	0.32	54	29	16.8	1.6	0.019	0.60	16	17	13	54
Upper subsoil (0.4–0.5)	0.5	8.4	2.09	84	32	22.3	1.8	0.093	0.40	15	15	16	55
Mid subsoil (0.7–0.8)	0.7	8.7	2.12	217	34	40.7	1.0	0.052	0.45	13	14	12	59

Interpretation of laboratory data

Strongly dispersive topsoil (ESI <0.05, ESP>5, high pH) overlies a non-dispersive (ESI >0.05) but strongly saline subsoil. Root growth by cotton is likely to be restricted below a depth of 0.3 m because of salinity. Structural regeneration potential is moderate (CEC = 20–40).

Differences in soil factors between 'high' yielding and 'low' yielding parts of the field

The 'poor' site is more sodic and saline than the 'good' site.

Management options to consider

Gypsum application (5 t/ha, possibly with 2.5 t/ha follow-up doses) is an option that should be assessed via the use of test strips. The soil is too alkaline for lime application to be successful. Improve the guidance of traffic so that furrows remain narrow and in the same position. Manage water application so that subsoil salt is pushed deeper (by no more than about 1 m). If sufficient summer rain falls, consider planting forage sorghum to overcome excessively-coarse tilth by shrink-swell processes.

If developing more land for cotton in this area, map the key soil properties such as sodicity. Try to avoid deep cuts when landforming if the subsoil is unstable in water.

Case study 2: Poor cotton yield in a strip through a light-textured cotton field

District: Macquarie Valley

Soil type: Hardsetting red soil (Chromosol)

Soil diagnosis for high-yielding section of field

Field observations

Lucerne was being grown after cotton, with controlled traffic. Shrinkage cracks were not obvious, although impregnation of the soil with a white paint solution indicated that they were the main macropores connecting the soil surface with the subsoil.

Soil test results

Depth (m)	Spak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay
Topsoil (0–0.1)	1.3	7.4	0.15	35	9	1.1	2.4	0.135	1.10	21	29	24	26
Subsurface (0.15–0.25)	0.9	7.7	0.06	15	10	2.0	2.7	0.030	0.95	20	29	27	26
Upper subsoil (0.4–0.5)	1.4	8.5	0.22	57	21	3.3	2.1	0.066	0.50	8	16	30	47
Mid subsoil (0.7–0.8)	1.7	8.7	0.21	83	22	4.3	1.6	0.049	0.45	4	23	30	43

Interpretation of laboratory data

The soil is unlikely to disperse in water (ESI >0.05), particularly at the soil surface, but has poor regeneration potential (low CEC).

Management options to consider

It is important to continue to restrict compaction to narrow laneways. Tillage should be minimised, particularly when the soil is dry and prone to dust formation. As much organic mulch as possible should be maintained at the soil surface.

Soil diagnosis for low-yielding section of field

Field observations

Lucerne was being grown after cotton, with controlled traffic. Shrinkage cracks were not obvious, although impregnation of the soil with a white paint solution indicated that they were the main macropores connecting the soil surface with the subsoil.

Soil test results

Depth (m)	S pak score	pH	EC	Cl	CEC	ESP	Ca/ Mg	ESI	OC	C sand	F sand	Silt	Clay
Topsoil (0–0.1)	1.2	7.9	0.10	20	10	1.5	2.4	0.067	1.20	28	30	19	23
Subsurface (0.15–0.25)	1.3	7.8	0.07	15	8	1.3	2.9	0.056	1.15	27	31	18	22
Upper subsoil (0.4–0.5)	1.6	7.9	0.06	22	14	2.9	3.8	0.021	0.65	21	20	21	40
Mid subsoil (0.7–0.8)	1.8	8.0	0.04	15	18	2.8	2.8	0.014	0.55	16	16	25	44

Interpretation of laboratory data

The soil is unlikely to disperse in water (ESI>0.05), particularly at the surface. It has poor structural regeneration potential (low CEC).

Differences in soil factors between 'high' yielding and 'low' yielding parts of the field

The 'poor' site has more sand in the subsoil than the 'good' site, causing greater deep drainage of water and nutrients.

Management options to consider

It is important to continue to restrict compaction to narrow laneways, and to minimise tillage (particularly when the soil is dry). As much organic mulch as possible should be maintained at the soil surface. Careful water management is required to minimise deep drainage.

COMPACTION MANAGEMENT ON A CRACKING CLAY

Case study 3

District: Darling Downs

Soil type: Grey cracking clay (Vertosol)

Two adjacent sites had been cultivated for 30 years, and furrow-irrigated (mainly with bore water) for 20 years. Cotton yield histories for the sites (referred to as Fields A and B) had been similar and above-average. The soil was a self- mulching grey clay; clay content at the soil surface was 53%, and ESP was 5.

In Field A, cotton was harvested after rain. During harvest, the soil surface and subsoil were wet, and remained so during subsequent land preparation. All of the preparation was done very quickly (within 7 days) as time was limited between the late picking and planting of the next cotton crop. Land preparation involved five passes over the field; in all but the last, a 4-wheel drive tractor with dual wheels, front and back, was used. The operations were: first rotary slashing to cut the cotton stalks, then tillage with straight chisels with 0.05 m wide points (to 0.12 m depth), followed by another two tillage passes with straight shanks with 0.1 m sweeps (to 0.1 m depth) and finally the planting of cotton. No fertiliser was applied pre-planting, as the plan was to fertilise through the early part of the growing season.

In Field B, the soil was dry when the crop was harvested; it was picked just before the rain. Unlike in Field A, the grower decided not to flatten the hills completely from the previous cotton crop. There were five passes over the field with the same tractor used as in Field A for passes 1–4. The operations were slashing of the cotton stalks, followed by tillage with straight chisels with 0.05 m wide points (to 0.12 m depth), then tillage with straight tines with 0.15 m sweeps to 0.12 m in the furrow bottoms with ‘go-devils’ to shape up the cotton hills. MAP and urea fertiliser were applied down each side of the hills before planting of the next cotton crop.

The wet cultivation Field A resulted in a 30% decrease in air-filled pores in the 0.2–0.4 m zone in Field A relative to the same zone in Field B. At the first irrigation the plants in Field A turned yellow and many fell over; many of the plants had ‘L-shaped’ roots. This response was so severe that the grower, faced with water shortages, decided to stop irrigating Field A and manage it as a dryland crop. There was a 70% lint yield difference between Fields A and B.

The vital point is that the measured structure degradation caused by wet picking did not directly cause the large yield loss; rather, it severely limited the owner’s management options.

It is also likely that lint yield in Field B could have been even greater if narrow-wheeled or tracked tractors had been used instead of duals, parts of which would have run over the plant lines.

For further information, see the paper by McGarry (1990) listed in Appendix 1.

OVERCOMING PROBLEMS WITH WATER PENETRATION ON A HARDSETTING SOIL

Case study 4

District: Macquarie Valley

Soil type: Hardsetting red soil (Chromosol)

Hardsetting red soil is not easy to prepare conventionally because if it is cultivated too dry, it is like talcum powder. When re-wet and then dried, it sets like concrete and is difficult to irrigate.

Direct drilling of cotton into wheat stubble can deal with hardsetting problems.

The following example indicates the benefits. There were great improvements in water penetration, and longer intervals between irrigations.

Comparisons were made with a neighbouring field which had some wheat stubble, but which was incorporated before planting.

Planting

Both fields were planted on the same day (29 September 1997) to Sicala V2. The planter setup was the same for both fields, with 3 kg/ha of Temik[R].

The no-till area was slower to establish because of cooler soil temperatures. Eventually, the no-till field had a denser plant stand.

Ground preparation

No-till Field 29	Conventional Field 30
nil	1 Mulch 1 Go-devil 1 Sled (gas) 1 Sled (incorporated) 1 Lilliston (2nd incorporation) Roller

Herbicides

Herbicide timing	No-till Field 29	Conventional Field 30
Fallow	2 X Roundup @ 1.2 L/ha	–
Incorporated	Diurex @ 1.7 kg/ha Stomp @ 3 L/ha	Cotoran @ 3 L/ha. Trifluralin @ 2.1 L/ha
Plant	Cotoran @ 3 L/ha (100% Band)	Cotoran @ 3 L/ha (50% Band)
Lay by	–	Diurex @ 1.1 kg/ha Prometryn @ 2 L/ha

Fertiliser

No-till Field 29	Conventional Field 30
Total of 180 kg/ha of N flown on in 2 applications	Total of 160 kg/ha of N applied as gas, and side-dressed as urea

Water

No-till Field 29	**Conventional Field 30**
5 irrigations; still drawing water from depth at the end of the season; able to infiltrate more water to depth	7 irrigations; water not getting through profile >80 cm after 1st irrigation

Differential costs

The following table shows the difference in production costs between the two fields. It includes only costs that are different (that is, it does not include insecticides).

$/Hectare	**No-till Field 29**	**Conventional Field 30**
Ground preparation	–	250
Herbicides	110	120
Sowing costs	30	30
Fertiliser	150	150
Chipping	110	74
Total	400	624

For further information, see the paper by Soulsby, Ryan and Finney (1998) listed in Appendix 1.

DEVELOPMENT OF NEW COUNTRY

Case study 5

District: Narromine

Soil type: Recent alluvium

Severe inherent problems in subsoil and topsoil can be avoided if soil pits are dug before development.

If the soil will need amelioration before cropping, this can be costed into the project. Soil evaluation also allows you to select appropriate irrigation systems.

The Macquarie Soil Management Service inspected a series of four pits on part of a farm where irrigation development was proposed. Two of the pits showed excellent profiles of alluvial river soil to below 1.5.m, with lots of root activity and earthworm channels throughout. The other two pits showed the same soil for the first 20 cm, but underneath was a very tight red soil with negligible root activity. Use of a dispersion test showed that this soil was highly dispersive. Subsequent laboratory testing confirmed that the subsoil was very sodic and expensive to treat.

Pits dug soon afterwards on a grid pattern allowed the area with unsuitable subsoil to be mapped and excluded from the development.

For further information, see the paper by Kay (1988) listed in Appendix 1.