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# soil and water

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## sawma VIEWPOINT

Reading the MAFF weather bulletins it would appear that the majority of the country has suffered from heavy rainfall in April. This, apart from the obvious difficulties in getting in spring crops, seedbed preparation and good drilling conditions raises one or two interesting points.

Did the heavy investment in irrigation machinery in 1976 pay for itself in that year? It is fairly certain that for potatoes, some vegetable crops, perhaps on sugar beet and grass for drying units, it did. The irrigation companies report that their sales and order books still look extremely healthy. If the current weather pattern continues will this trend disappear? The feeling is that the companies should give more effort into promoting the use of their equipment in seedbed preparation, boosting germination percentages and providing a 'When to use water' service to their machinery uses. D

### MUCK '77

One thing that became obvious whilst watching demonstrations at Muck '77 was the possible pollution problems that could occur from using pressurised spread slurry tankers shooting slurry many feet into the air. Drift and run off could pollute water courses, possibly get into irrigation systems and onto vegetable crops.

One development — placing slurry underground by pumping it into a timed channels does raise the question of whether the slurry at the proposed dispersal rates will have a detrimental effect on soil structure, uptake and mineral balance in available water, mineral lock up and finally to drainage if smearing occurs in most soil.

*Serious erosion on light land.*

## SAWMA VISIT Gleadthorpe EHF

The first of this year's SAWMA visits on June 9th has been arranged by courtesy of the Farm Director, Mr. S. P. McClean.

Gleadthorpe has been an Experimental Husbandry Farm since 1949 and serves the sand land and clay farmers in the drier parts of the Midlands and East Anglia. The majority of the soil varies from loamy coarse sands to coarse sandy loams, very pebbly in places, overlaying Bunter sandstone. The land is easy to work but crops, because of the low rainfall, 61.2 cm (24.25 ins), are very prone to drought. Less pebbly areas are prone to wind erosion.

The total area of the farm 185 ha (458 acres) has the River Meden running through the middle of it and is bordered by low-lying alluvion and peaty soils 29 ha (50 acres) is in permanent pasture and the remainder is farmed rotationally with potatoes, sugar beet, cereals and leys cashed through beef cattle.

The visit will be looking at:—

1. Soil improvement and crop rotation on sandland.
2. Cultivations for early sowing of spring barley.
3. Wind erosion control in sugar beet.
4. Crop responses to irrigation. U

## SUBSOILING DEMONSTRATION

For some years now there has been an increasing interest in the use and methods of subsoiling. Each manufacturer of subsoiling equipment. and there are a considerable number of them, have machines which have been developed by extensive research.

Last autumn was a particularly bad one for soil structure. After the long. hot, dry summer an unprecedented amount of rain fell to interrupt autumn drilling. It was often necessary to do land-work when conditions were not right and it is most evident that many soils will need some form of correction before the next crop.

This major demonstration, which is being actively planned by the Association's Technical Committee, The Agricultural Development and Ad-

*Continued on page 14.*

## In this issue

# DRAINAGE AND SOIL MANAGEMENT AT COCKLE PARK

Peter Askew from the Department of Soil Science at Newcastle-upon-Tyne University and Ron **Jarvis** of the Soil Survey of England and Wales present a history to the drainage **and** soil management at this years Farmers Weekly Drainage Demonstration Site.

This year's Farmer's Weekly International Drainage Event at Cockle Park Farm near Morpeth, Northumberland, will involve soils familiar to many farmers on clayey till (boulder clay) in Northern England. Northumberland has always taken agricultural research seriously and although Cockle Park has been operating since 1896, a scheme for an experimental farm in the county was proposed as long ago as 1797. Cockle Park was originally established as the Northumberland County Agricultural Experimental Station with the Professor of Agriculture at the University acting as its Director. This unique partnership between Northumberland County Council and the University continued unbroken until 1947 when Cockle Park was purchased by King's College, University of Durham, now the University of Newcastle upon Tyne. Cockle Park is still used predominantly for experimental work whilst Nafferton Farm near Stocksfield-on-Tyne is the University's main commercial farm.

Cockle Park was originally selected for experimental work because its soils were typical of the infertile, heavy, poorly drained boulder clay areas of south-east Northumberland. The Drainage Event is to be held on Long Rigg, Tree Field and Hanging Leaves Field, the last two being formerly sites of the classical experiments on the improvement of permanent grassland by the application of manures, particularly basic slag, which were begun in 1896 and for wh Cockle Park is so famous.

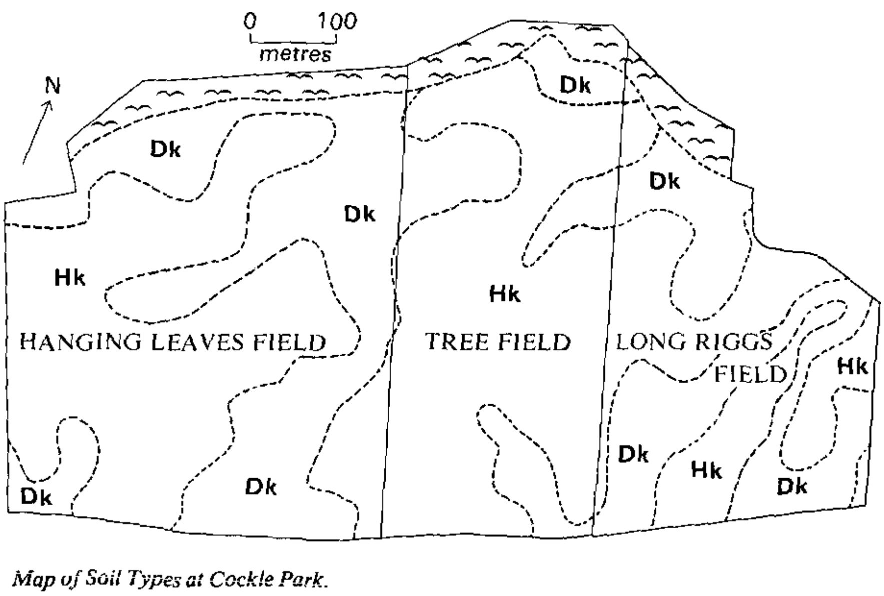
## Past and present farming

When Professor Somerville commenced his trials these fields had been in poor permanent pasture for many years though doubtless they had been ploughed during the more prosperous farming times earlier in the 19th century. With the agr cultural d ion they were allowed to tumble down, like so many other areas of clayland, to weedy, scrub pastures which received little if any manures and which supported only a low stocking of store cattle. Cockle Park was then a poor holding which much of its grazing valued at only 2/6 to 5/- per acre per annum. In 1896 the 461 acre farm was leased for 21 years at an annual rent of £200 which, even allowing for inflation, indicates the low quality of the farm at that time. Tree Field and Hanging Leaves continued as permanent pasture trial areas until 1956 since when, with the adjacent Long Riggs field which had been ploughed out of pasture during the Second World War, they have been under a ley-cereal system in whichgenerally a three years ley has been followed by a similar period of arable cropping. In preparation for the drainage demonstration both fields were reseeded last autumn after the harvest of winter wheat which was the second cereal crop following the ploughing up of a three year ley in 1975. Long Riggs was also reseeded in 1976 following three years of cereals.

There have been two previous attempts at draining this area of Cockle Park. About 150 years ago the old saddle-back type of tiles were inserted at a depth of 120 cm without any form of permeable fill. Whilst it seems that a few of these deep drains are still active the very low permeability of the overlying 90 cm or so of clay renders them generally ineffective though they probably functioned more satisfactorily for a number of years after installation prior to the disturbed clay settling back and compacting over the tiles. More recently when the grass trials were ploughed out in 1956 the fields were shallow drained at a depth of only 45 cm without permeable fill and at intervals of 7 m. These drains are now generally ineffective, the tiles have been broken and blocked.

HANGING LEAVES FIELD, TREE FIELD AND LONG RIGGS FIELD, COCKLE PARK, NORTHUMBERLAND

**Hk** Hallsworth soil series
**Dk** Dunkeswick soil series
~ Alluvial soils outside demonstration area




*1 Map of Soil Types at Cockle Park.*

## Soil Profiles

During a recent survey the soil profile was examined to 1 metre depth at 152 points within the 46 hectare drainage strat on are. At 5 of these site the HALLSWORTH soil series was identified, a heavy soil with a clay substrate starting within 40 cm of the surface, usually immediately beneath the plough layer. The soils at all but 4 of the 56 remaining locations belong to the DUNKESWICK series which has a layer of clay loam beneath the plough layer, with the clay substrate starting at between 40 and 80 cm from the surface. (The soil pattern is shown in the accompanying map).

The usefulness of both soils is limited by low permeability, which means a high poaching risk and prolonged waterlogging, making drainage essential on this very slightly sloping site and affecting cropping flexibility and timing of cultivations and grazing.

Management and cropping

The grassland studies at Cockle Park proved long ago that these soils can support highly productive and good quality swards though the nature of the soil inevitably restricts the grazing season in spring and autumn. Improvement of drainage would diminish but not remove the high susceptibility of these soils to poaching. The soils, whilst clearly unsuited to intensive arable cropping, will grow excellent crops of cereals especially winter wheat. In addition to the installation of satisfactory drainage system, timeliness of cultivations and the avoidance of damage to soil structure and drainage during top dressing, spraying and harvesting are the more important measure of good soil physical management. Inevitably there will always be the difficult season when some operation or other has to be carried out when the soil conditions are really too wet and as a consequence structure and soil permeability suffer. The soils are thus probably best suited to an arable-ley system in which two to three years of winter cereals are followed by well managed leys.

Relevance of the site

Although the drainage demonstration area forms little more than one sixth of the farmland at Cockle Park the soils are very typical of the whole farm, with the same variations in the depth to the clayey substrate beneath the clay loam. Only in four fields near the farm buildings are appreciable areas of markedly different soils found, where the boulder clay peters out and sandy loam soils with free natural drainage overlie coarse sandstone.

Cockle Park was selected as the site for an experimental farm because its soils were typical of south-east Northumberland. In fact similar soils occupy a large part of north-east England, extend down the length of the Pennines along the eastern side and are common in Lancashire. Climate is a key factor determining the utilization of these soils. Only in the drier lowlands of the North-East is cultivation possible, and permanent grass soon takes over once the land starts to rise. Cultivation is unprofitable in areas with a moisture deficit of less than 50 mm. The average maximum moisture deficit in the Lancashire uplands is only 57 mm, whereas that at Cockle Park is 104 mm. Where the moisture deficit is less than 50 mm most soils are liable to puddling. Moling is most effective, provided other conditions are suitable, where moisture deficit is 50–100 mm. For subsoiling the moisture deficit should be over 100 mm. ☐

## CULTURAL SYSTEMS IN POTATO PRODUCTION

**Duncan McM Kerr** of the National College of Agricultural Engineering has made a special study of cultural systems for the potato crop. The practical aspects concerning the soil management for the crop are described below.

***With a model of cultural systems it has been possible using a computer program to integrate work day probabilities for a given locality to timeliness in scheduling operations and optimizing equipment selection and replacement.***

***Such a model for potato planting has been developed which can be used by farm managers and agricultural advisers as a guide to decisions on methods of operation and management practice. [See Farmers Weekly, September 17th 1976]***

Cultural systems are modified by seasonal and climatic conditions though ultimately output or returns are dependent on the allocation of land, labour and capital to the enterprise. Shortage of labour has compelled growers to mechandise more completely and may mean that machinery is not being used to the best advantage or that field operations are not being carried out at the optimum time.

There are time constraints from soil tractability and weather criteria which determine the availability of work days in any locality and the adequacy of machine capacity.

Labour and machinery may be used more effectively by changing the system of culture.

The choice of system is influenced by management objectives and depends primarily on soil type.

In practice actual operations vary according to soil conditions and management decisions.

Soil type

Although the potato crop is grown on a wide range of soils, there is a tendency to intensify cultivation on medium loam, which is an ideal soil when relatively stone free.

In Scotland more than 80% of the area planted is on medium loam compared with about 40% in England and Wales.

For maincrop production in Great Britain figures for other soils are 14% light loam, 8% for heavy loam, peat and silt, 6% for limestone and skirt, 5% sand and 1% clay.

As the clay content of the soil increases, especially if the organic matter content is low, cultivations become more difficult and dependent on the weather.

All soils to a certain extent deteriorate unless there is sufficient organic matter, particularly those with high silt fraction, tending to cap and in

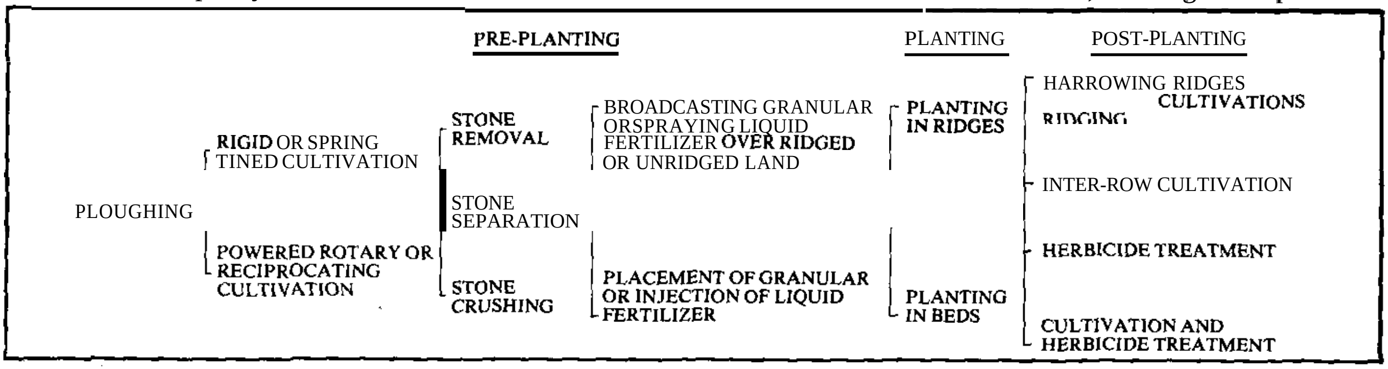



*Fig. 1. Alternative methods of seedbed preparation, stone treatment, fertilizer application, planting and weed control.*

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# Direct drill your way to fresh fields of super grass with 'Gramoxone.'

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extreme circumstances becoming completely unworkable.

Application of organic manure improves the structure and water holding capacity of soils in addition to providing some nutrients, though mineral fertilizers are the main source of nitrogen, phosphate and potash for the potato crop.

Well drained land is needed otherwise the crop may suffer through delayed seedbed preparation and planting or difficult harvesting conditions.

**Pre-planting operations**

Cultivations for the potato crop begin with early ploughing in the late summer or autumn followed by spring work limited to the depth of tilth.

If it is necessary to break up the lower soil to facilitate drainage it is advisable to subsoil rather than plough deeper as there is less risk of incorporating unweathered soil which will subsequently dry to form bard clods. With bed culture there is less risk of soil compaction during cultivation and reduced clod formation.

Many farmers consider stones to be more of a problem than clods, though unlike clods the prevalence of stones is not affected by normal cultivation.

After ploughing two to four pre-planting cultivations are usually needed.

The number of operations depends on whether seedbed preparation, fertilizer application and stone treatment are sequenced in relation to the planting operation, as in most farm situations or scheduled parallel, when machinery combinations are to he used having simultaneous functions.

Where land must be worked immediately prior to planting the rate of work should not be below that of the subsequent operation otherwise there will be a delay.

Seedbed preparation

This operation should aim to conserve soil moisture and avoid consolidation.

On light free draining land and those soils less liable to form hard clods seedbed preparation can be done without powered implements, though rotary cultivators with 'L' blades and reciprocating harrows are used on light soils.

These implements are unsuitable for heavy land, their power requirements would be very high, and on soils with appreciable clay content as this type of rotavator can impede the free drainage of the ɔper layer by smearing the lower soil.

With the same power requirement a rotary harrow is more effective than a reciprocating harrow.

The forward speed of the reciprocating harrow and the lateral speed of its tines tend to be limited and the rate of work can be less than that of planters.

*1. The greater forward speed of powered rotary tined implements permits their combination with planters. (Howard Rotavator Ltd.)*

It is possible to prepare a seedbed over a period on some heavy land with soils having appreciable organic matter, and for this rotary cultivators with spiked tines are suitable. These are more appropriate than reciprocating harrows, but less effective than rotary harrows.

On most arable soils it is advisable to work with the planter and do no more seedbed preparation than it is possible to plant.

The reason is that it takes far longer for the soil to dry after rain when prepared than if undisturbed.

Under these circumstances planting will need to be delayed until soil conditions are suitable.

Fertilizer application

Recommendations should take account of soil type and nutrient status as well as the specific requirements of the market for which the crop is being grown.

The method of application and the prices of fertilizers determine the optimum rates.

Nitrogen is not generally given before early March for main crops, but phosphate and potash can be applied during late winter.

Granular fertilizer may be broadcast and liquid fertilizer sprayed over ridged or unridged land before planting.

Alternatively, liquid fertilizer can be injected. and granular compounds placed in bands below the depth of planting.

Factors other than costs of fertilizers have to be assessed in comparing the efficiency of placement methods with broadcasting. Placement applications, usually 25 to 50% less than the broadcast rate, are more rewarding where low fertilizer rates tend to be used and in high rainfall areas.

This method is less effective for moderate to high rates, where soil nutrient status is satisfactory and not so worthwhile for large planted areas.

It is unfavourable in late seasons and in dry seedbeds where it is likely to cause scorch of seed, delaying emergence and possibly reducing yield, especially with sprouted seed.

Many farmers prefer to broadcast half the application and place the remainder at planting as this improves timeliness and increases speed in work.

*2. Equipment for liquid fertilizer application showing a tractor mounted tank and pumps fitted on the planter. (Chafer Ltd.)*

Attachments for granular fertilizer placement can he either front mounted on the tractor or planter.

ect on c quipment ep s on the type of planter and other technical considerations such as control of planting depth, load transfer, steering and the lifting capability of the tractor hydraulic linkage.

Stone treatment

Unless stones and clods are separated from the soil, treatment involving crushing and conditioning will require the use of high powered rotary cultivators until the material is reduced in size to pass through the harvester web.

The residual fragments of rocks such as sandstone and limestone will tend to be rounded compared to the flat and angular fragments of harder igneous rocks or flint stones.

It is essential that this treatment is effective as the over sized fragments can cause additional wear on machinery and almost as much damage to potatoes as the original stones, as well as being a hazard to tractor tyres.

In some farm situations therefore this treatment should be avoided.

The material can be separated at harvest or in the spring under suitable conditions when a cultivation is needed to bring the stones to the surface.

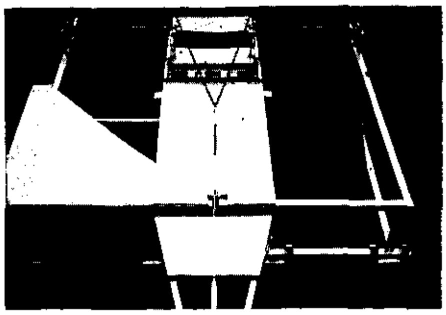
Machines for stone picking are comparable with elevator diggers, either loading trailers alongside or operating independently of transport with a skip on the machine that is emptied at the headland, thereby reducing field tracking. Stones influence soil temperature variations and levels of moisture.

There are indications of lower water infiltration, greater run-off and more compaction when stones are removed.

3. An illustration of surface erosion of ridges on a soil with low stone fraction.

Instead of taking the separated material off the field it can be placed in **windrows** between the beds or ridges to be planted. There is a problem on very stony soils of burying all the material within the furrow.

For beds the operation is done in a **single pass with appropriate machinery, but for ridge culture the operation may involve a double pass method of** stone windrowing.



4. ***A*** two row separating machine. (Root Harvester Ltd.)

Stone separating and windrowing is most appropriate for potato growers primarily interested in the land for only one season. The cost and effect of treatment are dependent on soil type, the quantity of stones, labour **requirements,** repair costs and improved harvester capacity.

The capital investment in equipment and the benefits to other field **operations** must be taken into account when estimating costs.

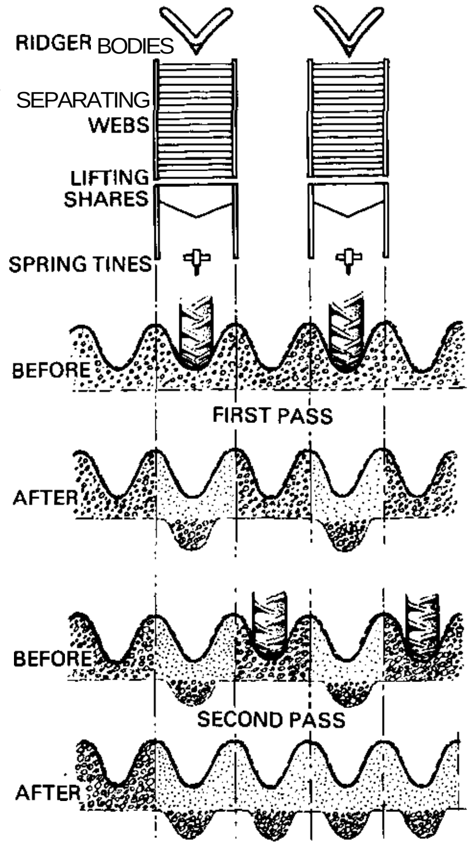



*Fig. 2. Method of operating the stone and clod separating, windrowing and covering machine.*

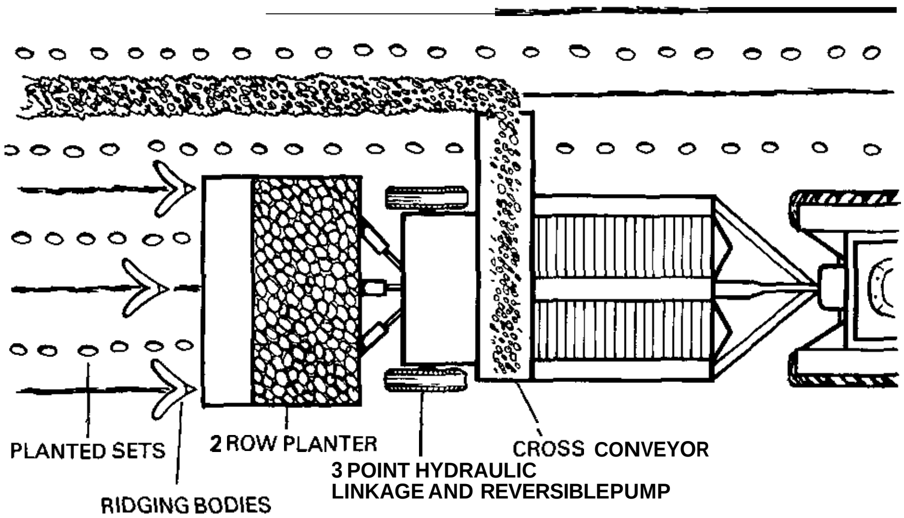



Fig. 3. The operations of stone windrowing and planting can be combined.

Planting operations

Planting is influenced by the probability of late spring frost and the need for temperatures to rise.

Below a soil temperature of 5°C there will be no growth.

Depth of planting affects both yield and the distribution of tubers within the ridge or bed.

With ploughing to a depth of 25 cm, about 15 cm of tilth in the seedbed will enable setts to be planted so that their lower surface is 10 cm below ground level, leaving at least 5 cm of tilth beneath them.

Planting after stone windrowing should avoid bringing the material back when covering the setts.

There is a trend towards planting in wider rows up to 90 cm, and over half the area now planted is on 75 cm row widths.

There are advantages from increasing row widths as long as wider rows can be integrated into the farming system that includes other row crops.

Changing from 75 to 90 cm rows will give a reduction of 16.7% in the length of row per hectare.

Providing the machinery can still be used at the same operating speed the rate of work will be increased by the same figure.

The bed system of culture was originally used with hand planting when the potato crop was first introduced.

Hand planting is now only significant in Scotland on 7% of the area and in England and Wales only 3% of the area in the South West is planted by this method.

More than 60% of the remaining land is planted by two row belt fed or other automatic machines.

The efficiency of planting as with other operations is affected by field parameters of size and shape, terrain and soil conditions.

The theoretical capacity of machinery is determined by row width, the number of rows and operating speed.

The ratio of the total time taken to complete planting, which includes time for loading, turning, machine adjustment and maintenance during work, to the time available is termed the field efficiency.

For irregular shaped fields this is expected to be significantly less than for rectangular fields because of excessive turning time.

Planting is normally carried out with the rows in the direction of the longest axis to minimise field travel and non-working time.

There are limitations to method of planting from the planter mechanism, hopper capacity and seed rate as well as methods of seed handling, seedbed preparation, stone treatment and fertilizer application.

If machinery cannot be adapted for bed culture or wide rows and is difficult or expensive to modify then replacement will be necessary.

Most farmers could not afford the direct capital outlay that would be involved.

However, replacement machinery can be purchased over a period, so that in time the change can be made, so long as it is justified.

Economic factors that need to be considered include labour requirements, yield in relation to timeliness and the quality of work in terms of accuracy in seed rate and regularity of spacing.

In beds close row spacing can be achieved with up to four rows of setts 'planted on the square', and two staggered rows can be planted in a wide ridge.

Investigations have shown that total yield in beds is reduced, though the seed fraction is less affected than ware yield. Consistently higher yields of the canning grade have been obtained from the two row ridge.

This method of planting would be more complimentary with regard to machinery requirements in a cropping system growing potatoes for both canning and ware markets.

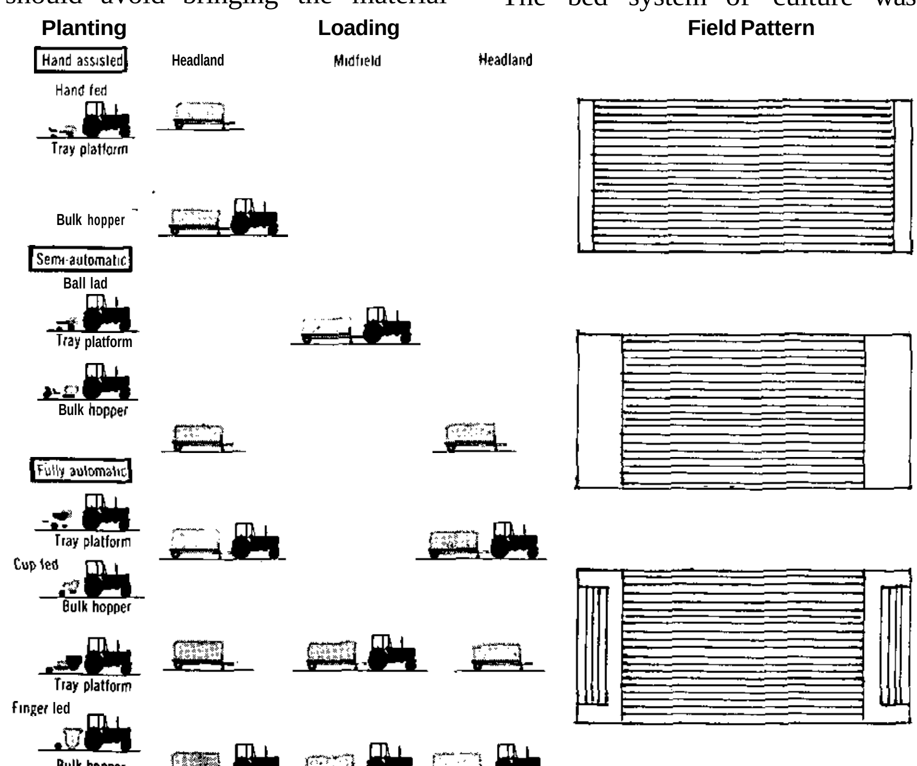



*Fig. 4. A schemative diagran representing planting machinery and methods of loading th different field patterns. (Reproduced by courtesy F rs* Weekly.)

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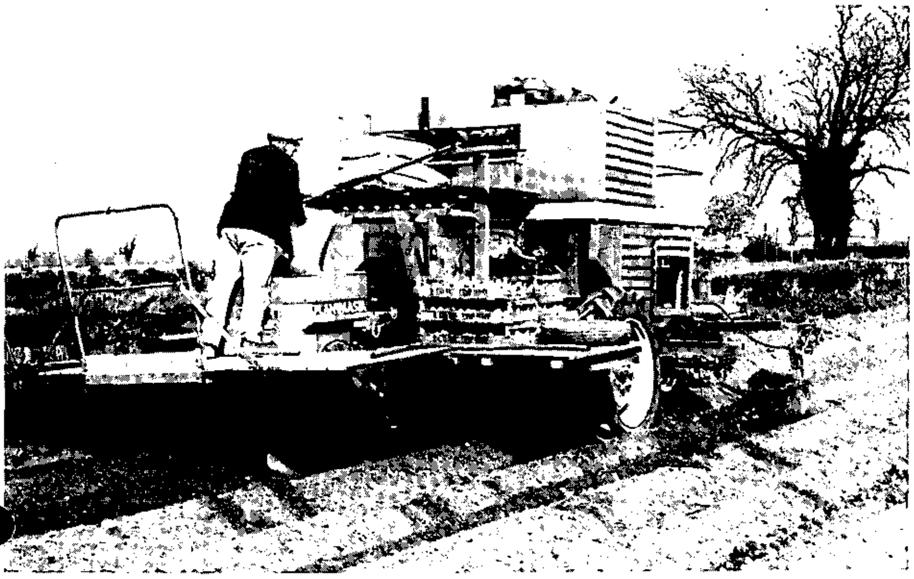


5. A machine capable of stone windrowing, fertilizer placement and automatic planting. (R. *Pearson* Ltd.)

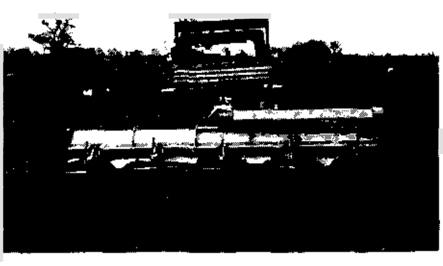
## Post-planting operations

The trend has been towards fewer and lighter cultivations and weed control by herbicide treatment.

The number of operations will vary according to the cultural system.

Widths of rows and beds affect the performance of all machinery operations in terms of effective field capacity and determine the requirement for tilth.

Adequate depth of cultivation is essential though inter-row cultivations can be carried out if more tilth is needed.



6. An inter-row rotary cultivator with riding bodies working a width *of 25* to 35 cm between the rows. *(Rumpstad)*

Generally the size and conformation of a ridge giving 650 to 775 $cm^2$ is ideal, as on 75 cm rows.

When spaced at 90 cm the ridges can be made the same size leaving a 30 cm area so that tractors with standard tyres can pass without consolidating the sides of the ridge.

Similarly beds with a width of 150 cm can have an area 30 cm wide between them which may be used for stone windrowing.

## Weed control

Row cropping was primarily adopted for potatoes allowing mechanical post-planting cultivations to control weed growth in the crop.

Herbicide treatment as an alternative method of control has enabled bed culture to come back into systems of commercial potato production.

Contact and pre-emergence treatment does not eliminate the need for subsequent herbicide application or light cultivations on ridges.

Any crop plants that have emerged by the time of spraying are temporarily damaged.

Post-emergence application to foliage is aimed at selectively killing weeds, though too much rain after spraying can mean that chemicals can cause damage to setts.

More residual herbicide treatments are soil acting and can be incorporated in the soil along with pesticides before the crop is planted.

Soil and weather conditions will therefore influence the time of application and also the time when the crop can eventually be planted.

Acknowledgments

Research at the National College of Agricultural Engineering has been concerned with a technico-economic evaluation of potato seed management and planting methods.

Investigations by the Department of Agricultural Engineering, Edinburgh School of Agriculture have been involved with stone treatment.

These studies have been sponsored by the Potato Marketing Board. The Scottish Institute of Agricultural Engineering has carried out other work.

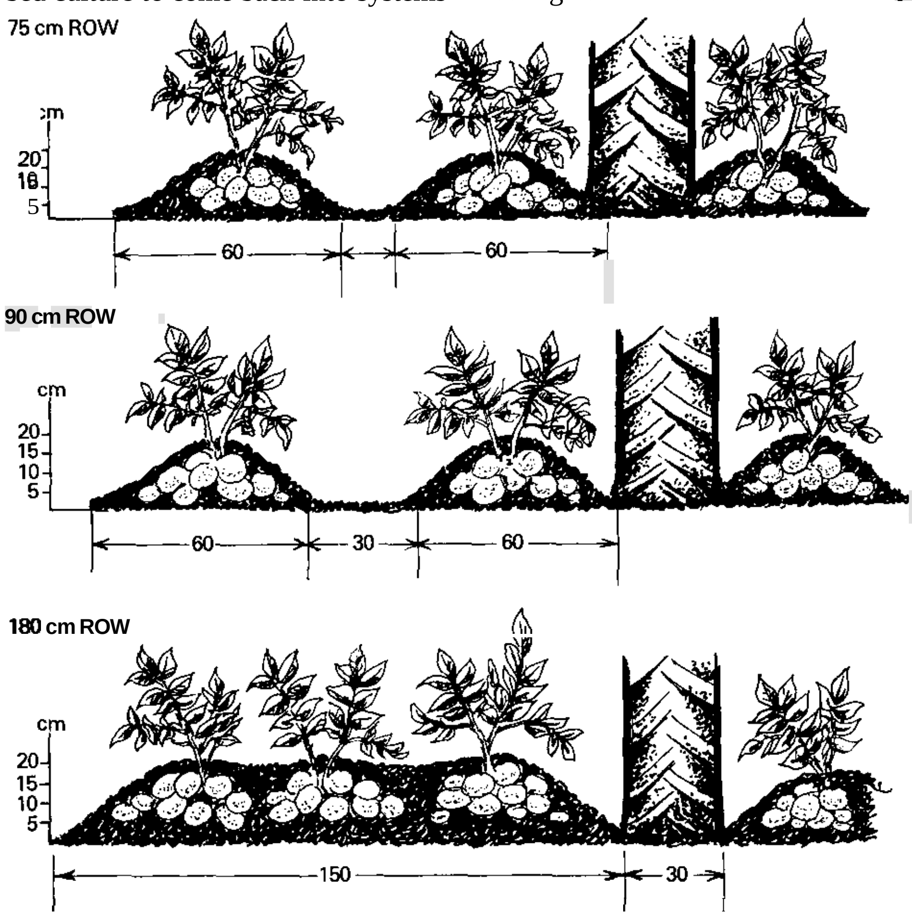
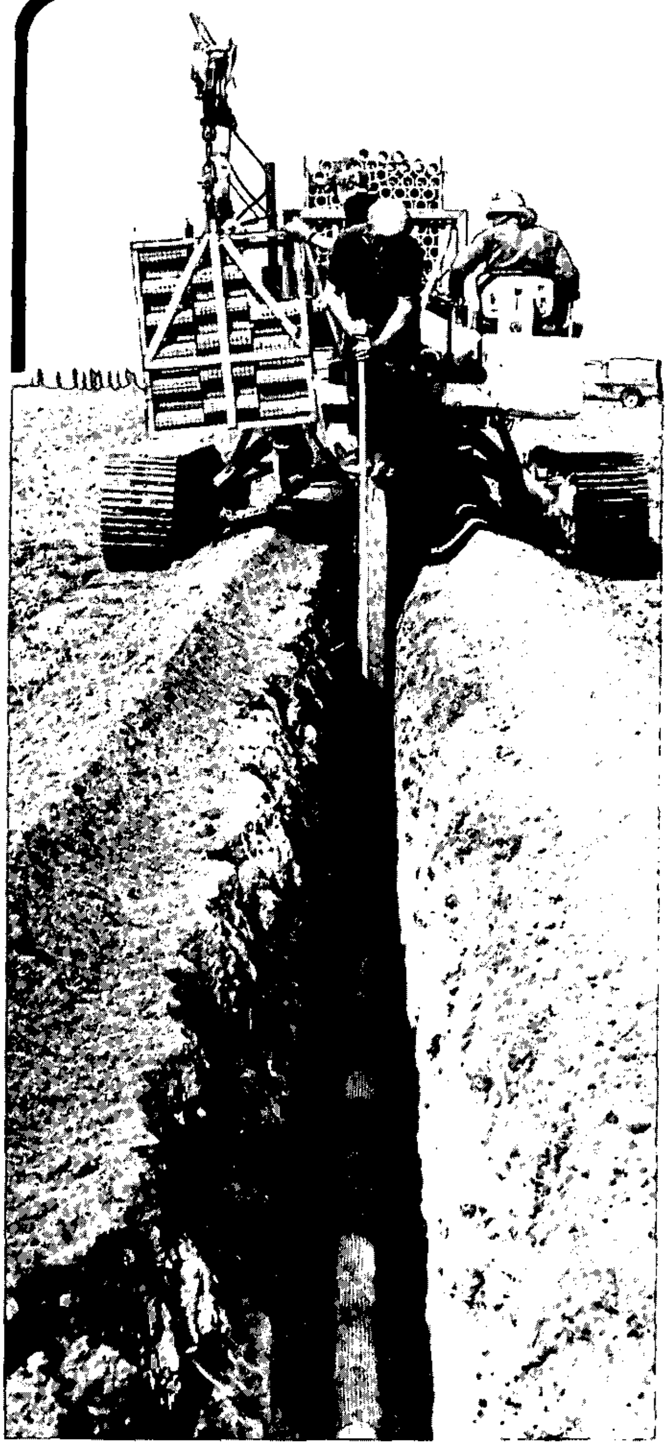



Fig. 5. Widths of rows and beds suitable for ware, seed and canning production.



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# Soil + Drilling

SOIL **STRUCTURE** AND **DIRECT** DRILLING

**Stephen** Bond of Velcourt Ltd., has been using the **Direct** Drilling technique on one of the company Farms for a considerable time. His description and conclusionsare given here together with a detailed look at **soil** structure **within** 3 fields by Mark **Gowman ICI.**

Velcourt started farming Elm Bank Farm, Cold Aston, Bourton-on-the-Water in October 1966, and have grown cereals continuously there since that time. In the autumn of 1970 40 ha (100 acres) were direct drilled with winter wheat for the first time. This gave satisfactory yields in excess of 5 tonnes/ha (2 ton/acre).

Following this success in 1971 the whole farm was direct drilled to winter wheat and since then a high percentage of wheat has been grown at Elm Bank Farm. This has alternated with barley when it has been felt necessary to do so.

Thus fields have been continuously direct drilled to winter wheat since 1970 in order to try to identify and solve the problems which could occur if this type of cropping regime were introduced on a larger scale.

The fields are still growing winter wheat and it appears that, while very high standards of management are required, it is perfectly feasible (and very rewarding) to continue with direct drilled winter wheat for a very long time.

The three soils at Elm Bank Farm are very different. A typical cotswold brash (Far Camp Ground). A heavy clay (Bullocks Furlong) and a very steep bank with a puffy light, calcareous soil (Not described).

The. obvious difficulty, having passed through the Take All barrier, was to keep the land free of weed infestation when the land has less than one month out of succeeding crops.

Couch grass was expected to be a problem but, provided the land was reasonably clean in the first place and a good, clean burn achieved, this need not become a problem. If there is a patch of couch grass it quickly develops a mat but does not spread more than a few inches a year as it does in conventional cultivation systems. Glyphosphate is now the best aid in stopping headland encroachment.

Annual weed seedlings can become more of a problem. Sterile Brome grass, Annual Meadow Grass, Chickweed, Speedwell and Field Pansy are some that enjoy early direct drilling germinating after the crop has been planted in the autumn. The use of a soil acting herbicide is therefore becoming essential. It has also been found that an early burn followed by a 2½ cm (1 ins) cultivation helps weed germination which can then be killed with Paraquatt. This speeds the drilling operation and helps the autumn soil acting herbicides to be more effective while not disturbing the Soil Stability.

Onion Couch has, in a limited number of situations become a major problem. A return to more traditional cultivations and an Oil Seed Rape break seems to be the most effective way of controlling this weed if you have it.

The overall conclusion that has been drawn from our experiences with this cropping technique is that continuous direct drilled autumn crops combined with a very high standard of management with an awareness of the factors that are likely to influence the field is a very effective way of producing good yields today and improving the soil for the future.

***NEAR CAMPGROUND***
***Cotswold brash type — 3 years direct drilled. Porous open structure, ideal for direct drilling. Top 25–30 cm of soil areshown.***

***Crumbstructurepresent in top 2.5 cm.***

***Larger aggregates. These are occasionally platy but nevertheless porous and represent no obstacle to root growth or drainage.***

FAR CAMP GROUND
Cotswold brash — adjacent to previous field. Direct drilled since Autumn 1969. Top 25–30 cm of soil are shown.

Well weathered top 2.5 cm with good crumb structure. Note the fibrous material present.

Soil below the surface is denser, in the form of larger aggregates. However, these are still porous enough to allow good root growth and drainage soil pores mainly due to old root channels in this example.

Soil Assessment

Field 1 Near Camp Ground

Direct drilled for two years following minimum cultivations.

Both Field 1 and 2 are typical cotswold brash. Such soils are stony, calcareous and normally well structured. Under direct drilling they appear to weather well in the top 0-2.5 cm generating a crumb structure which is ideal for further direct drilling. Below 2.5 cm the soil aggregates are larger with a tendency towards a platy structure. Although platiness indicates compaction on some soils, here it is of no consequence because the action of roots and earthworms has created a system of vertical pores in these aggregates. These pores are visible to the naked eye and are of vital significance for root penetration and drainage in direct drilled soils. Velcourts soils were well endowed with pores of this biological origin.

Field 2 Far Camp Ground

This field is adjacent to Field 1 but has been direct drilled for much longer (8 years). The same remarks apply as to field one except the soil units appeared to be larger. They are also much more porous, again with earthworm and old worm channels. The porosity of this soil can only be truly appreciated by pulling one of the aggregates out of a spitful of soil (as is shown here) and breaking it open). The complex network of biological pores pervading the soil is then revealed. The long term result is a soil which combines porosity with great structural strength.

Field 3. (8 years)

The soil in this field has a clay texture with a relatively high organic matter content especially in the surface which makes the soil behave as though it were much lighter. Perhaps this could be called a Fullers Earth soil, meaning that, as in Fullers Earth is is comprised of mainly montmorillonite clay. This is a clay which responds well to weathering and is present in many self-mulching soils.

This soil structure has a characteristic 'honeycomb' appearance. It is very uniform with few clods. Again the porosity can only be truly appreciated by handling the soil. It would appear that the effect of 8 years of direct drilling here have achieved a combination of a maximum of porosity with a maximum of structural stability. This effect has been observed on a number of long term direct drilled soils, and often some very heavy ones. Such soil structure is ideal for further direct drilling.

It is worth mentioning that the pores created under direct drilling are 'continuous', ie interconnected. Therefore they are sometimes better suited to drainage and rooting requirements than pores generated by cultivation which are more haphazard and random.

All these soils have been photographed after extracting a spitful of soil with as little disturbance as possible, a very effective way of assessing soil for direct drilling. □

**SUBSCRIPTIONS**

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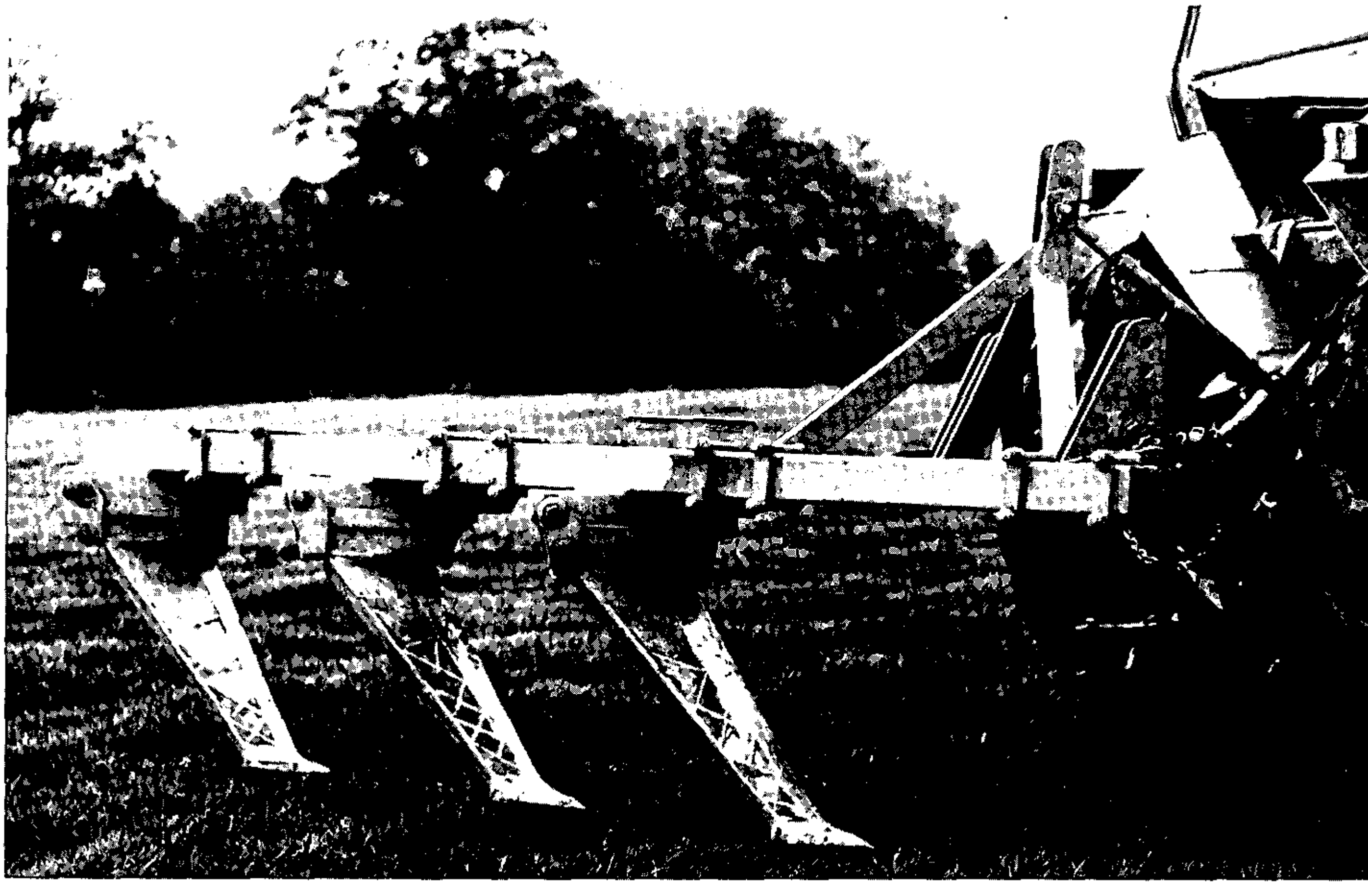
# Drainage + Soil

*BULLOCKS FURLONG*
*A clay soil with reasonable level of organic matter* ***direct*** *drilled since Autumn 1969 with cereals. Top 25-30 cm of soil are shown.*

*Good crumb structure in the surface 5 cm*

*From 5 cm-20 cm the soil is more dense but has a 'honeycomb structure' It is very uniform* ***with*** *few individual aggregates. Most pores here are derived from biological activity, ie. earthworms and roots. The true nature of the pores present in such soils is only revealed by breaking the soil open by hand and examining the soil closely. This soil structure is firmer* ***and*** *more* ***structurally*** *stable than anything obtainable by* ***cultivation.***

*Vertical fissures typical of a* ***well*** *structured clay soil.*



Continued *from page* 1.
visory Service, National College of Agricultural Engineering and The Soil Survey of Great Britain, will take place in August on a difficult clay soil, probably on a farm in Bedfordshire.

The theme of the demonstration is to demonstrate subsoiling techniques, the equipment available and to evaluate the effects of each machine. There are many aspects of subsoiling which we wish to demonstrate, for example the effect of depth and square moling, but before going too deeply into the demonstration, extracts from the book Soil Management by Bryan Davies, David Eagle and Brian Finney will help set the scene for the event.

## WHEN TO SUBSOIL

The most important factor for successful subsoiling is soil moisture. The right condition is when the soil is dry, or only slightly moist to the full depth of subsoiling. If the [illegible]d is too moist in the compacted zone, shattering cannot take place, and on heavy soils in particular, smearing occurs around the blade. On sands moisture content is less critical and successful lifting can take place in moist soil because of the brittle nature of compacted layers. When a dry autumn follows a wet August, the topsoil of cereal stubbles dry hard, and farmers are misled into believing that conditions are ideal for subsoiling, when in reality the subsoil is usually far too moist. In these conditions compaction down to about 12 to 14 in is best removed by using a deep cultivator with tines no more than 18 in apart.

Usually the best time to subsoil is through a ley which is to be ploughed up, of after an early crop like peas. The next best is after cereals harvested in July or August. It is rarely dry enough after roots harvested from October onwards. Good subsoiling conditions do not occur every year, but about every second or third year in eastern England, and less frequently

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in areas of higher summer rainfall. In general, sugar beet, potatoes and brassicae give the best financial response to subsoiling if pans are present, and preference should be given to land coming into these crops. Subsoiled land can be difficult to plough, and it is advisable to cross the lines of subsoiling at an angle.

**FREQUENCY OF SUBSOILING**

Subsoiling is required as often as the soil profile shows there is a need, but it is not possible to generalise on the frequency of need. Some farmers by refusing to cultivate or run on land when it is wet, and by encouraging earthworm activity with manure and occasional leys, avoid the need for subsoiling even on easily compacted soil. Other farmers need to subsoil frequently to avoid severe compaction building up, but it should-not b necessary to subsoil more frequently than every third or fourth year.

**DIRECTION, DEPTH, AND SPACING OF SUBSOILING**

If land is pipe drained, subsoiling should be at right angles to the lines of drains so that if water moves laterally in the loosened soil the distance to a drain is minimised. Sloping land should be subsoiled at an angle to reduce the risk both of soil erosion and of wet areas forming at the base of slopes. The optimum depth of subsoiling is determined by the position of the impeding layer. To obtain maximum lifting and displacement of a compact layer, the shoe of the implement should be set 3-4 in below the layer. Compaction caused by machinery is very unlikely to occur below 18 in at the most, and usually extends no deeper than 15 in, so that in most cases the subsoiler need not be set below 18 in.

In soils with natural compaction in the subsoil, of the types described earlier in the chapter, deeper subsoiling is usually required. Subsoiling used as a drainage aid should be deep enough to connect with stone backfill over pipe drains. The commonest fault is to set the blade of the subsoiler too shallow; this leaves compacted soil below the loosened layer and encourages waterlogging. For maximum benefit, the lifting effect of successive runs should meet. and to achieve this the distance between slits should be roughly equal to the depth of subsoiling.

The effective width of subsoiling can be increased by welding wings or bodies to the shoe, but obviously this substantially increases the draft.

**RISK OF DAMAGE**

Deep subsoiling can do more harm than good on undulating land with inadequate natural drainage. Rain falling on to subsoiled ladn quickly percolates to the depth of working, and unless there is a permeable subsoil, the land soon becomes saturated and the lower areas of the field waterlogged. Consequently, on poorly drained, and subsequently severe comwater moving through the subsoiled layers has access to pipe drains covered with stone. These should be sited in bottom of depressions and along the base of slopes.

In cases where land has been mole drained, nd subsequently severe compaction is produced at plough depth, there is a risk that deep subsoiling will disrupt the mole channels causing deterioration in the drainage. Three solutions are available and the choice will depend on the individual circumstances. It may be decided not to subsoil but to re-pull the moles at 6 ft intervals, when the land is dry enough to loosen the compaction. Alternatively, if the moles are in good condition and the compaction does not extend below about 1 ft, the compaction can be broken with a deep cultivator without any harm to the moles. If the compaction goes deeper than 1 ft, it should be possible to subsoil in between the mole runs where these can be located accurately.

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