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Measurement of drift from irrigators

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Front cover: Rainstar irrigator in use in the UK *(photo* – East of Scotland College of Agriculture, Edinburgh)

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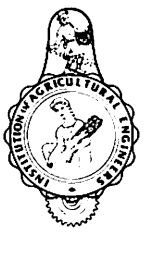


Reduced tillage
for energy and cost savings with cereals: practical and research experience

B C Ball

Significant savings of energy and labour are possible using reduced tillage. These are greatest when tillage is omitted completely (direct drilling). Two classification schemes of soil suitability for direct drilling and for other forms of reduced tillage are reviewed. These classifications indicate that more than half of the arable land area in Britain could be sown to winter cereals using reduced tillage.

Results from recent field experimentation indicate that long-term average yields of winter cereals with reduced tillage rarely differ from those with conventional tillage viz. ploughing to 25 cm and drilling. However, problems of compaction, weed control and straw disposal mitigate against the uptake of direct drilling and influence the choice of reduced tillage systems. This is confirmed by the small fraction of the area considered suitable for reduced tillage systems which is sown using such systems.

The use of single pass tillage implements in conjunction with seed broadcasting is likely to be more reliable than direct drilling.

A reliable guide which can be easily used by farmers is required to permit identification of the most suitable minimum tillage system applicable to a field for a given crop. One such system, applicable only to continuous winter barley in Scotland at present, is *CULTSAVE,* a simple interactive computer program.

The use of reduced tillage or direct drilling in Britain for cereals has always been limited and principally confined to soils where conventional tillage is difficult, for example clayey or stoney soils. This use has been further restricted in Northern Britain because of rotational cropping. Use of reduced and zero tillage systems has decreased further in recent years because of difficulties with weed control, build-up of soil compaction and limitations encountered by farmers in burning straw due to legal restrictions and the consequent requirement for straw incorporation (Cannell, 1985).

Reduced tillage has been also used by farmers to save time so that large areas of winter cereals can be established quickly (Ball, 1986). Reduction in tillage also allows savings of machinery, labour and fuel inputs (Allen, 1981 and Ball, 1986). The assessment of such savings, which include time and energy, made possible by the use of reduced tillage are particularly relevant when land and crop values are decreasing. This paper considers the alternative cultivation systems used in Britain for cereals, their energies and costs, their yield performance in field experiments and the problems involved in their application in practice. Scotland is considered separately from England and Wales because the crops, soils and climate are sufficiently different for crop responses to tillage to differ. The area available for arable crops and the types of crop grown are given in Table 1.

The area available for crops in England and Wales is about seven times greater than in Scotland. Cereal crops and oilseed rape may be sown with reduced cultivation systems. Other crops are potatoes, sugar beet, etc. which are taken to require conventional cultivation. Winter cereals form a much greater proportion of the total area of cereal crops in England and Wales than in Scotland.

Table 1 Crop areas – Scotland; England and Wales – as percentage of total cropping area, 1985

Crop		*Scotland,*	*England & Wales*
Cereal crops and oilseed rape		82.2	82.1
of which:			
Winter sown:	wheat	12.2	40.1
	barley	13.6	20.6
	oilseed rape	3.3	6.1
Spring sown:	barley and oats	53.1	15.3
Other crops: potatoes, peas, fodder roots, vegetables, bulbs		17.8	17.9
Total cropping area:		100.0	100.0
actual area, ha		669,500	4,519,000

Reduced tillage for larger areas of winter crops

The main reason why farmers wish to use reduced tillage is to sow as large an area as possible to winter crops in the limited time available. This is because the gross margins for winter cereals, particularly in Scotland, considerably exceed those for spring cereals. The increase in gross margins resulting from a switch from spring to winter cereals can be up to £185/ha and varies annually (Nix, 1987). Gross margins have dropped in recent years due to the decrease in cereal prices.

Tillage systems compared

Tillage and sowing systems can be allocated into three groups.

Bruce Ball is a Research Scientist at the Scottish Centre of Agricultural Engineering, Penicuik, Midlothian (refereed paper).

Table 2 Tillage grouping for winter barley in Scotland

Cultivation group	*Topsoil texture*	*Subsoil permeability*
1. Direct drilling	Sandy loam, loam	Free
2. Reduced tillage	Sandy loam, loam	Moderate
	Loamy sand, silty loam	Free or Moderate
3. Conventional tillage	All textures	Slow
	All clay loams and silty clay	Moderate

This grouping scheme shown in Table 2 was developed in Scotland for specifying tillage requirement according to soil texture and drainage (Ball and O'Sullivan, 1987).

The extent of cost, energy and time savings made possible by use of these reduced tillage options is shown in Table 3 where the cost, energy and time are expressed as a percentage of those in Cultivation Group 3 where they are greatest. Cultivation Group 3 corresponds to the conventional system of mouldboard ploughing to 20-25 cm and secondary cultivation before drilling.

Cultivation Group 1 has the smallest inputs of energy and cost which are about one-third of those for the conventional system (Group 3). In Cultivation Group 2, tillage to 5 to 15 cm is recommended. Possible systems are shallow ploughing and conventional drilling or alternatively broadcasting on to undisturbed soil and cultivating, a successful Scottish system extensively tested at the Scottish Centre of Agricultural Engineering (SCAE) and described further by Ball (1986). The total cost and energy from sowing to marketable crop for Cultivation Group 3 are also shown in Table 3. The cost savings for Group 1 or 2 (mostly machinery and labour) as a fraction of the total cost are significant but the saving of energy as a fraction of the total energy is much less significant. This mainly is because grain drying consumes much energy. The costs exclude the purchase of specialist machinery such as a direct drill.

Further, the cost and energy of spraying to control weeds and volunteers before direct drilling or reduced cultivation are excluded. This is because, with winter crops, such sprayings were not always necessary in field experiments run by SCAE or the East of Scotland College of Agriculture or were required for all tillage treatments. Table 3 also illustrates the main reason for adoption of reduced tillage systems, i.e. that the crop can be established up to four times quicker with reduced tillage than with conventional tillage. Speed of establishment is particularly important in Scotland where the time available for cultivation after harvest of the previous crop is shorter than in England and Wales. The times are the sums of times for passes of implements calculated from their widths and work rates.

Choosing the appropriate tillage system

In the 1970s, Cannell *et al* (1978) found that the yield of direct drilled cereals in comparison to conventionally sown cereals depended on whether they were sown in the spring or in the winter and on the soil type and climate. This was summarised into a classification of soil suitability for direct drilling. Table 4 is a simplified version of the classification.

According to this classification, 30% of the cereal growing areas of England and Wales are suitable for direct drilling spring cereals and 80% are suitable for direct drilling winter cereals. The classification was based on the limited information available at the time and seemed to allocate some soils wrongly and was confined to direct drilling. Subsequently, Scottish researchers developed the grouping scheme shown in Table 2 which identifies land appropriate for reduced tillage systems additional to that suitable for direct drilling. Since this grouping scheme is designed for application at the field scale, soil stoniness, depth, slope and climate-soil interactions are taken into account before grouping the soil. The arable soils of Scotland are divided almost equally among the three groups. In both this grouping scheme and in the classification of soil suitability for direct drilling, the slowly permeable or poorly drained soils are unsuitable for direct drilling or reduced cultivations.

Experimental results in England – cereal yields independent of tillage system

Performance is usually taken as the yield of a system in comparison to the yield of conventional ploughing and drilling. ADAS have shown that, from 133 experiment years the yield of winter cereals is independent of cultivation system, when averaged over all soils (D.B. Davies, personal communication, 1988). AFRC experimentation based mainly at Letcombe Laboratory has shown similar results (Cannell, 1985). Three examples of results from long-term tillage experiments are given (Figs 1-4). In these Figures the direct drilled yields are expressed as a percentage of the yield from the corresponding conventionally ploughed and drilled treatment.

Table 3 Cost, energy and time required for establishment of cereals with different tillage systems (as a % of conventional ploughing system)

Cultivation group	*Relative cost, %*	*Relative energy demand, %*	*Relative time required, %*
1. Direct drill	28	29	29
2. Shallow plough or shallow cultivate + conventional drill	85	74	65
Broadcast + shallow cultivate	54	46	20
3. Conventional plough and drill	100	100	100
Further costs, Group 3, from sowing to marketable crop			
– as % of conventional plough and drill	300	1050	
– as estimated actual values	(£340/ha)	(14,000 MJ/ha)	

Data from Ball, 1986.

Table 4 Classification of soil suitability for direct drilling developed for use in Great Britain

Soil and climate	*Suitability class*
Stable structure, well drained. Dry climate	for spring and winter cereals
Stable structure, moderate drainage. Moist climate	for winter cereals only
Unstable structure, poor drainage. Wet climate	not suitable

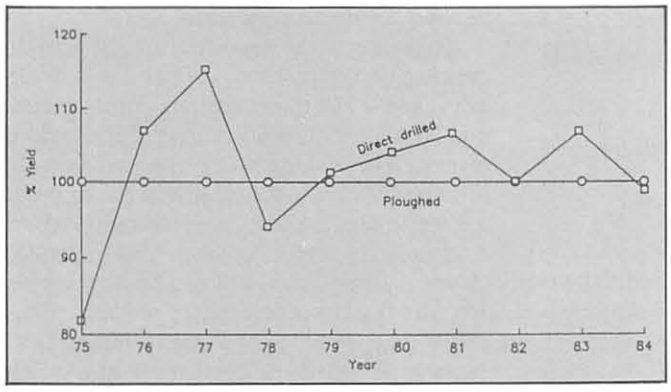


Fig 1. Yields after direct drilling in comparison to ploughing on a eutric gleysol, Denchworth series, classified as suitable for direct drilling of winter cereals, England. (Source: D G Christian, AFRC IACR Rothamsted Experimental Station).

In England, a large area of winter cereals is grown. Figs 1 and 2 show the results of two long-term experiments from south-east England which were under winter wheat in most years. The soil of the experiment shown in Fig 1 contains 50% clay and has stable structure and moderate drainage, properties which help make it suitable for direct drilling. This is confirmed by the yields which are mostly equal to or greater than those after ploughing. The soil of the experiment in Fig 2 is silt loam and is considered to be unsuitable for direct drilling because of structural instability. However, the average yield is the same as that after ploughing. In this Figure, the yields for a shallow tine treatment (two passes to about 7 cm depth) are included and this is generally the highest yielding treatment.

In Scotland – soil conditions more critical

In Scotland, more spring barley is grown than any other cereal and Fig 3 shows the results of a long-term experiment on spring barley. The experiment involves two soils on the same site. One soil, a cambisol (loam), is suitable for direct drilling whereas the other soil, a gleysol (clay loam), is not suitable. This gleysol is unsuitable for direct drilling because of the earlier date of return to field capacity than for the gleysol considered in Fig 1. Direct drilling of spring barley on both soils in the Scottish experiment gave lower yields than ploughing on average and thus can be considered unsuitable. The low yields under direct drilling were attributed to adverse soil physical conditions viz. high strength and poor aeration.

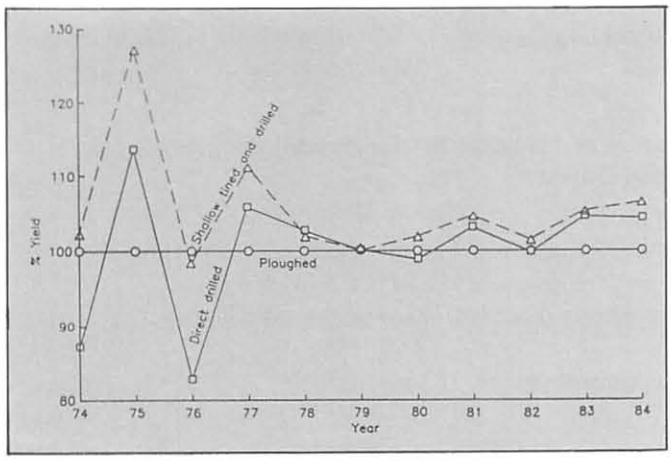


Fig 2. Yields after direct drilling in comparison to ploughing on an orthic luvisol, Hamble series, classified as unsuitable for direct drilling of winter cereals, England. (Source: D G Christian, AFRC IACR Rothamsted Experimental Station).

The 1983-8 yields are for winter barley where yields on both soils were on average greater than conventional ploughing and were little different. The reason for the different response to tillage of the winter and spring barley crops is currently under investigation, but is thought to be linked to the timing of the establishment of root systems. The results are for soils which have been continuously direct drilled since 1968. On changing from spring to winter barley, a previous deep ploughing treatment was replaced by a new direct drilling treatment. The yields for this treatment are included in Fig 4 which is an expansion of the winter barley yield portion of the previous graph.

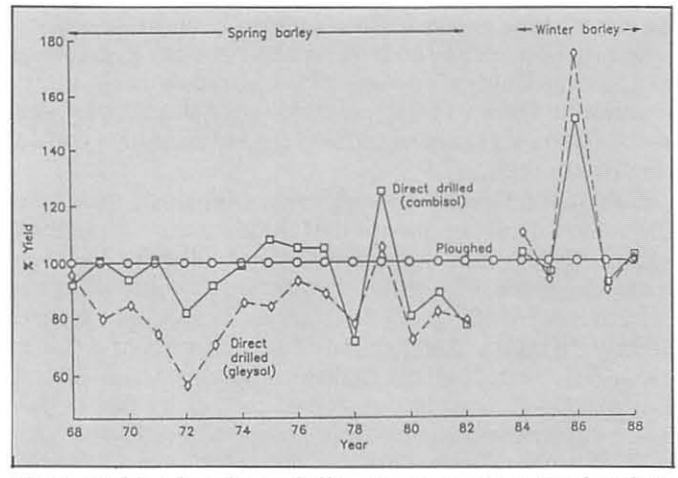


Fig 3. Yields after direct drilling in comparison to ploughing on a soil classified as suitable for direct drilling (cambisol, Macmerry series) and unsuitable for direct drilling (gleysol, Winton-Macmerry series) of cereals, Scotland. Both soils contained a ploughed reference treatment. (Source: East of Scotland College of Agriculture).

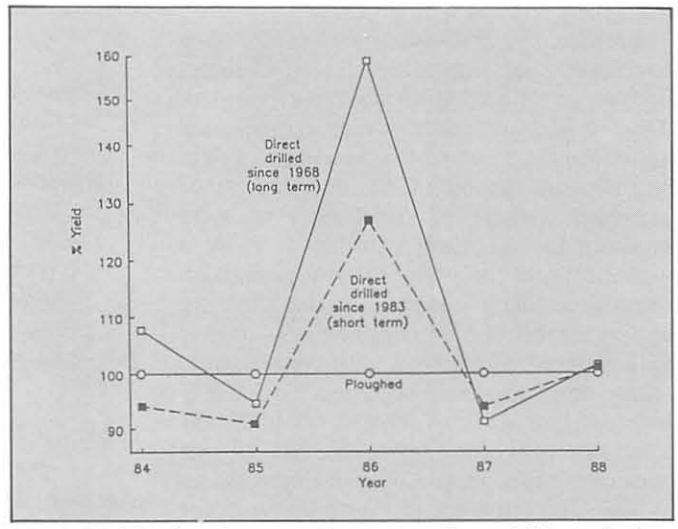


Fig 4. Yields after short- and long-term direct-drilling of winter barley in comparison to ploughing, Scotland. Yields are the means for the two soils in Fig 3.

The yields for short-term direct drilling were less than for the long-term treatment in the first three seasons of winter barley. Figs 1 and 2 showed that it was generally only after the first year that the direct drilled yields exceeded the ploughed. SCAE research has shown that, in the first year or two of direct drilling, the soil is most vulnerable to compaction during development of a continuous and stable pore structure and increased bearing capacity due to organic matter accumu-

lation at the surface and soil weathering (Ball *et al,* 1988). In general, though, winter barley yields are considerably less dependent on climate and soil type and condition than spring barley yields. Grass weeds, however, became a problem under direct drilling in the Scottish experiment. Infestation of the reduced tillage plots with *Bromus sterilis* (sterile brome grass) was sufficiently high in 1988 for the crop to be changed to oilseed rape to allow weed control.

These results indicate that both the land grouping and the classification are in error, at least for the prediction of soil suitability for long-term direct drilling and that some revision is required. The groupings are rather conservative and other methods of choosing tillage systems are required for field use by farmers.

Scope for much wider adoption of reduced tillage/direct drilling

Adoption by farmers of reduced tillage systems in 1985/6 is shown in Table 5 which contains the percentages of the cereal cropping area established with different tillage systems. The Table shows that most cereals were established conventionally. In Scotland, only 0.15% were direct drilled and 1% sown using reduced tillage. A bigger proportion of the area of England and Wales was established by non-ploughing techniques. The figure of 3% direct drilled is the same as that for 1981/2, but the 12% established by reduced tillage is a 5% drop since 1981/2. This is most likely due to the increased use of conventional ploughing for straw incorporation.

Table 5 Proportion (%) of cereal cropping area established according to tillage system in 1985/6. Data for England and Wales from Farmstat Limited, Newbury, Berks and for Scotland, from Scottish Agricultural Industries, Edinburgh.

Tillage system	*System adoption (% of cereal area)*	
	England & Wales	*Scotland*
Direct drilled	3.0	0.2
Reduced tillage	12.0	1.0
Conventional ploughed	85.0	98.8

The area of reduced cultivations in the three countries considerably exceeds that of direct drilling. Farmers tend to regard reduced cultivations as a less risky alternative to direct drilling. Problems encountered by farmers with direct drilling include slugs eating seed along exposed drill slits, build-up of grass weeds, *Bromus sterilis* in particular and compaction of the surface tilth at harvest. In addition, recent bye-laws insist that farmers incorporate straw or stubble ashes immediately after burning, thereby confining direct drilling to baled stubbles.

The areas of reduced tillage and direct drilling represented by the figures in Table 5 are only a small fraction of the areas of land indicated by the classification and grouping schemes (Tables 2 and 4) as suitable.

One reason for this low uptake by farmers is their indiscriminate method of choosing tillage systems. A system is chosen and applied on every field in the farm until it is considered to be no longer suitable because of yield losses or soil, weed and crop residue problems. Thus farmers may switch from direct drilling to conventional ploughing to reduced tillage. Such switches involve much expense for labour and machinery.

The problem is overcome by some farmers by adopting rotational tillage. Thus, dependent on soil conditions and crop disposal, different fields receive different cultivation treatments. This enables the work load to be spread and reduces labour and machinery inputs. However, direct drilling requires the purchase of a specialist drill.

Another problem preventing the uptake of reduced tillage systems is that the crop rotations found in northern and western Britain prevent continuous use of reduced tillage systems or direct drilling. Rotations therefore preclude the sustained improvement of soil structure under direct drilling which takes several seasons to develop.

Future savings in tillage energy by farmers will thus tend to come from greater, but selective, use of reduced cultivations using machinery existing on the farm. These savings are most likely to be realised with winter cereals.

Problems and their solution

Problems associated with surface soil condition, topsoil compaction, straw incorporation and grass weeds can influence the extent to which the energy savings possible with reduced tillage may be exploited. These problems and possible solutions are summarised in the panel on the next page.

The cultivator type used to tackle **surface problems** depends on the extent of the problem. Tine cultivation may be adequate where the soil is loose, but in stronger soils with more crop residues, rotary cultivation or shallow ploughing may be required. A suitable system tested extensively at SCAE is to broadcast the seed on to the undisturbed stubble and to incorporate this with the fertiliser, ash and stubble in one pass after sowing.

The next problem is that of **topsoil over-compaction.** This problem is greatest when first adopting a reduced tillage system after conventional cultivations or where the soil is poorly or imperfectly drained and grouped as unsuitable for direct drilling or reduced cultivations. Elimination of compaction on such soils by use of a zero traffic system can increase soil suitability for direct drilling (Campbell *et al,* 1986). Thus it is essential to minimise compaction in the first one or two seasons at least by some form of traffic control. This is most practically achieved by a tramline system of 12 m working width. Primary cultivations can be carried out by a one pass operation between the tramlines, but traffic on the loosened soil should be avoided until harvest by keeping to tramlines. The use of 12 m wide seed broadcasters and cultivators can help to achieve this aim.

Gantries

An alternative means of traffic control is to use a 12 m wide gantry. The area occupied by the gantry wheelways is one half of that occupied by a conventional tramline system of 12 m working width. Using a gantry, all operations except deep primary cultivation and possibly harvesting can be made without traffic in the 12 m span between the gantry wheels. Harvesters and grain trailers may require low ground pressure tyres and the trailers may be best restricted to the headlands.

Keeping the soil loose and clod-free by avoiding all wheel traffic can reduce the energy requirement for tillage by 50% both for winter cereals (Chamen *et al,* 1986) and spring cereals (Dickson, 1989) and increase the number of days available for cultivation. Gantry systems can be more profitable than conventional systems for rotational cereal cropping in England and Wales particularly on heavy soils. The reduction in costs largely results from the lower cultivation inputs (Heitbrink *et al,* 1988). Gantries are now commercially available. Some farmers have adopted such systems in conjunction with broadcasting.

Even though some traffic is controlled, the compactive effort of the other, random traffic at sowing and harvesting should be reduced by reducing vehicle weight e.g. by using smaller vehicles and then by fitting extra wheels or low ground pressure tyres to vehicles. Again the confinement of grain trailers to headlands is desirable.

Minimising harvest compaction and the depth of any wheel ruts is particularly important with reduced tillage systems where the opportunity to alleviate compaction by tillage is, by choice, reduced. Perennial, complete zero traffic systems using gantries would prove to be the ultimate solution to topsoil over-compaction.

Problems influencing reduced tillage and possible solutions

Problem	*Possible solutions*
Surface soil condition – presence of ashes, stubble and poor structure	Reduced tillage < 10 cm
Topsoil compaction	Tramlines for sowing, cultivation and subsequent operations. Low vehicle weight. Low ground pressure tyres. Grain trailers on headlands. Gantry system (zero traffic).
Perennial grass weeds	Normal ploughing as part of a rotation. Grow a break crop.
Straw incorporation	Normal ploughing as part of a rotation. Shallow ploughing.
Lack of skill and motivation	Alert farmers to the benefits of reduced tillage. Provide cash incentives.

For **straw incorporation,** ADAS recommend conventional ploughing without any previous cultivation as generally adequate with no adverse effects on grain yield. Unless incorporation is required every year, such incorporation tillage could be integrated with reduced tillage by using straw incorporation periodically in a rotation. Alternatively shallow incorporation of straw may be used. SCAE research has shown that shallow ploughing can be used for continuous cereals for up to 4 years with no adverse effect on yield.

Grass weeds often preclude the continuous use of reduced tillage. Perennial grass weeds may flourish under reduced depths of tillage, especially under direct drilling (Cannell, 1985). *Bromus sterilis* is particularly difficult to control as no herbicide is currently effective for winter cereals under direct drilling or reduced tillage.

In such circumstances conventional ploughing as part of a rotation (for example 1 year in 3) or substitution of a break crop such as oilseed rape may help control.

Until recently, this was a greater problem in England than in Scotland where experience with field experiments for winter barley generally showed only minor effects of tillage treatments on weed flora. However, the increasing use of winter cereals and the possible use of contaminated seed has led to an increase in perennial grass weed occurrence.

Choosing the tillage system

The uptake of novel systems is often hampered by **lack of knowledge** of the advantages which can result from use of such systems and by the high standards of management required to ensure their success. Farmers should be made more aware of the advantages of reduced tillage which extend beyond energy, machinery and labour savings to improved soil conservation (Cannell, 1985; Ball *et al,* 1988) and possible reduction in fertiliser nitrogen losses in comparison to conventional systems (Smith *et al,* 1988).

A simple guide to the choice and specification of the most economical tillage system on a field-by-field basis is required.

SCAE have recently developed such a guide for use with continuous winter barley in Scotland. This is a simple, inter - active computer system called *CULTSAVE.* The tillage selection method used in the program is based on the tillage grouping for winter barley in Scotland (Table 2). The program asks simple questions about soil type, drainage, climate and details of straw disposal, compaction and weed problems and then gives a recommendation.

Recommendations presented by *CULTSAVE* range from direct drilling to subsoiling plus ploughing. The emphasis is on specifying a system which maximises energy and labour savings while giving the same crop yield as a conventional ploughing system. The program runs on IBM-type microcomputers and is sufficiently 'user friendly' for a farmer to use. Further details are available from the author.

References

Allen H P (1981). *Direct drilling and reduced cultivations.* Farming Press, Suffolk.

Ball B C (1986). Cereal production with broadcast seed and reduced tillage: a review of recent experimental and farming experience. *J agric Engng Res,* **35,** 71-95.

Ball B C, O'Sullivan M F (1987). A land grouping system for cultivation and sowing requirements for winter barley: evaluation and modification of recommendations. *J Sci Fd Agric,* **39,** 25-34.

Ball B C, Lang R W, O'Sullivan M F, Franklin M F (1989). Cultivation and nitrogen requirements for continuous winter barley on a gleysol and a cambisol. *Soil Tillage Res,* **13,** 333-352.

Campbell D J, Dickson J W, Ball B C, Hunter R (1986). Controlled seedbed traffic after ploughing or direct drilling under winter barley in Scotland, 1980-1984. *Soil Tillage Res,* **8,** 3-28.

Cannell R Q (1985). Reduced tillage in North-West Europe – a review. *Soil Tillage Res,* **5,** 129-177.

Cannell R Q, Davies D B, Mackney D, Pidgeon J D (1978). The suitability of soils for sequential direct drilling of combine harvested crops in Britain: a provisional classification. *Outlook Agric,* **9,** 306-316.

Chamen W C T, Chittey E T, Armstrong M C (1986). Development and assessment of a wide-span vehicle for arable crops. Div. Note DN 1357, AFRC Inst Engng Res, Silsoe.

Dickson J W (1989). Spring barley responses to zero and conventional traffic systems on a clay loam, 1988. Dep Note 17, Scott. Centre Agric Engng, Penicuik.

Heitbrink O, Chamen W C T, Audsley E (1988). An economic comparison of gantry and tractor-based zero traffic systems used for growing a rotation of crops on a cereals farm. Div Note DN 1487, AFRC Inst Engng Res, Silsoe.

Nix J (1987). The economics of tillage – the scope for cost savings. *"Tillage – what now and what next",* ed G G Baldwin. Proc SAWMA/ADAS/ICI Conference, Feb 1987, Rothamsted Experimental Station, SAWMA, pp 33-40.

Smith K A, Howard R S, Crichton I J (1988). Efficiency of recovery of nitrogen fertiliser by winter barley. *"Nitrogen Efficiency in Agricultural Soils",* eds D S Jenkinson and K A Smith, Proc CEC Seminar, Sept 1987, Univ of Edinburgh, pp 73-84.

The effect of wind on the uniformity of sprinkler irrigation systems

J M Watermeyer points out that the performance information listed by sprinkler manufacturers is based purely on hydraulic formulae; it does not take into account the influence of wind on the uniformity of distribution under field conditions. He reports here on a programme of field tests undertaken in Zimbabwe by the, then, Rhodesian Department of Conservation and Extension to determine the most practical combination of nozzle diameter, pressure and spacings.

In the 1970s, during an air flight over a large Government controlled irrigation scheme in the Sabi Valley, a regular pattern of yellow circles was observed throughout the two thousand hectare scheme. The flight took place in early September at a stage when the winter irrigated wheat crop was about to mature. The yellow circles were indicative of areas that had received less water than the rest and consequently had dried out that much earlier.

Investigations showed that the scheme was well managed, and that irrigation scheduling had been determined by suitably qualified staff and had been strictly followed.

The design was similar to that generally recommended throughout the country; that is, single 7/32 inch or 1/4 inch nozzles operating at ± 350 kPa on an 18 × 18 metre spacing. This combination had been adopted as a reasonable compromise between capital cost and efficiency, and was well within the middle of the range advocated by sprinkler manufacturers.

Field trials to determine economic design criteria and management

With the assistance of equipment donated by leading local sprinkler irrigation firms, the Department embarked on investigations on a field trial basis to establish design criteria which would take into account the effect of wind on uniformity of distribution as well as ease of management; that is, only two lateral line movements per 24 hours.

Details of the test parameters are given in Table 1. The field measurements during the tests were made in collection cans, each with a funnel to reduce evaporation to a minimum. They were set out on a 2.0 m grid and the depth of water collected after one hour of sprinkler operation measured and recorded against prevailing wind speed.

It was found that tests exceeding one hour were influenced by changing wind conditions.

J M Watermeyer is a Consultant Irrigation Engineer in Zimbabwe and was Chief Irrigation Officer in their Ministry of Agriculture when this programme of field testing was conducted.

Table 1 The test parameters

Nozzle diameters

Single nozzles: All metric sizes from 2.5 mm rising by half millimetres to 7.0 mm.
All Imperial sizes from 7/64 inch rising by sixtyfourths to 17/64.

Double nozzles: The following combinations:
5.0 × 2.5 mm; 5.5 × 2.5 mm; 6.0 × 2.5 mm; 6.5 × 3.0 mm;
13/64 × 3/32 ins; 7/32 × 3/32 ins; 15/64 × 3/32 ins; 1/4 × 7/64 ins.

Operating pressures

Operating pressures varied from 270 kPa to 380 kPa depending on nozzle size and using four or more pressure variations differing in each test by 10 kPa.

Spacings

Tests were limited to the following spacings:
12 × 12 m; 12 × 15 m; 12 × 18 m; 15 × 15 m; 15 × 21 m; 18 × 18 m.

Winds

Wind measurement was by anomometer and classified as follows:

Light – below 7 km per hour
Medium – between 7 and 11 km per hour
High – over 11 km per hour

Winds in Zimbabwe vary in direction between SouthEast and NorthEast.

The depth of water trapped in containers was expressed as a percentage of the theoretical overall application and classified as indicated below.

(VG) Very Good – More than 85% in the range 80-120% and nil below 60% of theoretical application.

(G) Good – 80 to 85% in the range 80-120% and not exceeding 5% below 60% of theoretical application.

(F) Fair – 70 to 80% in the range 80-120% and not exceeding 10% below 60% of theoretical application.

(P) Poor – Below 50% in the range 80-120% of theoretical application.

Note: this method correlates very closely with Christiansen's Coefficient of Uniformity, and was adopted as being more easily understood by the farming community.

These parameters were shown on isoperimetrical drawings which are found to be an ideal method of extension. Examples are shown on Figures 1 and 2.

Details of those combinations which produced acceptable uniformity patterns are listed in Table 2.

Correct spacings important

It was found that spacings of 18 × 18 metres with single nozzles produced poor patterns of uniformity. However, double nozzles were satisfactory, especially the 1/4 × 7/64 inch and the 15/64 × 3/32 inch combinations. Unfortunately, all such combinations have high precipitation rates which necessitate three or four moves per 24 hour cycle, which is not conducive to ease of management.

Spacings of 18 × 12 metres gave excellent results, especially the 11/64 inch, 5/32 inch, 4.5 mm and 4.0 mm diameter nozzles at pressures of between 320 and 340 kPa. Their relatively low precipitation rates necessitate only two moves per day and can be adapted to both light and heavy textured soils.

Spacings involving 15 metre lateral line moves generally gave excellent results. It is a spacing favoured by tobacco growers,

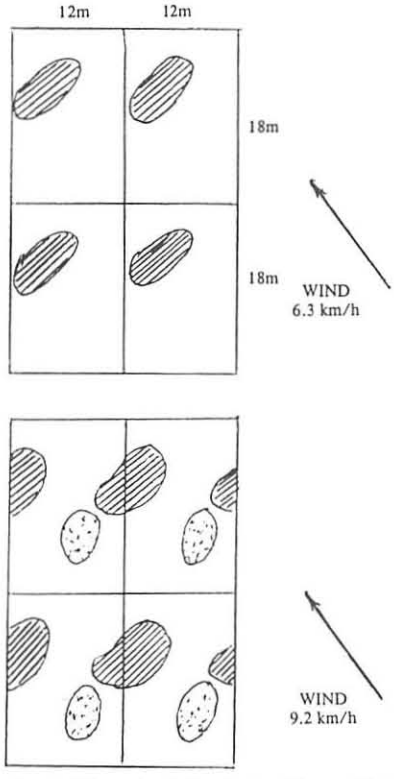


Fig 1. The relatively slight effect of light and medium winds on the distribution pattern using a small diameter (5/32 inch) single nozzle on 12m × 18m spacing @ 320 kPa.

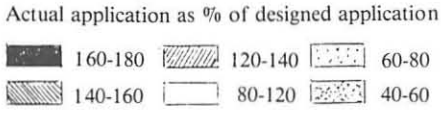
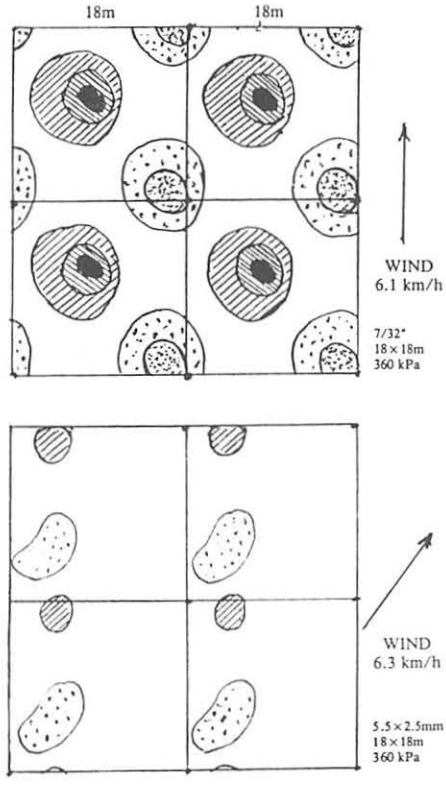


Fig 2. The comparative distribution patterns on 18 × 18m spacings between the use of double as against single nozzles.



A rotary sprinkler irrigation system giving a near-uniform distribution pattern (photo: Wright Rain Ltd)

but not otherwise popular, mainly because aluminium piping is normally supplied in 6 metre lengths.

Spacings of 12 × 12 metres with 1/8 inch or 3.5 mm diameter single nozzles gave excellent results and also require only two moves per day. Capital cost is, however, greater than for 18 × 12 m designs.

Immediate practical benefit

Prior to the conclusion of the tests, the almost universal design adopted in Zimbabwe was an 18 × 18 m spacing with single

continued at foot of next page

Table 2 Recommended sprinkler combinations and their reaction to wind under field conditions

Spacing, m	*Nozzle diameter ins* or *mm*	*Pressure, kPa*	*Precipitation rate, mm/h*	*Discharge per sprinkler, m^3/h*	*Reaction to wind (see text)*
18 × 18	7/32 × 3/32in	350	7.87	2.55	G – F/G – F
18 × 18	5.5 × 2.5mm	350	7.87	2.55	G – F/G – F
18 × 18	1/4 × 7/64in	380	10.80	3.50	G/VG – G – F
18 × 18	6.5 × 3.0mm	380	11.98	3.80	Test incomplete
18 × 18	13/64 × 3/32in	340	6.94	2.25	G – F/G – F/P
18 × 18	5.0 × 2.5mm	340	6.73	2.18	G – F/G – F/P
18 × 18	15/64 × 3/32in	360	9.10	2.95	G/VG – G – F
18 × 18	6.0 × 2.5mm	360	9.38	3.04	Test incomplete
18 × 12	11/64in	340	6.25	1.35	G/VG – F/G – F
18 × 12	5/32in	320	5.00	1.08	G/VG – F/G – F
18 × 12	4.5mm	330	6.39	1.38	G – F/G – F/P
18 × 12	4.0mm	320	5.00	1.08	G/VG – F/G – F
21 × 15	5.5mm	370	6.98	2.20	F/G – F/G – F
21 × 15	7/32in	370	7.24	2.28	F/G – F – P
15 × 15	3/16in	350	7.11	1.60	G – F/G – F
15 × 15	5.0mm	350	7.87	1.77	G – G – F
15 × 15	13/64in	350	8.36	1.88	G – G – F
15 × 15	5/32in	320	4.80	1.08	F/G – F/G – F
15 × 15	4.0mm	320	4.80	1.08	F/G – F/G – F
15 × 15	11/64in	340	6.00	1.35	G – F/G – F
15 × 15	4.5mm	330	6.13	1.38	G – F/G – F
15 × 12	9/64in	300	4.72	0.85	G/VG – F/G – F
15 × 12	3.5mm	300	4.44	0.80	G/VG – F/G – F
15 × 12	5/32in	320	6.00	1.08	G/VG – G – F
15 × 12	4.0mm	320	6.00	1.08	G/VG – G – F
12 × 12	1/8in	280	4.44	0.64	G/VG – G – F/G
12 × 12	3.0mm	260	3.82	0.55	G – G – F
12 × 12	7/64in	260	3.33	0.48	G – G – F
12 × 12	3.5mm	280	5.42	0.78	G/VG – G – F/G
12 × 12	9/64in	300	5.90	0.85	Test incomplete

Qualified engineers in Britain – the Engineering Council 1989 survey

by J B Finney

The 1989 survey indicates that the status of engineers in Britain is rising in pay and position terms and that the profession is giving a high level of job satisfaction. The overall conclusion is that the British engineering profession is in good heart.

At a Press Conference in London on 17 October 1989 the results of the latest survey of qualified engineers in Britain were presented by the Director General of the Engineering Council, Mr Denis Filer, the Director – Engineering Profession, Professor Jack Levy, and Mr Peter Steven of Remuneration Economics who conducted the survey. There were representatives present from some of the engineering institutions, a large number of specialist publications, and 5 national daily papers.

Women engineers – too few to be yet included

The biennial survey sampled 27,000 of the 189,000 registered engineers and technicians under the age of 65 with UK addresses. Those outside the United Kingdom were not included. The total number on the Council's register is 285,000.

Women were not included in the sample because numbers were so small as to have little meaning when divided between the categories of the survey. With 11% of those studying engineering in higher education now being women, however, this position will clearly change as the present students become registered with the Engineering Council.

Categories covered by the survey include: earnings, employment, occupation, employment group, qualifications, location, levels of responsibility, knowledge of languages, trade union membership, fringe benefits, overtime, further .training and career attitudes.

Survey of earnings

A major part of the survey concerns engineers' earnings.

The median earnings for Chartered Engineers increased 1% faster during the last 2 years than the average earnings index published in the Employment Gazette. Median earnings for Incorporated Engineers fell back by 1% in a similar comparison. The average total earnings per year were £24,705 for Chartered Engineers and £17,825 for Incorporated Engineers, compared to £20,387 and £15,124 respectively in the 1987 survey.

Some 64% of all Chartered Engineers are now earning more than £20,000, 37% earn more than £25,000 and 21% are now earning more than £30,000. There was evidence that qualifications, including post-graduate qualifications, were reflected in the earning capacity of engineers.

Unemployment, particularly among Incorporated Engineers, has fallen, with only 0.6% of engineers in the two groups being unemployed on the survey date of 1 April 1989.

Wider employer awareness of qualifications

There was evidence that employers who have been traditionally aware of the C.Eng status are now becoming equally aware of I.Eng and Eng.Tech.

The awareness figure was about 40%, so that there is still clearly room for further raising the awareness of Engineering Council standards among employers.

Language ability – basic rather than fluent

Other points made in the survey included comments on language ability where 40% of Chartered Engineers were said to have a basic knowledge of a foreign language, although this fell to less than 2% of all engineers at the standard of fluency. There has been an increase in the number of company cars available to engineers and a slight decline in trade union membership by engineers.

Highest median earnings for Chartered Engineers were in the armed forces, followed by the self-employed and then the nationalised industries. The range across these 3 groups on a median basis was less than £3,000 per annum.

The status of engineers is rising in pay and position terms. Some 9,500 registered engineers are now chief executives. Two-thirds of engineers would recommend engineering as a profession, quoting job satisfaction as the main reason. One in 8 engineers takes part in schools liaison work to encourage the next generation.

The overall conclusion was that the engineering profession is in good heart.

Brian Finney is Head of Product Services, ADAS, London

The report runs to 66 pages of A4, and is priced at £100. A copy is available on loan from the Institution offices in Silsoe.

continued from previous page

7/32 inch or 1/4 inch diameter nozzles operating at ± 350 kPa. Reference to Figure 2 highlights the inadvisability of using this design. However, the problem has been overcome by substituting a combination of either 13/64 × 3/32 inch or 5.0/2.5 mm double nozzles, which result in a good pattern of uniformity without the need for alterations to pump or motor.

Generally, if one considers uniformity of distribution, capital cost and ease of management, the tests have shown the wisdom of designs embodying an 18 × 12 m spacing with 4.0 mm or 5/32 inch diameter single nozzle operating at 320 kPa on light soils or a 4.5 mm or 11/64 inch diameter nozzle operating at 330 and 340 kPa respectively on heavier soils.

Careful management still all important

Poor performance under strong winds appears to be unavoidable, but can to some extent be overcome by careful management in the field; that is, by moving the sprinkler positions by half their design positions halfway through the normal "set" time. The move must be made as near as possible at right angles to the direction of wind. That is to say that, depending on wind direction, one should examine the effect of either moving sprinkler positions within the line or of moving the position of the line itself. The former is accomplished by removing, at the start of the lateral line, a section of piping equivalent to half the distance between sprinklers, the latter by adding or subtracting half the length of the header line and then repositioning the lateral line.

It is also essential to ensure that those areas irrigated at night are relegated to daylight irrigation in the subsequent cycle. This takes place automatically where the designed cycle includes a half day such as 7.5 or 8.5 days, etc.

Efficiency also demands that shortly after the start of each set, a check is made to ensure that there are no leaks at joints, hydrants, etc, and that the correct pressure is maintained throughout the set.

Acknowledgement

I would like to express my appreciation to the late Gavin Wilson who very ably undertook the analysis of all field tests listed in this article.

Rural industries in Scotland

– the Young Engineers Section 1989 tour

reported by T P Hodges, A J Scarlett, S S M Davies, W R Whalley, N V Nguyen, I Livingstone

With today's emphasis on diversification the Young Engineers 1989 tour was well planned to cover visits to a range of alternative enterprises and to research establishments serving agriculture and rural industry.

The Institution of Agricultural Engineers 'Young Engineers Section' Scottish tour took place 8th-12th May 1989. Nine members participated. They were Andrew Scarlett, Simon Davies, Richard Whalley, Vien Nguyen and Tim Hodges from AFRC Engineering, Tim Denison from Silsoe College, Iain Livingstone of the Centre for Rural Building, Aberdeen and Richard Landen and Jonathan Lace, both self-employed agricultural engineers.

The aim of the tour was to gain an insight into the agricultural systems and enterprises, and other rural industries peculiar to Scotland. It also provided an opportunity to look at research projects designed to provide answers to local difficulties and was timed to coincide with the Institution of Agricultural Engineers Annual Convention.

Demanding water requirement for fish farming

Our first visit was to Howietoun Fisheries at Sauchiburn near Stirling. The Fisheries operate two fish farms in conjunction with Stirling University, producing high quality trout and salmon solely for restocking ponds and reservoirs. Fry are delivered to the farm from a hatchery on the company's second site and are grown in a series of tanks and ponds until they attain a weight of 250 g, by which time they are approximately 275 mm in length, a process which takes about two years. The annual production of some 45 000 trout are all graded by hand and visually inspected for damage prior to being sold, usually between January and May.

The emphasis at all stages of production is on the maintenance of quality and to this end lower stocking densities than those found on commercial food fish farms are used. Any damaged fish are removed during grading and are sold to the smoking industry.

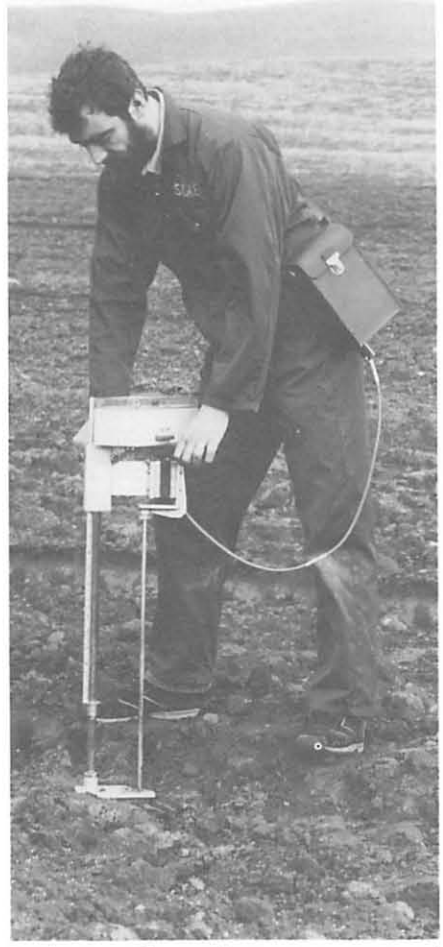
The primary requirement of the farm is a constant supply of between 1.5 and 2 million gallons of water a day, perhaps rising to 2.5 million during the summer if the oxygen content is low. To meet the quality requirements the water must be clear, of neutral pH and have low nitrate and phosphate contents, a requirement which conflicts to a certain extent with land drainage and improvement schemes in the water catchment areas.

Details of authors' employments are included in the text

Research, with commercial outlets, at the Scottish Centre of Agricultural Engineering

The visit to the Scottish Centre at Penicuik provided an overview of the research undertaken by each of the divisions to overcome typically local difficulties. However, much of the work is directly applicable to the whole of the United Kingdom.

The Soil Engineering Division is concerned with understanding the processes of soil compaction and of devising systems of work which minimise structural damage. To satisfy the requirements of field experimentation, instruments to measure soil strength and density have been developed and are now commercially produced.



Bush recording soil penetrometer and associated data collector – designed by scientists in the Soil Engineering Dept of SCAE and produced commercially by Findlay, Irvine Ltd, Bog Road, Penicuik, Midlothian

Studies of vehicle stability, both in static and dynamic situations are conducted by the Equipment Behaviour Division. Much of the static testing is carried out on a purpose-built hydraulic tilting table, whilst dynamic tests take place in the field. Of particular concern at present is the stability of pivot steer vehicles.

The work of the Operational Research Division is concerned with using mathematical models to identify management strategies likely to maximise the cost benefit ratio of an enterprise. Much of the group's work is devoted to the formulation of management policies for the production and harvesting of grass.

Minimisation of damage to potato tubers during harvesting and handling is one of the major areas of research undertaken by the Crop Handling Division. Additionally work is carried out to improve methods of sizing and grading potatoes.

Young Engineers Section – plans for Conference and further tour

The Scottish tour was organised specifically to coincide with the Annual Convention of the Institution which was held in Edinburgh and attended by all the tour participants. A full account of the convention has been published in earlier issues of this journal.

In addition to the main proceedings, the Young Engineers Section also held a meeting. This commenced with a slide presentation by Mr A J Scarlett in which he described the activities of the section during the 1988 European tour. The lecture was comprehensive and demonstrated the importance of establishing a broader perspective, particularly in regard of the Single European Market. Considerable interest was expressed in organising a similar tour for 1990, possibly visiting France and southern Germany.

A discussion concerning future events to be organised by the Young Engineers' Section followed Mr Scarlett's presentation. There was general agreement that one of these should take the form of a conference in which young engineers would present papers on subjects ranging from marketing

to research and development. This idea was prompted by the observation that the Institution Convention was dominated by the more senior members, particularly during the discussion periods.

Stress from human contact is problem at deer farm

Wednesday, 10th May began with an introduction to yet another type of alternative rural enterprise when we visited the Scottish Deer Centre at Cupar, Fife.

The Scottish Deer Centre was set up as an education centre; the aim being to publicise the rapidly growing Scottish deer farming industry. Some 200 head of red deer are kept on 25 hectares of fenced grassland, the layout of which has been designed specifically to permit visitor/animal contact, whilst retaining the 2.2 m high fencing necessary to enclose the animals.

Historically dwelling in the remote Highland deer forests and only coming into contact with man during hunting and culling, wild deer are naturally very timid. Since wild animals form the main source of new breeding stock, a major challenge facing the industry is the reduction in stress arising from human contact. Stress is resposible for losses of up to 10% in animals obtained from the wild, and since each hind only rears one calf per year over a breeding life of 15-20 years, such losses are to be avoided.

The Scottish Deer Centre receives funds from visitors, educational trips and from the sale of venison and breeding stock, whereas a commercial production unit would rely entirely on meat sales as a source of income.

Welfare of animals and humans top the list at the Centre for Rural Building

Moving north we visited the Centre for Rural Building at Aberdeen. This is a division of the North of Scotland College of Agriculture and is the Scottish Agricultural Colleges' lead centre for building research. Under the directorship of Dr James Bruce, the Centre undertakes a wide range of work in consultancy, education and research and development.

Animal welfare is one of the most important aspects of the work with researchers looking at high welfare systems for pigs and poultry. Attention is also being devoted to the reduction of environmental dust levels by means of improved livestock housing ventilation. This has been shown not only to reduce the likelihood of respiratory diseases in livestock, but also to improve the stockman's working environment.

A lot of the work has moved on from the research stage into commercial production, the most recent example being a pig feeder, which has been designed with the aid of a survey of pig dimensions. The feeder is claimed to greatly reduce feed wastage and eliminate aggression at the trough during feeding. Other examples of work which have been taken up by the industry have been the use of automatically controlled natural ventilation and ruminant feeding equipment.

The Scottish Deer Centre, Cupar – perimeter fencing 2.2m high

New golf course has automatic sprinklers and moisture sensors

Provision of leisure facilities is another important form of alternative enterprise and at the Newmacher golf course near Dyce we had an excellent opportunity to learn something of the design and construction work involved.

The visit to Newmacher was made all the more interesting by the presence of the amenity grassland consultant, Mr Paul Campbell, from the North of Scotland College of Agriculture. Mr Campbell is responsible for this site and he gave us an insight into the principles and practice of course construction and management.

Designed from the outset as a potential championship venue, construction of the 6800 yard, 18-hole course began in 1984, the first nine holes of which were opened in the first week of May this year. The transition from a greenfield site to a fully landscaped all-weather course required an investment of £1.5 million, this being raised by membership subscription and by partial sponsorship by BP. The course incorporates an automatic sprinkler system for watering each green, controlled by soil moisture deficit sensors along with many other features designed to aid management.

As the course borders a site of special scientific interest (SSSI), construction and management techniques required considerable care.

Forests give direct employment and support local industries

Forestry is an important industry in Scotland and to gain an impression of all the factors involved Thursday 11th saw us visiting both a Forestry Commission timber extraction site and a timber products factory. The Forestry Commission is responsible for the management of much of the forest around Inverness. The site at Glen Urquhart was one of the first to be planted when the Commission began its planting in the 1920s and these trees are currently being harvested, the newly harvested areas being replanted.

The majority of tree felling is carried out by local contractors, the work being too seasonal and irregular for the Commission to justify employing a sufficiently large workforce on a permanent basis. Once felled and trimmed, the trunks are transported to a forest track where they are sawn to length and stacked ready for loading.

Transportation within the forest is by one of three methods, depending largely upon the topography of the region. On the steepest slopes, where access by wheeled vehicles is difficult, all of the timber must be moved by overhead cableway. This consists of a carriage, suspended from a track cable, to which logs may be attached. The carriage itself can be hauled back and forth along the track by means of a pair of cables connected to a winch drum. This method of extraction has several disadvantages, the most significant being the cost of operation, this arises from several factors including the speed of extraction, the high labour requirement and the time required to set up the masts and establish suitable anchor points.

On less severe slopes, the 'forwarder' is the preferred vehicle. This comprises a tractor unit with a pivot steer trailer capable of carrying 20 tonnes of timber. Behind the cab is mounted a hydraulic crane with which the operator can load the trailer single handed. The majority of these machines are imported from Scandinavia and have a working life of 8-9 years, although their capital cost must be written off in 6 years. The cost of maintaining these vehicles during their working lives amounts to about 50% of their purchase price.

The final class of vehicle used in forestry operations is the 'skidder', a high powered tractor unit which simply drags felled trees out of the forest and onto the tracks where they can be sawn and stacked. Haulage of timber with the skidder requires a workforce of at least two, so is less favoured than the forwarder on purely economic grounds.

Forest transport – the forwarder (left); *the skidder* (right)

Highland Forest Products is situated in Morayhill, Inverness, and our visit there gave a further insight into the way the forestry areas create and support rural industry. The company was formed in 1983 by an American financier and was subsequently bought out by a Canadian company, Noranda Forest Inc. The plant produces Oriented Strand Board (OSB) under the brand name Sterling Board. The product is a high quality board which rivals softwood plywood imported from the United States and is used in a wide variety of applications including house building.

Some 85% of the timber used in the production of OSB is locally grown Scots pine, much of which is bought on fixed price contract from the Forestry Commission. On delivery to the mill, the logs are debarked and sliced into 'bolts' prior to being machined into wafers. These are then dried from an initial moisture content of 50-60% down to around 5%. The dried wafers are then screened to remove fines which are used for fuel. The plant runs almost entirely free from fossil fuels, utilising timber residues to supply the necessary process heat. The dried chips are coated with 1% by weight of paraffin wax and 2.5% phenolic resin prior to being laid out in three 'plys' on a web and transferred to a heated hydraulic press.

The plant at Morayhill currently consumes 620 tonnes of Scots pine thinnings per day and produces 300 m^3 of finished product. The company has plans to set up another production line, thus doubling the plant's capacity.

Oban Whisky Distillery

Whisky production is another, very traditional, Scottish industry based on a locally grown crop.

At the time of our visit, the Oban Whisky Distillery was in its 'silent season', a period of two to three months in which no production takes place and necessary plant maintenance is carried out. The whisky produced by the distillery is sold either as a 14 year old single malt under the name 'Oban' or as part of a blend.

Malted barley is delivered to the plant, where it is first boiled in order to reduce the malt sugars. The resulting liquor is then fermented for 2-3 days in large wooden vats, whilst the washed barley, or draft, is sold as cattle feed. Once the fermentation process is complete, the liquor is distilled first in one and then a second copper kettle. The raw spirit resulting from this process is clear and lacking in flavour and must be stored in wooden barrels, preferably old oak sherry casks, in order to mature. Once sealed in the casks, the whisky leaves the distillery to be stored in vast warehouses for up to 14 years before being taken to a bottling plant.

Scottish Agricultural Colleges, Advisory Service

In addition to their teaching and research roles, the Scottish Agricultural Colleges also undertake advisory work for the local farming community. To conclude this Scottish tour Mr John Watson, the Argyll area advisor gave a very informative presentation followed by a tour of the area around Oban. The following points were made:

Dairy farming: This is of relatively minor importance in the Argyll area, there being only two areas where dairy farming is practised. Dairy farming is in danger of decline, since many of the farmers have reached retiring age and younger farmers are reluctant to take over.

Livestock farming: This type of farming is of great importance in Argyll, there being 1.25 million hill sheep and 25000 beef cattle. One of the most popular and prolific sheep breeds is the Blackface, having lambing percentages as high as 160%. The most popular cattle breeds are Highland, Galloway and Aberdeen Angus, which are frequently crossbred with Simmental and Charolais. Other types of livestock farming are also practised, albeit on a smaller scale, these include poultry, goats and deer. Fish farming is becoming increasingly important, with at least 40 fish farms currently operating in the area.

Crofting: The crofting system is essentially a communal farming system which dates from the end of the last century. The rules within which crofting is practised are complex, indeed it is doubtful if the crofters themselves fully understand them, however the original principle was that the crofter either rented less than 100 acres or paid less than £100 in rent.

The land is owned by the landlord, but everything above the ground belongs to the crofter. In addition to his own land, the crofter also has access to common land, to which he and several other crofters have access on a 'share' basis. If the common land is used for grazing, one 'share' is considered to represent one cow. Larger machinery is often used by several crofters on a co-operative basis, however this does cause problems at busy times. Potential newcomers to crofting may find it difficult to become established in the system. This is because an agreement must be reached between the newcomer and a retiring crofter. Also the appointment of a new crofter must be approved by the Crofting Commission, which ensures that the aims and values of the crofting system are not undermined.

Forestry: Forestry forms an important part of the agriculture in the Argyll area. However, concern has been expressed over the expansion of forestry, since it tends to weaken the structure of the community due to its low labour requirements.

Tourism: This is becoming increasingly important as an additional enterprise in the agricultural community. An indication of the importance of tourism is that the population of Oban rises from around 7000 in winter to 25000 in the summer.

Acknowledgement

The Young Engineers Section would like to thank the following for support, financial and otherwise, without which the tour could not have succeeded.

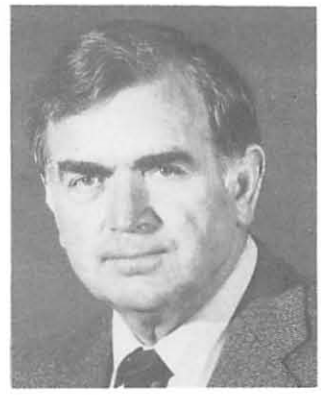
I Agr E Scottish Branch
I Agr E Council
Silsoe College
AFRC Engineering

and all the organisations we visited.

The mechanics of animal-draught cultivation implements

In this paper F M Inns sets out to explain through a series of propositions some essential concepts in the design of animal-draught cultivation (i.e. soil engaging) implements. A low angle of pull is shown to be undesirable (it increases the implement draught).

The principles are considered equally applicable to tractor-drawn implements and the propositions may be useful in suggesting new ways of looking at the design and operation of such equipment.



In this issue the author deals with the design implications for a chain-pulled implement. Consideration of a beam-pulled implement and of the implications for harnessing will be covered in future issues.

Animal draught cultivation implements have been used for some five thousand years. Designs have developed empirically to reach a very high level of technical excellence and of economic and social viability.

The ard, for example, can trace its descent from the earliest recorded implements and in various forms is still in widespread use today (Fig 1). In essence it is a tine set at an acute angle for good penetration and low draught with a simple and effective depth control system.

The plough is a derivative of the ard using a mouldboard to turn the soil in addition to loosening it. Because soil loads on the plough are non-symmetrical, problems of adjustment and control are more complex than those of the ard.

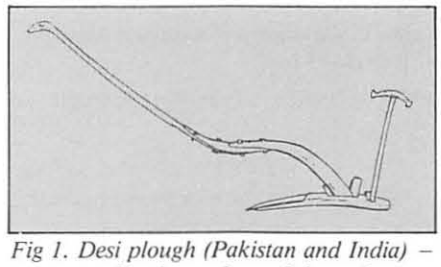


Fig 1. Desi plough (Pakistan and India) – a present day descendant of the ard.

Early design features empirical and not recorded

In temperate regions the design of animal-draught mouldboard ploughs probably reached its peak in the first half of this century. Many of the design features, which had been achieved empirically, can be explained and justified in the light of recent engineering based research (soil mechanics, implement control, etc) but no systematic design criteria and procedures have been recorded whilst the empirical knowledge passed on mainly by word and deed was largely lost when manufacture of the implements was discontinued.

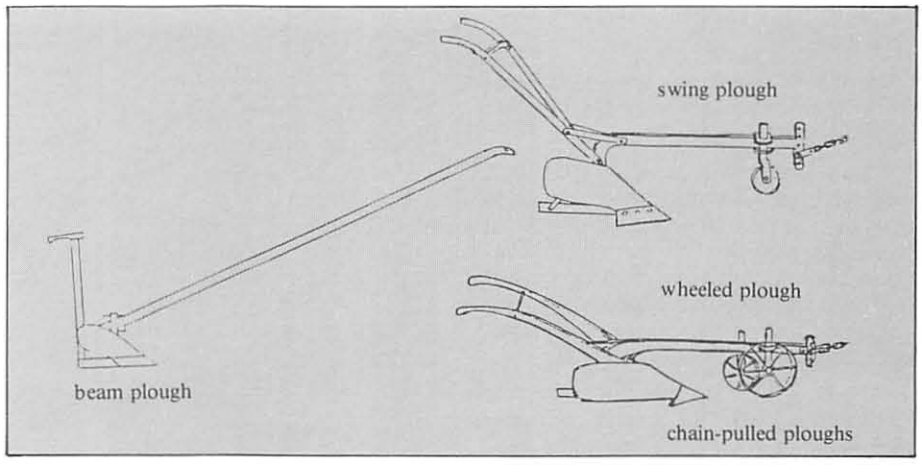
There are two basic types of cultivation implement for animal-draught – beam implements and chain-pulled implements. In the case of ploughs the chain-pulled types of plough are further sub-divided into swing ploughs and wheeled ploughs (Fig 2).

Beam implements are the most common type in the Near, Middle and Far East whilst chain-pulled implements are almost universally used in Africa south of the Sahara.

Beam implements are inherently more stable than chain-pulled ones and are usually controlled by one hand, while two handles are usually fitted for the control of a chain-pulled implement.

A swing plough has no depth control wheel(s) although it may have a small "nosewheel" fitted towards the front of the plough beam. The main purpose of the nosewheel is to assist in turning the plough at the headland and not to provide depth control. The wheeled plough normally has two or more wheels of relatively large diameter whose main purpose is to assist in depth control by supporting a significant proportion of the plough's weight.

Fig 2. Types of animal pulled plough.



Basic mechanics of equilibrium

The propositions now set out apply to all these types of soil engaging implement. Discussion will centre firstly on chain-pulled implements (this paper), then beam implements (to follow).

Many aspects of implement design and operation may be explained by reference to well known requirements for the equilibrium of an object in two dimensional space acted upon by three forces. These requirements are set out briefly in the adjoining panel.

Application of the principles of mechanics to design and operation

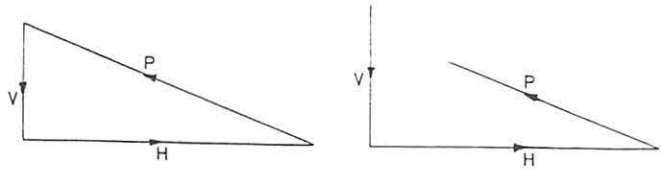
An animal-draught cultivation implement in steady work may be considered as an

Frank Inns is Professor of Agricultural Machinery Engineering at Silsoe College, Cranfield Institute of Technology, and was on secondment to the Agricultural Light Engineering Programme, North West Frontier Province, Pakistan.

Requirements for equilibrium of an object in two dimensional space acted upon by three forces

(a) The three forces must balance, i.e. when combined vectorially they must have no resultant. This condition may be considered either graphically or analytically:

(i) graphically: the force vector polygon (triangle in this case) must close.



force vector polygon closes forces in balance equilibrium is possible

force vector polygon does not close – an unbalanced resultant force – equilibrium not possible.

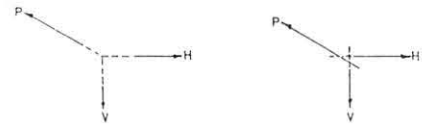
Note: a force vector diagram represents each force by a line whose length is in proportion to the ***magnitude*** *of the force and whose direction corresponds to the* ***direction*** *of the force. It does not represent the* ***position*** *of the force*

(ii) analytically: the sum of the force components, taken in any two arbitrary directions (usually "horizontal" and "vertical"), of the three forces must be zero, i.e.:

$\lesssim F_h = 0$ (sum of horizontal force components = zero) equation 1

$\lesssim F_v = 0$ (sum of vertical force components = zero) equation 2

(b) The line of action of the three forces must be concurrent in space:



the lines of action of the three forces are concurrent in space – equilibrium is possible

the lines of action of the three forces are not concurrent in space – equilibrium not possible

Note: a space diagram represents the ***direction*** *and* ***position*** *of each force but not necessarily their magnitude*

By comparing the conditions set out in (a) (i) and (a) (ii) it may further be seen that equation 2 gives, for the horizontal direction to the right:

$$H - P.\cos\alpha = 0$$

which may be written:

$H = P.\cos\alpha$ or $P = H/\cos\alpha$ equation 3

similarly for the vertically downward direction:

$V = P.\sin\alpha$ or $P = V/\sin\alpha$ equation 4

and, by combining these two equations:

$\tan\alpha = V/H$ or $H = V/\tan\alpha$ equation 5

object in equilibrium under the action of three forces, which must interact in accordance with the principles outlined in the panel. For a soil cultivation implement the three forces as viewed from the side are:

H: Implement draught. This is the sum of all the horizontal force components acting on the implement from the soil and the operator.

V: Effective vertical force. This is the sum of all the vertical force components acting on the implement due to its weight (gravitational force) and from the soil and the operator.

P: Pull. This is the hitch force acting on the implement from the animal through its harness.

If these concepts are fed into equation 5 ie $H = V/\tan\alpha$ (see panel) then the equation may be put in words as follows:

$$\text{draught} = \frac{\text{effective vertical force}}{\text{tangent of angle of pull}}$$

This effect may be quantified for various angles of pull as shown in Table 1 which then leads to:

Proposition 1. Implement draught increases as the angle of pull is reduced, for a given effective vertical force.

This proposition contradicts the widely held and often stated view that a low angle of pull is a desirable feature of animal harnessing systems. Possibly this misconception arises from a consideration only of the pull in the chain. For example, applying equation 3 to the forces acting on an implement (as shown at point 1 in Fig 3):

$$P_1 = H_1/\cos\alpha$$

so that for $\alpha = 15°$ (a possible but rather high value of α for a traditional neck or

Table 1. Variation of implement draught with angle of pull

Angle of pull	*Implement draught*
0°	∞
5°	11.4 × effective vertical force
10°	5.7 × effective vertical force
15°	3.7 × effective vertical force
20°	2.7 × effective vertical force
25°	2.1 × effective vertical force
30°	1.7 × effective vertical force

withers yoke) $P_1 = 1.04\ H_1$, i.e. the pull in the chain is 4% greater than the implement draught. This seems undesirable but when the force system acting at the yoke is considered (as shown at point 2 in Fig 3) equation 3 shows that:

$$H_2 = P_2.\cos\alpha$$

and since P_2 = tension in the chain = P_1 then:

$$H_2\ P_1.\cos\alpha = \frac{H_1}{\cos\alpha}.\cos\alpha = H_1$$

giving rise to:

Proposition 2. The forward thrust required from the draught animal(s) is equal to the implement draught and is unaffected by the angle of pull.

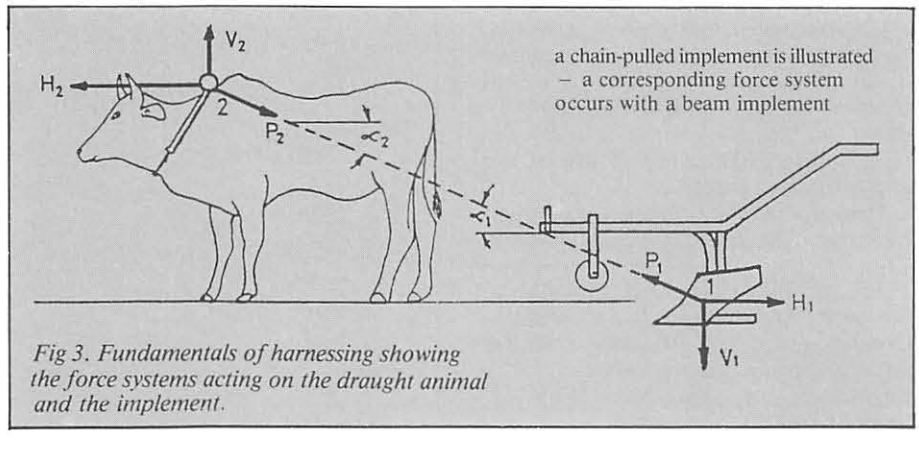
Similarly by applying equation 4 to the vertical forces at points 1 and 2 in Fig 3:

Proposition 3. The vertical load supported by the draught animal(s) is equal to the effective vertical force acting on the implement and is unaffected by the angle of pull.

Equation 5, $H = V/\tan\alpha$, gives rise to an additional proposition of considerable importance to the implement designer:

Proposition 4. In steady work the draught of an implement is determined by the effective vertical force acting on it and the angle of pull applied to it. The draught is unaffected by the soil resistance.

It may seem that this proposition is entering into the realm of the barely credible because it is well known that implement draught is dependent on soil resistance – calculations of implement draught have always been made on this basis. The ap-



a chain-pulled implement is illustrated – a corresponding force system occurs with a beam implement

Fig 3. Fundamentals of harnessing showing the force systems acting on the draught animal and the implement.

parent contradiction may be resolved once it is realised that:

Proposition 5. An implement will achieve its equilibrium draught (in accordance with proposition 4) by penetrating to an equilibrium depth determined by the soil resistance.

That is to say that the working depth is determined by three factors – the effective vertical force, the angle of pull and the soil resistance.

With animals – draught is the limiting factor

Propositions 4 and 5 merely reverse a conditioned thought process. Conventionally one considers the **draught** as dependent on soil resistance **for a given depth of work.** Propositions 4 and 5 show that the **depth of work** is dependent on soil resistance **for a given draught.**

There is no contradiction in these viewpoint but the second is considerably more useful when dealing with animal draught equipment for which the maximum allowable draught is a limiting factor of critical importance and the depth of work should be adjusted to suit.

Conventional (traditional) neck yokes do not provide for much variation in the angle of pull. It may be varied, by changing the length of the hitch chain and the point of attachment to the implement, through a range from about 10° to 15°.
Table 1 indicates that the implement draught will thus be about four to five times the effective vertical force.

It may be expected that a large part of the effective vertical force will be the weight of the implement. If this is taken as about 300 N (30 kgf) the resulting draught force would be in the order of 1.2 kN to 1.5 kN (120 kgf to 150 kgf).

The continuous pull available from work oxen is usually taken to be about 10% of body weight so that a pair of oxen with a combined body mass of 800 kg would produce a pull of about 800 N (80 kgf), consequently continuous operation of the above implement would be beyond the capacity of the draught animal pair.

To reduce the implement draught to 800 N when the pull angle is 10° to 15° the effective vertical force must be reduced to about 160 N to 200 N (16 kgf to 20 kgf), which is less than the weight of most animal draught chain ploughs. To establish how the effective vertical force might be reduced to this level it is necessary to examine the total force system acting upon the plough.

The force system acting on a chain-pulled swing plough

The major forces which might, depending on circumstances, act on a chain-pulled swing plough are defined in Fig 4 and the Notation. For convenience, the forces have been resolved into their horizontal and vertical components, with the exception of the hitch force (pull in the chain).

Three of the forces (G, S and P) are fundamental to the operation of the plough and must always be present. The others each have a potential role to play in operation of the implement but are not always in evidence.

Ideally the implement should work in the equilibrium state of steady motion under the action of the three fundamental forces, G, S and P. The soil force S usually has a vertical component so that it is inclined downwards at a small angle to the horizontal (S_v is small compared with S_h). The equilibrium state may then be achieved by careful hitching so that the line of action of the pull force P is concurrent with (passes through the point of intersection of) the other two forces, G and S – see Fig 5.

In practice this ideal condition is very delicately balanced and is easily disturbed by, for instance, variation in soil force S due to changes of soil condition or by variation in the direction of the pull P due to the motion of the draught animals. In addition (see foot of column one of this page) the

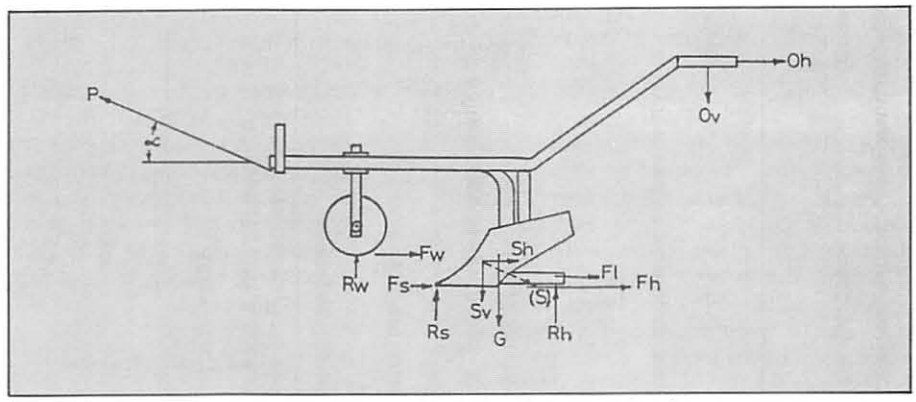


Fig 4. Force components acting on an animal draught swing plough.

Notation

Fundamental forces

G: implement weight (gravitational force).

P: pull (hitch force). For a chain pulled implement this force is the tension in the chain. Its line of action and position coincide with the direction and position of the chain.

S: fundamental force from the soil onto the working surfaces of the implement due to the implement's action in cutting and turning the soil. For convenience this force is resolved into two components:

- S_h: the horizontal component of the fundamental soil force.
- S_v: the vertical component of the fundamental soil force.

Parasitic and control forces

F_h: frictional force at the heel of the plough resulting from R_h.

F_l: frictional force at the landside resulting from the force between the landside and the furrow wall.

F_s: frictional force at the underside of the share resulting from R_s.

F_w: rolling resistance of the wheel resulting from the contact force R_v between the wheel and the ground. Some ploughs are fitted with a skid rather than a wheel. F_w is then a frictional force rather than a rolling resistance force.

O_h: Horizontal component of the force exerted by the operator on the control handles of the plough.

O_v: vertical component of the force exerted by the operator on the control handles of the plough.

R_h: support force at the heel of the plough, necessary if the depth of work required is less than that corresponding to the equilibrium working draught. The force may be increased by adjusting the heel or by the operator increasing the downward or rearward force applied to the handle.

R_s: support force acting at the underside of the plough share. This force reduces the equilibrium working draught, thereby restricting penetration. This force should be very low when the share is correctly designed and fitted and when it is new. It can become large with wear. Similar unwanted support forces may occur on other implements due to bad design or adjustment, for example along the bottom edge of the wings of a mouldboard ridger.

R_w: support force at the plough nosewheel arising from its contact with the ground. This contact force should not normally be needed for a well adjusted plough in steady work, hence the rolling resistance associated with the wheel may be eliminated. The main purpose of the nosewheel or skid should be to assist in turning the plough at the headland.

equilibrium draught would probably be unacceptably high for a pair of animals. It is therefore necessary to introduce additional forces to ensure stable and controlled operation of the implement.

Vertical forces to be as small as possible – by good design, maintenance and operational adjustment

The additional forces required to maintain stability and control give rise to parasitic forces. Referring to Fig 4 the vertical R components of force and the O components are those which may be needed to maintain stability and control.

The horizontal F components of the forces are parasitic inasmuch as they increase the draught of the implement with no useful effect in themselves.

The F components all increase as the vertical R component increases, due to frictional or rolling resistance effects. Therefore the R forces should be kept as small as possible – this may be achieved by good design, maintenance and operational adjustment of the plough.

The question then is "how to reduce the effective vertical force to a level which will result in acceptable draught?"

Referring to Fig 4 and the Notation it will be seen that the effective vertical force is the algebraic sum of the following components (taking the downward direction as positive):

+ G: implement weight is always positive
± S_v: vertical component of the fundamental soil force is usually positive
± O_v: vertical force applied to the handles by the operator is desirably positive but sometimes negative
– R_h: force at the heel of the plough is always negative
– R_s: support force from the soil at underside of the share or other soil contacting non-working surface is always negative
– R_w: force at the nosewheel is always negative.

In order to reduce the effective vertical force the negative force components must be increased in magnitude. Consider the possibilities in turn:

– O_v: increased upward force is achieved by lifting the handles. It is tiring to do this for other than short periods. Also the force is applied rather far back and upsets the working balance of the plough
– R_h: an adjustable heel may be designed to provide the required effect. The upward force it provides has a line of action quite close to that of the implement weight and so should have little effect on the working balance of the plough
– R_s: support force at the share etc. – these forces are undesirable as they are not readily controllable and may reduce the ability of the plough to penetrate to the required draught (and hence required working depth)
– R_w: an upward force at the nosewheel can result in considerable parasitic rolling resistance which will increase the implement draught (particularly in soft soil) and, because of the forward position of the nosewheel, the working balance of the plough may be upset.

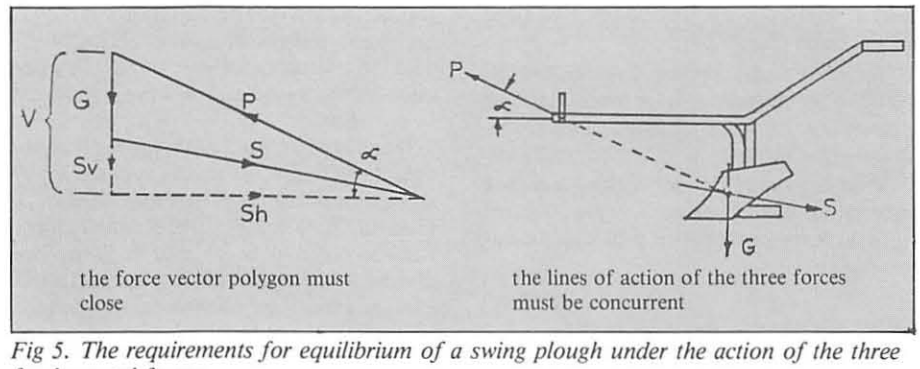


Fig 5. The requirements for equilibrium of a swing plough under the action of the three fundamental forces.

Adjustable heel or depth skid for draught control

A concluding proposition may now be stated in answer to the question "how to reduce the vertical force".

Proposition 6. An adjustable heel is the most effective method of controlling the draught, and hence the depth of work, of a swing plough being pulled at a set angle. An adjustable depth skid could serve the same function on other cultivation implements.

To maintain working balance the heel or skid should be situated close to the implement's centre of gravity consistent with the proper functioning of the implement and of its soil engaging components.

In Fig 5 it is shown how the line of action of the three fundamental forces acting on a plough are concurrent to give a balanced force system in work. The direction (angle α) of the pull force is determined by the vector addition of G and S. Its location is determined by the point of intersection of the lines of action of forces G and S.

The line of action of G can be determined easily by lifting the plough by the beam to find the point of balance (centre of gravity).

It is difficult to find the line of action of the soil force S without sophisticated instrumentation but for a single furrow animal-draught plough, provided that the centre of gravity of the plough is about 200 mm behind the point of the share, it is probably sufficient to assume that S intersects the line of action of the weight G at a point given by about half the working depth (point O in Fig 6).

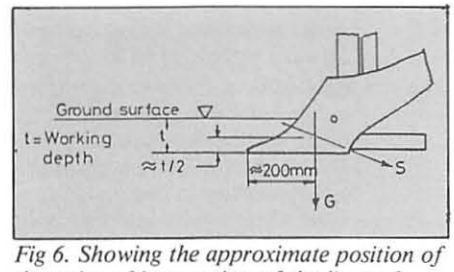


Fig 6. Showing the approximate position of the point of intersection of the lines of action of the forces G and S when G passes about 200 mm behind the share point (single furrow swing plough).

From this point various lines of action of P may be drawn according to the pull angles for which provision is to be made. At some point along each of these lines of action it will be necessary to make provision for attaching the pull chain to the implement – thus the position and range of adjustment for the hake plate may be decided.

Plough setting in practice

In theory it is possible for the plough to be in perfect equilibrium according to these arrangements. In practice such an equilibrium would be too delicate and easily upset by slight variations in the force system, such as those mentioned on the previous page.

In practice, therefore, the best line of pull will be when it passes, not through the point of intersection of G and S, but slightly above it by a few centimetres. This will create a nose-down couple on the plough which can be corrected (including random variations in its magnitude) by the operator applying a force with a downward and/or rearward inclination on the handles.

The force system just described will usually give a resultant downward force (G + S_v) which, with conventional pull angles, will cause an excessive draught force.

As discussed previously the effective vertical force (and hence implement draught) may be reduced by arranging for an upward (support) force to be applied at the nosewheel, heel or handles. The new effective vertical force will be the algebraic sum of the original one and the (negative) one(s) just introduced.

The position of the new effective vertical force will also usually change, depending on the magnitude and direction of the couple resulting from introduction of the support force.

A support force at the nosewheel will generate a couple whose effect will be to move the effective vertical force rearward, whilst a support (upward) force on the handles at the rear of the plough will move the effective vertical force forward. It would then be necessary to adjust the position (and

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also the angle if possible) of the pull force to give a new intersection at the new point of concurrence of effective vertical force and horizontal draught force.

On the other hand a support force, such as that at the heel, which acts close to the line of action of the original effective vertical force gives a reduced effective vertical force with relatively little change in its position. In this case the "balance" of the plough may be closely maintained and relatively little adjustment of the line of pull is necessary to restore it. Therefore the support force on the plough, or other cultivation implement, should be applied as nearly as possible through its centre of gravity.

Guidelines for the design of an animal-draught swing plough

Based on the foregoing analysis it is suggested that the design of a swing plough should be guided by the following considerations:

- The plough should be as light as possible consistent with the required:
  - equilibrium draught force. This should be limited to the maximum continuous pull available from the draught animal(s). It is dependent on the geometry of the harness and the effective vertical force (Table 1),
  - strength and
  - function.

Any weight above that needed for the equilibrium draught must be counteracted by additional support forces (increased angle of pull, more support at the plough heel, depth skids, etc). The greater the support forces needed, the more difficult it will be to adjust the plough and the greater the parasitic forces generated.

- The pull force from the implement hitch chain, in combination with the effective vertical force and the soil draught force, should be arranged to provide a small nose-down couple on the implement. This will make it easier for the operator to control the implement in steady work. The position of the plough's centre of gravity is important in meeting this requirement.
- Provision should be made for a variable support force to be applied to the implement in order to regulate the effective vertical force, and hence draught and depth of work, to a level to suit the work animals. The support force should be applied at a position where it has a minimal effect on the balance of forces (i.e., usually, close to the centre of gravity of the implement).
- Hake plate adjustments should be arranged to take account of expected variations in the angle of pull, in each case allowing the line of pull to pass a little above the point of concurrence of the implement draught force and the effective vertical force (see above).

Acknowledgements

The author wishes to acknowledge the assistance of Mark Sanders in preparing the paper and of Gul Mohammad, Senior Draughtsman for the Agricultural Light Engineering Programme, who drew the diagrams.

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Micro electronics on the farm – reliability in service

L H Agro have produced electronics for agriculture for the past 14 years. Product reliability is a company watchword and the in-service failure rate is now running at less than 0.1% of units supplied.

G A Thompson explains how this quality performance has been achieved and how it is being maintained.

In 1983 the L H Agro in-service failure rate was at about the average for electronic products generally available at the time. However, rejections in production were running as high as 18% and reworking the product was an expensive and time consuming item. First attention was therefore turned to improving reliability in production. A target was set to reduce rejections to 5% within two years. This was more than met and, in the event, rejections were reduced to 1.6%.

At that time, the main problem in manufacture was the introduction of many new products. The growing European demand for electronics on the farm meant that new products had to be designed and put on the market in the shortest possible time.

Design changes for improved manufacture and performance

The first move was to a radical alteration in product design. The company moved from casings of sheet steel or plastic and introduced aluminium casings on all new production.

The new casing design not only provided a very strong structure, but also acted as a shield against external radio interference – the major contributor to in-service failures. In addition, the smart aluminium casing had 'eye appeal' and so the improved design helped to increase sales.

A further change in production policy was to have all circuit boards manufactured by a specialist producer. This component is manufactured to L H Agro specification and we therefore retain the ultimate control over quality. Assembly and final testing continues to be carried out in the production plant at Aabybro, Denmark.

L H Agro also now use Computer Aided Design methods for their new products and so achieve favourable results in a much shorter time. This in turn allows them to channel more funds to the R & D department, where they spend the equivalent of 10% of their sales turnover.

Rigorous testing programme

It is, however, testing that we believe to be the single most important contributory factor to the present day reliability of their products.

No product is marketed until it has been fully tested. Our statement of policy is: –

1. We build a prototype – initially we test that prototype in the factory and make any obvious first stage improvements.
2. We install the product with the help of a farmer – one of many in Denmark who test our products for us – again we make improvements based on our findings.
3. Next we build 10 pre-production units and have these tested again under 'on-farm' conditions. If all is well we go into the first production run, if not, improvements are made and the process is repeated.
4. We build a production run of between 30 and 50 units depending on the type of product; these units are sold to selected customers and their performance continually monitored. The products may be sold anywhere in Europe. Of these, 3-5 units would normally be brought into the UK. Only after analysing the results and approving the operation of the product will it be placed on general release for manufacture.

Subsequently, there is stage by stage testing during assembly and all completed units are finally subjected to a rigorous 48-hour working test before they are pronounced fit for service and packaged ready for shipment.

The 48-hour test consists of feeding simulated information to the computer and at the same time varying the temperature of the product by placing it in a specially constructed oven, between 7°C and 72°C. Any unit failing to perform to the standards laid down is rejected.

Reliability in operation has given the company a reputation for quality which has resulted in good sales and customer satisfaction.

As a postscript: The attitude to R & D helped L H Agro win the coveted Institute of Design Prize in Denmark for their LH 865 Grain Capacity Indicator. There are only six prizes awarded each year and competition is very tough with companies like the mammoth Phillips company amongst the competitors.

Graham Thompson is UK Technical Sales Executive for L H Agro (UK) Ltd of Sudbury, Suffolk.

Review of recent British Standards

M D P Matthews

BS 3555: 1988, **Ring wrenches** (10 pages)

This British Standard specifies requirements for ring wrenches for metric, unified and British Standard hexagon bolts, nuts and machine screws, including hexagonal headed bolts of various materials in the aerospace series. It covers hexagon and bihexagon double-end ring wrenches for 3.2 mm to 60 mm (across flats) for the metric range, and approximate equivalents in imperial ranges.

A formula is provided from which the wrench length can be calculated (± 10%) from the nominal width across the flats of the larger end of the wrench. Other dimensions are tabulated. The material hardness and finish are specified with reference to existing British Standards. A format for marking the wrench size according to range is specified.

An appendix details a torque test from which wrenches are required to suffer no permanent deformation or damage. Two other appendices cover guidance on the safe use of ring wrenches and the specifications required when placing an order. The Standard includes reference to 19 BS or ISO Standards and these are listed.

BS 6916: Part 6: 1988 (ISO 7182-1984), **Chain saws, Part 6, Method of measurement of airborne noise at the operator's position** (4 pages)

A specification is provided for measuring the A-weighted and octave band sound pressure levels at the operator's position of noise emitted by portable hand-held internal combustion engine chain saws. Five references are provided regarding sound measurement and forestry machinery.

Measured values are required of A-weighted sound pressure in decibels determined with the frequency weighting and time weighting. Although spectral analysis is optional the octave bands are specified when required. The test conditions should simulate normal operating conditions in the forest but requirements are listed with regard to open or enclosed spaces, reflective surfaces, ground conditions, operator clothing, background noise and ambient conditions. The saw condition is specified and the required width of non-dried timber can be calculated from the length of the guidebar.

Recommendations are made on the measuring equipment used with regard to microphone diameters, the positioning and wind screening attachments, and the maximum allowable tolerances on the measured sound pressure level. Engine speed measurement, sound frequency analysis and instrument calibration are also covered. A test procedure with an example of a record sheet for reporting the measurement results with the saw idling, under full load and racing is detailed. A list is provided of recordings other than the sound level which are required.

Throughout the Standard reference is made to ISO and International Electrotechnical Commission (IEC) Standards.

BS 6949 : 1988, **Bitumen-based coatings for cold application, excluding use in contact with potable water** (6 pages)

Specifications are provided of the performance and marking requirements for bitumen-based solvent-borne coatings applied cold by brushing, spraying, rolling or dipping for corrosion protection of materials including iron and steel.

Taking account of recent developments in this type of paint, the coatings are defined and classified as to whether fillers are used and the solvents added in respect to their flashpoint. The Standard covers drying and overcoating times, the expected finish, protection from corrosion, bend resistance, shelf life and marking of containers.

Appendices provide instructions on the use of the coatings for cold application, listing their general properties, the precautions required, expected durability, methods of thinning, primer requirements, preparation of surfaces, and application. A method of preparing test pieces is specified and the subsequent tests for flashpoint, drying and overcoating times, finish, corrosion protection and bend resistance.

Reference is made to nine other British Standards and one HSE Note in this Standard.

BS 7025: 1988, **Preparation of test codes of engineering grade for measurement at the operator's or bystander's position of noise emitted by machinery** (10 pages)

The test codes covered by this Standard are intended for comparison of noise emissions of different machines under similar environmental conditions. It relates to the emissions of noise sources rather than the measurement of occupational noise exposures of workers.

Definitions are provided for 13 aspects including sound pressure level, A-weighted and A1-weighted sound pressure level, and equivalent continuous sound pressure level. The test environment for measurement purposes, the criterion for background noise and the ambient conditions are all specified. Suitable instrumentation systems, microphone positions and the installation and operating conditions of the equipment are recommended. Procedures to be adopted in the calibration of instruments and the actual measurement of sound pressure levels are listed, together with a method of correction for background noise. Recommendations are made for the compilation of a test report.

An appendix provides examples of suitable instrumentation systems and an equation is provided to compute equivalent continuous sound pressure levels from data taken with unequal sampling intervals.

BS 5983: Part 1: 1989 (ISO 6124-1: 1987) **Metric spherical plane bearings. Part 1 Specification for dimensions of spherical plane radial bearings, joint type, dimension series E and G** (3 pages)

This Standard supercedes that of the same number issued in 1980 and provides in table form the dimensions for spherical plane radial bearings Series E with bore diameters of 4-300 mm and Series G with bore diameters of 4-280 mm. Eight dimensions define the bearings geometrically but no restrictions are imposed as to the material or manufacturing method.

Reference is made to ISO 582, Rolling bearings chamfer dimension limits, and ISO 6125, Spherical plane radial bearings, joint type, tolerances.

Mike Matthews is Commercial Officer at AFRC Institute of Engineering Research, Silsoe, Bedford.

BS 7010: 1988, **A system of tolerances for the dimensions of plastics mouldings** (10 pages)

This is a code of practice which recommends a system of tolerances for items produced by compression, transfer or injection moulding with thermoplastic or thermosetting materials conditioned for 16 hours at 23°C and 50% relative humidity. The code does not apply to extrusions, blown or foamed mouldings or deep drawn or sintered parts.

Definitions are included of the commonly used terms, including moulding shrinkage and the shrinkage factor, mould related and non-mould related dimensions and tolerance groups and levels. A procedure for tolerance selection, using a table which correlates tolerance groups with moulding materials, and the tolerance values on dimensions for each group, is specified. A table also shows the shrinkage factors as related to the three dimensional tolerance groups.

Twelve other British Standards relating to plastics moulding materials are referred to in this Standard.

BS 4196: Part 7: 198 (ISO 3747: 1987) **Sound power levels of noise sources. Part 7 Survey method for determination of sound power levels of noise sources using a reference sound source** (17 pages)

This International Standard is one of eight specifying various methods for determining the sound power levels of machines and equipment in different test environments. This Standard involves the determination of sound power levels from equipment which is not movable from its installed position.

The use of a reference sound source with known acoustical characteristics will establish the environmental corrections to determine the true sound power level of the equipment. The Standard applies to sources which radiate broad band noise, narrow band noise, discrete tones and combinations of the three, but does not apply to isolated bursts or burst trains with repetition rates of less than 5 per second.

Eleven aspects of the procedure are defined and guidance is given on the acoustic environment. The Standard relates to any test site without restriction but requires a steady background noise of at least 3 dB below the A-weighted sound pressure level of the source under test or the reference sound source. Outdoor measurements are limited to times when the wind speed is below 5 m/s. The specifications of the sound level meters and the reference sound source are as stated in other Standards but the position of the microphones and the reference sound source are specified.

When under test acoustic measurements are made when the equipment is in normal use. The test code of the equipment should be followed if available otherwise measurements should be taken when the device is:

- under specified load and operating conditions,
- under full load,
- under no load,
- under the operating condition corresponding to the maximum sound generation,
- under simulated load with carefully defined conditions.

Formulae are provided for the calculation of the sound pressure level averaged over the measurement surface, the sound power level when A-weighted sound pressure levels are measured and sound power levels when octave band sound pressure levels are measured. The Standard concludes with information about the test site, instrumentation and data which has to be recorded and reported and fifteen illustrations are provided with regard to the positioning of microphones and the reference sound source.

Reference is made to 12 International Standards on acoustics and four publications of the International Electrotechnical Commission (IEC).

The BSI Registered Stockists System

Quality assurance in manufacture is covered by BS 5750 (ISO 9000): the International Standard for Quality Systems, but this does not relate to stockholding or distribution activities.

Companies involved in the supply of goods manufactured by separate companies can be assessed and registered against the BSI System and are entitled to use the BSI Registered Stockists symbol along with its registration number (RSNo). To ensure that the system is complied with BSI make biennial assessment visits to the stockist.

The scheme is in two parts: Part 1 requires stockists to maintain lot traceability of any material sold whereas Part 2 retains the supplier identity but under both Parts the material will have been acquired from a quality assured source.

It is not necessary for all goods purchased by the Registered Stockists to be from quality assured sources in order to serve the needs of a wide range of customers. It is therefore important for purchasers wishing to ensure that the materials comply with quality standards to specify that the Registered Stockist supplies the goods in accordance with the Registered Stockists' System. Purchasers should specify Part 1 or Part 2 at their own discretion.

Further information on the system can be obtained from BSI Quality Assurance, PO Box 375, Milton Keynes, MK14 6LL (Telephone (0908) 220908).

Copies of British Standards

are obtainable through libraries or can be purchased direct from:
British Standards Institution (Sales),
Linford Wood,
Milton Keynes, Bedford MK14 6LE.
Telephone: (0908) 220022 · Fax: (0908) 320856

Standards for measurement and testing

The National Measurement Accreditation Service (NAMAS) first yearbook provides specialised information of interest to those involved in measurement and quality control.

NAMAS was formed following the amalgamation of the British Calibration Service (BCS) with the National Testing Laboratory Accreditation Scheme (NATLAS) and the two laboratory accreditation services of the National Physical Laboratory (NPL). The combined service is responsible for disseminating national standards to industry thereby ensuring that measurement is to the required standards of today's markets for goods and services.

The yearbook is in six sections. The first deals with NAMAS as an organisation, the second is a review of certification systems overseas and the third is a similar review of accreditation in the UK. In Section 4 there is a description of some particular accreditation schemes including humidity measurement, site testing and performance testing of products relating to fire. The final two sections give more information on accredited calibration and testing laboratories.

The NAMAS Yearbook Edition 1, December 1988, is available from Sue Bridge Publishing Ltd, Surrey.

Nitrate and soil compaction

J Shotliff argues that soil compaction not only restricts water movement through the soil but it also encourages water run-off from the surface. The essential nitrogen thus not only fails to reach the plant but is instead leached off to cause pollution.

The effects of compaction can persist, he says, for long after the compaction itself is relieved. Additional treatment is necessary and an application of nitrogen stabiliser is recommended.

With existing and impending EEC legislation (Directive 80/778/EEC Council Resolution 88/C209/02 28 June 1988, Draft Directive Com (88) 708 final) and the consultation document "Nitrate Sensitive Areas Scheme" MAFF and WOAD, May 1989, attention is again being drawn to those measures that can reduce nitrogen losses.

Nitrate is highly soluble and readily moves through the soil. Its movement is affected by its concentration which among other things, will be a factor of the total amount of N applied and effective moisture and soil permeability. The presence of plant roots and soil organisms, soil oxygen and organic carbon are factors which need to be taken into account.

The main problem areas in terms of highest nitrate in ground water are those with a preponderantly arable cropping system.

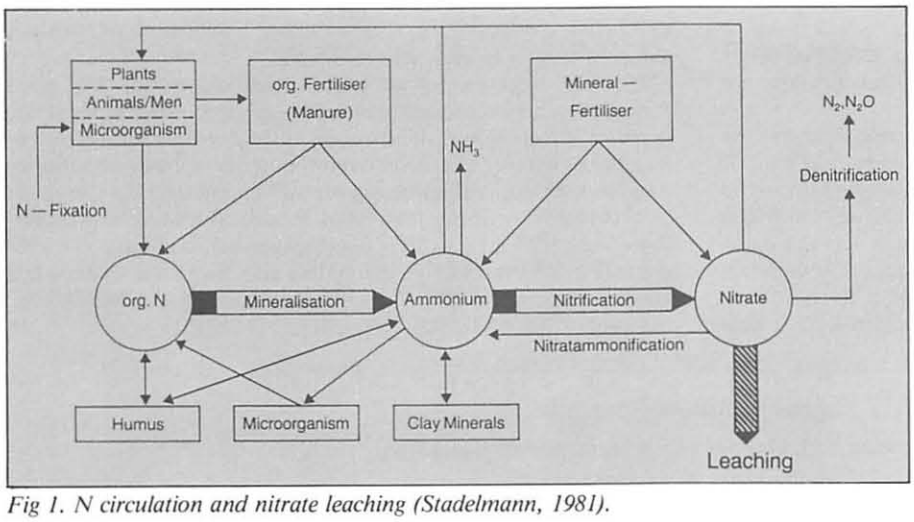


Fig 1. N circulation and nitrate leaching (Stadelmann, 1981).

Nitrate sensitive areas are already mapped and measures involving agricultural practice will eventually have to be taken to ensure that existing and proposed EEC legislation objectives are achieved.

Soil compaction influences nutrient availability, causes nitrogen loss

It is therefore essential to understand the interaction of soil, nitrogen, soil water and soil micro-organisms (Fig 1). Nutrients have to be available to the plant at the right time and one of the major problems affecting that is soil compaction. Where compaction exists water is only available in the top few centimetres and the excess runs off. Under wet conditions denitrification occurs and such losses can amount to 15% of total N applied in 2 days, 50% in 5 days and 95% in 10 days, according to work undertaken at Iowa State University.

Effects can persist for years

Compaction is not a problem of heavy soils alone and sandy soils are also vulnerable if worked in the wrong conditions. It has been estimated that the effect of working soils in conditions that are unsuitable in the autumn can last up to five years.

Soil compaction is a problem that can be easily identified; a spade hole deep enough to chase root activity down and a knife is all that is really required. If the knife is pushed into the sides of the trench and the area of resistance measured by pressure it can be a reliable guide to the degree of compaction.

Where compaction exists water penetration will be slow to occur, the soil will not be recharged and there will be problems in both dry and wet years.

Wheel traffic can reduce soil permeability by thousand fold every time the field is trafficked. Root growth is reduced and there is then very poor absorption of water and nutrients; the oxygen level in the soil is reduced, legumes do not produce nodules in the same way and the availability of nutrients can be dramatically reduced.

For example, the work at Iowa State University showed that under soil compaction conditions that 70% less potassium was available for the plant to take up, 30% less nitrogen, 20% less magnesium and 10% less calcium.

With the pressure of timeliness the temptation to work soils when they are too wet and then work them too often in an attempt to recover from problems produces results that can dramatically reduce yields. Crop yield reductions can range from 30% on winter wheat grown on heavy soils to 69% on peas grown on medium/light soils.

Farmers should check the moisture at the depth of cultivation and make sure that they are not adding to compaction. More powerful and heavier tractors that enable wet soils to be worked, add to the compaction problem simply because they are heavier and can easily work wet unsuitable soils.

Freezing during the winter months will not remedy problems that are caused in the autumn.

Tramlines can reduce the compaction area ...

With the introduction of tramlining compaction problems can be reduced especially if tramlines remain in the same place year after year as these provide a sacrificial area.

However, if tramlines are moved each year then compaction will spread over the whole area and will need remedial treatment to restore normal conditions. Failure to do so results in the "long corn short corn syndrome" that follows wheeled compaction routes.

With farmers paying the same fixed costs for the whole area it is essential that each area makes the same contribution to profits. Compaction will increase problems and occasional complaints about ineffective nitrogen fertilisation or agrochemical use can often be attributed to compaction.

... and a nitrogen stabiliser can mean fewer passes, longer availability – a reduced requirement

The compaction problem can be reduced by tramlines and by the "one pass option" involving nitrogen stabilised with Didin fluid (Alzon) since compaction is a function of

John Shotliff is a consultant with Fertiliquids, Calne, Wiltshire, a branch of Dalgety Agriculture Ltd

the number of times the soil is subject to traffic. Didin is a compound containing among other things Dicyandiamide which delays nitrification in soils by inhibiting the activity and multiplication of the soil bacteria responsible for converting ammonium N to nitrate N (Fig 2).

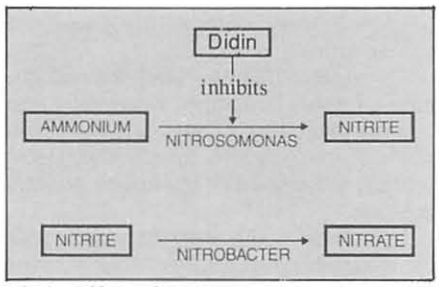


Fig 2. Effect of Didin on the nitrification of NH_4-N.

The effectiveness of Didin depends on its concentration in the soil since it is affected by soil temperature over a defined time period. Application rates can be adjusted to meet time and expected soil temperature conditions.

For winter wheats the ability to put on all the nitrogen in the period beginning February or end of March in one application must have much to commend it. Not only is the nitrogen held where it is available but ammonia held in that form is much less liable to leaching (Fig 3). The compaction that reduced nitrate availability is minimised so there will be a combination of benefits that will result in more nitrogen being available for the plant at the time when it needs it.

There are benefits to be obtained from dealing with compaction and nitrate leaching problems separately, the work from the Institute of Grassland and Animal Production, Hurley demonstrates the latter (Fig 4) as does the ADAS Gleadthorpe trial with Didin on potatoes where the yield benefit with Didin on the highest N treatment was approximately 4 tonnes/ha.

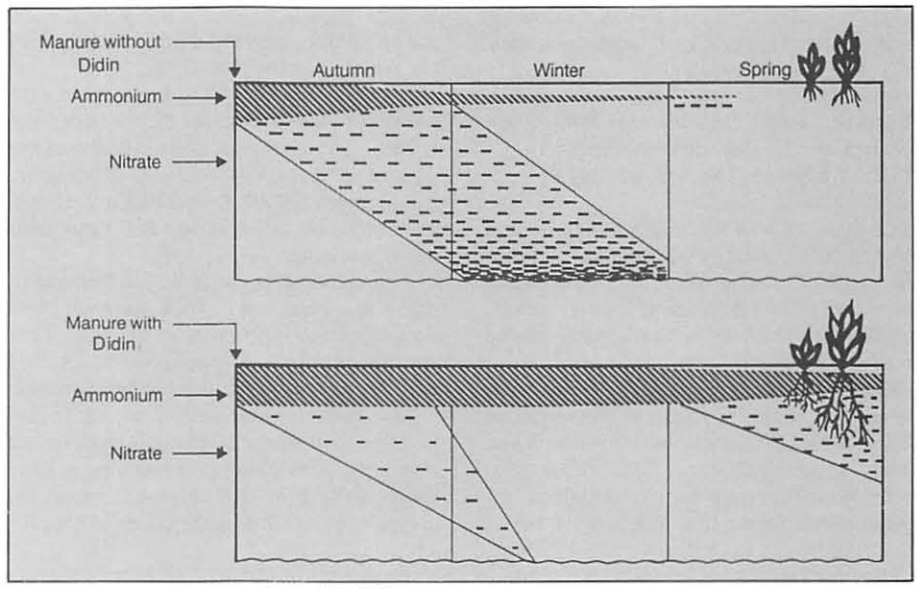


Fig 3. Nitrogen conservation with Didin.

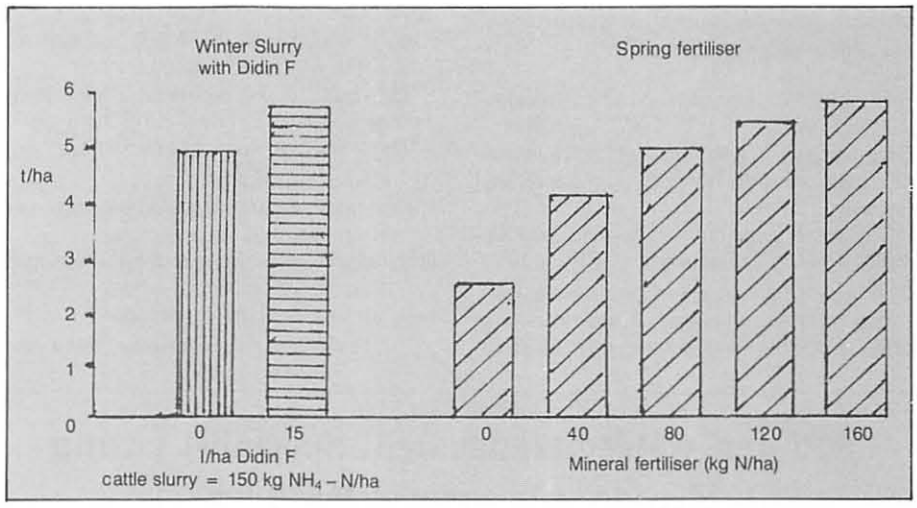


Fig 4. Effect of winter application Didin-F with cattle slurry on yield of grassland (1st cut); with comparison with spring fertiliser applications. (mean of 1 year, 5 locations)

The future – use less nitrogen, but more efficiently

The way ahead must be far lower total nitrogen use but higher efficiency of N use in cereals in particular and many other crops. We now have the tools to do the job – it must be right to use them properly before the legislative effects of not doing so are felt.

Make a note of the date!

Institution of Agricultural Engineers

Second International Conference

2-5 Sept 1991 – Robinson College, Cambridge

Engineering the Rural Environment

The wide spectrum of the subject theme will be covered by a series of parallel sessions each preceded by a keynote speaker.

There will be back-up poster sessions and a choice of technical visits.

REVIEWS AND REPORT

Agroforestry in agricultural education with a focus on practical implementation by Joachim Boehnert.

Publisher: Verlag Josef Margraf, W Germany
Distrib in UK: Gazelle Book Services
ISBN 3-8236 1117-8. Price: £18.95

This dissertation is the product of experience gained by the author working as a teacher in an agricultural college in Zambia and in an Agroforestry Project in Kenya, as well as other experiences in South America and other African countries.

The main objective has been to study and to identify ways in which agroforestry can become part of Agricultural Education and offer a sustainable way of farming for schools and college farms. Although the point is not made clear the aim would be that this basis in education would then allow the techniques developed to be spread into the wider farming community.

The first chapter in the book deals with many of the problems of forestry, the reduction in forest area and the likely effects of soil loss and atmospheric conditions. The subject has been well researched and presented in an easy-to-read clear and concise manner.

The second chapter is very refreshing in that the author has "stuck his neck out" and suggested how agroforestry may form possible solutions. The chapter is a detail of possibilities and potential for agroforestry.

In Chapter 3 the various fields of expansion in a range of climatic regions are explored. This chapter is perhaps a little disappointing in that it is not expansive enough but one does appreciate the breadth of the subject content.

The final component of the book is devoted to a study of education and harmony in agroforestry. It is particularly interesting in that it goes as far as providing a training syllabus together with its concepts and objectives. There are suggestions on the implementation, management and utilisation of Agroforestry systems for school and college farms.

To suggest that the book has all the answers would be foolish. However, I find it most interesting to have at hand someone's efforts to provide an educational and training solution to an immensely difficult problem.

I recommend this work to anyone with an interest in agroforestry, education or the general conservation of our planet.

MJH

Volatile emissions from livestock farming and sewage operations (Commission of the European Communities)

Edited by: V C Nielsen, MAFF Reading, J H Voorburg, Inst. of Agricultural Engineering, Wageningen, P L'Hermite, Commission of the European Communities, Brussels
Publisher: Elsevier Applied Science, London
ISBN 1-85166-227-8 245pp Price £29

The importance of measuring odours and other volatile emissions from livestock farming and organic sludges is an issue much considered at present. It will enable evaluation and comparisons of treatment and control systems to be made as well as measuring untreated emissions.

This book is the report of a workshop held at Uppsala, Sweden, 10-12 June 1987.

The workshop sessions covered are:

(i) odour measurement,
(ii) volatile odour and ammonia emissions from various sources,
(iii) volatile emissions from buildings and storage facilities,
(iv) control of volatile emissions.

For each of these sessions there are between 3 and 12 papers in the text. They are each in the form of a scientific paper reporting the findings of the various investigative procedures. The result is a book dealing with a wide range of topics with the original objectives well covered by a very impressive list of experts.

As a reference work on this specialist, sensitive and now very popularised issue, it is extremely valuable. I am sure it will find its way into most college, university and research institution libraries and be a useful resource on the subject.

MJH

Soil and water management Specialist Group
Meeting at Institute of Hydrology

The Soil & Water Management Specialist Group held a well attended meeting at the Institute of Hydrology (IH), Wallingford, on 22 November 1989.

After an opening welcome by Professor Brian Wilkinson, Director of IH, two other members of the Institute spoke in more detail about particular areas of the Institute's work.

Soil moisture meter

Henry Gunston reviewed the many areas of research linking soil, water and farming with which IH had been involved in Britain and many countries overseas. He dealt particularly with the development of the Wallingford neutron probe soil moisture meter.

Jimmy Blackie, also of IH, spoke on Hydrology and Upland Land Management. He explained how IH experimental studies in the British uplands had contributed numerical answers to the land use questions posed (often heatedly!) by upland farmers, foresters, planners and reservoir managers.

Irrigation topics

Two other speakers covered different aspects of irrigation. Fred Birkett, recently retired as Manager of A H Worth Farms, Holbeach, Lincs, focussed on the practicalities of irrigating fenland soils, and of abstracting water from the ground through well points rather than drawing from open water storage. He was followed by Keith Wetherhead of Silsoe College who showed how experimental measurements of the actual distribution of water from a rain gun under different wind conditions had been incorporated into modelling work which allowed likely changes in crop yield to be forecast.

Set-Aside Management

Another member from Silsoe College, Ian Shield, discussed his research on the currently topical issue of Set-Aside Management, noting that careful monitoring of changes in plant population after fields had been set aside was essential to help farm management, in case the land had to be brought back in production in the future.

The Group Chairman, John Ray, chaired the meeting and Professor Dick Godwin proposed a well received Vote of Thanks both to the speakers and to Professor Wilkinson and IH staff for organising and hosting the meeting.

The Wallingford neutron probe soil moisture meter, developed at the Institute of Hydrology, being used on drip irrigation trials in Mauritius (photo: Institute of Hydrology)

BOOK REVIEWS

Soil husbandry
A practical guide to the use and management of soils
by Tom Batey

Publisher: Soil and Land Use Consultancy, PO Box 294, Aberdeen, 1988
ISBN 0-9513605-0-7 £16.50 (hardback); £10.50 (paperback)

It should be made clear from the outset that this book has been written very much with the practitioner in mind. The text must therefore be judged as a guide to those using and caring for the soil.

It is a great pleasure to be able to report that this book as well as meeting its designated aim has gone much further and produced a text of great value on the topic of soil husbandry.

Of course it is not a definitive work on all aspects, but is most certainly a very useful reference to most practical as well as some theoretical aspects of the topic.

The book is presented in two sections, the first aims to provide the background science necessary to understand husbandry aspects. This section is well written, covering plant and root growth, soil texture and structure as well as organic matter, soil, water and aeration. These topics are dealt with in a practical "non jargon" way but this does not detract from the solid basic science which is imparted in a most refreshing style. A small criticism is that little mention is made of the effects of soil moisture content in consistency and strength properties, important features in soil husbandry.

The second section provides examples of soil husbandry in practice using a range of actual problems from the author's experience with a discussion of possible solutions. A criticism is that this is not a comprehensive survey but nevertheless the examples given are particularly valuable in the way they are presented. The aim is to provide the reader with the "tools" to be able to examine soils knowing what to look for. From this, solutions are much more likely to be forthcoming.

The author backs the text with very good photographic examples but I was particularly impressed with the sketches developed from original photographs and profiles. Their great value is that they help the reader to visualise the problem in realistic graphic detail. In short the second section is an excellent attempt to provide a guide to the practice of soil management.

As a whole the book can be thoroughly recommended to anyone interested in the care and use of the soil.

MJH

Farm building cost guide 1990

Edited by J A D MacCormack
Publisher: Centre for Rural Building, Aberdeen
ISBN 0-905084-91-8 Price £13.75

The sixteenth edition of this valuable publication is now available. The aim of the guide has always been to provide an accurate comprehensive and up to date source of building costs information. From the first edition in 1975 this aim has been achieved but, as would be expected over such a long period, with much improved format.

The costs are given in various forms to suit the requirements of different users. The quick guide section enables a rapid estimate of likely building costs to be made; a most useful tool at the planning and appraisal stage.

The sections on materials, plant, equipment and labour give information on the more basic cost components and is catalogued in an easy to use fashion. The measurement rate section presents the system used by builders and contractors in preparing estimates. This is presented in a standard ratio form and includes an allowance for profit and oncosts. Again I found these extremely well organised and easy to use.

The final section of this book is directed to building cost analyses. This gives the full cost of a range of selected buildings broken down by the trade and building element involved. The layout of this section is excellent; each building considered is accompanied by cross section, plan and elevation drawings as well as the cost breakdown, specification and some notes on the building use.

Information is also provided on the availability of grants and building investment appraisal.

The guide continues to be the reference work on farm building costs. With its improved format I can recommend it to anyone involved in the process of Farmstead Engineering.

MJH

Tractors and their power units – 4th edition
by J B Liljedahl, P K Turnquist, D W Smith, M Hoki

Publisher: van Nostrand Reinhold, New York
ISBN 0-442-25897-6 Price £34.95

The prime purpose of this excellent text book has always been to provide information to engineers and graduate students on the design of tractors. This new edition has that same purpose and as it still predominantly retains the same format it will continue to be a top quality text and reference work.

On comparing with the third edition one is struck by the similarities. The list of contents is almost identical which, in this case, is not a criticism as there seems little point in changing what has proven to be a good format. The main difference is the rationalisation and more logical approach to some subjects. This has certainly added to the quality.

There are a few changes, the chapter on costs has been removed leaving more space to expound other areas such as the traction component which has been extended to consider tyre design in more detail. There is also considerable updating particularly on the work on electrical systems and oil technology.

It is claimed that an effort has been made to make the text more international in scope. This is also given as the reason for adding Makoto Hoki as a new co-author, making use in particular of his experience in developing countries. However, it is very difficult to detect much influence and the text remains very much related to the USA. Apart from this minor issue this remains a text book of high quality, well presented and very much the state of the art in tractor design.

MJH

Farm dust and health

Written and compiled by: Jamie Robertson
Publisher: Centre for Rural Building
ISBN 0901766-68-2 Price £4.25

This new publication from the Centre for Rural Buildings is based on work carried out at the Centre over the last 6 years on the problem of dust and its effects on health in humans and animals.

Most of us brought up in the farming community are aware of the hazards relating to farmers' lung and its association with mould in grain and hay. However, the research by both the Centre and the Health and Safety Executive shows that a considerable number of stockmen and animals have other dust related problems.

This publication, written by Jamie Robertson, gives 28 pages of practical advice on the problems of dust and its effects on the health of animal and human. It also aims to heighten the awareness of all those involved in agriculture to the problem.

The work is very well presented with excellent figures and illustrations to augment the easily read format. The contents are divided into well defined short chapters dealing in turn with a quantitive description of dust, its effects on human and livestock health, methods of control, personal protection and finally a section reviewing the present legal position with regard to dust.

I am sure this excellent publication will become a standard in its field and will indeed heighten awareness and so importantly improve conditions for all.

MJH

BOOK REVIEWS

Farm machinery – 3rd edition
by Brian Bell

Publisher: Farming Press Price £11.95

Many will be acquainted with Brian Bell's book on farm machinery. The latest edition has much up-dating and I must compliment the quality of presentation. The new photo plates of machinery are of very good quality and "bang" up to date. The other figures which make up the 270 illustrations are well produced, clear and complement the text extremely well.

The book is aimed at providing a basic knowledge of the wide range of tractors and farm machinery in current use. It is particularly relevant to students studying for National Vocational Qualifications (NVQ) in Agriculture and Farm Machinery. It will also be of use to machinery users and anyone else seeking a better understanding of agricultural equipment. The format of the book remains mostly unchanged starting with Farm Tractors and their components which is covered very fully. Ploughs and cultivation machinery follow with chapters on drills, distribution, machinery and crop protection, all of these give a good background to the types available and their basic operating principles.

The same treatment is given to grass conservation and grain and root harvesting equipment. There are also chapters on farm power (a very basic approach) and the farm workshop. This is perhaps a little disappointing in the restrictive way the subject is approached, giving little guidance to the requirements of a workshop set-up.

The book can be recommended as a good first text on the subject of machinery types and operation. A good buy for users and students.

MJH

Pearls in the landscape
The conservation and management of ponds
by Chris Probert

Publisher: Farming Press Price £10.95

As engineers we are continuously being reminded of our responsibility to the environment when designing structures on agricultural land.

One aspect of this engineering has been the design and construction of ponds. This book by Chris Probert, who is Information Officer for the Northumberland National Park and has considerable experience as a Countryside Management Adviser, deals extremely well with the techniques necessary to develop ponds in a sensitive and practical way.

It deals with all sizes of ponds from garden to landscape feature. He details possible uses, the ecology of the ponds and the surrounding areas giving advice on methods of attracting the required inhabitants.

The book is extremely well illustrated with drawings and photographic plates which complement the text extremely well. It is also accompanied by an exhaustive list of references including sources of grant aid as well as species for planting in and around the pond margins.

As already suggested, the book contains chapters on pond life, design and construction as well as a very interesting section on habitat creation. However, the chapters which really interested me were those on pond utilisation and management. Not only is it very practical in content but also far reaching in its concepts.

MJH

Natural crop protection in the tropics
by Gaby Stoll

Publisher: Verlag Josef Margraf,
W. Germany
3rd Edition in English, 1989
Distributor in UK: Gazelle Book Services,
Lancaster
ISBN 3-8236 1117-8 Price £18.95

It is a real pleasure to be able to review this edition of this most valuable text on the natural protection of crops in the tropics.

The use of chemicals is at present a major topic in developed agriculture. It is most appropriate, therefore, that this new edition is published at this time. Similarly, the use of natural materials for protecting crops is an exceedingly important topic in developing agriculture. As well as protection of the environment, it is pertinent to consider the economic advantages of reduced reliance on expensive chemical solutions which, in some contexts are wholly inappropriate.

The book has been extremely well researched, as is evident by the quality of the text and the exhaustive list of references. It is refreshing to note, however, that the author still accepts that it is an incomplete work and invites criticism and suggestions of updating and improvement.

The book is aimed at the practitioner and seeks to follow the steps expected to be traced by anyone looking for a solution to a pest problem. A chapter presents the likely pests of a range of crops including rice, maize and a range of leguminous vegetables and fruits. In each case it provides diagrams of the pest in various stages of the life cycle and the likely damage it will cause. It should be possible from this to recognise the form of infestation that may be present in a crop.

There is a chapter dealing with a range of preventative measures related to a range of pests. It should be pointed out that this is rather limited and is an area for improvement.

The chapter on curative measures in contrast is excellent. It presents a whole range of plants and mixtures, animal substances and ashes which can be prepared to produce substances toxic to pests. There are details on preparation, application and likely effects. This is a most fascinating topic and shows a large range of possible alternatives to often unavailable chemicals.

The whole work is presented in a workmanlike and easy-to-follow manner. I can thoroughly recommend this work to anyone interested in crop protection.

MJH

Ecofarming in agricultural development
by J Kotschi, A Waters-Bayer,
R Adelhelm, U Hoesle

Publisher: Verlag Josef Margraf,
W. Germany, 1989
Distributor in UK: Gazelle Book Services
ISBN 3-8236-1163-1 Price £11.50

Ecofarming in the context of agricultural development is the effort to provide and practice forms of land use which make efficient use of locally available resources.

There are many forms of this concept practised around the world, e.g. ecologically sound agriculture, biological husbandry, organic farming, etc. All refer to forms of agriculture which depend primarily on local resources to achieve productivity – that is, *sustainable agriculture with low levels of external inputs.*

This text is a further contribution to developing the principles and methods of ecofarming. It is an extension of the work which appeared in the Kotschi and Adelhelm (1984) report on Ecofarming. In fact, an abbreviated version of this report is the subject of the first two chapters of this book.

The third chapter takes a closer look at the present state of indigenous agricultural knowledge and ecofarming practices. It goes on to discuss the possibility for collaboration in developing techniques for sustainable agriculture with various scientific research, training and technical bodies. In the following chapter it goes on to develop ideas as to how the co-operation suggested in Chapter 3 could be put into practice.

This book will appeal to all those with an interest in developing sustainable agriculture. It is well written in a very structural way with sufficient references and suggested background reading to give the enthusiast every chance to improve their knowledge.

In world agricultural terms ecofarming is an extremely important topic. A book which attempts to outline the problems of extending its use is to be welcomed as a must on library shelves.

MJH

Earthworms – their influence on the soil

"It may be doubted whether there are many other animals which have played so important a part in the history of the world as have these lowly organised creatures."

So said Darwin, in his book "The Formation of Vegetable Mould by the Earthworm ...", the result of 40 years of devoted study of this humble soil invertebrate.

Worldwide scientific work has since confirmed Darwin's observations and has gone further in outlining how earthworms are undeniably linked to promoting soil health.

On these following pages, three contributors now present different aspects of how earthwòrms influence the soil – and, also, how the soil condition influences the earthworms.

A worm in time saves ...

T R E Thompson reviews the several roles performed by the earthworm in the maintenance and improvement of soil conditions.

To the casual observer soils are mixtures of organic and mineral matter. It is easy to treat them as chemical or physical media, allbeit complex in nature. This is, however, too simple a view for no soil is complete without its living components – its fauna and flora. Without them it will not function. Using an architectural analogy, a building can be described and defined in terms of bricks and mortar, its dimensions and its services, but, until people live or work in it, it does not function. Nor is it maintained in good working order.

So it is with soil, for without its myriad of organisms, up to 20 million in a single cubic metre, its fertility and structure would decline.

Soil fauna are commonly classified by size into micro-, meso-, and macrofauna. The earthworms are perhaps the most widely recognised of the macrofauna.

Earthworms for soil permeability and fertility

Most British earthworms belong to the family Lumbricidae. Some twenty species are commonly found in our soils where they live by burrowing within the soil and ingesting organic and organo-mineral material. This they partly digest and pass as wormcasts either within the soil or on the surface depending on the species. The channels they create are often vertical and contribute directly to soil drainage and aeration.

Dick Thompson is Head of Environmental Quality Division, Soil Survey and Land Research Centre, Silsoe.

The value of earthworms in maintaining soil permeability and fertility was appreciated by early farmers and naturalists but it was Darwin who first described their activities in detail in 1881 in his classic work on vegetable mould and earthworms. His calculations of the volume of soil deposited annually by surface casting worms on pasture, 18-40 tonnes per hectare, equivalent to a layer 5 mm in depth, brought home the extent of their activities. If subterranean casting species are included, the total activity is far greater.

Organic-rich soils – over 2 million worms per hectare

Earthworms can constitute 50-75% of the total weight of animals in arable soils and on this basis alone assume a dominant influence on the life of such soils.

The number of worms varies with the soil and its management. Over 7 million have been found in a single hectare of Welsh grassland soil. Arable land with a long history of organic manuring at Rothamsted carries some 2.5 million while similar land without organic manure has less than half that number. Numbers are also influenced by acidity and decrease rapidly as the pH falls below 4.5.

Worms perform several roles in the maintenance and improvement of soil conditions. They fragment and partly digest dead and living organic matter and introduce it to the reprocessing cycle of the soil. They mix organic surface material deep into the soil preventing the build up of an acid surface layer. Surface casting species in particular increase the pH of topsoil by secreting calcium carbonate into the casts which are usually 0.5 units of pH higher than the surrounding soil.

Worms aerate soil by increasing the network of coarse pores throughout the surface layers and in the case of the deeper burrowing species, the subsoil. Where surface casting species are present in uncultivated fields, the top layers of the soil have greatly enhanced porosity and water-holding capacity because the proportions of both coarse and fine pore space are increased. Worm casts are more water stable than ordinary soil and they have a beneficial effect on structural stability.

Influence of man – for and against

During recent decades, several trends have developed in the use and management of land, some are beneficial to earthworms some not. Drainage of waterlogged soils, the development of minimum or zero tillage techniques, and the improvement of acid hill lands by lime and fertiliser increase earthworm populations.

On the other hand the separation of arable and stock-farming in some regions has increased the proportions of farmland that receives no organic manure. This and the use of heavy machinery in continuous arable rotations has decreased populations.

... saves the game?

The influence of the earthworm extends beyond agriculture for they also affect the balance of honour in that most British of pastimes, cricket. The nuisance of surface casts on first class wickets led to the use of lumbricides at a number of grounds. Without the corrective influences of the worms, the heavy roller quickly led to a compact soil and a dead wicket without bounce. While that may have pleased the batting fraternity at home it hardly helps the nation's best as they leave for a drubbing in the West Indies.

Influence of cultivation system on earthworm populations

H P Allen

In the foregoing article, T R E Thompson describes the part played by earthworms in increasing soil permeability.

Earlier work carried out jointly by Letcombe Laboratories and the Weed Research Organisation (WRO) at Begbroke from 1969-1978 has investigated the influence of tillage systems on soil/plant relationships.

The soils chosen for the WRO trials were: –

(a) free draining sandy soil at Begbroke (spring barley),
(b) calcareous clay at Buckland (Oxon) (spring barley and winter wheat),
(c) silty loam over chalk at Compton (Berks) (spring barley and winter wheat),

and the three tillage systems under comparison were: –

– mouldboard ploughing
– tine cultivation
– direct drilling.

Additionally Letcombe started their own experiments in 1974 (scheduled for 10 years) in which they studied the longer term effects of these three cultivation systems on soil conditions and plant growth.

Direct drilling shows highest soil density; lowest pore volume

Broadly speaking, and not unexpectedly, soil bulk density (of all the soils under study) was highest and total pore volume was lowest on the direct drilled plots. However, it was noted also that the continuity of the larger pores was clearly grater on the direct drilled plots than after ploughing because these pores were not destroyed by cultivation (Ellis *et al,* 1977; Douglas, Goss, Hill, 1980/81).

Those writers and others pointed out, however, that restraints imposed on root growth by mechanical stress must not be assessed purely from measurement of these bulk properties of a soil.

Ellis and Barnes (1981) made the point that, in the field, roots grow down the faces of soil blocks (peds) and through pores, *including the continuous cylindrical channels produced by the movement of earthworms.* They argue that the structural properties of a soil "may not be a completely reliable indication of the ability of plant roots to ramify through the soil; the existence of a continuous system of pores or channels of sufficient diameter to accommodate roots is a more important factor".

Better aeration possible in undisturbed soils

Another assumption, often made, is that more restricted aeration would be expected in uncultivated soil than in ploughed soil because of the higher bulk density and fewer large pores. In fact it has been demonstrated by Barnes and Ellis (1979) that *aeration may actually be promoted in undisturbed soil* because the continuous channels formed by cracking, old roots and earthworms have not been destroyed by deep cultivation.

R T Dowdell and his colleagues at Letcombe carried out a study of oxygen concentrations following direct drilling and ploughing systems on the calcareous clay soil at Buckland (mentioned earlier), a soil of low hydraulic conductivity, during the three years 1973-5. The land was sown with winter wheat in each of the three years.

Table 1. Effects of cultivation on mean concentrations of oxygen – averaged results for the three months January-March in two winters, 1973-4, 1974-5

Depth (cm)	*Oxygen concentration per cent (v/v)*		*Least sig diff*
	Direct drilled	*Ploughed*	
15	10.3	7.2	2.4
30	8.4	5.7	n.s.
60	3.9	5.3	n.s.

Source – Dowdell *et al.,* Letcombe 1979.
n.s. = not significant

Table 1 shows mean concentration of oxygen levels at 15, 30 and 60 cm. It will be seen that at 15 cm oxygen concentration was significantly higher in the direct drilled plots and tended to be higher at 30 cm depth. These writers warn, however, that more work on soils of higher water and clay content is necessary before conclusions can be drawn.

The work of Ellis and Barnes (1977) at Letcombe – Table 2 – illustrates the increase in earthworm population under direct drilled on the Buckland soil. This is supporting evidence for the existence of a better system of continuous channels in uncultivated soil. This improved channel system would explain the higher concentration of oxygen on the direct drilled plots to 15 cm depth.

The histograms shown in Figs 1 and 2 also demonstrate the increase in the population of *Lumbricus terrestris* under direct drilling

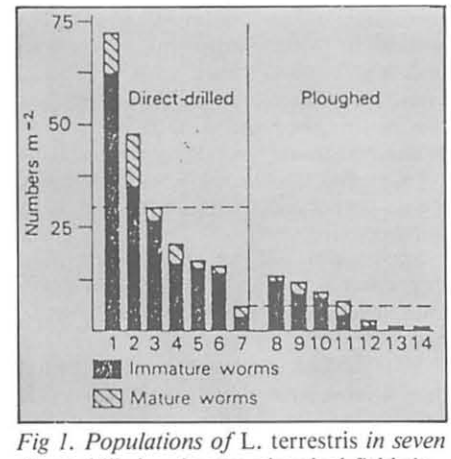


Fig 1. Populations of L. terrestris *in seven direct-drilled and seven ploughed fields in Sussex (Edwards CA 1983).*

Table 2 Earthworm population in a clay soil (Evesham series) at Buckland, direct drilled or ploughed in successive years 1973-6

Crop and year of experiment	*Date of sampling*	*Number of earthworms/m²*		*Ratio*
		Direct drilled (D/D)	*Ploughed (P)*	*D/D / P*
Spring barley				
Year 1	1/10/73	145	110	1.3
2	1/10/74	345	218	1.6
3	20/10/75	231	98	2.4
4	20/11/76	197	50	3.9
Winter wheat				
Year 4	26/11/76	152	95	1.6

Source – Ellis & Barnes, Letcombe, 1977

Dr Harry Allen was formerly UK Technical Manager with ICI Agrochemicals. He retired in 1978 and is now a Consultant.

regimes (C A Edwards, 1983). Note that the differences in favour of direct drilling were more clearly marked in the case of deep burrowing species.

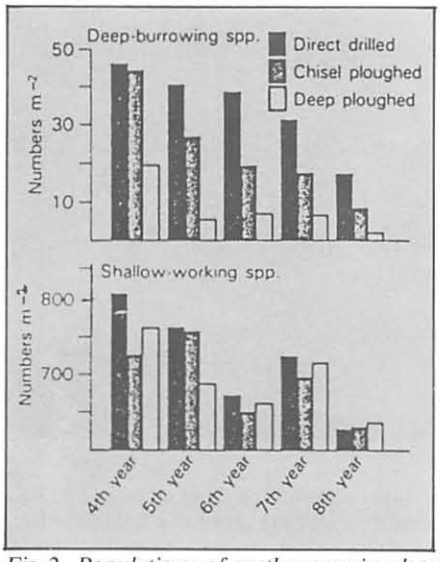


Fig 2. Populations of earthworms in plots that had been direct-drilled, chisel-ploughed or deep ploughed for eight years (Edwards CA 1983).

Direct drilling favours earthworms, favours root growth

To sum up: –

- It has been demonstrated that even though undisturbed soils have higher bulk density and lower total pore volume than cultivated soils, the channels left by decaying roots and by earthworms enable roots of crop plants to penetrate and ramify.
- Earthworm populations, especially of deeper burrowing species like *L terrestris* are increased markedly under direct drilling systems, and thus in turn produces a more continuous system of large pores.

References

WRO / Letcombe. Joint Tillage Project 1969/78. Letcombe Ann. Report 1978 p.12.
Ellis F B, Elliot J G, Barnes B T, Howie K R (1977). *Journal of Agric Science '89,* 631-42.
Douglas J T, Goss H J, Hill D. *Soil & Tillage Res.,* **1** (1980/81) 11-18.
Ellis F B, Barnes B T (1981). *Plant & Soil* 55, 283-95.
Barnes B T, Ellis F B (1979). *Journal of Soil Science* 30, 669-79.
Dowdell R T, Crees R, Burford J R, Cannell R Q. *Journal of Soil Science* 30, 235-45.
Ellis F B, Barnes B T (1977). Ref. ARC Letcombe 1976 p.50.
Edwards C A. Earthworm Ecology (ed. Satchell J E). Chapman & Hale 1983.

David Hallows is a consultant in land reclamation ecology – The Shielings, Bridge End, Great Bardfield, Braintree, Essex CM7 4TB

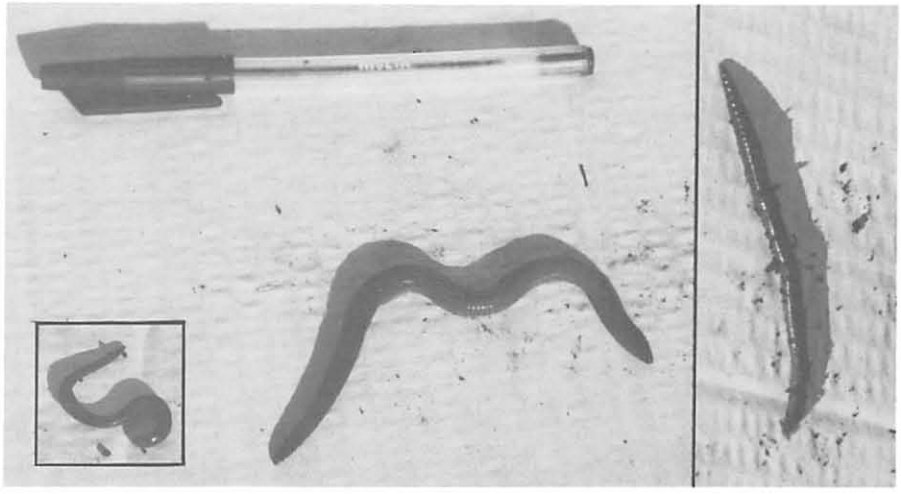
Land reclamation – earthworms and soil amelioration

D G Hallows points out that earthworms till the soil naturally. Given a friendly environment they can help significantly in land reclamation and improvement.

Before discussing the importance of earthworms in land reclamation it is worth recapping on what these creatures can achieve:

- Earthworms burrow in the soil, at the surface and at depth, creating channels which improve aeration, drainage and root penetration. Soils with worms may drain up to 10 times faster than soils without.
- The activity of burrowing, and casting within the soil profile, maintains a loose porous structure, increasing moisture retention capacity and reducing compaction.
- Earthworms consume organic matter deposited on the surface and accumulating in the root layers. They distribute it in the surface and sub-soil horizons preventing 'thatch like' or 'matt like' build ups.
- Earthworms eat the soil and associated organic matter, mixing it together and depositing it as castings, which are more aggregated as soil particles. Humus formation is accelerated, and overall texture, water stability, and retention are improved.
- At the same time, the physical and biological activity of the worm gut breaks down the soil organic matter and mineral fraction, releasing plant nutrients (increasing chemical exchange capacity), in their castings and through their excretary systems, thereby recycling nutrients locked up in decaying vegetation and soil mineral complexes.

In other words, the worm has an ability to till the soil naturally.



Earthworms for waste site rehabilitation – at left, compost worm Eisenia foetida; *centre, deep burrower* Allolobophora longa; *at right, surface-active* Lumbricus rubellus

We can therefore ask whether the worm has been used successfully in the past in particular reclamation / soil improvement situations.

- Work has been pioneered in New Zealand by Stockdill (1982), who recognised that European species belonged to a more efficient advanced family, the *Lumbricids* which were able to out compete the native *Megascolecids.* When introduced, pasture yields were increased by up to 72% and generally an increase in the proportion of higher fertility plants, such as ryegrass and clover, resulted in increased stock carrying capacity.
- In Holland, ripping up of the surface grass by grazing animals became a problem on reclaimed soils containing no earthworms. Subsequent earthworm introduction reduced this by encouraging root penetration below the soil profile surface, (Ejsackers 1983).
- Worms were stocked into coal strip mine spoil banks in Ohio by Vimmerstedt and Finney. Specifically, *Lumbricus terrestris* buried the equivalent of 5 tons/ha of leaf litter in a 2 year period incorporating organic matter into the mineral soil and increasing the exchangeable cations.
- Studies were conducted by Rushton (1986), on pasture land reclaimed from opencast coal mining in Northumberland, where it was found that management methods, ploughing and manure applica-

tions encouraged the re-establishment of surface dwelling species of worms, known to be early colonisers. They had seemingly survived the process of overburden and topsoil removal before the commencement of mining, and its subsequent storage and respreading. However, the deep burrowing species *Lumbricus terrestris,* was generally absent, and it was concluded that management methods may have impeded its development.

- Curry and Cotton (1983), reported no earthworms in 100 year old acidic barren copper mine spoil in Co. Wicklow, but found small areas which had been limed and sown with grass and clover four years previously to contain low numbers.
- Marfleet (1985) detailed an experiment at Park Lodge Farm, Harefield in the London Borough of Hillingdon, to introduce earthworms to a Landfill site capped with clay, which presented severe limitations to agricultural use. Results were encouraging on the 7 ha site.
- At Stockley Park, Middlesex where an 84 year old refuse tip is in the process of restoration to a golf course and office park, despite thorough searching, a study found no worms on the site.

Even if some species had survived topsoil and capping material storage, the intense physical soil working carried out in removal of unwanted rubble debris, from the capping material and the subsequent incorporation of sewage sludge, would have decimated any worm populations.

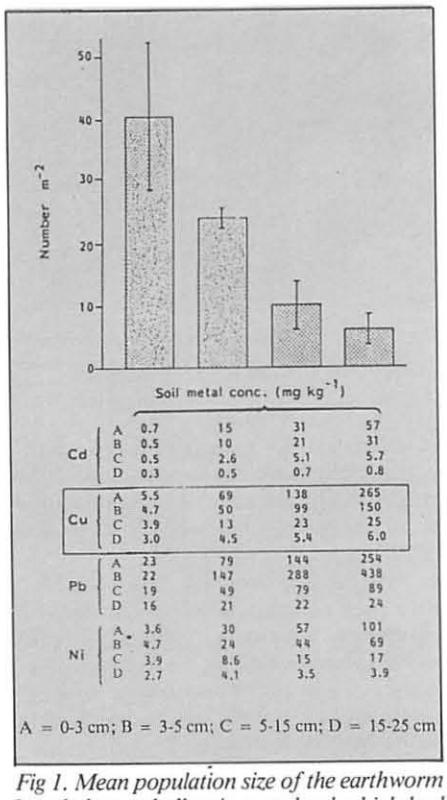


Fig 1. Mean population size of the earthworm Lumbricus rubellus *in grassland which had been amended with metal-contaminated sewage sludge at four rates (from Ma, 1988)*

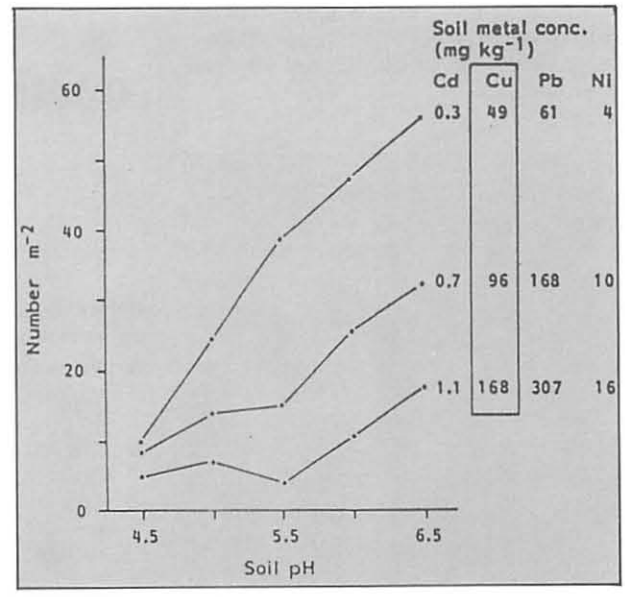


Fig 2. Mean population size of the earthworm Aporrectodea caliginosa *in an arable soil containing elevated soil metal levels caused by previous amendments with metal-contaminated municipal waste compost. The soil had been adjusted to various pH levels by the application of sulphur or lime (from Ma, 1988)*

Five species of worms were tested on a trial basis to assess their suitability for larger scale stocking of the finished site. After 18 months, four species had survived despite the initial shortage of decaying vegetable matter, drought conditions in spring and the presence of salty sewage sludge containing heavy metals.

At the conclusion of the study the population was seen to be reproducing successfully under a rich vegetation cover.

Favourable soil environment necessary

The absence of worms in reclaimed derelict lands may not be entirely due to physical disturbance alone. Colonisation by soil fauna is often seriously hampered by the toxicity of the substrate.

Ma (1988), found in a field study, Fig 1, that populations of *lumbricus rubellus,* a surface dwelling species were affected by the level of **heavy metal concentrations** present in the soil surface horizon of plots treated with contaminated sewage sludge. He also found that increasing the pH by liming, Fig 2, reduced the toxicity of the metals resulting in higher worm populations.

Generally, reproductive success is correlated to the levels of metal contaminants; the lower the reproductive rate, the lower the population density, until the levels of metals bring reproduction to a halt (Ma 1988).

Earthworms are especially vulnerable to osmotic stress caused by **high salinity.**

Temporary seawater flooding has been found to be directly toxic to earthworms (Piearce and Piearce 1979). Also sewage sludge amended soils were suspected of causing mortality to earthworms at experimental sites at Stockley Park, due to their raised salt levels. Pulverised fuel ash, when fresh, possesses raised salt levels and electrolytic conductivity and may pose a temporary problem on some sites, though weathering, for 2-3 years was found by Hutnik and Davis (1973) to reduce salinity to harmless levels.

Most earthworms avoid salinities of 1.4% total dissolved salts, with 2.9% being lethal. In areas of sufficient rainfall leaching generally rapidly reduces soil salinities to safe levels.

Fly ash, Fig 3, weathered wastes of asbestos rich serpentinitic rocks, chromate and bauxite refining wastes, when mixed with soils or dumped, can cause **high pH levels** which may be enough to be toxic to earthworms.

Low acid pH can result from the weathering of coal shales, the treatment of metal ores by acids, sulphide oxidation in tailing ponds and iron pyrites, rich wastes, etc. Earthworms generally do not occur in soils below pH 3.5 and can be classified func-tionally with regard to substrate pH, Fig 4, (Satchell 1955).

Not only does acid pH act alone as a factor affecting worm populations but so

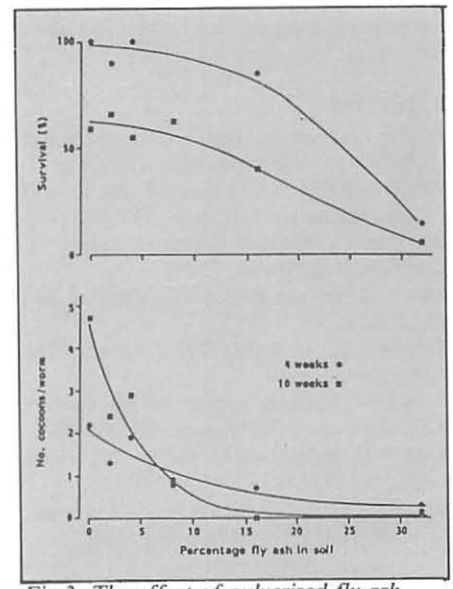


Fig 3. The effect of pulverised fly ash additions to soil substrate on survival and fecundity of the earthworm Lumbricus rubellus *(from Ma and Eijsackers, unpublished data)*

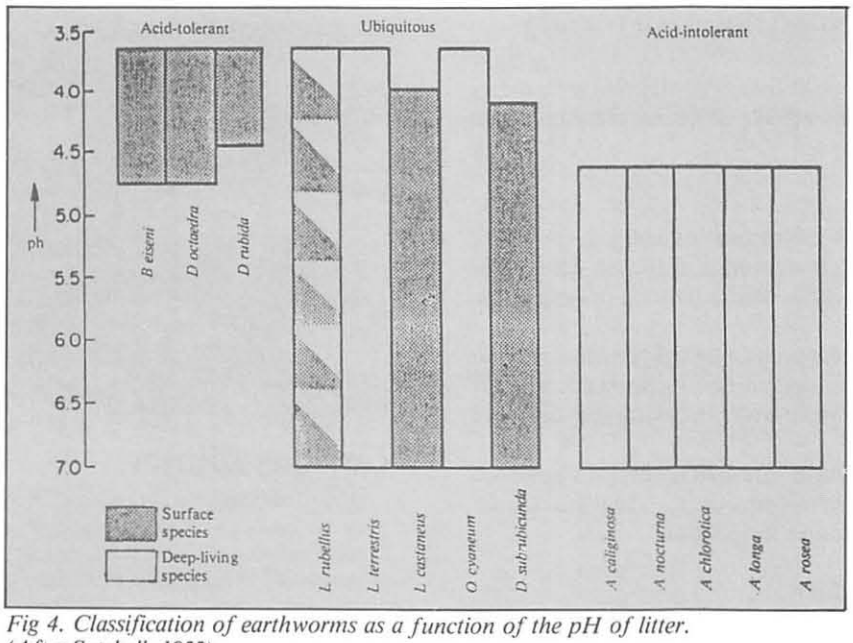


Fig 4. Classification of earthworms as a function of the pH of litter. (After Satchell, 1955)

also does the increased release of active heavy metals in contaminated acidic soils, Fig 2. Apparently in this experiment acid pH and heavy metal levels were acting independently.

Site treatment prior to earthworm introduction

We can see that each site will have its own restoration characteristics and problems with regard to earthworm rehabilitation. What is certain is that derelict soils cannot be restored back to health by the introduction of worms as the only method employed. Plants can recolonise such sites under suitable soil moisture and nutrient conditions but generally only very slowly.

Management techniques, as listed in the panel (Ma and Eijsackers 1989) – can be proposed to design an environment suitable for the build up of normal soil densities of earthworms.

The provision of organic matter as a food source, in the form of roots, soil surface vegetation and associated decaying litter, as well as a suitable soil structure, free from excessive compaction, water logging etc is essential for successful earthworm colonisation.

Ideally, after removal of toxic factors from the site by drainage/leaching, applications of lime to soils contaminated with heavy metals, and the addition of acid or acid based peats (moss peat may have a pH as low as 3.5) to excessively alkaline areas, the addition of some form of organic matter should follow.

Such materials – which must be free from non-degradable pollutants beyond toxic levels – are certainly available nationally if not locally in the form of bark, leaves, sewage and dredging sludges, agricultural waste manures, etc.

Agricultural wastes sometimes are so abundant as to pose pollution and disposal problems, not to mention the vast tonnages of straw that have in the past been burnt away after harvest, which chopped up, could form a base of mulch type material.

Where large amounts of raw organic matter are needed, on bare mineral type sites, in order to build up some soil structure, the compost/manure worm *Eisenia foetida* can be introduced. These will facilitate breakdown into a stable 'vermicompost' humus, ideal when soil incorporated to promote plant growth. However, this species is useful at this stage only, since it is far from being a true soil dweller.

Bradshaw (1983) showed that subsequent seeding with legumes can provide beneficial inputs of nitrogen to the system, in addition to that contained in sources of N rich organic matter e.g. sewage sludge/poultry manure.

Once at least one season's vegetational cover has been established, the soil dwelling varieties of worms, available for rehabilitation can be introduced.

At first the surface active moderately reproductive species e.g. *Lumbricus rubellus, Dendrobæna veneta* and *Allolobophora caliginesa,* can be introduced.

After those species have become established, the slowly reproducing deep burrowers, e.g. *Lumbricus terrestris* and *Allolobophra longa* should follow, since during their evolution they have become ecologically adapted to conditions of soil stability.

Of course such an earthworm stocking policy represents an ideal situation where freshly reclaimed sites are being dealt with. At older sites it would be most practical to stock both groups of earthworms at once.

Introducing the worms

Getting the worms into the soil is not difficult: they can be distributed into fissures or borings created in the surface and then readily find their own level.

Advice on quantities, times of application, etc is available and the worms themselves can also be obtained from specialist sources.

Perhaps even Darwin would have been amazed!

References

Stockdill S M J (1982). Effects of introduced earthworms on the productivity of New Zealand pastures. *Pedobiologia* 24, 29-35.

Eijsackers H J P (1983). Effects of earthworms on grassland on recently reclaimed polder soils in the Netherlands. Earthworm Ecology. Satchell J E (ed), Chapman and Hall, London, 495 pp.

Vimmerstedt J P, Finney J H. Impact of earthworm introduction on litter burial and nutrient distribution in Ohio strip-mine spoil banks.

Rushton S P (1986). Development of earthworm populations on pasture land reclaimed from opencast coal mining. *Pedobiologia* 29, 27-32.

Curry J P, Cotton D C F (1983). Earthworms Ecology. Satchell J E (ed), Chapman and Hall, London, 215 pp.

Marfleet B (1985). GLC Restoration experi-

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Proposed management scheme for rapid rehabilitation of waste sites with the aid of earthworms

Site treatment step		*Site developmental stage*
1	None	Non-reclaimed toxic site
2	Drainage, leaching, liming, etc.	Site with reduced substrate toxicity
3	(a) Organic amendments (sludge, etc.)	Site amended with stabilised organic matter
	(b) Introduction of compostworms – (e.g. *Eisenia fetida)*	
4	(a) Seeding (incl. legumes)	Revegetated site
	(b) Fertilisation	
5	(a) Introduction of surface-active species of soil-dwelling earthworms (e.g. *Lumbricus rubellus, Dendrobaena* sp., etc.)	Reclaimed site with stabilised ecosystem functioning
	(b) Introduction of endogenic and deep-burrowing species of soil-dwelling earthworms (e.g. *Lumbricus terrestris)*	

Tropical soils studied by Reading University

Reading University soil scientists have issued preliminary reports on two aspects of their overseas work on tropical soils and the effects of forest clearance and cultivation.

Needless loss of topsoil

According to Dr Steven Nortcliffe, thousands of tonnes of topsoil are being needlessly eroded every year following rain forest clearance in Brazil. The losses could easily be avoided, he says, if as little as 30% of the natural undergrowth was retained.

After a 10-month study, the first that has attempted to measure such soil loss, Dr Nortcliffe's team has found that erosion can usually be stopped completely by re-planting or properly managing existing ground cover. Leaving the soils bare can increase erosion one hundred-fold.

Alongside the erosion effects, the researchers have found that natural vegetation also acts as a valuable sponge to mop up tropical downpours – removal of the ground cover makes the lowland areas more prone to flooding.

Shifting cultivation adds to greenhouse effect

Besides this loss of soil and the other devastating effects of slash and burn farming and forest clearance the Reading soil scientists are also concerned that Third World farmers are unwittingly releasing vast quantities of greenhouse gasses simply by putting tropical soils to the plough.

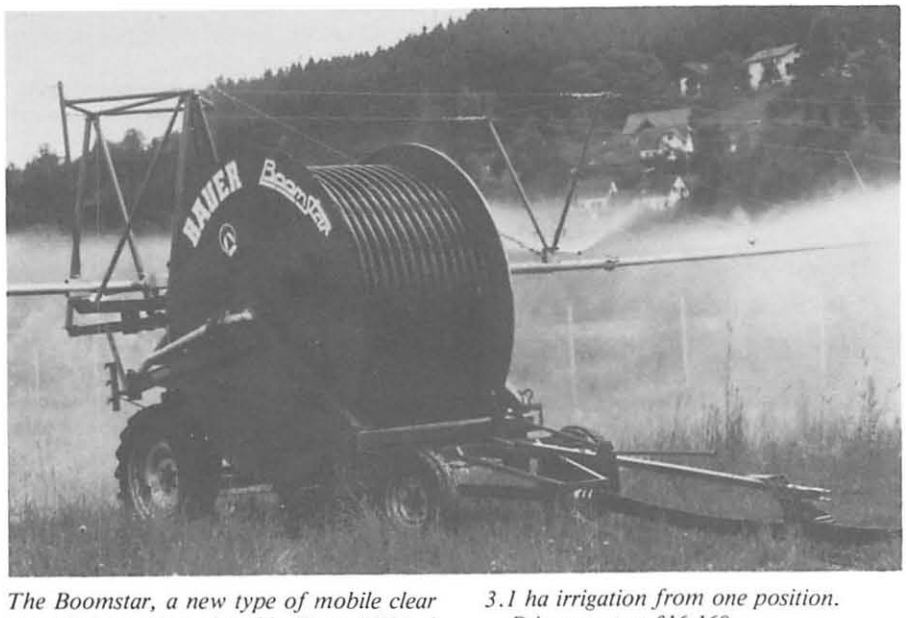
Soils have more carbon than either the atmosphere, plants, or animals and land under natural or grassland vegetation generally contains more than soils which have been cultivated for some time.

Up to 20% of the carbon dioxide responsible for the greenhouse effect is released from soils when the vast reserves of organic matter built up under natural tropical vegetation are disturbed under cultivation.

Most UK soils are in a state of equilibrium, with the cycling of carbon between the atmosphere and the soil hardly contributing to increased carbon dioxide levels.

"There is little that can be done to retain carbon in tropical soils once they are cultivated," says Dr David Jenkinson. "The only solution would be to stop bringing new land into production. This would create enormous social problems."

Dr Jenkinson and the Reading University researchers are continuing to refine a model that they hope will provide further evidence on the extent of greenhouse gas release from soils throughout the world.



The Boomstar, a new type of mobile clear water irrigator, introduced by Bauer UK Ltd to supplement their existing irrigator range.

With a 50 metre boom, the Boomstar, with Bauer SR15 sprinklers, can irrigate a 70-80 metre wide strip and can cover up to 3.1 ha irrigation from one position.

Prices start at £16,160.

Further information from Bauer UK Ltd, Prudential Buildings, High Street, Slough. Tel: 0753 691757.

New gas diluter

Providing fourteen dilution ratios of carbon dioxide in an air or nitrogen dilutent, the GD 600 from ADC Limited has been specifically designed for both field and laboratory experiments in agronomy, biotechnology, entomology or horticulture.

The Analytical Development Company Limited (ADC), Pindar Road, Hoddesdon, Herts EN11 0AQ. Tel: 0992 469638.

Perestroika has its drawbacks

The breathtaking political changes occurring in Eastern Europe may not be all good news for EEC farmers, predicts an article in the most recent 'Quarterly Review of Agriculture' published by Laurence Gould Consultants.

Highlighting the facts that:

- revitalised Eastern economics will have a strong demand for Western currencies;
- farm produce is one of the more obvious currency earners; and
- EC farm prosperity is dependent upon tariff barriers which are increasingly unpopular, both in Brussels and around the world.

Laurence Gould suggest that the political momentum now lies with aid, trade and co-operation with the Eastern Bloc and that the farming lobby is no longer the force it once was. The conclusion is that within three to five years the Eastern Bloc will boost its food exports and reverse the flow of imports at the expense of EC farmers.

Laurence Gould Consultants Ltd are at Birmingham Road, Saltisford, Warwicks CV34 4TT. Tel: 0926 496121.

Passive Solar Energy in buildings

Elsevier Science Publishers Report No. 17 on behalf of the Watt Committee on Energy explores the use of solar energy in a range of commercial, institutional and domestic buildings.

Of the six sections in the report those relating to offices, educational and service buildings are most likely to be of interest to our members, although there is no direct reference to agricultural engineering applications as such.

Nitraseal – the solution to pollution

Nitraseal from Flowcrete Systems Ltd is a new product designed to assist farmers in their efforts to prevent pollution by nitrates.

Aimed mainly for use in silage pits, Nitraseal is a pitch epoxy resin based product which provides a high performance chemical and water resistant coating, for use on concrete, renders, stone, bricks and also block work. Nitraseal can be easily applied by brush or roller.

More information from Rowcrete Systems Ltd, Radnor Park Industrial Estate, Back Lane, Congleton, Cheshire CW12 4XS. Tel: 0260 270631.

An 18 model range of very high quality, fully galvanised Slurry Tankers has been launched by Chillton Agricultural Equipment Ltd of Cannock, Staffs.

Besides the comprehensive standard specification, some of the sophisticated options are: hydraulically controlled auto-fill systems operated from the tractor seat, patented fully steerable rear axle system, internal mixing of slurry, plus many more.

Prices range from £3,593 to £9,985.

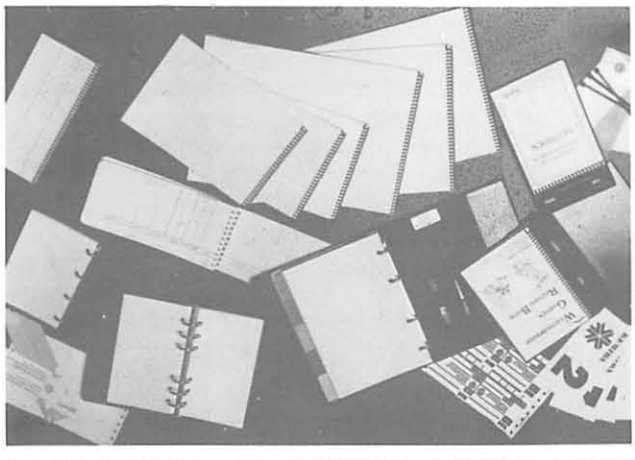
Research lagging on pest control alternatives

Britain is lagging behind several other European countries in research into alternative systems of pest control which could reduce the requirement for pesticides in arable crops, Dr Alastair Burn, the NFU's pesticides and plant health adviser, told a recent Friends of the Earth conference at Liphook, Hampshire.

He called for more research to improve the techniques available and to demonstrate to farmers and their advisers that they offer a viable long-term solution to the problems of pest, weed and disease control.

"There is still a lack of basic knowledge," said Dr Burn, "of the interactions between crop, pest, climate and natural enemies. There has been a failure to achieve an interdisciplinary approach; and the lack of data on the long-term economic and environmental benefits of integrated pest management has hindered the growth of research and its application in this area."

Write in wet, dirt or damp with AquaScribe weatherproof stationery



AquaScribe have introduced an extensive new product range, more than doubling (to over 50) the number of different items offered.

Details from AquaScribe, Westborough, Newark NG23 5HJ. Tel: 0400 81492.

New look for Landscape Industries '90

Landscape Industries '90, the international exhibition for everyone involved in the fast growing professional landscaping and leisure industries, will have a new look for 1990.

The event is organised by the Royal Agricultural Society of England and the British Association for Landscaping Industries (BALI), in association with PMS Landscaping Publications. It will be held at the National Agricultural Centre, Stoneleigh, Warwickshire on Wednesday 6th and Thursday 7th June 1990.

Among the major new features at the event will be the Machinery Demonstration Ring, organised by the RASE and the National Turfgrass Council.

Other exhibits being planned include an enlarged Land Use Resource Centre bringing landowners and farmers with land available for development together with those who can help them make best use of it; Landscape Training in Action, a feature organised by the Agricultural Training Board and BALI; the BALI Pentathlon, and a range of other technical and educational exhibits illustrating principles, design, research and training.

Pesticide Residues The ENZYTEC Test kit

For less than £9.00 per test, say Park Tonks Ltd, insecticides such as carbamates, organophosphates and thiophosphates can be detected within 5 minutes.

The ENZYTEC System, originally designed by the Mid West Research Institute USA for the US Army, uses an immobilised enzyme to collect, concentrate and detect insecticides in water, air, soil, produce, surfaces, solvents, spills, food and feed samples. The colour result shows whether insecticides are present down to parts per million or, when using a bioconcentrator, to parts per billion.

The ENZYTEC Test is self-contained and can be used in the field or laboratory by non-technical people. The detector is shaped in a polyethylene ticket bearing two white fibre discs, and uses the enzyme cholinesterase, and a colour-producing substrate, to produce a blue colour. If insecticides are present in the sample in sufficient amounts, the enzyme is killed and no colour develops.

The basic ENZYTEC kit contains a beaker, glass rod, full instructions, 10 tickets and 10 activator ampoules (for intensification of the sample needed). The tickets are supplied in 10, 25, 50 and 100 packs. The system is now available in the UK from: Park Tonks Limited, Abington House, 48 North Road, Great Abington, Cambridge CB1 6AS. Tel: 0223 891721.

New longer reach flail cutter from Bomford

Bomford, who export over 55% of their production of flail cutters, has introduced a new model aimed at all those users who need "just a bit more reach".

The new B577 has a maximum sideways reach of 5.7 m (18' 8") and a massive topping height of 6.3 m (20' 8"). The new model is three point linkage mounted and has the same overturning moment as the earlier 4.6 m (15' 3") reach machine it replaces.

A special two axis safety breakaway system protects not only the cutting head but the whole arm by lifting the cutting head as it falls back.

In standard trim the new B577 has a retail price of only £5454.00.

Bomford & Evershed Ltd, Evesham, Worcs WR11 5SW. Tel: 0789 773383.

New roof top fan unit brochure

The London Fan Company Ltd, 75/81 Stirling Road, London W3 8DJ, have issued a revised brochure dealing with the Breeza range of roof units.

These provide for air volume movement between 0.23 and 4.61 m^3/sec. In addition to the standard S range of models, a special version – VJI – is available for fume exhaust and dispersion.

All units are constructed in glass fibre for durability, and are available with shutters.

Centenary celebrations
H Cooper & Sons (Bristol) Ltd

Belated congratulations to H Cooper & Sons (Bristol) Ltd who have celebrated their company centenary last year.

It was in 1889 that, following an apprenticeship as a tin plate worker, the young Harry Cooper purchased the tools of the trade and set up in business in Bristol.

Things went well, his family grew up and the company became H Cooper & Sons. Their main line was the production of milking pails, churns and other sheet metal dairy equipment.

In 1933 a partnership was formed when R M Cooper, grandson of the founder, joined his father in the business. The company gained a reputation for quality and workmanship in building and installing cheese vats and moulds. Further success followed with new stainless steel pasteurisation vats and this, in turn, led to the designing of complete dairy installations.

Grain drying and storage equipment

A new product range was introduced in 1953 when the company started to manufacture grass and grain drying machines in association with a patentee company. It was in that year, too, that the decision was taken for incorporation as a limited company and before long the move was made to the purpose designed factory at Yate near Bristol – from which the company still manufacture and trade today.

In 1970 the production of grain storage and handling equipment began in conjunction with Brice-Baker & Co Ltd, with their design of round corrugated agricultural grain silos. The two companies have co-operated over the years and now offer the most comprehensive range of grain storage and grain drying equipment designed and made in the UK – for both the agricultural and industrial markets at home and abroad.

Another important joint product line is the design and manufacture of water tanks. Present day, the tanks are used extensively in horticulture and in fish farming – both at home and overseas.

"The success of the company," says Mr Colin Cooper, great grandson of the founder, "must be attributed in no small measure to the principal of 'Quality First'. Rigorous inspection and quality control ensure that all products leave Yate to the utmost standards of workmanship, design and perfection."

This attention to quality, combined with the ability to recognise new opportunities and the boldness to develop new products and markets have brought Coopers to their centenary anniversary. We wish them continued success and prosperity in the future.

Pipeline plan to rid the Australian Murray basin of salt

A report in the Australian Advertiser, 21st June 1989 by Rex Jory highlights the continuing problem of increasing salinity in the valuable rural land area along the River Murray basin.

A project is now being investigated to build a 2000 km pipeline 2 metres in diameter along the Murray basin. Linked to this pipeline every hectare of rural land along the Murray would then have sub-surface drainage to collect the rising saline groundwater and feed it into the pipe for eventual discharge to the sea.

Commenting on the salinity problem, Mr Ron Blackmore, Deputy Chief Executive of the Murray Darling Basin Commission says that the groundwater system of the Murray basin holds up to 6000 billion tons of salt. Farmland irrigation causes the water table to rise bringing up the salt, creating salinisation of the land and a loss of productivity.

Current measures to protect the land include drainage of saline water to evaporative ponds, improved farming management and the pumping of some saline water from the land into the Murray river. These measures are effective at this time but they are not seen to present a long-term sustainable solution. "The long-term solution," said Mr Blackmore, "must incorporate a disposal mechanism other than the Murray river."

The feasibility study now planned by the Murray Darling Basin Commission has been put out to tender and 28 firms have applied. If the study is favourable and the project is given the go-ahead the eventual pipeline will be constructed by the Commission which is itself jointly funded by the Federal and State Governments involved. A construction cost of more than £500m has been estimated.

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ment with earthworms. *Mineral Planning* 23, 9-12.
Ma W-C (1988). Toxicity of copper to *Lumbricid* earthworms in sandy agricultural soils amended with Cu-enriched organic waste materials. Proceedings of the Fourth European Ecology Symposium. *Ecology Bulletin (Stockholm), Ecological Bulletins (Copenhagen),* 39, 53-6.
Piearce T G, Piearce B (1979). Responses of *Lumbricidae* to saline inundation. *Journal of Applied Ecology,* 16, 461-73.
Hutnik R J, Davis G ed (1973). Ecology and reclamation of devastated land, New York: Gordon and Breach.
Satchell J E (1955). Some aspects of earthworm ecology. Soil Zoology, (ed. Kevan D K M), Butterworths, London, pp 180-201.
Ma W-C, Eijsackers H (1989). The influence of substrate toxicity on soil macrofauna return in reclaimed land. Animals in primary succession – the role of fauna in reclaimed lands (ed. Majer J D), Cambridge University Press 9. pp 223-44.
Bradshaw A D (1983). The reconstruction of ecosystems. *Journal of Applied Ecology,* 20, 1-17.

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Institution of Agricultural Engineers

1990 Annual Convention

Wednesday 9th – Thursday 10th May 1990 – National Agricultural Centre, Kenilworth

Opportunities and developments in manufacturing

Day 1 Wednesday 9th May

10.30 **Introduction**
J B Finney – President elect
Chairman: G W Burgess, Managing Director, Kidd Farm Machinery Ltd.

10.45 **Economics of manufacturing** – Presidential address
D M Walker, Managing Director, John Deere Ltd.

11.35 **New products, new markets**
J Bradley, Corporate Marketing Director, J C B Ltd.

12.10 **Computer aided design**
Dr J F Brindley, Senior Lecturer, Dept of Mech Engineering and Production – Coventry Polytechnic.

12.45 Closing remarks by the Chairman

.....

14.10 **Parallel sessions** – Specialist Groups
Soil and Water Management · Crop Drying and Storage · Vehicles · Electronics

.....

Annual dinner and presentation of awards
Principal guest: L J Weaver, C.Eng FIEE FIProdE FIMC CBIM FRSA
President elect – The Institution of Production Engineers

.....

Day 2 Thursday 10th May

10.00 **Parallel sessions** – Specialist Groups and Young Engineers
Forestry · Machinery Management · Young Engineers

.....

14.05 **Introduction**
Chairman: G W Burgess

14.15 **Computer aided engineering**
C Reed, Technical Director, Standen Engineering Ltd.

14.50 **Manufacturing in the Third World**
D H Sutton, Head, Overseas Division, AFRC Engineering

15.25 **Continuing education and training** – short paper by Young Engineer
M J Watchorn, Soil Machine Dynamics Ltd.

15.40 **The skills shortage**
B A Pamment, Managing Director, F W McConnel Ltd.

16.15 Closing remarks by the Chairman

Fees (inclusive of VAT)

Standard rate: Whole conference: £97.00; Day 1 only: £60.00; Day 2 only: £41.00
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