The Agricultural Engineer

Incorporating Soil and water

Volume 49 Number 1 Spring 1994

Waste disposal

Institution of Agricultural Engineers

ANNUAL CONVENTION 1994

May 17th — at 10.30 am

at Harper Adams Agricultural College, Newport, Shropshire

Environment and Amenity

Agricultural engineering was established as an engineering discipline at a time when intensification of agriculture was seen as a matter of high priority. As a result of the introduction of a wide range of technological innovations, agriculture in the UK has been transformed from a low input/low output system to a much more intensive system of production.

Circumstances have changed and policy for the countryside no longer revolves around food production. It now strikes a balance between this and other interests such as conservation and enhancement of the natural beauty of the countryside, and the enjoyment of it by the public. Agricultural policy is becoming greener, and new challenges arise for the profession in environmental management and the use of land for amenity purposes.

The 1994 Annual Convention will address these challenges. We are fortunate in having Lord Selbourne as the keynote speaker, and Cecil Currin, a prominent state conservationist from New Jersey, as leader of the plenary session. Specialist Groups will hold parallel sessions in the afternoon, and immediately before lunch, a light-hearted competition will be held between student groups. In addition, there will be site visits to places of interest in the amenity and environment fields.

The day will conclude with the presentation of awards at the Annual Dinner, at which the Principal Guest will be Geoff Burgess, Managing Director of Parmiter Ltd.

For further information, contact:
Mrs D Bradshaw, The Institution of Agricultural Engineers, West End Road, Silsoe, Bedford, MK45 4DU
tel: 0525 861096 fax: 0525 861660

Wind Power

Potential contribution to national energy requirements and impact on local environment

Opinions sought

The Welsh Affairs Committee of the House of Commons is conducting an inquiry into Wind Power. The terms of reference of the inquiry are to consider:

i. the effects of government policy and guidance on the development of wind farms in Wales;
ii. the potential contribution of wind energy to the national energy requirements; and
iii. the impact of wind farms on the environment.

It seems likely that the inquiry will be looking particularly at planning procedures concerning wind farms and at questions of noise and visual intrusion. To help the Parliamentary Committee in its enquiry, the Watt Committee on Energy is seeking to submit written evidence from its member institutions on relevant topics. The IAgrE has been approached for views, particularly, on:

- How can noise in a neighbourhood of mechanical plant in rural areas be evaluated?
- By what measures is it, or could it be, possible to limit such noise, especially noise from wind generators?

The inquiry has a short timetable. Any member who can contribute views and/or sources of useful evidence is asked to contact 'our man on the Committee', Laurie Osborne. He is at the Silsoe Research Institute, Wrest Park, Silsoe, Bedford MK45 4HS (Tel: 0525 860000; Fax: 0525 860156)

The Agricultural Engineer

Incorporating Soil and water

Journal and Proceedings

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Front cover: (left picture) A curtained-boom slurry applicator used by SAC's Soil Engineering Section on grassland traffic experiments. (right picture) Soil injection studies at Seale Hayne – see page 16.

Regular Features

CONTENTS

COMMENT

Allan Langley

With a response by approximately 25% of the membership, the synopsis of the questionnaire results makes interesting reading and will help determine the future direction of the Institution.

Also enclosed with the Journal is information concerning Continuing Professional Development (CPD) which grows in importance and may soon be a requirement of retaining Engineering Council registration.

This year's Annual Convention concerning "Environment and Amenity" will be held on 17 May at Harper Adams Agricultural College. A novel feature of the Convention will be a light-hearted competition between student groups – see inside front cover for further Convention details.

An aim of The Agricultural Engineer is to act as a communication vehicle between members – to this end your comments, letters and meeting reports are most valuable – keep them coming in.

Allan Langley, *Hon Editor*

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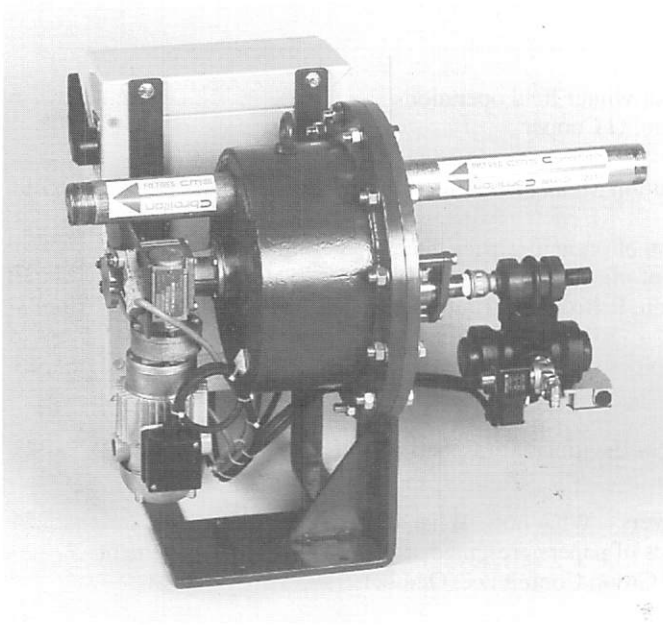
The Institution of Agricultural Engineers

Self-cleaning water filters



The 'F' and 'G' series coarse pressurised filters developed by the French manufacturer CMS Braillon are available for fluid flow rates from 6 to 24m³/h. They are self-cleaning without the need to interupt service.

Contained within a welded steel casing, the unit holding the filter elements rotates in fractions of a revolution and at each stop an element is positioned in front of a purge pipe which is vented to the exterior by an automatic valve. A counter-current created by the internal pressure of the filter (2.5 — 3bars) removes any impurities that may have built up.

Between six and twelve successive increments and purges, depending on the size of the filter, are sufficient to restore the cleanness of the filter elements. The interval between cleaning sequences is controlled by a potentiometer connected to an electric timer.

The 'F' series filters have metallic filter elements with pore sizes ranging from 90 to 200 microns. Their rated output is 6 or 12m³/h. The 'G' series have coarse mesh elements of plastic or stainless steel, providing coarse filtering equal to or better than 300 microns. Their rated output is 12 or 24m³/h.

The filters are suiitable for a wide range of applications, including pre-filtration of drinking water, water treatment, fish farming, etc.

CMS Braillon is currently looking for distributors in the UK. Further information can be obtained from the French Technology Press Bureau in London (Charlotte Barraclough)— 071 235 5330.

Tractors — sales and power up in 1993

Figures released in January by the Agricultural Engineers Association show significant increases in tractor registrations and unit power for 1993 compared with the previous year. Analysed on the basis of the MAFF Regions, every such region showed an increase — the lowest increase (Yorks & Lancs) being a Heartening 20%. Wales and N Ireland both comfortably exceeded a 50% increase. This reflects the degree of confidence existing in the dairy and livestock sectors. The total number of units registered in the period was 19101.

Cynics will no doubt argue that this represents merely a recovery from a previously depressed state but tractor manufacturers can take solace in the fact that the trend is upwards.

Also on the up is the average power output of each unit registered. Agricultural tractors (those over 40hp) averaged out at 98.2hp with sales of 120+hp machines showing a massive 65% increase. Only the 41 – 60hp range (and the 71 – 80hp range to an insignificant extent) suffered a drop in numbers sold.

So the trend to larger, more powerful units continues as farmers strive to maintain timeliness of operations in the face of a shrinking labour force.

Michael Faraday Award 1994

The Michael Faraday Award is made annually by the Council of the Royal Society to the scientist or scientists who, in the opinion of the Council, have done most to further, in the United Kingdom, the public understanding of science.

The Award consists of a silver gilt medal and a prize of £1000. The recipient of the Award is invited to give a public lecture at the Society.

Nominations for the 1994 Michael Faraday Award must be in by 31 March 1994. Further details are obtainable from The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG.

Respirators

A new range covering both 'maintenance-free' and reusable respirators has been developed by the 3M Occupational Health Group (tel 0800 212490) specifically for agriculture.

Each respirator meets the requirements of European Directives and carries the appropriate CE mark. Pictograms help users select the appropriate respirator for each of five farming activities: spraying, mixing chemicals, working in livestock housing, grain handling and working with hay.

Various particulate respirators are recommended, but for mixing chemicals and spraying an 'organic vapour/particulate' respirator is suggested for protection against solvent vapours and fine mists.

3M respirators are available through main agricultural suppliers.

New course on water and environmental engineering

A Higher National Diploma in Water and Environmental Engineering has been introduced at Lackham College in Wiltshire.

Designed to meet the needs of students who wish to estiblish a career in the water industry, the study areas of the course include Soils Engineering, Fluids, Irrigation, Drainage, Waste Management, Pollution Control, Landscape Engineering and Environmental Monitoring.

The HND is a two-year course with a five month sandwich period between each year. Potential students will require GCE 'A' level qualifications, National Diploma or extensive relevent experience.

Sponsor sought

The Festival of Food and Farming, that triennial extravaganza of agricultural awareness, has lost its major sponsor for the 1995 event.

ASDA, the name which has been synonymous with the event since its inception in 1989, has had to pull out for 'corporate reasons'.

So, if you've got the odd million burning a hole in your pocket how about directing it that way — the 'spin off' will make you a household name within and beyond the capital!

Ruffled feathers

Silsoe Research Institute, in collaboration with the Department of Civil Engineering of the University of Nottingham, has won an Agricultural and Food Research Council grant amounting to £32400.

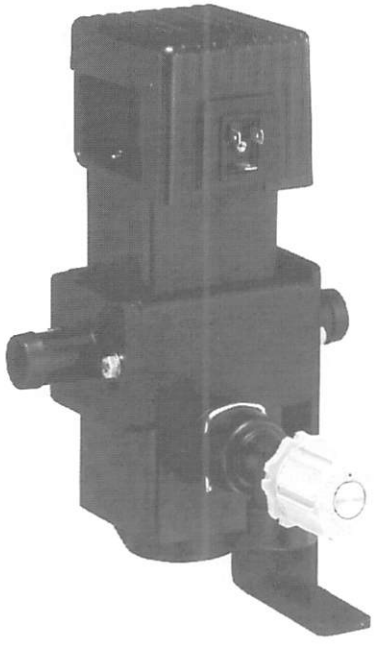
The topic under scrutiny is the aerodynamics and ventilation of poultry transport vehicles. The team leader at Silsoe is Dr C J Baker FIAgrE, who recently returned from New Zealand.

Future birds in transit will, no doubt, appreciate their feathers being ruffled by the fruits of this work.

Spray control valves

Two new remote control valves have been introduced by Spraying Systems, makers of TeeJet products.

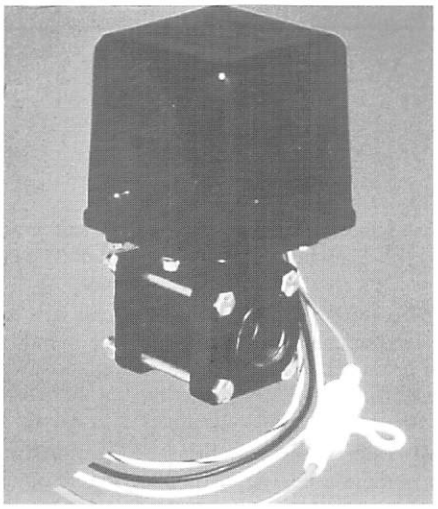
The three-way solenoid 155 Directo Valve is intended for boom section control, and incorporates an adjustable by-pass to maintain spray pressure on section shut off. Power requirement is reduced to allow more boom sections to be controlled without overloading fuses. A dual stage coil draws 6 amps for a fraction of a second, then the current drops to 1 amp steady state. Internal ferrous parts including the armature and stop are stainless steel.



The 155 DirectoValve solenoid valve

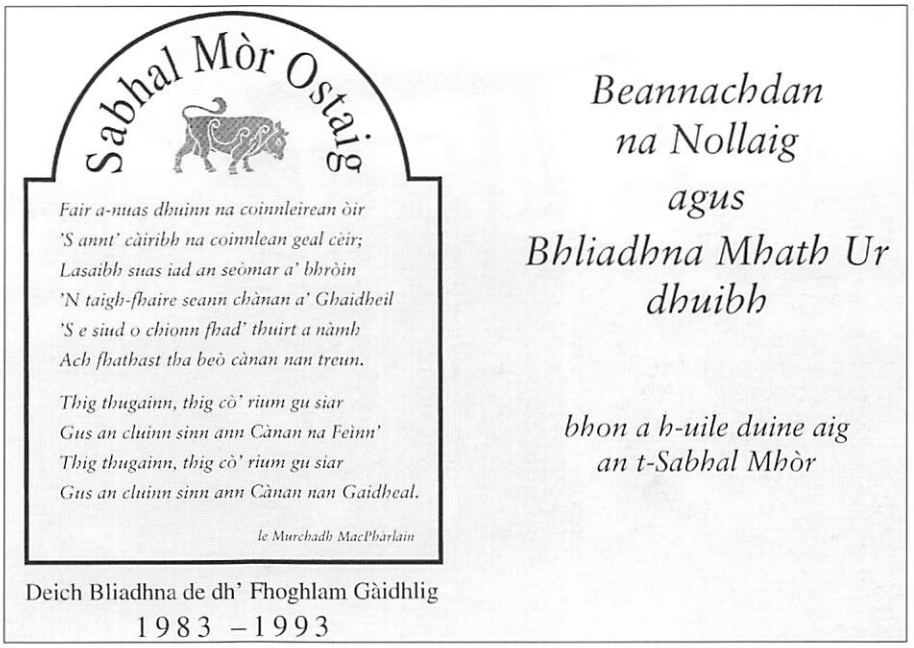
The 344EC electric two-way ball valve handles double the pressure at 20 bar and three times the flow rate of the standard solenoid valve. Operating current is 0.75 amps, and single pole switch operation makes this valve suitable for easy retrofitting. Time to start or stop flow is claimed to be within one second.

Further information – Spraying Systems Ltd, Godalming, Surrey, tel 0483 861168.



The 344EC electric ball valve

Gaelic Greetings — or is it ?



Amongst the multitude of greetings cards received at the Secretariat as Chistmas approached was this one. Obviously, it is celebrating 10 years of existence – but whose ? And what greetings does it bear ? We would like to know, and be able to reciprocate our best wishes.

Can any member having the Gaelic help with the translation ? Mysteries are intriguing, but need to be solved.

Pastures new

The Royal Academy of Engineering has found a new headquarters building. The new address will be 29 Great Peter Street, London SW1. The building is being refurbished and the Royal Academy will move in around Easter.

E J H MBE

The Institution is delighted to hear of the recognition in the New Year Honours List. of Edwina Holden's hard work.

Edwina is well known to Institution members having worked at the Secretariat for many years, and as a key figure in the preparation of the Newsletter. She surely deserves an award for that work alone but, in addition, she has also been tireless in fields of public service and charitable work.

We offer our heartfelt congratulations to Edwina on this long overdue honour.

Adrian Brewer is ploughing champion

Cornishman Adrian Brewer is the new British conventional ploughing champion. Using a Kverneland plough pulled by a Case IH 695 tractor on Firestone Radial 7000 tyres, Brewer beat off a determined challenge from top ploughmen at the 1993 British National Ploughing Championships held at Shillingford last October.

Brewer, who farms a mixed 220 hectares, will now go on to contest the World Ploughing Championship in New Zealand next year. Joining him in New Zealand will be Yorkshire's John Hill who once again claimed the British reversible ploughing title.

Watch your back ...

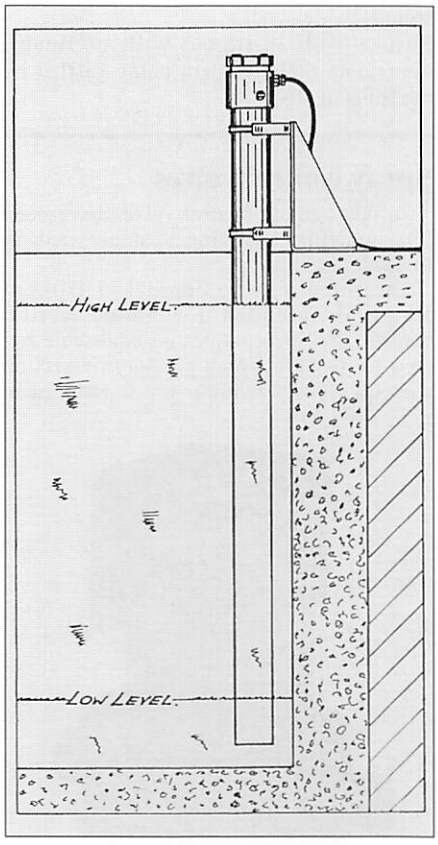
... is the slogan for a number of Health and Safety Executive initiatives to promote awareness of back injuries amongst manual workers.

The latest area to come under scrutiny is chainsaw work. To warn operators of the hazards and to go some way to advising them of the preventative measures they should be taking, the HSE has published a new leaflet specifically for this occupation, and a video is available in support.

The leaflet is free from the HSE Information Centre on 0742 892346. The video is available for hire or purchase from CFL Vision, PO Box 35, Wetherby LS23 7EX.

Two level controller for even the thickest slurries

Complementing the range of slurry handling, storage and separation systems offered by Carier Pollution Control is the new C-Level controller for accurate, high/low level monitoring even on the most difficult media.



The system is unaffected by turbulence, surface crusts or thick slurries, say Carier and it cannot be 'bridged' or entangled. No electrical components are submerged and the two level settings can be altered independently without entering the tank.

The standard 2.5m tube length can be trimmed if required, simply using a saw, and an extension kit is available to cater for operating depths up to 5m.

Carier Pollution Control Ltd, East Street, Braintree, Essex CM7 6JL (0376 323349).

Wind monitoring

A range of data loggers has been launched suitable for long term logging, as required in planning wind turbine installations. The portable loggers have extremely low power consumption and run on lithium batteries.

Different combinations of wind vanes and anemometers may be connected to the systems which are programmed and accessed via a PC. A low power weather station is also available with connections to barometer, rain-gauge, temperature sensors and radiation sensors.

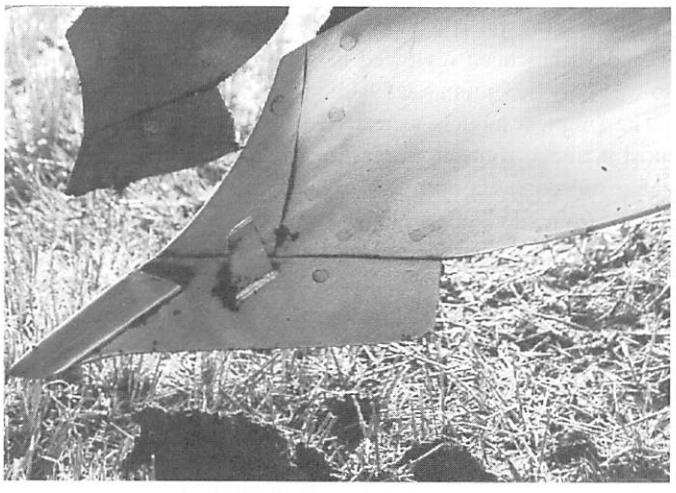
Further details from Bristol Industrial and Research Associates Ltd, Portishead, Bristol, tel 0275 847787.

Claims of 'conning' continue

The Health and Safety Executive is concerned that some so-called consultants have been mis-representing the HSE directives and scare-mongering companies into commissioning work that purports to be necessary to meet those directives.

The latest warning concerns portable oxy-fuel gas welding sets. Some firms have been advised that written schemes of examination are required under the Pressure Systems and Transportable Gas Welding Containers Regulations 1989. The HSE is at pains to refute this claim. Written schemes of examination are not required for user-owned components (regulators, gauges, hoses, etc).

Furrow splitter



A small wing welded to the ploughshare is claimed to eliminate the need for multiple secondary cultivations and the use of furrow presses on soils containing fine sand, silt or clay fractions.

The Furrow Splitter dissects the furrow underside, which then breaks up as it is inverted by the mouldboard. A level finish containing manageable soil aggregates results, ready for seed-bed preparation.

Suitable for fitment to both new and part worn shares, the splitters are supplied in handed pairs along with templates to ensure correct location.

New concept in farm power from Claas

Claas Ltd has unveiled a pre-series version of what it describes as a totally new concept in farm mechanisation. The Xerion 2000 offers power outputs of 200 and 300hp, and features a modular design which enables it to operate with a wide range of agricultural equipment – the concept was developed in conjunction with a number of implement manufacturers. The cab can be moved hydraulically to both central front and rear facing positions, in addition to an off-centre rear facing position which allows a clear view of the implement.

The novel transmission incorporating hydrostatic and mechanical elements uses an electronic control system to select between four modes: maximum power; constant speed; stepless speed adjustment at constant engine speed; and automatic for transport. Front and rear linkages are incorporated. Steering modes can be switched between front, rear, coordinated and crab.

Production is scheduled for 1995 and a small number of pre-series machines will be operating in 1994. Contact Claas UK Ltd, Bury St. Edmunds, tel 0284 763100

Antipodean detection

A sprayer with "eyes" is reported to be undergoing evaluation trials at the New South Wales Department of Agriculture in Australia. Light sensors ahead of solenoid-operated nozzles scan the ground surface for green material (so, at the moment, it is only suitable for 'bare ground' work). On detection of green colouration the appropriate nozzle/s is activated and the target treated.Termed the Detectspray S50 it is claimed to reduce chemical use by up to 95%.

The NSW DoA claim that this is the first use of optical electronic technology in agriculture to discriminate between green vegetation and other background colouration. It is envisaged (no pun intended) that the system will have applications not only in the delivery of herbicides but also in the use of fungicides and fertilisers.

Boom time for Lincolnshire contractors

Whole farm spraying contracts in Lincolnshire have increased dramatically in 1993 and the trend looks set to continue this year.

Strict legislation on chemicals and the inconvenience of fertiliser handling and storage may be contributory reasons in the trend to whole farm spraying, but the over-riding concern of most farmers is to cut costs without reducing crop inputs.

Many farm sprayers are now due for renewal — a legacy of the go-slow in farm machinery replacement since the 100% write-off against tax was scrapped in 1984.

Workdays for winter field operations

Malcolm McGechan and Gillian Cooper

Numbers of workdays per month for winter field operations are estimated using a soil moisture and heat simulation model which operates with daily historic weather data.

For most tractor operations such as tillage, soil is considered to be workable if its moisture content (considering the unfrozen component of soil water only) is below a certain value. However, for the operation of spreading pollutants such as slurry, the additional conditions of no snow cover and unfrozen soil are added.

Tabulated results indicate how workday numbers vary according to soil type, climate, whether or not the snow and frozen soil conditions are included, and the chosen limiting moisture content value. A large variability in numbers of workdays per month between years is also illustrated.

This study illustrates the value of a modelling approach to support decisions by policymakers in relation to environmental pollution, and for providing broad guidelines about machinery management and planning.

Weather conditions place severe constraints on time available for carrying out field operations during the winter period.

If tractors or tractor-drawn implements are used on wet soil, smearing and compaction take place, tractability (wheelslip) problems arise and tillage operations are ineffective since as many new clods are formed as are broken up by the operation.

Spreading of polluting substances such as slurry when rainwater is flowing to field drains from the soil surface or the upper soil layer leads to watercourse pollution. Whereas water drained from deeper levels has many of the pollutants filtered out, that drained from or near the surface has nearly all the components of whole slurry with its very high biological oxygen demand (BOD). Also, if spreading is carried out on frozen or snow covered ground, runoff of pollutants to watercourses will occur either at the time or when the snow thaws.

It is important, for machinery and operation management planning, to have an estimate of the number of days ('workdays') when such operations can be carried out at a particular farm. Also, with increasingly strict enforcement of water pollution control legislation, estimating workdays for spreading pollutants has become particularly important for effective planning of farm waste management.

Availability of workdays is very variable, partly because of local climatic differences and partly because the speed at which soil loses water by drainage after rainfall varies considerably in relation to soil type, condition of soil, local topography, and level of the water table.

This paper describes a method of estimating workdays for winter operations using a modelling technique with historic weather data.

Dr M McGechan is head of the Operational Research Unit and G Cooper is a Research Assistant working on the Scottish Climate Change Project, both at SAC's Scottish Centre of Agricultural Engineering, Penicuik.

(refereed paper)

Previous work on soil workability models

Previous work on soil workability models and estimation of workdays has been reviewed in detail by Rounsevell (1993), so will only be summarised here.

The simplest models were based on precipitation alone, but most included some consideration of soil, either as simple soil categories or as a complex consideration of soil strength. Some studies looked only at long term average workabilities for broad soil categories or land types.

Rounsevell broadly concluded that there is a reasonable consensus in favour of estimating workdays from some sort of soil moisture balance model, with the limiting moisture content for workability being at, or near to, field capacity.

Simulation models to estimate workdays

Like many other weather-dependent agricultural processes, workdays for winter operations can be studied very effectively using weather driven simulation models.

Modelling studies can make much more efficient use of researchers' time and resources than field experiments, and can cover a much wider range of conditions, in terms of both sites and years' weather.

This particular application requires a soil moisture balance simulation model, which takes account of incoming moisture from precipitation and moisture losses by evaporation, surface

runoff, drainage to field drains, and drainage to deep groundwater, together with a heat balance model to represent freezing and snow cover.

Since the soil moisture transfer processes are very complex, and a number of soil moisture simulation models were already in existence, these were examined for their suitability for the current application, rather than developing a new model. The models considered include one with a very simple treatment of drainage (Witney *et al*, 1982), used previously for estimating workdays for tillage (Witney and Eradat Oskoui, 1982), as well as the more complex models entitled WATBAL (Berghuijs-Van Dijk, 1990) and SWATRE (Belmans *et al*, 1983) from the Netherlands, and SOIL (Jansson, 1991) and MACRO (Jarvis, 1991) from Sweden. Most of these models had been developed primarily to study crop growth and constraints caused by lack of moisture during the summer period, so might have been expected to work better at the dry rather than the wet end of the soil moisture spectrum.

Out of these models, the Swedish model SOIL was eventually selected as being most appropriate for a number of reasons

- it is a multilayer model, so can simulate moisture in the surface layer down to a varying specified depth, which is important for determining soil workability;
- it simulates drainage of water both to field drains and to deep groundwater;
- it includes a soil heat simulation to represent freezing, and representation of falling and lying snow;
- it appears to work well at the wet end of the moisture spectrum; and, lastly,
- it could readily be set up to carry out simulations over a long run of years, rather than the crop growth period in the middle of one year only.

Soil hydraulic properties

Soil moisture movements, both as drainage in a downward direction in wet conditions, and as capillary movement in an upward direction during dry conditions, depend on two hydraulic parameters, the matric potential (or moisture release characteristic) and the hydraulic conductivity.

Water is held in the pore spaces of soil by capillary or surface tension forces, and a negative pressure must be exerted to pull water out of the pores. This pressure, commonly referred to as 'soil water tension' or 'matric potential', varies with soil moisture content; it is usually expressed on a logarithmic scale, where it is also called 'suction pF'. Hydraulic conductivity also varies widely with soil moisture content, reducing as soil becomes drier; it is commonly expressed either in terms of moisture content or in terms of matric potential, again on a logarithmic scale.

Values of hydraulic properties of two soil types found near Bush Estate, Penicuik were obtained. They had been measured over a range of moisture contents in small samples taken from the cultivated topsoil (depth 0 – 0.3m) and the undisturbed subsoil (depth >0.3m), by Vinten (Vinten *et al*, 1992). The two contrasting soils were a clay loam derived from glacial till, of Winton series, and a sandy clay loam developed from partially sorted glacial till, of Macmerry series. The Macmerry series soil was very freely draining, while the Winton series soil has a much lower hydraulic conductivity, implying a much greater resistance to drainage.

Subsequent analysis of hydraulic properties of soils from different areas of Scotland has suggested that parameter values for most soils are near to those for one or other of these chosen soils, or within the range between them.

Soil hydraulic data input required for simulation

The central part of the 'SOIL' model consists of two coupled differential equations representing water and heat flow, which are solved by an explicit numerical method. The equations use simple basic assumptions about flows as the result of gradients in water potential (Darcy's Law) and temperature (Fourrier's Law), together with the laws of conservation of mass and energy. Processes represented at the boundary between the soil and atmosphere include snowmelt, interception of precipitation (as rain or snow), and evapotranspiration.

The solution of the differential equations in the soil moisture model requires the variations in moisture release characteristics and hydraulic conductivity with moisture content to be represented by mathematical equations. Various alternative sets of equations have been suggested for the hydraulic relationships in soil moisture models, but the equations used by the SOIL model are those proposed by Brooks and Corey (1964).

Moisture release:

$$S_e = \frac{\theta - \theta_r}{\theta_s - \theta_r} = \left(\frac{\psi}{\psi_a}\right)^{-\lambda} \qquad (1)$$

Hydraulic conductivity:

$$\frac{k_w}{k_{mat}} = \left(\frac{\theta - \theta_r}{\theta_s - \theta_r}\right)^n = S_e{}^n \qquad (2)$$

where

θ	=	liquid water content (by volume)
θ_s	=	water content at saturation
θ_r	=	residual water content
ψ	=	soil water tension (matric potential), cm water
ψ_a	=	soil water tension at air entry
S_e	=	'effective saturation'
λ	=	pore size distribution index
k_w	=	unsaturated conductivity, mm/day
k_{mat}	=	saturated conductivity of soil matrix (excluding macropore flow)
n	=	$3 + \frac{2}{\lambda}$

The SOIL model includes a preliminary procedure for fitting the Brooks and Corey moisture release relationship to experimental data prior to simulation runs. This requires experimental data representing matric potential pressures over a range of moisture content values.

By logarithmic transformation of both parameters, a linearised least squares regression fit is obtained for log (S_e) against log (ψ), to give values of λ (the slope), ψ_a (the value of ψ when $S_e = 1$, ie saturation) and θ_r.

In theory, the residual water content, θ_r, is the water content at which the hydraulic conductivity can be considered to be negligible, but in practice it is merely a fitting parameter; alternatively, it can be set to zero to simplify the equations.

Values of the fitted parameters for the two layers of each of the two soil types considered in this study are listed in Table 1, and a sample fit is shown in Fig. 1, top. When back transformed, the moisture release characteristic curve is given

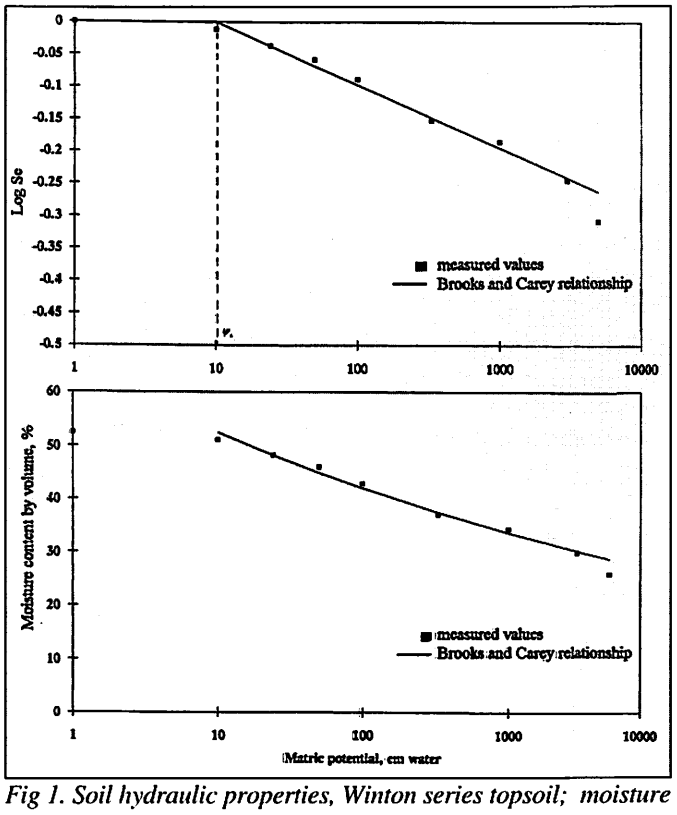


Fig 1. Soil hydraulic properties, Winton series topsoil; moisture release transformed to give straight line regression fit (top), moisture release curve (bottom).

in its usual form of moisture content (on a linear scale) against suction pF (matric potential on a logarithmic scale) as in Fig. 1, bottom. This fitted relationship is used by the model only for the middle part of the matric potential range. At moisture contents within 4% of saturation, an alternative linear relationship is assumed:

$$\psi = \left(\frac{\theta_s - \theta}{4} \right) \psi_m \qquad (3)$$

where ψ_m is the matric potential at a moisture content of θ_s - 4 %.

At very low moisture contents, an alternative log/linear relationship is assumed, but this part of the curve is of little interest in the current study.

The variation in the hydraulic conductivity of the soil matrix with soil water content or tension is given by Eqn (2), from the specified value of the saturated conductivity k_{mat}. The model can also include representation of 'macropore flow' which is assumed to occur only when the soil moisture content is within 4% of its saturation value; a second saturated conductivity value taking account of macropore flow (k_{sat}) should be specified in this case, from which the variation in hydraulic conductivity over the moisture content range θ_{sat-4} to θ_{sat} is calculated from Eqn 4.

$$k_w = 10 \left\{ \log(k_{w4}) + \frac{\theta - \theta_s - 4}{4} \log \left(\frac{k_{sat}}{k_{w4}} \right) \right\} \qquad (4)$$

where

k_{sat} = saturated conductivity including macropore flow

k_{w4} = hydraulic conductivity given by Eqn 2 with $\theta = \theta_s$-4

Macropore flow is particularly relevant for more structured, less freely draining soils where the hydraulic conductivity of the soil matrix (excluding macropore flow) is low. Conversely, it is of little importance in coarse-grained or sandy soils with high hydraulic conductivities.

In practice, hydraulic conductivities are difficult to measure with any confidence because some methods measure micropore flow alone, while others measure a combination of both types of flow.

The values of the two saturated conductivities, k_{mat} and k_{sat}, assumed in this study for the two soil types are listed in Table 1. They are based on hot and cold air method measurements of soil matrix flow only by Vinten *et al* (1992), together with some measurements by A Lilley (Personal communication, 1993) using a Guelph permeameter (which measures the combustion of soil matrix and macropore flows) for some other soils of similar texture to those represented in the current study. These values have been found to be appropriate for another study with the simpler, two layer model WATBAL, by A J A Vinten (personal communication, 1993). In particular, it was found necessary to assume a high macropore conductivity value in the upper topsoil layer with the Winton series soil to avoid the simulations giving very high surface runoffs during rainfall periods which do not happen in practice with cultivated arable soils.

Very high macropore conductivities for structured soils with low soil matrix flow hydraulic conductivities have also been reported by Jarvis *et al* (1991), and in the experiments of Douglas and Crawford (1993). Macropore flow was assumed

Table 1. Moisture release curve parameters and hydraulic conductivities for two soils

	Winton series			*Macmerry series*	
	upper topsoil	*lower topsoil*	*subsoil*	*topsoil*	*subsoil*
Layer depth, m	0-0.1	0.1-0.3	0.3-1.0	0-0.3	0.3-1.0
Porosity (θ_s), %	52.5	52.5	49.5	47.0	47.0
Pore size distribution index (λ)	0.096	0.096	0.077	0.149	0.233
Soil water tension at air entry (ψ_a), cm water	9.97	9.97	5.55	9.16	12.93
Residual water content (θ_r), %	0.30	0.30	0.30	0.22	0.16
Saturated hydraulic conductivity of soil matrix, excluding macropore flow, (k_{mat}), cm/day	1.0	1.0	0.5	40.6	12.7
Saturated hydraulic conductivity, including macropore flow (k_{sat}), cm/day	3500	13.8	0.5	40.6	12.7

not to take place at all with the coarse-grained Macmerry series soil, by setting k_{sat} equal to k_{mat}.

Weather data

Simulations using the SOIL model can be carried out using various alternative sets of weather parameters, and the recording interval can also vary. All these parameters except precipitation and air temperature are concerned with evapotranspiration, but very little evapotranspiration takes place during the winter period which is the subject of this study. For this reason, the smallest allowable set of weather parameters was chosen, consisting of dry bulb temperature, vapour pressure, wind speed, precipitation and 'cloudiness' (daytime hours without sunshine as a proportion of daylength). Files of daily historic weather data (with parameters measured at 0900h for the 24h period up to that time) for sites at Bush Estate (in the drier east of Scotland) and Dumfries (in the wetter west) for the period 1981-90 were prepared, and converted to the format required for the simulations.

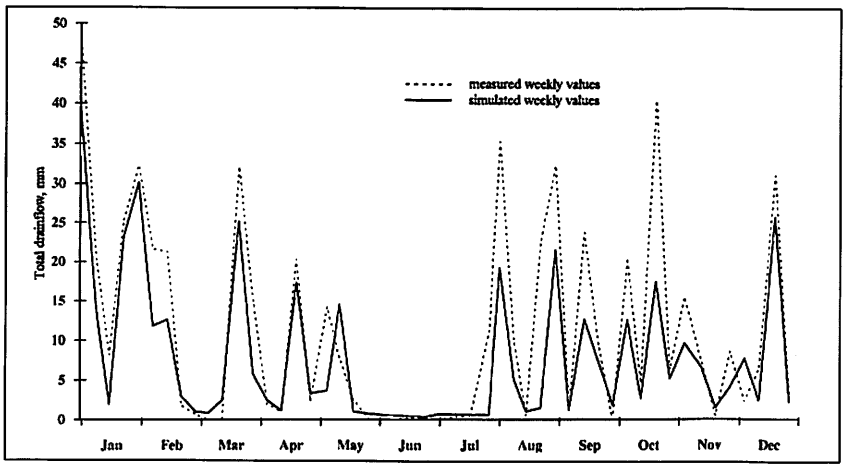


Fig 2. Simulated and measured flows to field drains. (Winton series at Bush 1988)

Other input specifications

A number of further parameters need to be specified for soil moisture simulations. The most important of these for the current study is the layer stratification which was specified as 8 layers at 0-0.1m, 0.1-0.2m, 0.2-0.3m, 0.3-0.4m, 0.4-0.6m, 0.6-0.8m, 0.8-1.0m and 1.0-3.0m. Field (tile) drains at a depth of 1.0 m and spacing of 10 m were also specified.

The model assumes that the outflow from field drains is not restricted by being partially or completely submerged, ie the outflow is above the main water table. However, a perched water table can be represented as a very high moisture content in a layer above another layer with a much lower hydraulic conductivity.

Other parameters specified included the maximum rooting depth at which a typical cereal crop extracts water, and the critical soil moisture tension above which actual evapotranspiration drops below its potential value (Table 2). In practice, assumed values of such parameters affecting evapotranspiration are of minor importance to the current study, since evapotranspiration is very low in winter months when soil moisture limits workability.

Output from the soil model

The simulation SOIL model produces output data for over 50 parameters, many of which are not relevant for the current study. The output parameters required for calculating workdays are soil moisture content in the top layer (0-0.1m), depth of frost penetration, and snow depth. Other output parameters were used for testing and validating the model, including flow rate to field drains, surface runoff flow rate, heat capacity in top layer, temperature in top layer, and moisture content in second layer.

Table 2. Crop moisture extraction parameters

	Maximum depth of roots, m	
Day of year	Winton soil	Macmerry soil
113	0.1	0.1
140	0.3	0.8
225	0.5	1.2
242 (harvest)	0.1	0.1
Critical soil moisture tension*, cm	500	100

*(above which actual evapotranspiration drops below potential evapotranspiration)

Testing model output against experimental data

Experimental measurements at the two sites with which to validate simulation runs with the model include extensive drain flow data, but very limited data on soil moisture contents measured with neutron probes at the site with the Macmerry soil only.

Simulated drain flows showed reasonable agreement with the measured values, as shown for example in Fig 2. Simulated moisture contents showed moderate agreement with neutron probe measurement for the second soil layer, with the model sometimes predicting higher and

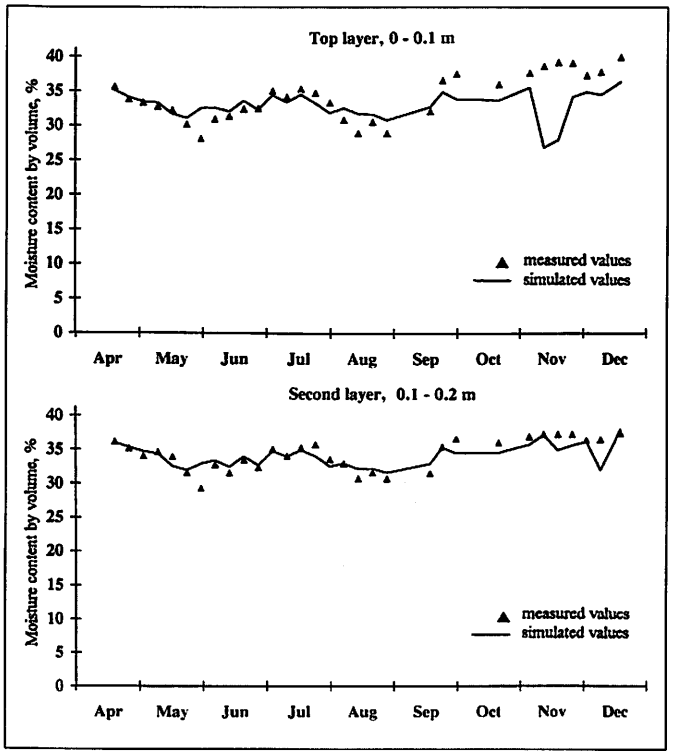


Fig 3. Simulated soil moisture contents compared with neutron probe measured values. (Macmerry series soil at Bush, 1991)

Table 3. Truth tables by month for simulated and recorded days with snow and frost (10 year totals)

Ground conditions			*Time of year*				
R = recorded; S = simulated							
	R	*S*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*
Snow cover	√	√	7	39	87	51	17
Bush	√	x	6	28	27	27	16
	x	√	18	18	31	21	25
	x	x	269	225	165	183	252
Snow cover	√	√	1	25	51	9	2
Dumfries	√	x	9	5	25	12	7
	x	√	10	35	33	27	18
	x	x	280	245	201	234	283
Frozen soil*	√	√	6	27	12	31	7
Bush	√	x	38	23	2	33	25
	x	√	3	9	3	14	4
	x	x	240	184	158	126	241
Frozen soil*	√	√	8	22	9	36	7
Dumfries	√	x	20	26	17	31	10
	x	√	2	12	12	12	2
	x	x	260	220	196	182	282

* on recorded snow-free days

sometimes lower values than those measured, but less good agreement for the top layer (Fig 3).

Neutron probes are generally regarded as a means of indicating upward and downward trends rather than for accurate absolute moisture content measurements. They are also known to be particularly inaccurate near the soil surface, so poor agreement in the top layer may have arisen due to shortcomings of the measurement technique rather than unsuccessful simulation by the model.

Overall agreement between simulations and measurements was considered to be close enough to justify the modelling approach using the chosen model as means of estimating approximate numbers of available workdays at a particular time of year, rather than soil workability on a particular day.

Simulated days with frozen soil (as indicated by a non-zero depth of frost penetration) and days with snow were compared with the 'ground condition' parameter recorded in daily weather data by the Meteorological Office. This ground parameter indicates when there is snow lying, and on days with no snow, two categories of freezing, true frozen soil, and soil with 'glaze' (corresponding roughly to days with thin ice on puddles but soft soil). This comparison is set out as 'truth tables' by month in Table 3.

It can be seen from Table 3 that there is only partial agreement about snow cover on individual days, but the total number of days with snow cover is roughly the same in the simulated results as in the recorded data. The simulations show somewhat fewer days with frozen soil than in those recorded as true frozen soil; days with glaze are represented in the model as unfrozen soil, as might be expected.

Overall, agreement between the simulated and recorded ground condition was considered to be adequate for estimating workdays, bearing in mind the subjective nature of the observed ground condition parameter.

Threshold soil moisture content for workability

In order to use a soil moisture simulation model to estimate numbers of soil workdays, a value of the threshold moisture content above which work cannot be done must be chosen, and this is likely to vary between soils. Some moisture content values which might be considered as this threshold are listed in Table 4. Rounsevell (1993) also discussed the suitability of such limits as described in some of the earlier studies.

Plastic limit represents a definite change in a soil workability type property so might be the obvious choice, but as this is well below field capacity it will give no workability at all during the winter, except perhaps when the soil is frozen.

Field capacity represents the moisture content at which capillary forces trying to hold water in the soil are in equilibrium with gravitational forces trying to make the water drop out of the soil. It is commonly assumed that field capacity is at the moisture content corresponding to a matric potential of

Table 4. Characteristic soil moisture contents

Soil series	*moisture content by volume, %*		*Plastic limit*	*Dry bulk density fraction*
	Field capacity topsoil (at 50cm water matric potential)	*At 100cm water matric potential (topsoil)*		
Winton	45.0	42.0	37.7	1.3
Macmerry	36.5	33.5	32.4	1.4

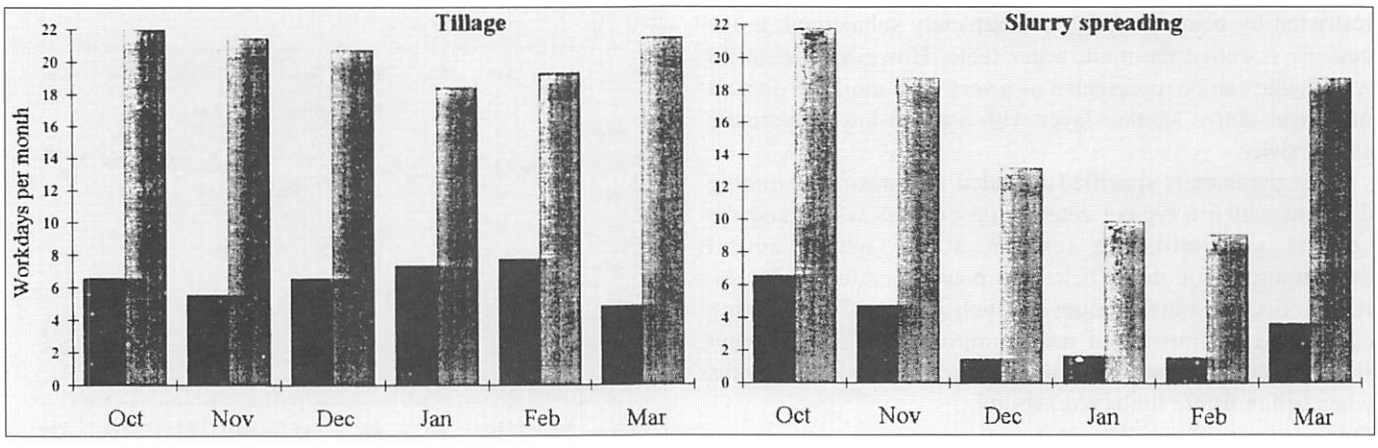


Fig 4. The effect of soil type on number of workdays per month. (10 year mean values, 1981-90, at Bush)

■ Winton series, moisture content limited to field capacity + 2%

□ Macmerry series, moisture content limited to field capacity

50cm water in the UK in the winter (Russell, 1973).

Van Wijk and Buitendijk (1988) report a survey of Dutch farmers' opinions about soil workability for planting potatoes in the spring, giving matric potential values in the top 5cm of soil in the range 40-110cm water (depending on soil type) as the limit of workability. Buitendijk (1985) assumed three alternative threshold matric potential values of 60, 80 and 100cm water for limits to workability in a study of harvesting sugar beet in the autumn.

Matric potential values of around 100cm water correspond to moisture contents below field capacity (Table 4), so are not attainable by drainage alone but assume some water loss by evaporation. This may be reasonable in spring and autumn, but in winter, evaporation is negligible, so field capacity represents the lowest value that can be considered as a threshold value.

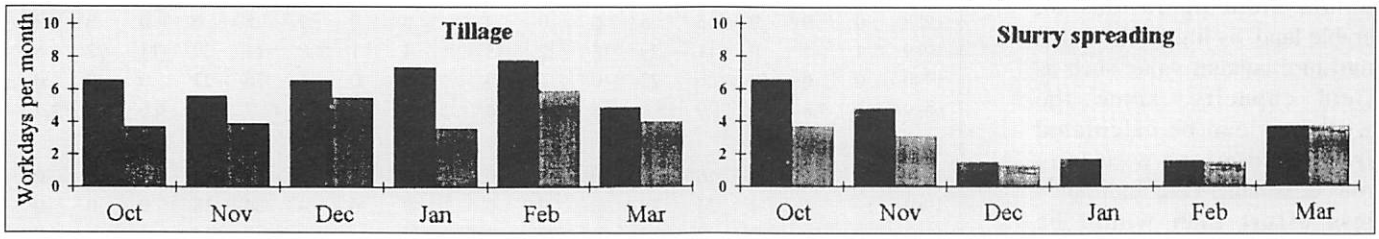


Fig 5. The effect of climate on number of workdays per month
(10 year mean values, 1981-90, Winton series soil, moisture content limited to field capacity + 2%)

In contrast, Witney and Eradat Oskoui (1982) consider alternative threshold values of 105, 110 and 115% of the field capacity moisture content as workability limits for winter tillage operations.

In the current study, field capacity (or the moisture content corresponding to a matric potential of 50cm water) was assumed, in the first instance, to be the most appropriate moisture content limit to workability, but for comparison some alternative figures based on moisture content limits of 2% and 4% above field capacity (or roughly 105% and 110% of field capacity) were also calculated.

Results of simulations

From the results of simulations with the SOIL model, numbers of workdays per month for the ten year period 1981-90, for the two soil types (Winton series and Macmerry series), and two sites (Bush and Dumfries) were calculated.

Each set of calculations was done with a soil moisture content criterion only, as appropriate for field operations with tractors such as tillage, and with the soil moisture criterion plus the requirement of no snow or frozen soil, appropriate for field spreading of pollutants such as slurry. Workdays were calculated both by month in individual years and as ten year means. In fact, with field capacity as the threshold moisture content, hardly any workdays at all were found with the Winton series soil, so it was decided to relax the threshold to 2% above field capacity for this soil only.

A complete set of these results with the workability threshold moisture content set at field capacity for the Macmerry series soil and at 2% above field capacity for the Winton series soil is presented in Table 5.

Some sample 10 year mean values are presented graphically in Figs. 4-6, showing the effects of soil type, whether or not frost and snow are included in the criterion, the effect of climate, and the effect of changing the threshold moisture content.

There are more workdays with the freely draining Macmerry soil than for the Winton soil, even with a tighter threshold moisture content for the Macmerry soil than for the Winton soil, for each set of other conditions (Fig. 4).

Workdays for tractor operations (tillage, etc) are more numerous than for slurry spreading, as would be expected. In fact, many of the days available for tillage and not for spreading are days when the ground is frozen, so the moisture content for liquid water (which is the form in which it appears in the simulation model output) is below the threshold value.

Farmers traditionally often carry out winter ploughing in frosty conditions when the soil appears relatively dry, and able to support tractors and give tractability, whereas unfrozen soil with the same total moisture content would be unworkable.

There are also more tillage workdays at the Bush site than at Dumfries, partly because of lower rainfall, and partly because there are more days when the liquid water content of the soil is reduced by frost. There is not quite such a big difference between the two sites for slurry spreading workdays.

When the workability threshold moisture content is varied, fewer workdays are given, particularly for tillage, when the threshold is set at the field capacity moisture content than to 2% above field capacity, as would be expected.

Looking at monthly workday numbers in individual years (Table 5), there are very large variations between years in all cases. In particular, there are no workdays at all by any of the criteria considered in January or February 1990 with the Winton soil, or in February 1990 with either soil. This illustrates how ten-year mean values can sometimes give a misleading impression of the overall pattern of workdays, so

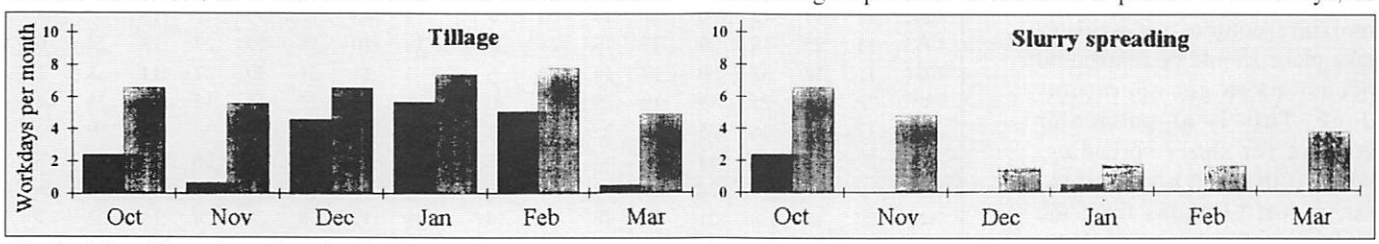


Fig 6. The effect of varying the limiting moisture content on number of workdays per month
(10 year mean values, 1981-90, Winton series soil at Bush)
■ moisture content limited to field capacity ▫ moisture content limited to field capacity + 2%

variations between years should also be considered.

Discussion and Conclusions

The soil moisture and heat simulation model used in this study has been tested against experimental data for soil moisture contents, drain flows, snow cover and frozen soil, and shown to be a reasonable representation of what happens in practice. It therefore represents an efficient method of estimating numbers of workdays for tillage and other winter field operations on arable land, as limited by a soil moisture content value such as field capacity, since the workdays can be calculated from simulations with long runs of weather data with much less effort than would be required to produce such estimates from field measurements alone.

— soil type and climate

The method shows how workday numbers are influenced by soil type and climate, and the sensitivity of the model to the chosen limiting moisture content value is indicated.

— snow and frozen ground

The even more severe restrictions on available work times for field spreading of pollutant substances such as slurry, as imposed by conditions about snow and frozen ground in addition to the maximum soil moisture content, are also illustrated.

— workdays per month

The variability in number of workdays per month between years, with hardly any workdays at all in some instances, poses the question about whether the limiting moisture content for work to take place should be relaxed on occasions to get operations done. This is of particular concern for slurry spreading, where if the limit is relaxed too far, runoff to drains from the surface or the upper soil layers may take pollutants into watercourses. Drainflow from

Table 5. Workdays per month for tractor field operations and for slurry spreading. Yearly values and ten-year means, 1981-90

Tractor field operations — moisture content < field capacity + 2%

Slurry spreading — moisture content < field capacity+2%, no snow cover and ground not frozen

Winton series soil

Bush

	Jan	Feb	Mar	Apr	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Sep	Oct	Nov	Dec
1981	22	20	1	25	18	0	0	24	13	7	0	23	18	0	0	0
1982	11	6	6	19	15	0	0	3	0	0	6	19	15	0	0	0
1983	0	9	0	7	9	0	24	5	0	0	0	7	9	0	24	5
1984	0	1	6	13	22	16	0	3	0	0	6	13	22	16	0	0
1985	20	23	8	3	0	16	7	4	0	6	4	3	0	16	2	0
1986	0	9	2	0	22	17	2	0	0	0	0	0	22	17	0	0
1987	17	9	9	10	7	4	0	10	0	2	4	10	7	4	0	2
1988	0	0	9	5	6	0	0	2	0	0	9	5	6	0	0	2
1989	4	1	0	11	29	13	22	15	4	1	0	11	29	13	22	6
1990	0	0	8	26	22	0	1	0	0	0	8	26	22	0	0	0
MEAN	7.4	7.8	4.9	11.9	15.0	6.6	5.6	6.6	1.7	1.6	3.7	11.7	15.0	6.6	4.8	1.5

Dumfries

1981	0	10	0	16	13	0	0	20	0	2	0	16	13	0	0	0
1982	11	1	4	24	18	0	0	0	0	0	4	24	18	0	0	0
1983	0	10	0	8	13	0	20	0	0	4	0	8	13	0	16	0
1984	8	0	11	28	18	0	0	2	0	0	11	28	18	0	0	0
1985	4	14	9	8	0	18	5	5	0	2	9	8	0	18	2	0
1986	1	18	7	6	24	11	0	0	0	2	4	6	24	11	0	0
1987	12	3	0	8	11	3	0	10	0	2	0	8	11	3	0	2
1988	0	3	3	5	6	0	1	0	0	3	3	5	6	0	0	0
1989	0	0	0	2	18	4	11	14	0	0	0	2	18	4	11	7
1990	0	0	6	23	30	1	2	4	0	0	6	23	30	1	2	4
MEAN	3.6	5.9	4.0	12.8	15.1	3.7	3.9	5.5	.0	1.5	3.7	12.8	15.1	3.7	3.1	1.3

Macmerry series soil

Bush

	Jan	Feb	Mar	Apr	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Sep	Oct	Nov	Dec
1981	28	25	13	30	25	10	17	28	15	9	9	27	25	10	17	2
1982	23	25	26	27	26	20	12	19	13	16	26	27	26	20	11	10
1983	25	27	22	28	25	25	29	25	18	6	22	26	25	25	29	23
1984	13	16	20	21	28	25	0	19	2	9	20	21	28	25	0	14
1985	31	28	24	11	14	27	26	6	11	10	16	11	14	27	18	2
1986	4	19	18	17	29	24	21	15	0	1	15	16	29	22	16	13
1987	24	27	23	16	29	20	30	25	8	14	12	16	29	20	28	15
1988	6	12	24	27	24	26	26	29	3	12	23	27	24	26	22	29
1989	24	15	20	30	30	31	30	26	24	14	20	30	30	31	28	11
1990	7	0	25	30	28	12	24	16	5	0	25	30	28	12	19	13
MEAN	18.5	19.4	21.5	23.7	25.8	22.0	21.5	20.8	9.9	9.1	18.8	23.1	25.8	21.8	18.8	13.2

Dumfries

1981	13	20	4	26	19	12	19	29	6	4	2	26	19	12	19	7
1982	25	15	12	30	21	13	0	6	11	13	12	30	21	13	0	3
1983	15	25	18	29	27	13	28	9	14	10	18	29	27	13	24	6
1984	11	14	31	30	27	14	1	6	1	11	31	30	27	14	1	2
1985	23	27	27	18	18	25	29	10	8	14	27	18	18	25	23	4
1986	13	28	26	25	30	25	10	2	1	10	20	25	30	25	10	2
1987	27	16	13	14	26	4	13	15	10	14	9	14	26	4	13	6
1988	0	7	14	24	18	18	30	26	0	7	14	24	18	18	26	26
1989	29	12	8	21	29	18	22	14	29	12	8	21	29	18	22	7
1990	0	0	14	30	30	15	25	18	0	0	14	30	30	15	25	17
MEAN	15.6	16.4	16.7	24.7	24.5	15.7	17.7	13.5	8.0	9.5	15.5	24.7	24.5	15.7	16.3	8.0

lower soil layers can be acceptable, due to the process of filtering harmful substances out of the water as it percolates downwards through the soil which has already been discussed. This filtering process is a complex subject, beyond the scope of the present study. However, there is a nitrogen cycling and soil solute dynamics model, SOILN (Bergström *et al,* 1991; Jansson *et al,* 1991), which links up with the SOIL model used in this study, and there are a number of other similar models such as ANIMO (Rijtema and Kroes, 1990) which links up with the soil moisture models SWATRE and WATBAL.

—further research needed

The current study has demonstrated a need for further research using these solute dynamics models, to study the pollution processes associated with slurry spreading, to ascertain appropriate soil moisture limits for particular soil types, and to provide a sound basis for calculating workdays.

For tillage and similar tractor operations, some flexibility in the limiting moisture content may be more justified (as assumed by Witney and Eradat Oskoui, 1982), since farmers may regard some soil damage or tractability problems as being acceptable penalties on a minority of occasions, and in this study it was found to be necessary to assume such flexibility with the Winton soil.

Despite some flexibility with the choice of limiting soil moisture content for tillage type operations, the method of estimating workdays from a simulation of soil moisture enables more rational judgements to be made than would be possible without the model. For soils in which the limit has to be set above field capacity, where farmers are known to do some field work during the winter period, the method still provides a means of estimating numbers of workdays to avoid work in very wet, totally unworkable conditions.

— value of the model already in strategic research

This study illustrates the value of a model in strategic research to show how availability of winter workdays is likely to be influenced by factors such as the particular operation, soil type, local climate, or perhaps changed climate arising due to global warming.

At this stage, such information is mainly of interest to policymakers and for giving broad guidelines to farm advisers.

The need for further research into the pollution processes associated with slurry spreading should also be of interest to policymakers.

— possible future application at farm level

In the future, there may be scope for applying this approach as a guide to machinery planning and management at a farm level, and for decisions about day-to-day timing of operations in relation to the weather. However, before this can be done, more satisfactory answers will have to be found about appropriate limiting soil moisture contents for different operations and soil types, and the model will need more thorough validation.

Acknowledgements

The authors wish to thank Dr P E Jansson of the Department of Soil Sciences, Swedish University of Agricultural Sciences, Uppsala, for permission to use and help with running the SOIL model, Dr A J A Vinten of the Soil Science Department, SAC Edinburgh for providing the soil hydraulic data and assistance with interpreting it, and the Scottish Office Agriculture and Fisheries Department for providing funds to carry out the work.

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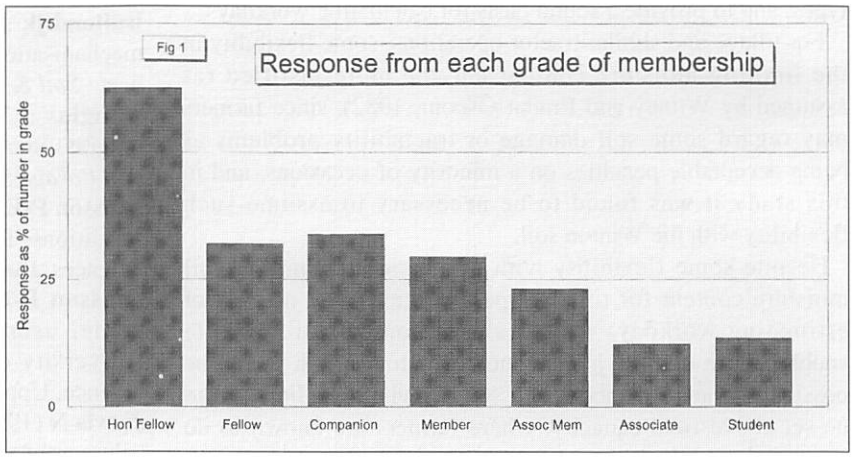
The Institution Membership Survey

Just over one quarter of the membership, 550 in total, returned completed survey forms, with over 500 additional comments, views, ideas and humour on the forms and in separate letters.
This response is outstanding by any standards.

The largest response came from the Member grade (260) followed by Associate Member (117), which corresponds with the size of these groups within the Institution. The responses expressed as a percentage of the population in each grade are shown in Fig 1. On a percentage basis, responses from Associate Members and Students were lower than we had hoped for in view of the importance of these mostly younger members to the future of the Institution.

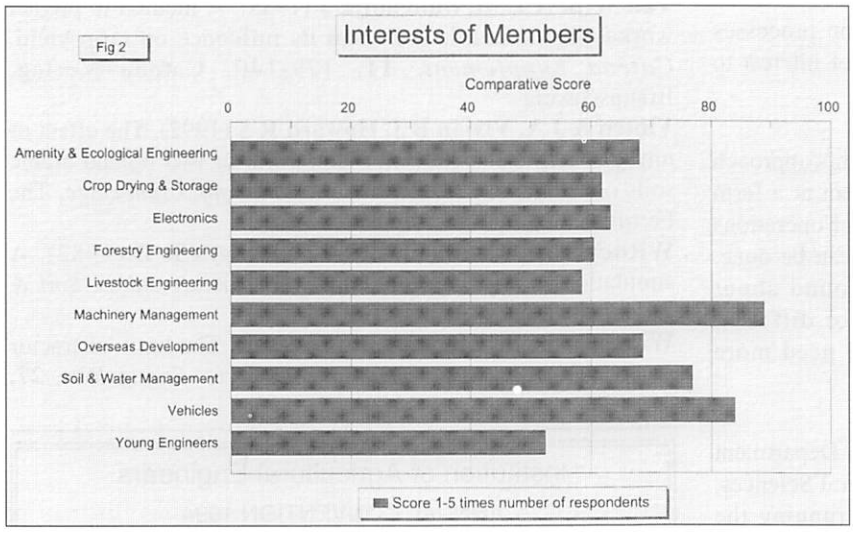
The general consensus was that the Institution was being managed on the right lines. There was no pressure for major change of policy with regard to publications, meetings and conferences, specialist groups and affiliations with other institutions and organisations. There was optimism on the vital future of agriculture and therefore agricultural engineering. The view prevailed that, whatever our diversification of interests, the application of all aspects of engineering to agriculture and horticulture should remain central to Institution activities.



The degree of satisfaction with present policy was such as to raise some doubt within the Executive Committee as to whether the wider membership had been kept properly informed of the delicately balanced financial state of the Institution at the present time.

Technical Interest of Members (Fig 2)

Members were asked to indicate their technical interest on a scale of 1 to 5. Fig 2 offers an index based on cumulative score. Machinery Management rates very highly, reflecting its importance to a wide range of members. Vehicles, Soil and Water, and Overseas Development are also extremely important. Other more specialised areas are especially important to fewer members and this cannot be fully recognised in the simple index . The level of interest is, however, indicated by the present Specialist Group activity within the Institution. What the survey results show is that there is, or should be, scope for much greater Specialist Group activity in certain subject areas, such as Livestock.



Attendance at meetings

Attendance at branch meetings in relation to total membership is poor. Only 28% of respondents attend one quarter or more of the meetings. 70% attend few or no branch meetings. National Conventions have attracted 1/3 of the respondents once or more in the last five years: 2/3 never attend. Since general satisfaction with the content on branch programmes and National Conventions is indicated, the reasons for non-attendance appears to be twofold:

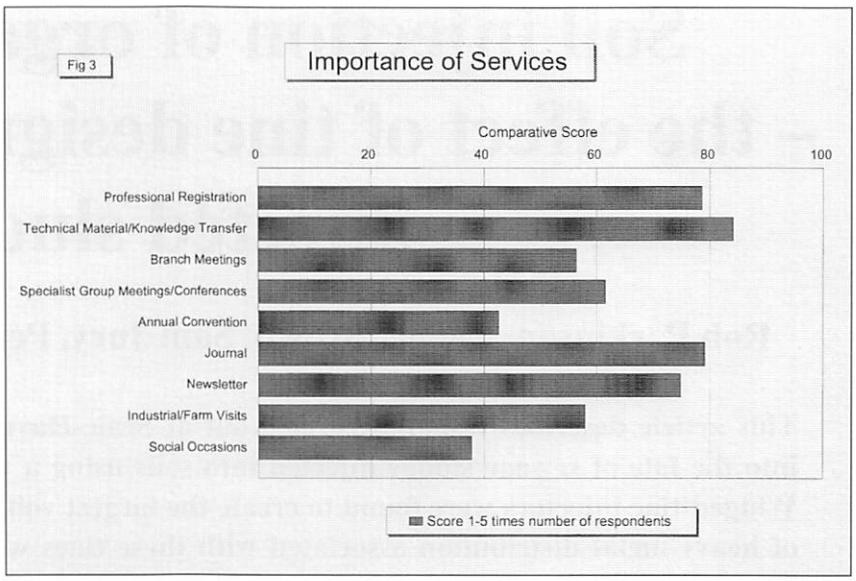
(i) the travelling distances, mainly in the evenings, are a deterrent.
(ii) the main value of Institution membership lies in written technical material, the use of "letters after the name" and professional registration.

There was very little support for amalgamation of branches, the main point being that this would increase travelling distances to impossible levels. Social events found little support, but there were good ideas for making technical programmes more attractive, especially for branch meetings sponsored by particular specialist groups. There was also good support for branch meetings being held jointly with other local organisations.

The current National Convention format and pricing was supported by 2/3 of the respondents. There were indications that some of the membership knew little about the

Conventions: publicity needs to be improved. The single keynote speech followed by Specialist Group activity could be varied. The keynote address could on occasions be dropped. But the clear message was that members favoured a one day, low cost, information packed convention.

There was support for 1-3 additional national conferences each year. These could be based on specialist groups, held at places well away from the National Convention to give a geographical spread, and might be open to the public to generate funds for IAgrE.



The Importance of Services (Fig 3)

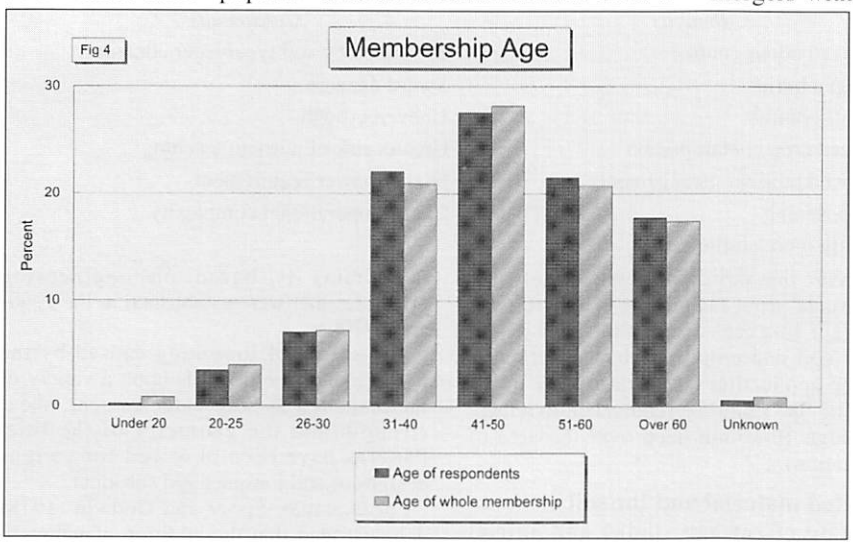
Technical knowledge transfer is rated as a top priority, so is the Journal and Newsletter, but not branch meetings or the National Convention. This indicates the absolutely vital part the Journal and Newsletter play and the need to develop and advance both as a matter of priority.

Journal and Newsletter

There is outstanding support for the Journal and Newsletter. 76% of respondents read over 50% of the material. 78% put the technical level at "about right". There was no great pressure to change the publication whilst the present title of 'The Agricultural Engineer' was generally favoured. Within all the comments there were 34 titles suggested for the Journal, however, which might be grouped as follows:

- AGRICULTURAL ENGINEERING, linked variously to buildings, food and environment (13)
- LAND, linked mainly to engineering and environment (11)
- RURAL, linked mainly to engineering and environment (8)
- BIOLOGY/ENVIRONMENT (2)

While 78% put the Journal content at about the right level, 70% wanted more "popular" articles. A contradiction? Or is it only confirmation of the present editorial policy of increasing review articles at the expense of research material.



Specialist Groups

The great majority, 69%, wish to reserve judgement on the formation of new specialist groups. Where new titles were suggested, it appeared that most of them could be attached to existing groups, at least until such time as they could lead a separate existence. Examples might be horticulture to be part of the Amenity Group, drainage and irrigation to the Soil & Water group, spraying and pesticide application to Machinery Management. There could be a good case for new Education & Training and Buildings & Structures groups, but the message from the respondents was to proceed with caution.

Institution Direction and Name

There was strong support for the current policies and management of the Institution, and to retain the current name while we address ever wider ranging technical areas. Around 40% of the respondents wanted the logo to be changed, whereas 55% wanted it to remain the same. Many comments suggested that any change in logo should be an adjustment rather than total change.

There were many suggestions for cooperation to share overheads with other organisations, but a 2:1 vote against mergers with like organisations, and 4:1 against merger with organisations less closely related. If mergers do come about, it will be because they are forced by economic stringency, not because they are favoured by IAgrE members.

Finally

The response to the survey was outstandingly good, both in quantity and quality. The large number of comments and ideas received have been noted and classified, and will be taken into consideration in guiding Institution policy. If your particular comments are not reflected in this short note, it is simply because it is not possible to convey every detail in the space available.

What is certain is that the information received must be used to make the Institution more attractive to a wider and younger membership (note Fig 4). The weight of the chart needs to move over to the left, and to achieve this we need to be open to radical changes of style and direction.

Our sincere thanks to all who contributed.

Brian Finney -President
Dick Godwin - President Elect

Soil injection of organic wastes – the effect of tine design on the fate of injected sludge

Rob Parkinson, Rachel Brown, Sam Jury, Peter O'Neill, Richard Heath

This article describes research carried out at Seale-Hayne Faculty, University of Plymouth, into the fate of sewage sludge injected into soils using a variety of different injector designs. Winged-tine injectors were found to create the largest volume of soil disturbance, but patterns of heavy metal distribution associated with these tines were found to be extremely variable. The fate of the liquid sludge component is also shown to depend on conditions before and during injection.

In 1990 the British Government bowed to pressure from our European neighbours and agreed to ban the dumping of sewage sludge at sea by 1998. At that time less than 40% of all sludge was recycled to agricultural land.

In the light of changes which will happen in the next few years, the water industry is working hard to increase the 'farmer acceptability' of sludge and so raise the proportion of sludge that is applied to agricultural land.

Pumping the waste under the soil surface is one method of achieving this aim.

Benefits of soil injection

The technique of soil injection is useful not only for the disposal of human waste; livestock slurry and even industrial wastes such as milk whey from creameries can be pumped into the soil rather than spread on the surface, with a number of agronomic benefits. These benefits, which include shorter no-grazing periods following application and reduced odour problems, as well as some of the constraints imposed by the injection process, are listed in Table 1.

Many technological developments create problems as well as solve them.

In the case of waste disposal by injection, reduced no-grazing periods and less pasture contamination may be accompanied by sward death close to the injection slot.

Reduced risk of run-off and less ammonia volatilisation after injection may improve nutrient management, but only if nitrate leaching is not a serious risk.

In addition the injection process is operationally complex, such that specialist contractors usually carry out the work.

Injector tine design

Considerable research effort has been put into determining the factors that influence the successful injection of sludges. In the U.K. this work has been conducted mainly by Professor Dick Godwin and colleagues at Silsoe College (Warner and Godwin, 1988; Godwin *et al* 1990).

Table 1. Some benefits and constraints associated with the subsurface injection of liquid human and animal wastes

Benefits	*Constraints*
Improved odour control	Restricted by soil type/water content
Pathogen burial	Sward damage
Run-off control	Uneven growth
Reduced crop contamination	Greater risk of nutrient leaching
Improved nutrient management	Higher power requirement
Soil loosening	Greater operational complexity
Visually more aesthetic	

Injector tine design has evolved over the last twenty years such that it is now feasible to inject in excess of 200m³/ha without major soil and crop disturbance, although routine application rates are usually in the order of 100-150m³/ha (equivalent to a layer of sludge 10-15mm deep over the area of application).

Injected material and the soil

The fate of sewage sludge and animal slurries injected into soils has been under investigation at Seale-Hayne for nearly ten years. This work has been sponsored by MAFF, amongst others.

In order to be able to judge the effectiveness of the injection process, it is necessary to monitor the fate of the materials contained within the sludge or slurry. For example, there are strict regulations concerning the quantities of heavy metals such as copper, zinc, nickel, lead and cadmium that may be added to agricultural soils. Conventional soil sampling as stipulated by the Sludge (Use in Agriculture) Regulations may not pick up all the metals if their distribution is dependant upon the type of injector, or the interaction between the injector and the soil.

Soil loosening by injector tines

The design of most deep working injectors (>100mm) is based on engineering principles that were established in the 1960s and 1970s.

The extent of loosening caused by the passage of a tine depends upon a variety of factors, such as soil water content, shear strength and the geometry of the tine. Patterns have been observed for various designs of soil loosener and subsoiler.

For example, Spoor and Godwin (1978) demonstrated that the addition of wings to the base of the tine substantially increased the zone of soil disturbance. Such principles have been applied to injector tines, which are in essence conventional soil looseners modified to accommodate a hollow section down which liquid wastes are pumped.

Extensive soil loosening during injection

Dr R J Parkinson is Principal Lecturer in Soil Science, R Brown and S J Jury were formerly Research Assistants and R P Heath is Senior Lecturer in Agricultural Engineering in the Department of Agriculture and Food Studies, Seale-Hayne Faculty, University of Plymouth, Newton Abbot. Dr P O'Neill is Head of the Department of Environmental Sciences, University of Plymouth.

Membership matters....

THE NEWSLETTER OF THE INSTITUTION OF AGRICULTURAL ENGINEERS

It's official – we're better off !

Hard to believe sometimes, but that's what the 1992 Survey of Engineers tells us and who would dare question that annual tome of statistics.

Chartered Engineers fared the worst with their salaries increasing only 2.4% faster than the Average Earnings Index.
Incorporated Engineers and Engineering Technicians are positively rolling in it with a 5.5% increase over the AEI.
Both groups have seen increases in excess of the Retail Price Index, a trend identified for the last three years.

The Survey is commissioned by the Engineering Council every year. This year some 25,841 questionnaires were sent out, 34.2% of these yielding processable replies

The Survey is comprehensive if nothing else. Every imaginable aspect of engineer employment is covered and viewed/analysed from a variety of angles – pay, age, qualifications, responsibilities, fringe benefits, career satisfaction, participation in continued professional development (CPD), and much more. Where appropriate, each is related to the other to build up as complete a picture as possible.

Here's some more snippets from those pages:

- 23% of CEng replies said they took up engineering because they wanted to be creative, 43% because they were good at maths and sciences,
- 70% have been involved with some CPD during the last year,
- the amount of time spent at work has increased for all categories of engineer, not all paid as overtime.
- despite the burden of taxation there has been a further increase in the number who enjoy the benefits of a company car (+4.9% of CEng; +2.0% of IEng),
- retirement ages are falling ...
- fewer engineers are members of a Trade Union,
- 5.5% of CEng and 2.5% of IEng hold the position of Chief Executive,
- the highest levels of earnings were in the Nationalised Industries and Public Corporations, the lowest — in Local Authorities and Universities

... and so it goes on. The detail is fascinating and complex and takes time to assimilate.

With only 0.1% of the CEng sample and 0.5% of the IEng sample coming from agricultural engineering, I'm not sure how to view the figures in my own context, or indeed how to view them at all, This document brings out the worst in you, so beware! Envy at times, cynicism at others. Occasionally, just occasionally – pride, only to be dashed when the page is turned. The grass is always greener ...

Your own personal copy of the Survey results will take most of the margin of your salary over non-engineering professions for the year — it costs £130! If you must have it, send your cheque to The Engineering Council, 10 Maltravers Street, London WC2R 3ER. Alternatively, you can browse the pages courtesy of our Institution — a copy is held at the Secretariat.

Unification – Take 2, stage II

The first stage of the investigation into the unification of the engineering professions received mixed support from the Institutions that make up the Engineering Council and, indeed from the industries and individuals represented. That first stage of the investigation was reached, and the deliberations of the Steering Group reported, with the publication of the booklet **Engineering into the Millenium.**

In an open letter to the Presidents of the Institutions, the Chairman of the Engineering Council, Sir John Fairclough FEng (who, incidentally, has been selected for a further three-year term of office) revealed that there was a great deal of support for the concept of a 'New Relationship' between a reformed Engineering Council and the Institutions. There were, however, mixed views on how this relationship might be achieved. The majority of respondants accepted the need for some form of grouping of the Institutions but the college concept set out in the Millenium report did not find favour and will not be pursued.

In place of the college concept, there is proposed a form of 'federal' relationship which would serve the profession with a powerful voice for central issues but would allow individual Institutions to retain their identities and roles. This 'federal' concept will now be investigated by a Policy Group, the main aim of which will be to establish a full proposal for the New Relationship between the EC and the Institutions. The target is to have this ready for scrutiny and comment by the Autumn of this year. To meet this target, the Policy Group has spawned three Working Groups. The first to draw up detailed plans of how this New Relationship will tackle the range of issues that need to be addressed, the second, to study the need, or otherwise, for new legislation to regulate the profession and, the third, to consider possible next steps beyond the New Relationship.

June 1995 is the date when all this deliberation should reach fruition and a reformed Engineering Council will first emerge into the light of day. Watch this space – but don't hold your breath!

Membership Survey

A very good response has been received to the survey questionnaire and much helpful information obtained.
Full details are published on pages 14 and 15 of this issue of the journal.

News of Members — Tony Chestney

Working with water – and other Natural Resources

Although I am pleased to have received some letters from members since the last Newsletter the number has been small and I would have liked to have had more. Surely, more of you must have something to say which will be of interest to other members?

Linking engineering to water ...

***Richard Boak** has recently joined Southern Science Ltd as a Senoir Hydrogeologist. Southern Science is a water resource, laboratory, and environmental services company based in Worthing and is part of the Southern Water group. Richard graduated in 1980 with a degree in Agricultural Engineering from the University of Newcastle upon Tyne, since when he has held a wide variety of posts. These have included two years as a Farm Manager and a spell of six years in Zambia and Kenya managing integrated rural development programmes, specialising in small-scale water supplies and agricultural engineering. More recently, a return to Newcastle to gain a Master's degree in Groundwater Engineering has been followed by two years as Hydrologist to South Staffordshire Water plc.*

Southern Science provides many services to the farming industry, including design and construction of boreholes for water supply and environmental impact assessments.

Thank you, Richard,for this interesting account of your career so far and I wish you continued success.

... to the environment ...

*I am pleased to report that **M P Duggan** has been awarded a National Diploma in Horticultural Engineering from Pershore College of Horticulture and that he also gained the top engineering student award for his year. He has now moved to Newcastle University where he has started the foundation year of the integrated BEng in Environmental and Ecological Engineering.*

Congratulations on your awards and I wish you every success with your course at Newcastle.

... and to the soil.

*After spending the summer on a temporary contract with Scott Wilson Kirkpatrick (on a land reclamation project in the Black Country) **Crispin Wingfield-Hayes** has gone to the University of Strathclyde to take an MSc. The course is in Soil and Water Management. It is of one year's duration and covers aspects of water engineering and water resources development with reference to UK and developing country situations. In addition, soils and soil science are covered, and some of these credits will be taken at the West of Scotland Agricultural College near Ayr. The course sounds very interesting and should offer many possibilities for the future. Good luck with that!*

***Lackson Kaluba** has moved to the Natural Resources Development College in Lusaka and I look forward to receiving further information from him for the next Newsletter.*

Don't forget us, please

*There are changes afoot at the Harper Adams Agricultural College. **Ian Gedye,** for many years the head of the Agricultural Engineering Department at that establishment, is retiring. He has been instrumental in raising the profile of the Engineering Department of that college to one which now commands global respect. In addition, he has been a stalwart supporter of our Institution and served in a multitude of guises. I doubt if his retirement will be particularly restful – it is unlikely that a man of his dynamism would want that – but at least he will be able to choose his involvements. We sincerely hope that the Institution will feature in his plans.*

One man who has not severed links on his 'retirement' is your "News of Members" correspondent, Tony Chestney. He works long and hard to bring you this column. Don't let him down — let him know what you are up to! His address is: 32 Beverley Crescent, Bedford MK40 4BY. *Ed*

ELECTRIC INFORMATION

Electrified lecturers

If you are involved in technical teaching at a college or university – this is for you.

The Farm Electric Centre has organised another one-day College Lecturers Course to update delegates on current (!) research and development projects.

The date is 10 November 1994 at the Farm Electric Centre. Previous such days have been intensive learning experiences, extremely informative and very enjoyable. There's no reason to suggest that this one will be any different.

Book your place now, contact Dr Dan Mitchell at The Farm Electric Centre, NAC, Stoneleigh, Kenilworth, Warwickshire CV8 2LS (phone: 0203 696512; fax: 0203 696360).

The cost is £200 per delegate which includes overnight accommodation on 9 November.

Current information for consultants too

The technical publications published by the Farm Electric Centre are something of a legend in our industry, there can't be many who have not delved into those pages at some time or other for the definitive answer to a problem.

Unless you are in regular, close contact with the FEC it is very easy to get out of touch with the latest techniques and technology.

Here's a way of keeping 'bang up to date' –

The Farm Electric Information Service

For an annual fee of £70 VAT you will not only receive a comprehensive set of existing Farm Electric publications but also a set of storage binders and copies of each new title or update as they are published. In addition, information on new products and services will be forwarded plus access to a telephone-line product locator service.

Miss C Molloy is the co-ordinator of the service, contact her at the above Farm electric address for details/membership.

It's got to be worth a look whatever your discipline – we all use electricity at some time in our vocation.

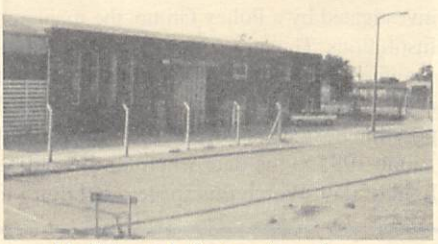
Low rent opportunity

A benevolent Fellow of our Institution has made an offer from which someone in our ranks can surely benefit. The offer is of an extremely low rent for a factory-warehouse to an Institution member who has, or is aspiring to have, an agricultural machinery venture.

The member making the offer is Frederick F Szirotta FIAgrE. The premises are situated in Thetford, Norfolk and comprise almost 4000sq ft of factory/warehouse space plus a little over 3000sq ft of covered area, generous office accommodation with all facilities in a site area of approximately 1.3 acres. The unit, built in 1975 has main road frontage.

Mr Szirotta has engineering, design and export/import experience plus a number of intercontinental connections, all of which he would be prepared to share to help the individual or company towards success.

Full details of the premises are available from Mr Richard Alliban, The Limes, 32 Bridge Street, Thetford, Norfolk IP24 3AG (Tel: 0842 764241; Fax: 0842 761316). For preferential treatment, direct contact can be made with Mr Szirotta at 19W231 Landsfield Place, Downers Grove, IL 60516, USA (Tel/Fax: 1-708-985-1087).



Mr Szirotta's factory/warehouse.

Admissions – A warm welcome to the following new members:

Member Grade: J A J Gander (Netherlands); A-G A Jimoh (Bedford)

Associate Member Grade: S B Cousins (Suffolk): A I J Heather (Leics); M N Hopkins (Bucks); J R Jones (Cumbria); A C Newbold (Cumbria); S Owusu-Sekyere (London)

Student: A G Bell (Cumbria); D W Finney (Worcs); J M Muriithi (Shrops); J R Woods (Sussex); D D Clark (Scotland); R D Powers (W Midlands); N M A Preece (Tyne & Wear); I Smith (Norfolk)

Transfers – Congratulations on the completion of a further phase of their professional development to:

Member Grade: R Earl (Bucks); J T Loud (Warwicks)

Associate Member Grade: R J Brindle (Scotland); S G May (Essex); M A Sijuwade (London); M W Spry (Devon); N P Morris (Wales); M Shipp (W Sussex); M Whiting (Somerset)

Student: M P Duggan (Tyne & Wear); M Fallon (Bedford); S G May (Essex); L Mwale (Shrops); H G Thomas (Wales); C Wingfield-Hayes (Scotland)

Re-instatement

A A Adeoye (Nigeria); M A Choudhary (Tyne & Wear); S M Friederich (French W Indies); K Rhodes (Jamaica); T Templeton (Scotland); D M E Thompson (Devon)

Death – Sad to record the death of:

K Y Ma (Malaysia)

Engineering Council Registrations – Congratulations to the following members on their inclusion on the register of professional engineers:

C Eng: J A J Gander (Netherlands); S M Hulangamuwa (Tyne & Wear); B A Kendall (Wilts); C A Morse (Worcs); J M Sharp (S Humberside)

EngTech: D A Yates (Notts)

Movements – In this section are listed members who have changed their address except where they remain in the same English county or, elsewhere, in the same country. We hope that the move has proven beneficial.

L V Brown (Kent to Herts); E D Coles (Cyprus to Indonesia); R Earl (Bucks to Beds); J D C Green (Cornwall to Bucks); B H Griffiths (S Africa to Singapore); N Hammond (Worcs to Tyne & Wear); S G May (Cheshire to Essex); B Noonan (Lesotho to W Midlands); G P Owens (Yorks to Avon); S C Price (W Sussex to USA); B A Roche (Wilts to Irish Republic); B L Roger (Wales to Tyne & Wear); S J Smith (Shrops to Cambs); S M Smith (Norway to Northumberland); M W Spry ('gone away' to Devon); A J Thomasson (Herts to Wales); D F Topping (Oxon to Malaysia); A E Turner (Scotland to Pakistan); M Whiting (Shrops to Somerset)

There must be lots of interesting News of Members in these moves. Why not drop a line to Tony Chestney and let him know why you moved – it could be to your advantage too. Ed

AWARDS

The Douglas Bomford Trust Awards re-aligned

The Trustees of The Douglas Bomford Trust have announced some major changes in their support for our industry. Gone are the traditional Post Graduate and Post Diploma Awards (though they remain willing to support outstanding candidates on an *ad hoc* basis in these areas). In are three new support programmes.

For engineers seeking to enhance their personal career development, the **Language Awards and Travel Awards** should enable successful candidates to broaden their horizons, quite literally.

To commemorate the birth of Douglas Bomford there is the new **Douglas Bomford Centenary Fellowship**. This is intended to support major research endeavours to find ways of reducing chemical inputs in farming. It is a co-operative programme jointly funded with the Agricultural and Food Research Council and will be based at Silsoe Research Institute.

Financial support for candidates undertaking extended PhD programmes (where additional major support is being offered by an industrial sponsor) comes in the form of the new **Parnaby Engineering Doctorate Programme** at Cranfield University.

Other DBT awards continue

Beyond these three new initiatives are **other DBT awards** with which Institution members are familiar. Indeed, many members have been grateful beneficiaries.

The annual **Douglas Bomford Meeting Award** is presented to an outstanding speaker at a conference or technical meeting of our Institution. There are the occasional and always significant **DB Memorial Lectures**, and the Trust supports prominent research and development in **Intermediate Technology**. Other **Discretionary Awards** and **Student Research Awards** are made on their merit.

The DBT was founded in 1972 by Mrs E F Bomford, in memory of her husband, for the advancement of education, training and research in the science and practice of agricultural engineering and mechanisation. The qualities of this remarkable man – integrity, determination and vision make these awards particularly poignant and apt.

Full details and the appropriate application forms are available from: The Secretary, The Douglas Bomford Trust, West Manor Lodge, Walberton, Arundel, West Sussex BN18 0PJ.

Cash from the Engineering Council

Entries for the 1994 versions of two perennial competitions organised by the Engineering Council are invited. For the 'rising stars' is the **Young Engineers for Britain** competition. Entrants must be aged 11 – 19 and in full-time education or working in industry. Entries can be from individuals or from teams of up to four people. The overall national winner receives £1000, a trophy and £1500 for their school or organisation, plus a great deal of prestige and potential. In addition, there are a host of subsidiary prizes on offer.

Last year's winner was 16-year-old Lucy Porter from Bath who invented a swing exerciser for disabled children.

How about something with an agricultural flavour taking the honours this year? Come on, dads, sow the seeds of an idea with your heirs-apparent!

If the said heirs-apparent need leading by example, how about an entry in the second 1994 competition from the Engineering Council – the **1994 Environment Award for Engineers**. This event is open to individuals and teams, too. Individuals must be registered with the EC, teams must comprise at least one registered member. The aim is to devise an engineering solution to an environmental problem. Total prize money amounts to £6000 with the winning engineer/team collecting half of that. Second and third places gain to the tune of £2000 and £1000 respectively.

Full details, rules and entry forms for both these competitions are available from The Engineering Council, 10 Maltravers Street, London WC2R 3ER.

MacRobert Award goes to ICI

The development of a CFC replacement has won ICI the sanction of the Royal Academy of Engineering through the **MacRobert Award for Innovation in Engineering**.

KLEA 134a, as the new product is called, is an ozone benign hydrofluorocarbon developed to replace fluorocarbon in refrigeration and air conditioning plant.

A team at ICI has devised and implemented a production route for the commercial manufacture of this new refrigerant. For their efforts they were presented with this prestigious award plus £50000 by the Senior Fellow of the Academy, HRH The Duke of Edinburgh, at the Science Museum in December.

Smooth moves

Wrekin Branch (DC)

It seems that '93/94 is the 'year' for transmission explorations – the Wrekin Branch was one of several looking at developments in this area. The title of their evening's presentation was Transmission Developments for Off-Highway Vehicles, the speaker was David Tinker from Silsoe Research Institute. David's brief, which he accomplished in typically entertaining fashion, was to review the latest thinking on linking the 'grunt' to the ground.

After a comprehensive appraisal of what was available now on tractors, he moved (shifted?!) to a look at continuously variable transmissions (CTVs) and their prospects off-highway. Starting with the familiar variator, albeit in chain-drive form, David taxed the mental dexterity of the audience by describing two further CTVs – the nutating (a sophisticated version of a ring-cone drive) and the toroidal traction drive system. Compound and shunt variations of these transmissions were briefly considered which could provide the range of output speeds necessary for tractor operation.

An excellent evening's entertainment. If you want to know more, volume 54 (1993) of the JAER will reveal David's review paper on the subject, but I strongly recommend you book him for an evening meeting.

From the sublime ...

A few weeks before David Tinker discussed these areas of engineering sophistication, the Branch had been treated to a look at the other end of the spectrum – Mechanisation in Developing Countries. Boring ? Seen it, done it ? Not when I tell you that the speaker was John Kilgour. That man's wealth of innovative experience, fertile mind and sense of humour made sure of that! John used three examples to demonstrate the application of engineering principles to the problems faced out there.

In **Tanzania**, John had been posed the problem of **mechanising draft operations** such as ploughing. With conventional tractors out of the question through cost, the use of a smaller derivative might seem the answer but he demonstrated mathematically that even a 7kW tractor would need to weigh a tonne if it were to to be used to pull a plough directly. A more efficient solution was found – use the 7kW to drive a winch and pull the plough from the headland. It works, and he ran a video to prove it, though the cost of such a tractor is still several times the annual income of most of the local farmers. Hire it out ? The logistics make it difficult under most circumstances.

The **Uganda** tea industry was in ruins after Amin and Mitchell Cotts saw an opportunity to restore and improve the growing of that crop. They approached Silsoe College for help and John was assigned to head a team with the aim of devising and **developing a tea harvester.** The resulting machine has proved its worth for a decade and the lessons learnt have lead to the designing of a much improved derivative. Unfortunately, Mitchell Cotts no longer exists and a sponsor is being actively sought to support the venture. At this stage, John revealed a moral dilemma faced by all who introduce mechanised operations into developing countries – should such machines be introduced or should the abundant and already under-employed labour force be used ?

Just the opposite problem faced John in his third exposé of his exploits – a **date harvesting platform** in **Saudi Arabia.** Here the Saudis are concerned about the influx of 'guest workers' into their country and are seeking to mechanise previously manual operations. They needed a platform capable of working on uneven ground in orchards where the palm trees were often planted in a random pattern. The platform had to be mounted on a turntable to facilitate access to several trees between moves. John explained, with the help of a video, the solution to the problem – an adaptation of a lamp-post servicing platform on a four-wheel-steer base unit, with a host of safety systems to protect machine and operator. Lessons learnt from this design are being incorporated into an improved design at the moment.

In typical JK style, John concluded his presentation with a few artifacts and anecdotes from his travels which took the audience from amazement to amusement, and back again, to well earn the extended applause !

LITERATURE

Pastures new ?

In an effort to help engineers who are job hunting, the Institution of Electronics and Electrical Incorporated Engineers (IEEIE) has published an open learning package which should give applicants a better than average chance of getting an interview.

Your Move consists of two workbooks and 23 task sheets. Tutorial support is available as an optional extra. The self-study course should take about 20 hours to complete.

The study-packs cost £90 each. Tutorial support, if required, is an extra £47. Full details from the IEEIE, Savoy Hill House, Savoy Hill. London WC2R 0BS.

... and Soil makes Three

Completing a trilogy of Codes of Good Agricultural Practice is the latest, just published, for the Protection of the Soil.

As in its predecessors, this latest code offers practical advice, to all involved in using soil, on how to preserve and enhance the properties of this most essential component of our industry.

Copies are free from MAFF Publications, London SE99 7TP ('phone: 081 694 8862) or from the Welsh Office Agricultural Department, Cathays Park, Cardiff ('phone: 0222 825641).

Safety in view

Many of our members, at some time in their career, work on a construction site and are exposed to the same hazards as full-time construction employees. That is why we bring to your attention the availability of a new video produced by the Construction Industry Research and Information Association (CIRIA) entitled Not Just an Accident.

Further details are available from David Churcher at CIRIA, 'phone: 071 222 8891; fax: 071 222 1708.

Lost Members

If any member knows the present address of the following would they please contact the Secretariat:

J Crisp 36 Whoberley Avenue, Chapelfields, Coventry CV5 8EP

C J Parker P O Box 110159, Solwezi, N W Province, Zambia.

National Science, Engineering and Technology Week

The week of 18 – 27 March has been officially designated with this title.

Although too late to initiate a particular event to mark the occasion, members are urged to give their support to any complementary activities in their area. let the country know that Agricultural Engineering is a force to be reckoned with!

Branch/Specialist Group Meetings 1994

March			
9	**AGM** 7.00 pm, – followed by Dinner7.30 pm	O Statham
	Southern Branch – Wessex House Hotel, Sherfield on Lodden	0865 714455
14	**AGM**, followed by **Grain storage in Syria** – Mr D Williams,	M Sheldon
	West Midlands Branch – Pershore College of Horticulture	0926 651367
14	**AGM** 7.00 pm	B Bell
	East Anglia Branch – Brome Grange Hotel	0473 890456
17	**AGM** 7.30pm, followed by **Farm waste managemnt** –Dr I Svoboda	P Rogers
	Northern Branch – Carrol House Hotel, Carlton, Carlisle	0388 814141
22	**AGM** 6.30, – followed by **Corrosion** – C Pearce, Anachrome Ltd	P A Hill
	Herts & Essex Branch – FNH Boreham House	0245 420705
April		
27	**Unsurfaced roads in the rural environment** – Conference	G Freedman
	Forestry Engng Specialist Grp – Trusthouse Forte, Birmingham Airport	031 334 0303

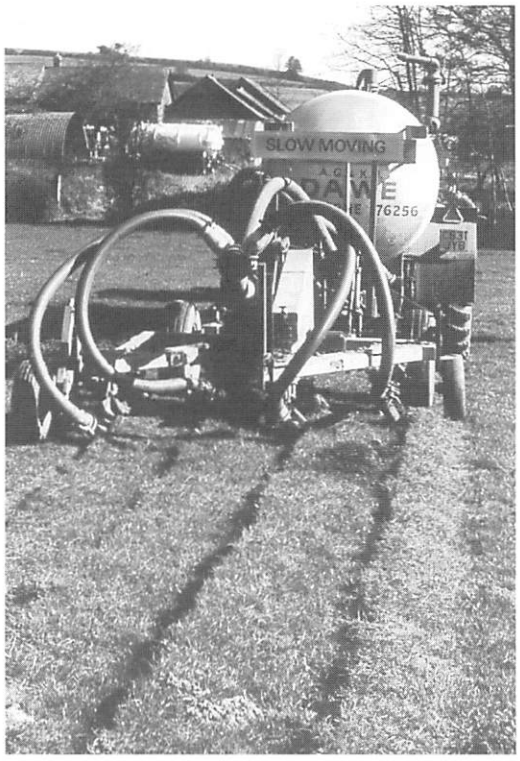


Fig 1. Slant-legged injector (SLA) working in grassland.

Fig 2. Straight-legged winged injector (WIN) working in grassland.

is essential in order to create the volume of voids needed to absorb the large volumes of liquid that may be injected.

Twomlow *et al* (1991) described a loosening experiment at Seale-Hayne which illustrated the benefits that can accrue following the passage of a winged tine through the soil. These included reduced bulk density, an increase in the volume of water transmisson pores and enhanced drainage efficiency.

Trials at Seale Hayne

Three tine configurations were investigated as a part of a series of experiments carried out at Seale-Hayne designed to evaluate the fate of injected sewage sludge. The three configurations were:-

- a straight-legged, wingless tine (STR) designed to work 200-300mm below the soil surface,
- a straight-legged, winged tine (WIN) designed to work at 100-250mm, and
- a slant-legged tine (SLA) designed to work at 100-200mm.

The experimental site was cropped with grass, and underlain by a medium to heavy textured silt loam/clay loam. Injections were carried out in both the spring and autumn.

Fig 1 shows the slant-legged injector and Fig 2 shows the straight-legged injector working in grassland. In both cases very little sward damage is evident, but the surface condition left after passage of the tines is uneven. Rolling several days after injection can minimise this surface irregularity.

Soil disturbance patterns measured several days after injection, allowing sufficient time for the liquid fraction of the sludge to dissipate, are displayed in Fig 3.

Injections carried out in the spring are shown in Fig 3A and 3C. The STR tine produced a restricted zone of loosening centred at a depth of 200mm (Fig 3A), while, in contrast, the SLA tine produced a zone of loosening which reflects the working angle of the machine (Fig 3C).

When injection was carried out in the autumn under drier soil conditions with the winged (WIN) tine, the zone of loosening was observed to be much more extensive (Fig 3B), with low soil shear strengths occurring across virtually the whole working section.

The benefits of fitting wings to subsoilers are well established, and the patterns observed in our experiments confirm these advantages when injecting.

Heavy metal distribution following injection

Sub-surface injection of sewage sludge can

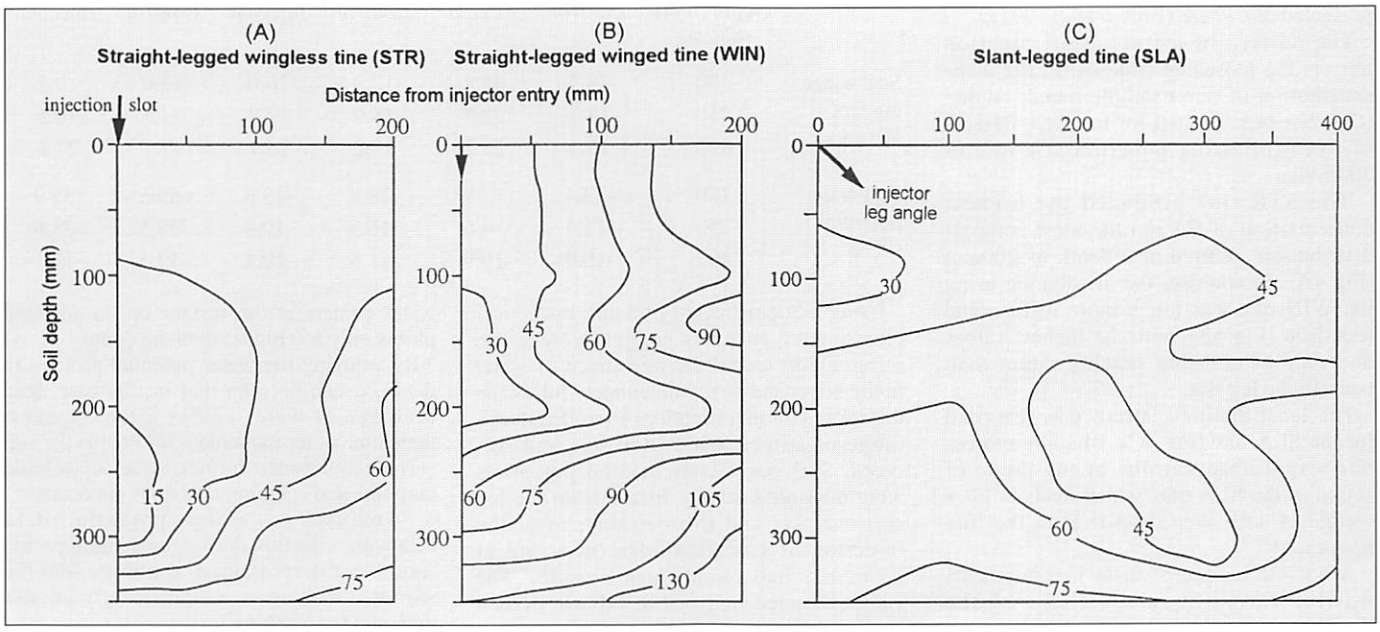


Fig 3. Soil loosening patterns (contours of shear strength in kPa) following the injection of sewage sludge using (A) straight-legged wingless tine (STR), (B) straight-legged winged tine (WIN) and (C) slant legged tine (SLA).

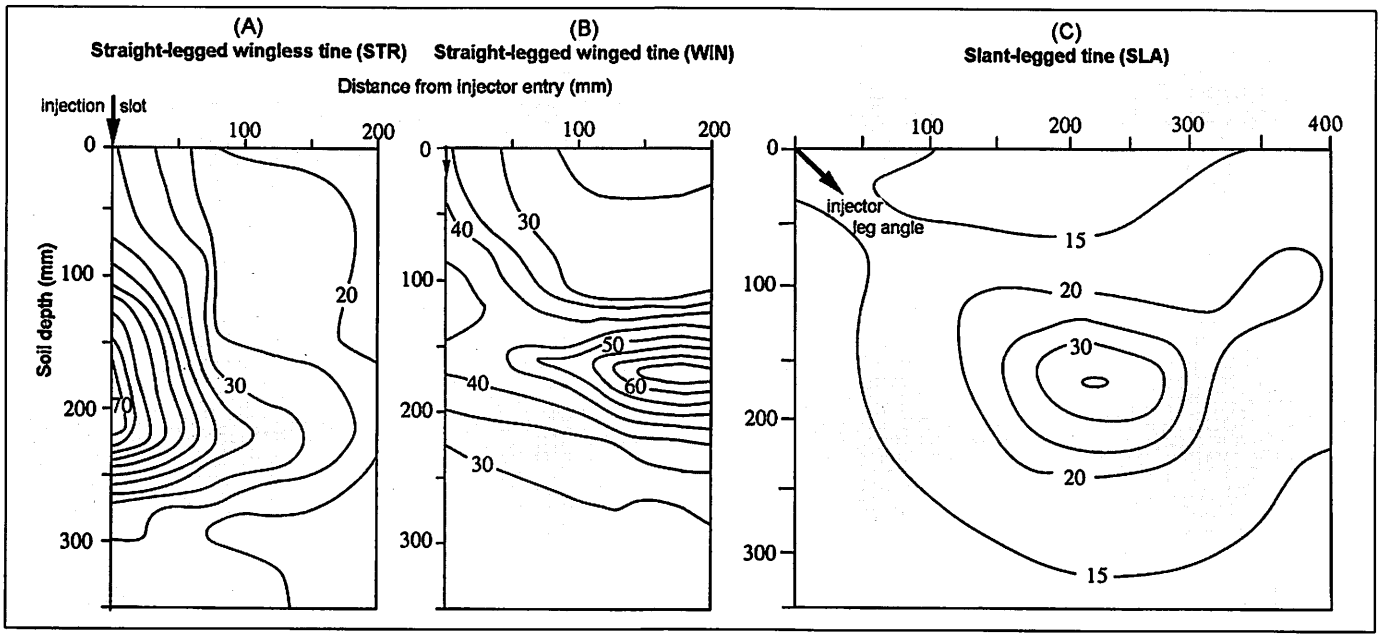


Fig 4. Soil total copper content (mg/kg dry soil) following the injection of sewage sludge using (A) straight-legged wingless tine (STR) (B) straight-legged winged tine (WIN) and (C) slant legged tine (SLA)

lead to an 'out of sight, out of mind' philosophy. There is a tendency to imagine that successful sub-surface disposal is the end of the story. However, waste materials with substantial heavy metal loadings such as sewage sludge need to be monitored post-injection.

Current EC and UK sludge disposal regulations specify that soil sampling must be carried out prior to disposal, in order to assess soil suitability (i.e. not too acidic) and then at regular intervals thereafter if disposal continues on a regular basis.

During the course of our experiments, we carried out detailed soil analyses in order to determine patterns of metal distribution before and after injection of sewage sludge at different rates. Detailed results from these experiments have been presented elsewhere (Brown *et al* 1991).

The pattern of metals after injection mirrors the loosening patterns. In Fig 4 the distribution of one example metal, copper (Cu), has been plotted for the three designs of tines following injection at a rate of 300m³/ha.

The STR tine produced the highest concentration of Cu and the most compact distribution, centred at a depth of 200mm (Fig 4A). In contrast, the distribution using the WIN tine was much more diffuse and less deep (Fig 4B), with the highest values observed at mid-tine spacing rather than beneath the leg slot.

The least distinct pattern was recorded for the SLA tine (Fig 4C), which reinforces our visual observations of the mode of action of the SLA tine, which tends to lift a wedge of soil, then drop it after the tine has passed.

A notable feature of these measurements was the variability associated with the distribution of Cu and other metals in the soil. Individual point values were found to vary by up to 80%, reflecting the uneven distribution of injected sludge, despite our efforts to standardise experimental conditions.

Fate of the liquid fraction of the sludge

The environmental efficacy of the injection process depends upon our ability to retain the mobile fraction of the sludge in the soil near the zone of injection, thus preventing potential pollutants such as nitrates entering drainage systems or groundwater.

Using a sophisticated pressure transducer tensiometer and data logger system, we were able to record the movement of water in the hours and days immediately following injection. Our investigations extended over a range of antecedent conditions and soil types. Soil water contents and potentials were measured 50mm distant from the leg slot one, six and thirteen days after the injection of sewage sludge (at a rate of 150m³/ha) into a sandy loam in spring. The values obtained are listed in Table 2. In each case comparative values for an adjacent undisturbed control site are given.

One day after injection the difference between the injected and control water content near the surface was 27%, but only 4% at 400mm depth, indicating that the liquid fraction of the sludge was still at the depth of emplacement. The low water potentials recorded at the same time also indicate high water contents, just below saturation (0 kPa).

Progressive drying out and movement of water to depth is indicated by declining water contents and increasingly negative water potentials, until Day 13 when the water content at the surface on the injected plot is only 6% higher than the control.

By studying the water potential profiles in detail, it can be seen that in this case deep drainage of water ceases after six days; thereafter water movement is towards the soil surface and hence further losses of soluble nutrients and contaminants does not occur.

Analysis of water potential data following injection during the autumn period shows that deep drainage continued into the winter, resulting in a significantly greater potential for leaching losses.

Further detailed research is continuing in

concluded at foot of next page

Table 2. Soil water content and matric potential measured 1, 6 and 13 days after the injection of sewage sludge using a straight-legged winged tine (WIN). Measurements taken 50 mm from the injection slot.

		Day 1		*Day 6*		*Day 13*	
	Depth (mm) injected	*Control*	*Injected*	*Control*	*Injected*	*Control*	*Injected*
Soil water content (% v/v)	100	18.7	45.8	17.8	26.0	13.0	19.5
	250	18.7	22.2	16.9	22.2	14.5	19.5
	400	18.1	22.2	17.2	23.1	17.1	24.1
Soil water potential (kPa)	100	-12.4	-2.9	-38.8	-13.3	-69.3	-55.9
	250	-11.5	-4.6	-16.5	-10.4	-39.5	-25.6
	400	-10.9	-10.9	-11.8	-10.4	-12.4	-12.1

Safety is everyone's business

Sir,

Accidents in Agriculture

While all in the industry must accept that there are still far too many accidents in agriculture and consequently no grounds whatsoever for complacency, we must also guard against donning the hair shirt too hastily. The Institution's Autumn Newsletter, reviewing farm accident statistics, asserted that 'the products of our industry caused most deaths' and went on to imply shortcomings in the design of agricultural machinery.

An examination of the referenced statistics, however, shows that six fatalities resulting from overturned tractors involved vehicles without safety cabs/frames ie. old machines way below current specifications. Four other deaths involving machines were caused by negligence on the part of the operator rather than the designer; in three other cases, poor maintenance appeared to be the principle factor, yet superficially they were all 'machine accidents'.

Safety is everyone's business, yet a cursory examination of the facts as undertaken in the Newsletter can reach a different conclusion. At best this unfair and at worst it distorts the targeting of remedial action, neither of which serves the interests of safety.

R F Saunders, Technical Director
A E A

Advice for the aspiring

Sir,

Choosing your business studies course

I write this as an interested onlooker and claim no special level of expertise. The following is my own opinion based on limited evidence. As an engineer I should be ashamed of myself but as a father and after years in industry, what I say may have some value.

The present panic flowing through the ranks of potential students for the 'soft option' courses due to government policy and the oft repeated joke of – "What do you say to a Sociology/Social Studies/Business Studies graduate in employment?" – answer "A triple burger and fries please" may not be totally rational. However, my experience of seeing my daughter graduate with hundreds of others with a similar Business Studies qualification along with a handful of engineers rang bells of disquiet. She had few clearly definable skills – which could be bettered by a competent typist – and she only obtained her present post by first selling shoes and then insurance. It was her determination and personality she needed and used. Her 'common skills' made her stand out from the crowd, not her academic achievements, however good they were.

There is a need in modern industry for people with the ability to manage but it is my opinion that they also need a clear focus and real skills and knowledge. A lot of good management is common sense. It is an ability to analyse a problem, arrive at a viable solution and then have the drive and personality to see the task through to its conclusion.

The ability to analyse a problem is based on logical approach and a thorough understanding of the environment in which the problem is seated. Similarly, the solution must be related to the real world we live in with all its physical and human constraints. On the surface, management problems in the hotel business may be similar to those in engineering but the core constraints and possible solutions will be very different. Superficially they may be the same but like beauty these similarities may be only skin deep.

By all means do a course containing business studies in its title, but choose an industry you are interested in. Find some area you want to manage and choose a course that gives you the basic skills in that area and then enhance this with an overlay of business skills. Don't do it the other way round. Business Studies with options is no substitute for Engineering or Agriculture with business studies if those are the industries you want to be associated with.

The third requirement for being a good manager is the ability to see the solution through to its conclusion. This requires personal skills that cannot be taught. They can be developed and enhanced and in choosing your course you need to find a university or college where the individual is important. You need a college with its own strong personality and community spirit.

If you can find the course and the institution that matches up to your requirements you will still need to rely on your own commitment. You do not succeed in business because you have a qualification, you succeed because of YOU and you make the best use of all your innate and aquired skills.

Good luck, enjoy yourself and change the world.

G F D Wakeham

The Bankruptcy Association

Latest figures state that, in the first six months of 1993, a total of 32,448 business failures was recorded – up 5% on the same period last year. Many of these businesses were small, run by hard-working entrepreneurs who were squeezed out, often through no fault of their own and often by larger companies who would not pay up for goods or services.

The devastation caused by bankruptcy has been experienced personally by John McQueen who, in an effort to help others in a similar position, set up The Bankruptcy Association ten years ago. The scale of the problem can be gauged by the fact that this association has grown to over 3,000 members.

Membership of the Association costs £15 per annum. Amongst the services offered is a telephone advice line open day and evening to help those running into financial difficulties. Further details can be had by 'phoning the Association's national enquiry line on 0482 658701.

continued from page 18

order to evaluate the extent of water movement away from the zone of injection.

Implications and conclusions

Injection is a very variable process. Even under 'controlled' experimental conditions, the variability in the depth of operation (±100mm) and metal content described here illustrates that 'out of sight, out of mind' is not a sound philosophy.

Sampling to 'the depth of injection' in order to satisfy the Sludge (Use in Agriculture) Regulations and as described in the WRc Code of Practice (WRc, undated) may not give a meaningful assessment of the total metal loading following disposal by injection. There is a real danger that metal loadings will be seriously underestimated due to the variability of the injection process.

More research is needed into the losses of mobile sludge components, particularly after injection into coarse textured soils in the spring and autumn when water contents are at, or near, field capacity .

Acknowledgements

Rachel Brown held a MAFF postgraduate studentship while carrying out some of the experimental work described in this paper.

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Thermal control and energy efficiency in the built environment

Scottish Branch

Peter Copeland, Building Services Engineer, Dundee University, gave a review of heat energy production, distribution and control on the Dundee Campus. Occupying more than 15 ha, the buildings range in style and construction from late Georgian to modern day, – the New Library was built in 1987.

With an energy requirement totalling 50GWh per year and an associated running cost of £1 million, there is a considerable incentive to seeking ways of making economies.

Modifications over the last ten years to the 25MW centralised heating plant have reduced its fuel consumption by over 40% while serving 35% more area.

Reduced transmission costs, lower working temperatures, better insulation and reduced hot water leakage are some of the factors which have improved the system but the major influence has been achieved through better system control.

Boiler house automation – special systems needed

In 1989, the boiler house was automated and a proprietary SCADA package was used to monitor plant function. However the complete removal of operators posed numerous problems. The ability to see ahead to anticipate load changes was totally absent, resulting in set values being increased to avoid underheating.

This situation was improved by installing a predictive loading algorithm based on degree day data.

Three days' data are summarised on a continuous basis and the values averaged and compared with bench mark values in the control programme. These values are examined at the start of each day to establish the plant operating regime and in this way seasonal variations are automatically accommodated.

Mr Copeland speculated that the experience of Dundee University demonstrated that centralised (district) heating systems could be developed successfully with rejected waste heat being absorbed efficiently, for example, in preheating domestic hot water.

Biofuel was another area which required investigation, citing the example of Denmark where straw, wood and waste fuels provide 25% of the energy source of the heating requirements. Greater use of these renewable sources has to be made and a future role for the agricultural engineer may be one of energy producer/manager.

(25 October 1993 at Dundee University)

Power shift, in two stages

Herts and Essex Branch

Following the very successful evening meeting held in the Spring of last year, the Herts & Essex Branch complemented that presentation on the New Holland Ford full powershift gearbox with a delve into the Partial Powershift Transmission also offered on some of that company's products. **Michael Hall** was the presenter.

Full powershift has several advantages, but on the less expensive products there are penalties – power losses and cost particularly. The 'stepped' powershift overcomes most of these and many seem to prefer this type of system. NHF's version has 16 forward/reverse gears in a 4 x4 layout. All shifts, including the optional creeper speeds, are either synchronised or powershift. A torsional damper replaces the normal dry clutch. A microprocessor ('borrowed' from the car industry) monitors, amongst other things, the oil viscosity and feathers the clutch packs for smooth changes irrespective of oil temperature through special spool valves. The clutch pedal is devoid of 'feel' since it controls a potentiometer.

This gearbox has now been in production for over two years and no major problems have become apparent. The future, will see this type of gearbox commonplace even on the lower power ranges of tractors.

Fishing amongst the chips

Herts & Essex Branch

A few weeks after hearing about the microprocessor in the NHF 'box, the Branch presented an evening on Electronics in Agriculture. It was a joint meeting with the Herts Machinery Club; the speakers for the event were **Chris Thomas** of Agri-TEK and **Andrew Scarlett** from Silsoe Research Institute.

Agri-TEK are the importers of Dickey-John equipment and this company's range of over 2000 products made up the core of Chris' presentation. He described the development of electronics in our industry from initial, rather crude, monitoring of functions to more sophisticated stages, leading to the now well-known abilities of these devices in the control of functions. The hardware depicting the progression was brought along for inspection.

Andrew Scarlett, after an initial review of how electronics are controlling engines, transmissions and hydraulics, got onto his current work at SRI – integrated systems – getting the three separate systems to talk to each other. He gave the gathering an insight into future field operations where output and efficiency would be increased but not at the expense of quality.

It would appear that there are few tasks that could not be improved upon with the adoption of an integrated control system.

(Reports by Richard Langley)

Golf course engineering - from green field to fine turf

The inaugural meeting of the Institution of Agricultural Engineers' newly-formed Amenity and Ecological Engineering Group.

This seminar – Golf Course Engineering – was held in conjunction with the BIGGA Turf Management Exhibition in Harrogate, on Thursday 20 January 1994 and was attended by sixty delegates.

The meeting set out to address three areas of specific interest to engineers, greenkeepers and others concerned with the future development and application of machines, methods and systems employed within the professional turf and grounds maintenance industry.

A trio of authoritative speakers addressed the meeting, which was chaired by Mr **Brian Hurtley**, vice president of Kubota (UK) Ltd and Chairman of the Amenity and Ecological Engineering Specialist Group.

The first speaker, **Dr Bill Adams** from the University of Wales, discussed developments in the construction and drainage of golf greens, tees and fairways with particular emphasis on the different approaches and materials needed in the design and maintenance of sports turf drainage compared with systems used in agriculture.

Mr **Neil Squires**, of the Sports Turf Research Institute, presented an overview of current turf maintenance equipment and questioned whether greenkeepers and groundstaff have available to them the best machinery designs and technology for the job.

Last to take the floor was leading golf course architect, Mr **Peter McEvoy**, who considered the design and development of new courses working in harmony and sympathy with the natural landscape and local environment. Mr McEvoy's co-presenter was landscape architect Mr **Ian Lyne** who discussed and illustrated their golf course development at Fota Island in Ireland, produced very much in sympathy with the environment.

For further information concerning the Amenity and Ecological Engineering Specialist Group, contact M Bird, Honorary Press Officer, 1 Whitehall Strand, Glos. GL5 1HA.

(It is hoped to have expanded reports of these papers in a future issue of the Agricultural Engineer - Ed.)

Drainage pipes for ventilation

Chris Bishop

The use of corrugated polypropylene drainage pipe for crop ventilation is considered. The free area and airflow of the piping are measured and shown to be adequate for grain drying with modification. The deformation of the pipe was measured under different grain loadings and was recorded as no more than 5% even with the modified pipe under a simulated 12m of grain. The drainage pipes were shown to be adequate for bulk potato storage without modification.

For a number of years, limited use has been made of corrugated polypropylene drainage piping for above ground ventilation ducts or laterals (Ryan 1985, Bishop and Tomkins 1987). Pipes of 260mm diameter have about the same cross sectional area as a standard weld mesh and hessian lateral and are available in 6m lengths, weighing 12kg and easily moveable, and in 45m rolls. For assembly, the same type of connectors are used as in drainage systems to join lengths together. At the end of the tubing away from the main duct, a piece of hessian is tied over the pipe end to prevent the grain or other crop from entering.

In most cases, pipes are used for grain ventilation. The advantages cited are;

- A typical price for the drainage pipe is £4.00/m length compared to about £8.00/m for weld mesh and hessian and £13.00/m for above ground steel laterals of similar cross sectional area.
- Installation is easy due to the low weight of the pipe. Pipes are flexible and if they receive a slight knock during the loading of the store, a crack will not open through which grain can enter and possibly restrict or even block ventilation.
- The pipes can be easily hung up out of the way when not in use so providing extra space for other storage purposes.
- The pipes are less susceptible to damage from rodents than hessian.

Concerns over slot area and possible deformation

The major concerns expressed by farmers which have served to limit uptake of the system are that the slot area in the drainage pipe is insufficient for grain ventilation and that the polypropylene pipe might deform under load. It is these concerns which were addressed by the work at Writtle College.

Airflow trials at Writtle College

For grain drying, the recommended minimum airflow is 0.05m³/s/t and with laterals spaced at one metre centres a free area of not less than 0.03m² per metre length of lateral is required (McLean 1989). A standard 260mm diameter drainage pipe from Aquapipes Ltd has between 0.009m² and 0.011m² free area per metre length (Peskett 1992, Tomkins 1987).

Table 1 Air flow at diferent free areas — 260mm o/d pipe

Test number	*Tube free area m²/m*	*Air flow m³/s*	*Static pressure mm H_2O*
1	0.0094	0.034	61
2	0.0175	0.046	46
3	0.0196	0.060	33
4	0.0361	0.070	30

NB moisture content of grain 20.2%

During an on-farm trial, 260mm diameter pipes were used as laterals under 3m of wheat (Avalon 16.5% moisture content) and after three hours ventilation, the airflow measured through the grain was 0.0175m³/s. Assuming a wheat density of 780kg/m³, this figure is equivalent to 0.0075 m³/s/t (Tomkins 1987).

— effect of changing free area outlet

At Writtle College, trials were carried out using a test rig (Fig 2) to identify the increase in airflow when the corrugated pipe free area is increased. Previous work on this subject (Carson *et al* 1980) only considered perforated areas of up to 0.0046m² per metre length of piping whereas for grain drying a figure eight times greater is required.

The test rig comprised of a tank of grain, 750mm x 750mm x 500mm. The length of pipe under test was placed on the floor of the tank and covered with grain to a depth of 320mm. The pipe radial position was recorded and a centrifugal fan was connected via a 5m length of non-perforated pipe. Twelve velocity pressure readings, using a pitot tube and inclined manometer, were taken in the smooth tube in addition to static pressure and temperature. The pipe was then rotated through 90° and the readings repeated. Four sets of readings were taken for each pipe. All joints were checked for leaks at regular intervals.

Four free air outlet areas on the 260mm diameter pipe were measured. The standard method of achieving perforations or slots is with a hot wire which produces a slot approximately 24mm x 2mm. Eight regularly spaced slots are produced around the channel of the corrugated tubing. With 24 slotted rings per metre, a free area of 0.0094m²/m (Test 1) is achieved. A slot width of 2mm is the maximum possible to avoid grains passing through the slots.

For Test 2 the slots were increased in length from 24mm to an average of 45mm which gave an increased free area of 0.0175m²/m length.

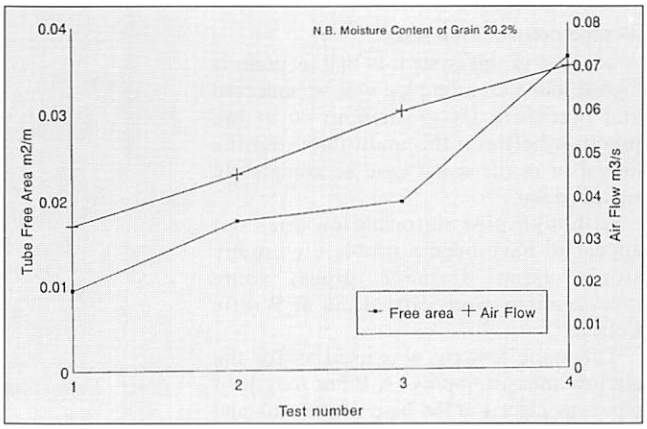

Fig 1. Free area and air flow against Test Number.

In order to further increase the free area, slots were cut in the ribs of the pipe using a saw. Eight 50mm slots were cut to give a free area of 0.0196m²/m length (Test 3).

C Bishop is Senior Lecturer in Agricultural Engineering at Writtle College of Agriculture, Essex.

Finally a second ring of slots was cut in the ribs to give a total free area of 0.0361m²/m length (Test 4).

The results from the test rig are given in Table 1 and Fig 1.

If the grain is assumed to be 3m deep with a bulk density of 750kg/m³ and laterals are at one metre centres, the fourth option shown in Table 1 would give an airflow of 0.059m³/s/t at a similar static pressure, this is higher than the recommended minimum airflow.

It can be seen that the free area has been increased by a factor of four whereas the airflow has only doubled. The reason for this differing rate of increase is not known but it may be due to the rougher edges with the cut slots as opposed to the original ones which were formed by a hot wire.

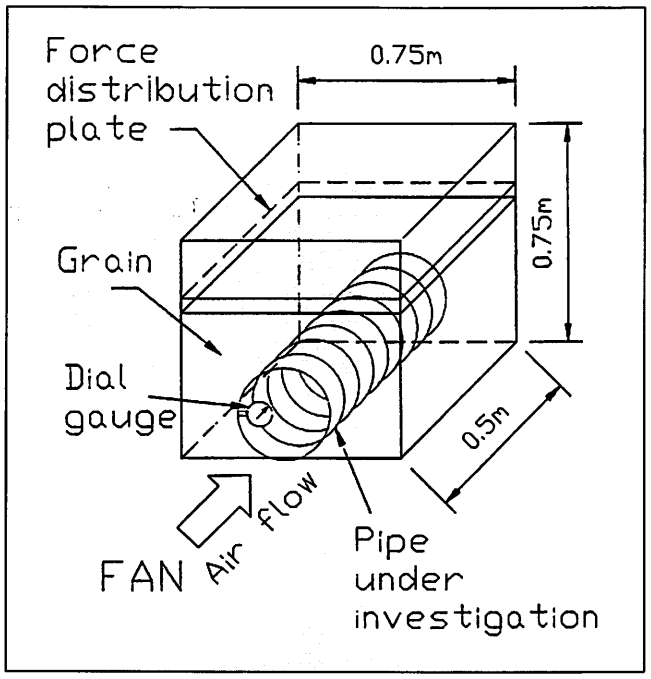

Fig 2. Test rig for deformation of drainage pipes.

— pipe deformation tests

A concern of this system is that as grain is loaded into store, the pipe will be squeezed and therefore let grain pour in at the junction between the main duct and the lateral or in the worst case be completely squashed flat.

Although pipe deformation does not appear to have been a problem with any stores using drainage pipes, some investigations were carried out at Writtle College.

The same test rig was used as for the airflow measurements. A 0.5m length of pipe was placed in the base of the tank and covered to a depth of 660mm with grain. A 750mmx750mmx3mm force distribution steel plate was placed on top of the grain (see Fig 2). The plate was reinforced to ensure an even compressive force. A hydraulic press applied a force to the plate so as to simulate an additional weight of the depth of grain. Dial gauges were placed on the walls of the pipe to measure deflection.

The pipe was progressively loaded with the hydraulic press up to a reading of 2200kg. The loading was again repeated after each airflow test.

The results from the load rig are given in Table 2 and Fig 3. It can be seen that the deflection in the drainage tubes at the equivalent of 4m of grain is still only 5% even in the case of the largest free area.

Ventilation of other crops

As well as having potential for the ventilation of cereal crops there has also been interest in using the drainage pipes for ventilating potatoes. As the size of each tuber is so much greater than of an individual grain the potatoes rest on the ribs of the corrugations and so do not obstruct any of the slot. The free area of a standard drainage pipe was found to be adequate with no modification for the ventilation of potatoes (McGarry 1993).

Acknowledgements

The provision of the drainage pipes used in these trials by Aquapipes is gratefully acknowledged.

Table 2. Tube deflection for different grain depths (m)

Tube free area m²/m	*Deflection mm*	*Equivalent grain depth m*
0.0094	0.00	0.00
	1.26	2.82
	4.28	4.51
	5.34	5.07
	8.30	6.77
	10.40	9.07
0.0175	0.00	0.00
	2.42	1.18
	6.16	2.82
	11.80	4.51
	12.80	5.07
	19.00	6.77
	22.20	9.02
0.0196	0.00	0.00
	9.00	2.84
	14.50	4.51
	15.00	5.07
	21.00	6.72
	27.84	9.02
0.0361	0.00	0.00
	9.06	2.54
	15.16	4.51
	18.26	5.63
	24.64	6.77
	32.60	9.02
	40.26	11.28
	54.84	16.40
	58.80	18.45

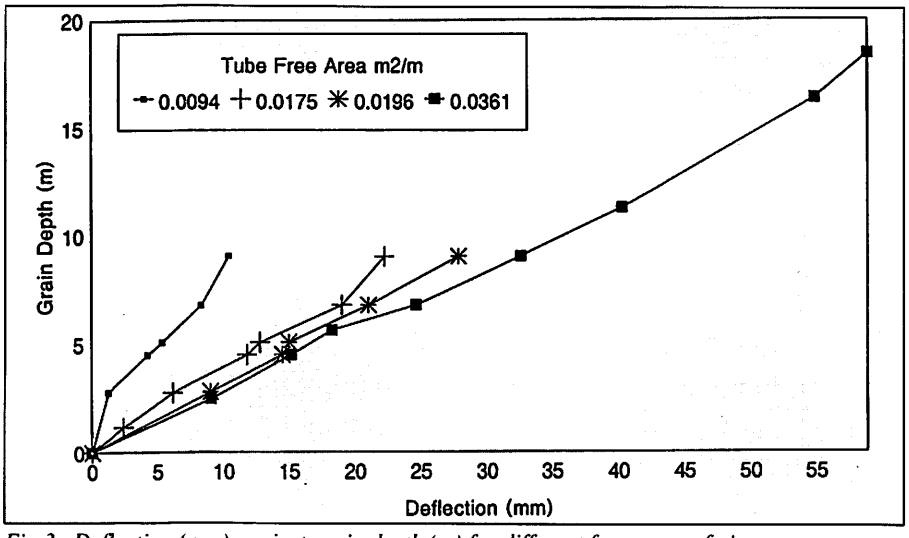

Fig 3. Deflection (mm) against grain depth (m) for different free areas of pipe.

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The demise of the itinerant raspberry picker?

Philip Killington

Twenty-five years spans the period between the initiation of mechanical raspberry research in Scotland and the commercial uptake of the system.

From four machines used in 1992, the total increased to fourteen in 1993. Difficulty in obtaining a large number of casual workers for a relatively short period and the availability of grants to help with the purchase of machines are responsible for this increase.

Currently, under 10% of the crop is harvested by machine thus demonstrating the potential for further increase.

The objectives of raspberry harvesting are threefold:

- to pick all ripe fruit and leave green unripe fruit
- to collect all ripe fruit and remove all the undesirable material collected during the process
- to minimise damage to both the fruiting (second year) and primo (first year) canes.

Raspberry picking machines

Machines comprise of a picking system, a catching system and a conveying system to transfer fruit to the final container. Debris in the sample is removed by fans.

— the picking system

The picking system normally consists of two freely rotating drums. Fingers protrude from the outer surface and the canes pass between the drums allowing the fingers to penetrate the bushes. Fingers vibrate either in a vertical or a horizontal plane and shake the berries from the bush.

— the catching system

Fruit catching devices consist of a series of spring-loaded overlapping hinged plates (fishplates) on each side of the machine. Plates slope upward from each side of the machine towards the centreline.

As the harvester moves along the row, the fishplates move horizontally to accommodate the varying growth habit of the crop. Fruit falling onto the fishplates then rolls to the conveying system.

Considerable damage can be caused to the canes (especially the primo canes - the source of the following year's crop) by the fishplates rubbing against them. Disease can enter these wounds and damage vascular tissue.

An alternative catching system used on Pattenden harvesters employs a series of narrow horizontal spring-loaded trays which moves backward at the same speed as the forward speed of the harvester with the result that there is no relative movement between the canes and the catching device.

Harvesting techniques

Scottish raspberry growers have had to adapt their plantations to allow machine use.

— longer and wider rows

Longer and wider rows are being established with stronger posts and wires used to support the bushes.

— larger headlands

Larger headlands are required and pest and disease control programmes have had to be modified.

— harvesting frequency

Raspberries separate from the plug more easily in warm weather and picking frequency will vary with the intended market(s). Generally, raspberries are machine harvested every 2-5 days, a minimum of five picks is required.

Forward speed is about 0.5m/s and a driver and two pickers would be required for fruit destined for pulping. For a higher quality market (eg individually quick frozen raspberries (IQF)), the number of pickers could be increased to eight if the machine can accommodate them.

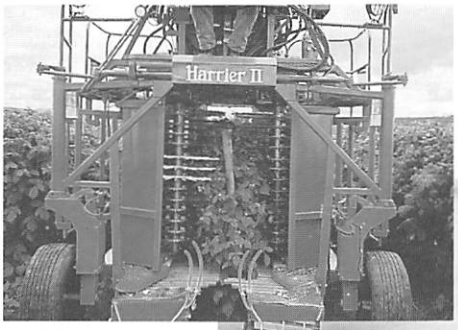
Harvesting costs reduced ...

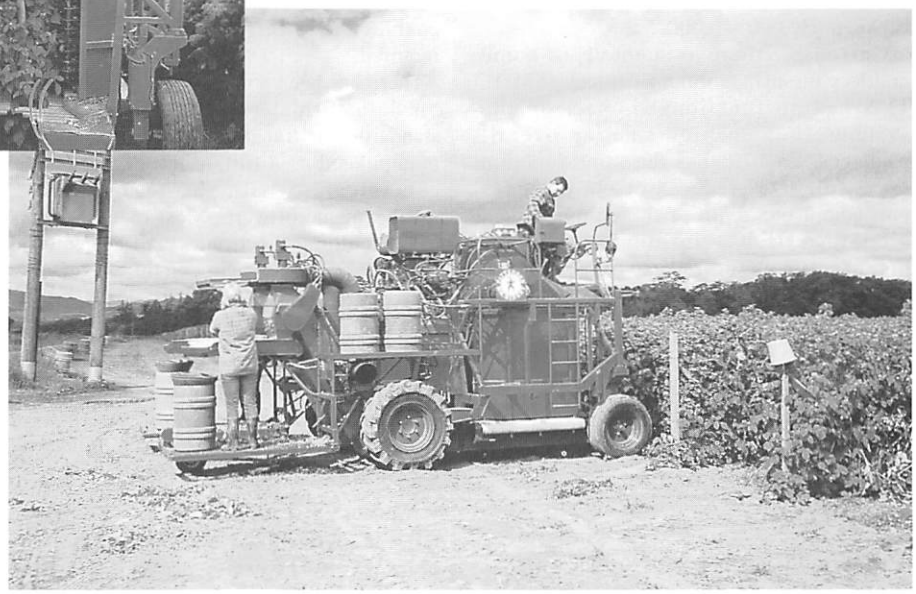
Machine harvested raspberries are primarily being sold for pulping (eg jams, purees, yoghurts) but some have been sold in trays for the whole and broken fruit market. Scottish weather conditions in July – wet! – render high quality fruit picking by machine difficult.

Raspberry harvesters are here to stay in Scotland. It is a way forward that allows growers to reduce their production costs and to compete with imported raspberry prices from Eastern Europe. Other advantages are that increased flexibility is achieved as squads are unwilling to work in showery weather and are unable to start at short notice.

... and hygiene improved

The system also better complies with food hygiene standards due to the reduced handling of the fruit.





The raspberry harvester developed at SCRI.

P Killington is a SAC Horticultural Advisor based at SCRI, Invergowrie.

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Developments in electronics

R C Dandy, RDS Technology Ltd

Electronics in themselves do not form any sort of limitation as far as agricultural technology is concerned today. Whatever is required can be accomplished efficiently, economically and reliably. This is a far cry from how things were when I joined Silsoe College (then NCAE) as an undergraduate in 1971. At that time, there was one scientific calculator in the college, kept securely locked away.

Sprayer electronics

At RDS, we employ 50 people and have 25 PCs, or network terminals. Everything is computerised - CAE, CAD, DAM, DTP, PCB layout, graphics and, of course, accounts. Without this technology, we would not be able to exist.

The same leap forward in technology has had its impact on sprayer electronics. Twenty years ago there was no such thing as sprayer electronics.

The first microprocessor-based instrument which we produced in the mid-70s had a 2k EPROM at a time of memory famine. To get the device at all, we had to buy it directly in the USA at a price of £30.00-40.00. Today we would not dream of designing something with less than 512k of EPROM - and the device costs us £1.25. So you can easily see that, if we were paying the old price per bit, a 512k chip should cost between £30,000 -40,000.

Currently, there is a move in some quarters to surface mount devices (SMD). This has no functional impact on the systems, but enables smaller overall packages. Each IC has the same function as its full size predecessor but occupies only about one tenth of the volume. Such miniaturisation introduces major manufacturing complications and the technology is not supplanting full size technology in all areas.

Display technology continues to evolve. LCDs now have an adequate temperature specification for agricultural application. Dot matrix technology improves all the time with better viewing angle, contrast and temperature specification.

The applications

— Rate controllers

Well-accepted by farmers, two basic approaches are taken, these being flow-based or pressure-based. The former uses a flow sensor directly in the spray line; the latter uses a pressure sensor, and the pressure to flow rate relationship for each nozzle type has to be programmed into the instrument. In either case, the spraying pressure is controlled by a reversible butterfly or pressure control valve.

— Data transfer

There is a major potential source of error from hand-written field records being transferred from tractor to office.

Most modern rate controllers have the ability to log individual field records within the instrument and then download to an in-cab printer or via some medium to a PC.

There are three common approaches to the link. In its simplest form, a wire from the cab straight into the office will do the job - albeit rather inelegantly. A memory card is another means - this is a neat approach - but requires extra hardware in the cab and at the PC. Another approach is to use something like a Psion Organiser. This minimises the hardware cost and enables the farmer to view the content if required.

There has been some standardisation work on data format resulting in the ADIS standard. The transferred data can either be manipulated as a file on the PC, or better, can integrate with the farmer's crop management software. Most manufacturers of agricultural electronics and agricultural software are co-operating on this subject.

— Direct injection

From an electronics point of view, this application poses no major technological difficulties. However, the availability of electronics will not push direct injection systems into the market. Legislation will be the governing factor.

— Sensors/Sensing

Our industry does not use sufficient volumes of sensors to justify the sensor industry developing customised products. Therefore, industrial sensors are used which, in many cases, unfortunately, are unnecessarily precise, too expensive and not sufficiently durable.

Sourcing and proving suitable sensors is a major operation at RDS.

The same problems are encountered when selecting actuators.

Integration of operations

As farming becomes more complex, it becomes difficult to focus on one element in isolation. RDS is developing SVAPS (Spatially Variable Agricultural Production Systems) to allow integration of many operations (Fig 1 – see facing page).

User friendly/foolproof operation

I am sure you are all familiar with the KISS motto, and it is certainly lore at RDS. Every externally accessible switch, knob and programmable factor is a potential source of disaster. The ideal instrument has an on-off switch and that is all. If we, the industry, do not take heed of this, then we will regret it.

With SVAPS, direct injection, etc just around the corner, we could find that we have to supply an RDS engineer with every system to ride in the cab as a sort of flight engineer. Much can be done in the software to avert disaster. For example, error messages of the type - "Are you sure that you want a rate of 2000 litres per square metre?" can be displayed.

The user friendly/foolproof operation is a much greater challenge than the functional one.

Specialised suppliers necessary

We see clearly that there is a 'second wave' of agricultural electronics. The traditional tractor/plough/barbed wire dealer may not be the best supply route. I certainly mean no disrespect in saying this but, with spraying becoming so complex, the supply, support and training needs to come from a specialist sprayer supplier; one who does nothing else but sprayers and sprayer electronics.

Conclusions

Electronics is not the limiting factor in the development of spraying technology. It is available, affordable and reliable.

The application of electronics is limited by:

— acceptance of the technology by the farmers

— absence of legislation, (ie direct injection)

— concern about service infrastructure.

see facing page for Fig 1.

Crop Sprayers – What Now, What Next?

The Machinery Management Specialist Group Conference

Ninety delegates attended this conference on crop sprayer developments on 26th, October, 1993 at Silsoe College. In the last issue of 'The Agricultural Engineer', Mark Paice's paper on 'Patch Spraying' was reported. We are indebted to Bill Jeffrey and David Puller for the summaries of the other ten papers now presented in this issue.

Mechanical weed control - the state of the art

David Pullen, Silsoe College

Pressure to reduce costs and adopt techniques that are environmentally friendly has revived interest in non-chemical weed control methods.

This paper reviewed the state of mechanical weed control techniques and their impact on weed control methods on farms in the future.

Harrows are now available in machine widths of 12m and 24m. Intended for working through a crop, the weeding effect depends upon the crop being deeper rooted than the weeds. Recent trials in Denmark, Germany and New Zealand have indicated control up to 82% of annual weeds, but harrowing was ineffective against deeper rooted perennial weeds.

Hoes operate between the crop rows, so are less dependent on the growth stage of the weed population than harrowing. Each row may be covered by one or more hoes, depending on the spacing. *Sweep hoes* have been widely used in the UK for weeding row crops. The blade, configured in either an "L" or "A" shape, achieves control by cutting the weed roots just below the surface. The depth of operation is normally about 25mm.

The *ducksfoot hoe*, normally fitted to a spring-tine, is well documented. Weeds in the path of the hoe are uprooted, typically with a 90% kill rate in dry conditions; 57% being killed by incorporation in the soil and 33% by desiccation on the surface. A soil cover of 15mm killed small weeds and one of 20mm killed larger plants. At high forward speeds the depth of soil covering increases – improving the weed kill.

The *powered rotary weeder* is fitted with rotating L-shaped blades driven off the tractor PTO. Each unit is individually spring-loaded and the width of the rotor can be adjusted to different row widths. These work well on light, stone free soils but will damage soils with a weak structure.

Non powered rotary weeders normally have two ground driven rotors in each row. The leading rotor moves soil in one direction and the second returns it. Each rotor is made of several spider wheels, the number being changed to cater for different row widths. Tillage intensity is adjusted by changing the rotor angle in relation to the direction of travel and changing the forward speed. The machine is reported to work best on light, stone free soils where penetration is easy. Weed control, achieved partly by dragging entire plants onto the soil surface and partly by burial, is best when the weeds are small.

The *brush weeder* is the latest mechanical weeding machine to be introduced. PTO driven brushes may rotate on vertical or horizontal axes, but only the latter is available in the UK. Mounted between shields which protect the rows, the brushes rotate in the direction of travel and strip the weeds from the soil. Larger weeds demand higher brush speeds, and any increase in forward speed should be matched by a corresponding increase in brush speed. Weeding under very dry conditions is less effective than with a conventional hoe.

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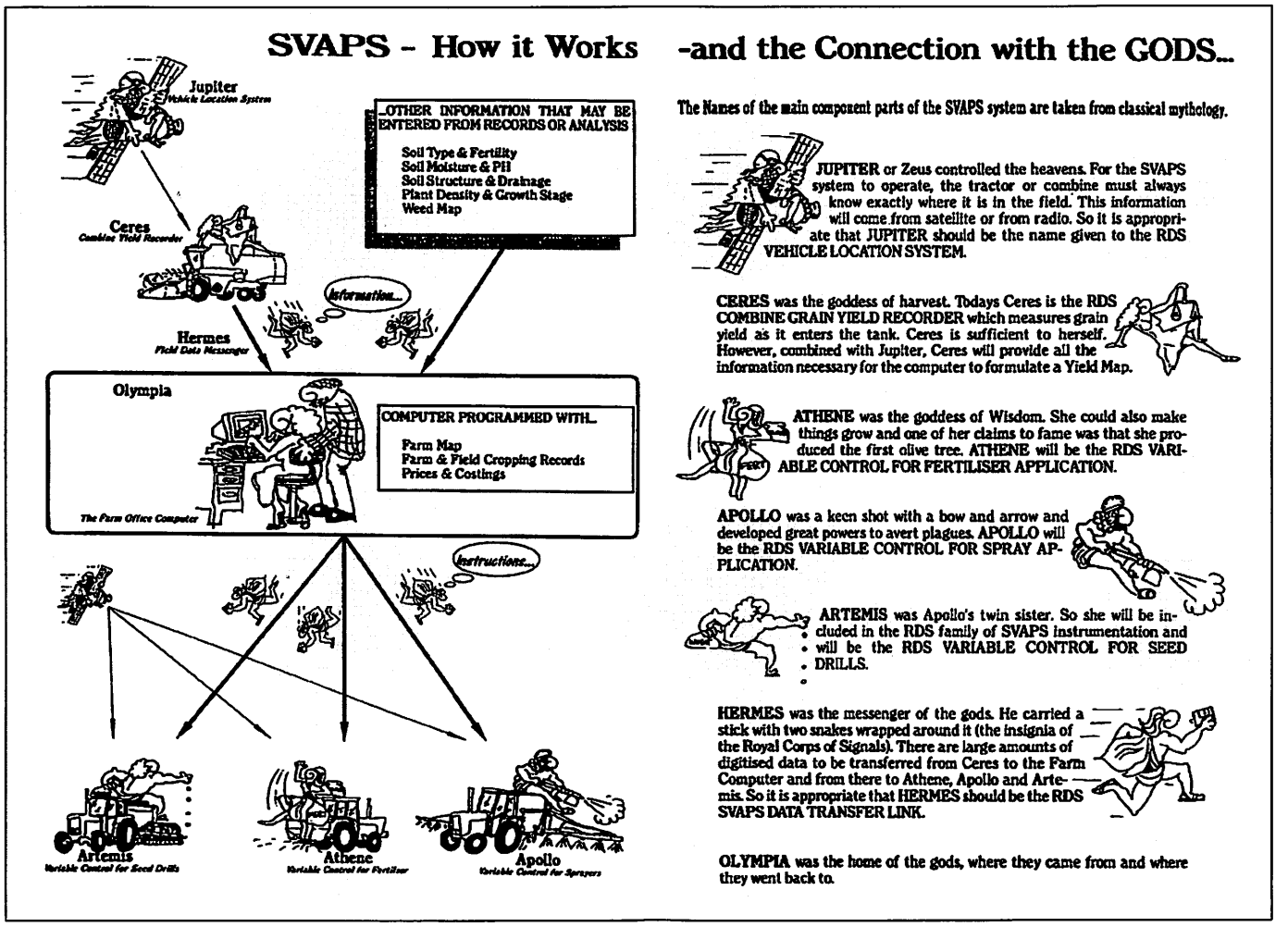

Fig 1. SVAPS – Spatially Variable Agricultural Production Systems.

Empty pesticide container rinsing

A Lavers, Shell Research Ltd

The objectives of container decontamination are to ensure that the empty containers pose no threat to man or the environment and the empty units can be handled along with normal domestic waste. Equally, containers should pose no threat to those who may unintentionally or otherwise re-use them in an unauthorised fashion.

The effectiveness of container rinsing is dependent upon the physical properties of the packed formulation, the ease of emptying the container, the efficiency of the rinse procedure and the absorption or adsorption of the formulation into or onto the container walls. Increasing interest in the disposal and recycling potential of empty single journey containers has added rinsability testing to the series of container tests already in place.

There are currently three recognised container rinse methods

— Lance pressure rinsing,
— Triple manual rinsing
— the 'Dutch Covenant' rinsing system.

The latter two methods were compared for their efficiencies in rinsing a selection of containers used to pack FORTROL, a 50% suspension concentrate of the herbicide BLADEX (cyanazine). Where clean water was used to rinse both one and five litre capacity containers, 99.99% of the originally packed formulation was removed. However, high viscosity liquids, particularly those likely to "cake" on container walls, will obviously present increased decontamination problems.

This series of trials has indicated that the Dutch standard is attainable by various rinse techniques. It must be remembered that clean water was used as the rinsate (in most cases) and rinsing was carried out with freshly filled containers. Under field conditions a quick, reliable rinse technique will gain acceptance where initial product removal can be achieved by using the spray liquid as the rinsing medium. Final rinsing, to an agreed standard may only be achieved using clean water. However, the decontamination standard will be determined by the eventual fate of the container.

Design, operation and performance of direct injection crop sprayers

Andrew Landers, Royal Agricultural College

The paper reviews developments in direct injection sprayers and how they can be used to reduce environmental pollution from pesticides, reduce operator contamination and improve the accuracy of application.

The increasing public awareness of environmental pollution has resulted in legislation regarding pesticide application. In addition, a decrease in profit margins requires closer attention to production costs such as pesticide use.The use of an overall or blanket spraying policy can result in a waste of pesticide and money. Direct injection sprayers allow the operator to select specific pesticides for specific areas (eg. for patches of different weed species or disease).

The direct injection crop sprayer

A crop sprayer is fitted with an injection system comprising one to four pumps that dispense pesticide at a known rate into the water stream, (Fig 1). The main tank of the sprayer holds clean water only. The pesticide is mixed with water, either in the manifold or at the main water pump and the resultant mix flows to the booms and nozzles.

The idea is not new and the first systems were imported from Finland in the late 1970s. There are now several machines available.

The advantages of direct injection systems are:

- Reduced environmental pollution
- Reduced operator risk
- Improved accuracy
- Spot treatment of weeds
- Dose rate adjustment on the move
- Reduced flushing (Table 1)

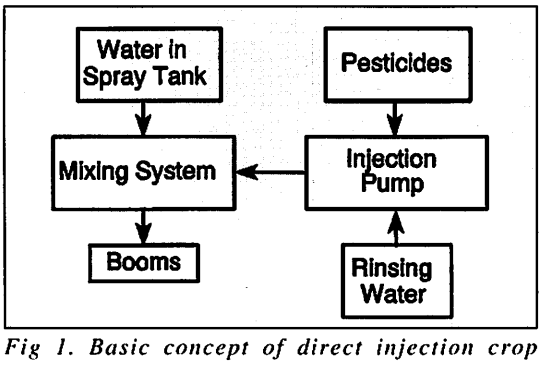

Fig 1. Basic concept of direct injection crop sprayers.

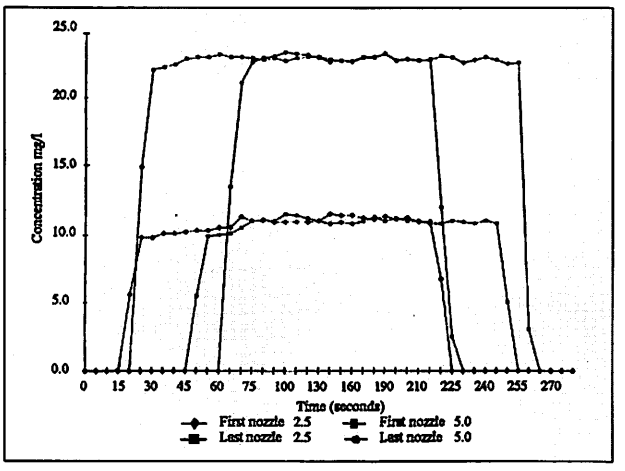

Fig 2. Uniformity of concentration between nozzles.

The designers of direct injection systems need to be aware of mixing effectiveness, response times, and accuracy when changes in operating parameters occur. Safety is important when designing a system to inject concentrated pesticide.

Direct injection sprayers offer considerable benefits

Accurate dispensing pumps are available but it is important that their performance with different products is understood. Effective mixing chambers are also available (Figs 2 and 3), but the time delay, (Fig 4) could remain a problem because of the injector(s) position. Injecting directly at the nozzle would overcome this problem but would involve considerable additional piping.

Table 1. Pesticide residues in conventional crop sprayers.

Model	*Tank capacity (l)*	*Boom width (m)*	*Capacity remaining (l)*
Trailed	2000	24	83.3
Trailed	1500	18	40.5
Mounted	625	12	13.5

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The development and use of a coupling system for small volume refillable containers

M A Perryman, Micro Matic Limited

'Macro Valve' is a coupling system integrated into a small volume refillable (SVR) container which allows the liquid pesticide to be transferred in a closed manner using a pumped, vacuum or pressure dispense system. It consists basically of two items:

i. an extractor valve integrated within the container;
ii. a coupler which, when connected to the extractor valve, allows safe transfer of product from the container.

Proprietary closed chemical measure and transfer systems are available to deliver product to the sprayer. Once the required volume of pesticide has been transferred, the coupler and transfer line can be flushed through with water by connection to a cleaning socket. Containers are designed to be filled on automated packaging lines via the extractor valve, which remains in place in the container neck. These machines can also carry out container rinsing/cleaning prior to filling.

The system is constructed in stainless steel with elastomeric sealing and is suitable for incorporation into stainless steel or rotationally moulded plastic containers of between 10 and 100 litres.

An important benefit of the coupling/SVR system is that container rinsing and disposal on-farm is eliminated.

Environmental aspects

As a leading supplier of valve systems for beer containers, Micro Matic was approached by some major North American agrochemical producers to develop the coupling system. More recently, the development has been supported by the European producers, represented by the European Crop Protection Association (ECPA). The agrochemical industry's objectives have been to adopt closed transfer from container to sprayer, and to reduce the environmental impact of waste packaging .

The draft directive on packaging waste has been issued to EC member governments and is scheduled to be discussed and then adopted by April 1994. Although the precise details will doubtless change during the consultative phase, the likelihood is that the final directive will contain challenging targets for collection, recovery and recycling of packaging materials. Implicit within the directive is the encouragement of re-use systems and likely financial penalties for single trip systems, through tariffs on construction material or container disposal.

The package/coupling system is compatible with these objectives since the re-usable life time of a stainless steel container should be up to 25 years, and bar coding or similar technology provides optimum container traceability.

Project status

Production is under way in Micro Matic's Danish factory, mostly of stainless steel containers of 20, 30 and 60 litre sizes produced for the US market.

In Europe, the system has been extensively tested but, as yet, agrochemicals are not commercially available in containers incorporating it. As a prelude to this, however, it has been agreed by ECPA Packaging and Safe Handling Task Forces to adopt Macro Valve as the standard interface for SVR containers.

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The concurrent development of Global Positioning Systems (GPS) will aid the reduction in pesticide use and allow spray to be applied to certain areas within a field.

As public awareness of pesticide application increases, with more legislation, there is a considerable benefit to farmers and growers in the use of direct injection sprayers.

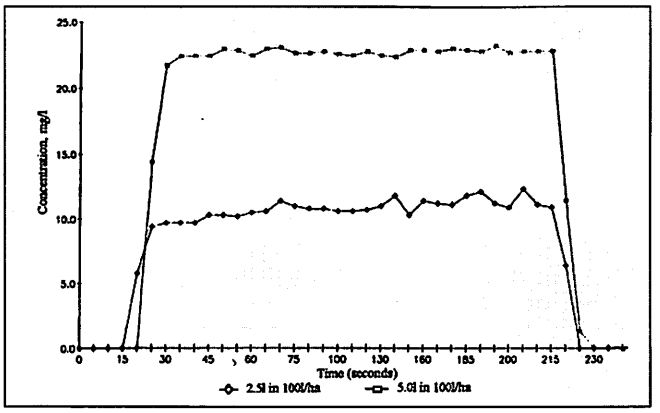


Fig 3. Uniformity of mixture concentration.

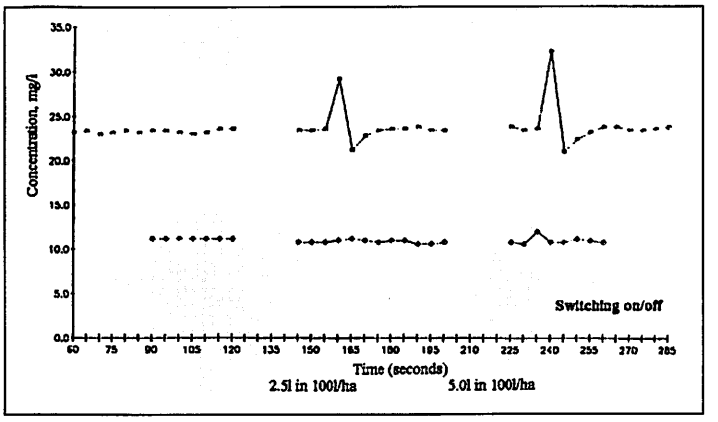
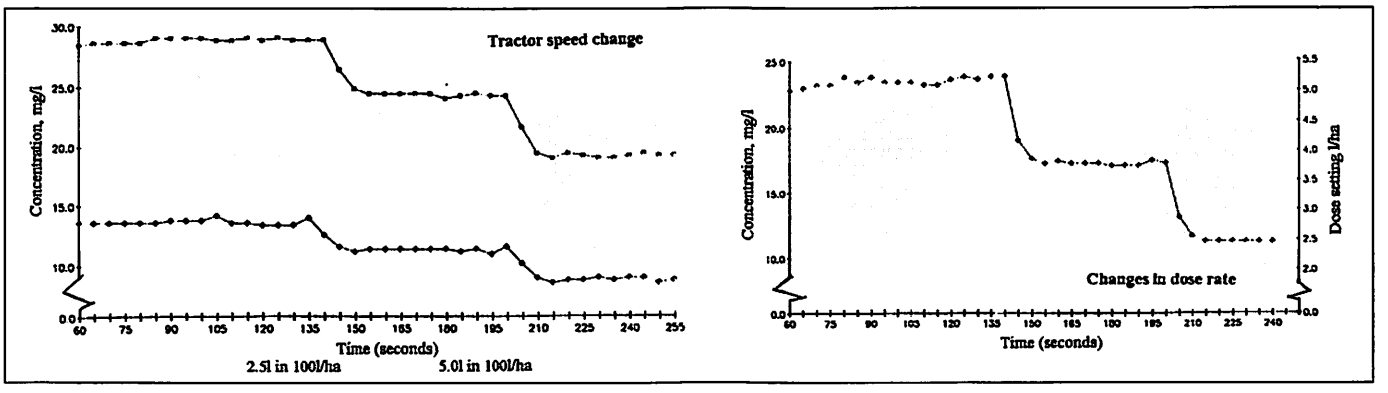


Fig 4. (above and below) System response.



Nozzles and nozzle performance

Paul C H Miller, Silsoe Research Institute

Nozzle selection and performance are crucial elements in all pesticide spray applications. Recently there has been an increased emphasis on selecting nozzles to give some control of spray drift as well as to maintain the efficacy of the application. In this way, contamination of non-target organisms can be minimised.

Improved spray drift control

Examples of nozzle developments that aim at improved spray drift control, in addition to other benefits, include:

- the use of a pre-orifice in flat fan nozzle bodies;
- in-fluid nozzle designs;
- the addition of heat from a flame directed at the region of spray sheet break-up beneath a nozzle.

Defining droplet performance

The need to provide information relating to nozzle performance, particularly the characteristics of droplet size distribution, to aid the process of nozzle selection was recognised in the early 1980s and led to the development, introduction and now widespread use of the British Crop Protection Council (BCPC) nozzle classification scheme. This is a comparative scheme based on reference flat fan nozzles which defines five spray quality categories from very fine to very coarse. The need for this approach arose partly because droplet size measurements give different numerical values with different instrumentation systems due to differences in the methods of sampling sprays and expressing results.

This classification system is now used on pesticide labels, in Codes of Practice, training literature and handbooks. However the scheme has been found to have some limitations in terms of:

- the difficulty of classifying systems that produce sprays which are very physically different from those of the reference flat fan nozzles including spinning discs and twin-fluid nozzles;
- providing direct indication of the risk of drift given that the classification relates only to a comparative measure of the droplet size.

Research project to extend existing classification scheme

A collaborative study involving the major centres concerned with nozzle performance research in the United Kingdom was conducted during 1991/1992 using wind tunnel tests to define standardised protocols which could be used to extend the existing scheme.

The results from the study showed:

- relatively good agreement between different wind tunnel conditions and sampling methods particularly at wind speeds of 2.0 - 2.5m/s (Fig 1);
- relatively low and inconsistent spray drift measured when a fan spray was aligned with the fan in the direction of the air flow (Fig 2);
- a need to have a tunnel cross-section of at least 1.5m for conventional nozzle designs if interaction between the drifting spray and tunnel walls is to be avoided – specialist nozzles may need larger tunnels;
- that drifting spray 2m downwind of the nozzle was typically in droplets less than 100mm in diameter.

It was concluded that wind tunnel tests do form a basis for extending the existing classification in terms of 'driftability' providing that some reference nozzle conditions are included in the test protocol and that collectors with a high collection efficiency are used in the test arrangements.

Further work is now in progress to develop this extended classification and to relate nozzle 'driftability' to the risk of drift from complete spraying machines using computer simulation models and limited field tests in well-defined conditions.

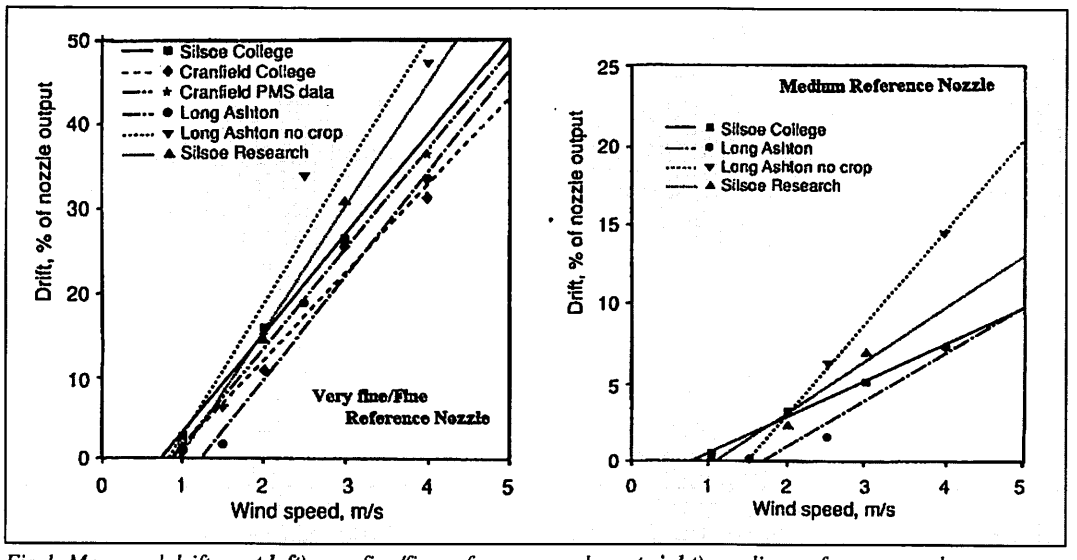


*Fig 1. Measured drift — **at left)** very fine/fine reference nozzles; **at right)** medium reference nozzles.*

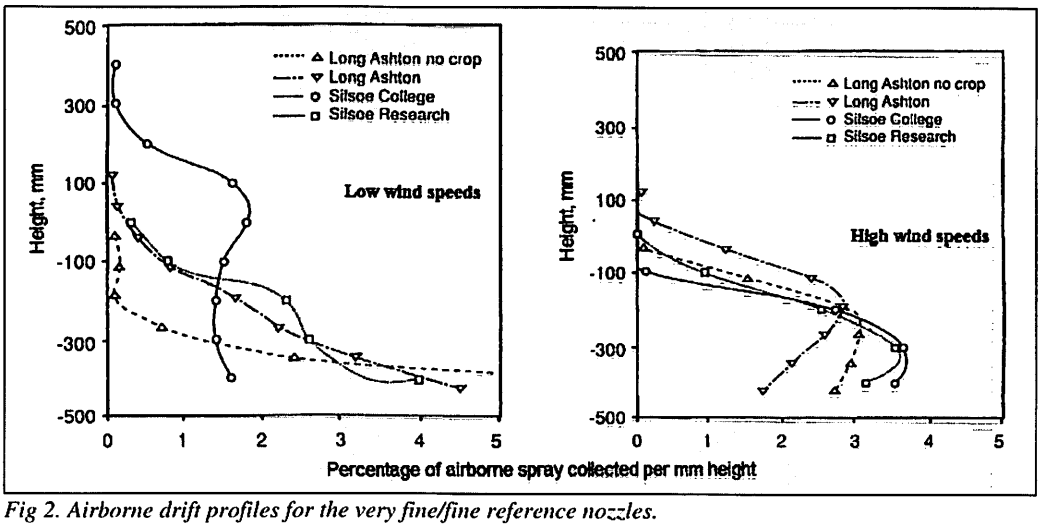


Fig 2. Airborne drift profiles for the very fine/fine reference nozzles.

Scheme for the classification of pesticide equipment by hazard

C S Parkin, A J Gilbert, E S E Southcombe

Official bodies, whose role it is to approve agricultural chemicals and their safe use via suitable equipment, are increasingly seeking a method of classifying pesticide application equipment according to the potential contamination hazard to the operator and the environment. At present a coherent scheme is not available.

Following the widespread acceptance of the British Crop Protection Council (BCPC) spray nozzle classification scheme (Doble *et al* 1985), the BCPC has devised a comprehensive classification scheme, based on potential contamination hazard, that should be applicable to all forms of pesticide application equipment and be capable of being updated in line with future developments. The scheme is the result of a working group of the BCPC consisting of representatives of the equipment manufacturers, chemical manufacturers, regulatory advisors, consultants, and research organisations.

The proposed scheme is designed to be operated by an expert committee acceptable to the regulatory authorities. This will be complimentary to the approval schemes which operate for pesticides. The scheme provides a simple classification that can be easily understood by the user.

Terms defined under the scheme are shown in italics.

Classification structure

In the first instance, the scheme deals with generic categories of equipment, rather than individual designs. Where hazard data on individual designs are available this will be used in the assessment.

Equipment will be classified by the expert committee into *Hazard Categories* based on a hierarchical series of easily identified characteristics each resulting in a *Hazard Index* score.

The individual *Hazard Indices* combine to give an *Overall Hazard Index* which determines the *Hazard Category* for the equipment. *The Hazard Categories* will be communicated to the equipment user via product labelling and the equipment instruction manual. Where the use of different settings, or fittings such as nozzles, can result in different *Hazard Categories*, this information will also be included to guide the user.

It is intended that designs will be categorised using the *Overall Hazard Index* but, should the index result in a classification close to another category, the scheme provides for the manufacturer to be guided by the expert committee, either to provide hazard data, or to modify the equipment to reduce hazard.

The scheme would, by its structure, highlight areas of concern, enabling the manufacture to address any problem directly. This is similar to the structure of the approval schemes for pesticides.

The scheme is based on the following assumptions:-

i. Operators of pesticide application equipment follow Good Agricultural Practice.

ii. The manner in which the equipment can be operated should be closely specified through the equipment instruction manual.

Thus, a *Hazard Category* can be specified for the equipment by virtue of its characteristics of construction and function. This may, however, be modified by its *Technique Of Use* to provide an overall assessment of hazard. This point will be addressed later.

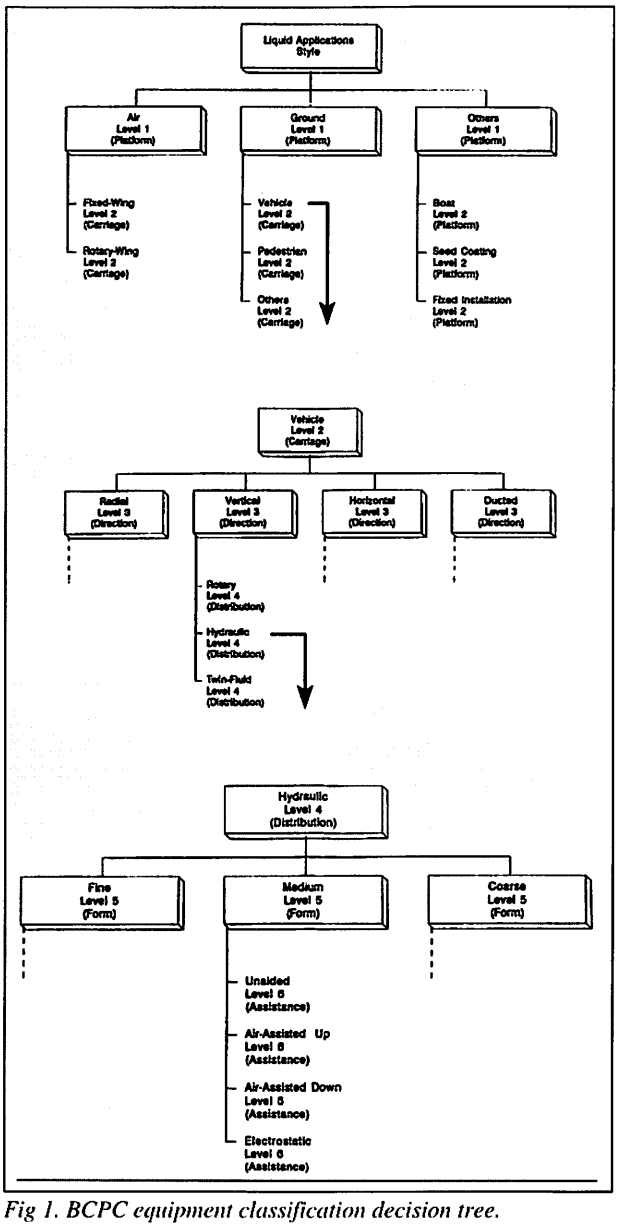


Fig 1. BCPC equipment classification decision tree.

C S Parkin is a Lecturer in Crop Protection at Silsoe College, Cranfield University. A J Gilbert is a Scientific Officer with the Applications Hazard Unit, Central Science Laboratory, MAFF, Harpenden. E S E Southcombe is a Field Scientist in the Applications Department, Schering Agrochemicals Ltd., Chesterford Park Research Station, Saffron Walden.

Hazard Category

– four basic styles of application

The contamination hazard to the operator and the environment from the pesticide application equipment is classified using a series of easily identified characteristics that have a hierarchical structure. Four basic *Styles* of application represent the top level of a decision tree.

The four basic *Styles* are identified as

- Liquid Applications
- Space Applications
- Solid Applications
- Direct Applications

These *Styles* can be subdivided to a maximum of *6 Levels*. Typically, the *Levels* are (with examples in parentheses)

Platform	(ground, fixed, air)
Carriage	(pedestrian, vehicle)
Direction	(up, down, side)
Distribution	(nozzle, scatter plate)
Form	(spray quality, particle size)
Assistance	(un-aided, air-assisted, charged)

Fig 1 illustrates sections of a typical decision tree for a *Liquid Application Style*. For clarity only key sections are shown.

At each level, each characteristic is given a rating related to its contribution to the net contamination hazard for that use. The rating is determined from a consensus of the expert committee, based on available generic or individual data.

Overall Hazard Index

Because the overall hazard of the equipment depends on the interaction of each of the parameters characterised by the *Levels*, the *Overall Hazard Index* will be calculated by multiplying the individual *Hazard Indices* at each *Level*. This results in a geometric *Overall Hazard Index*. It is therefore necessary to examine the classification of equipment using a logarithmic scale.

To establish an objective classification, a test data set consisting of 51 generic applications has been examined by the working group. These applications are outlined in Table 1.

The standard against which the working group compared hazard was a tractor-based, downward-directed, spray application using a BCPC medium quality spray (Doble *et al* 1985). This benchmark was allocated a 1.0 index for each *Level*, thus giving an *Overall Hazard Index* of 1.0.

The *Overall Hazard Indices* of the test data set are plotted in Fig. 2. As might be expected from a large data set of multiplicative indices, the logarithmic values for the *Overall Hazard Indices* appear to be normally distributed.

To classify the applications for the user, four *Hazard Categories* have been constructed. They are based on the quartiles of the generic distribution and thus represent an objective classification.

The lower quartile value was found to be at an *Overall Hazard Index* of 0.75, the median at 1.25, and the upper quartile at around 2.00. These values were therefore adopted as the category boundaries. This is illustrated in Fig 3.

The four *Hazard Categories* proposed are, in increasing order

- Very low hazard
- Low hazard
- Moderate hazard
- High hazard

As stated earlier, it is these *Hazard Categories* that will be presented to the user. Individual *Overall Hazard Indices* will be not be communicated directly to the user. This framework is similar to the labelling guidance that occurs with the approval of pesticides.

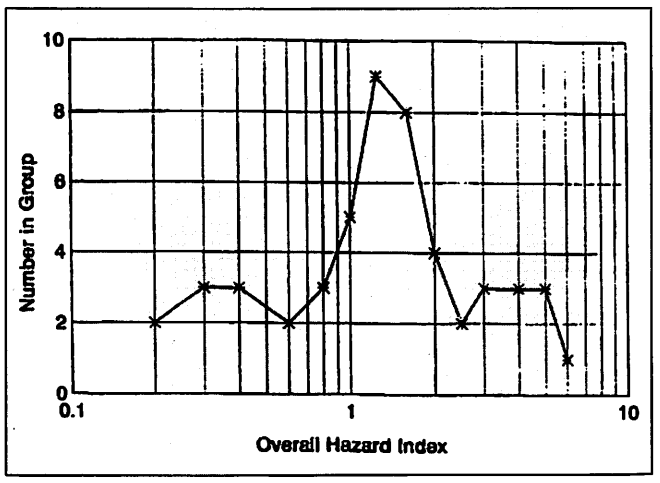


Fig 2. Frequency distribution of generic equipment data set.

Table 1. Examples of generic equipment dataset.

Liquid Sprayers	Space Treatments
Knapsack sprayer	Aerosol can
Knapsack overhead	Thermal fogger
Knapsack mistblower	Cold fogger
CDA sprayer	Mosquito electric pad
CDA placement	
CDA drift	**Solids Applicators**
Standard ground	Granules scattered
Standard low drift	Granules placed
Standard Twin-Fluid	Seed drills
Standard air-assisted	Soil incorporation
ATV ride-on	Hand duster
ATV vehicle	Spot applicator
CDA vehicle drift	
CDA vehicle directed	**Direct Applications**
Air-assisted directed	Rodent baiting
Fruit sprayer axial fan	Tree injection
Fruit sprayer cross-flow	Animal pour-on
Fruit sprayer tunnel	Sheep dip
Roller table hydraulic nozzle	Bulb dip
Roller-table electrostatic	Gel application
Animal spray race	Paint application
Aircraft hydraulic nozzles	Weed wiper
	Seed treatment

(**note**: *several conditions were examined with some equipment. e.g. Fine, Medium Coarse spray quality)*

Assessing the hazard

To illustrate the end result of the classification, a series of generic applications will be examined in relation to typical pesticide application scenarios. Each will represent the typical choices confronting a user. Where applications lie close to a category boundary, both categories have been given.

– Scenario A

Considering an application by tractor-based boom equipment using hydraulic nozzles onto an arable crop, what influence does BCPC Spray Quality have on hazard?

Choice	*Spray*	*Hazard*
(1)	Fine	Moderate/Low
(2)	Medium	Low
(3)	Coarse	Very Low

Thus the equipment in Choice (1) may require specific data to place the equipment in the *Low Hazard Category* and will depend on individual designs.

– Scenario B

Considering an application made to a tree fruit crop using air-assisted spraying, what type of equipment gives the lowest hazard?

Choice	*Spray*	*Hazard*
(1)	Axial-flow	High
(2)	Cross-flow	High/Moderate
(3)	Tunnel	Very Low

Again, Choice (2) may require more data.

– Scenario C

Considering the methods of weed control available to farmers for use around buildings, what method gives the lowest hazard?

Application	*Hazard*
(1) Knapsack sprayer	Moderate
(2) Directed rotary CDA	Very Low
(3) Granular spot application	Very Low

Techniques of use

Although each design can be given a *Hazard Category*, the way it is used may well

well modify its potential contamination hazard in use.

The scheme assumes Good Agricultural Practice, with adherence to all the relevant codes of practice established by the regulatory and safety authorities, and accepted standards for controlling the risk of exposure to hazardous substances.

Use of application techniques which do not follow these codes, or do not meet accepted standards may increase the equipment's potential hazard, even raise it to a higher *Hazard Category*.

This is summarised under the heading *Techniques Of Use*. These are outlined below and are based on current United Kingdom practice (Anon. 1990) and regulations.

Techniques Of Use which will improve safety in use include operating with:

- Cab filtration units
- Closed-transfer systems

These features are not yet an established part of Good Agricultural Practice but in due course they may be incorporated, thus raising the accepted safety standard.

Techniques Of Use which will increase the potential hazard and thus require individual risk assessment include operating with:

- Higher than specified forward speeds
- Zero wind inversion conditions
- Adverse wind directions
- Higher than recommended spray pressures
- Lack of buffer or exclusion zones
- Simultaneously conducting other work

Techniques of use which will automatically move equipment into a higher *Hazard Category*, for example *Low* to *Moderate Hazard*, include operating with:

- No cab on vehicle
- Wind speeds over 2.7 m/s
- Release height over 1.5 m
- Operator/boom proximity less than 1 m
- Working in a confined or enclosed space

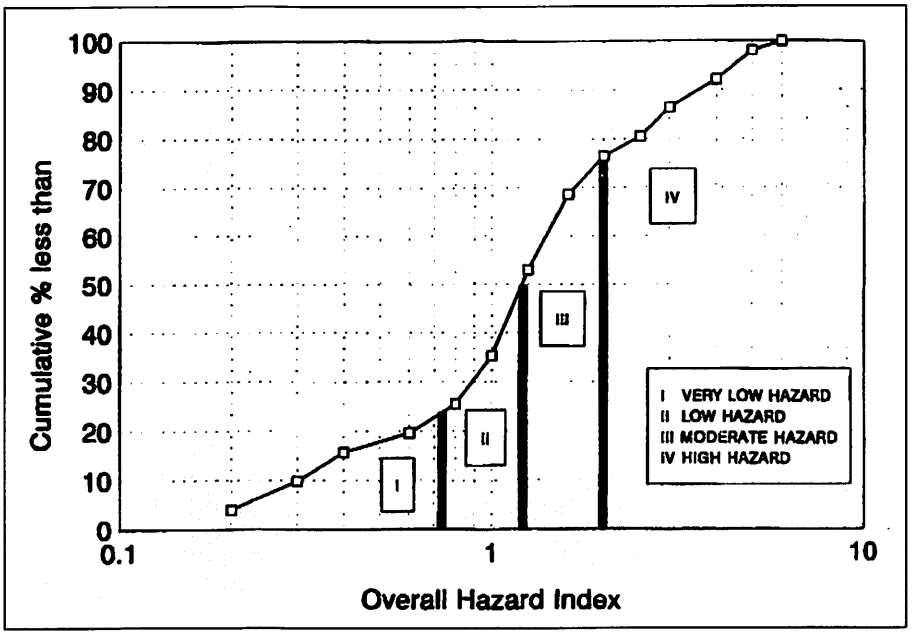


Fig 3. Cumulative distribution of generic equipment data set.

Discussion

No hazard classification scheme can be regarded as perfect but the scheme outlined here should provide an important working framework.

There is no doubt that the scheme as presented will require some 'fine tuning' and that its true test will come with use and experience.

However, since the scheme is flexible, in that the classification structure can be extended and modified, the *Hazard Indices* can be adjusted to reflect the latest research data, and the *Hazard Categories* can be redefined as improvements in safety occur. The scheme should thus be capable of coping with future developments.

An indication of the improvements in safety that could be made is shown in the distribution of the *Overall Hazard Index* of the generic group (Fig 3). In the generic data set considered by the working group 65% of applications were considered to be more hazardous than the benchmark application. As more safe application systems are introduced, the position of this standard in the generic group should be expected to improve.

Acknowledgements

The authors are grateful for the assistance of the other members of the BCPC Equipment Classification Working Group and the statistical advice of C J Marshall, Silsoe College. The working group was set up by the BCPC Chemical Application Committee.

References

Doble S J, Matthews GA, Rutherford I, Southcombe E S E (1985). A System for classifying hydraulic nozzles and other atomizers into categories of spray quality. *Proc British Crop Protection Conf-Weeds*, 3, p 1125-1133

ANON (1990). *Pesticides: Code of practice for the safe use of pesticides on farms and holdings*. HMSO London, 75 pages

Pesticide application in Europe

Mark Thomas, Masstock Arable UK Ltd

In 1990, the author was the recipient of a Nuffield Farming Scholarship to study crop agronomy in Europe. His particular interest was in new techniques for pest control being developed in response to the perceived environmental impact of arable farming. The investigation centred on crop protection – the techniques, products and systems – together with an examination of the legislative controls being imposed upon the industry.

European countries were seen to differ in the level to which consumer lobbying has influenced government-initiated programmes to reform agricultural practices. Some controls are based on real issues, others address perceived concerns. The Netherlands, Germany and Denmark have introduced stringent targets on pesticide use, along with various operator and equipment certification schemes. Compliance with the Danish regulations was largely left to individuals' consciences rather than being effectively policed. Achieving a reduction in active ingredient to specific targets was proving difficult, and the emphasis was changing from a simple reduction of pesticide usage to a policy of sustainable agriculture.

In all the countries visited, including the UK, most spraying appeared to be carried out by conventional hydraulic systems. Most recently, air assisted and twin fluid machines do seem to be on the increase. In Holland, funding was being made available for research into new "alternative" techniques.

The author identifies consumer demand as being for high quality, hygienic food, produced in an environmentally sensitive manner. This will require, among other things, that crop protection products must be applied in a controlled and accurate manner that optimises the activity of the compound, and has a positive influence on the overheads of the farming business.

Field evaluation of air assisted spray applications on cereals

W A Jeffrey, Scottish Agricultural College

Several types of air assisted sleeve or ducted boom sprayers are now available.

As part of a project funded by the Home Grown Cereals Authority (HGCA), a series of trials was conducted over two seasons to compare air assisted with conventional spraying techniques in cereals. Assessments included crop and weed responses, spray deposition and spray drift.

A Hardi Twin sprayer was chosen to be representative of the type. This sprayer is fitted with flat fan nozzles at 500mm spacing, allowing it to operate as a conventional sprayer when the fan is turned off. In each treatment a reference spray was applied at 200l/ha using the full pesticide dose. Further sprays concentrated on a spray volume of 100l/ha and reduced pesticide rates, the objective being to accentuate any differences between application methods.

Deposition on the lower parts of the stems was increased by air assistance applied to a 200l/ha medium spray.

Ground deposits from a 100l/ha fine spray were **reduced** by air assistance when the spray bar was angled towards the rear, and spray distribution on the plants was biased towards the upper strata.

Airborne spray drift was measured at an advanced crop growth stage. Introducing air assistance **reduced drift** by about 50% from both medium and fine sprays.

In both seasons there was evidence of an **improvement in weed control** when air assistance was used with reduced dose herbicide sprays. Weed control varied with boom orientation but the effects were not consistent between species. Air speed was less important, although in general the higher speed produced marginally better results. Fungicide response, as measured by crop yield, was fairly uniform.

A **small yield gain** was evident from air assisted treatments on spring barley, but results from trials on winter wheat crops showed no consistent response.

Closed transfer of pesticides

E S E Southcombe, Schering Agrochemicals Limited

The risks to the operator and to the environment in manual pouring of agrochemicals are well researched and shown to be serious.

Current interest in health and safety is prompting a number of investigations into the need for, and the development of, safer transfer systems.

Standardised containers

The European Crop Protection Association (ECPA) group of agrochemical companies has initiated standardisation now covering much of the world on container design for easier handling, safer pouring and better rinsing. Standard cap sizes and threads for most containers have eased the attachment of coupling systems for returnable containers, transfer systems, container rinsing systems and container disposal.

ECPA considers it to be important to have these developments ready now, even if the demand in Europe is still not certain, and actively liaises with commercial developers of such systems.

Several other groups are developing suitable standards, both nationally and internationally, to ensure that acceptable levels of performance are achieved. This is important, as many new transfer devices and systems have been developed or proposed during the last year.

Health and Safety Regulations

The future of transfer systems for agrochemical products will depend very much on the attitudes of the health and safety authorities.

At present, in the EC, only the Netherlands has regulations making the use of induction hoppers and container rinse probes compulsory. Should closed transfer systems be enforced more broadly, difficulties could arise in supplying the very large and diverse market quickly with suitable systems at reasonable cost.

The debate into the need for transfer systems for products of low hazard category, what standards of 'closed' systems are required and the timing of their introduction will no doubt continue.

VIDEO REVIEW

Traction Engines - a technical insight

Farming Press Videos, Ipswich*

Running time: 37 minutes. £14.95

This video sketches the engineering which led to the development of one of the most evocative of our mechanical aids.

The story begins in the 1700s with the beam engines built for Cornish mines. The world's largest working beam engine is shown being started and operated, and there is an explanation of how it works.

Using archive pictures, Jonathan Theobold (former editor of 'What's New in Farming'). shows how the major problems of converting to rotary motion and constructing pressurised boilers were solved so that the traction engine could be developed. A visit to a traditional boilermaker who builds and repairs boilers with methods similar to a hundred years ago, gives a clear insight into the heart of the machine.

A commentary by Gary Wragg of the Hampshire Museums Service provides some technical details but at a rather superficial level even for those who want an introduction to the world of agricultural steam.

JK

Farming with Steam

Farming Press Videos, Ipswich*

Running time: 48 minutes. £14.95

The unique way steam fitted into traditional agriculture is demonstrated in this video where portable and traction steam engines are shown at work threshing, ploughing, hauling timber and driving a saw bench. Each operation has been filmed in detail with Jonathan Theobold giving a clear, knowledgeable commentary,

The long section on steam ploughing is particularly informative on a subject which has not often been so fully covered.

Hands-on experience is vividly recalled through interviews with an older generation who remember working with steam in their youth and the social background is given by Lesley Colsell of the Museum of East Anglian Rural Life.

The steam threshing gang occupies a key place in the history of rural life, a link between traditional communal manual labour and the age of labour-replacing mechanisation ushered in by the tractor. For those who have an interest in the traditional pattern of activity, this video will make fascinating and instructive viewing. It is highly recommended if you are interested in steam engines.

JK

** Farming Press Videos are at Wharfedale Road, Ipswich IP1 4LG (Tel: 0473 241122).*

DIARY

March	**22–24**	**Environmental Technology 1994** – N A C, Birmingham.
	Exhibition	*Reed Ltd, 26 The Quadrant, Richmond TW9 1DL, (Tel: 081 948 9800)*
	23	**Postharvest technology for Third World development** – Silsoe College
	Convention	*Silsoe College, Silsoe, MK45 4DT (Tel: 0525 860428; Fax: 0525 861527)*
	23–24	**Non-wood fibres for industry** – Silsoe Research Institute
	Conference	*Pira Int, Randalls Rd, Leatherhead KT22 7RU (Tel: 0372 376161)*
April	**27**	**Unsurfaced roads in the rural environment** – IAgrE Forestry Engineering
	Conference	*See back cover*
May	**11**	**Grassland South West** – The Showground, Shepton Mallet, Somerset
	Demo	*Royal Bath and West Society, Shepton Mallet BA4 6QN, (Tel: 0749 823211)*
	17	**Environment and Amenity – IAgrE Annual Convention**
	Conference	*See panel notice inside front cover*
June	**8–9**	**Landscape Industries '94** – NAC, Stoneleigh, Kenilworth, Warwicks
	Demo	*RASE, Kenilworth CV8 2LZ (Tel:0203 696969; Fax: 0203 696969)*

June	29/6 – 5/7	**Computer Technology in Agriculture** – University of Cambridge
July	4–7	**Royal Show** – NAC, Stoneleigh, Kenilworth, Warwicks
	24–29	**ISTRO Conference on Soil Tillage** – Aalborg, Denmark
August	24–26	**Conference on Soil Dynamics** – Silsoe College

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THE INSTITUTION OF AGRICULTURAL ENGINEERS

Forestry Engineering Specialist Group

Unsurfaced roads in the rural environment

27 April 1994 — 0845 – 1700 — Trusthouse Forte, Birmingham Airport

0845 – 0915	Registration/coffee	
0915 – 0920	Introduction	R Hay, *FESG Chairman*
0920 – 0945	Planning and Legislation	R Hay
0945 – 1045	Environmental aspects	S Bell
1045 – 1115	Coffee	
1115 – 1215	Design	
	Geometrics	B P A Jones
	Structural	D Killer
1215 – 1245	The role of fines in an unsurfaced road	A Woodside
1245 – 1300	Discussion	
1300 – 1400	Lunch	
1400 – 1500	Construction	
	Achieving low cost/local resources	J E Anstey
	Pavement/peat/fabrics/soil stabilisation	I D M Hampson
1500 – 1520	Maintenance	F Clough
1520 – 1545	Tea	
1545 – 1630	Bridges and culverts	G Freedman
1630 – 1700	Discussion and Close	R Hay

Our nine speakers come almost exclusively from the Forestry Commission and, therefore, the emphasis will be on low cost, good value and difficult conditions.The Forestry Commission's experience spans 60 years, with16000km of roads and over 2000 bridges constructed, in conditions varying from the harsh north of Scotland to the subdued, balmy New Forest in the south.

Although there are many established construction methods and techniques which will be included, new ones have recently been added – for example, with the increased need to build roads on peat.

In England, and soon in Scotland, Local Authorities require notification before construction of any public roads.This requirement has been introduced because of some bad practice, mainly scarring of hillsides, through a lack of insight into the environmental aspects of road design. This subject and also the landscaping of the roads will be fully covered.

Construction, Design and Maintenance will be discussed and documented in a set of papers which could be used as a design manual. The contents will relate to single-track, unsurfaced roads with geometry and strength to carry up to 40 tonne articulated vehicles with a single drive axle. The grading of the stone for the pavement will be discussed in some detail, especially its effect on slurry formation and pumping action.

Finally, a set of standard bridge solutions will be shown. The most common types are steel/concrete composite; pre-stressed concrete 'T' beams and steel/timber for short to 12 metre spans. Many other past solutions will be shown for their particular merits and the best future ones will be explored.

Costs: £100 plus VAT (Members £80 plus VAT) (Student reductions)
Contact: Geoff Freedman, 231 Corstorphine Road, Edinburgh EH12 7AT
(Tel: 031 334 0303; Fax: 031 334 3047)