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soil and water

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SAWMA VIEWPOINT

At the time of writing this, May will soon be with us although it appears to be an extensi f winter. There is no need for me to point out that all crops and g a a a long vay behind their *normal stage of develop nent.* One good thing could come out of this. It is an to do some 'In-Crop Drainage' which surprisingly enough does little crop damage if done before ADAS cereal growth stage 5. I am sure your local Officer can give you some well documented details on this. Your drainage contractor would, I am sure, be pleased to extend his drainage season which logically should reduce his contract costs.

In the first Newsletter this year, there was a programme for a SAWMA sponsored Conference 'Drainage and Soil Structure' which took place on 14th March at the N.A.C. This was very well supported with 190 persons attending 40% of whom were farmers. In talking to the delegates it became clear that the very many practical points which were made by these leading speakers under the Chairmanship of Sir Nigel Strutt were of great value. Many of these points could certainly be applied with benefit. In a later Journal there will possibly be a re-print of some of the papers., If you do require a full set please write m.

Drainage Course

Now an established SAWMA Course we will once again be holding this at Rycotewood College in Oxfordshire in the third week of December 1978. Last year's Course really was tremendous with stimulating lectures. lively li serious practical guidance all the The College goes out of its way to look after the Association which all together makes it three days which anyone concerned with any facet of the Drainage Industry cannot afford to miss. Manufacturers, Advisors, Contractors and Farmers, you should all be there. Book now with Peter Watkins.

In reply to my query about the photograph on the front cover of the last Journal, I am pleased to re-print the following letters:—

Dear Sirs,

Re. Photograph Front Page Vol. 6, No. 1, 1978. Old Clay Drain

Working in Staffordshire in 1949; I found similar pipes conducting spring water to the site of an old flint working, on high around west of Burton-on-Trent.

I formed the opinion that they were not drainage pipes as such, but carrier pipes for the water. The joints appeared to be clay sealed on a fairly well defined gradient. They appeared to be hand made, and the age in relation to the site would place them possibly about the late 1700s or before.

It may be of interest to note that the terminal arrangement adjacent to the flint works; (assumed for the very large amount of chipped flint in the area) on level ground was a very large horseshoe drain approximately 18–22 inches vertical section; of which very little remained, but which was capable of f greater capacity than the pipes — indicating perhaps that there may have been other piped to area.

Regretfully I have been unable to trace the exact location from any of my personal records, or indeed to remember the site accurately after all these years.

Yours sincerely,
H. R. Grosvenor,
District Drainage Officer,
ADAS.
River Ridge,
Courtlands Park,
Carmarthen, Dyfed.

Dear Sir,

I read with interest of the finding of the unusual clay pipe on a farm in Yorkshire as reported in the recent issue of your Journal.

Whilst there is evidence of the Romans bringing much land drainage skill and experience to this country, there is no firm evidence that they used clay pipes for this purpose (they used open end stone or brush filled ditches), although such pipes were used for domestic purposes e.g. water supply etc.

A similar shaped pipe was described in the RASE Journal of 1852; this pipe was extruded with one end being opened up on a conical former while the other was rounded off thus providing a spiggot and socket joint.

It may be significant that the pipe in your photograph was in thrown or possibly coiled clay and I have seen similar samples used for what was thought to be a water supply conduit in the vicinity of a Roman site in Devon.

Yours sincerely,
C. A. Brown,
Senior Drainage and Water Supply Officer,
Ministry of Agriculture, Fisheries and Food,
Great Westminster House,
Horseferry Road,
London SW1P 2AE.

The Royal Agricultural Society of England's Journal for 1852 says in its report of exhibition and trial implements the following:—

"Tile Machines — Four machines were started for this prize, each of which possesses considerable merit. They began by screening the clay which there were to use, and then made pipes as near two inches in diameter of bore as they could; but as the makers did not possess dies of the same size, the judges recommended that in future the required

In this issue

Name	Stand	Article	Width of Bore	Number of Pips and their lengths		Revolutions of Testing Machine while driving Piston forward	Total Revolutions during which the Men were employed	Weight on break	Number of Men employed	Price		
			Inches	Pipes	Inches			lbs.		£	s	d.
Scraggs	46	1	2	102 6	3 10§	108	155	14	2	16	0	0
Williams	63	18	2	56 4	13½ 29§	133	155	8	2	16	16	0
Armitage	27	1	2	45 5	13 24§	107	155	8	2	14	0	0*
Kearsley	45	1	2⅟₁₆	56 B	14% 59§	111	155	13	2	29	0	0

* The top tier of tiles crushed the bottom.

§ These figures show the number and length of the streams of clay which had passed through the machine, but had not been cut into lengths when the given number of revolutions was completed.

diameter of pipe and width of bore should be stated in the prize list, which would allow a much more accurate comparison to be made. Mr. Scraggs exhibited a novel plan of superceding a collar in many instances, at the small extra expense of 2s. per 1000. The prongs of the horse have a conical collar, which is forced into the tiles when they are taken from the machine: one end of the pipes is thus funnel-shaped: the pipe is then removed and stands a few hours, when it has the other end cut round on the outer side to enable it to fit the wide end of another tile. This idea seemed to the judges to deserve a medal; but experience must decide whether the plan can be advantageously adopted in practice. Below the data from which the judges decided that Mr. Scraggs' machine was the best:—

Irrigation Seminar

The 18 people who attended this first SAWMA Irrigation Seminar at the National College of Agricultural Engineering were more than pleased with the guidelines and information presented to them. Irrigation is one of the few areas of agriculture where nearly everyone knows it pays but the variables of soil type, rainfall, varietal response differences and market factors make it very difficult for anyone to give any hard budgeting facts. Looking around for information to give on this there are very few leads but I hope to have an article on the subject in a Journal later this year.

As the Course progressed it became apparent that there is a great lack of enthusiasm for water scheduling using balance sheet methods. ADAS in conjunction with the Met Office have developed a new scheme for this which would be well worthwhile following.

The next course takes place in December 1978.

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Drainage

A REVIEW OF DRAINAGE MACHINERY IN ENGLAND AND WALES

Tony Bailey, Head of the Field Drainage Experimental Unit at Anstey Hall, Trumpington, reviews in this article the U.K. Land Drainage Industry and draws some conclusions for future action.

DRAINAGE NEED

In 1969 a sample survey was carried out by MAFF to determine the extent of drainage need in England and Wales. This survey showed that an area of 2.88 million hectares was in need of subsurface drainage.

The rate of drainage over, the last decade has shown an increasing trend and even allowing for a fall during the 1976 drought averages 100,000 hectares per annum over recent years. Figure I shows the area drained annually by grant aided underdrainage in England and Wales over recent years.

Updating the 1969 Survey is complicated by the fact that in addition to 'new' drainage problems being alleviated, old decaying systems are also being replaced and are accounted for in the 100,000 ha average annual figure. The best information available to MAFF suggests that in 1977 there still remains a drainage need of 2.6 million hectares.

DRAINAGE PROBLEMS

The drainage problems can be simplified to

- Watertable or groundwater problems
- Impermeable subsoils
- Springs

Watertable

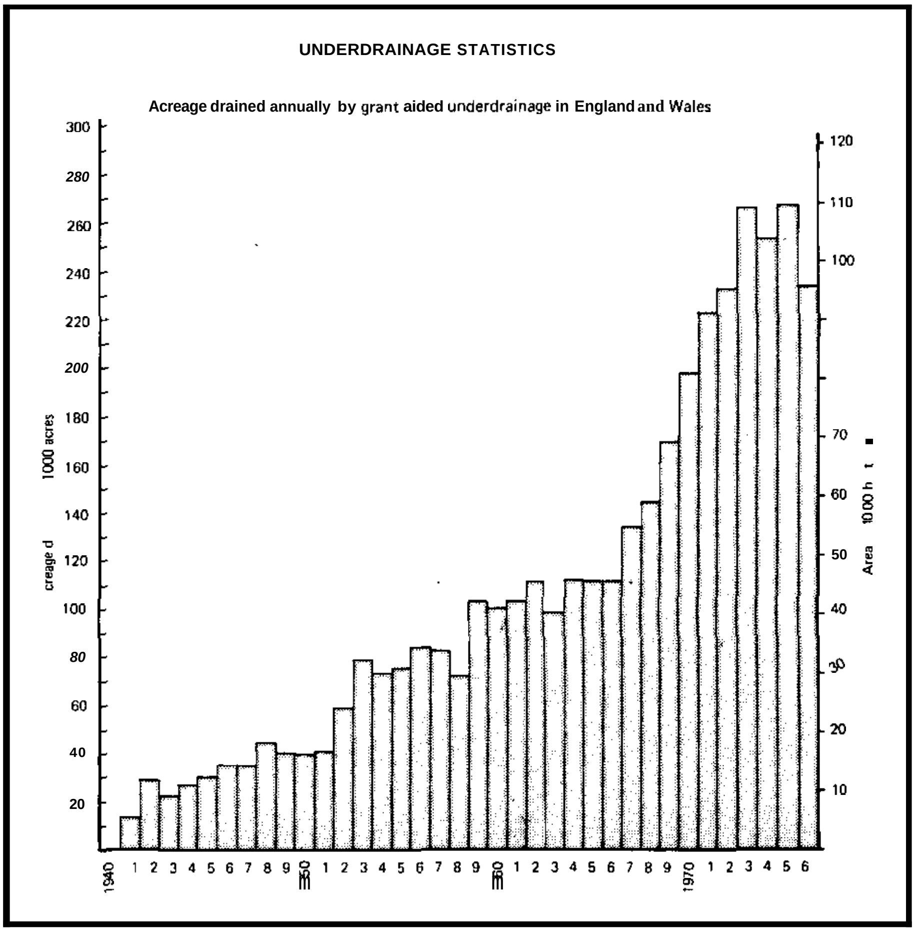
The problem is associated with rising groundwater, characteristically found in the Fen areas and in river valleys. The problem is capable of solution by 'classical' drainage design methods. Subject to outfall conditions being adequate, deeper pipes can give economies on pipe spacing. Machines working in these areas should have depth capabilities down to, say, 2 metres.

Impermeable subsoils

Clay soils are by far the greater problem in UK drainage because of the very slow water movement through the subsoil. Many of the heavy soils require either mole drainage or subsoil modification by subsoiling to give effective subsoil drainage. With mole drainage operations limited to 600 mm depth, there is little advantage in going for average pipe depths greater than, say, 900 mm.

Springs

Involve considerable site exploration involving slow open trench work. The current workload and drainage problems in MAFF Regions are shown in Figure II in terms of the 3 year average 1974–1977.



Fig, I. Land Drainage Service. Agricultural Developmenl and Advisory Service, Ministry of Agriculture, Fisheries and Food.

MACHINERY AVAILABLE

The drainage machines available can be divided thus:

i) Backacters — open trenchers with a discontinuous action
ii) Continuous trenchers —
   a) wheel trencher — continuous action
   b) chain trencher — continuous action
iii) Trenchless (winched) — driven by power winches towards remote anchors, pulling in the pipe in a 'moling' technique
iv) Trenchless (Crawler) — self contained tractor units, 'moling' in the pipe

A survey was carried out by the Land Drainage Service of ADAS in 1976 to determine the size of the national drainage machine fleet. The distribution and location of machines is shown in Figure III.

The national average annual performance figure of available machines is shown in Table 1, based on the mean annual drain length laid over the period 1974–1976. Clearly, all machines are not being used, or in the case of backacters are being used on the other additional work. A well organised machine team should be capable of 150–200 km/annum, and there is therefore clear evidence of ample spare capacity. A factor not known from this data is the age and condition of the machinery.

Table I. Machine performance.

Machine	Total drain length laid — Km (Average annual)	'Apparent' mean performance Km/machine
Backacter	4,080	6
Continuous trencher	38.200	71
Trenchless (Winched)	3.270	38
Trenchless (Crawler)	71i	91

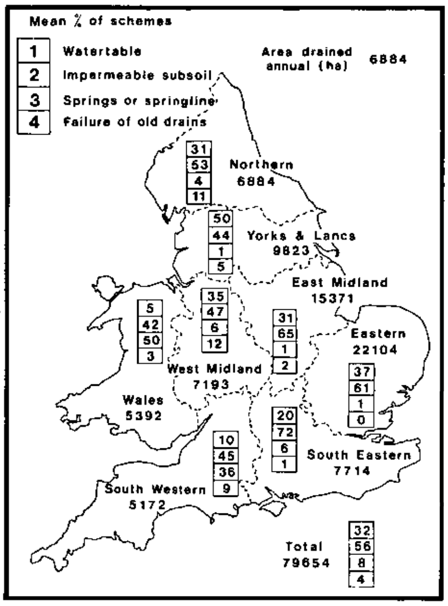


Fig. 2. England and Wales Drainage Problems.

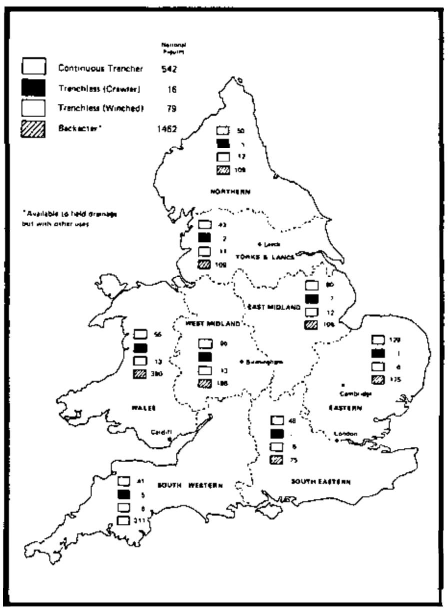


Fig. 3. Drainage machinery distribution.

MACHINE CAPABILITY

Effect of scheme size

An important factor influencing speed of installation is the size and shape of field; and the suitability of the machine for these conditions. The average scheme size in England and Wales is only 6.6 ha, with a distribution skewed towards the smaller scheme as shown in Table II. The relative small size of schemes in the UK limits the high speed potential of some of the larger machines now available.

Table II. Scheme size distribution.

Scheme size ha	Percentage distribution
2	17
2– 4	26
4– 8	32.5
8–16	24.3
16–32	0.2
32–64	0.1
64	—

In practice the continuous trenchers and winched trenchless are operating throughout the job size range, backacters on smaller jobs, and the crawler trenchless most active in the range between 6–16 ha. The general operating range is shown in Figure IV.

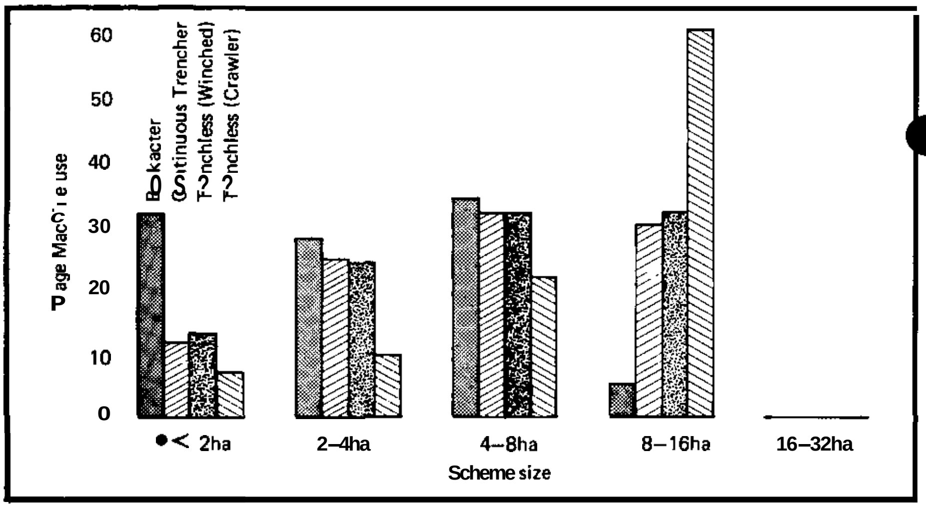


Fig. 4. Machine use/job size.

Effect of trenching hazards

The majority of schemes carried out have few trenching hazards but where they do occur can have a significant effect on the choice of machine.

Table III shows the general experience in the UK of machine use against trench hazard.

In unstable soil conditions problems can be encountered by the creation of slurry conditions and smearing by the continuous trenchers and trenchless machines.

Table III. Trench hazards.

Trenching hazard	Percentage machine use			
	Backacter	Continuous trencher	Trenchless (Winched)	Trenchless (Crawler)
No hazards	45	81	67	77
Unstable soils	6	4	1	3
Solid rack	9	1	3	1
Many stones	36	9	25	18
Fossil trees	0	3	1	0
Others	4	2	3	1

In stony ground there is considerable wear on the cutting teeth of continuous trenchers whereas trenchless machines can cope with stones and small rocks. In excessively stony or rock situations backacter support will be required.

General performance

Backacter —

An extremelv versatile machine. tracked or wheeled, and now mostly hydraulic controlled. It is not exclusive to field drainage works and has universal use outside this activity.

It is used in the UK on hill land drainage projects, small schemes, rocky ground conditions, spring interception schemes, and in support to continuous trenchers and trenchless machines.

Site to site transportation is generally easy, short moves direct, or low loader for distant moves.

Continuous trenchers —

They cover a very wide range — tracked, four-wheel drive, rotaped and towed. Digging methods include ous chain, centre wheel drive or rim drive. There are variations of mechanical and hydrostatic drive, while geared or infinitely variable speeds may be either related or unrelated to rate of forward travel. There is considerable variation on digging depth maximums.

These machines carry out by far the largest amount of work in the UK, the wide range providing considerable versatility. The larger machines work well on the big fenland schemes in the east of England, but there is some concern that these costly, heavy machines were designed for conditions other than those found on the relatively small UK schemes where their high speed/performance potential cannot be realised and the clay soils are susceptible to traction damage.

Some four-wheel drive machines can move site to site themselves, but

V6 - 2

CLAY DRAIN FRIEND OF THE EARTH

Land drain pipes with a high water carrying capacity are more efficient and are less likely to silt up.

Water carrying capacity is dependent on cross-sectional area.

The cross-sectional area of a 3 inch clayware pipe is more than double that of a 60mm plastic pipe.

Further Information from

The British Clayware Land Drain Industry,
Weston House, West Bar Green, Sheffield.
Telephone (0742) 730261

the majority require low-loader transport.

Trenchless —
The versatility is found in the combined range of winched and tracked machines. Their utilisation in the UK is not great but is increasing. UK manufacturers are providing for the machines to handle both clay and plastic pipe, but their full potential seems to be very much related to coiled plastic pipe.

The same concern exists over the big trenchless machines as the big continuous trenchers. The matching of machine to job is considered to be of utmost importance, and oversized machines in small field conditions considerably limit their potential performance.

Transport of the machines is normally by low loader, the big machines requiring specialised transport.

Typical machine specification and performance are summarised in Table IV.

COSTS

Machine costs

Typical costs (1976) of new drainage machinery in the UK is shown in Table V. There is concern amongst some UK drainage contractors at the high replacement costs for machines — particularly the large high performance machines.

Drainage *costs*

The national average costs of UK drainage work (1976) is shown for four typical specifications in Table VI. The significant factor is that there is little difference in unit costs between continuous trenchers and trenchless machines laying clay or plastic pipe. A difference is observed when permeable **backfill** is used — the advantage going to the trenchless machines using less permeable fill.

Using typical performance figures of an average drainage team it is possible to show that within the current unit rate the actual machine cost element is small and that the materials cost dominate. This aspect is illustrated in Table VII. It is likely that the effects of the very expensive machines now available are not yet showing through in these 'national' figures and may yet have a very significant effect on costs.

CONCLUSIONS

Machinery for the UK should be judged against the following requirements:

1) Average scheme size of 6.6 ha, in a range from 2–30 ha
2) High number of moves per machine
3) High percentage of clay soils with soil damage potential from heavy machinery

Table IV. Drainage machinery performance — **smaller/larger** machines.

Machine type	Power (kw)	Maximum digging depth (m)	Trench width (mm)	Working speed (km/hr)
Backacter	36/62	3.5/4.5	305/610	0.2
Continuous trenchers				
a) Chain digger	56/165	1.5/3.5	140/150	0.5/4.6
b) Wheel digger	50	1.8	125/600	0.2/1.0
Trenchless				
a) Winched	22/78	1.2/1.7	120/230	2.0
b) Crawler	100/200	1.5/2.1	120/200	2.0/5.5

Table V. Machine costs

Machine/Equipment	Cost f
Backacter	13,000
Continuous trencher, 50–150 kw	15,500–53,000
Trenchless (winched) 20–80 kw	19,000–33,000
Trenchless (Crawler) 100–200 kw	52,000–76,000
Mole plough or subsoiling tractor unit	20,000
Laser grading equipment	10,000

Table VI. National average costs — **pence/m (based** on **1975/76** data).

Specification	Machine type			
	Backacter	Continuous trencher	Trenchless (Winched)	Trenchless (Crawler)
75 mm clay pipe	61	39	38	36
75 mm clay pipe+ permeable fill	74	68	60	54
60/70 mm plastic	63	41	39	37
60/70 mm plastic+ permeable fill	76	70	62	56

4) Average depth in the heavy soils of 900 mm
5) Average depth requirement in light soils of 2 metres
6) High percentage of secondary treatments and therefore use of imported permeable fill
7) Capability for handling both clay and plastic pipes.

Table VII. Cost elements

Cost element	Trencher Av cost 68 p/m	Trenchless Av cost 62 p/m
Drainage machine	11.5%	11.5%
Labour	11.0%	10.0%
Materials — pipe	23.5%	29.0%
permeable fill	34.0%	29.0%
Overheads	20.0%	20.0%

The increasing sophistication of machines and grading techniques will demand ever increasing operator skill and therefore training facility.

V6 - 2.

The whys and wheres of Wavin land drainage.

The whys.

A. Distributors throughout Britain ensure availability of WavinCoil and WavinFlow anytime, anywhere. Just look at the list opposite.

B. Trenchless or Trenched. WavinCoil corrugated and perforated uPVC plastic pipe comes in five diameters (50, 60, 80, 100 and 125mm) and coiled lengths up to 200 metres for automated continuous laying. WavinFlow rigid, slotted uPVC pipe comes in 20 ft. lengths and three diameters (50, 70 and 90 mm) for open trench installations.

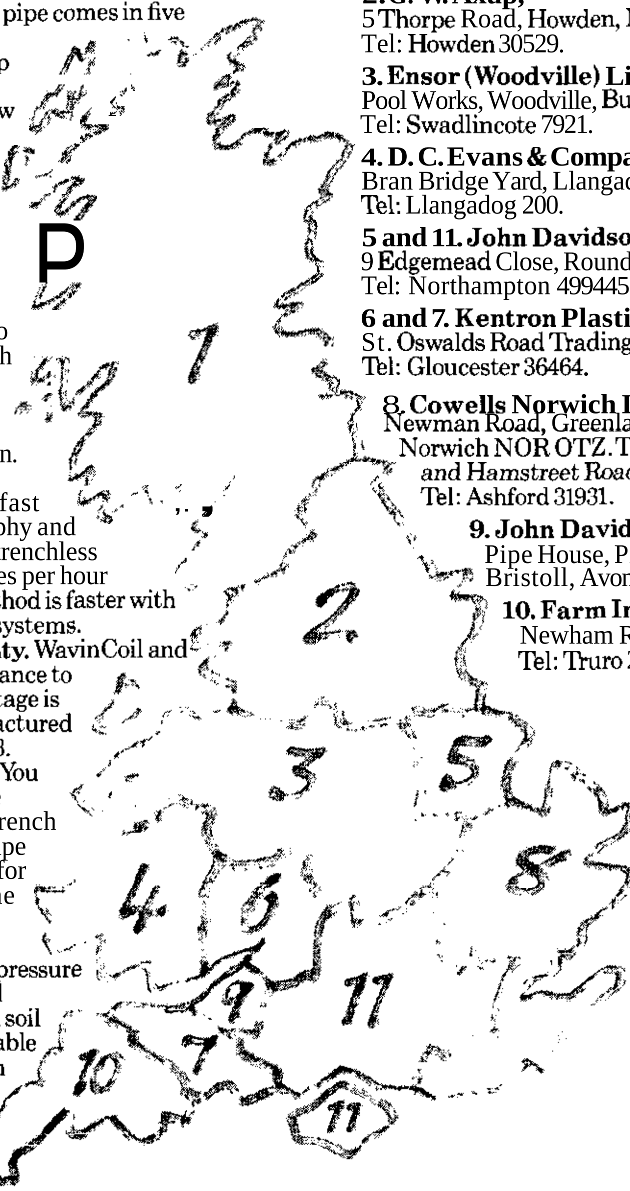
C. Easy handling. Both WavinCoil and WavinFlow are lightweight and virtually unbreakable. So you need fewer men and much less mechanical handling equipment. WavinFlow and WavinCoil are easy to load, unload, cut, carry, lay and join. You save time and money.

D. Faster laying. How fast depends on method, topography and equipment – one automated trenchless machine manages 5 kilometres per hour with WavinCoil! But any method is faster with Wavin plastic land drainage systems.

E. Strength plus quality. WavinCoil and WavinFlow have a high resistance to impact and crushing. So wastage is no problem. Both are manufactured to British Standard 4962:1973.

F. No special backfill. You need less backfill because the trench can be narrower. The trench is narrower because plastic pipe diameters are narrower. And for backfill, you use what suits the soil.

G. Ideal for unstable conditions. Resilient under pressure and vibration, WavinCoil and WavinFlow are immune from soil and chemical attack. In unstable ground, they will not misalign and therefore become blocked by soil entry.



The wheres.

1. John Davidson Plastics Limited,
18 Lithgow Place, College Milton North, East Kilhride, Lanarkshire. Scotland. Tel: East Kilbride 36849.

2. G. W. Axup,
5 Thorpe Road, Howden, Nr. Goole, North Humberside. Tel: Howden 30529.

3. Ensor (Woodville) Limited,
Pool Works, Woodville, Burton-on-Trent, Staffordshire. Tel: Swadlincote 7921.

4. D. C. Evans & Company,
Bran Bridge Yard, Llangadog, Dyfed. Tel: Llangadog 200.

5 and 11. John Davidson Plastics Limited,
9 Edgemead Close, Round Spinney, Northampton. Tel: Northampton 499445.

6 and 7. Kentron Plastics Limited,
St. Oswalds Road Trading Estate, Gloucester. Tel: Gloucester 36464.

8. Cowells Norwich Limited,
Newman Road, Greenlane West, Rackheath, Norwich NOR OTZ. Tel: 0603 720611
and Hamstreet Road, Kingsnorth, Ashford, Kent. Tel: Ashford 31931.

9. John Davidson Plastics Limited,
Pipe House, Pipe Lane, Templegate Bristoll, Avon. Tel: 0272 211031.

10. Farm Industries Ltd.,
Newham Road, Truro, Cornwall, Tel: Truro 2424.

Install Wavin uPVC land drainage systems. Send for literature and more information.

WavinCoil
WavinFlow

Wavin Plastics Limited, PO Box 12, Hayes, Middlesex UB3 1EY. Telephone: 01-573 7799. Telex: 23898. wavin

IRRIGATION SCHEDULING

David Dent **(l in soil science), Richard Hey (lecturer in hydrology) and** Peter **Scammell** (senior **:h :iate. School of Environmental Sciences.** University of **East** Anglia) face up to the questions of ***when to irrigate*** and ***how much water to apply.***

If the soil cannot supply water to meet the crop's full transpiration requirements, moisture stress develops, growth is retarded and the potential yield is reduced.

Following heavy rain or irrigation, drainage ceases when the water in the soil is held at low tension, between 0.05 and0.1 bar (l bar = 14.5 **lbs** per sq. inch). In this condition **the soil** is said to be at ***field capacity*** and soil water is readily available to plants.

During growth water is lost by transpiration from the crop and direct evaporation from the soil surface. The tension at which the remaining water is held increases and the rate at which it is transmitted through the soil is reduced. The maximum water tension at which plants can survive is between **12** and 18 bars and in this condition the soil is said to be at ***permanent wilting point.*** Water held at tensions greater than 12–18 bars is not available to plants.

The amount of water held by a soil between field **capacity** and permanent **wilting point is known as the *available water capacity.***

Although crops can survive at soil water tensions up to the permanent wilting point, potential yields are reduced by much lower tensions. An elegant demonstration of the effect of increased water tension on yields of tomatoes was given by Hudson and Salter (1953) table 1.

Table 1. Effect of soil water tension on yield of tomatoes.

Maximum soil water tension **(bars)**	Average yield of **ripe** fruit per **plant (kg)**	
	variety **Ailsa Craig**	variety **Single** Cross
0.1	3.4	2.6
0.2	3.2	2.2
0.4	3.1	2.2
0.8	2.6	1.8

For optimum yields sufficient water must be supplied to maintain the soil water tension at less than the critical level for the crop in question. At the same time waterlogging and washout of fertilizer must be avoided. Potatoes, tomatoes and green vegetables are sensitive to moisture stress at tensions considerably below **1** bar at all stages of their growth. Some other crops, such as peas, beans and soft fruits, are particularly sensitive during relatively short critical stages of growth.

When to Irrigate

1. Crop Conditions — To delay **irrigation** until the crop is visibly wilting is unsatisfactory. If wilting is due to shortage of available water growth will have already been **re**tarded and potential yield reduced. On **the other** hand, some lush crops will wilt somewhat on a hot sunny day, even when the soil is close to field capacity, but will recover during the night.

2. Soil Conditions — Irrigation **according** to the appearance or feel of the soil is unsatisfactory since the moisture conditions at the soil surface may be quite different from those in the main rooting zone of the crop. Equally, the ability of soils to supply water varies, even at the same water content.

3. Water Budget Approach — Advice on when to irrigate is available through A.D.A.S., based on a water balance between rainfall and an estimate of actual **evapotran**spiration from the crop and soil. (**M.A.F.F.** tech. bulls. 16. 138: **McLean 1975). Estimates of evapotranspiration in 1978** will be **based** on calculations of potential evapotranspiration issued by the Met. Office every seven days for 40 km' areas, using data for **insolation,** air temperature, relative humidity and run of wind. **A** complete ground cover of short turf and an unrestricted water supply is assumed in the calculation of potential evapotranspiration (M.A.F.F. tech. bull. **16,** 1967). To estimate actual evapotranspiration an empirical correction is made to allow for the reduced rates of water loss as soils dry out. **Transpiration** is assumed to occur at the **full** potential rate when the soil moisture deficit is less than 50 mm; the next 50 mm is lost at half the potential rate and a further 25 **mm at** one quarter of the potential rate (M.A.F.F. tech. bull. 35, **1976). The** soil is assumed to be at field capacity at the beginning of the **growing** season and the **esti**mated actual evapotranspiration in excess of rainfall defines the soil moisture deficit.

A simple water balance sheet has several deficiencies when applied to irrigation scheduling.

i Because of the local variability of summer rainfall an on site rain gauge is essential for the compilation of a reasonable water budget. Estimates of potential evapotranspiration are interpolated from widely spaced sam**ple** stations. They are adjusted for the mean altitude of the area but cannot be adjusted for local variations in slope, aspect and exposure. **South**-facing slopes will experience higher values than predicted, and **north**-facing slopes lower values.

ii Soils vary enormously in their water retention characteristics, according to their texture, structure, organic matter content, stoniness and thickness. Figure I depicts the soil water retention characteristics of four contrasting East **Anglian** soils. Each

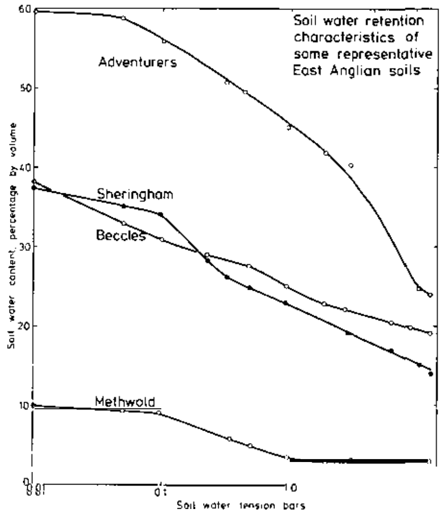


Fig. 1.

curve is an average value of three or more 500 cm' undisturbed topsoil samples. Figure 2 shows, for each soil, the amount of water held within different ranges of tension in the upper metre, assuming the soils are uniform with depth. In the case of Methwold series, a shallow sandy soil overlying chalk, effective rooting depth is commonly less than 50 cm so that the available water capacity may be less than 30 mm.

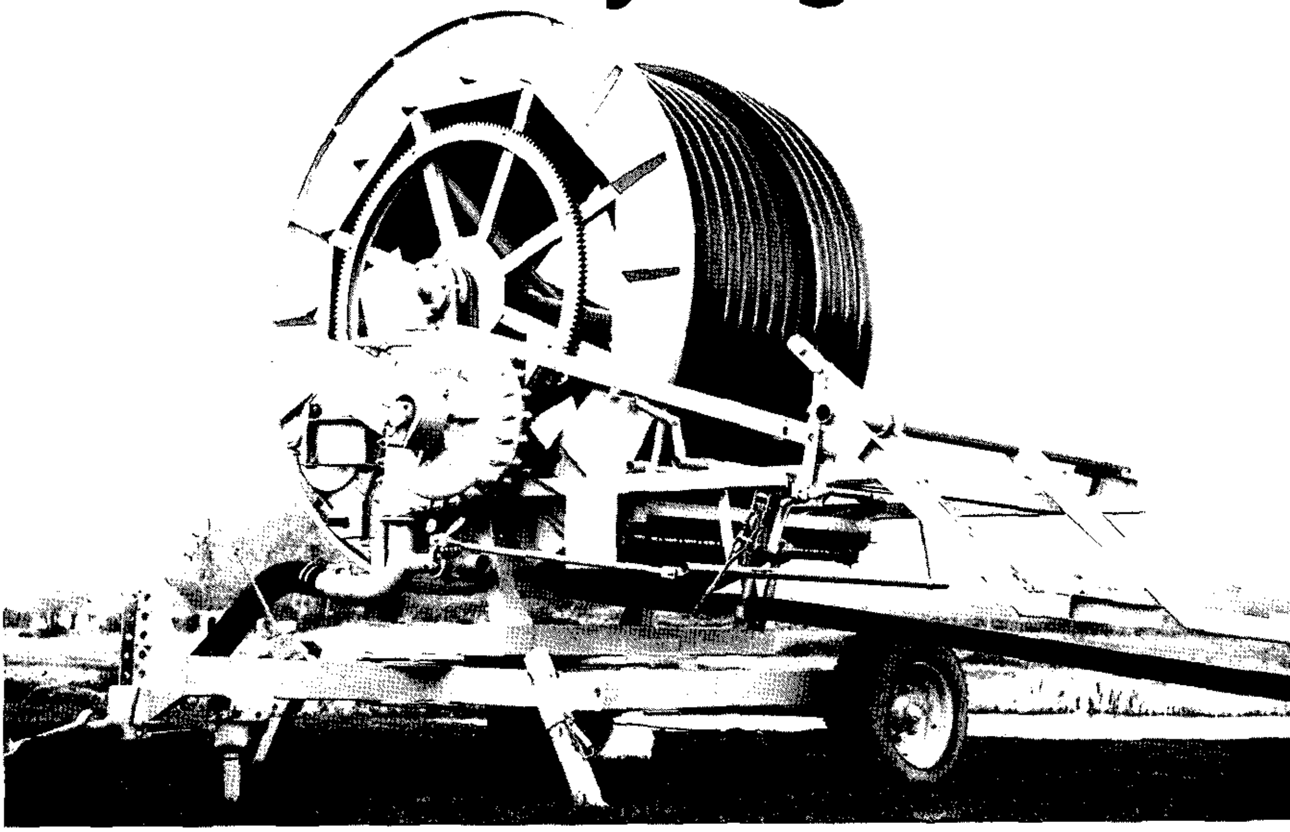
A.D.A.S. make allowance for differences in available water capacities by advocating irrigation of sandy soils at lowei soil moisture deficits **than heavier soils. It is not practicable to make allowance for the effects of** different water retention characteristics on actual evapotranspiration rates.

iii The rate of water loss is also determined by the crop cover and stage of growth. Again, empirical corrections may be made.

iv Much of the water applied by spray irrigation is intercepted by the crop and evaporates without contributing to the soil water reserve.

Vb - 2.

R winds up selling more than any other brand. 'Touraine' by Wright Rain.



It's a fact—since **automatic hose** reel **irrigators** were **introduced** into the **UK,** more **Wright Rain 'Touraine'** machines have been sold than any other **brand** It's not **really** surprising though when you consider ALL the **facts.**

Cost Effective Labour saving equipment.

'Touraine' automatic irrigators cut labour costs to bring rich returns on a wide variety of crops; in fields of all shapes and sizes, the hose winds up automatically, pulling the wheeled sprinkler unit through the crop. One man and a tractor can reposition the hose drum in minutes.

The 'Touraine' offers much more:

- *Full flow turbine* means no by-pass mechanism and no wasteful discharge of water as with alternative piston/bellow systems which result in undesirable friction losses.

  Turbine responds to varying short term loads.
- *Fewer stoppages* caused by dirty water—turbine can cope with dirty and gritty water.
- *Drive mechanism* operates in full rotary manner for maximum efficiency—no need to convert from reciprocating movement as with piston/bellows drive.
- *Variable speed pulley*—allows simple and precise selection of pull-in speeds to suit different requirements.
- *Sprinkler carriage* fitted with either three or four wheels to minimise crop damage.
- *Four models* available to cope from 6 to 19 acres per day coverage, applying 1" water.

Complete, Big Company Back-up.

This year Wright Rain celebrates twenty-five years of irrigation. So you can buy in the confidence that our comprehensive service will always be here whenever you need us.

You can rely on the after sales service too, with over one hundred dealers throughout the UK—we even have a hose repair service, in case accidental damage occurs to the hose.

Wright Rain Finance makes it easy

Competitive purchase or leasing terms can quickly and easily he arranged through Wriglit Rain Finance.

Send for details.

SW 5/78

Please send me full details of the 'Touraine', your other profitable irrigation systems and the Wright Rain Finance plan.

NAME

ADDRESS

TEL:

Wright Rain

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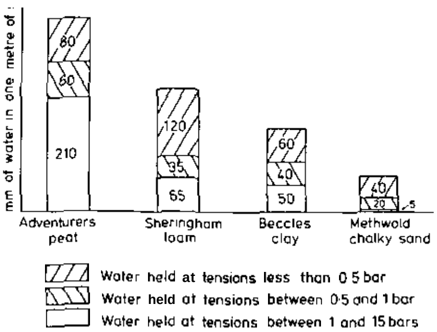

Fig. 2. Available water capacities of some representativeEasr A nglian soils.

Under a full crop cover the irrigation efficiency, calculated by dividing the increase in soil water content by the volume of water applied, can be as low as 10 per cent. for a light irrigation or rainfall. Irrigation efficiences of greater than 50 per cent. are rarely achieved in practice.

In theory it is possible to make correction for all these deficiencies in the calculation of soil moisture defi- ; and provide a good daily estimate of ε .l evapotranspiration but this would require an extensive field calibration programme. A.D.A.S. consider that the present method is sufficiently accurate for irrigation g purp c es sinc the amount of water applied during irrigation is not accurately metered and not evenly distributed.

v The water dget approach ca not l lied l multi or glasshouse situations.

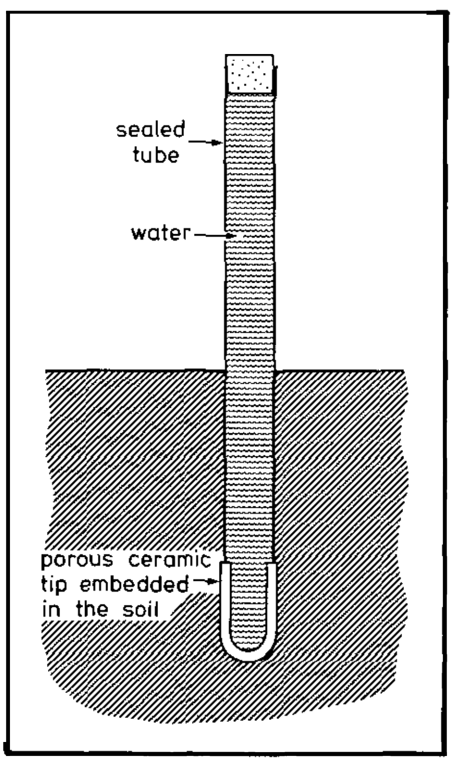

Fig. 3a. Tensiometer.

4. Direct Measurement: Tensiometer Method — Some of the deficiencies inherent in the water budget method are avoided by direct measurement of soil water tension using a tensiometer — a sealed water filled tube with a porous ceramic tip emplaced in the soil (figure 3). At field capacity water fills small pores in the soil and forms a film around larger pores. This water is in contact with water in the tensiometer through the pores in the ceramic tip of the instrument. As water is extracted from the soil the water films become thinner, the soil water tension is increased and water is drawn from the tensiometer through the ceramic, creating a partial vacuum in the instrument.

When water is added to the soil the soil water tension is reduced and water flows back into the tensiometer until a new equilibrium is established.

The equilibrium value between soil water tension and the partial vacuum in the tensiometer may be measured directly using a manometer or vacuum gauge. The instrument records zero tension when the soil is saturated with water. At soil water tensions in excess of 0.85 bar air bubbles are drawn into the tensiometer through the ceramic and it must be re-primed.

Tensiometers inserted within the rooting zone of the crop permit accurate day to day measurement of soil water tension. When the critical tension for the crop in question is reached irrigation can be applied to restore the soil to field capacity or any desired water content. The amount of water required can be read from the soil water retention curve and the efficiency of water application can be determined from the tensiometer readings.

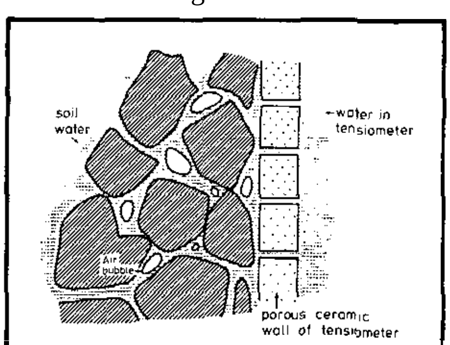

Fig. 3b. Enlarged section of the ceramic rip embedded in the soil.

By this method precise control of irrigation is possible. Soil water tension can be maintained within the optimum range for any crop; excess water use leading to waterlogging or washout of fertilizer can be avoided; and manpower can be saved by eliminating unnecessary irrigations on soils with high water holding capacities. When water or equipment become limiting during the irrigation season, the facility of direct measurement of soil water tension enables informed decisions to be made on which crops need priority.

Problems inherent in the use of tensiometers for irrigation scheduling are:

i Any direct measurement applies only to a single point in the crop. Even within a field soils may vary enormously in their water retention characteristics so soil survey is required to identify the soil types present and their distribution pattern. Where soils of contrasting water retention characteristics occur the instruments nay be located in the soil which olds the least amount of water below the critical tension for the crop in question and which occupies a significant area. In this way the requirements of this soil will be met and all other soils will be within the optimum range of water tension.

Instruments are best located in pairs, one in the upper part of the rooting zone and one in the lower part. The upper instrument records when the critical tension is reached in the zone where the main part of the root system and most of the plant nutrients are located. The lower instrument records when rainfall or irrigation water has infiltrated the deeper rooting zone.

ii The tensiometer will measure only the lower part of the range of available water (up to 0.85 bar). However for crops which benefit most from irrigation the value of soil water tension for optimum growth is well below 0.85 bar. If required other types of instruments are available which are sensitive up to 15 bars.

Comparison between water budget and tensiometer scheduling

The use of either the water budget method or the tensiometer method of irrigation scheduling can be expected to give substantially higher crop yields than ad hoc application of water. A comparison between the water budget and tensiometer method using cabbages (Scammell and Hey 1976) showed a 38 per cent. improvement in yield, a 20 per cent. reduction in water use and an earlier, better

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Table 2. Effect of varying irrigation treatment on water use and cabbage yield: May–July 1976.

	Water Budget corrected for irrigation efficiency	Tensiometer Scheduling	Rainfall Only
First irrigation	June 15	June 9	—
No. of irrigations	3	4	—
Total amount of irrigation water applied (mm)	229	182	—
Rainfall (mm)	35	35	35
Yield as percentage of Water Budget Method	100	138	44

quality crop using tensiometer scheduling, table 2.

In this comparison the plots were returned to field capacity with each irrigation. The water budget was calculated from fortnightly figures for potential evapotranspiration, corrected for the water retention characteristics of the soil and measured irrigation efficiencies.

A.D.A.S. advice in 1978 will use weekly data for potential evapotranspiration and revised allowances for the effects of crop cover. Applied to the 1976 trial this would have scheduled the first irrigation on June 2nd; six irrigations; and a total of 150 mm of water without allowance for irrigation efficiency (R. J. Adams personal communication). This compares with 180 mm scheduled in the 1976 trial without a similar allowance.

The agreement between this value and the amount scheduled by the tensiometer method is to be expected because the soil had an available water capacity close to the value assumed in the A.D.A.S. calculations of actual evapotranspiration. For soils with a significantly greater or smaller available water capacity the amounts of water scheduled by the two methods would have been different.

The differences in yields obtained in the 1976 trial can only be attributed to differences in the timing of irrigation.

Conclusions

Accurate estimation of irrigation requirements on a day-to-day basis using the water budget approach requires several empirical corrections, notably for crop cover, soil ,water retention characteristics, and irrigation efficiency. Computing facilities or some rather involved book-keeping are also needed. Direct measurement of soil water tension using tensiometers offers the possibility of precise control of soil water, tailored to the crop and soil in question. However, the advantages of direct measurement are lost unless the instruments are sited so that they accurately reflect the water status of the crop as a whole and unless irrigation water is applied reasonably evenly.

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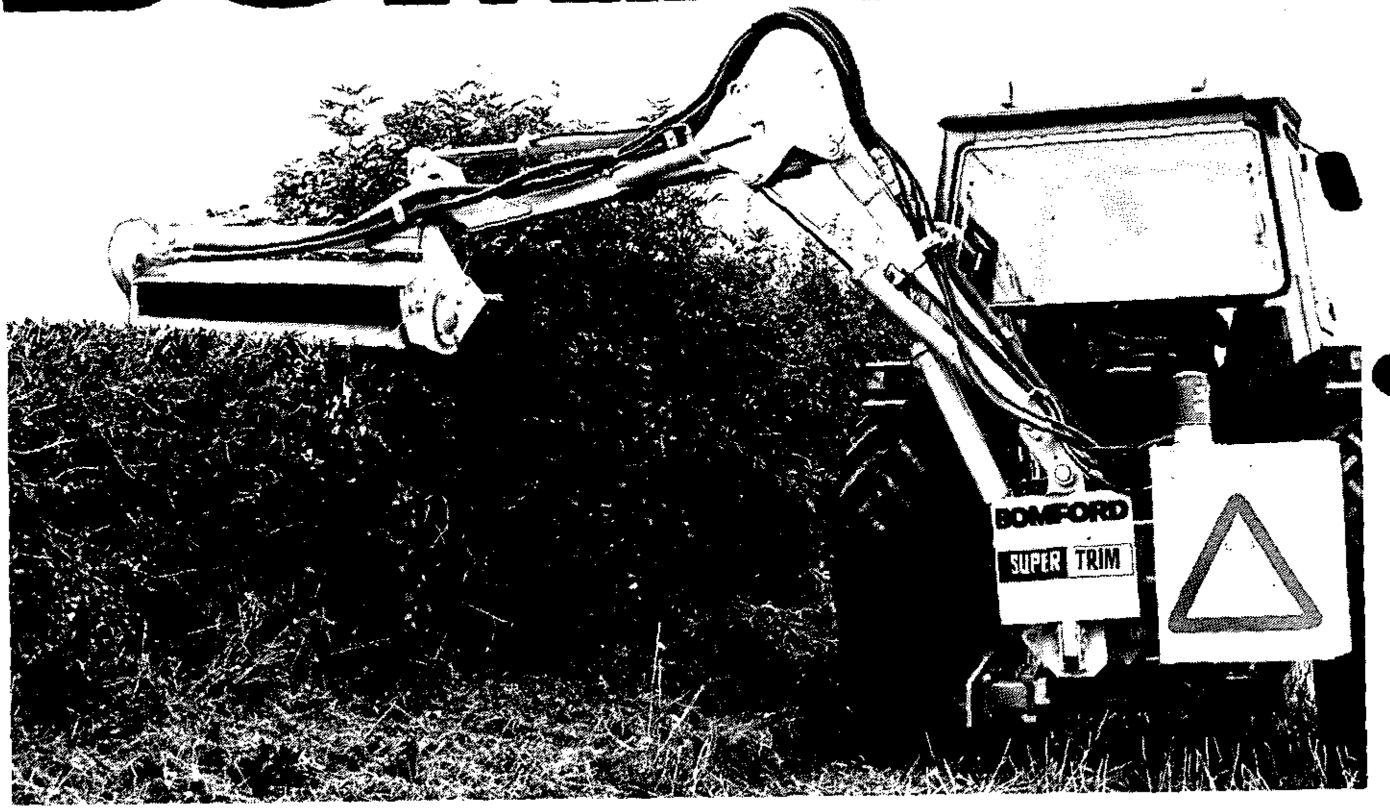

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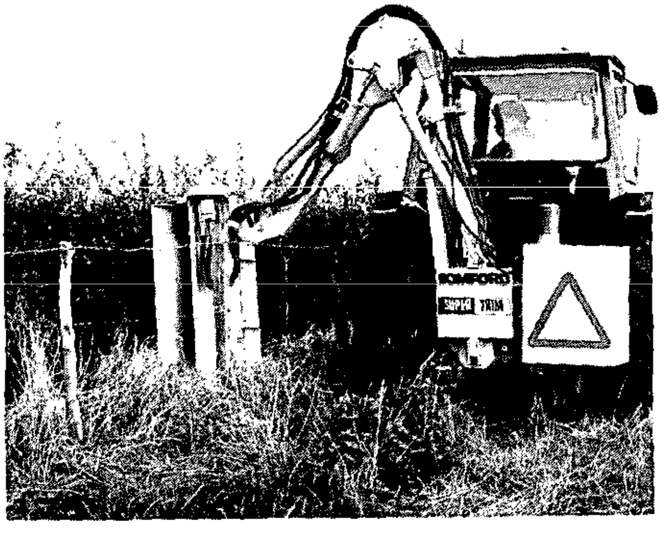

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