THE AGRICULTURAL ENGINEER

JOURNAL and Proceedings of the INSTITUTION of AGRICULTURAL ENGINEERS

Volume 30 Spring 1975 No 1

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CONTENTS

Front cover: Chitting seed potatoes experimentally in trays and pallet boxes under polythene sheeting out of doors prior to mechanical planting.

Corrigenda — FRONTISPIECE in the last issue was incorrectly described as 'Vegetables being placed in a freezing machine'. The photograph showed NIAE experimental equipment for the removal of field heat from soft fruit and vegetables by evaporative cooling. One advantage of vacuum cooling is that it can be controlled to rapidly cool produce without risk of freezing!

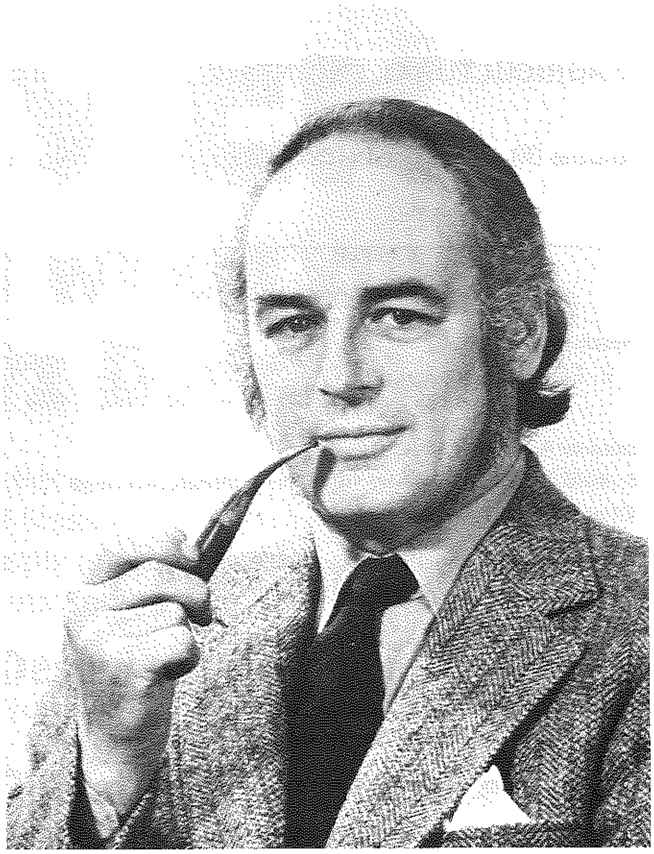
British CIGR Association

by Peter Payne

Background

FOR something like 25 years Britain has stood on the side-lines while her nearest continental neighbours have founded and developed the most important organisation for international understanding and co-operation available to the agricultural engineering profession. The organisation is the *Commission International du Genie Rural* (CIGR). The expression "stood on the side-lines" is used because, while we have regularly attended the Management Committee meetings we have only paid the minimum subscription rate – really intended for countries whose agricultural engineering profession is still in embryonic state – and held a derisively small number of officially recognised Section Meetings; about one per decade!

Initially we could probably have been forgiven for having wished to see whether the fledgling intended to make itself truly international and outward looking or whether it would remain somewhat exclusive. However, now that there are active participants from every continent except Antarctica, our only excuse has been that Her Majesty's Government, though not antagonistic, has certainly not given the material encouragement enjoyed by the majority of member nations. The physical disadvantage of paying a minimum subscription has been that we have only two votes while other countries with significant manufacturing industries, including, for example, Spain and Israel, have either five or the maximum of six votes. More humiliating though, than the lack of voting influence, has been the fact that we have been treated as a serious member nation only out of what can best be described as charity.



CIGR's activities

Mr Claude Culpin, for many years our representative on the Management Committee, wrote a full report on CIGR and our Institution in the January 1971 issue of this Journal. Recapitulating briefly, CIGR membership is open to professional bodies representing agricultural engineering interests in all countries and, where no such body exists, to individual membership. Its interests are divided into five Sections each of which has a national correspondent, viz:—

	Section	*UK national correspondent*
I	Soil and Water Engineering	N W Hudson (W B J Withers acting for 1975), NCAE, Silsoe, Bedford.
II	Farm Buildings & Associated Engineering Problems	S Baxter, Scottish Farm Buildings Investigation Unit, Craibstone, Bucksburn, Aberdeen.
III	Power and Machinery	J Neville, NCAE, Silsoe, Bedford.
IV	Application of Electricity to Agriculture	P Wakeford, Electricity Council, Agricultural Dept, 30 Millbank, London SW1.
V	Scientific Organisation of Agricultural Work	R R Menneer, Ministry of Agriculture, Fisheries & Food, Gt Westminster House, Horseferry Road, London SW1.

The main activity of the Commission is a quinquennial Congress, the three most recent of which have been held in Lausanne in 1964, Baden Baden in 1969 and Flevohof in 1974. Between congresses the technical work is carried on by the section committees and the administration by the part-time General Secretary whose office is in Paris. Member nations are expected to offer to host occasional section conferences and the Congress perhaps once in 30 years. Britain has never acted as host to the Congress, but may be expected to offer a centre in 1984. Based on length of membership, it would have been propitious for us to have offered to stage the 1979 Congress, but in the event the USA is expected to fulfil the role.

British CIGR

Since Britain first joined CIGR our Institution has been the obvious choice as the organisation to represent our national interests on CIGR and has fulfilled its responsibilities to the best of its ability, paying the minimum national membership subscription of about £50 per annum out of its own coffers. Mr Culpin represented us on the management committee and the Electricity Council and the Farm Buildings Association have played a role in Sections II and IV respectively. Mr D P Evans took over Mr Culpin's seat on the Management Committee when he succeeded him as Chief Mechanisation Officer in ADAS and the author has acted as deputy for them both. At least twice in the past, concerned members have called together ad hoc committees to consider how the necessary funds could be arranged for Britain to play her proper role and subscription and each time the efforts have proved abortive, including appeals for support from public funds. However, towards the end of his Presidential term, J A C Gibb, supported by D P Evans, succeeded in bringing together representatives of a number of organisations interested in CIGR activities, four of whom agreed to pay almost a quarter of the full subscription each, with the newly-formed Soil & Water Management Association providing the small balance – all it could afford so early in its life. To date, the British CIGR Association has paid the first full subscription to the CIGR Secretariat and drawn up a Memorandum of Intent, the most significant sections of which are as follows:—

Objectives – To promote British participation and interest in the objectives of the *Commission Internationale du Genie Rural:—*

1. To give effective assistance with all work of general interest in the field of agricultural engineering.

2. To promote in each country the establishment of a national association of agricultural engineers, surveyors, architects and all those concerned with mechanised agriculture.

3. To put agricultural engineering specialists from different countries into contact with one another.

4. To promote the art, science and techniques of agricultural engineering.

5. To encourage and co-ordinate scientific and technical research in this field.

6. To encourage and improve the training of and continuous provision of information to all those concerned with mechanised agriculture.

7. To draw up and perfect directives concerning the organisation of congresses, conferences and all other international functions or enterprises of interest to all those concerned with mechanised agriculture.

8. To set up a documentation service and to publish in an appropriate form and at a suitable time all works which may be of interest to all those concerned with mechanised agriculture.

Membership — Membership shall be open to British organisations with an interest in at least one of the CIGR sections (currently five). Individual membership is not permitted. The founder members are:—

Electricity Council
Farm Buildings Association
Institution of Agricultural Engineers
Royal Institute of Chartered Surveyors
Soil and Water Management Association

Government — The Association shall be controlled by a Council appointed annually. The Council shall consist in the first instance of not more than three appointees made by each of the founder member organisations; the five Section Correspondents for the British Isles (ex-officio); and any British nationals currently serving as officers of CIGR (ex-officio).

The Council shall have power to co-opt at its discretion.

The Council shall elect annually a President and a Secretary and at its discretion any other officers from among its members. Its Officers shall retire at the Annual General Meeting, but shall be eligible for re-election.

The Council shall have power to initiate changes in the Constitution.

The Council shall have power to admit new members and to decide upon appropriate representation and fees.

Some of the provisos and terminology are required by CIGR, but it is the intention that the new association should fulfil its purpose through its member organisations and while being the proper channel for CIGR matters in the UK it will take care not to duplicate existing activities.

Apart from the intrinsic value of the new Association, the Institution can take pride in having brought together its four partners in this common enterprise and it is to be hoped that other organisations with an interest in one or more of the branches of agricultural engineering will join in the future. Furthermore, working with the other partners should assist IAgrE to strengthen its activities outside the field of Power and Machinery.

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Report on 1974 Congress

CIGR's quinquennial "re-dedication" took place at Flevohof during September this year. The East Flevohof Polder is one of the newest in the Netherlands and unlike most of its predecessors, has been divided in use between agriculture and recreational pursuits. The Congress centre has been planned by the Dutch government as a permanent exhibition concerned mainly with demonstrating agriculture to the million or so city dwellers who visit it every year.

Of the roughly 400 delegates from 34 countries the German Federal Republic provided the largest visiting contingent at 32 followed closely by France and the USA. The British delegation was slightly above average at 16. Each Congress includes technical sessions and visits plus the plenary and sectional business sessions and elections.

As usual at such international events it is virtually impossible without causing offence, for the organising committee to restrict the number of papers. In consequence, general rapporteurs are appointed to achieve the impossible by digesting and reporting on ten to fifty papers, some of which have only the vaguest connection with the published theme. At the risk of revealing my prejudice I believe Britain has something to offer to the continent in "conference discipline" and that our contributions, whether by rapporteur, author or speaker from the floor, were of above average quality.

It was disappointing to me that virtually all the themes were of a detailed technical nature such as "The transport of substances in suspension through irrigation installations" or "Automation of field machinery". Speaking among competing countries it is expecting too much of authors to reveal their most exciting new technical ideas and in fact, many of the papers were little more than reviews. I should have liked to have seen the opportunity being taken of discussion between nations as to how agricultural engineers in design, in research and in education can best alter direction to meet the commodity and financial crises that face the world.

During the business meetings a number of constitutional changes were made; the most important of which were the creation of a new office of Vice-President and the addition of District Planning and Environmental Improvement to CIGR activities.

Mr F Coolman, Director of *Instituut voor Landbouwtechniek en Rationalisatie,* Wageningen, was elected President. Mr Coolman is well known in Britain and has for a number of years played a leading part in CIGR as President of Section III. His Vice-President is T W Edminster of the USA's Agricultural Research Service and unusually, it was agreed that he would take over the Presidency before 1979. Mr Carlier of *l'Institut National Agronomique,* was once again elected unopposed, as Secretary General. Englishmen were elected to the management boards of Sections III, IV and V. Let us hope that with the formation of the British CIGR Association the UK will be better represented after the 1979 elections.

Reprint Service

CHANGES have recently been introduced in the reprint service offered to members of the Institution. The Editorial Panel has now made arrangements with University Microfilms Limited, St. John's Road, Tylers Green, High Wycombe, Bucks., for *The AGRICULTURAL ENGINEER* to be placed on microfilm from which enlarged copies of articles or papers can be obtained. Those members wishing to obtain copies of articles should now address their requests direct to University Microfilms Limited who will make a charge for this service at the rate of $3 each for articles and 8c. per page for complete issues. Charges will of course be made in sterling, the equivalent being obtained by conversion at the rate current at the time of placing order.

At the present time only Volume 28 is available under this service but it is planned to place earlier volumes of the Journal on microfilm in the future.

A few back numbers of the Journal are still in stock at Institution Headquarters and will be made available to members upon application. Once Institution Journal and paper supplies have been used up it will no longer be possible to offer members up to six items a year free of charge and post-free through University Microfilms Limited.

Potato seed handling and planting

by F E Shotton

Introduction

I PREVIOUSLY spoke at your Conference in 1964 on the subject of sprouting seed potatoes. Looking back those were rather simpler times when one could reasonably think of the seed potato in isolation from the machine which was to plant it. Today one cannot, one must think of the seed, its treatment, the planter and the planting process all as part of the business of growing a profitable crop of potatoes.

So I welcome my present title which involves both the handling of the seed and its planting and shall devote most of my time to the interaction between planters and seed and on how both effect yield. In part I shall talk about experimental results and in part, and rather tentatively, about the results of a survey of planters carried out in England in 1973.

The value of sprouting

I do not intend to labour this subject. In Scotland you are not persuaded of its value and only about 12% of the potato growers were shown by the 1968 PMB Survey of Maincrop Potato Growing to be sprouting their seed as compared with 37% in Great Britain as a whole.

In England most experiments have shown a gain in ware yield from sprouting ranging up to about 10 t/ha and averaging at around 3.8 t/ha. I am not too well aware of the Scottish results but recent work at Edinburgh has shown a marked increase in total yield up to 12.5 t/ha. However, there was generally a reduction in the yield of seed. I imagine that had the objective been to produce the highest possible yield of seed rather than to test a sprouting technique, that it might have been possible to have harvested at a different time and obtained either a) a higher yield of seed from the sprouted seed or b) the same yield of seed at an earlier date of harvest. This latter point is not without value.

Planter filling time

One obvious problem with sprouting is its cost and the need to handle the traditional chitting trays. When planting with a hand-fed planter which works at say 2–2.5 km/h the filling time may take about 20 minutes an hour. With the faster planters now available which may be travelling at 10 km/h the filling time is liable to increase to occupy 40 min/h. Filling from 50 kg bags will not necessarily take a shorter time than filling from trays it will depend on how the job is organised.

The problem here is the smallness of the unit being handled — the tray or the sack — and work is now going on to look at the use of larger containers. These may be either large boxes or alternatively may consist of a heap of potatoes which will subsequently be handled mechanically by a tractor-mounted bucket. Work on this subject is in process at Terrington EHF and the preliminary results suggest that chitting in 500 kg boxes may give a reasonably satisfactory answer, but that chitting in heaps in a barn is not likely to do so.

If the eventual result of chitting in 500 kg boxes proves to be satisfactory and if these boxes can be tipped into the planter hopper in about one minute then the filling time will become a very much reduced proportion of the total working time. We shall then be faced with the question as to whether, if there is any reduction in the yield as a result of chitting in the large boxes, the saving in planter time will compensate for this.

F E Shotton, of ADAS, Shardlow Hall, Shardlow, Derby, read this paper at the Conference of the Scottish Branch of the Institution of Agricultural Engineers, Dublane, on 27 February 1974.

Damage to sprouts

The first of the modern "automatic" planters were the continental cup-fed type. Two things were at once obvious about these machines: firstly, they spaced the seed exceedingly accurately and secondly they caused damage to the sprouts. Farmers at once began to ask whether this damage was important and trials were conducted at Terrington EHF to investigate this point.

Tables 1, 2 and 3 show the relative performance of three types of planter. From table 1 it is apparent that the cup-fed planter does cause more damage to sprouts than other types of planter and that potatoes that have been sprouted for a short period suffer more severely than those sprouted for longer periods. From table 2 it is apparent that this damage is reflected in the time taken for the crop to emerge, but the differences appear rather small.

Table 3, however, shows that the yield obtained from the cup-fed planters was less than that obtained from the hand-fed planters,

Table 1 Sprout damage — % of sets with all sprouts severely damaged or removed — means 1969-1971

Planter	*Long sprouting period*	*Short sprouting period*
Hand-fed	17	25
Cup-fed	57	66
Belt-fed	36	44

Table 2 Crop emergence — number of days from planting to 75% emergence — means 1969-1971

Planter	*Long sprouting period*	*Short sprouting period*
Hand-fed	30	33
Cup-fed	33	36
Belt-fed	31	33

Table 3 King Edward yields — saleable ware 45-82 mm (t/ha)

Planter		*Long sprouting period*	*Short sprouting period*
Hand-fed	1969	24.8	24.6
	1970	27.1	28.1
	1971	31.9	30.1
	Mean	28.0	27.6
Cup-fed	1969	24.4	20.1
	1970	25.9	26.6
	1971	30.9	28.9
	Mean	27.1	25.1
Belt-fed	1969	22.3	20.6
	1970	24.9	24.9
	1971	29.1	28.4
	Mean	25.4	24.6

whether the seed had been sprouted for long periods or for a short period. The reduction was particularly severe with the latter type of seed due to the large reduction in yield in 1969 and subsequent trials have shown that this sort of large reduction will occur from time to time and should be reckoned with. In fact in 22 trials at Terrington the reduction on 14 occasions has been 1.5 t/ha due to sprout damage by the cup-fed planter but on eight occasions the reduction has been at a higher level ranging from 3.3 t/ha with green sprouts to 4.5 t/ha with soft pale sprouts. There is a very strong suggestion in these results that it is undesirable to sprout for a very short period in order to obtain very short sprouts which in turn are soft, to use with this type of planter. It is apparent that the yields from the belt-fed planter were in fact lower than from either of the other two types of planter even though this planter had caused less damage to sprouts and only very slight delay to emergence.

When the belt-fed planters were first introduced the most obvious thing about them was that they planted in a rather irregular fashion and in this case the question arose whether this irregularity would effect yield. Table 4 gives the results of trials which have been conducted in England and in Scotland at four centres. The belt-fed planter will normally plant with an irregularity varying between moderate, when it is being carefully controlled, and high, when it is not working particularly well. Cases have been recorded where the irregularity has been worse than that recorded as high here (60% coefficient of variation). These trials were planted by hand and the actual machine did not intervene: the object was to simulate the sort of spacing resulting from belt-fed planters.

It will be seen that in all cases the yield was lower at the high degree of irregularity even though the seed rate and the mean spacing were the same. The reduction in yield was very slight in Scotland and was greatest at the Terrington EHF. This latter result agrees quite well with that reported in table 3, when we allow for the fact that when the belt-fed planter itself is in operation it does cause rather more damage to sprouts than does a hand-fed planter.

We appear to have shown adverse yield effects from using both the cup-fed and belt-fed planters. These results were obtained from experiments and, as is normal in experiments, the seed were planted by the various means on the same day. It is claimed that this is not what would happen in practice but that the "automatic" planters which travel faster would plant the crop sooner. There is experimental evidence to show that earlier planting will frequently lead to high yield. A series of trials in the eastern region of England showed that comparing end of April planting with early April planting the yield of sprouted seed fell by 4.3 t/ha while the yield of unsprouted seed fell by 8.5 t/ha. Experiments at Terrington EHF 1971 and 1972 showed the yield of sprouted seed fell by 3.3 t/ha between mid April and early May. The Terrington trials appeared to support the fairly widely held view that there may be no particular advantage in planting main crop potatoes on many soils before about 10 April, but that after that date yield will fall.

Faster planting

From these results it would appear that if early planting is advantageous then planters which travel faster should plant sooner and so should produce an increased yield. This is the sort of thing that cannot be tested in experiments, but we attempted to test it in 1973 by a survey of what actually happened on the farms using a variety of planters across the centre of England. The most important part of this survey was the report by the farmers of the days on which they actually planted potatoes and when they finished planting.

Table 5 shows the mean results for a total of 70 planters grouped in three main categories. It will be seen that the acreage of main crop potatoes planted by each of the three main groups was on average very similar. The most striking thing about the table is the marked similarity between the number of days worked and the number of hours worked by the three groups of planters on average and also the striking agreement between the finishing dates.

Tables 6 and 7 give a breakdown between the three types of planters according to row width and indicate the two types of belt-fed planter found in the survey. It will be seen that there were quite marked differences both in the area of potatoes farm and in the finishing date, but there was still remarkable similarity in the days worked to plant the crop. This suggests that farmers adopted a system which under their conditions enabled them to plant their crop in a period of from 10-14 days on average.

Perhaps the most interesting comparison in these two tables is between the 4-row hand-fed planter, 4-row cup-fed planter and 2-row belt-fed ' "Rotoplanter". The latter two of these were planting a similar area, but the potato area on farms using hand-fed planters was higher/farm though similar/planter. It will be seen that on farms using the hand-fed 4-row planter days worked and hours worked were longer than on farms using the other types of planter, but that the finishing date was in fact earlier than on the other farms. Whatever the reason for this, and it looks as if it were partly

Table 4 Effect of irregularity on yield t/ha

Degree of irregularity *Coefficient of variation %*	*Even* *0*	*Slight* *20*	*Mod* *40*	*High* *60*
Terrington 1970-72 (ware)				
King Edward	32.6	31.9	31.6	30.6
Pentland Crown	40.9	40.2	39.4	38.7
Norfolk Agricultural Station 1970-72 (ware)				
King Edward	27.6	27.6	27.1	26.6
Pentland Crown	40.9	39.7	38.9	39.7
Nottingham University				
King Edward (1970)	32.1	33.9	33.9	30.1
Pentland Crown (1971 & 72)	48.8			45.6
Maris Peer (1969 & 71)	36.2			35.1
NIAE (Scottish Station)				
Large	40.4			39.4
Small	37.2			36.7

Table 5

Planter	*No*	*Start date March*	*Finish date April*	*Days duration*	*Days worked*	*Hours worked*	*Ha m.c.*
Hand-fed	18	22	14	24	12.4	95	26 (23)
Cup-fed	15	27	16	21	11.3	90	29
Belt-fed	37	23	12	22	11.3	92	32

Figures in this table and tables 6 and 7 are on a "per farm" basis except for the figures in paranthesis which are on a "per planter" basis.

Table 6

Planter	No of farms (& planters)	Start date March	Finish date April	Days duration	Days worked	Hours worked	Area per farm (& per planter) (ha)
Hand-fed							
2-row	4	25	21	28	13.0	101	18.2
3-row	9 (11)	22	15	25	12.0	88	21.9 (17.8)
4-row	5 (6)	20	8	20	12.8	104	41.3 (34.4)
Cup-fed							
2-row	5	2 Apr	19	18	10.6	92	20.2
4-row	9	25	15	22	11.9	92	34.0
Belt-fed							
Rotoplanter	30	22	10	20	10.6	88	32.0
Setrite	6	24	22	30	15.3	116	32.0

Table 7

Planter	No of farms (& planters)	Ha planted per 10 h	Ha planted per 100 man h	Labour gang M	Labour gang W	Labour gang T
Hand fed						
2-row	4	1.7	3.4	4.2	1.0	5.2
3-row	9 (11)	2.5 (2.0)	3.5	5.1	2.7	7.9
4-row	5 (6)	4.0 (3.3)	3.5	5.8	4.0	9.8
Cup-fed						
2-row	5	2.2	5.9	3.8		3.8
4-row.	9	3.7	7.4	4.5	0.5	5.0
Belt-fed						
Rotoplanter	30	3.6	7.8	4.4	0.2	4.6
Setrite	6	2.8	5.0	4.8	0.1	4.9

because planting started earlier on these farms, there is no suggestion from these data for 1973 — which was a very easy planting season — that the farmers using hand-fed planters would have lost yield on account of being late in planting their crop.

From table 7 it is apparent that those who employed hand-fed planters used more labour to serve the planters. Figures given are for the whole labour gang employed in the field at the time of planting whether they were actually serving the planter, spreading fertiliser or cultivating the land. The greater gang size on the farms using hand-fed planters is reflected in the markedly lower output/100 man-hours, but rather surprisingly it will be seen that the area planted/10 h/farm was higher on these farms even though the area planted planter was rather lower.

On the basis of the survey in this one year it appears that the main effect of changing from the slowest moving planter to the fastest moving planter was virtually to eliminate the need for casual labour but was not to increase the actual rate of planting or to bring forward the date by which planting was completed.

Economics of planter usage

On the basis of the trials and of the survey results it is possible to begin to make an assessment of the cost/benefit resulting from the change from a 4-row hand-fed planter to a 2-row belt-fed planter. The change to a 4-row cup-fed planter would on the basis of our information, have produced much the same results. It should be stressed that the figures that are now to be given are extremely tentative. In fact some of the figures are given as alternatives to one another. The main reason for putting these figures forward is not to add them up and arrive at any definitive answer, but to serve as a basis for discussion. (Table 8).

The loss in yield from the "automatic" planters appears to be well established although the magnitude of the loss varies from experiment to experiment and the two alternatives are given. It would seem that there would be the minimum loss of almost £800 on a farm growing 32 ha of potatoes. The savings in cost are given on the basis either of the time actually worked in planting potatoes on the farms using hand-fed planters or alternatively for the total duration of planting less three Sundays, on the assumption that it might be necessary to pay the casual workers even when they are not planting potatoes. Up to this point it would appear that the change over has not led to an increase in profit, but there is now the suggestion that it might be possible by using an "automatic" planter to save a man for the whole year. In that case the figures for gain become comparable to those for loss.

From the 1973 survey we have seen that it is not possible to allocate any gain in revenue due to earlier planting.

There remains the question of the value of the work done on any days saved from potato planting (two days in the case of the 2-row belt-fed planter). It is clear that over the range of British agriculture such time might equally be employed on highly productive work such as planting high value horticultural crops or, on the other hand, in painting machinery. We have no basis at the moment to decide what value might be allocated to such saving, but I hope that in 1974 we may be able to make a limited number of studies which would give some indication of this.

Wider rows

I wish to close with a brief reference to the movement which is now afoot to grow potatoes on rows wider than 75 cm apart. The survey already referred to and the survey of harvester performance in 1971

Table 8 Effect of change from 4-row hand-fed to 4-row cup-fed or 2-row belt-fed planter 1973 — possible data

	Gain £	Loss £
Yield loss		
32 ha @ 1.2 t/ha @ £20		768
32 ha @ 2.4 t/ha @ £20		1 536
Saving in labour		
Casuals : 5 @ £4 for 8 days	160	
5 @ £4 for 17 days	340	
Regular : Saving 1 man — whole year?	1 250	
Gain in yield from earlier planting	Nil	
Value of work done in days saved from potato planting	?	

both showed that about 12% of the area covered by those surveys was planted on 90 cm rows.

Trials have shown that the effect of such a change of row width would be minimal as regards crop yield. There may be a small reduction in total yield but some experiments have shown a very small increase in saleable yield through the reduction in the proportion of green tubers. Trials have also shown that clods in the ridge have been reduced through growing tubers on wider rows and that an improvement in work rate could be effected which was in agreement with the theoretical improvement which would result from the shortening of the distance 16.6% travelled.

Table 9 is an extract of the information collected in the 1971 PMB/ADAS survey of harvester performance and refers to single row Grimme and Whitsed harvesters only. From this it will be seen

Table 9 PMB/ADAS 1971 Survey of harvester performance – Grimme and Whitsed harvesters

Row width (cm)	*70 cm*	*75 cm*	*80 cm*	*90 cm*
Number	24	61	6	19
Net rate of work (ha/h)	0.109	0.126	0.138	0.150
As % of 75 cm	89	100	109	118
Theoretical	93	100	107	120

that there was an improvement in the net rate of work as the row width increased from 70 to 90 cm and that the improvement was closely similar to the theoretical improvement which would be expected through the reduction in distance to travel.

It should be pointed out that improvements in work rate can only be effected if the harvester is not at present fully loaded and the other parts of the harvesting operation, such as the supply of trailers, is adequate to cope with the increased output. Furthermore it should be emphasised that yield can only be expected to remain constant if the seed rate is kept constant and that this will mean closing up the spacing to compensate for the widening between the rows.

Conclusion

Summing up, I would like to suggest that the main objective of all potato growers is to maximise the profitability of their crop. On some farms this may be achieved by following intensive practices, such as sprouting in traditional chitting trays in order to maximise the profitability of their crop. On some farms this may be achieved by following intensive practices, such as sprouting in traditional chitting trays in order to maximise yield. On other farms it may be possible to achieve the same result by saving cost through marked economies in labour. It is clear that not all farms will find the same system suitable for their conditions. It would seem from the present information that on farms where labour is available the traditional type of potato husbandry, with chitting and hand-assisted planting, is still likely to prove profitable. On the other hand if labour is inadequate for this system there must clearly be a change to a more highly mechanised system.

What management should do is endeavour to ensure that the adoption of a new system does in fact bring about an overall improvement in the farm economy and that the gains achieved outweigh the losses.

The Summer issue of The AGRICULTURAL ENGINEER will be published on 5 June 1975. Advertisement orders and copy should be forwarded to the advertisement office by 5 April 1975.

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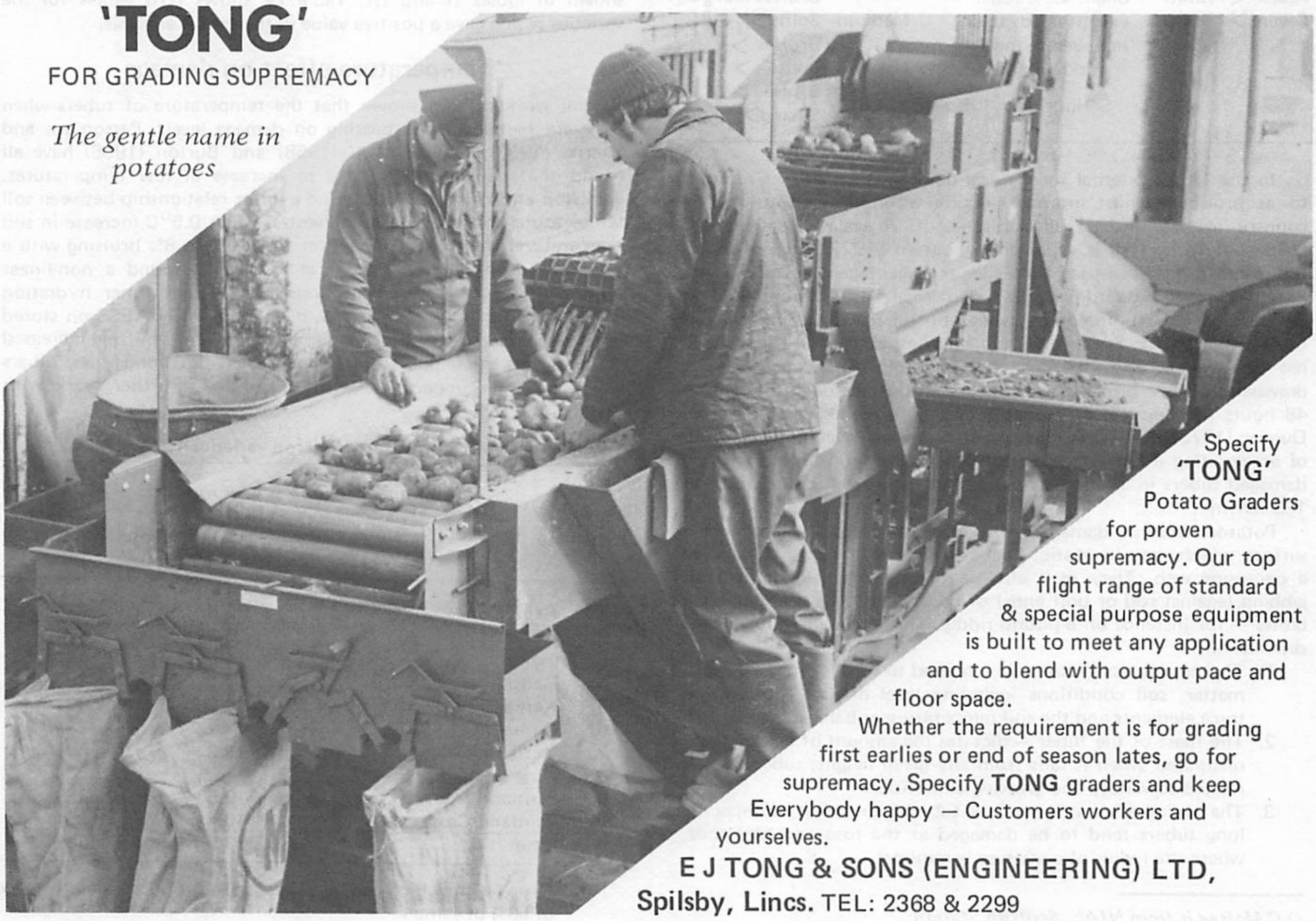

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Potato handling and damage

by D C McRae

THE growing demand for better quality potatoes has led to the raising of the PMB ware standard and many farmers are becoming more concerned about potato damage.

An appreciation of the factors affecting damage and a consideration of how they relate to the handling process could make possible quite marked improvements in the quality of the potatoes reaching retail outlets and processors. The purpose of this paper is firstly to outline some of the factors conspiring to produce damage and then to consider sites in handling systems where it may occur.

Potato damage

Throughout the world, a considerable research effort has been made in the post-war years into many aspects of potato damage. As yet, there is no international agreement on how damage should be classified, though there is a measure of agreement between workers in European countries. Methods used in the UK, USA and USSR are shown in table 1.

Table 1 Damage classification

UK	USA	USSR
Undamaged	Undamaged	Undamaged
Scuffed	Blemished	Slight —Splits $\frac{1}{15}$D
Peeler <1½mm	Slight <5% tuber	Bruises dia. $\frac{1}{8}$D
Severe >1½mm	weight needs to be	Medium—Splits $>\frac{D}{15}<\frac{D}{4}$
	removed by peeling.	Bruises $>\frac{D}{8}$
	Moderate 5-10%	Heavy —Splits $>\frac{D}{4}$
		Bruise $>\frac{D}{4}$
	Serious over 10%	Slicing $>\frac{D}{15}$ long

In the USA, external mechanical damage is sometimes referred to as bruising, whilst internal discolouration referred to in this country as bruising, is called black-spot. A scale of severity of black-spot from 1-10 is reported by Larsen (1972). In Holland, a bruise index has been used by Meijer at Wageningen. In the UK, the Potato Marketing Board has used a numerical classification based on the number of 10 mm thick slices of tuber containing bruised tissue. At the NIAE, Scottish Station, an assessment of bruise volume has been made, but has been found to be time-consuming. A drawback of any bruise assessment method is the delay of at least 48 hours necessary after impact before bruising begins to develop. Duncan (1973) at the University of Glasgow has developed a method of accelerating the development of bruise discolouration by putting damaged tubers in an atmosphere of pure oxygen for two hours at 138 KN/m^2.

Potatoes become damaged when they fall from a height onto a surface which may be static, such as a hopper floor, or moving eg a conveyor web. They may also be damaged by slicing (share), jabbing (against rod or bolt ends) or be bruised by a series of small blows — for instance on a potato riddle. The severity of the damage depends on:

1. The potato tissue strength — related to variety, maturity, dry matter, soil conditions including level of lime, potash and trace elements and the soil temperature at harvest.
2. The mass of the tuber — dictates the amount of energy to be dissipated when it falls from any given height; tuber mass is related to variety and growing conditions.
3. The radius of curvature of the tuber at the point of impact — long tubers tend to be damaged at the rose and heel ends, where the radius of curvature is minimal.
4. The nature of the surface it impacts upon — determines the tissue contact area within which the energy must be dissipated.

A number of experimental methods of measuring physical properties which may affect the propensity to damage has been developed. Simple drop and pendulum tests have been used by Tabachuk (1953), Volbracht (1956), Timofeev (1956) and Green (1956). Huff (1966) measured mechanical properties of tuber material such as the modulus of elasticity. Finney (1967) calculated Poisson's ratio (0.492) and found the modulus of elasticity to be 3.74 MN/m^2. He also quotes a figure of 0.46 for the degree of elasticity defined as the elastic deformation divided by the total deformation.

Potato material shows elastic hysteresis — a proportion of energy absorbed during deformation being dissipated within the tissues on release of the load. Potatoes are vulnerable to local tissue injury under impact loading. At NIAE, Scottish Station, it was decided that a drop-test using typical impact surfaces could provide necessary information on the drop height tolerance of the 10 most important (on an acreage basis) UK potato varieties. Plots of potatoes grown at East Craigs under similar husbandry and fertilizer treatments were carefully dug by hand. After weighing, tubers were dropped onto either a flat steel plate or a web rod. After dropping, they were examined for external damage and a proportion for bruising. H-50 values — the height from which 50% of tubers could be expected to suffer damage when dropped on the above surfaces are shown in tables II and III. Table IV shows H10 values for the varieties which gave a positive value in the probit analysis.

Temperature effect on damage

Several workers have shown that the temperature of tubers when they are handled has a bearing on damage levels. Personious and Sharpe (1938), Ophius *et al* (1958) and Burton (1966) have all found that damage levels tend to increase at low temperatures. Johnston and Wilson (1960) found a linear relationship between soil temperature and bruising at harvest time. A 0.5°C increase in soil temperature produced a reduction from 9% to 8% bruising with a 305 mm drop height. Smittle *et al* (1972) found a non-linear response to temperature variations at different tuber hydration levels with respect to bruising. A pilot study at NIAESS on stored potatoes indicated that bruising tended to fall and splitting increased with increasing temperature. Generally it is found that tubers which split on impact show little bruising. Further work with

Table 2 Drop test results for maincrop varieties 1973

Impact surface — web rod

	Variety	H 50* in	H 50* mm
1.	Record	20.8	529
2.	Maris Piper	16.2	411
3.	Majestic	15.6	401
4.	Redskin	14.3	363
5.	Kerr's Pink	14.2	361
6.	Desirée	13.1	333
7.	Pentland Dell	12.9	328
8.	King Edward	11.2	284
9.	Pentland Ivory	10.6	269
10.	Pentland Crown	10.4	264
	Mean	13.9	354

*H50—Drop height which can be expected to produce severe damage in 50% of sample.

D C McRae is from NIAE, Scottish Station

Table 3 Drop test results for maincrop varieties 1973

Impact surface – flat steel plate

	Variety	H 50* in	H 50* mm	Rank order when dropped on web-rod
1.	Pentland Dell	51.2	1300	7
2.	Redskin	47.7	1212	4
3.	Maris Piper	43.9	1115	2
4.	Pentland Ivory	43.9	1115	9
5.	Pentland Crown	38.6	980	10
6.	Majestic	38.1	968	3
7.	Record	34.2	869	1
8.	King Edward	33.9	861	8
9.	Desirée	32.7	831	6
10.	Kerr's Pink	31.1	790	5
	Mean	39.5	1004	

Test 4 Drop test results for maincrop varieties 1973

	Variety	Surface-flat steel plate H10 in	Surface-flat steel plate H10 mm	Surface-web rod H10 in	Surface-web rod H10 mm
1.	Pentland Dell	30.5	774	9.0	229
2.	Record	28.8	732	11.9	303
3.	Pentland Ivory	25.9	658	7.8	198
4.	Redskin	25.3	642	8.6	218
5.	Maris Piper	24.3	617	12.0	304
6.	Kerr's Pink	20.1	525	8.8	223
7.	Majestic	19.8	504	8.3	210
8.	King Edward	19.3	489	–	–
9.	Pentland Crown	18.7	476	–	–
10.	Desirée	13.7	348	–	–
	Mean	22.7	576	9.5	241

larger samples is necessary to give a more accurate picture of the temperature damage relationship for different varieties.

In order to link drop test data more readily with experience in the field, a pseudo potato is being developed at Scottish Station and the associated telemetry with the co-operation of the Poultry Research Centre, Edinburgh. The "potato" will be introduced to harvesting and handling systems, having been calibrated on the drop tester from heights producing damage in common varieties. As it passes through the system any shocks encountered by the "potato" are transmitted to a receiver and the data recorded for later analysis. In this way it is hoped to identify, more quickly, the serious damage zones in handling systems without recourse to extensive sampling and catechol testing.

Potato handling

The first point where damage may occur in potato handling is on the discharge of potatoes from potato harvesters into trailers. Larsson, in Sweden, found that the damage level when potatoes fall on bare floor boards is 10 times greater than when they fall onto potatoes covering the trailer floor. The bottom layer of potatoes in a typical farm trailer constitutes about 8% of the load.

Reference has been made in a previous paper in this Journal to a conveyor with automatic height control which has been developed at NIAESS (McRae, 1973). It could be fitted to currently available commercial harvesters which have a hydraulically operated delivery height adjustment.

Transport to the store

Potatoes are transported to the store in a variety of trailers or in boxes. There is evidence of damage in transit, though the proportion of damage attributable to filling, transit and emptying, is uncertain. In the USA, Weaver *et al* (1965) reported that a reduction of 29% in bruising and 52% in external injury has been achieved by using trucks partially filled with water to cushion tubers in handling from harvester to store. This system is of course only applicable to tubers being pre-packed after washing and sold shortly after harvest.

At the NIAESS, a system of handling from the field to store is being developed. Elements in the system are a new type of trailer and a reception hopper designed to accept tubers from the trailer with minimum damage. The trailer is called a cradle trailer because the body hangs from two pins on the chassis like a cradle, (fig 1).

Fig 1 The cradle trailer open.

To release the load, the cradle opens in the manner of a clamshell. Cushioning of the load in transit is achieved by connecting the wheels to the chassis by two independent trailing arms fitted with coil springs and dampers. Vertical accelerations with the springs, both operational and inoperative, were measured over a range of road and field conditions and with different tyre pressures. Tyre pressure was surprisingly important and tests with a conventional farm trailer are planned to determine optimum pressures for a given load. The results of tests on the cradle trailer show a clear advantage in favour of springing.

The mean accelerations measured without springing were 1.65 times higher than those with springs operating and were of the order 0.95 g. Apart from cushioning the load, the use of springs reduces the shock and torsional loading on the trailer chassis.

Handling at the store

At the store the cradle trailer is driven onto the reception hopper ramps and the cradle is opened. The potatoes escape downwards onto a conveyor belt which forms the base of the hopper. The belt is suspended on cables and when the trailer begins to empty, the belt is in a raised position. As the load is transferred, the conveyor is allowed to decend by bleeding oil through a valve controlling the conveyor lift ram. In this way the transfer is achieved without the dropping or avalanching associated with conventional tipping farm trailers. To reduce the possibility of damage to tubers by scuffing between tuber and conveyor belt, an anti-scuffing belt made from woven glass impregnated with PTFE is used. It is wound up like a roller blind, exposing the load from the discharge point towards the rear figs 2, 3.

Fig 2 The reception hopper with conveyor lowered.

Bulk heaps and bins

When filling bulk faces or hoppers, damage may easily occur unless great care is exercised in controlling the drop height. Bins can pose special problems, though bin filling equipment (mainly German) of a

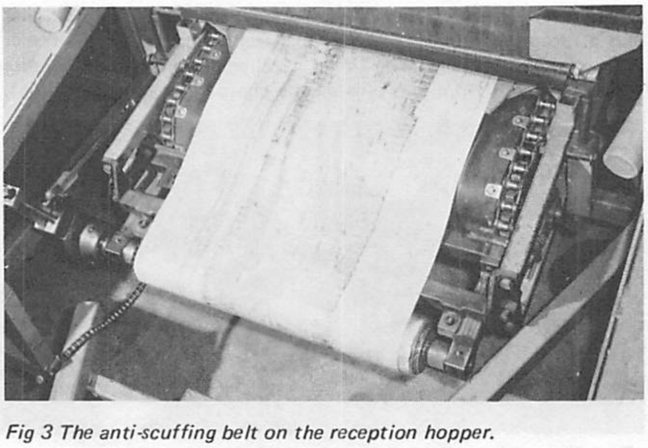

Fig 3 The anti-scuffing belt on the reception hopper.

sophisticated nature is available. A bulk store/bulk lorry filling conveyor using the principle developed at NIAESS is now being manufactured by a Huntingdon firm fig 4. The design could be adapted for bin filling.

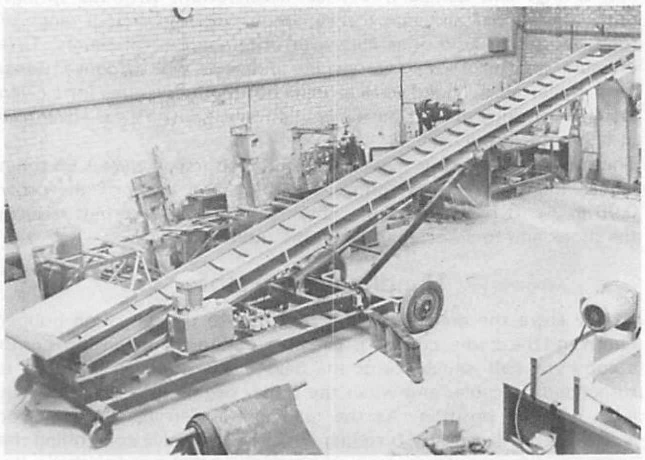

Fig 4 Pre-production proto-type of a conveyor for filling bulk stores or lorries.

Emptying stores

Perhaps the most common form of unloading used in the UK is by a bucket mounted on a farm or an industrial loader. There is not a great deal of information on the damage caused by root buckets. A report by Johnston *et al* (1968) suggests that round-backed buckets appear to produce less damage than buckets with square or forward sloping backs and that a curved wedge shaped fillet at the junctions of leading edge of the bucket and the side, helps to deflect the potatoes with minimal damage as the bucket is thrust into the heap. The damage produced by buckets is also very much dependent on the drop height into hoppers feeding the grading line or when filling boxes. Damage at this stage could be reduced by using rubber straps stretched across the top of the hopper – a method used in Holland. The straps decelerate the potatoes as they fall to the floor. Work on the design and development of a low damage potato bucket is in progress at NIAESS.

Grading and inspection

Damage during grading is generally confined to scuffing and, as indicated in NIAE Test Report (1965 and 1966), it is minimal where loading is optimum. There appears, however, to be little information on bruising during grading and inspection. In the USA handling potatoes at temperatures below 5°C is not recommended. A machine developed in Holland simulates the action of a grader and subjects a sample to 280 movements per minute vertically upwards of at an amplitude of 30 mm. About 30 seconds of this treatment suffices to produce quite extensive bruising in certain conditions.

Damage may occur when tubers pass from the grading line into boxes, and conveyors which adjust automatically as the box fills are commercially available. A modified NIAESS conveyor is fitted at the end of a grading line in East Lothian and has filled over 2 000 one tonne boxes. Damage has been reduced significantly by this device.

Farm store to retail outlet

Potatoes in sacks or bags incur damage in transit. In Idaho, Sparks (1957) found that an increase 2% damage occurred between the warehouse and the retail store. The 25.45 paper sack used so extensively in UK presents an alarming proportion of its contents to the bumps and impacts which occur in handling. Measurements at NIAESS indicate that in a typical bag containing Redskin, 40% of the tubers are in the outside layer. For large Pentland Crown the figure was 68%. At the moment there appears to be few alternatives to the paper sack due to the high cost of rigid packaging.

Conclusions

The low tolerance to drops – especially onto bare metal – of many potato varieties, makes it imperative that in harvesting and post harvest handling, hard surfaces on equipment should be cushioned and drops reduced to the minimum compatible with blockage-free operation of conveyors. Attention must be paid to the temperature of tubers when they are handled at harvest and in the store.

Though new techniques and test equipment are being evolved, much still remains to be done in the field of damage testing, so that improvements to machinery for handling the potato crop can be more accurately assessed.

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Note this date: 13 MAY 1975

USE OF ENERGY IN AGRICULTURE CONFERENCE FOLLOWING THE ANNUAL GENERAL MEETING VENUE: BLOOMSBURY HOTEL – LONDON

THE 1975 Conference provides a forum for analyses of this vital subject and of ways to contribute to world-wide economies in the future.

Chairman: Professor J R O'Callaghan BE MSc CEng FIMechE FIAgrE. Dean of Faculty of Newcastle. Long before the 1973 crisis he was constructively drawing attention to the approaching problem; he was Chairman of the Energy Working Party of the Joint Consultative Organisation for Research and Development in Agriculture and Food.

PROGRAMME

10 30	Registration and coffee.
11 15	The Chairman sets the scene.
11 30	'Energy in Agricultural Systems' by Dr D J White Bsc DIC PhD CEng MIMechE, of the Chief Scientist's Group, Ministry of Agriculture, Fisheries and Food. An analysis will be made of energy use in agriculture and an introduction given to the concept of energy budgets for commodities and the conclusions that may be drawn from these.
12 00	'Energy Sources' will be reviewed by G E Bowman BSc, of the National Institute of Agricultural Engineering. The prospect of better use of solar energy particularly in relationship to glasshouse crops will be dealt with.
12 20	'Economy in Use of Manufactured Fertilisers' will be discussed by R B Austin, of the Plant Breeding Institute, Cambridge. At present, British agriculture is heavily dependent on fertilisers for maintaining and increasing crop yields. The prospects for reducing fertiliser use, by altering the biological characteristics of crops and by crop rotation, will be considered.
12 40	Questions.
13 00	Annual luncheon.
	Guest of honour: Dr H C Pereira PhD Dsc FIBiol FRS, Chief Scientist, Ministry of Agriculture, Fisheries and Food.
14 30	'Efficient Use of Tractors' will be analysed by J Matthews Bsc FIAgrE, of the National Institute of Agricultural Engineering, with particular reference being made to potential economies when cultivating soil
14 50	'Straw and Grass – Problems in Using their Potential Energy'. I R Rutherford NDA NDAgrE MIAgrE, of the Ministry of Agriculture, Fisheries and Food, and Dr R W Radley PhD MAAB MBSALS, of the National College of Agricultural Engineering, will discuss straw. T C D Manby BSc MScEng CEng FIMechE FIAgrE, and G Shepperson BSc(Agric) FIAgrE, of the National Institute of Agricultural Engineering, will discuss grass.
15 20	Questions.
15 30	Open forum.
16 30	Closure, tea will be available.

Registration forms and requests for further information should be addressed to the convenors, T C D Manby, NIAE, Silsoe, Bedford (tel: Silsoe 60000) and Dr D J White, Chief Scientist's Group, Great Westminster House, Horseferry Road, London SW1P 2AE (tel: 01-216 7270), or Ray J Fryett, Institution Secretary.

Some economic aspects of ensilage mechanisation for beef production

by B D Witney MSc PhD CEng MIMechE MIAgrE
and J L Beveridge BSc DipAgric MSc MA

Summary

A METHOD is described for selecting a mechanisation system for silage making which incorporates not only the direct costs of alternative labour and machinery complements, but also the indirect costs associated with timeliness of harvest and dry matter losses from cutting to feeding. A two-man direct-cut system, a three-man wilting system with double-chop harvester and a four-man wilting system with precision-chop harvester are compared for one and two cut harvests. Indirect costs are measured in terms of value of beef output foregone. These costs are derived for two silage dry matters 20% and 30%, and two steer liveweights, 300 kg and 450 kg, using a price of £0.35/kg to value liveweight gain.

Conventional mechanisation cost curves are transformed in shape and relative position by the incorporation of harvest timeliness costs. By plotting the combined costs, expressed as a percentage of livestock output, against area to be harvested, a more realistic basis for mechanisation system selection is provided. Mechanisation system selection using combined costs results in a precision-chop system for harvest areas in excess of approximately 40 ha/a for a single cut crop, whereas the conventional mechanisation cost curves set this area at 80 ha/a. The minimum cost points are not very sensitive to change in annual area and harvest period could be extended to 25 days without drastic penalty.

Costs of potential energy losses between cutting grass and feeding the resulting silage are shown to be much more significant than mechanisation and harvest timeliness costs. Silage making systems which have high mechanisation costs may therefore be more easily justified by reductions in energy loss after harvest than by reductions in energy loss during harvest. The inclusion of differential energy losses during ensilage for direct-cut and wilting systems facilitates direct comparisons between the cost curves. Assuming 20% energy loss for direct-cut and 10% for wilted material, it is cheaper to have a flail harvester system up to 20 ha/a, a double-chop harvester system from 20 to 40 ha/a and a precision-chop harvester system above 40 ha/a.

With two cuts, the mechanisation and indirect costs as a percentage of output per hectare remain unchanged. Thus the more expensive silage mechanisation systems can be justified for lower areas.

1 Introduction

As machinery and labour costs continue to rise the selection of optimum mechanisation systems for silage making is becoming increasingly important. The desirability of wilting, fine chopping and fast filling within as short a period as possible is advocated. Wilting increases the effective capacity of trailer and silo, reduces silo effluent and the associated nutrient losses and increases the dry matter intake of animals. Fine chopping reduces the specific volume of the ensiled material, encourages better fermentation and makes material handling easier. Fast filling ensures a high quality product and enables best advantage to be taken of the quantity and quality of grass available for cutting. To achieve these objectives, improved system organisation, higher tractor power and larger capacity equipment are required. Specialised silage making equipment has high annual fixed costs. Unit costs are therefore reduced if the area harvested is increased. This can, however, result in extending the harvest period with the consequence that indirect costs relating to loss of quality are incurred. In order to determine the best system for various quantities of silage, it is necessary to measure both the costs for different machine combinations and the associated timeliness penalties.

The selection of silage making systems for milk production enterprises formed the basis of an earlier study at the University of Reading (Dalton and Kettleborough, 1973). In the analysis, machine depreciation and repair are calculated on an annual basis (not related to hourly use) which over-emphasises the penalty of producing small quantities of silage. This factor combined with the more significant timeliness penalty for milk production as opposed to beef production produces a mechanisation cost curve whose sensitivity to the annual harvest area appears to be greater than that found in practice. The allocation of annual machine overheads to first-cut silage also introduces, to the production of further cuts of silage, an opportunity cost element which is difficult to quantify. If the machine overheads are based on hourly use, more rapid depreciation is fairly allocated to the heavily used machine by shortening the working life irrespective of whether the high use is due to one cut on a large area harvested or to a large number of cuts on a small harvest area. The use of average conservation efficiencies at an early stage in the analysis also effectively prevent an assessment of differential ensiling losses for direct cut and wilted silage systems. As the latter area is one which is receiving considerable attention but for which scant information is available it is desirable to retain flexibility in any analytical procedure. A different analytical procedure is developed in an attempt to overcome some of these limitations.

2 Mechanisation system cost

For comparative purposes, three matched silage making systems requiring two, three and four men were investigated. The two-man direct-cut system uses an in-line flail forage harvester with a permanently coupled trailer. The second man, who does the buckraking, was assumed to be available for 0.4 of the day. The three-man system incorporates wilting with part time mowing and one man with a double-chop forage harvester towing a trailer. The second man ferries trailers to the pits where the third fills with a buckrake. The four-man system also incorporates wilting but its output is increased by the use of a wide mower, precision-chop forage harvester and large trailers. Details of labour and machinery requirements are given in table 1. The overall rates of work for the mowers were taken as 0.75 ha/h for the 1.5 m model and 1.2 ha/h for the wide mower (Morrison 1973). One third of trailer use was apportioned to silage making.

The capital costs of the machinery were average values abstracted from a list of recommended manufacturers' prices in the *Power Farming Machinery Market Guide,* April 1974. Machinery costs included straight line depreciation, interest at 16% on half of the capital sum, and annual repairs. Machine life and annual repairs as a percentage of the capital cost were related to various levels of use (Culpin 1968).

The capital cost of the tractors is based on manufacturers' recommended prices in *Power Farming Tractor Market Guide,* December 1973 and updated to March 1974 (table 2).

→ page 13

The authors, B D Witney and J L Beveridge are from Edinburgh School of Agriculture.

Table 1 Mechanisation systems

Men	Tractors No	Tractors kW	Trailer no and size	Direct cut or wilted, % dm & harvester type	Method of operation	Systems Output (ha/h)	Capital cost £	
2	1 1	45 34	1 3 m x 2 m	Direct cut 20% flail	One man cuts with in line harvester, transports & tips, second man buckrakes part-time. Haul length – 0.4 km	0.25	Harvester Trailer (1/3 h) Buckrake	620 226 100 946
3	2 1	45 34	2 3 m x 2 m	Wilted 30% double chop	Part-time mowing; one man picking up; one shuttle transport; one buckrake. Haul length – 0.8 km	0.4	Mower Harvester 2 Trailers (1/3 h) Buckrake	530 940 452 220 2142
4	1 2 1	56 45 34	2 3.5 m x 2 m	Wilted 30% precision chop	One man mowing; one man harvesting; one shuttle transport; one buckrake. Haul length – 1 km	0.7	Mower Harvester 2 Trailers (1/3 h) Buckrake	1600 1800 700 220 4320

Table 2 Tractor prices

Power rating	*Capital cost*
34 kW	£1650
45 kW	£2050
56 kW	£2400

Straight line depreciation was taken as 14% for 1000 hours annual use, repairs as 8% of the capital cost, interest at 16% on half the capital sum and labour at £0.70/h. The tractor tax was £5/year and insurance was based on £5 for the first £500 of the capital cost plus £0.63 per £100 thereafter. Tractor operating costs for different power ratings were charged at an hourly rate calculated for an annual use of 1000 hours (Witney 1974). Fuel consumption is taken as 66% of the fuel consumption at maximum power (ADAS 1972) and the fuel price was £0.046/l (£0.21/gal). Tyre costs were estimated from tyre life data given in the same ADAS source.

Total mechanisation costs (labour and machinery) as a function of annual area are presented in fig 1. These costs per hectare decrease rapidly as the annual area is extended. The extent of each cost curve in terms of maximum annual area for each system is arbitrarily constrained because there exists no objective appraisal of either the limiting area for each system or the cost differential between direct-cut and wilting systems.

3 Indirect costs

Costs indirectly but closely associated with crop mechanisation are those which are incurred because the work is not completed on time and because of losses in the dry matter of the ensiled material with the result, that both quantity and quality of the product are affected. Quantifying such costs is more difficult to achieve because it involves the manipulation of livestock performance data.

The costs were first divided into two distinct parts, those relating to failure to cut the grass at a target *D* value and those which could potentially be incurred as a result of losses during the time from cutting until the silage is fed. The two types of costs are used for different purposes. Costs incurred at the cutting stages are incorporated with mechanisation system costs whereas costs of subsequent losses (which are extremely variable) are used to

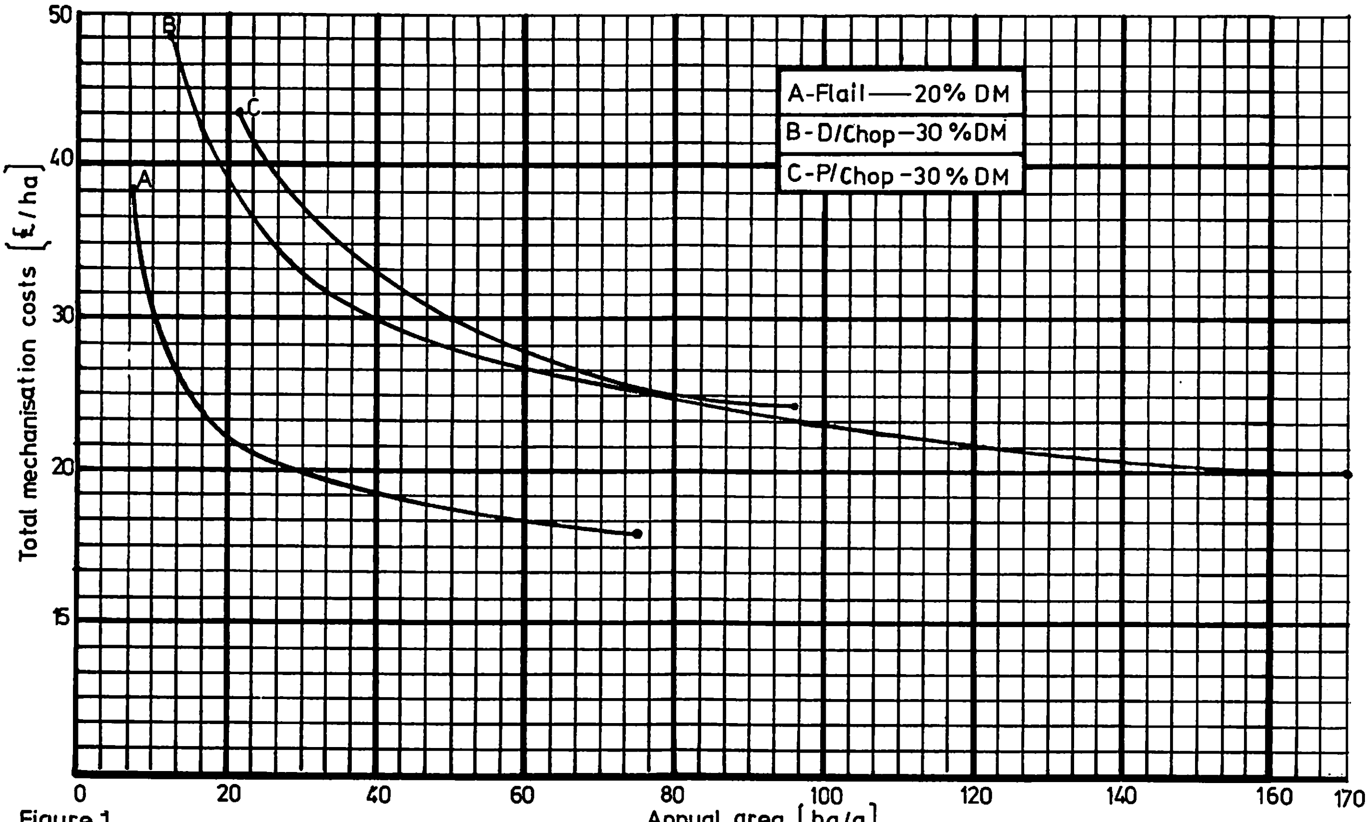

Figure 1
Total mechanisation costs for three forage harvesting systems

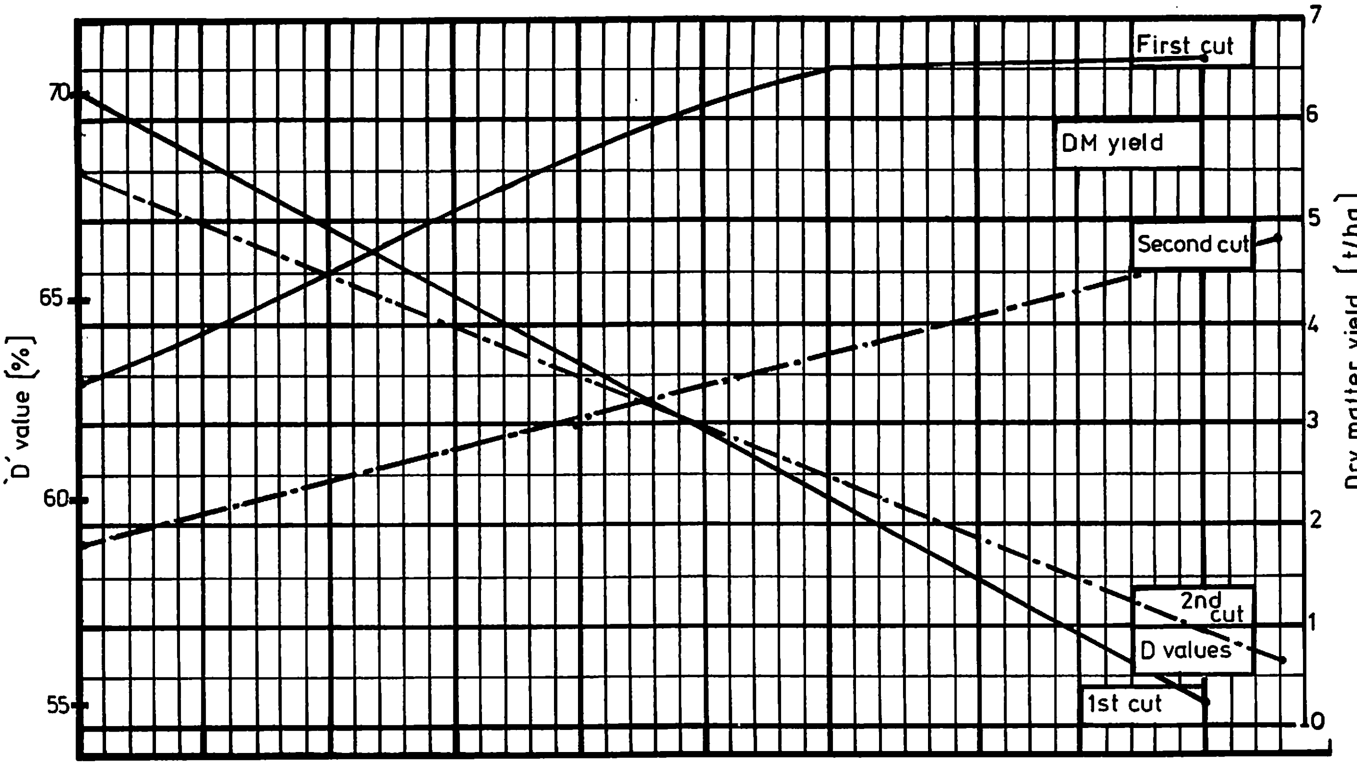

Figure 2 Dry matter yield and D values for first and second cut grass

demonstrate their relative significance at varying levels compared with the mechanisation system costs. In this way it is possible to discount those losses in silage making which occur irrespective of aspects of silage making procedure affected by the mechanisation system employed.

In assessing the indirect costs, two major problems had to be faced. One was how to estimate the changes in nutritive value of a grass sward which take place over time for both the first and second cuts. The other was how to adjust dry matter intake to allow for the changes in nutritive value in order to place a cash value on the resultant livestock product. The following method was adopted.

Estimations of the changes in nutritive value of a pure S.24 Perennial Ryegrass sward were made on an energy basis. This species was selected as being one for which most information was available. The changes in dry matter yield per hectare and in *D* value for first and second cuts are based on the findings of Green *et al* (1971). The National Institute of Agricultural Botany (1973-74) and on information provided by Mr G S Swift of the Edinburgh School of Agriculture (fig 2).

The energy concentration of the resulting herbage is given by the formula:

Metabolisable energy (MJ/kg) = $D \times E \times 0.82$

where D is the digestible organic dry matter, (DOMD) E is the gross energy value of the DOMD (taken as 20 MJ/kg for direct cut grass and 19 MJ/kg for wilted grass) and 0.82 is the factor for deriving metabolisable energy from digestible energy. The metabolisable energy production per hectare was calculated for grass cut at *D* values ranging from 0.70 to 0.55 and 0.68 to 0.55 for first and second cut material respectively assuming, at this stage, that the grass cut and the silage fed were of identical energy value ie no losses between cutting and feeding.

Beef was chosen for the evaluation of the varying levels of energy production in terms of a saleable livestock product. Assuming that the sole diet was silage fed to appetite, the liveweight gains/hectare were estimated for each level of energy production. As the liveweight increase responses are different for various ages of animal, two liveweights of animal, 300 kg and 450 kg, are considered with two silage dry matters, 20% and 30%. Estimates of dry matter intake level for two weights of animal were derived in consultation with Dr Lewis of the Edinburgh School of Agriculture using the following regression equation for silage with a *D* value of 0.64:

Intake (kg) = $0.016\,W + 0.042\,DM - 0.37$

where *W* is the weight of the animal (kg) and *DM* is the dry matter of the ensiled material (%). Because of the lack of experimental data on the relation between *D* value and intake of beef cattle, an arbitrary adjustment was made of 0.1 kg change for a unit change in *D* value increasing above and decreasing below the 0.64 *D* value intake level for both steer liveweights. The liveweight increases which the silage diets of varying qualities could be expected to produce were calculated from information tabulated in Edwards and McDonald (1974). The monetary values of the liveweight increases (outputs) hectare were obtained by assuming that, irrespective of stage of animal growth, the gain was saleable at the same price/kilogram liveweight as that of a finished animal. A price of £0.35/kg was taken. Average outputs for one and two cuts were calculated for harvest periods of increasing duration extended equally about the *D* value of peak livestock output, assuming that *D* value changed by one unit every three days for first cut grass and every four days for second cut grass (fig 3 and 4).

No allowance has been made in the foregoing calculations for changes in crude protein content which occur with declining *D* value. It is recognised, however, that such changes could, in some circumstances, be of economic significance.

The average timeliness losses are represented by the decrement in average livestock output with harvest duration. As these losses occur irrespective of whether the grass is ensiled fresh or wilted, mean values of the losses were calculated, one for the 300 kg liveweight steer and the other for the 450 kg liveweight steer. These are presented for one and two cuts in figures 5 and 6.

Losses subsequent to cutting grass occur for a number of different reasons and to varying degrees. The silage mechanisation system can be responsible for at least a proportion of such losses, for example, relating to the method of picking up the grass, the speed of filling the silo and to the ease and success of consolidation. In order to compare the level of mechanisation system costs with the potential benefits of reduced ensiling losses, the costs from cutting to feeding, in terms of livestock gross output foregone, were taken as 20% for the direct-cut system and 10% for the wilted system.

4 Combined costs

In order to combine the mechanisation costs with the indirect costs, the financial data must be translated to a standard form. Harvest duration and harvest area were related by means of the assumptions that the working time was eight hours/day and, out of every 15 days, 12 days were available for direct cut operations whereas only nine

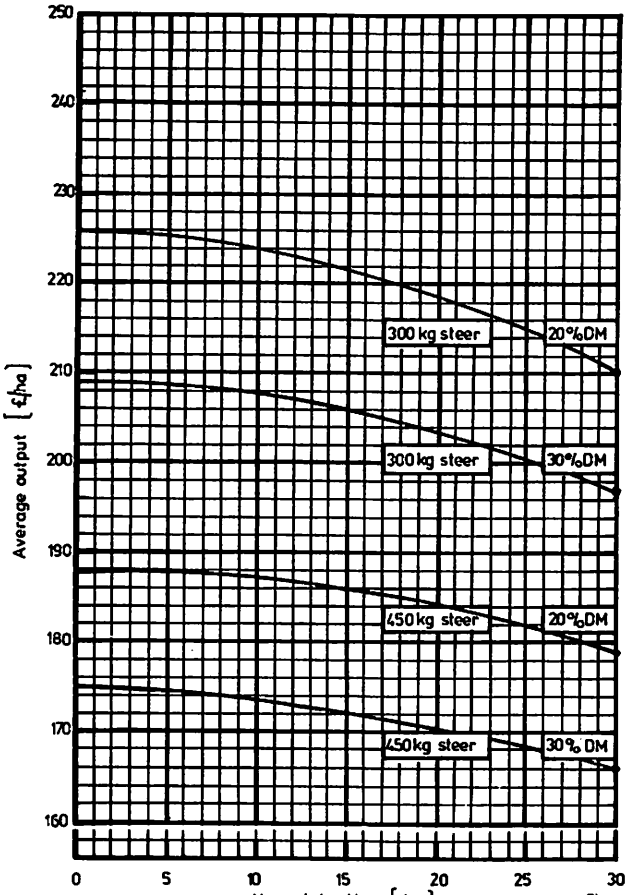

Figure 3

Average outputs for two steer liveweights from a single cut of grass ensiled at 20% DM and 30% DM

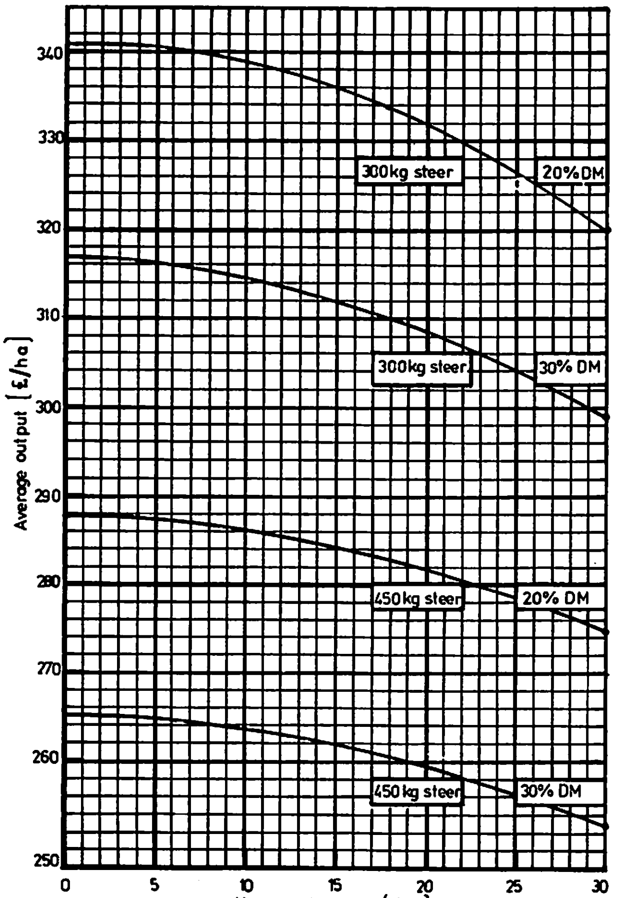

Figure 4

Average outputs for two steer liveweights from two cuts of grass ensiled at 20% DM and 30% DM

The editor regrets the delay in publication of this issue of THE AGRICULTURAL ENGINEER due to circumstances beyond his control.

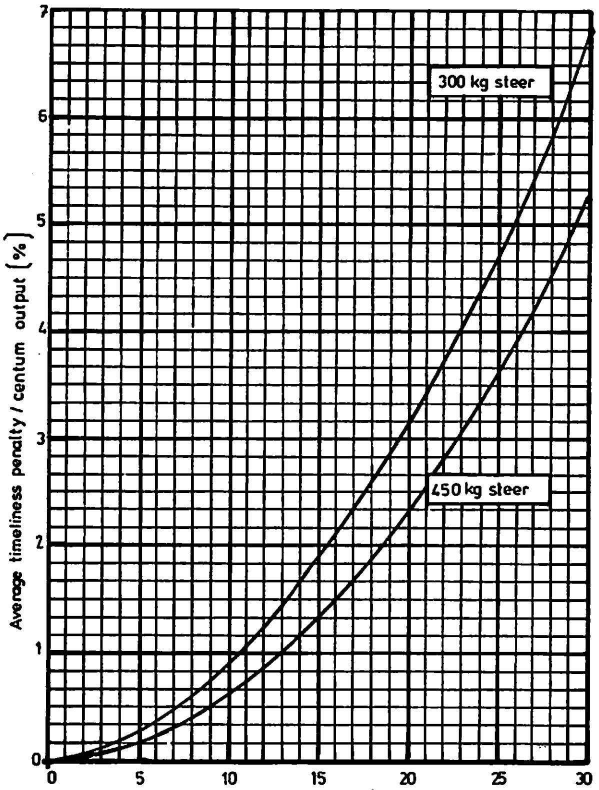

Figure 5

Average timeliness penalties as a percentage of the output from a single cut of ensiled grass.

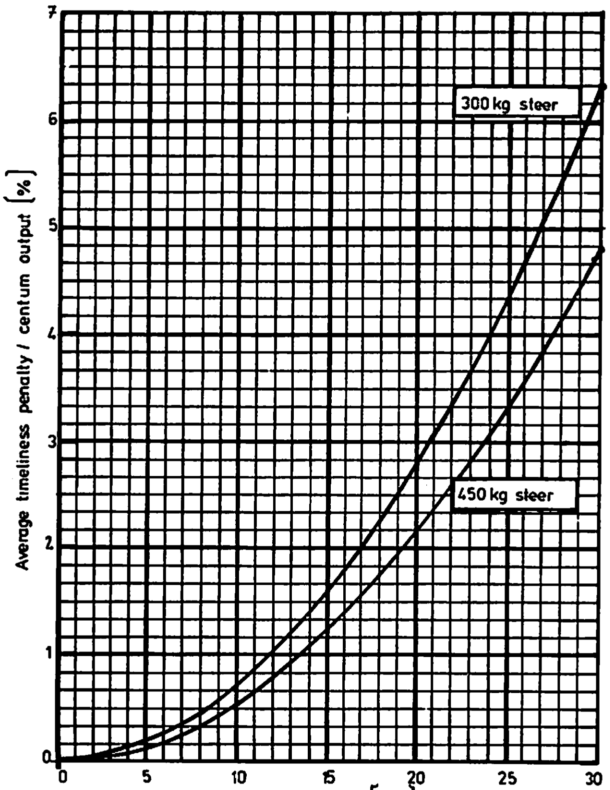

Figure 6

Average timeliness penalties as a percentage of the output from two cuts of ensiled grass

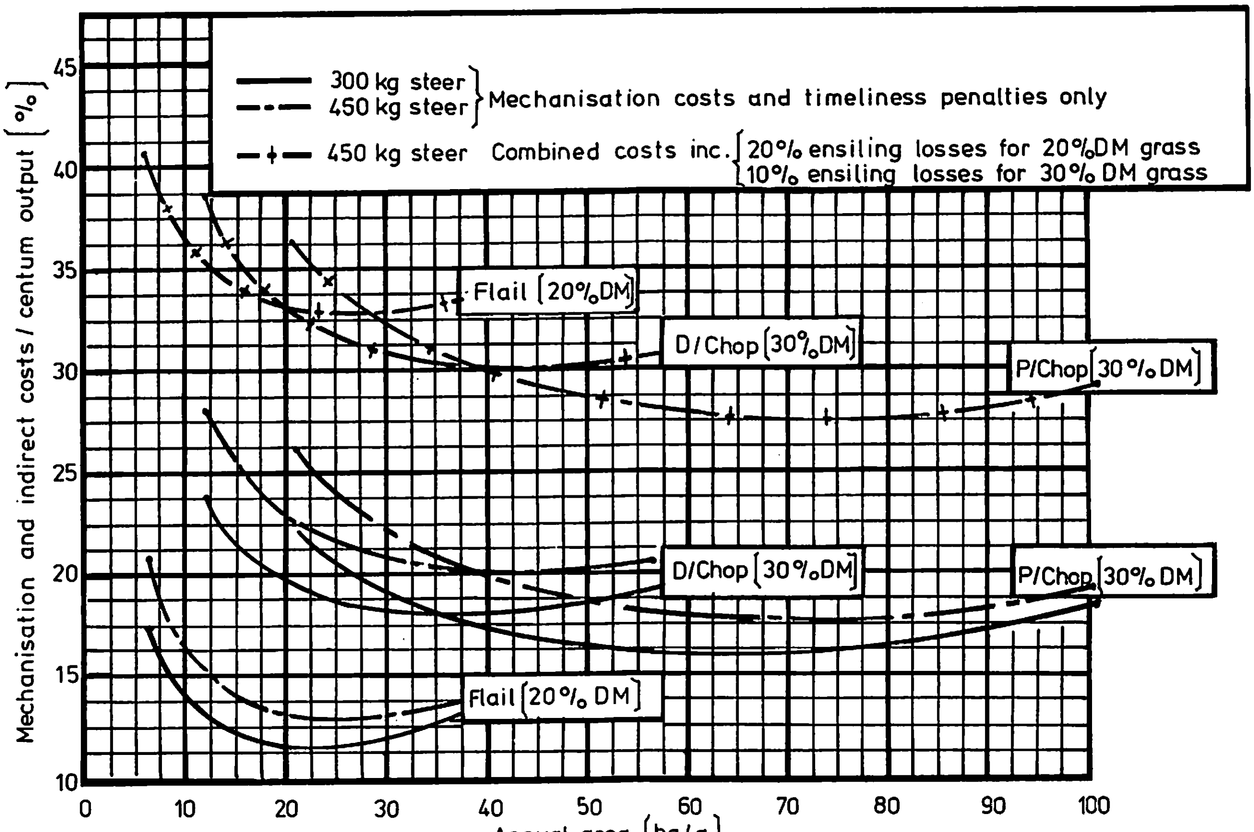

Figure 7 Mechanisation and indirect costs per centum output for one cut

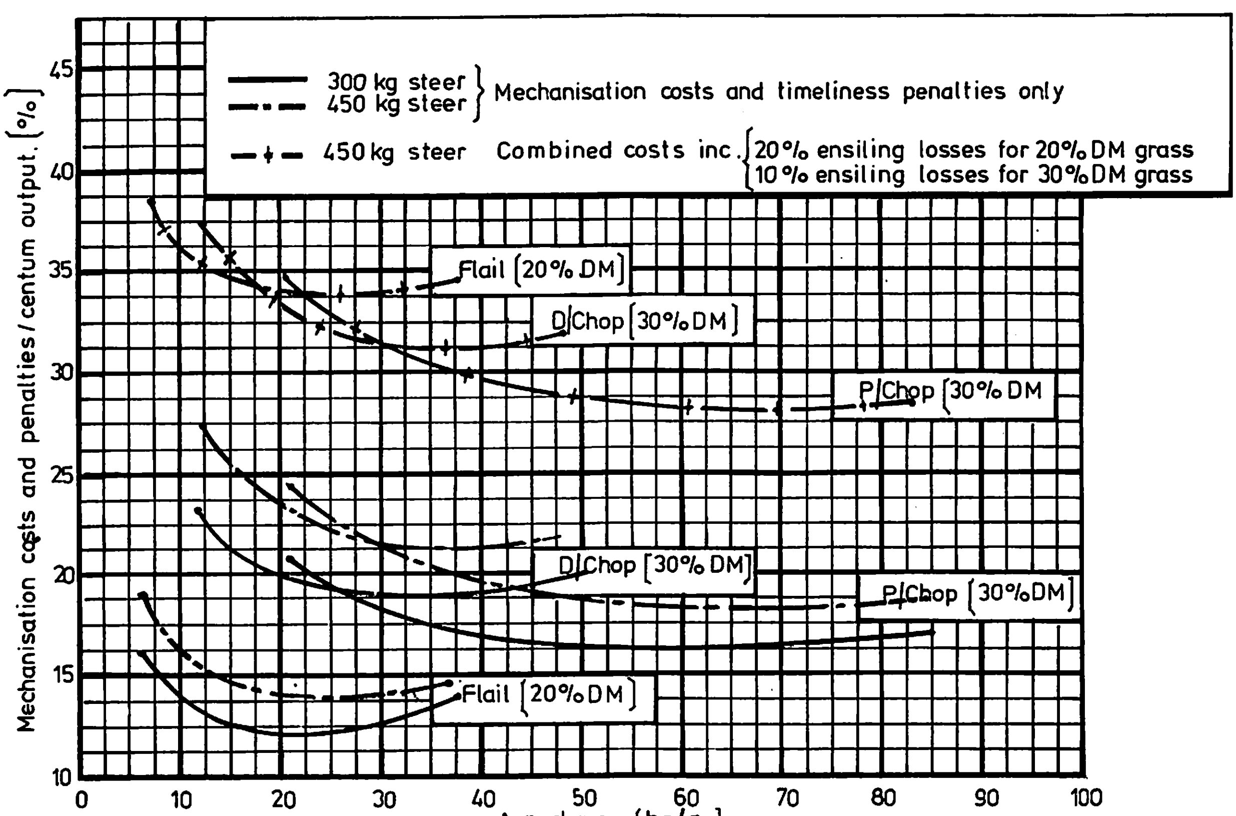

Figure 8. Mechanisation and indirect costs per centum output for two cuts

days were available for wilting. Whilst single cut data may be presented in the form of cost/hectare for various harvest areas, the combined effect of two cuts on total costs cannot be shown. For this reason, the costs are presented in a dimensionless form of 'mechanisation and indirect costs per £100 of output/hectare' against 'harvest areas' (fig 7). The summation of data for two cuts involved two further assumptions, namely that the same area was cut twice and that all machine operations were carried out at the same rate of work, although, in practice, machine travel speed is influenced by swathe weight to a limited extent (fig 8).

5 Discussion

The costs of alternative machine systems for farm operations illustrated in fig 1 are commonly used to select least cost power and machine combinations. The data are incomplete, however, because indirect costs of mechanisation, inclusion of which may significantly affect the relative positions of such mechanisation cost curves, are ignored, as is the value of output achieved. Mechanisation costs/hectare decrease as the area harvested increases and the flail forage harvesting system is considerably cheaper than the other two systems considered (fig 1). It is also demonstrated that, although the cost differential between the double-chop and precision-chop systems is not large, the precision-chop system becomes cheaper per hectare harvested than the double-chop system for areas in excess of approximately 80 ha/a.

To transform the mechanisation cost curves of fig 1 into the more realistic "least cost" curves of figures 7 and 8 indirect costs associated with timeliness of harvest, expressed in terms of livestock output foregone, were derived and incorporated. The type and age of animal to be fed the harvested product obviously affect the significance of the penalty cost incurred as quality declines. The value of livestock output/hectare rises to a peak at a specific *D* value and then declines, the *D* value at which peak output is achieved depending on the metabolisable energy/hectare produced from the grass. In practice, silage harvesting takes place over a period of time so that the *D* value of the grass changes as harvest progresses. As the harvest duration about the time of optimum *D* value is extended the penalty costs (livestock output foregone) increase (fig 3 to 6). The heavier beef cattle produce their peak output at a lower *D* value that the lighter animals and are less sensitive to declining quality. Average output falls slowly with declining *D* value. The possibility that this trend was a reflection or arbitrary changes of intake was not supported by the results of a sensitivity analysis. There is, of course, the practical difficulty of determining when to start harvest, and the risk of incurring higher penalty costs when longer harvests are spread about a target *D* value.

The curves presented in figures 7 and 8 are of particular practical significance because they relate mechanisation and timeliness penalty costs to the value of output achieved, a situation which is essential if the term least cost is to have any relevance. Compared with the data in fig 1, the relative positions of the three curves have not altered greatly, but their shapes have. Mechanisation system selection based on this presentation of the information would result in a precision-chop system for harvest areas in excess of approximately 40 ha/a for a single cut crop, whereas selection of this system based on the curves of fig 1 is deferred until the harvest area extends to approximately 80 ha/a; from the least cost curves, the minimum cost point is not very sensitive to harvest area and the harvest period could be extended from 15 to 25 days without incurring a drastic penalty.

The reductions in livestock output from ensiling losses which are incorporated in the curves of figures 7 and 8 were selected quite arbitrarily. They serve to emphasise first the potential significance of costs of energy losses between cutting grass and feeding silage compared with mechanisation and timeliness costs, and second that if the percentage energy losses during ensiling changed relative one to another, the machine system selected for a specific harvest area could also change. Systems which have high mechanisation costs may be justified more readily in terms of reduced ensilage losses than in terms of reduced timeliness losses. Information on the differential effects of harvesting systems on energy losses during ensiling is difficult to find but it can, for example, be calculated that, at 40 ha/a, the direct-cut system would be most economic if the ensiling losses for wilting systems were changed to 15% whilst the flail system losses remained at 20%.

Greater mechanisation costs/hectare are incurred with two cuts, but, because machine overheads are spread by extended usage and because of a higher livestock output/hectare, the mechanisation and indirect costs as a percentage of output/hectare remain virtually unchanged. Thus the margin/hectare is larger, and the more expensive mechanisation systems can be justified at lower areas.

6 Conclusions

The conclusions drawn from the study must be interpreted in relation to the assumptions incorporated in the analysis. The three mechanisation systems in the study were matched in terms of labour, power and machines. The determination of timeliness penalties required assumptions for system rates of work, operating hours and weather risk. Energy production of the silage was evaluated in terms of beef as the saleable livestock product assuming no losses during ensilage in the first instance, assuming silage fed to appetite and assuming no limitation from changes in crude protein content with declining *D* value. Ensiling losses were evaluated in terms of livestock product foregone and added to the mechanisation costs. Based on these assumptions, a number of interesting points emerge from the analysis.

Combining timeliness penalties with mechanisation costs for forage harvesting generates minimum cost curves.

The minimum cost points are not very sensitive to changes in annual area and harvest period could be extended to 25 days without a drastic penalty.

The cost of energy losses during ensilage is very significant compared with mechanisation costs and more important than timeliness penalties.

The inclusion of differential energy losses during ensilage for direct-cut and wilting systems facilitates direct comparisons between the cost curves. Assuming 20% energy loss for direct-cut and 10% for wilted material, it is cheaper to have a flail harvester system up to 20 ha/a, a double-chop harvester system from 20 to 40 ha/a and a precision-chop harvester system above 40 ha/a.

With two cuts, the mechanisation and indirect costs as a percentage of output per hectare remain unchanged. Thus the more expensive silage mechanisation systems can be justified at lower areas.

Acknowledgements

The assistance and advice of Doctors Donaldson, Edwards, Lewis and Whittemore and of Mr G Swift, all of the Edinburgh School of Agriculture is gratefully acknowledged.

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The National Diploma In Agricultural Engineering (NDAgrE)

by G C Mouat BSc NDAgrE FIAgrE

FROM its inception the Institution of Agricultural Engineers has aimed at furthering the interests of agricultural engineers and farm mechanisation specialists, and certainly it has made a major contribution in the field of agricultural engineering education.-When the Institution was first formed in 1938, the founder President, Colonel Johnson, emphasised the importance of education so that British agricultural engineering concerns could recruit suitable staff and compete successfully with those in other European countries and in the USA.

After the second world war, when the idea of a National Diploma in Agricultural Engineering received active consideration by the Institution, British agriculture and the agricultural engineering industry presented a quite different picture to that which is seen today. Although agriculture was highly mechanised the machines in use were crude and most of the better designs originated in America. Many engineering firms were turning from war time production and, in the tradition of "swords to plough shares", were looking to agriculture to find new outlets for their products. The result was the appearance in the fields of this country of many grotesque machines which failed to stand up to work in an agricultural environment. Reference to the reports of the sugarbeet harvester demonstrations of those days shows that many mechanical engineers, employed by distinguished manufacturers, were designing machines which were totally inadequate for their agricultural function. The case for improved education in agricultural engineering was irresistible.

Establishing the NDAgrE in 1951 is only one of a number of contributions which the Institution has made to agricultural engineering education. It was the influence of the Institution-at that time the Institution of British Agricultural Engineers-which helped in the establishment in 1947 of the MSc courses in Agricultural Engineering at Kings College, Newcastle, now part of the University of Newcastle. Similarly, in 1948 the Institution, through the East Anglian Branch, played its part in the formation of Farm Machinery Operation and Care courses for training skilled operators necessary for the more sophisticated machines then being developed; from these courses have grown the range now available for operators and agricultural engineering technicians organised and administrated by the City and Guilds of London Institute. The year 1948 also saw the formation of the Institution's own Education Committee which led in 1951 to the introduction of the NDAgrE Later, pressure from this Committee enabled the IAgrE to influence Government policy which in 1962 provided for the National College of Agricultural Engineering.

One man who played a major part in the shaping of the Institution's thinking over this period was Alexander Hay OBE, chairman for many years of both the Education Committee and the Examination Board. From the many others who guided the Institution and assisted in the success of the NDAgrE over the years two who must receive special mention are D I McLaren of the NIAE and J A C Gibb OBE, the Institution's Immediate Past President.

The original concept of the one-year NDAgrE was to provide men with the technical knowledge and practical ability to meet the need for agricultural engineers and farm mechanisation specialists at home and overseas. The requirements of the Commonwealth were very much in mind as it was realised that trained personnel could improve the use of farm machinery in the agriculture of underdeveloped countries and the production of much needed food supplies. Provision was made for nationals from overseas to train in this country and many of the first British NDAgrE holders found worthwhile employment developing equipment and mechanised systems for food production overseas. The syllabuses for the Diploma reflected the overseas needs and, for example, the subject of field engineering included sections on soil and water conservation and on specialist equipment such as disc ploughs.

At home in the early 1950's agricultural education was expanding and many holders of the Diploma were in demand as lecturers in agricultural engineering. Surprisingly, the agricultural engineering industry, in the form of the major manufacturers and dealers, was slow to appreciate the value of the NDAgrE. As the years went by some of the smaller and medium sized firms recruited trained agricultural engineers and in recent times an increasing number of NDAgrE holders have been employed in field test and in the servicing and marketing departments of some of the biggest firms in the country. Today, diploma holders are to be found in practically all branches of agricultural engineering and farm mechanisation including land drainage, rural electrical supply, farm mechanisation research, advisory work and farm management. Many men have progressed to the most senior posts as managing directors and as marketing and service managers; others have made a success of their own construction or contracting business. One distinguished holder of the NDAgrE is John Fox, President of the Institution and Managing Director of Bomford and Evershed.

From the beginning, two types of student were recruited to the NDAgrE courses – holders of first qualifications in agriculture, usually the National Diploma in Agriculture, and those holding qualifications in engineering, normally the OND or City and Guilds Agricultural Engineering Technicians qualifications. No attempt was made to turn agriculturalists into engineers in one year, but the aim of the course was to provide agriculturalists with the knowledge appropriate to mechanisation specialists and a sufficient appreciation of engineering science and drawing to understand and assist the engineer. Similarly, the engineer could not be made into a qualified agriculturalist in one year and the task was to introduce the engineer to the biological sciences, to agriculture, and to the application of his engineering knowledge to agricultural situations. The engineer was led to appreciate that many of the farmer's problems could not be resolved by precise mathematical formulae. Engineers and agriculturalists studying together offer a tremendous challenge to the teaching staff involved, but the mixing and exchange of ideas between the two groups has proved stimulating and is one of the major advantages of having the two types of NDAgrE courses at the same agricultural colleges. As a spur to endeavour, and as an honour to it's Founder President, Colonel Johnson, the Institution in 1953 instituted the Johnson Medal to be awarded to students of sufficient merit passing the NDAgrE. Today, there are distinguished holders of the Johnson Medal in many parts of the world.

Holders of the NDAgrE have been eligible for corporate membership of the IAgrE and through the Institution for T Eng status awarded by the Engineers Registration Board.

Changes sometimes become necessary, and over the years alterations in the national administration and pattern of agricultural, horticultural and engineering education have meant that it is no longer necessary for the Institution to provide its own Diploma. The last examinations for the NDAgrE were held in the summer of 1974 at the West of Scotland College of Agriculture.

What then of the future? Both the Writtle Agricultural College and the West of Scotland Agricultural College (Auchincruive), the colleges mainly concerned with the NDAgrE, have made provision for suitable alternative courses in agricultural engineering and mechanisation at technician level. Writtle, through its distinguished Principal B H Harvey OBE, who retired in 1974, has developed over the years into one of the foremost agricultural and horticultural colleges in the country. The College was early to see the need for the type of training which the NDAgrE provided and offered appropriate courses from 1952 onwards. Today, the College offers a wide range of courses in agriculture and horticulture including advanced courses associated with its strong machinery and management departments. The Writtle course most nearly approaching the old NDAgrE is the one-year full-time supplementary course in mechanisation for holders of Higher National Diplomas in Agriculture or Horticulture or other equivalent qualifications. With Britain a member of the Common Market and realising the need for marketing staff concerned with the export of equipment overseas, a feature of the Writtle course is the provision for the study of a foreign language.

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Additionally, with the need of manufacturers in mind, Writtle is planning short intensive agricultural appreciation courses for farm building specialists and for those completing apprentice training in engineering science. Another short course is planned to meet the specific requirements of the horticultural industry and is devoted to the mechanisation of protected (glasshouse) crop production.

In Scotland it has been the West of Scotland College which undertook NDAgrE training. The College is the centre not only for agricultural, horticultural, food technology and poultry husbandry education but also is the headquarters of the advisory service for the West of Scotland. Another important aspect of the work at Auchincruive is research and development to meet the needs of farmers in the region. Over the years the College has pioneered research on barn hay drying and other methods of grass conservation, and at the present is actively concerned with work on waste disposal. The College holds the distinction of appointing the first lecturer in agricultural engineering in Britain, John Malcolm, who took up his post in 1920, joined the Institution in 1938 and eventually retired in 1953. Today Auchincruive offers the College Diploma in Agricultural Engineering, a course based on the NDAgrE but modified to reflect the changes in the agricultural and agricultural engineering industries and the increased use of electronics and control systems. Provision is made so that the course can be taken by holders of suitable qualifications in engineering (City and Guilds 030 Parts I and II) or agricultural qualifications (normally the HND in agriculture or horticulture.)

City and Guilds Part III, a qualification for Agricultural Engineering Technicians, is also attractive to candidates who in the past might have taken the NDAgrE and is offered by the Rycotewood College, Thame, and the Kesteven Agricultural College, Lincolnshire.

In 1974 the last full NDAgrE examinations were held and the Institution's participation in formal examinations ceased with a very small number of resit examinations in 1975. The task which the Education Committee set itself in providing Diploma education in agricultural engineering has been well done and has influenced our profession throughout the world. Certainly, the performance of Diploma holders over the years is impressive and one of which we can be proud. In future the Institution will not be so directly involved in training at NDAgrE level; other bodies including the Technical Educational Council (TEC) in England and Wales, SCOTEC (the equivalent body to TEC in Scotland) and the City and Guilds of London Institute have now taken over responsibility for training and qualifications. The Institution's interest over the whole field of agricultural engineering and mechanisation education remains and it will continue to support all concerned with educational efforts at the high standard it has set itself in the past.

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The undermentioned have been admitted to the Institution, transferred from one grade to another, or have resigned.

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AROUND THE BRANCHES

South East Midlands

Machinery requirements of the continental European farmer during the next five years

THE Branch winter meeting programme was opened by Comte Louis de Lauriston, farming and executive director of Federation of Landowning Farmers, France.

Approximately 85 members and visitors were informed in the speakers opening remarks that, in his view, enough had been said already about fuel shortages and the energy problem and these were in any event of relatively little importance compared with current and future food shortages.

An important factor relevant to machinery requirements was considered to be field size. Comte de Lauriston discussed the French land regrouping programme and quoted one example where 91 fields of average area 0.1 ha had now been regrouped as 12 fields. The average rate of regrouping was 350 000 ha each year at a cost of between £20 and £60/ha. Seventy per cent of this cost was normally met by the state, the remainder being paid for by long term loans (12—15 years). It is hoped that the regrouping programme will lead to an increase in the average farm size in France from 11 to 16—18 ha.

From past experience in France it is likely that farmers will continue to preserve their independence by private ownership of machinery rather than working in co-operative groups. Crops harvested or processed where timing is important are particularly difficult in this respect. Following a survey made in France in 1973 it was found that tractor power was available at approximately 1.1 kW/ha and that the current average tractor power was in the range 28—30 kW but for tractors more than ten years old the average power was 21 kW. Tractor use was found to be influenced by farm size as indicated.

There was evidence to show that farmers in the past had decided to purchase increased tractor power because power was cheaper than labour. To-day, however, with the difficulty of utilising fully the power available in very high powered tractors there was the risk that the cost of power in this form would overtake the savings in labour. In view of this he believed that in future engine power would increase to an optimum of around 67 kW. He noted that at last year's Paris Show farmers had been putting much more emphasis on workspace features such as the seat, cabin design and even fitted radios, than in the past. Farmers will in the future require equipment which can be fitted to tractors much more easily and quickly than at present, eg loaders.

Equipment requirements in the next five years were considered to be closely connected with the future of agriculture which is likely to be uncertain. Agricultural land has decreased by 1.8%/annum during the past years in the nine EEC countries as a result of urban and environmental developments. Alternative food sources unconnected with agricultural land will continue to be sought. Equipment problems will be solved by adaption and not by invention. Timing of such adaption will be important and should always correspond with farming needs, taking careful account of other factors such as price and availability of spares.

In conclusion, Comte de Lauriston offered sympathy for the engineer who would in future be called upon to develop machinery and equipment to meet farmers needs which appear to be changing at an every increasing rate.

During the discussion in answer to a question on the number and cost of labour in agriculture, the Count said 15% of the working French population were engaged in farming as compared with 3% in Britain. He considered this number to be far too great. In his view social politics and economic politics often do not go together. Country children are now, however, being given a wider education and training so that farming is not the only career open to them. Farm size would effectively increase about three times to an average of about 60 hectares during the next ten years as a result of co-operation, but the Count felt that contracting services would not increase to the extent they have in The Netherlands because the French farmer is simply not ready for this change.

The Branch is indebted to BP International for all their assistance in helping to make this meeting possible.

•

TWENTY-TWO members and their wives had a most enjoyable evening at The Farmer's Club, Cambridge, in November, good food, good company and an excellent slide interlude organised by Martin Nellist.

In November a joint meeting was held with the local branch of The Farm Buildings Association where Professor Aldrich of Pennsylvania State University reviewed farm building layouts and construction in the eastern states of USA. A good discussion ensued on materials and on the somewhat luxurious designs selected by farmers which were not backed up by experimental results.

To round off the programme before Christmas, John Ashburner, of The National College of Agricultural Engineering, presented a detailed paper on the problems associated with producing farm machinery in developing countries. The paper was based on his experiences in India and South America and highlighted the problems of delayed delivery of materials, quality control, lack of special purpose materials and extension facilities. The advantages and disadvantages of manufacture under licence and national manufacture were discussed fully.

Southern

THE Committee of the newly formed Southern Branch of the Institution of Agricultural Engineers met recently at Rycotewood College, Thame, to plan a programme for spring 1975.

This Branch under the chairmanship of David Webb of Rycotewood College, has a potential membership of nearly 200 and covers an extensive area — Oxon, Berkshire, Surrey, Hants and Sussex.

The first open meeting was held at Basingstoke on Friday 17 January, being a social event aimed at welcoming all members and introducing Branch officials. The topic for the evening being "Green Crop Preservation".

A further meeting was held at Merristwood College, Guildford, on 21 February on "Amenity Horticulture".

It is the intention of the Committee to plan a full and eventful programme and all members and guests are welcome at any meeting.

Further details from the Branch Secretary, A David B Gardiner, Rycotewood College, Priest End, Thame, Oxon. (tel: Thame 2501).

West Midlands

A burning topic

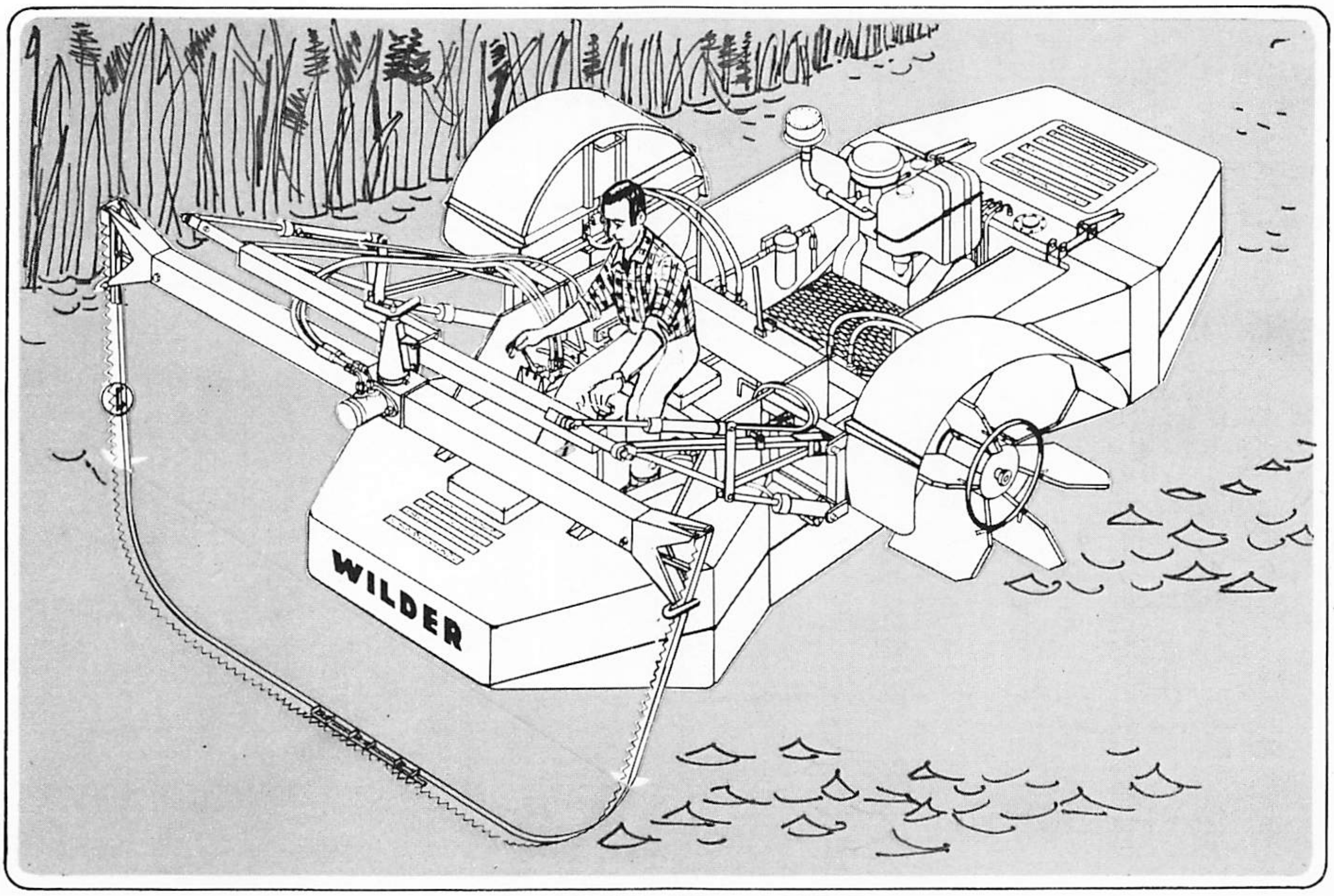
TWENTY three per cent of all straw was burned off the fields of Warwickshire, compared with 48% in counties like Essex, the West Midlands Branch of the Institution of Agricultural Engineers was told at a forum entitled "Straw: its problems and potentials", held at the Warwickshire College of Agriculture, Moreton Morrell, on 28 October.

A panel of three speakers, Mr K A McLean, ADAS, Chelmsford; Mr B Wilton, University of Nottingham School of Agriculture and Mr R Yallop, marketing manager of Stramit Ltd, Suffolk, gave the views of the farm mechanisation adviser, the farmer and biologist, and the industrial manufacturer of straw-board products respectively.

Forty per cent of all the straw fires in Essex, said Mr McLean, were started accidentally, in spite of the fact that the regulation "Code of Practice" had been adopted as a bye-law in that county.

Much accidental damage was caused by uncontrolled fires, but with straw being bulky, and of relatively low value, merchants found it uneconomical to transport long distances to areas where it was in demand. One promising approach had been the packaging of standard-sized bales into big blocks for road transport and mechanical handling.

Mr Wilton told the meeting that much work was being done at



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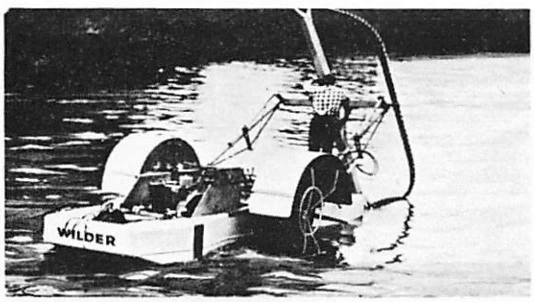
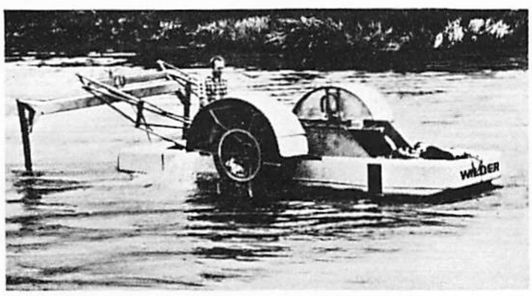


The cutter can operate ahead of the boat . . .



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