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FOOD
FOR THOUGHT

Annual Conference
of **The Institution of Agricultural Engineers** with the **Annual General Meeting** and **Awards Ceremony**

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Professor Brian Witney,
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Principal Speaker
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"Food safety disasters: why do we not learn from experience?"

Deidre Hutton, Chairman of the Scottish Consumers' Council
"Is it good to eat?"

Dr Dennis Legge, Head of Food Technology Division, Loughry College, Northern Ireland
"Developing people – for a competitive food industry"

Dr Eric Hillerton, Institute of Animal Health, Compton
"The equipment to meet milk standards"

Roger Balls, Engineering Consultant
"Engineering for the benefit of the product and the consumer"

Andrew Muir, SAC Crops Division
"Monitoring the quality of produce"

The conference explores the issues and controversies surrounding the need to meet higher food standards and the response of food technologists and engineers who have to create new machines and systems to enable the farmer and others in the food supply chain to reach and even surpass these standards.

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9 May 2000

Details from:
The Secretariat,
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West End Road, Silsoe, Bedford MK45 4DU
Tel: 01525 861096 Fax: 01525 861660
E-mail: secretary@iagre.demon.co.uk
or
Eur Ing Douglas McRae
19 Broomhall Avenue, Penicuik, Midlothian EH26 9EG
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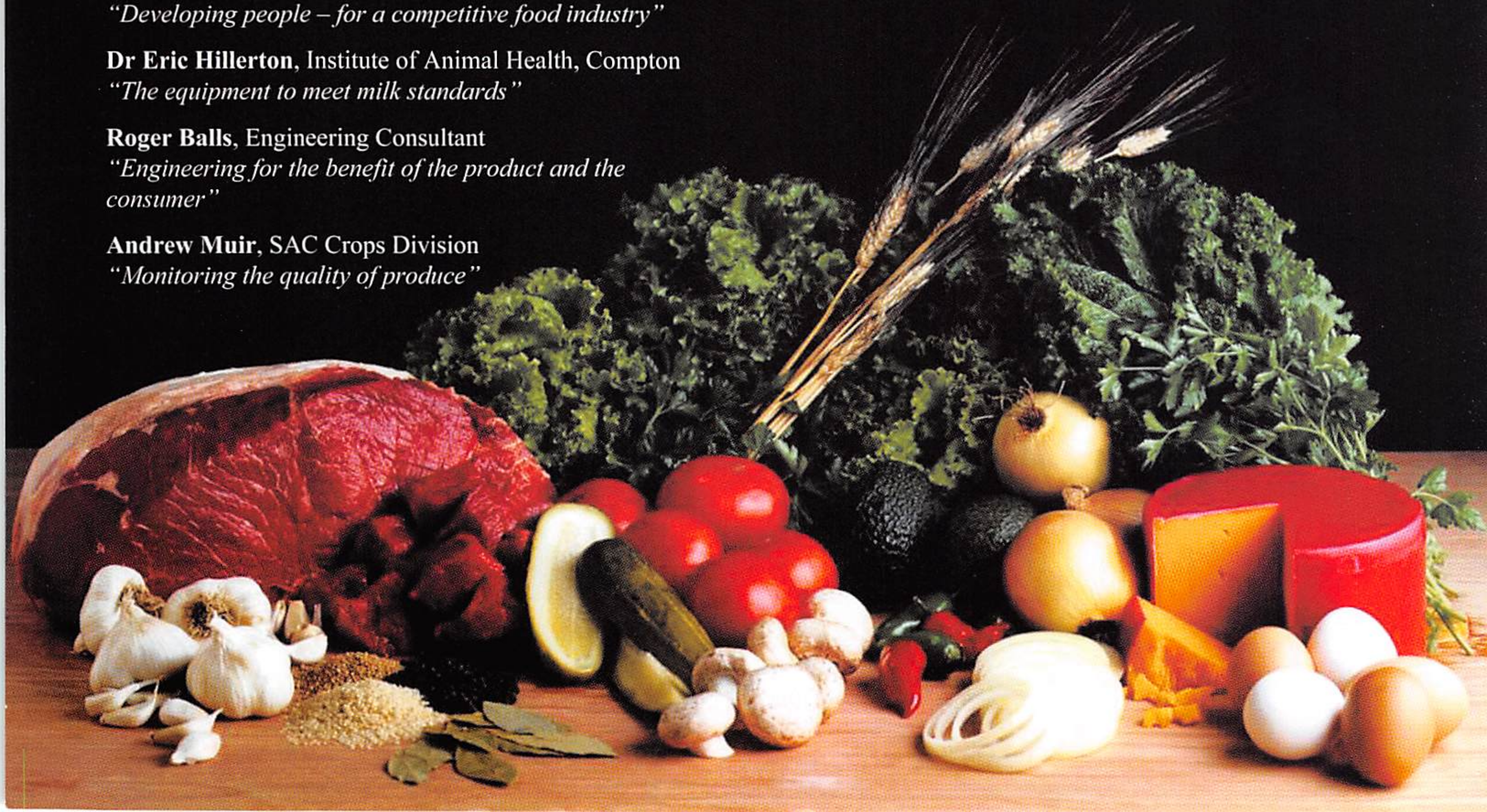

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Editor
Eur Ing Prof Brian D Witney
PhD CEng FIMechE HonFIAgrE MemASAE
LAND TECHNOLOGY LTD
33 South Barnton Ave,
Edinburgh, EH4 6AN
Tel/Fax: 0131 336 3129
E-mail: landtec@ednet.co.uk

Advertising
All enquiries to the Institution of Agricultural Engineers
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Fax: 01525 861660

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Web site at
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Front cover: *Horticultural enterprise in perspective* (*photo: Geoff Lawson*)

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Colour vision in forest and wood engineering

Gary W Krutz, Harry G Gibson, Daniel L Cassens, and Min Zhang



Abstract

Colour is an important factor in the wood industry. Wood products are often graded by producers and consumers using colour parameters. Colour is used to sort wood for defects, but also to perform genetic screenings or to make an aesthetic judgement. The task of sorting wood following a colour scale is very complex, requiring special illumination (Singh et al., 1993; Paulsen & Mcclure, 1986) and training (Lidror & Prussia, 1989). Also, this task cannot be performed for long durations without fatigue and loss of accuracy. This paper describes a machine vision system designed to perform colour classification in real-time. Applications for sorting a variety of products are included, e.g. seeds, meat, baked goods, plants and wood. First the theory of colour classification of agricultural and biological materials is introduced. Then, some tools for classifier development are presented. Finally, the implementation of the algorithm on real-time image processing hardware and example applications for industry are described. This paper also presents an image analysis algorithm and a prototype machine vision system which was developed for industry. This system will automatically locate the surface of some plants using a digital camera and predict information such as size, potential value and type of this plant. The algorithm developed will be feasible for real-time identification in an industrial environment.

Keywords: colour machine vision, real-time image processing, colour classification theory, statistical pattern recognition, neural networks, quality control, wood, wood products

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The authors are at Purdue University, Agricultural and Biological Engineering and Forestry Departments, West Lafayette, Indiana 47907, USA.

1. Introduction

Colour classification background

Separating different products based on visual aspects is a classification operation, which everybody does without thinking. An evaluation of the colour aspect of the object is followed by a decision on the object quality or palatability based on personal criterion or on standards. This process needs to be reproduced in an automatic system. This system has to first estimate the colour distribution of the object and then make a decision on the object quality.

There are numerous algorithms and methods for classification. Two major approaches are the statistical and neural network. Many examples of these two methods of classification can be found in the literature for biomaterial colour classification (Hetzroni, 1994; Benaday, 1993; Precetti, 1994).

The statistical approach is generally based on the assumption that the information data are normally distributed, whereas the neural network approach incrementally seeks a solution minimizing a measure of error. These two classification approaches for biomaterials have been compared in many publications (Deck *et al.*, 1991; Zhuang *et al.*, 1993; Precetti, 1994).

The development of a neural network colour classification system to determine the network structure was often made by trial and error. However, our approach differs in that we define a network structure depending only on the number of colour classes. Since real-time colour classification requires algorithms to fit specialized hardware, we opted for the simpler structure of a Binary Linear Classifier (Precetti, 1994). This structure is built by a

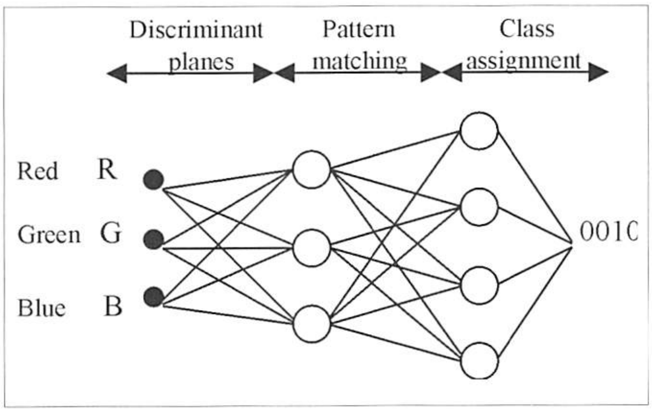

Fig. 1 Binary linear classifier (BLC) for a 4 class problem

recursive dichotomy of the colour space, isolating colour classes from each other using linear discriminant functions. Each pixel's colour position with respect to the discriminant planes is computed using perceptrons (Zurada, 1992) in the network's first layer, and pattern matching realises the class assignment in the second layer (*Fig. 1*).

2. Real-time colour classification

2.1. Colour classification model

Adapting to industry needs and demands, we developed a standard model to build colour classification systems. Since the machine vision system is copying human colour classification, it is necessary to collect both the colour information available to the electronic system and the expert classification. When dealing with full objects to classify, it is expected that the colour distribution of each object is not uniform. An example of this colour distribution in an object can be seen in an image of croissants (*Fig. 2*).

The expert classification is needed for the final quality assignment based on the 'fuzziness' of the colour makeup. The image colour information is processed in what we call a first level classification, the result being a 'classified image' in which each pixel is assigned a colour class. The results of the classification are the percentage of each colour class detected on the object. Results are then processed in a second level classification modelled after the expert. The end result is what a human grader would qualify as the quality classification of an object based on colour variations.

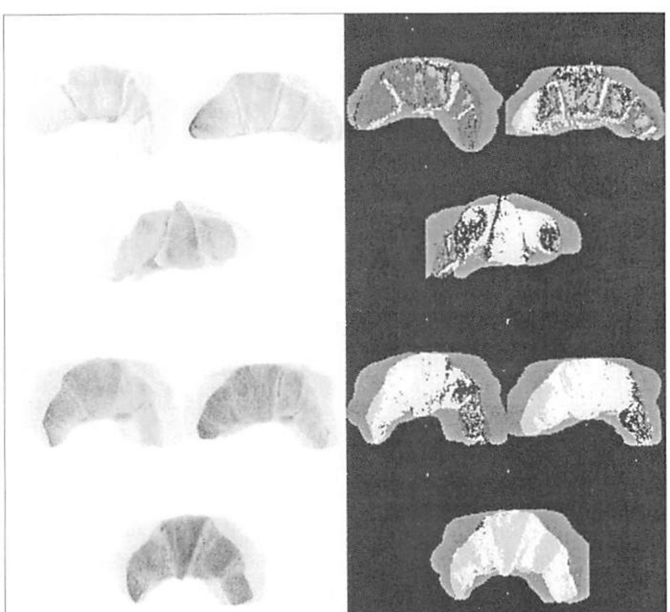

Fig. 2. Examples of colour classification of croissants (colour image on left, classified image on right)

This two-step neural network approach allows the system to be very flexible. It can easily be retrained to classify different objects or the same object based on different criteria, whereas traditional threshold methods would require a lot of data collection and analysis to change products or classification criteria. The following schematic illustrates the model for developing a colour classification system (*Fig. 3*).

The output of the second level is the expert class assignment, which can be unrelated to the first level colours. The number of input parameters is the number of colour classes in the first level. This low number, compared to the number of pixels in the image, allows the usage of more computationally intensive classifiers such as nearest-neighbours or quadratic Bayes classifiers. The decision on which classification scheme is based to implement is the result of extensive testing of the second level classification.

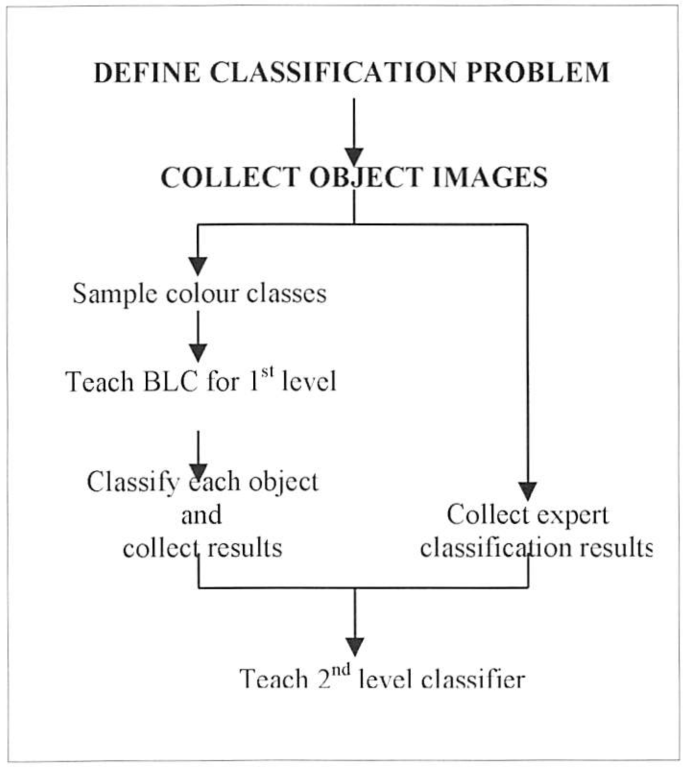

Fig. 3 Colour classification model schematic; BLC, binary linear classifier

2.2. Colour classifier evaluations

When using multivariate distributions, it is advantageous to discover any underlying parameters (Fukunaga, 1990), which reduce the dimensionality of computations. For colour classification, the optimal dimensionality is the colour band combination that yields the best

Table 1 Dimensionality analysis for seed corn colour classification on the linear and quadratic Bayes classifier and the binary linear classifier (BLC) with % resubstitution error; RGB, red green blue

Classifier	*Resubstitution error, %*						
	RGB	*RG*	*RB*	*GB*	*R*	*G*	*B*
Linear	3.3	19.2	2.6	9.7	26.2	34.9	22.1
Quadratic	1.6	2.3	2.2	3.1	21.2	35.2	19.3
BLC	0.5	1.8	1.1	2.4	27.4	38.7	35.7

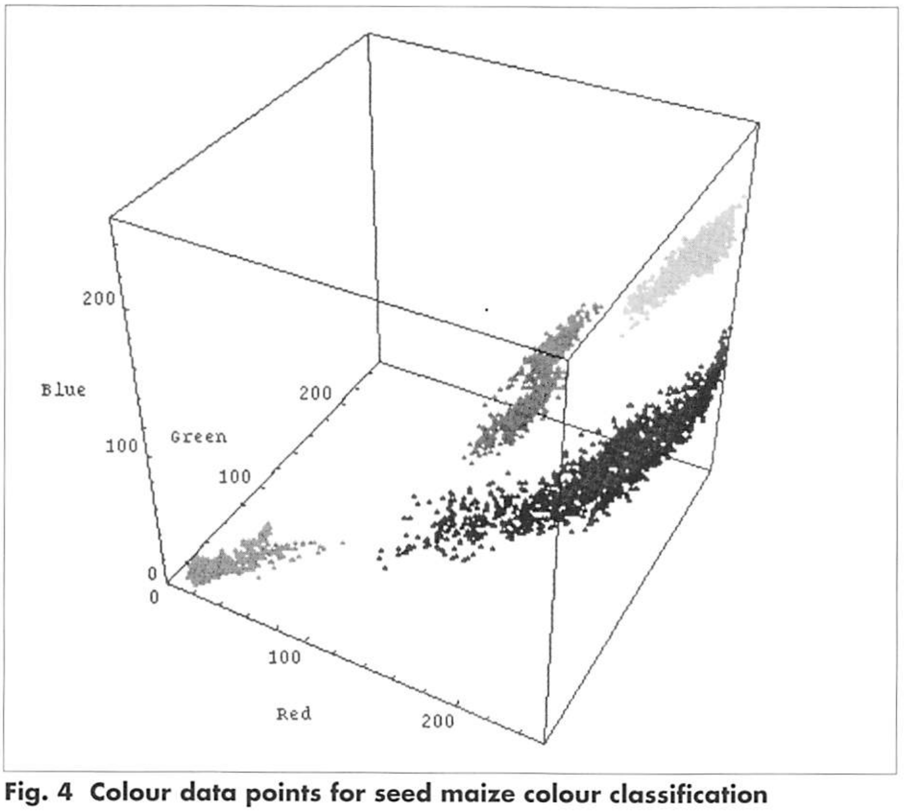

Fig. 4 Colour data points for seed maize colour classification

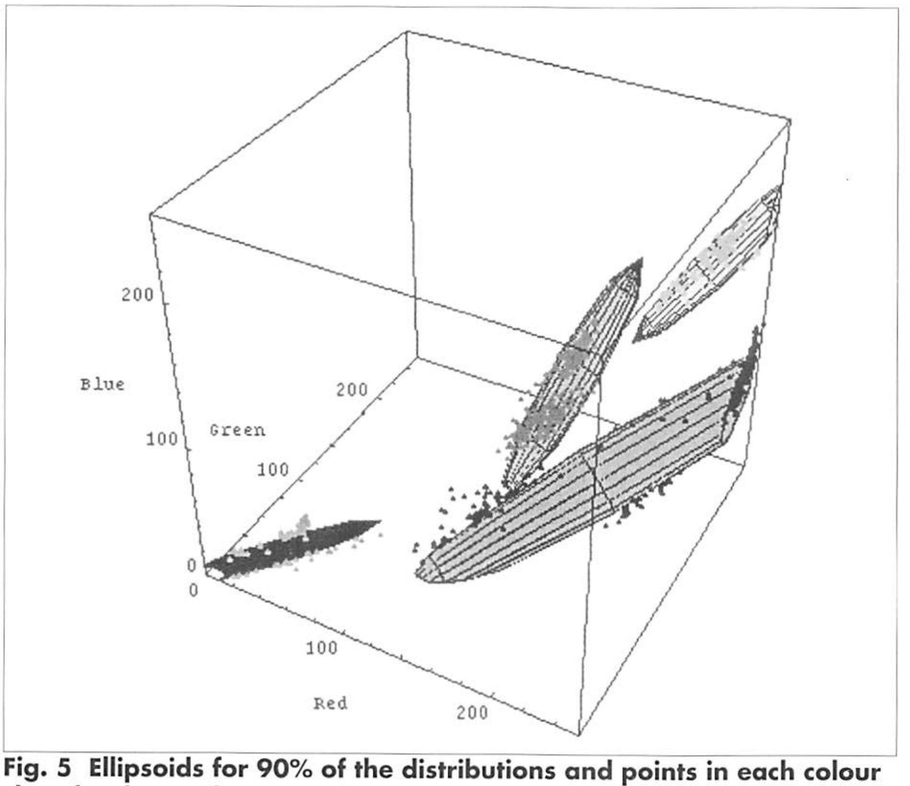

Fig. 5 Ellipsoids for 90% of the distributions and points in each colour class for the seed maize colour database

classifier. The resubstitution error, error of the classifier on the collected data, is used as a criterion. Colour classification software were developed to compute this analysis (Precetti & Krutz, 1993a, 1993b). Table 1 presents a dimensionality analysis for a seed maize colour classification and three classifiers, which shows the trade-offs between the dimensionality and the classifier accuracy.

Visual tools were also developed to help developers of colour classifiers to understand the colour distributions and the classification process. A three dimensional plot of colour distribution (*Fig. 4*) and the normal distribution ellipsoids (*Fig. 5*) are used to understand colour classes and their overlap.

A dimensionality analysis can be performed using these simple plots, as it is visible that the class distributions are aligned with the intensity axis (main diagonal). Thus, a bivariate classifier could perform almost as well as the trivariate classifiers. This is confirmed by the numerical dimensionality analysis (Table 1).

From all our applications in biomaterials colour classification, we found some distinctive results. The orientation of the colour classes were found to be consistently orientated with the intensity axis in red, green and blue (RGB) space, except in the cases of monochromatic objects such as red meat. Also, we found using a Chi-square test, that most colour distributions sampled by an operator are close to a normal distribution (Hadji-Thomas, 1994). Therefore, it is possible to reduce the amount of data needed for building a colour classifier. Since only the outer layers of each colour distribution and the overlapped regions are likely to be used in the neural network correction algorithm, the database can be sharply pruned (Precetti, 1994). Finally, during the learning phase of the BLC building, there are changes in neural network correction factors needed to ensure network convergence and to speed up the process. However, adjusting the parameters for optimal BLC learning requires much operator training. An expert system was developed to follow some simple rules to choose the initial correction factors and set the number of learning iterations. This expert system is integrated within Samplex (© Purdue Research Foundation, 1995), an image sampling and neural network building software package.

2.3. Hardware and application constraints

The development of industrial applications required the establishment of constraints such as processing speed, cost of hardware, and user interfaces. The colour classification algorithms had to be adapted to the available hardware, and the final product is a real-time system that is able to process up to 6 images/second. This experience of developing the system allows us to point to potential pitfalls and bottlenecks in future generations of hardware and algorithms.

The Matrox IM series system was used as image processing hardware. It consists of three boards, the IM-CLD colour frame grabber, the IM-RPT real-time processing unit, and the IM-640 base board. This system holds 4 Mbytes of image memory organized into 4 Mbytes frame buffers. Two main limitations are arithmetic computation and amount of memory. Memory is necessary to store the classifiers intermediate results. A Bayes quadratic classifier requires 5.6 Mbytes of memory, whereas a BLC classifier requires only 3.1 Mbytes for a 5 class colour classification. Therefore, the choice of classification algorithm is dependent on the amount of buffer memory and the number of classes. Furthermore, parameters of discriminant functions had to be 8 bit integers, with a result coded on 16 bit integers. This significantly reduces the classifier accuracy compared to using floating point parameters (Precetti, 1994). Today, new computer architecture has reduced some of the significance of these limitations. Faster bus speeds and more image memory make the current state-of-the-art hardware much faster.

2.4. Colour of wood samples

The purpose of this study was to determine if the diameter of a log or the location within a log affect a board's colour. Forty-eight samples were tested using a colour vision classification system that detects shifts in colour RGB space. Diameter did affect a board's colour; this colour shift can be seen in assembled furniture.

2.4.1. Introduction

In an effort to understand the colour variations in wood, red oak top logs were used in the experiment. These logs are evenly divided among three diameter classes: Category 1, 19.1-24.0 mm; Category 2,24.1-29.0 mm; and Category 3,29.1-34.0 mm. To determine the effect of position, the logs were cut into bolts that were distributed within two positions and two replications per position. From each of these position classes the individual boards were cut and their vertical location was recorded. The board was either cut from the lower or upper section of the log. Thus the study has two variables: log diameter and position within the log. The boards were analysed to determine if there are colour differences between these factors. Defects can be detected along with colours and grain patterns (*Fig. 6*).

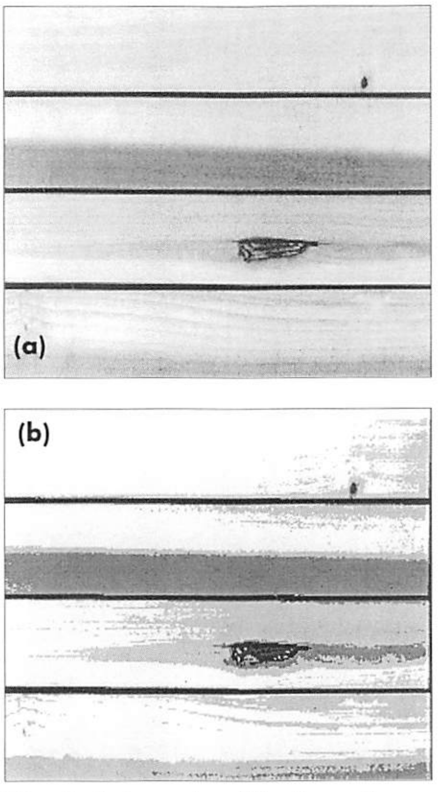

Fig. 6 Colour classification of wood slats for: (a) sorting; and (b) and detection of defects

2.4.2. Material and methods

For this study, we had 48 wood samples. These samples were distributed within 16 subsample sets by diameter. In fact, four were tested for each different replication. Each sample had four images; two on each side were analysed. The images have been taken with a colour charge coupled device (CCD) camera RGB and saved in a host computer before they were sent to the UNIX station to be analysed. Images were taken after the wood samples were put in a white box equipped with two 500 W halogen lights. Four different methods were used to compare the samples. In the first comparison, the differences of the means were evaluated for the three colour bands: red, green, and blue. In the second comparison, only the luminance L of the laboratory space was used to assess colour - thus, the colour differences of samples. In the third comparison, we have used the software 'Sort' developed by L. Haney, Agricultural Engineering Dept., Purdue University, that classifies the wood sample in three categories: light, medium, and dark. In the last method, a multivariate statistical analysis was used called 'Comparisons of Several Multivariate Means' using a Chi-square distribution.

2.4.3. Discussion of wood colour results

The first analysis is simply a comparison of the mean for each colour band, red, green, and blue. The smallest diameter had a value for R of 182, G of 151, and B of 119; and the middle diameter had a value for R of 181, G of 150, and B of 117. These were pretty close compared to the large diameter with R of 174, G of 143,and B of 110. The second result showed that the position in the log was not as important between the diameters as the colour difference shown.

The second analysis method showed that the three diameter categories may be put in the same colour class. This result is given by the software 'Sort' which has classified almost all the samples in the light categories. This analysis confirmed the large diameter is darker than the two others. This study looked at the number of pixels classified in each category, light, medium and dark, compared to the whole of samples per diameter.

This analysis also confirms by the value of luminance L (smallest value of 82, middle value of 82, largest value of 80) which, for Phelps (1994), is sufficient to classify the wood in colour. Also J. Phelps said: "If the difference of values is inferior to 3, the wood has the same colour," which was verified in this experiment.

A multivariate statistical analysis gave the same results. The method calculated the percentage of resemblance between a reference sample for a diameter and another sample of this diameter. The reference is the sample which has the same colour RGB for the colour band mean of that sample diameter. For the

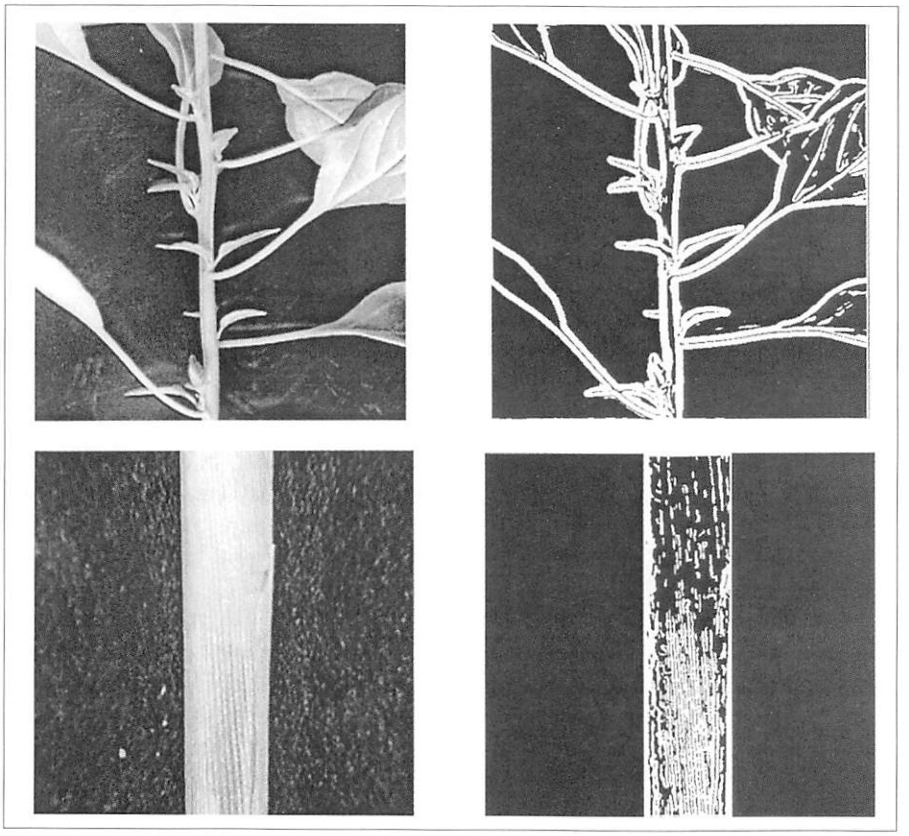

Fig. 7 Edge detection on some bio-materials: top, pepper; bottom, maize stem

smallest diameter, all the samples are identical at 94%, for the middle diameter we have 92%, and for the large diameter we have 86%. These values show that the smallest diameter is the most homogenous category. This statistical analysis confirms that the position in the log is not important.

In conclusion, the three diameters are classified in the same categories of colour (light), with the large diameter darker than the middle and the smallest diameter. We can say also the smallest diameter is the most homogenous class.

Lumber sorted by grade
↓
Lumber rough-planed
↓
Lumber gang-ripped into strips
↓
Strips cross-cut into boards
↓
Boards sorted by width, length, and product
↓
Boards colour matched and loose-assembled into panel
↓
Glue applied to board edges
↓
Panel pressed and cured
↓
Panel sanded
↓
Panels shrink-wrapped
↓
Panels shipped to cabinet manufacturers

Fig. 8 Typical manufacturing process of edge-glued panels (Phelps et al., 1994)

2.4.4. Pattern recognition of plant stems

The identification and location of plants is an important issue for the development of potential automatic agricultural machines. The applications of machine vision systems in this work included pepper, maize, logs, *etc.* This resulted in developing new potential approaches for biological applications.

Computer vision and image analysis have been found to be a potentially powerful approach for many aspects of agricultural engineering, and are two major elements in this research. A feasibility investigation of using colour machine vision technology to identify the stems of some plants in a complex agricultural environment was conducted. An edge detection algorithm was proposed to classify the types of plants using colour digital images. This algorithm was successful in determining plant types from a group. *Figure 7* shows the result of the algorithm working on some plants (stems).

2.5. Wood grain pattern recognition

The manner in which a board is sawn influences its grain pattern; the actual figure present will vary and is what the end-user views. Thus, for the duration of this study, references is made to the figure and not the sawing method used. Flat-grained is used to describe a part which has a U- or V-shaped figure. 'Rift-grained' refers to a piece which has parallel lines. The terms quarter-grain and rift-grain, although distinct, are considered to be flexible (Hoadley, 1980). Hence, the more general term, rift-grain, is used. Mixed-grained is the catch-all term to describe that which is neither predominately flat- nor rift-grained.

Edge-glued panels are a common method for making wood furniture. *Figure 8* shows a basic flowchart of the manufacturing process. The sorting operations shown are currently done by human inspectors.

A potential way of describing different wood grains is as a texture (*Fig. 9*). Texture has many different meanings depending upon the context in which it is used. Although the concept is intuitive, a formal definition of texture in the fields of image processing and machine vision has not been fully developed. A basic definition would be the regular arrangement of pixels in an image. Even without a precise understanding of what texture is, two main approaches to texture description have developed: statistical and structural (Haney, 1997).

A statistical analysis develops measures about the variation of the local features. These values are then used to group pixels into similarly textured areas. This approach is generally used for textures which are micro-texture (*i.e.*

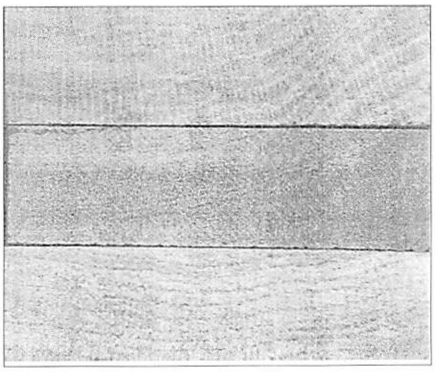

Fig. 9 Image of the cross-sections of three staves

made of several nearby pixels) in nature. These measures tend to blur boundaries between textures because they require relatively large areas to achieve stable results.

2.6. Thresholding for segmentation in wood vision systems

After acquiring the image, the next step is to process the image so that the desired features are enhanced. Wood grain on the surface of a board could be described as a difference in the colour between the earlywood and latewood. The lighter earlywood might be successfully segmented from the darker latewood by a thresholding operation. Thus, it must be determined if a more appropriate threshold exists than the histogram of the appropriate colour band showing two distinct peaks. Histograms exhibiting bimodal characteristics have the best seperability and result in the best segmentations.

2.7. Gradient-based edge detection

A common image processing technique to emphasise an area of local grey-level variation is edge detection. There are many methods of edge detection, from simple one-pass algorithms to complex iterative approaches. The appropriate detection scheme used is dependent on the nature of the application and the image quality.

2.8. Difference-based edge dectection

The research showed that the Sobel edge detector is ineffective at segmenting the image. One of its main limitations was the 3 by 3 neighbourhood it uses to determine orientation. Grain patterns are a larger, macro-feature. The board surface is littered with micro-features (rays, rough surfacing, and colour irregularities) to which the small Sobel mask responds. Smoothing helped to reduce the scale, but the orientation information was still unable to help.

The advantage of the difference of Guassian (DoG) filter is that the values of σ_1 and σ_2 can be changed to optimize the filter's scale to fit the scale of the image. The Sobel operator does not have this flexibility. *Figure 10* illustrates the effect of the DoG filter. These DoG filters have two smoothing operations which can be a smoothing function defined by σ_1 and σ_2. In practice, however, smoothing is performed by iterative use of a single 3 by 3 Gaussian kernel.

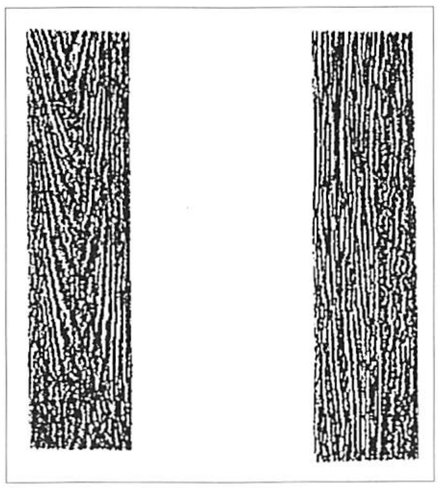

Fig. 10 Effect of a 2 by 2 difference of Gaussian (DoG) filter on white oak

2.9. Feature extraction

After extracting the grain pattern, the image is still at a low level of abstraction. The image has been processed but all that is known is contained in an array of numbers. Ideally, all preceding steps have eliminated irrelevant data so that the remaining pixels convey all necessary data. At this point, no size or shape information has been gathered. *Figure 11* illustrates the generalised shapes that will be presented to the grain recognition system to be recognised. The goal of the analysis is to know the distribution of shapes within a scene. Are all lines vertical? Do the lines lean in one direction or both? Flat-grained parts will have lines with opposing directions and/or parabolas.

Since lines and parabolas will be present, the shape analysis strategy needs the ability to determine if an object is a line or parabola. The Matrox Image-Series processing board provides several types of shape analysis options. One algorithm scans the image from the top and registers the coordinates of the first pixel for each object. This procedure can also be performed in reverse by starting the scanning at the bottom. Thus, after two scans of the image, both the top and bottom coordinates of each object can be known. Another shape analysis algorithm finds the bounding box for each object. In two passes over the image, each object's *extrema* for each axis is found. There are many other shape features available for study; however these would require processing of the image on the host system. The process of transferring the image from the Matrox board to the host would take nearly a second. After the host has received the image, processing would take even more time. Thus with the architecture of the current hardware, host-based processing is unrealistic for a real-time industrial system.

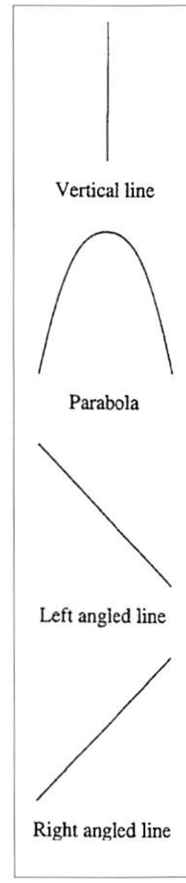

Fig. 11 Generalised shapes resulting after the DoG filtering

The goal now is to determine if the endpoints and bounding box are sufficient information for classification. *Figure 12* illustrates how these features would differ for the generalised shapes of *Fig. 11*. It is apparent from the illustration that the width of the bounding box will differ for a straight grain pattern as opposed to a parabolic or angled pattern. The object width is less for straight lines than for parabolas or angled lines. Thus, a simple thresholding operation of the object width should be necessary to differentiate an object into a straight grain classification or other category.

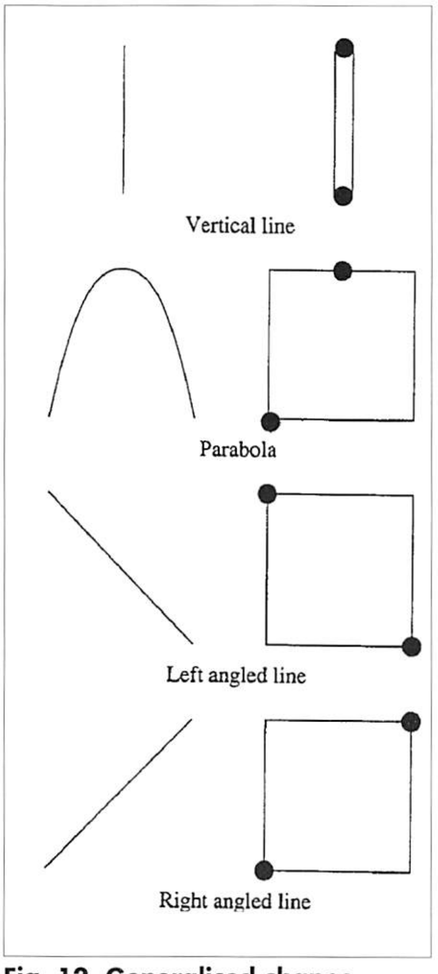

Fig. 12 Generalised shapes with their corresponding bounding box and endpoints

For those features not classified as a straight pattern, it is necessary to determine if it is a parabola or an angled line. This distinction is important in order to separate flat-grained and mixed staves. Mixed-grained staves should have lines with a consistent direction of slant. Flat-grained staves should contain parabolas and the lines should be distributed in both the left and right directions. The bounding box is insufficient to distinguish between parabolas and angled lines. Thus it is necessary to use the endpoints (*Fig. 13*).

3. Scene analysis and decision making

The processing of the image has now reached a sufficient level of abstraction to make a judgement.

1. If the stave has only a straight pattern, then it should be classified as rift-grained.
2. If the stave has several parabolas or a similar number of left and right slanted lines, then its classification should be flat-grained.
3. If it is neither rift-grained nor flat-grained, then it is a mixed-grained stave.

3.1. Colour band results

To find the best colour band, assumptions must be made for the shape analysis parameters which have yet to be optimised. The assumptions are set to values that seemed to produce good results during algorithm development. For this test the object length was held at 30 pixels. The object width threshold was set to 20 pixels and a value of 0.8 was used for the width-ration parameter. The DoG filter was varied over the range of 1 to 10 iterations for both the first and second smoothing operations. One hundred staves were classified and compared to the manually created standard. The results are summarised in Tables 2 and 3.

3.2. Overall accuracy

Thus far, the analysis has only examined the classification rate, and the distribution

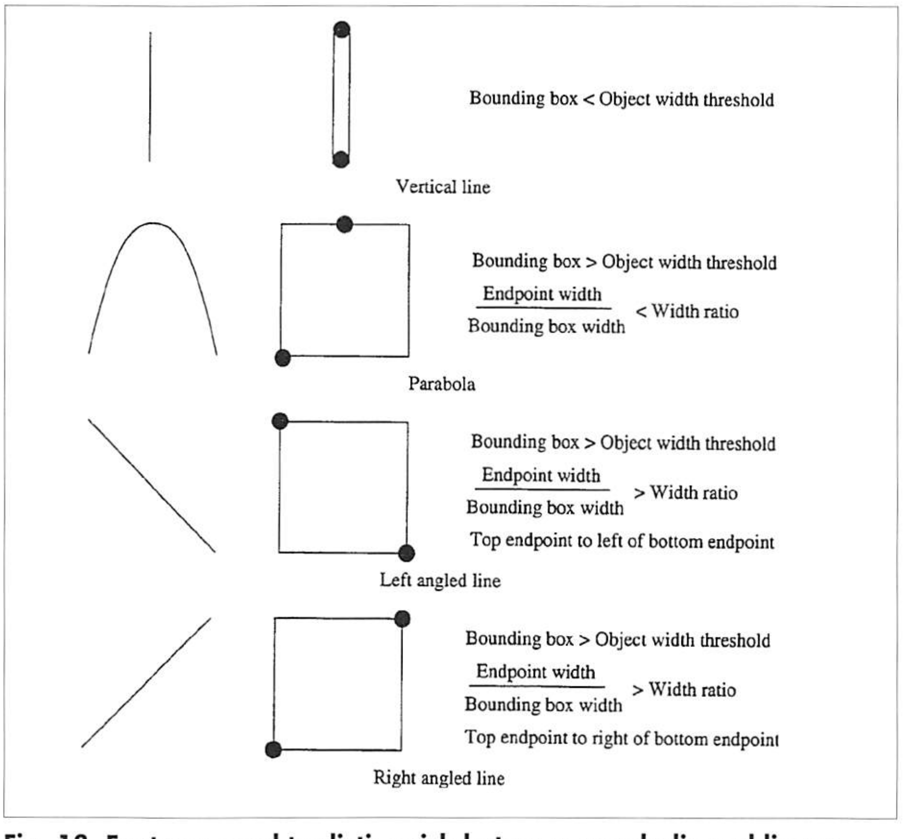

Fig. 13 Features used to distinguish between parabolic and linear objects

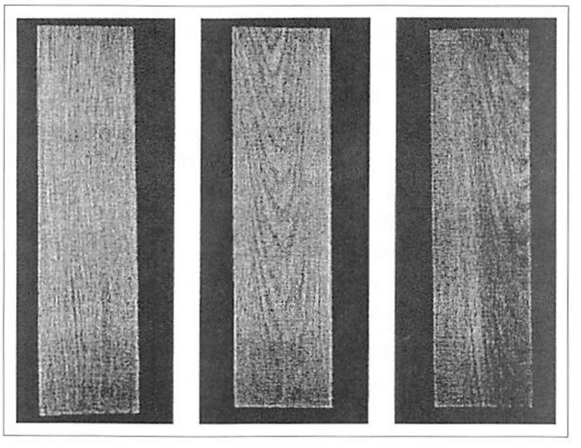

Fig. 14 Examples of the figure classes: left, rift-grained; middle, flat-grained; right, mixed-grained

of errors is unknown. The algorithm has been designed to classify each stave into one of three categories. Table 4 breaks down the classification of the optimal filter. If the classification rate were 100%, then all off-diagonal components would be 0. This table shows that the greatest source of error is a misclassification of flat-grained and rift-grained parts as mixed-grained. Sixteen mixed-grained parts were improperly classified while one rift-grained and four flat-

Table 2 Summary of colour band test

Colour band	*Red*	*Green*	*Blue*
Overall average classification rate	39.8%	41.7%	40.0%
Number of filters with classification rates over 50%	10	17	3
Average classification for filters over 50%	62.2%	63.5%	56.7%

Table 3 Summary of optimal parameter values for algorithm

Parameter	*Value*
Colour band	Green
Iterations of first Gaussian	4
Iterations of second Gaussian	2
Object length	10 pixels
Object width	20 pixels
Width ratio	0.8

Table 4 Error distribution for the 4 by 2 difference of Gaussian (DoG) filter

		Classified		
		Flat-grained	*Mixed-grained*	*Rift-grained*
Actual	Flat-grained	40	4	0
	Mixed-grained	9	28	7
	Rift-grained	0	1	11

grained staves were erroneously assigned.

A possible industrial integration of this algorithm would make use of the rift-grained and flat-grained staves. The mixed-grained staves with their irregular grain pattern would probably have a lower value, thus the classification of a rift-grained piece being used with the properly classified flat-grained and rift-grained pieces. Although these staves' full value would not be utilized, the end product would not be devalued. An errant mixed-grained in a high-end panel would be costly, especially if the panel is rejected after being shipped overseas. Table 4 surveys algorithm results.

The grain pattern exhibited on the surface of a board is highly variable. This pattern is intermixed with physiological factors such as rays and with machining marks from sawing and surfacing. Several approaches to extracting the grain pattern using the Sobel edge operator were ineffective. The difference of Gaussian filter was the only method which was able to effectively extract the grain. The DoG is a scalable filter which allows it to be used with different sized features.

The shape analysis algorithm designed is able to differentiate between rift-grain, flat-grain, and mixed-grain patterns. This algorithm uses the bounding box and end points of each labelled object to classify it into a general shape. The distribution of these shapes determines the final classification for the stave. An absolute accuracy of 79% was achieved by this approach. Weighting the errors to disregard staves misclassified as mixed-grained increased the accuracy to 98%, although the absolute accuracy dropped. Repeatability was 86% for the 4 by 2 DoG filter. The current system was also shown to be capable of operating in real-time with conveyor speeds of 0.7 m/s.

4. Conclusions

Thus the approach outlined is feasible and suitable for further testing in an industrial environment. Current uses include successfully identifying over 200 standing tree and plant species.

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Timber quality in Great Britain – key issues and implications for forestry engineering

Elspeth Macdonald

Abstract

Concerns about the quality of future supplies of British grown softwood sawlogs have been voiced throughout the forestry and wood using industries in Great Britain. In response to these concerns, the Timber Quality Research Programme within Forest Research aims to develop methods of assessing and predicting timber quality, with initial emphasis on Sitka spruce. This paper highlights some of the possible implications of timber quality issues for forestry engineering, including development of technology to ensure optimal use of the existing forest resource and engineering solutions to facilitate the production of high quality timber from future crops.

Introduction

Timber production in the United Kingdom is expected to rise significantly over the next 25 years. As shown in *Fig. 1*, the average annual output of coniferous sawlogs is forecast to more than double by 2020, from the current level of 4.6 million cubic metres to 9.9 million cubic metres (Whiteman, 1996). Over the same period, it is predicted that the domestic demand for sawn timber will remain relatively static. Given this scenario of increasing supply but stable demand, successful marketing of future supplies of UK sawn timber will require an increase in the share of the domestic market, which must be brought about by displacing imported material.

At present, more than two-thirds of UK produced sawn timber is absorbed by the lower value pallet, packaging and fencing markets (McIntosh, 1997). As the supply of UK sawn timber increases, these market sectors are likely to become saturated by home produced material. Greater penetration of the higher value construction market will therefore be necessary. The ability of the sawmilling industry to supply timber of the required quality at a competitive price will be crucial if this increase in market share is to be achieved.

Timber quality requirements for construction

For construction purposes, the principal quality criteria applied to sawn timber are:

- dimensions
- bending stiffness (Modulus of Elasticity, MOE)
- bending strength (Modulus of Rupture, MOR)
- dimensional stability

The dimensions, strength and stiffness of

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Elspeth Macdonald is at Forest Research, Northern Research Station, Roslin, Midlothian EH25 9SY, Scotland, UK.

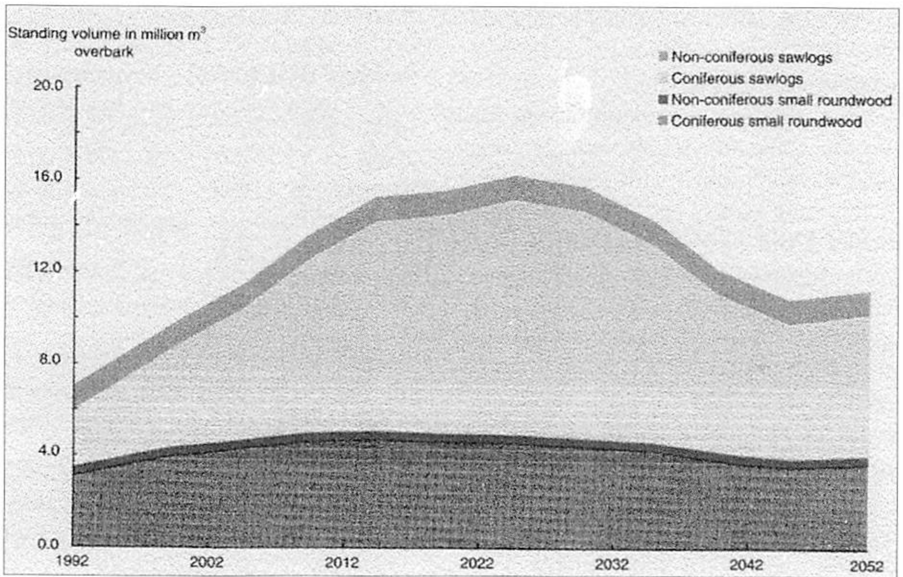

Fig. 1 Forecast of roundwood supply from UK forests (after Whiteman, 1996)

sawn timber are crucial to its suitability for use in a specific situation: their importance has long been recognised. The majority of UK sawn timber supplied for construction purposes is mechanically stress graded to assess its mechanical properties. European Standard EN388: 'Structural timber – strength classes' gives details of the nine strength classes for conifers, C14 to C40 (CEN, 1995). The most widely used structural grades are C16, C24 and C27.

The dimensional stability of timber refers to the changes in dimensions that occur as moisture content varies, sometimes resulting in severe distortion of sawn timber. This includes the shrinkage that takes place when timber is dried from a green state to a moisture content appropriate to the end-use environment and the 'movement' of timber that is the result of fluctuating moisture content once the timber is in service.

Differential shrinkage of timber during kiln drying can result in distortion of sawn battens in the form of twist, bow, spring and cup. In severe cases these defects will result in the battens being classed as reject material under grading regulations, while in less severe cases the acceptability of the material to the construction market may still be reduced. The importance of the straightness of sawn battens after drying is being increasingly recognised and is now considered by some to be of equal importance to mechanical properties (Kliger *et al.*, 1994).

Movement of timber once in service is also a serious defect. Changes in dimensions of sawn material can result in nail loosening or gaps appearing once the timber is in place: this can also significantly affect acceptability in the construction market.

As a consequence the main quality requirements for sawlogs to be converted to construction grade sawn timber are:

- **dimensions** – logs must be sufficiently long to enable battens of the required length to be cut and have a specified minimum top diameter, generally 16 cm under bark;
- **straightness** – logs which are not straight result in reduced recovery of sawn timber, the deviations in grain angle and increased compression wood formation that accompany crooked stems resulting in poorer mechanical performance and increased drying distortion in the sawn timber; and
- **knot size and frequency** – logs which have large and/or frequent knots result in a high knot area in sawn battens, and consequently reduced stiffness and strength (Brazier, 1986).

Timber quality issues

Concerns about the quality of future supplies of British grown softwood sawlogs have been voiced throughout the forest and wood using industries in Great Britain. It is feared that many sawlogs will be of too low a quality to provide material suitable for the market for construction grade timber. These concerns, which are focused on Sitka spruce, are based on the evidence of timber coming onto the market in recent years and on the likely consequences of the changes in silvicultural practice that have taken place over the past 50 years (Mason, 1993).

The move to wider initial plant spacing in the late 1960s to reduce establishment costs, can be expected to have resulted in the production of timber with larger knots, a reduced average wood density, a larger juvenile core and poorer average stem form (Brazier, 1970; Brazier, 1977; Brazier & Mobbs, 1993; Gardiner & O'Sullivan, 1978). Increased planting on exposed upland sites, resulting in less stable stands, has limited the options available in terms of thinning regimes and rotation lengths, reducing the opportunities for favouring better quality trees and/or growing larger trees with less juvenile wood. The combination of these factors is likely to result in sawn timber with inferior mechanical properties and which distorts more when kiln dried.

It is possible to draw these general conclusions about the impact of developments in silvicultural practice on wood quality, but further research is required to quantify the expected changes and to assess their practical and economic impact.

Two main issues relating to the timber quality of Sitka spruce in Great Britain can be identified.

1. What are the quality characteristics of Sitka spruce stands which will be harvested over the next 20 years?

This information is required to guide the investments in sawmilling technology that are required to bring the increased softwood supply to the construction market at a competitive rate. Without improved information about the quality of future timber supplies, these investments are unlikely to take place.

2. What are the principal factors influencing Sitka spruce timber quality in Great Britain and can their effects be quantified?

This information is required to enable forest managers to evaluate alternative silvicultural options and their impact on timber quality.

The Timber Quality programme within Forest Research aims to address these two questions. The approaches being adopted and some possible implications for developments in forestry engineering are outlined below.

1. Quality of future Sitka spruce timber supplies

The objective is to develop methods of assessing and forecasting Sitka spruce timber quality in standing trees that can be used to provide improved information about the quality of future timber supplies to forest managers and the wood using industries.

A strategic evaluation of timber quality requires a standardised method of assessment that can be applied to stands

Table 1 Straightness scoring system

Score allocated to tree	*No. of straight logs counted in butt 6 m*			
	≥ 5 m	*≥ 4 m < 5 m*	*≥ 3 m < 4m*	*≥ 2 m < 3m*
1				
2				1
3				2
4			1	
5			1	1
6		1		
7	1			

throughout Britain. A prototype method of assessing log quality in standing Sitka spruce trees was developed by Forest Research in collaboration with industry representatives and is described in a recent Forestry Commission Information Note (Methley, 1998). Straightness was identified as the most important single factor affecting log quality in Sitka spruce. Although knots were acknowledged to have a significant impact on log and sawn timber quality, they were not considered the primary cause of downgrade in spruce logs. An assessment method based on an estimate of straight log lengths in the first 6m of the stem was devised.

This prototype method has been further refined and validated on a range of sites throughout Great Britain and is now considered robust enough to be used on a wider scale. The number and length of straight log lengths in the first 6 metres of the stem are assessed visually and the tree is allocated a score of 1 to 7 as shown in Table 1. The definition for straightness applied during the assessment is that which is used in the sale of softwood sawlogs in Britain, *i.e.* '*Bow not to exceed 1 cm for every 1 m length and this in one plane and one direction only. Bow is measured as the maximum deviation at any point of a straight line joining centres at each end of the log from the actual centre line of the log*' (Forestry Commission, 1993).

Four quality grades, based on the distribution of straightness scores in the stand, have been defined as a useful way of classifying stands in terms of log straightness:

Grade A – with 40% score 6 or higher
Grade B – with > 50% score 4 or higher but < 40% score 6 or higher
Grade C – with 50% score 3 or lower but < 40% score 1
Grade D – with 40% score 1

Thus Grade A stands, the best quality in terms of straightness, are those where 40% or more of the trees have a straight log of at least 4 metres in length in the first 6 metres of the stem. At the other extreme Grade D stands are those where 40% or more of the trees have no straight lengths of 2 metres or more in the first 6 metres.

This method will be used to make a strategic assessment of timber quality at a national level. A forecast of the *quantity* of timber to be harvested from forests in Great Britain is prepared quinquennially by the Forestry Commission (Rothnie & Selmes, 1996). To date, there has been no comparable estimate of *quality*.

A range of sites will be sampled to investigate the relationship between stem straightness and selected crop and site parameters, including thinning history, planting year, initial spacing, yield class and windiness. Where quantifiable relationships between stem straightness and crop/site parameters are identified, these will be incorporated into a predictive model, which can then be integrated with existing production forecasting programmes for Forestry Commission and private forests to produce an estimate of the stem straightness of future timber supplies.

Implications for forestry engineering

Four main areas of interaction between the timber quality of existing crops and forestry engineering, aimed at making the best possible use of available material, can be identified.

• Gathering information about the quality of future timber supplies

The proposed straightness assessment system classifies stands into four broad quality grades. It is not considered feasible to link the straightness assessment to a more detailed assessment of product out-turn at a national level, given the widely varying market conditions found throughout Britain. However, use of computing software in harvesters could enable forest managers to make these assessments at a local level. Detailed records of out-turn of different products can be recorded at the coupe or sub-compartment level and then linked to pre-harvest straightness assessments of these crops. In this way, a local picture of how straightness score relates to out-turn can be built up. For future planning, this can be used to estimate quantities of different products likely to come out of particular areas.

• Optimising quality in the forest

At present many harvesters have computing software designed to optimise the production of higher value products on the basis of stem dimensions, when provided with cutting specifications and an associated price list. The operator still has to make a decision about quality – *i.e.* are there any quality defects on a stem that preclude sawlogs from a particular category being cut? Such defects include stem sweep and crook, heavy branching, ramicorn branches, butt rot and scars or wounds. It can be particularly difficult for an operator to assess stem sweep and crook, the most frequent defects in Sitka spruce, as it is not possible to view the stem from different sides and visibility can be poor, particularly in the low light levels likely to be encountered in thinnings. Decisions which can greatly affect profitability have to be made by the operator very quickly and in difficult conditions.

An engineering solution to this problem would be to develop a scanner on harvester heads to assess straightness of the stem and allow optimisation not only on stem dimensions but also on stem shape. This would probably involve a double pass of the stem through the harvester head prior to cross-cutting, but an improvement in the out-turn of better quality material should compensate for this loss in productivity. Britain relies heavily on shortwood systems of harvesting and extraction involving the use of harvesters and forwarders. Given the increase in volumes of timber to be harvested in the coming 20 years there may be a market for the development of such technology, which could have a dramatic impact on the out-turn of straight logs from variable crops.

• Optimising quality in the sawmill

Scanners to optimise cross-cutting of stems in the sawmill are beginning to come into use in Britain. Whole poles, generally 12-14 metres in length but up to 20 metres, are scanned on a cross-cutting line to produce an accurate assessment of their profile from which an optimised out-turn of logs can be cut. The benefit of this system to the sawmill is that they can optimise the out-turn of required products *and* be more flexible about changing specifications for logs at short notice, thus responding more quickly to their customers' demands than when cross-cutting takes place in the forest. If this system could be extended to include scanning for such defects as rot or compression wood in logs the targeting of timber to most appropriate end-uses could be improved.

Cross-cutting in the sawmill requires harvesting and haulage systems geared to extracting and transporting whole poles. In many areas, current practice is not set up for this and engineering input in the form of modifications to forwarders and lorries, such as bunk extensions or trailers, are likely to be required.

• *Engineered wood products*
If concerns about the quality of future timber supplies are well founded, ways in which the available material can be processed to produce products suitable for use in construction are required. Developments in the production of engineered wood products, such as laminated veneer lumber (LVL), parallel strand lumber (PSL), laminated strand lumber (LSL) and finger jointing using green gluing technology offer possible means of achieving this *(Fig. 2)*. The principle behind these techniques is to produce a high quality end-product with consistent, known characteristics from relatively low quality raw material. Wood is either cut into short sections or sliced into veneer sections and strength reducing defects, such as knots, are either removed or redistributed to reduce their impact before the wood pieces are glued together. The resultant products generally have superior strength properties and improved dimensional stability compared to the raw material and can be used in more demanding situations.
Engineered wood products offer a way of 'making a silk purse out of a sow's ear', but they are expensive to produce. The market for such products is likely to be relatively limited, particularly when high quality imported sawn timber is available at competitive prices. In certain circumstances, however, engineered wood products might be a competitive alternative to other engineering materials such as steel, or might be a means of gaining access to the high value joinery sector for the production of components such as window frames. Unless the costs of production are significantly reduced, however, it seems unlikely that this sector will absorb a significant amount of the increased volume of timber that will be coming on the market.

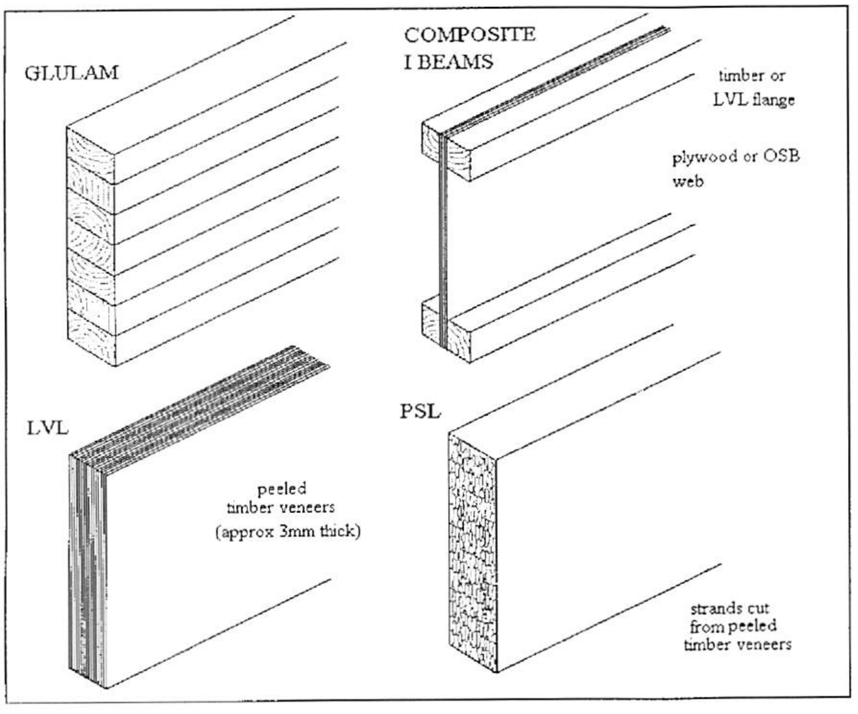

Fig. 2 Examples of engineered wood products (after Milner & Bainbridge, 1999); GLULAM, glued-laminated timber; LVL, laminated veneer lumber; PSL, parallel strand lumber

2. Factors affecting Sitka spruce timber quality in Great Britain

The objective of this project is to determine and quantify the effects of silvicultural practice and site factors upon Sitka spruce timber quality.

A major task within the project is to develop a computer based model to predict sawn timber quality on the basis of tree growth patterns, as affected by silvicultural practice and site factors. The model will ultimately be closely linked with stand growth models for Sitka spruce developed within Forest Research (Matthews & Methley, 1998). The factors considered likely to affect timber quality are age, initial spacing, Yield Class, thinning pattern, windiness and site quality. The outputs from this modelling process will include distributions within the standing tree of branches (and hence knots), wood density, grain angle, juvenile wood and compression wood. The model will link into existing models predicting sawn timber performance that have been developed by the Building Research Establishment (Maun, 1992).

This type of model will enable forest managers to evaluate different management options for existing and future forests in terms of timber quality.

Implications for forestry engineering

The potential for the timber quality of future crops to be improved through silvicultural practice could be increased by advances in forestry engineering. Some possibilities for future developments are outlined below.

• *Establishment techniques*
Timber quality is influenced significantly by initial spacing at planting. Successful achievement of intended plant stocking densities is therefore an important consideration in producing timber of the desired quality. Two factors determine whether or not intended stocking densities are achieved. Firstly, the correct number of plants must be planted at the required spacing and, secondly, a high level of plant survival must be achieved. Understocked plantations brought about by an insufficient number of plants being planted results in similar problems to wider spaced stands, while the patchy stocking that results from uneven plant survival encourages the formation of asymmetric crowns with a consequent increase in the development of compression wood.

At present, ground preparation for replanting felled areas in Britain generally involves either excavator mounding or scarification. At the current target stocking levels of 2500 stems per hectare there can be difficulties creating sufficient evenly spaced planting positions due to the presence of thick brash zones created during harvesting to support forwarders and prevent ground damage. Improvements in ground preparation techniques brought about either by advances in machine design or developments in working methods could help enable the correct level of stocking to be achieved. Systems for chipping brash on site to produce an evenly distributed mulch rather than very thick concentrated brash zones would also be beneficial.

• *Stem selection in thinning*

Thinning is an important element of producing high quality timber. Development of low cost mechanised thinning techniques which are flexible enough to enable a selective silvicultural thinning to be completed will enhance the timber quality of the final crop.

• *Pre-commercial thinning*

In areas where commercial thinning is not possible due to economic or stability reasons, the development of techniques for cost-effective mechanical or chemical pre-commercial thinning would provide the opportunity for the quality of the final crop to be improved.

• *Pruning*

Pruning of conifers is generally not practised in Britain at present and there is no established market for the clear timber that can be produced from pruned stands. In addition to restricting knotty timber to a central core, pruning has also been reported to reduce taper (Henman, 1963) and reduce the volume of juvenile wood produced (Briggs & Smith, 1986), thus enhancing general wood quality. If a cheap, reliable method of pruning stands could be developed, this might be a means of improving the quality of many understocked plantations which will otherwise develop heavy branching and large knots. Such a method would also enable wider spaced regimes to be used in the future without a penalty in terms of branch size.

Conclusions

Timber quality issues in Britain are focused on Sitka spruce, the timber of which is often marginal for the construction market and which accounts for more than 60% of timber produced. Forest engineering has an important role to play both in enabling the best use to be made of existing crops and facilitating the production of high quality crops in the future. The four main areas where forest engineering could have a significant impact are:

1. improved systems for assessing stem form automatically, particularly in the forest;
2. improved detection of defects, such as knots, rot and compression wood, both in logs and in sawn timber;
3. further developments in the production of high quality engineered wood products from low quality timber; and
4. designing improved, low cost techniques and machinery for silvicultural operations such as ground preparation, pruning and thinning.

Good communication between silviculturists, wood technologists and forest engineers is required to ensure mutual awareness of problems and possible solutions.

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HSE-funded research shows over a million workers at risk from hand-arm vibration

New Health and Safety Executive (HSE)-funded research, published today, suggests that over a million workers are exposed to potentially harmful levels of hand-arm vibration.

HSE commissioned the research to investigate how many people are affected and in which industries workers are most at risk. The sectors studied included construction; agriculture and horticulture; foundries; road, rail and air transport; mines and quarries; public utilities; civil engineering; ceramics and metal products. The research found that the construction industry has the greatest number of workers (around 460,000) exposed to potentially hazardous levels of hand-arm vibration.

Hand-arm vibration syndrome (HAVS) is the name given to a group of diseases, of which the most widely known is vibration white finger. Workers using hand-held tools and equipment are at risk of exposure. The research also studied exposure levels of whole-body vibration. This reaches operators and drivers of industrial vehicles and machines through the seat or platform and is associated with lower-back pain.

The studies, published today as four research reports, were produced by Professor Mike Griffin at the Institute of Sound and Vibration Research and Dr Keith Palmer at the Medical Research Council's Environmental Epidemiology Unit. The reports found that:

- almost 4.9 million people are exposed to hand-transmitted vibration in a one week period;
- over 1.2 million workers are exposed to vibration levels at which HSE recommends that employers should be taking action;
- 242,000 cases of extensive cold-induced finger blanching are likely to be attributable to hand-arm vibration; and
- 460,000 construction workers are exposed above the HSE action level.

The report evaluating some of the common sources of exposure found that although people were generally accurate in reporting the sources of their exposure, they tended to overestimate its duration. In addition, it found that there were wide differences in the ways workers used tools and in the vibration magnitude of tools of the same category. The report also found that few of the companies observed had health surveillance systems for vibration-induced injuries.

The report's key findings on whole-body vibration are:

- 0 9 million people are exposed to whole-body vibration in a one week period;
- 383,000 workers' exposure exceed a suggested British Standards Institution (BSI) action level.

The report found that lower-back pain was common in all occupations but concluded that the risk of lower-back pain from vibration exposure was generally lower than anticipated and likely to be small in most workers. The report found that jobs exposing people to vibration often involve physical stresses such as twisting back movements, loading and unloading the vehicle manually, digging and shovelling and concluded that these factors play a greater part in causing lower-back pain than whole-body vibration does.

Brian Coles, of HSE's Physical Agents Policy Unit, said: 'We already know that work equipment which transmits powerful vibration to peoples' hands can cause diseases like vibration white finger and carpal tunnel syndrome. This new research suggests that the problem may be much more widespread than previously thought. Construction stands out as the industry with most people exposed and the report suggests that workers such as bricklayers, carpenters, electricians and plumbers, who regularly use hand-held power tools, are reporting symptoms of white finger and nerve damage.

'At the same time, the findings on whole-body vibration cast some doubt over the strength of the link with lower-back pain and how widespread the risk might be. This research will be invaluable in determining what future action we need to take to control risks from both hand-arm and whole-body vibration.'

There are several publications available from HSE Books including: *'Hand-arm Vibration'* (Ref. HS(G)88), ISBN 0 7176 0743 7 price £7.50, and the pocket card, *'Hand-Arm Vibration Syndrome' (Ref.*INDG296P), free. A CD ROM, is also available: *'The successful management of hand-arm vibration'* price £95.

Contact: **HSE Information Centre, Broad Lane, Sheffield, S3 7HQ. Tel: 0541 545500.**

New from NESTA...

The UK has always had its fair share of brilliant minds, but hasn't always been so quick to harvest their business potential. Scientists, inventors and artists simply haven't had the support they need to develop their ideas into marketable services, products or techniques that can benefit our economy. Instead many have looked overseas or failed to fulfil their potential.

The National Endowment for Science, Technology and the Arts (NESTA) was created by an Act of Parliament in 1998 to help set this to rights. The Invention and Innovation programme will provide a tailor-made package of support for those truly exceptional ideas that will shape our futures. This could include research and development, helping you to secure intellectual property rights or establish your business.

If you have a great idea, but need that extra support to realise it, they'd like to hear from you.

Contact: **NESTA, Fishmongers' Chambers, 110 Upper Thames Street, London EC4R 3TJ. Tel: 020 7645 9538 e-mail: nesta@nesta.org.uk**

The new landscape farmers

Britain's farmers are beginning to recognise that by managing their land jointly to create a more attractive landscape richer in wildlife, they might enhance their diminished standing in the eyes of the public and help smooth the way, towards reliable government compensation for meeting environmental objectives. To some extent, their view is influenced by their current economic plight.

New research funded by, the ESRC analysing the responses of farmers in an area bounded by Wiltshire, Gloucestershire and Oxfordshire established that each one was prepared to consider jointly implementing 'whole landscape management'. This implies farmers co-operating across privately owned boundaries - by planting hedges and buffer zones to boost biodiversity, and by permitting the reflooding of the Thames Valley, for example.

The cost of implementing the changes could be around £2m annually since it would involve land - mostly arable and improved grassland - being taken out of production. Farmers would also have to take a big step in changing management practices. A survey of hedgerows and wildlife in the area, for instance, found many hedgerows in poor physical shape and little variety of shrubs, birds and butterflies.

The interdisciplinary study, led by Professor Tim O'Riordan, School of Environmental Sciences, University of East Anglia, broke new technical ground by constructing 2D geographical data system maps of the landscape as it is now, and linking these with virtual reality modelling language software to create 3D versions of parts of the future landscape, as planned by the farmers, for two main scenarios:

- 'landscape character' - the focus maximising visual amenity with tree planting alongside roads, rivers and streams and conversion of some riverside fields to improved grassland, with biodiversity providing important amenity value
- 'biodiversity conservation', which would be environmentally more rigorous. It would include all flood plain farmland reverting to extensive grassland, and a major programme to restore and replant hedges, and buffering of all streams and ditches. Two farms on the Thames flood plain would have 80 per cent of current arable land converted to unimproved meadow.

The maps and the chance to 'walk through' parts of the future enabled farmers to visualise the results of their pending co-operation. The farmers found the precise images a considerable help in understanding the possibilities on offer, for each of their properties, and for the whole landscape. Land planners and representative conservation groups as well as farmers were interviewed on three separate occasions.

Estimates of the compensation costs would vary greatly according to farm type. The study puts a total of £2m annually on implementing the biodiversity scenarios, for instance, some of which might come from arable payments being redirected and other funds generated by the switch from production incentives to sustainable agriculture that is long overdue in the reform of the Common Agricultural Policy.

The farms totalled 95 km², of which 42 km² were arable fields. The farmers were a mix of landowners and tenant farmers, part of the study area being centred on the Buscot and Coleshill estate owned by the National Trust. This is by no means an area in crisis - 26 of the 31 farms had been profitable for the five years to 1998. The larger farms were tending to get bigger and few farmers expressed interest in getting off the land. But the economic uncertainties of farming were still very much a factor in the farmers responding fairly positively to suggestions of how environmental improvements might be incorporated in making farming more viable.

Contact: **Professor Tim O'Riordan. Tel: 01603 592840. e-mail: t.oriordan@uea.ac.uk**

Loughborough designed safety system for new telescopic handlers

Loughborough Projects Ltd, specialist manufacturer of load moment indicator systems, has developed a new display for the range of telescopic handlers produced by JCB. The new display will assist the driver to operate the telehandler safely, while performing agricultural duties, by indicating when the vehicle is at its safe load limit.

By working closely with JCB's engineers, the Loughborough-based company has designed an ergonomic, value-for-money indicator which progressively shows the effect of load as the boom of the telehandler is extended. The display complies with the requirements of BS EN 1459:1999 and the European Machinery Directive which stipulates that variable reach lifting equipment must be fitted with load moment indicators.

The stylish new display with its digital electronics and advanced software is easy to install and boasts many interesting features. It fits neatly into cab pillar mouldings thereby aiding JCB to render a sleek and modern design to its latest range of cabs. JCB will fit the display to all its telescopic handlers.

The display is readily calibrated but, to prevent accidental or unauthorised access, calibration can only take place via a secure procedure. Once the calibration mode is acquired, the calibration points are simply selected through two button presses. The display also provides error codes to aid engineers during installation or when it is serviced.

Although the new indicator system boasts many extra features, compared with similar equipment, it offers exceptional value for money. By employing careful design practice and adopting advanced software techniques, Loughborough Projects has reduced the display's size and the number of components it requires and so lowering manufacturing costs.

Contact: **Andrew Sanders, Sales manager, Loughborough Projects Ltd, Swingbridge Road, Loughborough LE11 5JB. Tel: 01509 262042. e-mail: Sales@LoughboroughProjects.co.uk**

Membership Matters

Quarterly The Newsletter of the Institution of Agricultural Engineers Spring 2000

Engineering Council update - IAgrE audit outcome

In the months building up to the 5 yearly Engineering Council Audit of the Institution in September last year, much preparatory work was done by John Neville in preparing our documentation for this important event. The audit, carried out by a panel from EngC, was to determine the Institution's suitability to continue as a nominated body of the Engineering Council.

Members will have noted that Malcolm Shirley's article in the Winter edition of *Landwards* on the EngC Activity Review outlined how, *inter alia*, the Engineering Council was seeking to pass on mature and well established tasks to other organisations better equipped to run them.

One of the main tasks to be passed on to member institutions or nominated bodies is that of maintaining an on-going audit of the internal workings of these nominated bodies, particularly as they relate to Engineering Council matters.

This effectively means that once licensed by the EngC, nominated bodies will use their own internal procedures to maintain quality and consistency, particularly as they relate to membership and EngC registration criteria. Thus, the former, 5 yearly, audit is replaced by a 5 yearly 'light touch' audit.

Our previous audit in 1995 gave IAgrE the licence to accredit academic courses and standards with full certification at IEng and EngTech levels and, with the help of ICE at CEng level through a bilateral agreement. On this occasion, IAgrE applied for full licensing and accreditation at all levels but with the proviso that we would intend to maintain our links with ICE at CEng level, although on a less formal basis. The main reason for seeking this level of licensing was to provide a higher level of service to Members seeking CEng registration by reducing some of the time delays inherent in a bilateral working arrangement.

The good news is that, as a result of the recent EngC audit under the old system, EngC have certified the Institution to these standards again, through to 31st October 2004 for IEng & EngTech and to 31st October 2000 for CEng. This latter certification is to give the IAgrE time to:

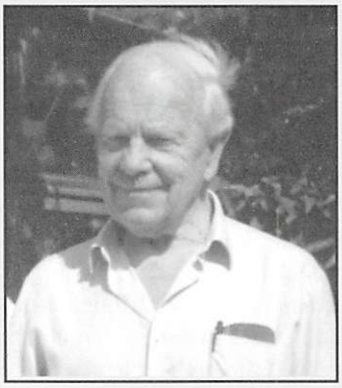
- establish internal audit procedures of sufficient standing to qualify us for the 'light touch' audit procedures being introduced by EngC for future nominated body audits and
- finalise our procedures under the new SARTOR 3 regulations.

John Neville continues to work on our SARTOR 3 documentation and I am working towards finalising our internal audit procedures prior to a re-audit on CEng procedures in October 2000.

Our thanks must go, in particular to John, but also to our President (Prof Brian Legg), President Elect (Geoff Freedman) and Immediate Past President (Prof Dick Godwin) who, together with Dr Steve Parkin formed the team which met the EngC assessors. Thanks also to the EngC team who could not have been more helpful.

Chris Whetnall

Theo Sherwen a celebration



On 7th March 2000 Theo Sherwen, CEng, HonFIAgrE, celebrated his 90th Birthday. President of the Institution of Agricultural Engineers from 1967-69, he was made an Honorary Fellow in 1974. Theo began his distinguished career in Mechanical and Agricultural Engineering as a draughtsman with the Squire Car Co. of Remenham, Berkshire. There he had a hand in designing the supercharged 2-litre Squire sports car in the 1930's – a notable model comparable to the Aston Martins and Frazer-Nash cars of that era, but of which only a few were made, and just two or three of the original cars remain in going order.

He then joined Harry Ferguson, where among other original design developments he was responsible for the Ferguson automatic trailer hitch, since copied by all other tractor manufacturers, allowing the use of two-wheeled trailers with the axle at the rear and the consequent transfer of weight to the tractor's rear wheels, and greatly adding to the tractive ability

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of a light tractor. He is particularly proud of this invention, which recent press coverage has highlighted not only for its worldwide use in farming, but also for its life-saving potential in the tragic circumstances of the plight of the Kurdish refugees escaping from Northern Iraq, and subsequently the Kosovans fleeing from the Serbs in the Balkans. Their means of transport on difficult and mountainous roads was invariably by tractor and trailer – all with the Sherwen-designed hitch enabling them to carry many people to relative safety in such terrain.

Later, as an independent consulting engineer, Theo specialised in applications of hydraulics, which featured in papers he gave to the Institution, in 1959 on the problems of a development engineer, and in 1965 on power transmission in agricultural machinery. One of his special projects was the weed-cutting boat produced in collaboration with John Wilder Engineering Ltd., of Wallingford. He was also instrumental in the design of a small tractor with four innovative hydraulic wheel motors, in collaboration with BSA, which regrettably was discontinued when that firm was taken over.

He was involved in early discussions with the Council of Engineering Institutions (CEI) and instrumental in the Institution's membership of the Engineers Registration Board, which provided the foundation in later years for the routes to Engineering Registration under CEI and its successor body, the Engineering Council. Also of major significance to the Institution was Theo's involvement in the discussions preceding the inauguration of the Douglas Bomford Trust, of which he served as Chairman for some 16 years from its foundation in 1972.

Innovator, design engineer, Past President, Honorary Fellow, pioneer in contributing to the Institution's eventual status as a Nominated Body of the Engineering Council, and of the routes to Registration as CEng, IEng or EngTech for appropriately-qualified members, the Institution pays tribute to Theo Sherwen for his important contributions to Agricultural Engineering as he reaches his 90th Birthday, and wishes him well in his retirement at Chiselborough, Somerset.

Ian Gibb

Grain-facility design conference

The Grain Elevator & Processing Society (GEAPS) today announced plans to conduct an international conference that will focus on the design of grain-handling and storage facilities and related systems. The programme to be held July 27-31, 2002, in St. Charles, Illinois, USA, is intended for engineers, contractors, project managers, facility-operations managers, equipment suppliers and others knowledgeable about and interested in grain-facility and systems design.

In conjunction with the announcement, GEAPS issued a call for presentations and is currently seeking qualified speakers to address the following pre-selected conference topics:

- trends of global grain trading;
- strategic operations planning;
- project scope definition, development and management;
- design-development constraints;
- receiving systems;
- weighing systems;
- sampling & inspection systems;
- conveying systems;
- distribution systems;
- grain cleaners and cleaning systems;
- grain dryers and drying systems;
- grain-storage and aeration systems;
- shipping systems;
- coatings, finishes, waterproofing and insulation;
- electric power and power-distribution systems;
- automation and control systems;
- emissions control systems; and
- fire and life-safety systems.

The conference will be held on the campus of the Center for Professional Development in St. Charles, which is about 40 miles west of Chicago.

GEAPS, based in Minneapolis, is a 2,800-member professional society dedicated to networking, exchange of information, innovation, quality and safety in grain-related industry operations worldwide.
e-mail: info@geaps.com

Long service certificates

50 years

Name	*Grade*	*Date of anniversary*
Douglas Ian **McLaren**	FIAgrE	1 Mar 2000

35 years

Robert James **Burcombe**	EngTech AMIAgrE	4 Feb 2000
Roger Donald **Dines**	EngTech AMIAgrE	4 Feb 2000
Robert John **Painting**	IEng MIAgrE	4 Feb 2000
Bryan **Webb**	EngTech AMIAgrE	4 Feb 2000
Barry **Linton**	IEng MIAgrE	4 Feb 2000
Christopher John **Darcel**	MIAgrE	11 Mar 2000
Colin Wesley **Dennis**	CEng MIAgrE	11 Mar 2000

25 years

Simon James Peter **Evans**	CEng MIAgrE	22 Jan 2000
Brian Huw **Griffiths**	EngTech AMIAgrE	22 Jan 2000
Richard Peter **Marks**	AIAgrE	22 Jan 2000
Hartley Frank **Young**	IEng MIAgrE	25 Jan 2000
Ian Kingsley **Smout**	MIAgrE	10 Feb 2000
David Brennand **Williams**	CEng MIAgrE	10 Feb 2000
Alan John **Denton**	IEng MIAgrE	10 Feb 2000
David John **Wilks**	AIAgrE	15 Feb 2000
Philip Geoffrey **Park**	AIAgrE	12 Mar 2000
Michael Anthony **Stephenson**	AIAgrE	14 Mar 2000

Agricultural mechanisation among century's top engineering achievements

Agricultural engineering shared the limelight in Washington DC, when Agricultural Mechanisation was named among the twenty greatest engineering achievements of the 20th century. The announcement was made on behalf of the National Academy of Engineering (NAE) by astronaut/engineer Neil Armstrong. Ranked number seven on the list, Agricultural Mechanisation stood alongside such other engineering accomplishments as Television, Automobiles, Computers, Safe and Abundant Water Supply, and – receiving the top citation – Electrification. Larry Huggins, President of the ASAE and associate Dean of Engineering, Purdue University, credits engineers' efforts to mechanise agriculture with dramatic changes in farm productivity and labour movement: "Mechanisation enabled much of the population to leave production agriculture and industrialise the world, and it has simultaneously improved the quality of diet and lowered food costs." A complete description of each of the 20 achievements can be found at http://www.greatachievements.org/ and the relevant information on Agricultural Mechanisation is reproduced below.

At the beginning of the 20th century it took a large team of farmers and field hands weeks to plant and harvest one crop, and it took four farmers to feed 10 people. Today, machinery allows the entire midwestern maize crop to be planted in 10 days and harvested in 20; and one US farmer can produce enough food to feed 97 Americans and 32 people in other countries.

Twentieth century engineering has made the difference. The tractor, the reaper, the combine, and hundreds of other machines gave farmers the mechanical advantage they had long needed to ease their burdens and make their lands truly profitable. Agricultural mechanisation enormously increased farm efficiency and productivity.

Engineering began to affect the farmer late in the 19th century, with steam-powered tractors and various tools for drilling seed holes and planting. Still, most fieldwork was done with hand tools like the spade, hoe, and scythe, or with hand- or animal-driven ploughs. A farmer's day was labour-intensive, beginning well before sunrise and ending at sunset.

Mechanisation did not advance rapidly until the 20th century, with the advent of the internal combustion engine. As the chief power source for vehicles, it began replacing both horses and steam for planting, cultivating, and harvesting equipment. It made the evolution of the tractor possible, and led to sweeping changes in agriculture.

The number of tractors in developed countries increased dramatically, especially in the United States. In 1907, some 600 tractors were in use; by 1950, the figure had grown to almost 3,400,000. Major changes in tractor design include the power takeoff, the all-purpose or tricycle-type tractor, which enabled farmers to cultivate planted crops mechanically; rubber tyres, which facilitated faster operating speeds; treads that could negotiate soft soil without getting stuck; and the switch to four-wheel drive and diesel power in the 1950s and 1960s, which greatly increased the tractor's pulling power. More recent innovations have led to the development of enormous tractors that can pull several gangs of ploughs, while electronic systems monitor or control almost all of the power functions.

A large number of fatal injuries from tractors tipping over led to the design of rollover bars. They became commercially available in 1956 and later evolved into cabs, which provide a protective zone for operators, noise control, and a comfortable environment.

Engineering design for planting and harvesting was hampered by the wide variety of crops, all with different shapes and consistencies (*e.g.*, maize, soya beans, wheat, cotton, and tomatoes). Nevertheless, an amazing array of innovations peppered the century, such as tractor-attachable cultivators and harvesters. Self-tying hay and straw balers arrived in 1940 along with a spindle cotton picker. Shielded maize-snapping rolls were developed in 1952, and rotary and tine separator combines were introduced in 1976, each reducing labour significantly.

A major necessity on many farms is a way to control soil erosion and reduce the time and energy to prepare seedbeds. The development of chisel and disc tillage tools and no-till planters in the 1970s and 1980s solved these problems. Even in the 1940s, sweep ploughs undercut wheat stubble to reduce wind and water erosion and conserve water.

At the turn of the century there were about 6 + million hectares of irrigated land in the United States. Today there are over 25 million hectares, made possible by various types of mechanised irrigation, such as gated-pipe, side-roll, big-gun, or centre-pivot machines. These machines can automatically irrigate areas from 60 to 240 hectares, and can also apply some fertilisers and pesticides.

Over the century, the average amount of labour required per hectare to produce and harvest maize, hay, and cereal crops gradually fell more than 75 percent. In the process, a massive shift from rural to urban life took place. This shift began to have a lasting impact on the nature of work, the consumer economy, women's roles in society, and even the size and nature of families. For women, farm mechanisation freed them from many of the time-consuming household chores required to support a large family and any helpers hired to work the farm. They no longer had to grow, prepare, preserve and cook the massive quantities of food needed on a daily basis. Mechanisation meant empowerment for women, who soon became major consumers as the American economy gradually changed from the barter system to cash.

Mechanisation also meant empowerment for men. Traditionally, farm

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Engineering in a knowledge-driven economy

Much of 1999 was dominated by the necessary, but time-consuming work of the Engineering Council's 'Activity Review' – an appraisal of the continuing relevance of the Council's work. All but completed in 1999, we have successfully refined our activity base, restructured organisationally and put in place considerable efficiency measures to move into the year 2000 and beyond. The ultimate aim of the Review was to give the Council's 260,000 registered engineers, from whom it receives about 80% of its income, more direct benefits and a greater return for their annual subscription. I am glad to report that we have frozen registration fees for this year at least and created headroom in our resources for new activities. For example, the year 2000 will see the launch of *Recognising Excellence*, a campaign to promote the benefits of Institution membership and professional registration through the Engineering Council to employers and ultimately to engineers and technicians.

As a result, at the start of this new decade, we are well positioned to be able to respond more rapidly to change. A critical success factor for the engineering profession, hence for the Engineering Council, is its ability to remain relevant and flexible in the face of constant change. Our business world today is characterised by megamergers and increasing globalisation - and there's no escape for the engineering sector. A key ingredient for business success is clearly the need to adapt to this increasing speed of business and technological change. I'm reminded of some recent research by a team from the Warwick Business School who report that firms who are prepared to continually change their structure, processes and boundaries, will be the ones with the highest performance. We're seeing examples of this happening every month. A few years ago, a significant part of GEC's turnover relied on heavy industry and defence, but over a very short space of time, it has reinvented itself as Marconi, a major telecommunications and systems player.

The pace of technological change is dramatically altering established patterns and creating exciting opportunities for all engineers. Recently, three physics and one computing student from Nottingham Trent University sold a part of their company – an Internet guide to college courses, accommodation and publications – to a US firm for £10m. It's remarkable to see now the City's love affair with anything 'dot.com' related has exploded. This is yet another facet of the revolution taking place in engineering. Having stressed to the City over the years the value of engineering to UK plc, perhaps it's time once again to open their eyes (and many others) to the broader influence of engineering both within and on our economy. Certainly, I believe we are making an increasingly significant contribution in promoting the wider understanding of engineering.

It is against this background that at the request of Lord Sainsbury, the Engineering Council and the DTI have set up a small working group (The Hawley Group), to explore the role of the Engineering Council in today's rapidly changing world. Under the leadership of Dr Robert Hawley, Chairman of the Engineering Council, the Group is considering how the Council can add value to the broader engineering community in such areas as the promotion and standards of engineering. The Group aims to build on existing synergies with other organisations in order to position engineering as a major contributor to the knowledge-driven economy.

If The Hawley Group is to succeed, it needs to consult as widely as possible across – and even beyond - the engineering community. This has already been done for the first stage and is vital not only to keep everyone informed of the developing ideas of the review, but also to receive input to those ideas from all interested parties. This will ensure that the small review team will be best able to develop a mechanism for the Engineering Council to serve the needs of all of us.

The Group completed its first stage of developing strategic objectives on schedule at the end of January, but over the next six months, it will need further contributions from all organisations being consulted if the ambitious programme is to succeed.

So what is the Group looking at? A starting point has been to define the wider 'engineering community' and to develop communication channels with that community to establish commitment, bring coherence and act as a forum to bring people together. Other objectives are likely cover the need for effectiveness of the promotion of the understanding of engineering and its contribution to the knowledge economy and sustainable development, the definition of the present and future skills needs of industry and the means to fulfil these needs, all education issues relevant to engineering and the knowledge of developments abroad, especially in the EU.

The Hawley Group will also wait with interest to see the results from another working group, set up by the

FROM PREVIOUS PAGE

ownership and responsibility shifted from generation to generation; roles were set at birth, and choosing a career was not an option. Mechanised farms meant less people were needed to work them, and that brought a different kind of personal freedom for many.

Farm mechanisation has almost entirely replaced human and animal power in developed nations, and is now transforming agriculture in many developing areas. In combination with other improvements in crop techniques and food processing, it has significantly altered food production and distribution throughout the world.

Bringing this standard to all the countries of the world is a major goal of the next century, and an attainable goal, according to the Food and Agricultural Organisation (FAO) of the United Nations. In a recent report, the FAO noted that world agricultural production, stimulated by improving technology, reached a record high in the mid-1990s - good news for the 6 billion people who inhabit the planet.

Council with The Royal Academy of Engineering. A result of the ever-increasing technological change is the need to explore the horizons of engineering and feed valuable information into the broader consultation process.

But the key to all of this is the profession's continuing relevance in the changing marketplace of business and the need for engineers to be more adaptable and more multi-skilled. They must be prepared to take risks, have well-developed communication skills, and be wholly committed to updating regularly their knowledge base. Much of this is enshrined in the new Standards and Routes to Registration and demonstrates the vital role for the Council and the engineering Institutions.

At a recent professional development conference which we ran in conjunction with the IEE, many of the speakers highlighted the urgency for engineers and importantly, their employers to embrace 'lifelong learning' as central to their careers and to business success. In 1970, it was predicted that a graduate engineer would require formal updating every twenty years. In 1980, that dropped to ten years and then to five in 1990. The latest estimates suggest that this has now fallen to just three years – a need for truly *continuing* professional development. In today's competitive, global economy, capital is mobile and technology can migrate quickly. To secure the future of engineering in the UK, we must produce and retain better 'home-grown' engineers who are drivers of professional excellence, innovation and business success. The rate at which engineers learn and then act is, as David Brown, Chairman of Motorola said at the conference, the last sustainable competitive advantage that companies will have in the future. The Engineering Council and its partner Institutions are crucial to ensuring this professional development of engineers. Lifelong learning is a key focus for us all and an important philosophy to be developed across the profession.

With such exciting developments afoot in the Council over forthcoming months, you would be forgiven for thinking that all our energy has been spent on driving forward these programmes. But our underpinning work still goes on as usual. Thirty new or re-elected members are now in place on our Senate, drawn from a broad spectrum within and outside the profession. Among the newly-elected members is the MP for Lichfield, Michael Fabricant (Conservative). Along with re-elected MP for Crosby, Claire Curtis-Thomas (Labour), the engineering profession now has a strong voice in parliament, with representation in each of the main political parties. We're also very pleased to have Lord Puttnam of Queensgate CBE joining the Senate as a Privy Council nominee. Lord Puttnam is Chairman of the National Endowment for Science, Technology and the Arts (NESTA), an Oscar-winning film maker, and now Chairman of the General Teaching Council, the recently-created body responsible for setting and enforcing professional standards for teachers.

In December, we ran a Forum on Innovation Management, an intensive one-day conference, opened by Lord Sainsbury, which attracted over a hundred delegates and high profile speakers from both industry and academia. Forums are part of our Industry Affiliate programme and our next one takes place on 22 June on the subject of risk management.

Young Engineer for Britain, our annual competition giving young people the opportunity to demonstrate their ingenuity and inventiveness, has come round again and entry forms are now available. It's the biggest event of its kind in Europe and offers a showcase to education and industry of the wealth of innovation and creativity amongst young people in UK schools and colleges. I am grateful for the support it gets from the Institutions. The 2000 Environment Award for Engineers is also underway. This is the only award which recognises the achievements of individual engineers in their work to protect or enhance the environment and to resolve environmental problems.

Overall, as we work ever closer with the Institutions, it is exciting to see how the many existing activities are developing. I am also greatly looking forward to the new ones which are in the pipeline, and with more emphasis on effective and efficient communication to the engineering community and beyond, it's also important to mention the launch of our new website (www.engc.org.uk). Watch that virtual space – perhaps it's the only one capable now of keeping up with the ever-changing developments in our world!

Malcolm Shirley,
Director General, Engineering Council

Membership movements

Mem No	*Name*	*From*	*To*
6662	J K Bailey	Derbyshire	Bedfordshire
6427	D G Bennett	Essex	India
1865	R C Bilborough	London	Preston
5306	B S Blackmore	Bedfordshire	Denmark
5208	J F Browning	Viet Nam	Oxfordshire
4144	R J Butt-Evans	Herefordshire	Gloucestershire
5674	D A Clare	Warwickshire	Oxfordshire
3660	B H Griffiths	South Africa	Madagascar
6031	S M Hulangamuwa	Sri Lanka	Botswana
6362	A Kaminski	Warwickshire	Essex
6687	M R Kitson	Staffordshire	Cleveland
3064	R D J Lacey	Dorset	Argentina
0995	A Lavers	Kent	Herefordshire
6567	S M Maguire	Northern Ireland	Bedfordshire
6346	S G May	Cheshire	Glasgow
5602	T T F Mottram	Somerset	Hertfordshire
6423	J Nemeth	Cumbria	Warwickshire
6518	M W Peters	Bedfordshire	South Devon
2715	K A Pollock	Birmingham	Worcester
6376	N M A Preece	Hertfordshire	York
1395	J W Roberts	Essex	South Yorkshire
4963	J A C Steel	Namibia	Mozambique
6510	S W Wise	Bedfordshire	Lincolnshire

Gone away - does anyone know the whereabouts?

Name	*Last known address*
Brian Charles Robinson	2 Shannon Close, Telscombe Cliffs, Peacehaven,East Sussex

Institution membership changes

Admissions – a warm welcome to the following new members:

Member
E S A Ajisegiri (Germany)

Associate Member
R N Clemas (Derbyshire)
J A Duggleby (Northamptonshire)
Z Z Hammouda (Bahrain)
P O'Kane (Northern Ireland)
A J Ruff (Suffolk)

Associate
M Eudall (Leicestershire)
C Lewis (Oxfordshire)

Student
M A Conroy (Cheshire)

Readmission
H Morgan (Lancashire)

Transfers – congratulations on achieving a further phase in your professional development:

Member
N J Handy (Wiltshire)
M Mutema (Gloucestershire)
J Owen (West Lothian)
R A Smith (Warwickshire)

Associate Member
T J Lane (Hampshire)
P J Moseley (Bedfordshire)
S Reilly (West Glamorgan)
C Saunders (Bedfordshire)
S G S Steger-Lewis (Hampshire)

Deaths – with great sadness, we record the death of:
C M Bates (Aberdeen)
J H Miller (Berkshire)
J R Pollock (Ayrshire)

Engineering Council

Registrations

CEng
J Campbell (Scotland))
M J Copeland (Swaziland)

IEng
N J Handy (Wiltshire)
G B Lovelace (Hertfordshire)
G T Queen (Scotland)

Commercial Members

Autec Design Ltd
Stockley Road, Heddington, Caine
Wiltshire SN11 0PS

Bomford Turner Ltd
Salford Priors, Evesham,
Worcestershire WR11 5SW

BSW Harvesting Ltd
Robertson House, Perth Business Park,
Whitefriars Crescent,
Perth PH2 0NX

Douglas Bomford Trust
16 The Oaks, Silsoe,
Bedford MK45 4EL

Environmental Care & Construction
Llwyn-yr-ynn, Llandeilo Road
Gorslas, Llanelli, Dyfed SA14 7LU

Farm Energy Centre
NAC, Stoneleigh, Kenilworth
Warwickshire CV8 2LS

G C Professional Services
Highdown Cottage
Compton Down
Nr Winchester, Hampshire
SO21 2AP

White Horse Contractors Ltd
Lodge Hill, Abingdon
Oxon OX14 2JD

Academic Members

Cranfield University
Siisoe Campus
Silsoe
Bedford MK45 4DT

Harper Adams University College
Newport
Shropshire
TF10 8NB

Lackham College
Lacock, Chippenham
Wilts SN15 2NY

News *of Members*

Richard Orr who was at NCAE, Silsoe from 1967 to 1970, and who has spent 23 years working for Booker Tate, has taken up a new appointment with Kakira Sugar Works (1985) Ltd on the shores of Lake Victoria in Uganda. Richard says that this estate has had a chequered history and so too has the Ugandan sugar industry as a whole. Uganda produces approximately 150,000 tonnes of sugar annually and has a population of over 20 million. Rainfall is 1,000 mm per annum and cane can survive without irrigation, although yields would be better under irrigation. He says that the estate was partially irrigated in the 1960s but then Idi Amin came on the scene and that was that until the mid 1980s when the owners were allowed back into the country to rehabilitate the old cane fields and the sugar mill. The place was derelict. Sugar production is now on the increase and irrigation is being considered once more but it will be difficult to justify in a wet year.

Although when Richard was working for Booker Tate he was based at Thame, he spent most of his time on secondment somewhere overseas to one of the many sugar estates which they manage. Before leaving he was in Swaziland for 4 + years and before that he spent 5 years in Ethiopia. Richard says that Swaziland is one of those African countries that is dynamic, vibrant and progressive. Agriculture plays a significant part in their economy and success. Sugar production is over 450,000 tonnes per annum and the population is just under 1 million. Sugar cane is grown under irrigation, as there is only 650 mm of rain per annum. A good proportion of Swaziland's water is used for irrigation and as this resource is becoming scarce all over southern Africa, measures are now being taken to use water more efficiently. Richard had been working on an interesting large scale project converting the traditional sprinkler irrigation to a much more efficient sub-surface drip irrigation system (1.8 m row spacing, 0.93 m emitter spacing and 1.6 *l*/h emitter flow rate). Yield increase was impressive but maintenance will have to be of the highest quality for sustained production. Richard says that Booker Tate has been a wonderful company to work for and he has many good memories. If there are any young budding professionals (agricultural engineers, *etc.*) looking for a life of travel, then he recommends that they should get in touch with them in Thame.

Dr Sarath Hulangamuwa is now a Principal Research Officer (M&E) at the Department of Agricultural Research in Botswana, which is the Premier Research Organisation of the Government of Botswana in animal production and arable research. It is located at Sebele, about 12 km from the capital, Gaborone. The Arable Research Division focuses mainly on grain, legumes and oilseeds, which are of national importance. Crops of interest include maize, sorghum, millet, cowpea, ground nut and sunflower. Sarath is responsible for the Mechanisation and Engineering Research Programme which has four projects, namely: (1) introduction of appropriate tillage technologies; (2) generation of technical information on agricultural machinery – preparation of handbooks, manuals, test reports, draft standards, *etc.*; (3) R & D of harvest and post harvest technologies for the above crops, and (4) introduction of labour saving weeding techniques. Sarath says that there is a shortage of agricultural engineers in the country. The University of Botswana has an Agricultural College, but it does not offer a basic degree in Agricultural Engineering. Thus, most of its graduates lack basic engineering skills, which are needed to take up agricultural engineering as a profession. Another drawback is that Botswana is flooded with all makes of agricultural machinery and has no standardisation. Added to this problem there are very few skilled mechanics in tractor and implement repair in the country. Fortunately, some tractors introduced in the 1970s, such as Massey Ferguson 35, 135, 165 and the 200 series are still working satisfactorily. This is mainly due to the local agent, Mechanised Farming (Pty) Ltd, which is the only tractor dealer who provides efficient servicing with expatriate skilled workmen.

Sarath says that Botswana is semi-arid and water is a scarce resource. Introduction of water conservation and management techniques in irrigation for agriculture is an area where more research still needs to be done. He says that he would be glad to inform the Institution when such openings occur. The need is not for pure research scientists, but for engineers capable of doing research in the problem areas and coming up with practical solutions.

There is a big expatriate community in Botswana, so anyone going there should be quite comfortable. However, one should bear in mind that more people die of 'Aids' than any other natural cause!

If anyone wishes to contact Sarath, his e-mail address is dar@info.bw Attention: Sarath.H.

Norman Skea who works for Nestle in China is the Engineering Manager of a milk products and ice cream factory.

During the past year, **David Williams** has been working in Geneva, Florence and in the Ukraine. At first he was working with a USAID (United States Agency for International Development) project that was intended to assist the activities of the major agricultural supply companies. These included AGCO, New Holland, Case, Caterpillar and all of the major agrochemical and seed companies. At the end of this he wrote a strategic plan for a change in direction for USAID efforts in the Ukraine. Gordon Graham of AGCO and Malcolm Johnstone of Case also contributed to the plan. His most recent project is in Kiev where he is concerned with setting the stage for a new strategy, which is to be implemented this year. The plan is to concentrate efforts in relatively small areas, rather than dissipating effort and money over the whole country, which is almost exactly the same size as France.

John Colman who recently received his 50 year Membership Certificate says that, although he should now be retired, he is still actively engaged in a marketing consultancy, mostly for farm machinery companies. He is particularly interested in helping companies to export and in looking after some European company's products in the UK. He helps farmer-inventors with development of their innovations and finally to find a manufacturer who will pay them a royalty.

Over the years, he has founded companies such as Mitchell Colman, Colman International, Opancol and others, who no longer exist, but whose names are still remembered and some of their products are still in production by other manufacturers. John says that he has a lot of pleasure looking back at past achievements, although our industry has had a long record of downturns, but fortunately they have been followed by good years.

Congratulations to **Stephen Wise** who has recently received his Engineering Doctorate from Cranfield University – Silsoe. Between 1995 and 1999, Stephen has been looking at the development of a holistic approach to the use of wastewater sludge phosphorus in agriculture. This involved working with both the water industry and the agricultural industry to evaluate the role and effectiveness of current and new wastewater sludge products and phosphorus providers when used in agriculture. This was to ensure that the recycling of wastewater sludge phosphorus to agriculture is undertaken in a manner which is both environmentally sustainable and agronomically beneficial. This also led to the development of a model for the water industry to use when considering the application of wastewater sludge products to agricultural land.

Towards the end of his doctorate, Stephen was asked to help manage a research project in association with Anglian Water and Organic Recycling looking at the beneficial effects of compost used in agriculture and ways to improve the composting process. In October 1999, this led to an offer of a job with Organic Recycling as their Technical Manager. His responsibilities with the company include managing the quality and production at the 25,000 tonne composting facility, liaising with the Environment Agency and local authorities, helping to develop the business and marketing strategies, development of the research and development programme and the development of their web site and other on-line operations.

The composted products produced by Organic Recycling are used as soil improvers for both agricultural and amenity markets. For their work on quality control and production they have received the Soil Association organic product award which allows them to market to the rapidly expanding organic farming sector.

Stephen can be contacted at: stephen@organicrecycling.co.uk and their web site is at: www.organicrecycling.co.uk

After leaving Harper Adams University College, **Mark Kitson** took up an appointment with JCB Landpower in Staffordshire from where he was seconded to work in Melbourne, Australia for three months.

After 18 years at Silsoe College, 14 as a member of staff, Prof **Simon Blackmore** has decided to take up an offer of a Chair at the Royal Veterinary and Agricultural University in Denmark, which is situated near to Copenhagen. Simon will be setting up a new group of academic and technical staff, as well as research students, to carry out research and development in the precision farming area. He says that he hopes to develop international links and asks former colleagues to keep in touch.

His new address is: Prof Simon Blackmore, Royal Veterinary and Agricultural University, Department of Agricultural Sciences, 10 Agrovej, DK-2630 Taastrup, Denmark. E-mail address: s.blackmore@kvl.dk Web site - http://www.agsci.kvl.dk/jbteknik/ Tel: +45 35 28 35 92

After 22 years with the BBC, Dr **Ken Pollock** has taken early retirement to pursue his interest in television production. He has set up his own company called Ambrose Associates and an early project is to be a programme for the BBC in Northern Ireland on the Ulster Motor Show. This will incorporate a history of motor engineering in the province and he is planning to include a reference to Harry Ferguson and his influential work on tractor design. Ken can be contacted at: Ambrose Associates Ltd, Combe Cottage, The Hill, Great Witley, Worcester, WR6 6HX. Tel: 01299 896587. Fax: 01299 896480.

Congratulations to **Neil Gunn** on completing his Masters Degree. He has now moved to Kent where he is working for the Environment Agency as a Development Control Officer.

Dr **John A C Steel** has moved to Mozambique where he is working as the Farming Systems Agronomist assisting smallholders to try and improve their output, particularly through networking and marketing associations. He says that besides trading within the country, there appears to be large market opportunities with neighbouring countries particularly Malawi.

Since finishing his PhD at the University of Newcastle in December 1995, John has worked on two medium term EU funded consultancies in the Philippines. The first consultancy (started in February 1996) was working at three agricultural colleges in trying to assist teaching staff incorporate more practical and relevant exercises in their teaching by improving some of their research and extension activities. This gave him the opportunity to work with staff and students in widely varying environments on Luzon islands ranging from Aurora on the Pacific cost to Ifagou in the centre (with all the rise terracing of Banuae) and to Abra in the north-west with cattle and fruit. The second consultancy (started May 1997) in the Philippines was part of a mid-term review for a rural programme concerned with strengthening local institutions. Its purpose was to investigate how planning was being implemented at barangy (village) and municipal levels as many government activities have been decentralised since the Marcos regime was removed from power.

More recently John has just finished (July 1997 – November 1999) working in Namibia where he was the Co-Director for a rural development and resettlement project in the northern part of the country, funded by the Spanish Cooperation Agency (AECI). This was a pilot programme assisting the Namibian Government to settle landless people on previously white owned farmland. The pilot project was on a 6,500 ha farm settling 14 families (approx 140 people). This was reckoned to be the maximum number of people that could be accommodated on this land area if they are to have a chance of being able to support themselves in this arid and rocky region. Before starting there was no infrastructure, no roads or houses. Small scale irrigation areas were set up at different points around the farm. The reason for the dispersion of people to different parts of the farm was to enable better use of the land and its limited resources.

Having moved to Mozambique John says that the contrast in climate, especially rainfall, is quite dramatic. For the time that he was in Namibia annual rainfall never exceeded 300 mm on the farm. In Gurue (Mozambique), where he is now based, the rainfall is 2000 mm plus.

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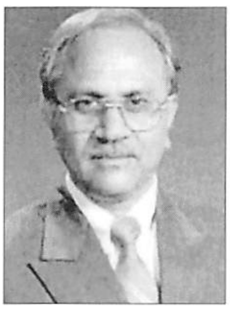
Growth pattern and performance characteristics of tractors used in India

Gyanendra Singh



Abstract

The use of tractors in India has increased. Initially, tractors were imported but, gradually, local production started in 1961-62 with foreign collaboration from East European countries. Since then, growth in production and sales within and outside the country has increased. To-day, more than 257 449 tractors are manufactured every year by more than 13 leading manufacturers. Financial incentives from the Government and institutional credit provided by the Banks has helped the farmers in adapting to tractors, even though size of the land holdings is small. Growth trends and performance characteristics of 53 models of tractors have been analysed. This will enable the research institution and policy planners to take appropriate measures for development of matching equipment and to improve the performance of the tractors, including ergonomic considerations. The use of the tractors however, is limited to few field operations such as ploughing, sowing and haulage. The specific fuel consumption of the majority of the Indian tractors were, by and large, within the limit stipulated by the Government. Higher power tractors (> 37 kW) consumed more fuel per hectare due to inherent engine designs and unmatched ploughs. Soil characteristics, and the deeper ploughing which could not be precisely controlled in the field, resulted in slower tractor speeds and a lower rate of increase in area coverage, and also contributed to higher fuel consumption per unit area.

Dr Gyanendra Singh is Director of the Central Institute of Agricultural Engineering, Bhopal-462 038, India where his responsibilities include development and manufacturing of agricultural equipment for agricultural mechanization and value addition of farm produce; e-mail: gsingh@ciae.mp.nic.in

1. Introduction

Farm power availability on a per hectare basis is considered as one of the parameters that indicate the level of farm mechanisation. This is further refined by an index which represents the ratio of mechanical farm power to total farm power or mechanical tractive farm power to total farm power. Actual utilisation of farm power sources, be it animate or mechanical, depend upon agro-ecological, technological, energetic and socio-economic factors. Percentage of machine work to the sum of manual and machine work, expressed in energy units, therefore, is more appropriate (Singh & De, 1999). An FAO study (Alexandratos, 1988) indicated that in 93 developing countries, power requirements falling short of that available from draught animal power is provided by human and mechanical power sources. The share of draught animal power and human/mechanical power vary among countries with (a) the level of economic development as measured by *per capita* incomes and (b) the relative abundance or scarcity of labour in relation to cultivated land (ha per person).

Indian agriculture is characterised by small fragmented land holdings, hill agriculture and shifting cultivation. Out of the total 329 million hectare geographical area, 165.6 million hectare is available for cultivation. During the last thirty years, the net sown area has remained at around 138-142 million hectares. The gross cropped area, however, has increased to 189.5 million hectare in 1997-98 (Ministry of Agriculture, 1999). This land is divided amongst 106 million farm holders (1991) with an average farm holding size of 1.57 ha. Animate power has been used extensively in agriculture and continues to be used by the farmers on small farms and in regions where the economic status of the farmers is not sound. Intensive cultivation requires higher energy inputs and better management practices. Use of human and animal energy in Indian agriculture still has relevance but, due to increased cropping intensity and to ensure timeliness, higher energy input is required (Singh *et al.*, 1997). The animate power thus

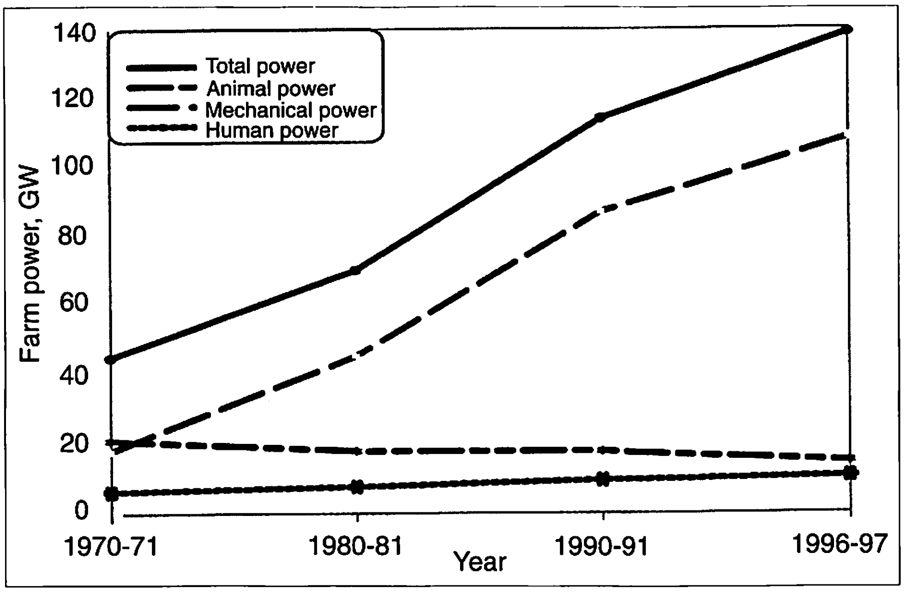


Fig. 1 Trends in growth of farm power sources

has been supplemented by mechanical power for tractive and stationary operations (*Fig. 1*). Developmental support in the form of subsidies for electricity, prime movers and farm equipment has enhanced the pace of mechanisation. An analysis has been made in this paper to assess the farm power use in general and growth and characteristics of tractors used in India in particular. This will help in formulating policy strategy for upgrading tractor technology in general and development of matching equipment in particular.

2. Materials and methods

The population dynamics analysis of animate and mechanical farm power sources is based on the secondary data of Livestock Census Reports published by the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India (Ministry of Agriculture, 1972, 1977, 1982, 1987 and 1992). The Livestock Census Report also includes data on growth in use of tractors, diesel pumps and electric motor operated irrigation pumps. The data for the analysis of tractors characteristics and their performance is adopted from the Tractor Performance Data published by Central Farm Machinery Training and Testing Institute (CFM&TI), Budni, Ministry of Agriculture, Government of India (CFM&TI, 1997). The CFMT&TI conducts tests on pre-production models, production samples and batch testing of tractors in accordance with Indian Test Codes and with OECD Standard Test Codes. The performance characteristics of the each tractor included laboratory and field results. Performance evaluation results of each tractor is published and is available for users. These performance characteristics have been reviewed and analysed in this paper to assess the general tractor technology scenario in India. In the field, soil and operating conditions (depth of ploughing, harrowing and speed) varied considerably, and affected the fuel consumption and field capacity of the tractor. Minimum and maximum performance values reported for each tractor have been used in developing the generalised performance correlations functions.

3. Farm power in India

3.1. Growth trends in farm power sources

Traditionally draught animals (oxen and bull buffaloes) have been used in India. With increased cropping intensity, farmers have supplemented animate power with tractors, power tillers, diesel engines and electric motors. These are discussed in the following paragraphs.

3.1.1. Animate power

Seventy eight percent of very small (1-2 ha) and marginal (<1 ha) farm holders possess 32% of the 165.6 million ha of land. Human, animal, mechanical and electrical power sources are used for performing farm operations as per availability and relevance. Draught animals (oxen and buffaloes) are the chief farm power source. The population of draught animals has declined to about 77.69 million in 1991-92 from 80.75 million in 1971-72 with a negative growth of 0.19% per annum (Ministry of Agriculture, 1972; Singh, 1999). The draught animal population is estimated at 77.13 million in 1996-97. The use of draught animals on a per hectare basis has declined as farmers prefer ploughing by tractors and irrigation by diesel engine and electric pumps (Singh & De, 1999). Human power is predominantly used for farm operations such as sowing, transplanting, fertiliser application, interculture, earthing, crop harvesting, threshing, cleaning, root crop digging and transport. The 1991 Census Report estimated the population of agricultural workers as 186.5 million in 1991-92, which is 64.8% of the total workers (Singh & De, 1999). Annual growth in population of agricultural workers has been 2%. Increasing use of mechanical power has not reduced the use of human power per hectare due to higher crop productivity (Singh & De, 1999).

3.1.2. Tractors

Twenty two percent of the small (2-4 ha), medium (4-10 ha), and large (>10 ha) farm holders, own 112.82 million hectares (68 %) of the total cultivable area of 165.60 million hectares. The all India average land possessed by these groups of farmers is thus, 4.8 ha per farm holder. This is considered suitable for cultivation by tractor power. The tractors in India were introduced through importation. There were only 8,635 imported tractors in use in 1951. The local tractor production started in 1961-62 with 880 units. India is now manufacturing more than 257,449 tractors per year (1998-99), with an annual growth of 16.59%. The estimated population in 1996-97 was 1.824 million, with an average command area of 77.85 ha per tractor.

3.1.3. Engines and electric motors for stationary farm operations

Diesel engines and electric motors are used for stationary operations especially for operating power threshers, grain mills, oil crushers and sugarcane crushers, and for lifting water for irrigation. The population of electrically operated irrigation pumps was 9.73 million and diesel engine driven pumps 5.58 million

Table 1 Unit farm power availability in India

Year	*Unit farm power, kW/ha*	*Tractive to total power, %*
1951-52	0.20	0.82
1961-62	0.22	2.38
1971-72	0.32	7.73
1981-82	0.50	17.61
1991-92	0.75	26.75
1996-76	0.90	32.25

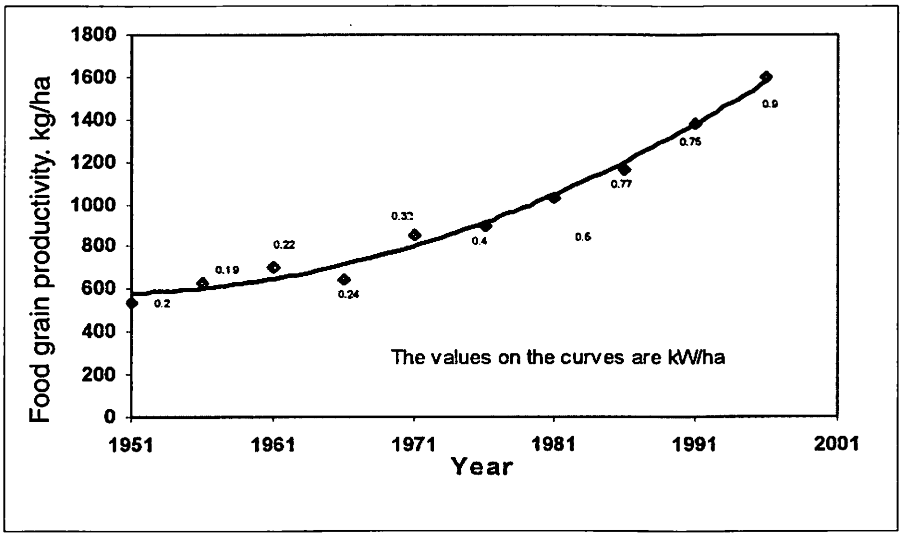


Fig. 2 Trends in food grain productivity and unit power input.

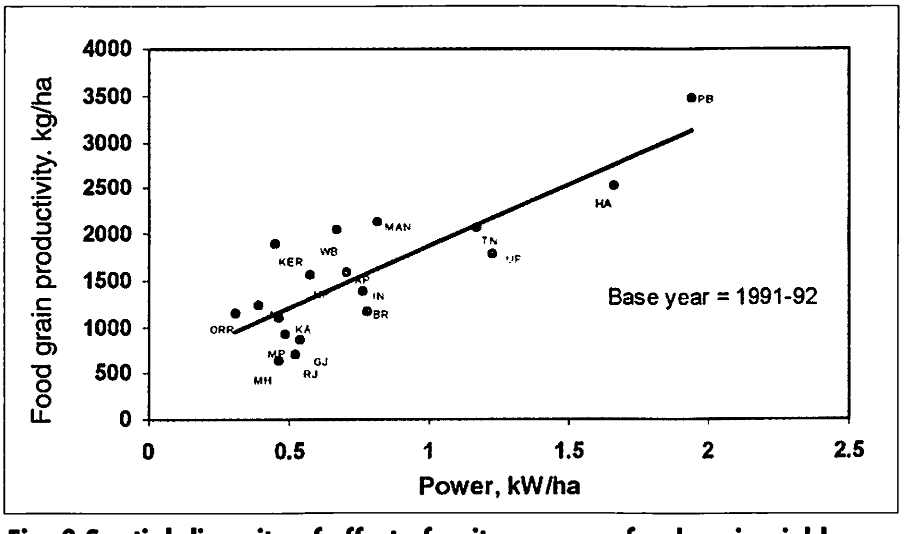


Fig. 3 Spatial diversity of effect of unit power on food grain yield

(total 15.31 million irrigation pumps) in 1996-97, with an average command area of 9.27 ha per pump (Planning Commission, 1996). The growth in use of irrigation pumps since 1971-72 has been 6.5% per annum.

3.1.4. Crop yield as influenced by unit farm power

Improved seeds, fertiliser and irrigation are the major inputs which affect the crop yield. Farm power ensures timeliness in operations, besides reducing drudgery. Available farm power and energy use per hectare are the indicators of modernisation of agriculture. Growth of the all India average potential availability of unit farm power sources from animate, electrical and mechanical sources is given in Table 1. The growth has been 4.22% per annum since 1971-72. The average availability is 0.90 kW/ha in 1996-97, which is very low compared to many advanced countries in the world. The share of mechanical tractive power to total farm power is 32.25% in 1996-97 which is indicative of the tractorisation potential in India. A macro analysis of influence of power on yield is presented in *Fig. 2* (all India average) and *Fig. 3* (State average). The positive correlation in yield and unit power input, as time elapsed, is an indicator of influence of technological advancement in agriculture including power. *Figure 3*, however, represents the effect of spatial diversity unit power input affecting food grain yield at a given reference time (1991-92). This is less affected by adoption of other inputs by the farmers. *Figures 2 & 3* are thus indicative of the need for more unit power input for higher crop yield.

4. Tractors production in India

Manufacture of tractors in India started with foreign collaboration and gradually the technologies have been assimilated with indigenous experience. The growth of the tractor industry and production/sales have been analysed by various authors (Ministry of Industry, 1987; Ministry of Science and Technology, 1990; Singh & Doharey, 1999; Tractor Manufacturers Association, 1998). The Central Farm Machinery Training and Testing Institute (Singh, 1999) is mandated to conduct official tests on tractors and other farm machinery for the benefit of manufacturers and users. These reports have been the base for analysis of design characteristics and their performance.

4.1. Trends in indigenous production and sales

Tractors in India were introduced through importation. This continued till 1961-62 when 880 indigenous tractors were produced for the first time. Since the pace of production was slow, the Government of India continued to allow limited import of tractors from East European countries to meet the demand of the farmers till 1974. While approving foreign collaboration in the manufacture of tractors, the Government of India made it mandatory that tractors manufactured for the home market should be tested under laboratory and field conditions to ensure that they are suitable to Indian conditions. A *batch testing scheme* was introduced which enabled the manufacturer to continuously upgrade the technology and to safeguard user's interest. To improve the quality of products, the Government of India fixed norms of specific fuel consumption, noise, vibration, exhaust emission levels,

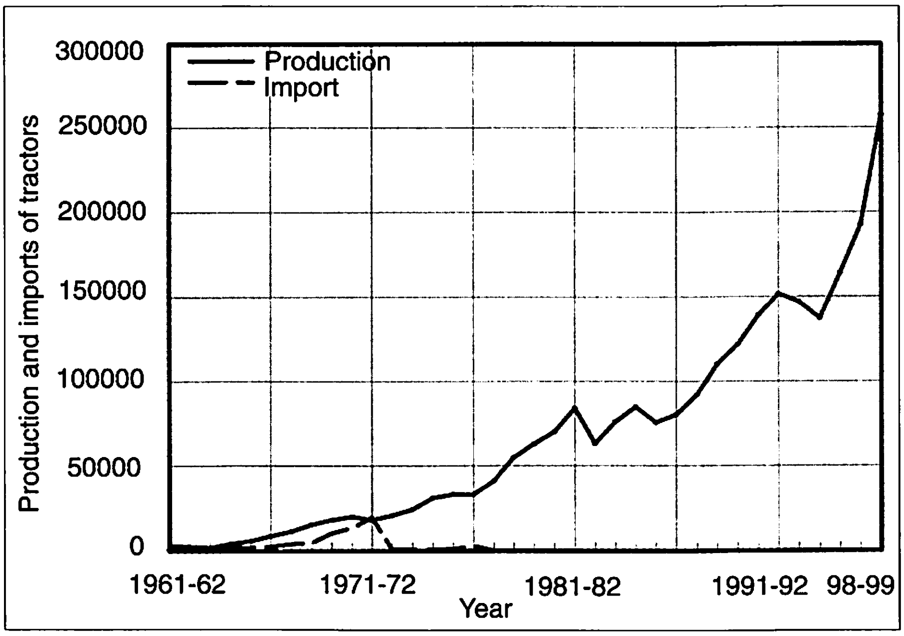


Fig. 4 Growth in yearly import and production of tractors

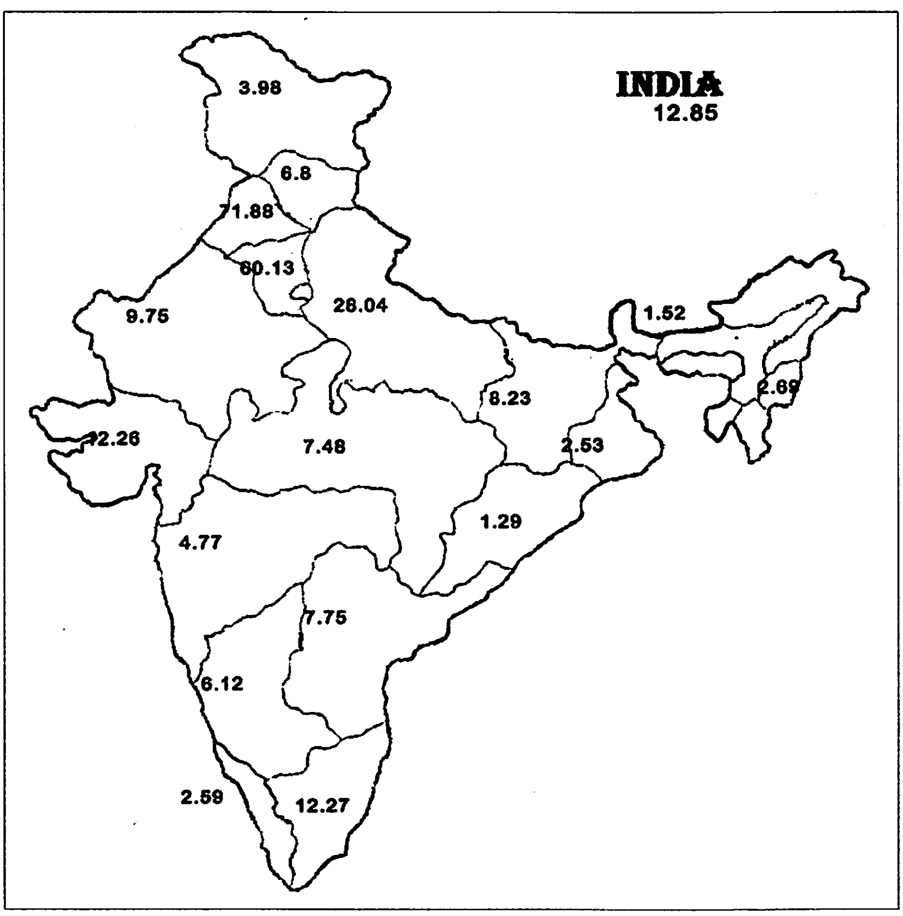


Fig. 5 Spatial distribution of Indian tractors in India, 1996-1997 (Tractors/1000 ha)

Table 2 Engine displacement and power rating of tractors manufactured in India

Engine	*No of models*	*Capacity, ml*	*Power, kW*
Single cylinder	06	1102 - 1559	09.00 - 15.1
Two cylinder	12	1261- 1963	12.00 - 22.9
Three cylinder	25	1788 - 3420	21.30 - 33.9
Four cylinder	10	2384 - 4667	29.00 - 48.9

Note: only Mitsubishi MT 1800 has a 900 m*l* engine with 3 cylinders developing 11.6 kW pto power

ergonomics and safety measures. The tractor industry has now established itself. It has started exporting at a modest level to African countries. Since 1992, the Government's licence to manufacture tractors is no longer required. The Government of India also allowed foreign companies to manufacture tractors, following certain prescribed procedures. India is now one of the leading countries in the world in the manufacture of tractors with increased production of more than 257 449 in 1998-99 (*Fig. 4*).

4.2. Spatial distribution in tractors intensity

The growth of the tractor population in the country has not been uniform in all provinces. This varied from State to State and, as a result, availability varied from 14 to 1145 ha/tractor. The tractor intensity (tractor/1000 ha) is presented in *Fig. 5*. Sale of tractors in a few Northern and Western States has been much higher. These states account for 75% of the tractor sale in 1996-97. The tractor intensity in the states of Punjab (14 ha/ tractor) and Haryana (16.6 ha/tractor) is much higher than other states. The average availability of tractors in the country is 78 ha/tractor or 12.85 tractors per thousand hectares.

4.3. Characteristics of Indian tractors

4.3.1. Size of the tractors

Tractors in India are used for tractive field operations and for transport. They are also used for stationary operations such as threshing and irrigation. The farm sizes being small and road terrain difficult, medium sized general purpose tractors are popular. There are more than 13 tractor manufacturers in the country manufacturing about 53 models of tractors ranging from 9 kW to 49 kW in size (Table 2). There are three tractor models of up to 13 kW, 10 in the range of 13-18 kW, 20 in the range of 18-26 kW, 16 in the range of 26-37 kW and only 4 models have a power rating of more than 37 kW. Trends in the sale of different sizes of tractors is indicated in *Fig. 6*. As seen, the most popular size of tractor amongst Indian farmers has been in the range of 23-30 kW. The overall weighted average power size of tractors, at an all India level, has been found to be 25 kW (*Fig. 7*).

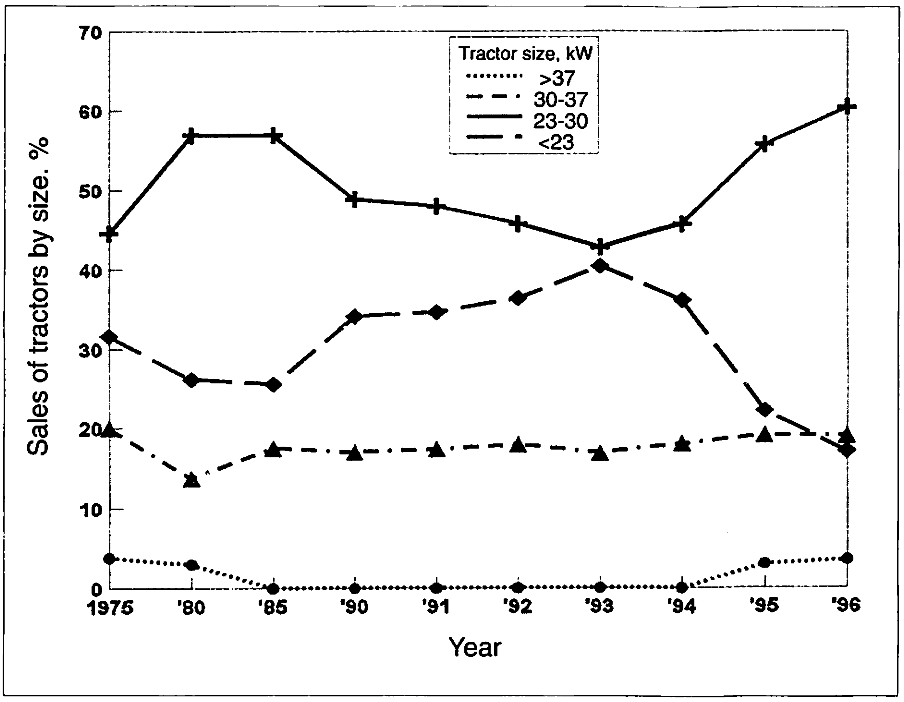


Fig. 6 Trends in tractor sales by power category

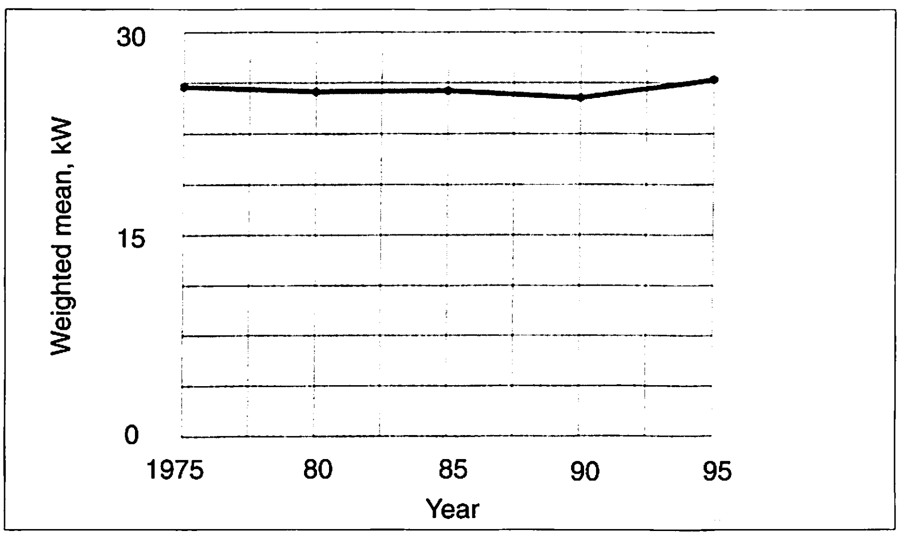


Fig. 7 Trends in average size of tractors used in India

Table 3 Noise and vibration levels of Indian and foreign tractors

Power range, kW	Noise levels, dB(A)	Vibrations, microns	
		Steering	Seat
< 20	92-102	95-500	27-200
20-26	95-104	95-800	24-360
26-41	86-104	55-700	32-220
> 41	94-099	60-260	32-140

Note: noise levels should not exceed 90 dB (A) at the operators ear level in open air; permissible vibration limit 100 microns (Indian Standards, IS: 5994-1987)

4.3.2. Engine capacities

Tractors in India are manufactured with: single cylinder, 1102-1559 m*l*, engines (6 models), having a power range of 9-15.1 kW; two cylinder, 1261-1963 m*l*, engines (12 models), having a power range of 12-22.9 kW; 3 cylinder, 1788-3420 m*l*, engines (25 models), having a power range of 21.3-33.9 kW; and 4 cylinder, 2384-4667 m*l*, engines (10 models), having 29-48.9 kW power range. The majority of the tractors are equipped with water cooling systems and only in 8 models are air cooled systems provided. Rated speed of the engines varied between 1650 and 2370 rev/min. Fifteen tractor models have 2000 rev/min rated speed and 19 models 2200 rev/min. The tractors in India, by and large, use fuel efficient engines compared to international tractor models as seen from the specific fuel consumption (Table 2). Turbocharging improves the engine power output and fuel efficiency, but the additional cost of turbocharging and its maintenance affects the advantage in medium sized tractors and, therefore, is not used in Indian tractors.

4.3.3. Safety and comfort

The design of most of the tractors made in India is based on European technology. The roll over protective frame has been made compulsory in many countries. These aspects have hardly been looked into in India, mainly to reduce cost, except in new generation models being introduced. Encased cab design under the Indian hot environment is unlikely to be accepted by the operators without a proper cooling system. In some models, hoods are provided to protect the operator from sun and rain. Hydrostatic steering, oil-immersed brakes, ergonomically designed operator seat with control panels and instruments located within easy reach and visibility are necessary features of improved tractor design to reduce accidents.

More than 45 tractors out of 53 models studied were found to generate high levels of vibration at the steering wheel. At seat level, only 18 models have vibrations exceeding the permissible level which showed that seats are comparatively better designed (Tables 3 & 4). Noise levels in Indian tractors are certainly higher than the safe threshold limit for operators.

4.4. Fuel consumption of the Indian tractors

The Government of India established the Tractor Training and Testing Centre at Budni in 1955 (since 1983, Central Farm Machinery Training and Testing Institute) to undertake confidential and commercial testing of tractors. The Indian Standards Institution (now Bureau of Indian Standards) helped in establishing specifications for tractors test codes and test procedures. It also conducts OECD standard test for export. The data for the analysis of fuel consumption and field capacity of the Indian models of tractors was taken from the Tractor Performance Data published by CFMT&TI (1997).

Table 4 Noise levels of Indian tractors at operators ear level

Noise levels, dB(A)	*No of models*
Up to 90	1
91 - 95	6
96 - 100	40
> 100	6

Safe level as recommended by International Labour Organization, 90 dB (A)

Table 5 Specific fuel consumption (SFC) of Indian tractors

Power range, kW	*No. of models*	*Specific fuel consumption, g/kWh*	
		Measured	*GOI norm*
< 18	13 (10)	259-351	279
18-26	20 (15)	243-339	272
26-40	18 (13)	233-297	265
> 40	02 (00)	267-277	252

Note : the values in brackets indicate the models which met the Government of India (GOI) norm for SFC.

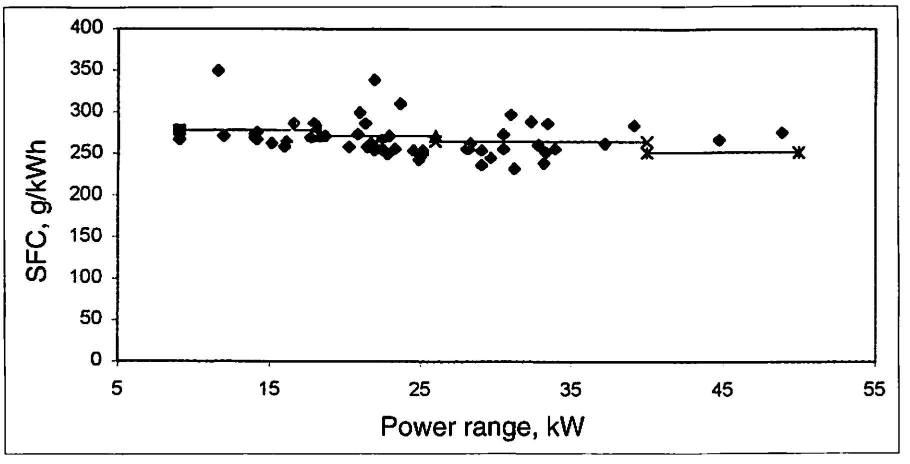


Fig. 8 Specific fuel consumption of Indian tractors

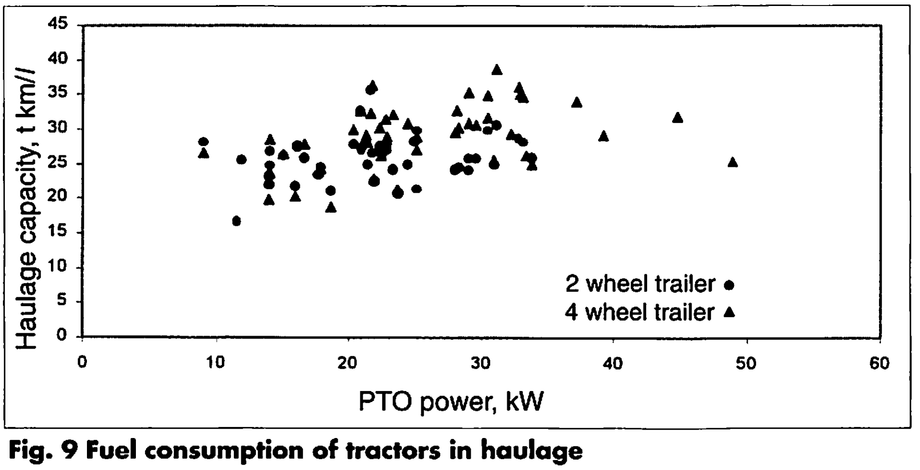


Fig. 9 Fuel consumption of tractors in haulage

4.4.1. Specific fuel consumption of tractors

The fuel consumption of the tractor varies according to its use. Under laboratory conditions, it is measured and expressed as specific fuel consumption (SFC) based on maximum pto power in g/kWh [pto]. Out of the 53 tractors evaluated by the Central Farm Machinery Testing and Training Institute, Budni, 38 tractors met the stipulated norms of specific fuel consumption as fixed by Government of India (Table 5). From *Fig. 8*, it is observed that as the power of the tractor increased, the SFC decreased except in few cases of tractors in the high power range. In the lower power range (< 18 kW), the specific fuel consumption varied from 259 to 351 g/kWh as against the norm of 279 g/kWh. In the power range 18-26 kW, this varied from 243 to 339 g/kWh against 272 g/kWh norm and, thus, these tractors are more efficient. The specific fuel consumption of tractors in the power range of 26-40 kW varied from 233-297 g/kWh as against 265 g/kWh. There were 18 tractors in this range and 13 met the SFC norm. In the high power range (>40 kW), there were two tractor models and their fuel consumption varied from 267 to 277 g/kWh as against 252 g/kWh norm and, thus, none could meet the requirement.

4.4.2. Fuel consumption of tractors in haulage

Tractors in India are extensively used for haulage, more than for field operations. The fuel consumption in haulage of the various models of manufactured tractors in the different power ranges are plotted in *Figs 9 and 10*. Tractors up to 18 kW power use 3-4.5 t capacity of trailer: 18-37 kW tractors use 5-5.5 t trailers; and tractors more than 37 kW use 6-8 t trailers. Out of the 53 models of tractors, 37 models used trailers between 4 and 6 t. Two wheel and four wheel trailers are equally used. *Figure 9* represents the relationship between specific haulage capacity in t km/*l* [fuel] and size of the tractors (pto power in kW) for two wheel and four wheel trailers. It is seen that there is no distinct correlation between specific haulage capacity and size of the tractors. Specific haulage capacity was also computed by grouping the size of tractors (Table 6). The average specific haulage capacity in the case of two wheel trailers was 25.34 t km/*l*, with 80% of the tractors having a specific haulage capacity of 21-28 t km/*l*. With four wheel trailers, the average specific haulage capacity was 28.24 t km/*l* with 80 % tractors having a specific haulage capacity of between 23.64 to 34.64 t km/*l*. Four wheel trailers have better stability and therefore, a larger size can be used with same size of tractor.

The above analysis is based on travelling along standard metalled roads with fully laden trailers. Tractor manoeuvrability with a trailer on narrow Indian roads is difficult and therefore trailers are usually partially loaded. The fuel consumption of the tractors in haulage was also plotted without consideration of tonnage (*Fig. 10*). It is seen that partial loading of trailers with smaller tractors may give a better specific haulage capacity. The correlation is expressed as:

$$Y = 9.13\, e^{-0.02P} \quad (1)$$

Table 6 Trends in specific haulage capacity

Pto power, kW	*Specific haulage capacity, t km/l*	
	With 2-wheel trailer	*With 4-wheel trailer*
<13	23.46	26.58
13-18	24.65	24.30
18-26	26.65	28.55
26-37	26.60	31.66
> 37	-	30.12
Average	25.34	28.24

where, Y is the specific haulage distance in km/l and P is tractor pto power in kW, and where the value for the coefficient of determination R^2 is 0.65.

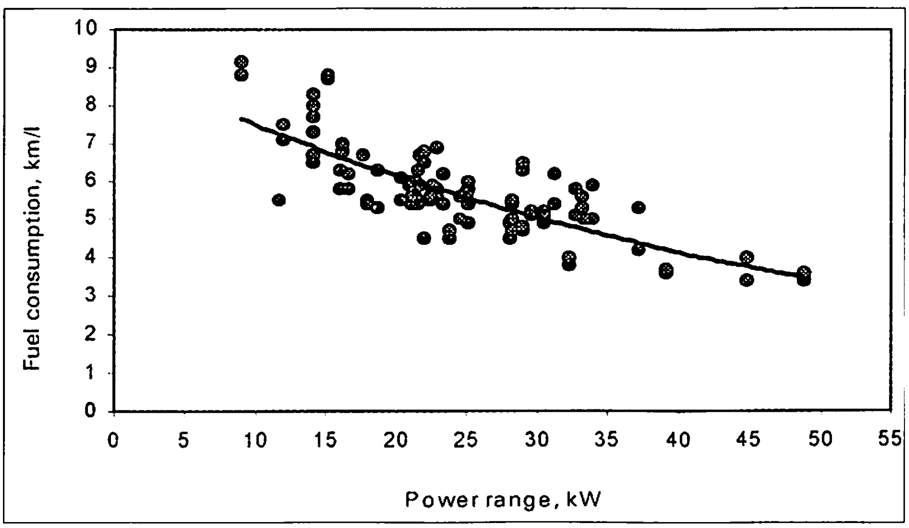


Fig. 10 Fuel consumption of Indian tractors in haulage

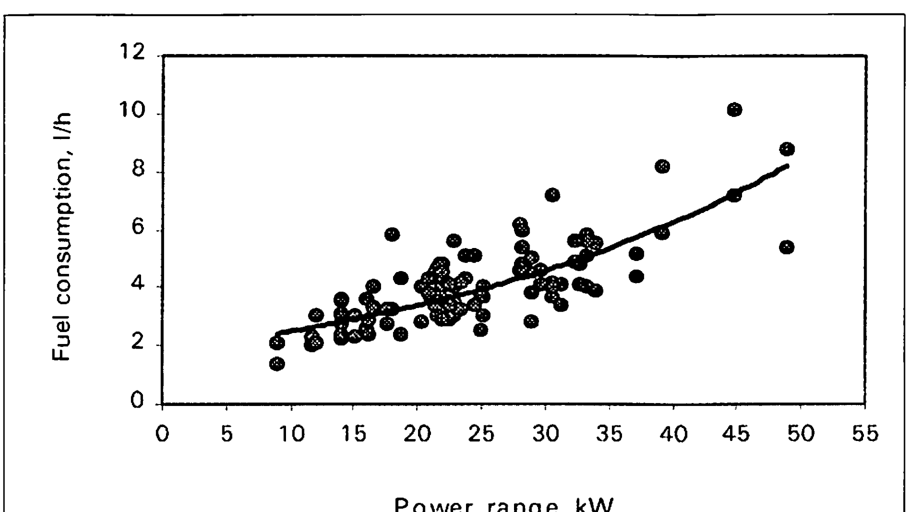


Fig. 11 Fuel consumption of Indian tractors in ploughing

4.4.3. Fuel consumption of tractors in field operations

Tractors are largely used in ploughing and harrowing in India. The fuel consumption in these operations vary with the design of the farm machinery, depth of ploughing, speed of the tractors, and soil conditions. Although operating conditions under which a particular tractor was evaluated was available in full Test Reports published by the Testing Institute, the range of minimum and maximum average values of all tractors in this macro analysis have been used without giving due consideration of farm machinery design and operating conditions. The average depth varied from 14 to 23 cm in ploughing and from 8 to 12 cm in harrowing and cultivation. The fuel consumptions in ploughing and in harrowing/cultivation for different models of tractors as per their pto power size are given in *Figs 11 and 12*.

Although the values are scattered, definite correlations exist for ploughing:

$$f_p = 1.8\ e^{0.04P} \quad (2)$$

and for harrowing /cultivation:

$$f_h = 2.35\ e^{0.026P} \quad (3)$$

where f_p and f_h are the fuel consumption in l/h in ploughing and in harrowing, respectively, and P is tractor pto power in kW, and where the value for R^2 is 0.58 in both.

It was observed that fuel consumption per hour for harrowing and cultivation was higher compared to that for the ploughing operation and it increased as the size of the tractor increased. This varied from 2.41 l/h to 4.6 l/h as the tractor power increased from 9 kW to more than 45 kW. The tractors in harrowing/cultivation are operated at a higher speed compared to those in ploughing and, thus, the higher fuel consumption. However, in case of high power tractors, fuel consumption per litre was higher, as ploughing could be performed at higher speed. It increased from 2.15 l/h to 6.9 l/h, as the power size increased from 9 kW to 45kW.

4.5. Field capacity of tractors

Different sizes of cultivator and disc harrows are used for seedbed preparation. However, due to small plot size and small farm holdings, cultivators with more than 15 tines and disc harrows with more than 18 discs are rarely used. Thus, the power from high power tractors is not fully utilised. As the power increased, the capacity in ploughing increased but marginally. The field capacity in ploughing varied from 0.112 ha/h to 0.345 ha/h as the tractor size increased from 9 kW to 45 kW (*Fig. 13*). In harrowing/cultivation operations, the field capacity ranged from 0.475 to 1.682 ha/h as the tractor power size increased (*Fig.14*).

The correlation between field capacity and tractor size for ploughing is expressed as:

$$a_p = 0.088\ e^{0.035P} \quad (4)$$

and for harrowing/cultivation:

$$a_h = 0.412\ e^{0.03P} \quad (5)$$

where a_p and a_h are field capacities in ha/h for ploughing and for harrowing and P is pto power size of the tractors in kW, and where the values for R^2 are 0.35 and 0.37, respectively.

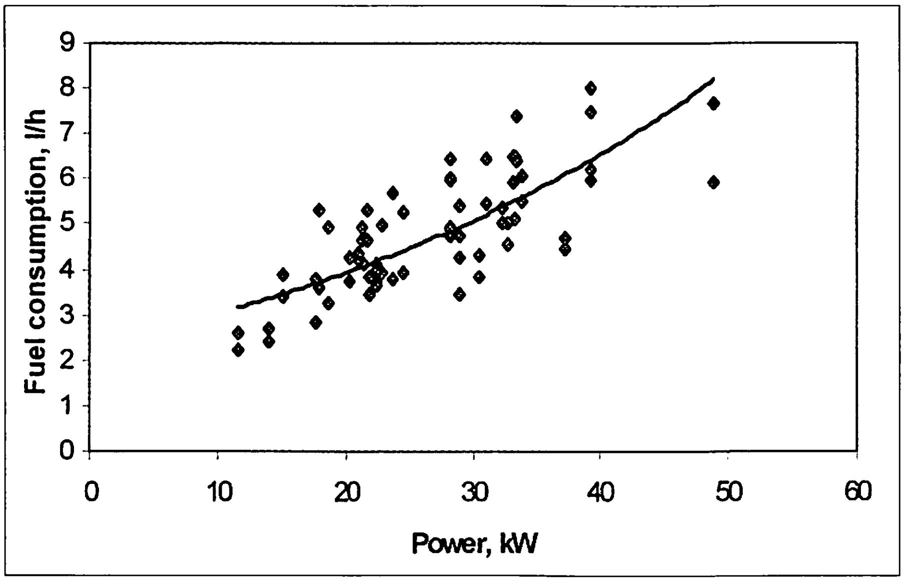


Fig. 12 Fuel consumption of Indian tractors in harrowing/cultivation

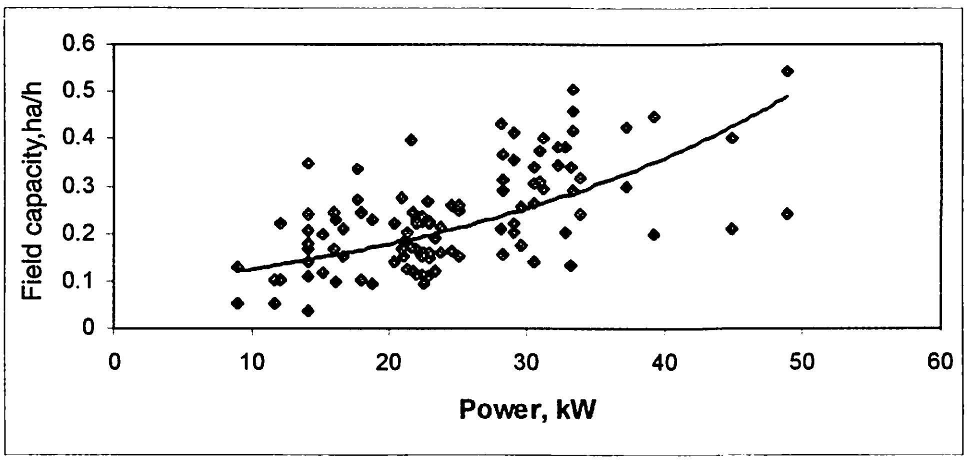


Fig. 13 Field performance of Indian tractors in ploughing

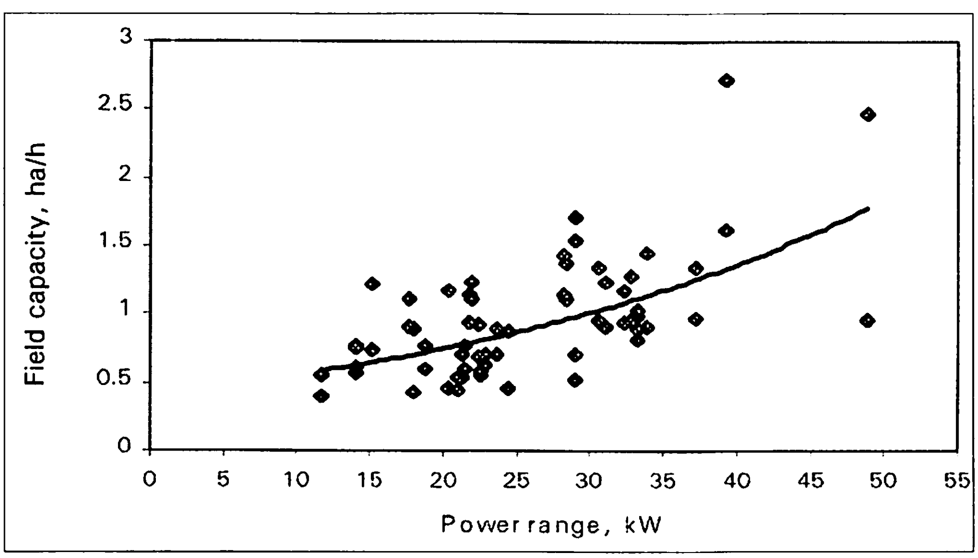


Fig. 14 Field performance of Indian tractors in harrowing/cultivation

4.6. Fuel consumption of tractors per hectare

The relationship between average fuel consumption per hectare and power size of the tractor for various models could be computed by dividing the Eqns (2) and (3) by Eqns (4) and (5), respectively, *i.e.* l/ha = (l/h)/(ha/h). Substitution yields, for ploughing:

$$f'_p = 20.41\ e^{0.005P} \qquad (6)$$

and for harrowing/cultivation:

$$f'_h = 5.59\ e^{-0.0043P} \qquad (7)$$

where, f'_p and f'_h are the fuel consumption in l/ha for ploughing and for harrowing and P is tractor pto power, kW.

It may be observed from Eqns (6) and (7) that fuel consumption in ploughing per hectare increased and in harrowing it decreased, as the size of the tractor increased. Projected fuel consumption in ploughing and harrowing/cultivation are plotted in *Fig. 15*. More fuel consumed by the higher power tractor in ploughing is partly due to inherent engine designs. Unmatched ploughs, higher depth of ploughing, which could not be precisely controlled in the field resulting slower speed of the tractor, and soil moisture content also contributed in lower rate of increase in area. Only 2-3 furrow ploughs are generally used with tractors in India. In the case of harrowing and cultivating operations, fuel consumption per hectare reduced as the tractor power size increased. This is due to higher speed of operation, resulting more area coverage per hour, even though the bigger size tractor consumed more fuel.

5. Conclusions

Manufacturing of tractors in India started with a modest number of 880 tractors per year in 1961 with foreign collaboration. Since then, the growth has been phenomenal. Today, India is manufacturing more than 257 449 tractors per year. The all India average availability of tractors is 77.85 ha/tractor in 1996-97. Government financial incentives and credit support from the Banks has helped the farmers in adapting to tractors. Medium sized tractors are most popular with a weighted average size of 25 kW. In recent years, higher power tractors have also been introduced in few Provinces.

Seedbed preparation, sowing, puddling with cage wheel, crop threshing with stationary power thresher and haulage are the farm operations for which tractors are usually used.

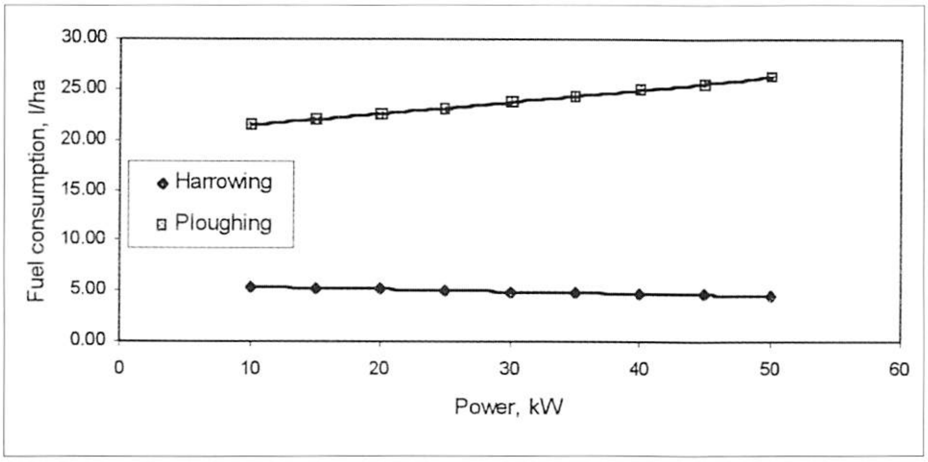


Fig. 15 Projected fuel consumption for Indian tractors in ploughing and harrowing

Technologically, Indian tractor designs are fuel efficient with more than 70% of the models meeting SFC norms fixed by the Government. The average fuel consumption varied from 2.41 to 4.6 *l*/h in harrowing and from 2.15 to 6.9 *l*/h in ploughing. Ergonomic consideration in the design of tractors, especially sound, vibration, safety cab, transmission system, steering, *etc.* is yet to be given due consideration from safety and comfort.

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Timber standards

A list of all the British Standards relating to timber has been published by TRADA Technology. The nearly 700 standards listed encompass not only the raw material itself and products made from it but also adhesives, fixings and finishes together with the use of timber in industries from aerospace to agricultural buildings.

Contact: **TRADA Technology, Stocking Lane, Hughenden Valley, High Wycombe, Bukinghamshire HP14 4ND. Tel: 01491 563091.** Price £10 (£5 to TRADA members).

Profitable cereals – reducing establishment costs

Iain James

Cut costs and cut them now delegates were told at a conference in November, held at Cranfield University, Silsoe by the Soil and Water Management Specialist Group of the IAgrE.

Enthusiastically chaired by the NFU President Ben Gill, the conference entitled 'Profitable cereals – reducing established costs' received presentations from farmers, machinery manufacturers and academics on methods of reducing tillage and establishment costs whilst maintaining output and profit margins.

John Bailey, Senior Mechanisation Consultant at ADAS, highlighted the fact that labour and machinery form two-thirds of the fixed costs of a farming enterprise, with cultivations forming 50% of this cost. He suggested that farmers should be aiming to reduce establishment costs down to 60 to 80 £/ha and a number of speakers presented methods for reducing these figures.

Only till when and where necessary was the advice given by Prof. Gordon Spoor, formerly of Cranfield University, Silsoe. He encouraged farmers to get out and investigate the soil to assess compaction and the need to till but also to reduce any compaction by targeting its causes. Lowering ground pressures by increasing tyre width and number, lowering tyre pressure, and looking at weight distribution through the tractor and implement is advice that has been consistently offered for a number of years, but is rarely heeded on farms, a point enforced by Frans Tijink of the IRS in the Netherlands.

With tillage systems under scrutiny three farmers presented their solutions to the conference. Chris Lewis farms 700 hectares of arable land in Oxfordshire, where all the land is subsoiled, ploughed, disced and pressed. Whilst being satisfied with the yield results from this method, he felt that he subsoiled too much, but a change in his system would be prohibitively expensive. John Errington, farming 800 hectares in Bedfordshire demonstrated his three year block rotational tillage system that has replaced the 11 passes it used to take to get a seedbed. All tillage is completed by two staff over three tractors.

Steps towards reducing establishment costs

- Till only where and when necessary
- Remove the causes of compaction-look at ground pressures and weight distribution
- Look critically at labour requirements and alternatives
- Evaluate the cost of any tillage practice and evolve tillage systems through planned machinery replacement.
- Maximize the cost benefits of minimum tillage, whilst having a system for all conditions
- Reduce the weed seed bank through tillage and rotation to reduce control costs

The successes of Jim Bullock's minimum tillage system on his 800 acres were received with interest. The purchase of a triple disc no-till drill has resulted in a time saving of 60% with a total saving of £40 per hectare. The minimum tillage system has saved money, time, and has reduced his power and labour requirement but as Miles Silcock pointed out, minimum tillage machinery is not a lazy-man's tool - timeliness is essential.

Benefits of minimum tillage from the Long Ashton LIFE Projects

- 28% reduction in nitrogen lost through drainage
- 48% reduction in herbicides outflow
- 17% reduction in fungicide outflow
- 52 min/ha saving in work time
- Reduced occurrence of BYDV

Having sold his plough and power harrow on delivery of his direct drill, he was troubled after having to disc the seedbed four times in winter wheat straw to get a good enough seedbed. This resulted in compaction and flooding. Since then he removes wheat straw for better discing results.

Timing is the secret to direct drilling because weather conditions in his region do not permit drilling beyond the end of September. If the ground is too wet it is not possible to direct drill. Consequently he has purchased a second combination drill and a plough as there is no single system for every situation.

So what has changed since the Eighties when the first minimum tillage revolution was rejected by farmers in the UK? Firstly, the recent economic climate is forcing farmers to look at their input costs as they strive to maintain profit margins, then there is increased public awareness of farming practice, applying environmental pressure and, thirdly, drill technology has advanced, with a number of companies launching minimum or no tillage drills recently.

Simba, Väderstad, Wallis (Great Plains) Drills, Kverneland and John Deere all presented their latest minimum tillage equipment, all designed to work in stubble and lower quality seedbeds. Michael Alsop from Dowdeswell, asked to speak on the plough, was concerned, however, that the replacement of traditional systems would see competition minimum tillage replacing competition ploughing and the renaming of the local pub from 'The Plough' to 'The No Till Drill'.

Whilst advances in plough, cultivator and drill technology are being made, a common request made by all speakers, was for improved straw spreading from combine harvesters. Current straw

Iain James is a research student at the Institute of AgriTechnology, Cranfield University.

chopper design does not produce an even spread of straw, especially over larger cutter-bar widths, making minimum pass, shallow cultivations very difficult.

A quality top-down stale seedbed is the key to minimum tillage, Steve Townsend told the conference. Using a system of precise cultivations and rotation, the seed bank in any field can be reduced by targeting the weaknesses of individual weed species and creating conditions that will cause a weed to grow outside the cropping area, so that it may be sprayed off with a non-specific herbicide. For example, blackgrass, a shallow autumn germinator, can be encouraged to germinate by keeping it near the surface (*i.e.* not ploughing) and using rotations to maximise its germination rate outside the crop. He also found that consolidation was a key; using a disc and a press roll results in three times the germination of a single disc pass, also decreasing the risk of slug damage. The reduced tillage is then followed by two to three applications of glyphosate herbicide.

Concerns were raised regarding the negative public perception of multiple spray passes. Ben Gill, NFU President advised that it is important to educate the public as to the relative safety of glyphosate herbicides, suggesting that information boards on public rights of way as a very good idea.

Vic Jordan presented the results from the LIFE minimum tillage project at IACR Long Ashton, showing that with minimum tillage there is better spray residue breakdown in the soil, with reduced chemical and nutrient outflow. Results have also shown that flushing weeds and spraying off earlier gives better control and is cheaper than control later on in the growing season. Increased worm and beetle populations leads to a higher rate of natural regulation of pests in the crop and the increased organic matter gives a soil that is more easily worked with time, all additional benefits.

So with developments in drill technology allowing accurate seed placement in lower quality seedbeds and increased knowledge of stale seedbed systems, minimum tillage is a viable option for farmers to help reduce input costs. Timeliness, however, is very important.

There is undoubtedly a need for UK farmers to reduce their establishment costs both by reducing cultivation costs and by taking a hard look at labour and machinery requirements. Whilst it is financially difficult to replace a whole tillage system at the moment, the key, as John Bailey pointed out, is evolution of a farmers tillage system to be able to make the most of any conditions.

Throughout the conference there was a call from farmers for closer working between those in research and those in farming practice, with the NFU President calling for technology interaction as a replacement for technology transfer and stating that, 'With meetings such as this, we are able to cross fertilise our knowledge and look again.'

Tractor registrations up 14.4% in 1999

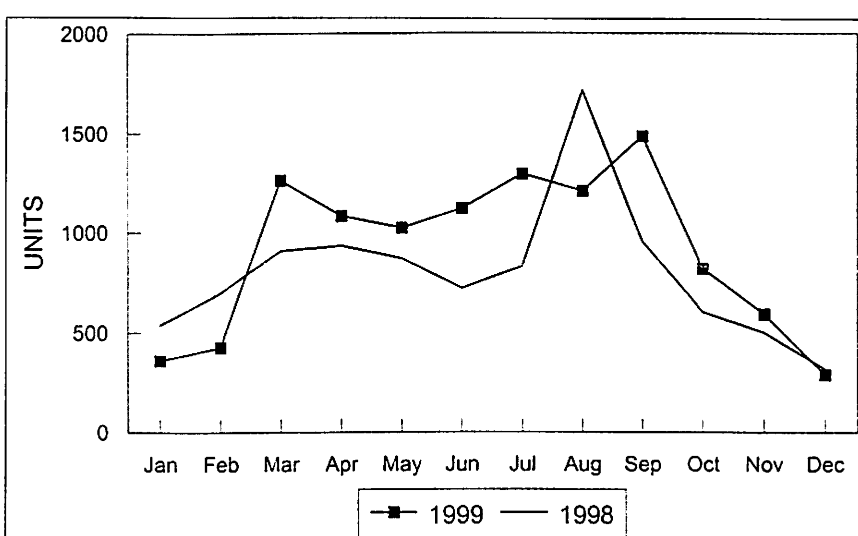
Registrations of agricultural tractors (over 30 kW) in the UK in 1999 reached 10,969 units, an increase of 14.4% on the preceding year.

The average size of unit was 87.5 kW, which was a rise of 6.7% leaving total power sold at £1,279 m (plus 22%). This was a notable increase associated with the restructuring of agriculture, where farmers have attempted to use fewer larger machines and so reduce unit costs.

Another feature of the year was the change in the seasonal pattem of purchasing following an adjustment to licensing procedures. Whereas previously there had been a strong autumn peak at the time of the annual change of age identifier of number plates, under the new system there are two changes each year, in March and September, and the pattern can be clearly seen on the accompanying graph.

Despite this welcome improvement, it has to be recognised that this was still the second lowest level of demand ever recorded and that agriculture remains in the doldrums. As there is no immediate prospect of recovery in the farming world, so it is likely that demand for tractors in the early part of next year will remain modest. Any future recovery later will depend upon the improvement of product prices and/or a reduction in the value of the Pound.

Contact: **C J Evans, Economist, The Agricultural Engineers Association. e-mail: aeaecon@farmline.com**



Branch Diary

Scottish Branch

Tuesday, 9 May 2000
Venue: Stakis Hotel, Edinburgh Airport
National Conference
Food for thought

Hon Sec: Mr G M Owen Tel: 01968 675943

West Midlands Branch

For further details contact the Honorary Secretary. Location plans are available on request. You are advised to confirm the details on the day, especially if travelling a long way.
All meetings are at 7.30 pm unless highlighted.

Thursday, 13 April 2000
Venue: AGCO Ltd., (Massey Ferguson), Banner Lane, Coventry
Precision farming for engineers
Speaker: Mike Looney, Project Engineer
(A joint meeting with the Institution of Mechanical Engineers)

Saturday, 10 June 2000 at 2.00 pm
Visit to Ironbridge Gorge Museum
Speaker: John Challen
Numbers are restricted; please pre-book with Branch Secretary

Hon Sec: M C Sheldon Tel: 01926 318333

South East Midlands Branch

For further details contact the Social/ Visits Secretary. Some events require pre-booking. All meetings are at 7.30 pm unless highlighted.

Monday, 17 April 2000
Venue: Silsoe Research Institute, conference room
Engineering aspects of precision farming
Speakers: Mark Moore, AGCO; Adrian Hipwell, Farmade Ltd
(Joint meeting with IEE and IMechE)

Week Beginning 26 April 2000
Date and venue to be announced
Visit to a poultry processing plant
(Follow up of talk on 7 February 2000)
Contact Social Secretary by 12 April 2000

Saturday, 17 June 2000
at 7.00 pm
Barbecue
Contact Social Secretary by 12 June 2000

Social/ Events Sec: Chris Saunders Tel: 01525 863000 E-mail: c.saunders@cranfield.ac.uk

Southern Branch

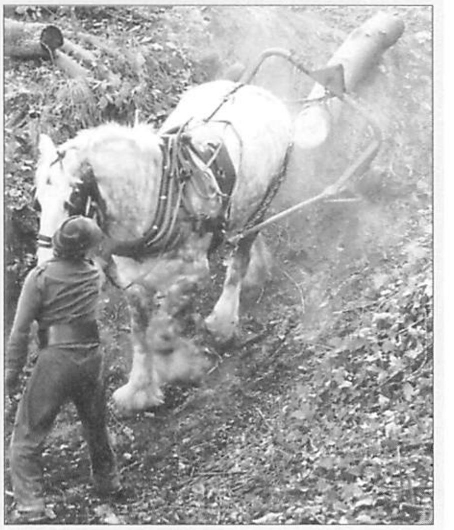
For further details contact the Honorary Secretary. All meetings are at 7.30 pm unless highlighted.

Wednesday, 12 April 2000
Venue: Rycotewood College
Data Logging – Engine to the ground

Sunday, 4 June 2000
Venue: Weald and Downland Open Air Museum, Singleton, Chichester, Sussex
Heavy Horse Show Summer Spectacular
Details to be confirmed

Hon Sec: O J H Statham Tel: 01865 782259

Leaf it to horse power



The pros and cons of heavy horses and specialist small machinery are weighed up in the latest of the National Urban Forestry Unit's *Urban Forestry in Practice* Case Studies.

'In small urban woodlands there is often the need for selective felling of trees for example to improve access, create glades and even to generate income from the timber,' said Nerys Jones, Chief Executive of the National Urban Forestry Unit. 'But timber extraction should be carried out with the minimum amount of damage and the cost kept as low as possible. This calls for alternatives to the heavy machinery which is usually used in large scale forestry.'

One of the most environmentally sensitive and popular means of extracting timber from small woodlands is by the use of heavy horses. The case study *Timber extraction from small woodlands* explores this and other ecofriendly techniques.

Contact: **Mark Dixon, National Urban Forestry Unit, The Science Park, Stafford Road, Wolverhampton WV10 9RT. Tel: 01902 828600.**

Racal announces further coverage for DGPS service

Racal Survey Group Ltd now offers users of its Racal LandStar Differential Global Positioning System (DGPS) coverage across Asia and the Pacific Rim. This follows on from the news in September that a new global beam satellite would bring important benefits to users of the service in Africa and the Middle East.

The latest new beam replaces Racal's use of localised spot beam services and provides LandStar users with unbroken coverage across the globe. 'There is much interest for Racal LandStar in Asia and the Pacific Rim. It is very important to ensure our customers receive high quality DGPS services exactly where they are needed. This latest enhancement gives us unrivalled coverage throughout the world,' says Angus Cooper, General Manager, Signals, for the Racal Survey Group.

The improved LandStar coverage service in Asia and the Pacific Rim follows the provision of a new Inmarsat satellite positioned 109 E. With the recently extended coverage throughout the world. The existing L-band spot beam satellite services used for broadcasting LandStar Differential corrections in Europe and North America provide excellent coverage and will continue to form an integral part of the network.

All of the new Inmarsat satellite broadcasts are also in L-band so LandStar subscribers can use their current LandStar equipment to receive the signals from these new broadcasts. The rugged construction and simple operation of the LandStar receiver has ensured its success through a wide range of applications. These include the agriculture, forestry, mining and utility markets. LandStar has won extensive praise for being simple to install and ready for immediate operation.

Racal Survey Group Limited is a member of Racal Electronics plc which has operations world-wide. With a global network of business units, the Racal Survey Group provides a complete range of integrated survey services including precise positioning, integrated geosciences, remotely operated vehicle (ROV) manufacture and operation, vessel and vehicle tracking as well as data management services. These are provided to land and offshore industries for oil and gas exploration and construction, telecommunications, surveying, mapping and agriculture.

Contact: **Racal Corporate Communications Centre, Communications House, PO Box 3620, Western Road, Bracknell, Berkshire RG1 21WL. Tel: 01344 388000. Fax: 01344 388061.**

New pump range from Berendsen

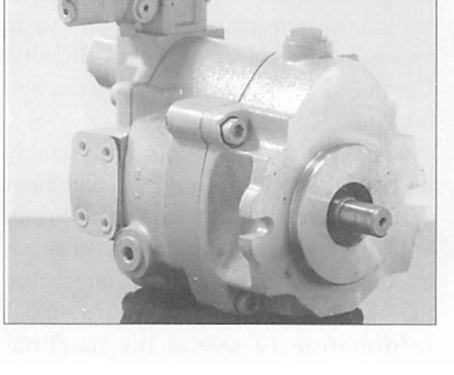
Innovative detail design and many years experience have been brought together by Eaton Hydraulics Division, Vickers Systems to produce a series of axial piston pumps that offer improved life, quiet operation, lower installed and in-service costs, installation flexibility and improved performance. Both industrial and mobile variants of these new open loop pumps are available in the UK through Berendsen PMC Ltd.

Improvements in service life and reduction of in-service costs have been achieved with the adoption of high load bearings, stiff shaft, and a stiff saddle type yoke design which reduces deflection of components within the pumps and therefore reduces the load applied to the bearing surfaces.

Both air and fluid borne noise levels have been reduced, these new pumps feature a unique three piece body design, flange, housing and valve block, which was specifically created to reduce noise levels. Another feature is the bimetallic timing plate that improves pump filling and so reduces noise generation. Pressure ripple is astonishingly low at 4%; again this reduces noise but also reduces the stress in the systems pipework improving the integrity of the system as a whole.

The new design PVH pumps are variable displacement axial piston units. They are available in six sizes from 18 to 131 ml/rev and an adjustable maximum flow stop is provided as standard enabling the accurate matching of the pump to system requirements. All sizes are suitable for 280 bar continuous operation (320 bar intermittent & 350 bar peak). The industrial derivative is designed to run at up to 1800 rpm and the mobile versions up to 2000 rpm for the 131 ml model and 2800 for the 18 ml pump. An extensive array of port, flange, shaft, through drive and control options are offered, making this series of pumps easy to incorporate into existing systems. Further adding to the family's installation flexibility is their compact size, due to the use of a single control piston, and the abundance of case drain positions that permit the pump to be mounted in various positions.

Contact: **Paul Hensman, Berendsen PMC Ltd, Sandy Way, Amington Industrial Estate, Tamworth, Staffordshire, B77 4DS. Tel: 01827 306000. Fax: 01827 306100.**



The new Valmet 860 forwarder

The Valmet 860 machine has been completely redesigned to improve economy, capacity, performance and driver environment. 'The marketplace has accepted the new machine very favourably,' said Jorgan Johansson of the Valmet Production Support, speaking to a group of contractors, prior to a demonstration in the Forest of Ae in Dumfriesshire recently.

Partek Forest's new Valmet 860 at a demonstration in the Forest of Ae, Dumfriesshire

The new machine is the ideal choice for contractors forwarding large loads over long distances with difficult terrain. Now a larger bunk than the previous model, and rated at 14 tonnes, the new Valmet 860 is a solid work platform. With difficult conditions in mind, a small turning radius and the new portal bogie system offer big advantages. Good agility and large ground clearance speed up extraction cycle times. Increased productivity is the result of extensive testing by Valmet, selecting performance matched components. The result is greater sensitivity and control.

Deep at the heart of the machine is a new Valmet engine. The 620 DWR engine has been designed specifically for forestry and off road operations, with extremely high torque - 700 Nm at 1400 rpm - compared to competitive engines, on an uphill climb. Torque is maintained longer; thus lugging of the load is well under control before stalling.

The transmission space is very accessible, enabling the various components, such as the hydraulic parts behind the transmission and motor to be viewed and serviced without difficulty. Control is hydrostatic mechanical through our Maxi Control System.

The modern Maxi Control System is an advanced control and management system that allows key components to talk with one another. Instantaneous data can be shown on the operator's display while the system gathers detailed operational information to assess the machine performance, driving style and assist with routine maintenance and fault diagnosis. Access is by way of a keypad, mounted on the armrest, with colour graphic display. The Loader speed and sensitivity preferences for nine operators are adjustable.

Operator comfort has received special attention for extra long days. The cab is larger and wider with tinted windows that extend down to provide good views of the wheels and upward to see the crane is also good. Furnishings are of the soft touch type and also heating and air conditioning is of a high capacity.

For contractors who work with various lengths of timber and assortment ranges, the Valmet 860 offers highly flexible load space. This, along with its advanced bunk system, is also available with widening kits, and will hold 14 tonnes, which is high in relation to the size of the machine. There is also a cushion mounted headboard offering a number of alternative positions.

The trailer assembly rests on Valmet's own newly developed 'high clearance' portal bogie, which gives good ground clearance over the entire width of the machine, and results in further enhancing the 860's tractability and flexibility. The portals in the geared bogie are fully contained within the wheel rims. The speed reduction is within the wheel hub, not within the axle. This means that the gears and bearings rotating in the bogie are relatively stress free. Competitors' bogies are under load throughout, as speed reduction and the transformation to high torque takes place in the axle assembly before the bogie.

Valmet states that this is the way forward. The well balanced portal gear bogie is of robust construction and has low maintenance requirements.

The Valmet 860 comes with either 6 or 8 wheels. The approximate weight with 6 wheels is 14,000 kg and with 8 wheels 16,000 kg. It also has a steering wheel which comes into its own on rough ground, or when extra comfort is required whilst driving the machine over distance on roads.

'We also have a new Cranab loader programme with 720 and 850', said Jorgan Johansson. The first boom section lengths and the outer boom articulations have been specifically designed for the Valmet 860. The reach of the 720 is 7.2 metres or 9.1 metres combi extension and the 850 is 7.5 metres or 9.2 metres combi extension. The new 285 has thicker arms and better leg rolling properties.

New optimised loader geometry permits natural and easy movement, over both the bunks and at close range when selecting timber. The pivot housing is of rigid solid construction, and built-in strength is a feature throughout the 860. The slewing power is high and the loader can be parked directly on the trailer with the help of the main boom.

Cranab have new modern testing techniques that pinpoint the exact stress points where fatigue is likely to occur. To ensure stress free operation, a number of strengthening plates are visible on the booms. These are intended to guarantee that fatigue does not appear, and that the quality of the crane will be maintained from day one to approximately 14,000 hours.

Contact: **Kenny Paterson, Partek Forest Ltd, Longtown Industrial Estate, Longtown, Cumbria, CA6 5TJ. Tel: 01228 792018. e-mail: partek@globalnet.co.uk**

Ritchie turkey weigher

Suspended from a top mounted load cell, the weighing cage of the Ritchie Turkey Weigher has generous vertical dimensions of 765 mm. This is to ease the handling of large birds and help reduce stress caused by the tight restriction caused by some existing designs.

The load cell position helps protect it from contamination, and provide accurate data to the well-proven Trutest Eziweigh 2 digital readout. Clear and easy to read, the Eziweigh 2 can be set to work in standard or fine weigh modes. The latter offers a minimum weighing resolution of 100 grams.

The weigh cage has entry and exit gates that hinge to either side, attachment lugs on the main frame enabling guide hurdles to be easily attached. Large diameter wheels are also fitted as standard to make the 68 kg unit easier to move over uneven surfaces. Price, carriage paid British Mainland, is £759 plus VAT.

Contact: **Bob Ritchie, Ritchie Farm Equipment, Suttieside, Forfar, Angus, Scotland, DD8 3EE. Tel: 01307 462271.**

BG Technology wins first MiniGen order

The Capstone MicroTurbine will provide heat and power to a large commercial glasshouse

BG Technology, an internationally active organisation providing innovative technology solutions to the energy market, today announced the first commercial installation of MiniGen in the United Kingdom.MiniGen is an ultra-low emission microturbine based package providing clean, cost effective electricity that can be used in a range of power generation and cogeneration (combined heat and power) applications. The first MiniGen has been installed for W. J. Findon & Son, a large horticultural grower based in Stratford-upon-Avon. In this application, the 30 kWe MiniGen unit powered by a Capstone MicroTurbine™, will provide heat and power to a large commercial glasshouse. In addition, the clean exhaust will be passed directly into the glasshouse to boost carbon dioxide CO_2 levels, improving plant quality. Expensive exhaust gas clean-up equipment is not required as the exhaust of the Capstone MicroTurbine™ is sufficiently clean to use directly.

Contact: **BG Technology, Gas Research & Technology Centre, Ashby Road, Loughborough, Leicestershire, LE11 3GR. Tel: 01509 282525. e-mail: carl.jasper@bgtech.co.uk**

Wireless data link

The licence exempt TX7120 radio telemetry transmitter can broadcast analogue, digital and pulse counter data for a distance of up to 20 km line of sight and 1 to 3 km in buildings. An LCD display is provided so that one analogue, one pulse counter and four digital inputs can be displayed in real time. With an internal battery which can last for up to four years, the TX7120 is ideal for deploying in remote and inaccessible areas, monitoring moving machinery and energy metering.
Contact: **Andrew Wiggin, Warwick Industrial Electronics Ltd, The Manor, Aston Flamville, Leicestershire LE1O 3AQ. Tel: 01455 233616. Fax: 01455 233179. e-mail: sales@radiotelemetry.co.uk**

The TX7120 is ideal for deploying in remote and inaccessible areas

Immersion mixers outperform stirrers and agitators

The range of standard immersion mixers manufactured by Advanced Engineering (Middleton) Ltd are designed for high performance operation and uniform mixing. This includes homogenising, blending, dispersing and emulsifying a wide range of products used in the preparation and production of pharmaceutical and food products as well as chemicals and general industrial processing.

These are precision mixers with all product contact parts manufactured in 316 stainless steel for compatibility with sterile production, while also providing good chemical resistance to aggressive mediums. The advantages over conventional stirrer with agitator systems include reduced processing times with more consistent results, combined with virtually self cleaning, maintenance free operation over long periods.

The secret of their performance is the interchangeable mixer heads that can be supplied. These incorporate single or double-sided bladed rotor units operating at high speeds within a fixed outer ring or stator incorporating various cutter features. Material is drawn into the cutting chamber where it is subject to a rigorous mixing and cutting action. It is then forced at high velocity under centrifugal action through the stator cutting head, generating a powerful shear action. This process is repeated continuously with the whole vessel contents, which are subject to both uniform and progressive processing but with little or no aeration or surface disturbance.

The interchangeability of mixer heads guarantees that a wide range of shear options can be achieved from the same machine. A versatile general purpose disintegrating head provides a vigorous mixing action ideal for the preparation of gels, thickeners, suspensions, solutions and slurries. A slotted head is designed for fibrous materials including animal and vegetable tissues as well as rubbers and polymers. A high shear head is available for the rapid reduction of soluble and insoluble granular solids and the preparation of emulsions and fine colloidal suspensions. A specialised emulsifying head can also be supplied for fine, medium and coarse results.

The mixers can be fitted with optional circular or rectangular flanges for direct mounting on to vessels or channel bearers. Virtually any shape of mixing vessel can be used, with vertical cylindrical containers without internal baffles being most appropriate. Mixers ranging from 0.75 – 15 kW can be supplied in a variety of shaft lengths, and fitted with optional downthrust propeller or baffle plates, together with either 2, 3 or 4 radial supports. The mixing capacities of all machines vary with the process material, viscosity and shape of vessel, *etc.*

Options available include flameproof or two speed motors, electronic speed control, alternative materials of manufacture and various customised features.

Contact: **Advanced Engineering (Middleton) Ltd, Ambrose Street, Rochdale, Lancashire OL11 1QX. Tel: 01706 759003. Fax: 01706 759004**

Investment brings better quality to UK vegetables

Russell Burgess, the Peterborough-based root vegetable grower and marketing company, is not surprised by the results of the recent NFU survey indicating UK consumers perceive British agricultural products to be good quality.

The company has invested heavily in an agronomy support service with the aim of improving produce quality and promoting environmentally friendly farming practices. Russell Burgess Chief Executive William Burgess says, 'We employed our first agronomist eight years ago with the intention of bringing scientific methods and new technology to the vegetable growing process. The result has been a continual programme of improvement resulting in high quality produce, less waste, reductions in the use of agro-chemicals and improved water conservation,' he says. 'The NFU survey shows that consumers have recognised the improvements in British quality and the idea of branding UK produced food is an excellent way to help consumers choose the products that they want.'

The Russell Burgess agronomy service provides dedicated support to its Grower Group, members of which are located throughout the country, from the Isle of Wight in the south to Lincolnshire in the north. All members of the Russell Burgess Grower Group are required to have 'Assured Produce Accreditation'. This certification, which is renewed every year, includes maintaining an accurate crop history and following Integrated Crop Management practices *i.e.* only using chemicals when they are justified.

Advice on integrated crop management tools is a vital part of the Russell Burgess agronomy service. The use of ground positioning satellite sampling, farm and field hygiene routines, computerised field weather stations and pre-programmed irrigation are just some of the techniques that have been utilised in the drive for improved quality.

'Our heavy investment in agronomy is providing benefits for everyone,' says William Burgess. 'Growers get a better return on their crop, the retailers get a consistently high quality product with complete traceability, and the consumers get the quality they are looking for.'

Contact: **William Burgess, Russell Burgess, Station Bridge, Yaxley, Peterborough, PE7 3EL. Tel: 01733 240491. Fax: 01733 244572.**

New Kverneland Taarup T8 in-line bale wrapper features automatic wheel steering to track the baler – even as it moves backwards

New auto-steering in-line bale wrapper goes round the bend

The new Kverneland Taarup T8 bale wrapper utilises well proven Kverneland technology to match the best possible wrapping performance to the output of the fastest round balers. The T8 can be used either as a 'conventional' trailed machine, or in-line behind most makes of baler, for the higher output demanded by the larger farmer or contractor.

Silage quality maintained as output increases

A challenge facing the T8 wrapper's designers was how to ensure that no loss of wrapping quality occurs as productivity is raised. In fact, the result has been quite the reverse. Active wheel steering, known as Autosteer, and the unique loading 'skateboard' proactively ensure that the bale is in exactly the right position to achieve the correct degree of film overlap, and hence maximise silage quality. This is achieved even when the wrapper is following the baler round sharp bends, or across a hillside.

Autosteer tracks the baler forwards AND backwards

Automatic sensing allows the wrapper to operate in one of four modes:

- following directly in line behind the baler (normal operation)
- track following (to negotiate gateways and awkward in-field obstacles such as pylons)
- locked in centre position (for high speed road transport)
- manual steering (operated by means of a joystick, for specific manoeuvring)

All the operating modes, including reversing, can be overridden manually by the operator if required. Joystick adjustments can be made on the move with a return to automatic function by a single push of a button. Autosteer can also be programmed to steer the wrapper to the side when unloading the bale, allowing better clearance on the next round and avoiding damaging previously wrapped bales. This is important when swath widths are narrow, or tractor tyres are particularly wide. On hillsides, the T8 can be set to track slightly downhill of the baler, ensuring smooth transfer from the baler to wrapper.

Uni-directional rotation boosts output

Smooth and precise rotation of the bale is crucial in order to achieve the correct stretch film overlap. Whatever the shape, size or consistency of the bale, it will be correctly wrapped. Large, conical side support rollers keep the bale in the right position, and as the bale rotates in only one direction, high wrapping speeds can be used without the risk of the bale being thrown off the table.

Twin satellite cuts wrapping time

By using two pre-stretchers, less time is taken to wrap each bale, and the film rolls require replacement less often. The pre-stretchers are mounted close to the bale, thereby limiting the amount of air which can be trapped under the film, even when the satellites rotate at high speed. This can in turn lead to higher silage quality.

Unique sliding 'skateboard' maximises output

The T8 is equipped with a unique 'skateboard', a sliding board that brings the bale into its correct position before it is moved to the wrapper table. The need for precise placing of the bale is reduced, which means more bales wrapped per hour. The wrapper table leans forward when the bale is loaded, to ensure that the bale is brought directly into the correct position for wrapping. A low unloading height reduces damage to the bale as it rolls off once the wrapping cycle is complete.

Performance proven in UK conditions

Operators using test machines in the UK during 1999 have found the T8's performance impressive. Contractor John Fletcher from Mill Farm, Boroughbridge, North Yorkshire, comments: 'When baling 45-50 bales per hour, the wrapper managed to match this capacity even when I put 8 layers of plastic on the bales. And when using the wrapper solo, I managed to wrap 67 bales (4 layers of film) in only 50 minutes, equating to a spot rate of 80 bales per hour!'

Retail price of the Taarup T8 Wrapper is from £13,570 with fixed axles and single satellite. Price with Autosteer and twin satellites, £19,520.

Contact: **Robert Edwards, Grass Product Manager, Kverneland (UK) Ltd, Haydock Lane, Haydock Lane Industrial Estate, St Helens, Merseyside WA11 9UU. Tel: 01642 272 777. e-mail: robert.edwards@kverneland.com**

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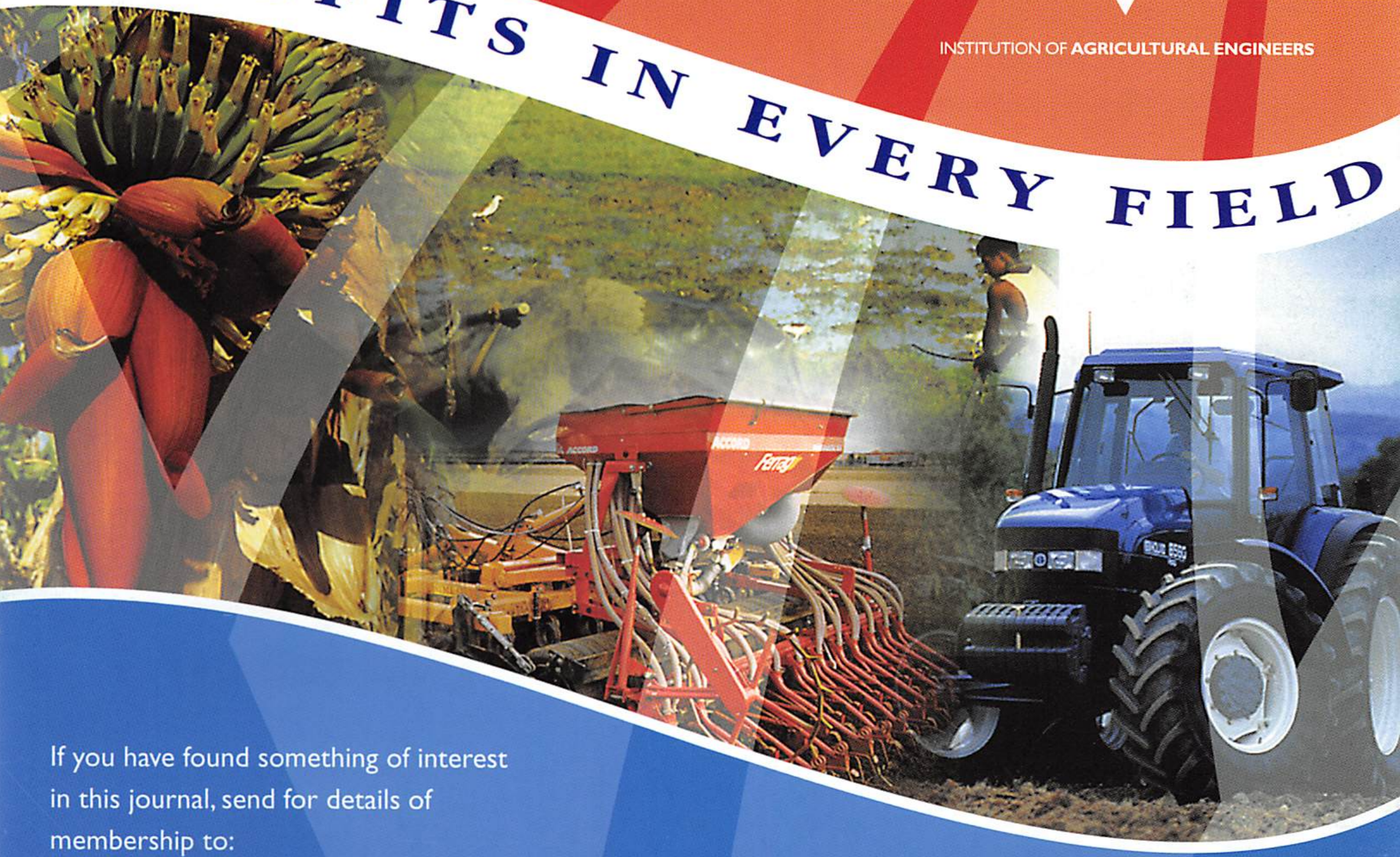

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