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1981 National Conferences

Spring "Engineering in horticulture"
17 March, Wye College, Ashford, Kent.

Annual "Innovation in Agricultural Engineering — its Encouragement and Utilisation"
12 May, National Agricultural Centre, Stoneleigh.

Registration forms will be distributed to UK members as they became available. Overseas members wishing to register are invited to contact the Conference Secretary, Mrs Edwina J Holden, at the Silsoe Secretariat.

1981 Branch Conferences

Scottish Branch "Silage production and feeding"
18 February, Dunblane Hotel Hydro.

Registration details obtainable from:
J A Pascal, Branch Honorary Secretary, "Donmaree", Springhill Road, Peebles EH45 9ER.

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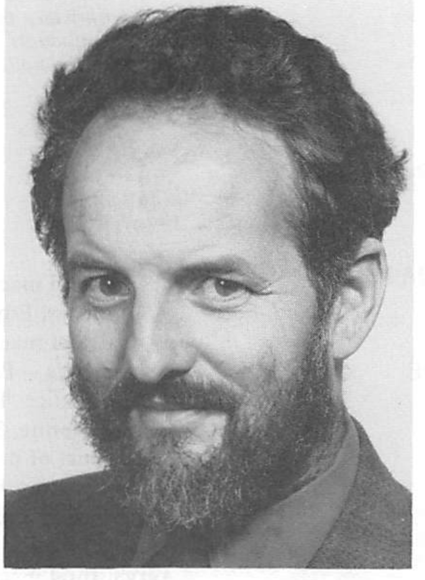
Agricultural machinery manufacture in developing countries

I M Johnson

WITH manufacturers in most developed countries cutting production and laying off staff, it might be considered inopportune to start talking about how to build up more manufacturing capacity, but as Mr F Moore pointed out in his paper, to do so may be an essential part of maintaining trading links with the developing countries. This conference was the second of a series designed to focus attention of the problems of the developing world (the first was in Spring 1978 on Small Tractors). At the moment developing countries only account for about 12% of the agricultural machinery used, and this market is far from saturated. However, this does not mean an unlimited market for surplus machines from the developed countries. There are about ninety distinct countries in the developing world, each with its particular climate, cropping patterns and customs, and conventional machines cannot always be adapted to suit their needs.

When I took on the job of convener for the Autumn Conference from Mr Derek Sutton, who must take all the credit for the basic structure and theme of the conference, I had visions of papers describing, in detail, production techniques and machine tools and it was most interesting to see, in the papers submitted, how little emphasis was placed on manufacturing techniques and how much on product planning, marketing, finance and organisation. With hindsight this is obviously right. There are, all over the world, workshops that can produce copies of existing designs. They do not always work, as I discovered when trying one day to demonstrate what appeared to be a standard British plough that had been made locally the previous week to meet the deadline for the demonstration. The shape was right, but some of the angles were wrong, and it would not work. What seems to be lacking in most cases is what might be described as the entrepreneurial skill to turn an ordinary jobbing workshop into a viable manufacturing plant. I do not wish to suggest that the only qualifications required to make a success of manufacturing are commercial ones but for an Institution, many of whose members are familiar with the "nuts and bolts", it is essential that the commercial aspects are emphasised.

When the conference was being planned there was considerable discussion as to the most convenient date for overseas visitors, and no suitable compromise could be reached. Few overseas members could justify the cost



of travel to the UK for a one day conference alone, whilst dates near to the Smithfield or Royal Shows are not convenient for the UK members. The same factors restricted the availability of speakers. The inevitable result was that attendance (not interest) from overseas was low. To allow for this the speakers were asked to write their papers so they would stand on their own, and not form notes to cover a verbal presentation. As if to emphasise the problems of timing international conferences, one of the speakers had to delay his departure on a MAFF export mission.

The first paper by Mr F Moore took the point of view of the well established company considering manufacturing, or having its designs manufactured in a developing country, and he gives a very useful checklist for anyone contemplating such a step.

This was followed with a paper by Mr J Frost of the Intermediate Technology Industrial Service, an organisation dedicated to assisting developing countries to set up their own industries. This paper emphasised the obvious, but often forgotten point that there is much more to manufacturing than setting up a workshop and producing something. The product has to be right in terms of price, ability, service back-up and reliability. Even that is not sufficient for the manufacturer. He has to be certain of his supplies of raw materials, and most important of all in these days of high interest rates he has to be certain of finance both to set up the plant, and with the seasonal nature of agricultural sales, finance the making of goods for stock.

One problem with manufacturing in most of the 90 developing countries is the size of the market. Most are relatively small, and historically communications tend to be between developed and developing countries rather than between one developing country and another, reducing the opportunities for exporting.

The third speaker, Mr G Cooper, described the development of agricultural machinery manufacture in China, a country that certainly cannot be described as small. It presented an interesting contrast of small workshops and large factories. Even China has its communications problems, and much of the manufacturing only serves a small area around the factory.

After lunch the papers were more concerned with the small manufacturer making simple hand or animal draught tools. An interesting concept of a package designed to start the small man off was presented by Mr A Stokes. He described various levels of package from a design only to a fully equipped workshop and a year's supply of raw materials. It was interesting to note that, with the relatively static technology of animal draught equipment, Mr Stokes recommended a once and for all payment for know-how, whereas Mr Moore, with his high technology equipment, made a plea for continued involvement, with a constant exchange of technical information.

Professor Inns in his paper looked at local manufacture in the context of national development from both the agricultural and industrial point of view. He considered it important that the bulk of the rural population should benefit from mechanisation. Supplementation of human labour might best be provided by draught animals or small tractors requiring relatively modest management skills but designed to deal with a wide variety of agricultural operations. Such an approach is readily compatible with local machinery manufacture.

The final paper by Mr R Bell of the Overseas Division at the NIAE summarised the problems of manufacturers in developing countries under the headings of the requirements, the farmer, the manufacturers, and the dealers responsible for the sales of the manufacturers' products, an essential link in the chain. Again the emphasis was on the fact that in a free economy, every

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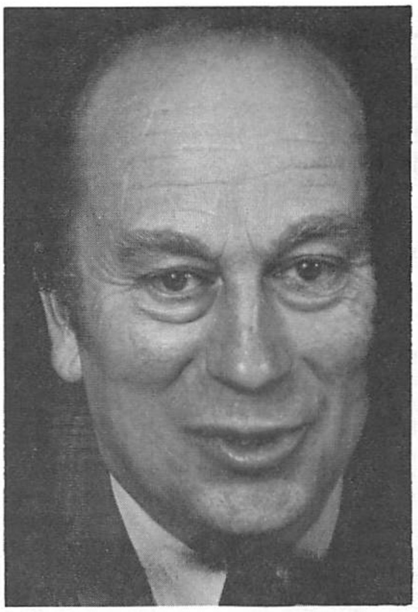
The export of proven technology and manufacturing capacity

F P D Moore

Summary

THE paper examines the motives and pressures for the licensing of product manufacture overseas and for the setting up of overseas manufacturing units on both a wholly owned or a joint venture basis and points out some of the pitfalls that may be encountered.

Furthermore, the paper examines current trends and discusses the arguments for and against exporting ingenuity rather than hardware.



THE only reason for a manufacturer to decide to transfer either technology or manufacturing capacity from his home base is because he is forced to do so by circumstances.

Obviously, every additional plant, manufacturing the identical product to that produced at home, or one competitive to it, dilutes the volume and carries an additional overhead, Why do it then?

The first reason may be because there is no chance of direct exports to the country concerned, since no import licence will be granted. There are, unfortunately, many examples of this.

The second reason may be that unless one decides to set up a manufacturing unit in the country, someone else will do so and then claim total protection and a ban on imports from other sources. Such a manufacturer thus becomes yet another export competitor in other countries.

Thirdly the existing or threatened tariff barrier may be so high that there is no chance of one's machine being sold in that country because of the resultant price.

The fourth reason, valid in some areas, is that it is actually cheaper, even taking into account the loss of overhead contribution in the home plant, to produce or partly produce locally. This is particularly true of machines that consist of large standard section frame members with some more sophisticated parts attached. In fact, local production normally starts with the manufacture of the unsophisticated parts and the importation of the more sophisticated parts for local assembly.

A fifth possible reason is that there are specialised local conditions which make the machine so different from the original product that it is more practical and economic to manufacture it in the market concerned, especially where continuous development in conditions not found in the UK may be required.

But before we go further, let us look at the underlying and inescapable facts of the situation in the developing world and draw some conclusions.

First, the population situation. Table 1 shows the current and projected population and growth rates, both now and in the year 2000.

Second, let us look at the power availability in the 90 developing countries listed by the FAO. Table 2 shows the total amount of machine power available in 1975 and that projected by the year 2000, the percentage of the harvested area cultivated mechanically in 1980 and the projected increase by the year 2000, and the percentage of the world agricultural machinery produced today in developing countries together with their target for the year 2000. It is seen that only 6% is produced in those countries. But only 12% of world agricultural machinery production is actually used in those 90 developing countries, a figure which must, surely, increase:

These figures give some indication of the future needs for farm machinery in countries which, at present at least, and excepting some of the oil producing states, have no way of creating sufficient foreign exchange for the import of equipment and spare parts on the scale

F P D Moore is of the Howard Rotavator Co Ltd.

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link must profit from the manufacture, sale and use of the machines. Any attempt to control the price artificially is likely to lead to a break in the chain with the result that no one prospers.

The conference was opened by the President of the Institution, and this was followed by a short introduction by the Chairman, Mr John Fox. In his opening remarks 'Setting the Scene', he made a plea that some tax incentive should be given to British manufacturers who share their knowledge with the developing world.

This was taken up from the floor at the end of the conference with questions about the viability of patents or copyright, and how to stop rival manufacturers pirating designs or even staff. The general consensus was that there would be little hope of legal protection. Every manufacturer would have to survive on his own by producing goods cheaper than his competitor, and at the same time paying his staff more. Unfortunately there was no concrete suggestions as to how this could be achieved!

At the end of the conference Mr B Pothecary gave an example of what he considered an excellent instance of the development of an agricultural implement manufacturing organisation in Upper Volta. This is one of the least developed and more remote countries of Africa.

Financed by a number of bilateral and multilateral agencies, an organisation had been built up based on a central workshop and buying facility to supply part manufactured components to a series of small workshops or blacksmiths where the manufacture and assembly of ox ploughs and hand implements was carried out.

At the end of the conference delegates were left with the feeling that the growth of small manufacturing plants in the developing countries was inevitable and that this would certainly affect the export of low technology equipment from the developed world. Although the direct financial benefits from setting up local plants would be small, the indirect benefits could be great both in terms of retaining markets for high technology equipment and, in some cases, as a source of parts with a high labour input.

Table 1 **Population (millions)**

	1980	*2000 (est)*	*Annual growth rate*
Total world	4339	6079	1.7%
Developed countries	1166	1343	0.7%
China	908	1148	1.2%
Developing countries	2233	3539	2.3%

Source: FAO

Table 2 **Power available in 90 developing countries**

	1975	*2000 (est)*
Total machine power	5%	13%
Percentage of harvested area cultivated mechanically	*1980* 24%	50%
Percentage of world agricultural machinery production		
Developed countries	94%	75%
Developing countries	6%	25% (target)

Note: Current percentage usage of agricultural machinery in developing countries is 12%.

they really need. Local manufacture in these areas is, in my view, inevitable. I must admit that my own company has limited experience in licensing manufacture to an overseas manufacturer with whom we have no financial or joint venture ties. I think that the danger here is in assuming that it is a "one-off" deal — the sale of a substantial quantity of machines, followed by partial manufacture, followed by total manufacture of the product. Drawings are supplied, technical training given and then we all go home. Ten years later, we wonder what happened to that market and twenty years later the local manufacturer is still making a totally obsolete machine. The lesson is, therefore, that some clause for future co-operation as well as minimum performance should, if possible, be written into the agreement.

In the case of progressive manufacture, whether by a licensee or by a wholly or partly owned subsidiary, the major cause of dispute will almost certainly arise over pricing and deletions of components. Frankly, the only really satisfactory way to avoid this is to have a fully priced master parts list which, subject to minor amendments and inflation, can be taken as the supply or deletion cost of every individual part. Any attempt to "load" the cost of parts supplied and reduce the cost of parts deleted will soon be spotted, and will be the cause of accusations of bad faith and some mistrust between the partners in the future. It pays to be totally honest once it is certain that a prospective partner's enthusiasm is genuine and he is not playing you off against another potential supplier.

The actual proportion and nature of the parts locally made may well depend on the skills, materials and engineering facilities available and, in many areas, the high quality of all of these would surprise those who have not investigated this subject. This is particularly true of South East Asia and some Latin American countries. In general, however, the mere assembly of parts shipped from the UK without any local content is almost a total waste of time.

As with all operations, people count most, and if it is necessary to recruit locally it is important to employ someone who has first hand experience of the type of work contemplated and, with him, to examine the estimated costs of material and manufacturing right up to the finished product. On many occasions, these estimates will prove that a start must be made either by importing or sub-contracting the difficult-to-make parts which require sophisticated machine tools or tooling. When this is completed, it is necessary to find out what the exact unit production will be and make the first rough calculations of production overhead in order to calculate the amount of factory overhead which it is necessary for each unit to carry.

Thus in setting up a local manufacturing unit, a company must know by the end of the preliminary planning exercise the following facts:

1. What it is going to make
2. How it is going to make it
3. The material costs involved
4. An estimate of the quantity required each year
5. The number of men needed to carry this out
6. The amount of factory overhead necessary to support them
7. The approximate contribution to factory overhead each machine would be required to bear

In the case of a joint venture, one of the most difficult yet important calculations to get right, if partners are to work harmoniously, is the amount of working capital required before the venture is self-supporting. Cash is required for raw material and work in progress, finished machines and for all the operating expenses, including the wage bill, until cash from sales starts to roll in — sometimes a long wait! To have a cash crisis at an early stage is highly detrimental to the success of the venture, yet this can easily happen if only the capital costs have been considered. What must be clear from the start is where the money is coming from to finance the entire joint venture operation and it is wise to add 10% contingency to the final figure.

Many things have to be covered. Should a building be bought or rented? How much will machine tools cost both to buy and instal? What capital expenditure is necessary for office equipment, vehicles, material handling equipment, as well as machine tools? Will these need to be rented, leased or bought?

So far as working capital is concerned, a rule of thumb method which might be applied is to say that one needs enough to cover one month's production in raw material, a second month for work in progress going through the shop and a third month for finished machines awaiting shipment. This, with spare parts would give a total stock holding of approximately ten weeks of sales. Add to that the rate at which invoices are paid and another eight weeks of sales outstanding might be needed.

To offset these outgoings, there is, of course, the credit which may be available from suppliers.

Adding the cost of training and start-up, which should be estimated separately, there is now possibly enough data to enable a rough draft of the first profit and loss account to be made. If this does not come out correctly, the whole project may have to be re-thought, making sure that no particular item has been overlooked. On the other hand, if the profit looks too rosy, it is very probable that some of the costs have been under-estimated.

Depending on these figures, it should be possible to decide the type of operation such as how much of the machine should be bought in CKD or alternatively sub-contracted locally.

So far as the proportion of equity held is concerned, the split seems to matter less than the need to have a definite and strong management clause. A 50/50 equity arrangement will work satisfactorily so long as it is made quite clear who *runs* the business ie there must be a management contract.

Another major cause for concern, and for complete clarification from the start, regardless whether it is a licensing or joint venture involved, is the question of exporting from the new organisation. There will, understandably, be a great deal of pressure from the licensee company to increase its potential volume by allowing it to export at least into neighbouring countries, and it may well be in the interest of the licenser to allow this, provided it is fully controlled. The company must, however, be prepared to operate profitably within the country concerned and the reasons for excluding export arrangements must be fully explained and understood.

A deterrent to any manufacturer offering a licensing or joint venture agreement is a situation where he finds himself in direct competition with a partner in third markets, with the partner having the advantage of substantial

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Small scale manufacturing of agricultural equipment in developing countries

J Frost

Summary

THE criteria for success in the production of agricultural machinery and equipment on a small scale are reviewed. Fiscal, sociological and technical aspects are summarised. Examples are given of several locally manufactured products and the degree of success which they have enjoyed.

IT may seem that the difficulties and problems of setting up a small manufacturing unit to make and sell agricultural equipment are almost insuperable. Sir Winston Churchill once annotated a memo "Don't argue the difficulties, they will argue for themselves" meaning, one would suppose, that problems should be regarded as a challenge to be overcome. Many successful enterprises have been set up in the past and, no doubt, several more will be set up in the future so there are various ways of overcoming the problems presented. However, it is not a field for the faint-hearted.

Equipment design

IT goes without saying that the equipment design must meet a local need and most manufacturing enterprises need to have a stable and, if possible, profitable "Home Market". It is likely that equipment from developed countries will require some modification or a unique design will be needed for a local acceptance. Design of the proposed equipment is probably fundamental to success. A good design will not guarantee success but a bad design will inevitably lead to failure.

When a suitable design has been established, a further problem of testing in the correct environmental conditions faces a manufacturer. Leaving aside the social considerations, the actual soil, climate and plant interface with the design are of vital importance to the technical performance and this may require costly and time-consuming trials.

Another consideration in the design would be the equipment weight. Traditionally, agricultural equipment has been heavy, either for the reason that heavy equipment has an operational advantage or because some heavy materials are cheap. As the cost of transport from manufacturer to customer increases the effect of weight and, sometimes, volume becomes a factor to be considered. This is particularly so when a comparatively low priced article has to be transported over large distances as in the case of export from the U.K. or across a large Developing Country from a local producer. Quality of the design would probably be judged by the following criteria:-

- cheapness of manufacture from available materials.
- efficient performance of a needed operation.
- lightness and robustness to withstand delivery transportation
- length of service life
- possible recycle value.

Price to the customer

The acceptance of equipment by the market will be determined, to a very large degree, by the selling price in relationship to the benefit or return, often in cash, which can be proved or projected. In Britain and in many other western countries the benefit is frequently judged in labour-saving to which a money value can be assigned. A similar calculation is not usually acceptable in developing countries where labour costs are not a dominant factor. A more usual price justification is based on increased yield of an agricultural product or the reduction of some other costed input. Naturally, conditions will vary within wide limits but a good basis on which to make an assessment is that the purchase price should be recovered in three years. If it can be recovered in the first year, in most cases it is a truly remarkable device. On the other hand, if the recovery takes five years it is on the very edge of economic viability.

Customer ability to pay

In many developing countries the

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export subsidies or long term cheap credit schemes available to him.

If exporting is allowed, then it is even more essential that strict quality standards are maintained, especially if the machine carries the originator's name or trade mark. This may well mean that the licenser will have to provide a highly skilled supervisor to advise on the production of the product over an extended period; how he is going to be paid must be decided from the outset. Even such relatively trivial matters as who pays the cost of the parent company's directors' fares and expenses when attending board meetings should be agreed in advance.

Let us now turn back again to the whole question of "should we or shouldn't we?".

As was said at the start, the natural reaction to overseas manufacture of one's "own" product is to say "NO", but we live in an economy where even the most efficient production plant is facing more rapidly increasing costs than most of its competitors,. We have, however, one great asset — INVENTIVENESS — in design, ingenuity and implementation. If we lose that, the future for our industry is bleak indeed.

The fact is that the manufacture of farm machinery in developing countries is bound to increase. In the developed countries, where the "vacuum" of the 25 years of 1945-70 has been filled, it is bound to diminish in overall volume terms. This points to the direction in which many of us must look in future and we may have to depend on the income from overseas licences and joint ventures to support at least a proportion of the vital research and development which must remain the top priority in our industry.

majority of farmers survive around the subsistence level. Those who have achieved a cash economy sometimes have a very tenuous hold indeed depending on favourable weather conditions and are quite unable to survive even small disasters. Most of the savings, of even the successful farmers, are not held in cash but in additional livestock or other quasi capital goods. The best potential customer might be persuaded to sell a couple of goats to pay for equipment on delivery but the majority will wish to, or need to, pay out of income. So some sort of loan arrangement will be required in the majority of cases, involving a financial institution of some kind.

After sales service

The cost of providing some after sales service must not be overlooked. It will not always be possible to reclaim the full cost of this service from the customer, particularly in the first year or so after introduction. Some of the service operation will be seen by the customers as warranty and there will be a need to overcome the service problems quickly to avoid jeopardising future sales. Where most of the customers are paying for the equipment out of income they have much more "leverage" over the speed and cost of service than an outright sale customer.

Spares

Spares and after sales service are very much linked together. Except where the manufacturer has supreme and, perhaps, foolhardy confidence in his product, a stock of spares should be available at the time the first production unit is sold. The early spares requirements are most likely to be for transport damage and early misuse rather than operational wear, but the fact that the equipment cannot be used when it is required could have an effect on future sales. The cost of stocking spares at this early stage can, to some extent, be offset by recycling stocks into production.

The effect of local conditions

It has been found from experience, particularly in developing countries, that the establishment of a viable enterprise offering agricultural equipment takes a very long time. Establishing a design which meets a need in the fullest sense of the word can take up to ten years. It is not always the originator of the device who benefits from the market which is eventually established. The choice of equipment range needs very careful attention to provide, if possible, a steady annual sale.

Some products which are not weather or crop dependent such as, perhaps, water pumps or animal feed dispensers, could form a single line range, but a more flexible position would be achieved by a study of local conditions to integrate the product range to seasonal sales demands. Possibly hoes or tillage equipment with scythes or harvesting equipment backed up by thatching needles or farm building hardware such as gate hinges might be a suitable combination.

Trial marketing

Unlike a sophisticated market which will sometimes buy on written or illustrated information, customers in developing countries essentially need to see the actual equipment under operating conditions. In many cases they need to use it for themselves perhaps for an extended period rather than a one day demonstration.

The intending manufacturer would be very wise to encourage this kind of market evaluation as many quite unforeseen problems can be identified which need to be solved before a quantity of the unit is made. For small and low priced equipment, a number between five and twenty is usually sufficient to be operated locally for a "season". Depending on the operation a season may be two weeks or a year. At the time of the trials at least a notional selling price must be established and made known to the farmer using the equipment. The decision whether to ask the farmer to pay something for the use of the equipment must be left to an assessment of the local circumstances and the confidence the designer has in the equipment on offer. There is no doubt that the very best evaluation is achieved if the farmer pays the full market price when he takes delivery, but this is a high risk method to use.

Trial manufacturing

If the trial marketing batch has been made by a non-production method, perhaps in a different location, the trial pre-production batch, perhaps 20 units, will present different problems which a prudent entrepreneur will wish to overcome before going forward to series production. This is the time when such things, as the suitability of local raw materials, the accuracy of production tooling, the proving of the skills of the artisan work force and, very important, the final quality of the product can be assessed and established. Consideration might be given to exchanging the units already in the field under the trial marketing exercise for the pre-production units for confirmation user trials.

Fig 1 Kiyito windmill in Kenya

The Kijito windmill

Perhaps not strictly a piece of agricultural equipment, and certainly not low priced, but an example of a very creditable attempt to establish a local enterprise is the manufacturing of the *ITDG water pumping windmill* by Bobs Harries Engineering Limited in Keyna (fig 1). With the increase in energy prices and the over-riding need for water, both animal drinking and irrigation, Kenya had been importing increasing numbers of wind pumps. A locally made device, properly designed, was offered by **BHEL** at less than half the price of imported units delivered on site. This is partly because of the high freight costs of the imported device and partly the difficult cash flow situation arising when establishing letters of credit perhaps six months before installation of the imported units.

The job planter

The device pioneered by the International Institute for Tropical Agriculture in Nigeria which can be used in conditions of minimum or zero till is the jab planter.

Fig 2 Rolling jab planter with several dibbers

This system can be either a single unit used by hand or a rolling unit with several dibbers which can be pushed by hand or power driven (fig 2). It has the advantage of being quicker generally than conventional hand planting and the rolling version provides more accurate seed spacing. Extensive trials have been carried out in Nigeria and the equipment is now being made by at least two workshops in the Ibadan area and sold locally. It is too early to confirm that it can be made and sold profitably at a price which the farmers can afford but the enterprise looks promising.

Hand thresher

The two previous cases have the appearance of being successful, but there are many failures. A typical case comes from Pakistan where a small company set out to make and sell a small thresher for rice and barley. The design was simple and well tried. It had been widely accepted in other developing countries and was reported to be a commercially viable product in the Philippines. Indeed the production from the workshop in Pakistan met a demand in that country and it achieved a good reputation.

This was the main product of the workshop for which there was a sharply seasonal demand and, over a period of years, the financial state of the enterprise deteriorated due to not being able to finance the building for stock and then not being able to meet demand at harvest time.

Animal plough

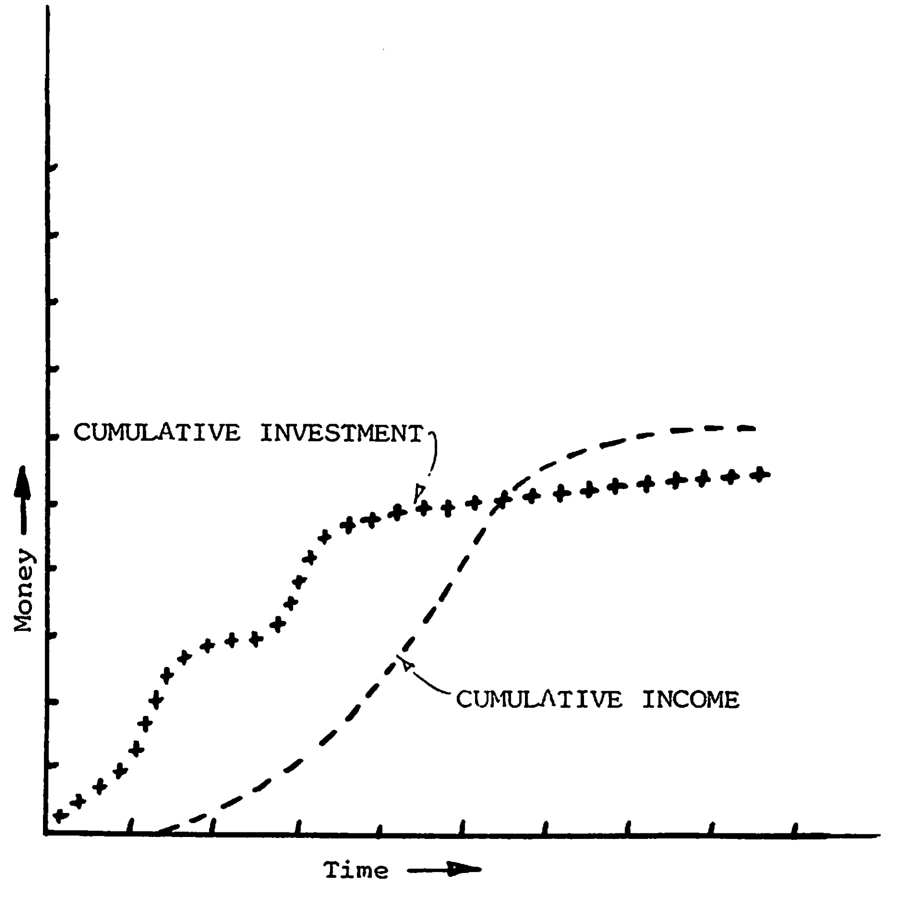
An agricultural development unit in Ethiopia set out to re-design the local "ard" plough to extend the life of the equipment. Metal was used instead of timber and very extended trials were carried out on the development unit's own farm, right at the middle of the area where it was to be introduced. However, no substantial user trials were carried out before a considerable batch was manufactured and offered for sale. It was not adopted by local farmers because it was much heavier than the traditional plough which they carried home each night; also, being heavier, it ploughed deeper and oxen were unable to pull it as easily as the "ard". The whole production batch was eventually scrapped and the ADU disbanded.

Investment in manufacturing

In most countries money is expected to earn more money and there are often local opportunities for it to increase easily, quickly and safely. The competition which manufacturing investment faces, depends on the local circumstances. These circumstances also determine the risk of the manufacturing investment which, in turn, will help to set the level of return or profit expected from the investment. In the setting of local risk, the investor will be interested in the fixed assets, or the total value of the enterprise if it were to be sold: also the anticipated profit for at least three years on a year by year basis. Occasionally money is available based on considerations other than financial, such as government funds to provide import substitution, local employment, export revenue and several other political factors. Sometimes individuals invest for perceived personal, family or even altruistic reasons but these cases cannot be used as examples or bases for calculation. If they are available then the enterprise has a greater chance of success than if the money is invested at a competitive rate.

Figure 3 indicates a typical pattern of investment and income relating to a new product.

Fig 3 Manufacturing "break even" diagram zero time represents the beginning of the market survey. The "break even" point is at the intersection of the two graphs



Energy

It can be said immediately that no manufacturing enterprise could survive or even start without energy. This does not mean that mains electricity must be available, or even fossil fuel, but there must be a source of power whether it is human, animal, biomass or solar based. The sources of power, other than fossil hydro-carbons, are considerable, and should have been taken into account in the market survey projection of manufacturing costs. However, the local availability must be considered. As an example, suppose hydro generated electricity was assumed. The rainfall and catchment area may be such that the main energy demand of the workshop cannot be met at the time of peak production to satisfy a particular market. Energy is likely to be one of the most valuable resources on which a manufacturing unit will have to depend.

Metals

It is most likely that any small scale agricultural equipment which can be sold at a profit will contain some metal. Most metals are energy intensive, both in their original creation and in their manipulation. Iron, or its alloy steel, is most likely to be used in the majority of simple equipment for agriculture and the continued availability will be necessary for the enterprise to survive.

Sizes and specification which are required for the chosen design will also be important, particularly if the steel is not made locally, as changes of specification could seriously upset the material cost, the production rate or the efficiency of the final product.

Castings

Where the shaping of metal is carried out by melting and cooling in a mould, the sizes and specification of raw material will not need to be so closely defined. In this case fuel or energy for melting, trace materials and operator skills will be more important. The use of castings sometimes provides more independence from raw material supplies as compared, for instance, to rolled steel bar.

Fasteners

Conventionally, the main fastener requirement in engineering products is for metal threaded components, bolts and screws. Joining, as opposed to fastening, can be achieved in many other ways but ease of assembly and, particularly later, service or replacement is really only achieved by the use of fasteners. The availability of bolts or facilities to make male and female threads is likely to play a major role in the design and manufacturers of agricultural equipment containing metal parts.

Local availability of skills

There are several skills necessary for a small manufacturing business to thrive, ranging from management, through finance and marketing to artisan activities in the actual making of the product. The acquisition of such skills usually depends on experience, education or a combination of both. The emphasis in most developing countries is to encourage local nationals into manufacturing enterprises and in some countries there is competition for the people with the required levels of skill.

Availability of tools and equipment

At the very least simple tools will be required. The choice of tools and equipment will depend on materials to be manipulated, the accuracy required, labour content anticipated and the skills available. As it is most probable that steel will feature somewhere in the product, metal working tools will be required. These may be available locally and, if not, importation may be necessary. When importing metal working machines the effect on cash flow of transportation times and the availability of foreign currency will need to be taken into account.

Servicing and spares for production tools

It is usually wise to establish some "in house" capability to service the tools and equipment used in the manufacturing process and the equipment should be chosen initially with this in mind. When metal working tools are imported it is important to consider a kit of spare parts to cover one year's use in the workshop. Unless this is done, serious manufacturing delays could arise due to broken or badly worn parts which could not be replaced locally. Items such as drive belts and cutting surfaces are particularly vulnerable.

Typical workshop equipment

The range of metal working tools is very wide covering cutting in various forms, bending, shaping, grinding and pressing.

A typical small manufacturing unit might require the following:-

- forge for heating and shaping metal
- hacksaw, either hand or power operated
- guillotine for cutting sheet metal up to about 10 SWG
- drilling machine of some kind either hand or power operated
- grinding machine either hand or power operated.

A larger workshop would probably, have in addition:-

- electric or gas welding equipment
- lathe for turning and threading metal
- metal bending machine to manipulate sheet metal.

Where specialised manufacturing operations are required for metal working and processing some further equipment might be required including:-

- spark erosion machine for making forging dies
- thread rolling machine for making bolts
- planer for long straight steel members
- router for cutting complex shapes tapping machine for making female threads
- galvanizing plant for coating steel
- spray painting facilities.

Conclusions

The aspects to be taken into consideration in order of importance in setting up a manufacturing operation in developing countries are usually the following:-

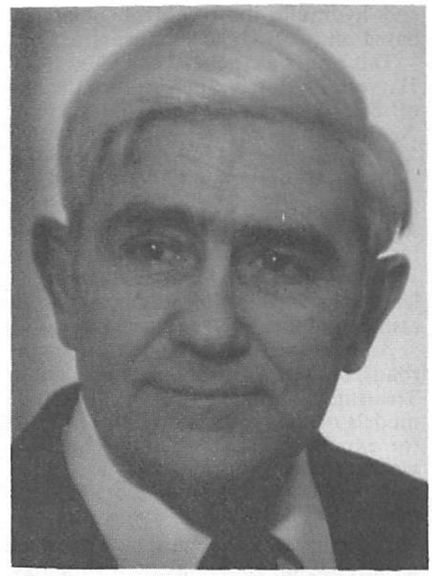
- appropriately high quality of the equipment designed.
- the necessity for local acceptance trials
- the investigation of local agricultural conditions to determine a product range
- the manufacturing investment profile
- the longer term availability of raw materials and resources
- the continuing availability of the necessary labour skills
- the correct choice of manufacturing tools and equipment.

Agricultural machinery production and development in The People's Republic of China

F Cooper

Summary

THIS paper presents some aspects of the agricultural machinery situation in China, a country where the ancient and modern in agriculture exist side by side. It includes details of some machines, particularly harvesting equipment, and notes on the various Research Institutions. Much of the information stems from the author's visits to China, but other sources are quoted.



MY first acquaintance with the People's Republic of China was in 1972, when my employer exhibited at the Trade Exposition which the Chinese invited Canada to hold in Peking. In 1978, we again exhibited at a 12-nation exhibition of agricultural machinery there.

Before, during and after this exhibition, company representatives had numerous conferences with the Chinese, with a view to possible machinery sales and technology transfer. In this connection visits were made to the principal tractor and combine factories. For some additional facts and figures. , I am indebted to a paper produced[1] as a result of the visit to China in August/September 1979 of a 15-member delegation from the American Society of Agricultural Engineers, and to Colleagues within the company.

China has about a quarter of the world's population, and ending the periodic famines is one of the major accomplishments of the Communist revolution. She is now the world's largest producer of food, and, to assist this, has a comprehensive agricultural machinery industry.

The Chinese claim more than 1600 factories making farm machines, located in nearly all provinces and in all three municipal areas — Beijing (Peking), Shanghai and Guangzhou (Canton) — and producing some 1300 different products.

Until 1979 the industry was administered by a government agency entitled First Ministry of Machine Building, but then the responsibility passed to a special Ministry of Farm Machinery.

Tractors

Both by common observation and from the above figures, 2-wheel "walking" tractors are the commonest farm machine, being manufactured throughout the country. Like all wheeled tractors in China, however, they form an important part of the transport system — for every tractor seen working in a field, there are three or more hauling trailers of produce or people. A single-pin hitch connects the tractor to a 2-wheeled pneumatic-tyred trailer, this having a wide seat at the front for a driver and two or three companions. Such trailers are commonly built in commune workshops.

The commonest tractors have diesel engines of about 12 hp, of simple rugged construction with hopper cooling, usually boiling merrily. Primary drive is by vee-belt to a geared transmission. Implements include ploughs, cultivators, and transplanting machines, sometimes with a castor rear wheel and seat so the operator may ride (see fig 1). They can also be used to drive stationary machinery.

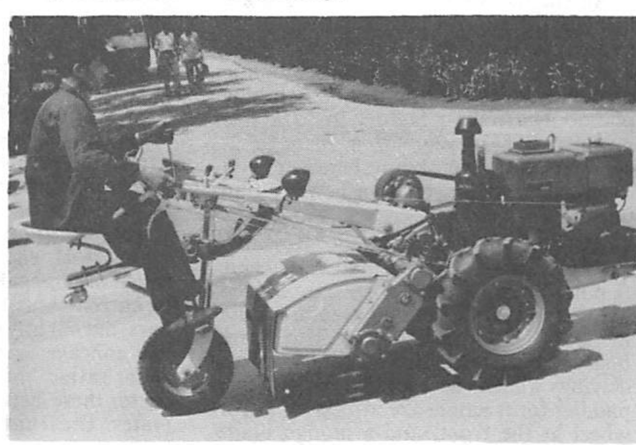


Fig 1 Two-wheel tractor

Figures published for 1978 showed

	In use	*1978 production*
Walking tractors	Nearly 1.5 million	Over 300,000
Larger tractors	About 0.5 million	Over 100,000
Engines (for irrigation etc)	About 65 million hp	Over 250,000 hp
Combine harvesters	About 20 thousand	About 4,000

There are claimed to be 2700 plants engaged on repair, with some manufacturing, and another half-million workshops on the farms.

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In the early years of the present regime, say 1950-1960, tractor design and production was based on Soviet assistance and designs. One such factory, the Dongfanghong ("The East is Red") works at Luoyang in east-central China, is now the largest tractor factory.

Described by one western executive as "an absolute mess, productivity was abysmal", it nevertheless produces over 22,000/year of a 75 hp crawler tractor, evidently one of the original Soviet designs. This has a four-cylinder diesel engine built in Beijing, but almost everything else is made on the spot. It is used for all types of field work. Another Luoyang model in quantity production is a 4-wheel 40 hp one with 3-point linkage and hydraulic draft control, obviously based on the original Ferguson ideas.

This brings us to the "Feng Shou (Rich Harvest) 35" tractor, produced at the rate of 8500/year at a Shanghai factory. Apart from its engine, it is a copy of the MF 35 tractor, some 2000 of which were sold a to China around 1960.

The Feng Shou 35 has been offered for sale at the Canton Trade Fair, but not, as far as I know, exported in any quantity. Ploughs, cultivators and a planter, at least are available for attachment to it, also a combine harvester (see below).

Another tractor commonly seen on the roads, built in a Russian-assisted plant in Tientsin, is reminiscent of the "Farmall" models of the 1950's. It has been offered for export as the TN-55. For highway work it frequently draws a 4-wheel trailer and has an air compressor for the breaking system.

A factory in Chanchun, now operated as part of Jilin University of Technology, produces a 4-wheel tractor, with a 2-cylinder 28 hp, diesel engine. It too has 3-point hitch, and adjustable wheels for row-crop work.

All the factories so far mentioned are located in Eastern China, relatively close to the sea coast, but 2000 miles to the west, the city of Urumchi, in Sinjiang province, has both tractor and combine plants. The tractor factory in 1978 was producing 1350/year of a massive 2-cylinder 28 hp tractor, but there were said to be plans to convert to a newer 50 hp one.

At the National Tractor Research Institute in Luoyang, and elsewhere (Chou Yong-Chuan 1979) research is being conducted on a small tractor for use in flooded rice fields (fig 2). This has a boat-shaped "hull" for flotation, and two driving wheels at the rear with large paddles for traction. Steering is by castor wheel at the front, and a plough blade may be mounted on a linkage at the rear.

These are only a few of the tractor types produced in China: indeed the multiplicity of models and consequent lack of standardisation have been the subject of criticism and concern.

Engines

The principal engine plant appears to be in Beijing, with a production of around 50,000 four-cylinder units per year. Luoyang and Shanghai are also producers, the latter being the Ministry's ICE Research Institute. The hopper-

Fig 2 Boat tractor for rice field working

cooled engines used in the 2-wheel tractors are equally suitable for stationary use, and consequently are in production all over the country, including Sinjiang.

Combines

Production in 1978 ranged from old-fashioned pull-types, plainly dating from the days of Russian assistance and in turn reminiscent of North American models of the 1930's, to relatively modern designs.

The old-style machine was seen in production in two plants, Kaifeng in East-Central China, and Urumchi in the far West. The Kaifeng factory, evidently a well-run concern, produced 1000 or more per year of a version with its own 75 hp diesel engine. The Urumchi model was pto type. Like their western forerunners, both combines carry an operating crew, of up to four men, this feature being continued in a more modern Urumchi model.

The author and his colleagues had the privilege of visiting two well-equipped factories in the north-eastern provinces which produce self-propelled combines.

The "East Wind" model, built in Siping at 1000/year, takes a header of 3 m width, with hydraulic lift and a spring-balanced tilting arrangement to compensate for irregular terrain. Like most Chinese combines, it uses a pick-up type feathering reel.

The threshing cylinder has a width of 1.2 m, with eight rasp bars of material rolled in Shangahi. These are very similar to current Massey-Ferguson production bars, but slightly smaller. The nine bars of the concave were seen to have milled slots, rather than drilled holes, for the wires, these being held down by keeper plates. The front six keepers had serrated faces like the rasp bars, thus giving a serrated surface like some Australian concaves.

Variable-speed belt drive to the cylinder, straw walkers, and cleaning apparatus are conventional.

The engine is basically the same Peking 4-cylinder diesel unit as used in the tractors, but the arrangement of drives is unusual in that while the cylinder drives comes from the normal "rear" end of the crank-shaft, the ground drive, also by V/S belt, is fitted to the "front" end.

Power is conveyed to a 3-speed-and-reverse gearbox, thence to planetary reduction gears in the wheel hubs, the drive shafts being inside the tubular axle.

A Russian-style straw compactor occupies the rear of the walker body.

The town of Jiamusi in the extreme north-east of China has three or more farm machinery plants. The biggest is the combine harvester factory, where they build a combine called the "Feng Shou" (like the tractor) of Chinese design and considered by some as China's most modern design (fig 3). Yearly production, which takes place from May-September, was reported as 500, from a well-run plant with potential for expansion.

Like the Siping combine, the Feng Shou uses the Peking engine, with drives from both ends of the crankshaft, gearbox and axle also being similar. Like some German combines, it has a covered grain tank and slinger-type conveyor for the shoe tailings. The cylinder is 550 x 900 mm and its speed range is 575-1320 r/min.

The header width is 3.3 m. We received no mention of alternative headers of other widths being available, nor any arrangements for working in maize (ear corn).

The Feng Shou is the only Chinese combine seen with a cab. In the writer's observation it may be a doubtful asset, since it appeared to have neither heat nor sound insulation, and no air conditioner or clean air supply. On a cool day the cab temperature might be comfortable, but on a warm sunshiny day I would expect it to get uncomfortably hot and stuffy. Further, with all mechanisms running and no crop going through, the noise level is horrendous.

The same cylinder size is used in the "Beijing — 2.5" SP combine, designed jointly by the Research Institute and Beinjing Combine Factory, where it has been in production since 1975.

Many details of the Chinese combines looked familiar to myself and my M-F colleagues, and it would seem that both North American and European imports

Fig 3 Feng-Shou combine

have been used as models. Indeed various visitors to the Canton Trade Fair in 1972 saw a combine exhibited that was clearly a copy of the M-F 510 (Watts 1972) but nothing has been heard of this since. Imitation, men say, is the sincerest form of flattery!

Almost unique to China, and of more than passing interest, is a tractor-mounted combine built near Guangzhou and principally, if not wholly, used for rice harvesting. Two varieties exist, one for mounting on the 35 hp wheel tractor, another to suit the old crawler (fig 4) Crop cut by a header about 2.5 m wide is carried into a raddle-chain conveyor on the left side of the tractor, where it is fed tangentially into an axial-flow threshing and separating cylinder mounted transversely behind the driver, and quite high up. The cylinder is believed to have helically-arranged rows of peg teeth, and the cover has helical internal ribs to promote axial movement of the crop. A threshing-and-separating unit, in fact, reminiscent of that developed by the International Rice Research Institute in the Philippines (McMennamy 1977). Straw is ejected rearward; the separate crop falls to a cleaning unit, and grain goes to a bagger.

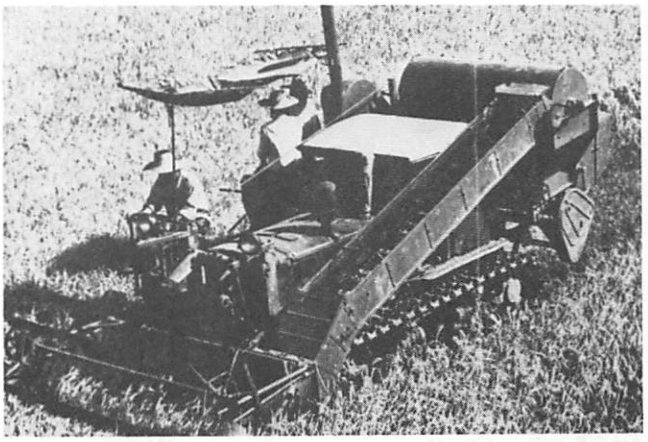

Fig 4 Tractor-mounted rice combine

Other harvesting machinery

The Jiamusi combine factory, when not building combines, produces a portable threshing machine at a volume of 1000/year. It is a neatly-designed all-steel machine, of particular interest in that it incorporates tandem threshing cylinders, like some Russian combines. Such units have been the subject of laboratory research at the Beijing Institute (Gao Yan-An, 1979). Sheaves, hand-loaded on to a conveyor, are transported to the first cylinder and concave unit, which is of peg-tooth type. Non-separated crop then flows to a second cylinder of rasp-bar type and subsequently to straw walkers.

Good threshing and separation performance have been obtained, particularly in the moist crops characteristic of North China.

A somewhat similar thresher was seen in production, at the rate of 200/year, at the "Red Star" commune near Peking. Most agricultural communes have some industrial activity, and such plants probably form a significant proportion of the 1600 figure given.

Agricultural conditions in north-east China are recognised by both Chinese and outside observers as being similar in many respects to Western Canada. There the swathing of cereal crops is standard practice, having several advantages over straight combining, and it was no surprise to find a swather in 1000/year production at Jiamusi Harvester Works. However, this was a very different proposition from the light, fast, highly manoeuvrable machines of the Canadian west, being built for front-mounting on the old Russian crawler tractor.

It had hydraulic lift for the header, but visibility of the cutter bar from the driver's seat would be very poor, even though a line of sight might be possible through the crop discharge opening on the left side. The height of the metal-bat-type reel was adjustable, but not during operation. One would give the design high marks, however, for a very neat arc-welded frame, thoughtfully composed of standard steel sections, including square tubing and special pressings.

Like the combines, all or most of the bearings require regular greasing, and the knife drive included an open scotch yoke mechanism which, being close to the ground, might be expected to wear quickly.

A harvesting scene from Shandong province shows a light tractor-mounted swather of about 2 m cut, delivering to the right. There being in the background a small army at work hand-tying sheaves, recalls the fact that we never saw or heard of pick-up attachments for the Chinese combines. Such scenes showing modern powered machines operating side-by-side with large gangs of hand workers are not uncommon in China, and illustrate the mixture of technological levels which typifies their crop-raising business.

The third Jaimusi factory we visited was then producing disc harrows, but had on display a pull-behind, whole-plant maize harvester, surely a quite unique machine? It too is designed for use with the crawler tractor, with pto drive. It takes two rows of plants, spaced 70 cm apart, cutting them off at the base, and transfers them to snapping rolls to remove the ears. The stalks then pass to a packing platform, whence they are ejected in piles for collection and use as fuel and other purposes. The ears pass over a husking bed and thence by conveyor into a trailer.

A great deal of rice is still harvested by hand, and threshed by portable drums, against which handfuls of stalks are held. Portable electric fans assist winnowing: a respectable heritage here, for the Chinese actually invented a fan-operated winnower as far back as the Han Dynasty (206BC-221AD). By the 15th century the fan principle had reached Europe (Quick, 1978).

Hay and forage harvesting

I believe it is correct to say of China that, compared to tractors and grain harvesting machinery, the level of interest in hay equipment has been far lower. This was true of the 1978 Exhibition, of statements made by the Chinese, and of the amount of information picked up, formally or informally. Correspondingly, the level of technology would seem to be lower. A 1976 hay harvesting scene shows again two old horse-type mowers being pulled by a tractor, with a horse-drawn mower and rake in the background, and hay being hand forked (Cowley 1976). There are no reports of balers seen around the country.

Jiamusi Harvester Factory showed us a forage cutter-blower, but no details are available.

Soil preparation

Various types of ploughs, tractor-mounted or drawn by tractor or animal power, may be seen, and are presumably built in a multiplicity of smaller-scale plants. Cultivation is also done by hand or animal-powered methods, again probably with locally-produced implements. A commune near Peking, for instance, was seen mass-producing forks, rakes and hoes. On the other hand No 2 Agricultural Machinery Works at Jiamusi produces disc harrows at 6-8000/year, including making the spherical disc blades on a continuous flow pressing and heat-treating line. To us the design of the implement was rather old-fashioned, and it had no form of lift for transport.

Seeding and planting

The Harbin Agricultural Machinery Factory produces in quantity a grain-and-fertiliser drill, no doubt destined for the wide fields of the north east. In the south the great crop is rice, and a variety of special machinery is in course of production or development, including the boat-tractor and tractor-mounted combines mentioned above.

Factories and research establishments in several centres, particularly in the Shanghai and Guangzhou (Canton) areas are engaged in research and production of implements for pulling and transplanting rice seedlings (fig 5). With up to three croppings per year, time is vital, and the benefits of mechanisation in rapidity of operation, uniform planting, and lowering of grain waste, are well recognised.

Research and development

All three levels of government in China — national, provincial, and municipal — run research establishments. In 1978 the

Fig 5 Rice transplanter

First Ministry of Machine Building operated a central Research Institute, divided into nine research units. Seven of these were located at an establishment on the northern outskirts of Beijing, for research on all types of implements, (including harvesters) materials, irrigation and drainage, livestock and poultry equipment, hydraulics and instrumentation, machinery testing, and information storage and publishing. The laboratories were observed to be well equipped, but under-utilised in the view of more than one observer.

The other two units were the ICE Research Institute in Shanghai and the Tractor Research Institute in Luoyang.

The whole institute employs about 1000 people. It also maintains liaison with the Provincial Research Institutes, such as those of Guangdong, and Hebei (Chou 1979) and the municipal ones; at Shanghai, for example. My personal impression is that a great deal of country-wide co-ordination and information exchange takes place between research, development, and production units. Standards exist, and draftsmen at Jiamusi Combine Factory were seen to be using a very comprehensive handbook of machine design.

Quality control, however, remains a major problem, with many criticisms voiced in the press and elsewhere, and no less a person than the Minister of Machine Building is on record as apologising for the poor quality of products. The reasons are manifold and complex, and even more complicated is the whole question of the directions into which the planners should guide the development of agricultural methods and equipment.

Acknowledgements

For the preparation of this paper I acknowledge with many thanks the assistance of my colleagues within Massey-Ferguson Ltd; also the co-operation of Mr James Basselman of the ASAE and of Gary Owens of *Implement and Tractor* magazine for supplying most of the illustrations.

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Crop drying and storage specialist group

THE inaugural meeting of the Crop Drying and Storage Specialist Group, which is the first of its type within the Institution, was held in Edinburgh on Tuesday 21 October 1980, and attended by some 35 people.

After a welcoming introduction by the Institution President, Mr J C Turner, who took the chair at the opening of the meeting, an election was held to determine the committee of the Group. Mr Peter Bailey, of SIAE, was unanimously voted chairman with Dr M E Nellist of NIAE, as secretary. Three committee members: Messrs D Greig (Newcastle University), R R Morrison (East of Scotland College) and B C Stenning (NCAE) were elected.

The aims of the Group were agreed as follows:

a) To provide an opportunity for discussion and interchange of technical information and new techniques of crop drying and storage.
b) To provide a forum for discussion at a more specialised level than would be appropriate at branch or national meetings.
c) To promote the greater adoption and understanding of modern drying and storage technology.
d) To maintain, by these activities appropriately publicised, the status of the Institution as a professional body affiliated to the CEI.

The technical aspect of the meeting comprised a discussion on the thermodynamics of low temperature drying which was initiated by Mr W J "Bill" Lamond of SIAE:—

Grain is normally dried by blowing conditioned air through a bed of the moist crop. The energy required for drying is usually regarded as being wholly provided by the "artificial" heating applied to air, or by the energy naturally contained within the ambient air. But is there a useful and usable energy component which is provided by the pressuring of the air by the fan, which in agricultural driers is usually sited upstream of the grain bed? This question was answered convincingly by Mr Lamond.

The answer, "No", is encouraging to some observers but disappointing to others. The encouragement arises from the fact that those who theorise on the operation of driers habitually neglect this factor. The disappointment is that the intuitive feeling that pressurised air has some inherent "drying potential" is false — at least under the conditions normally experienced in agricultural driers, and nothing is to be gained by "over fanning" a drier.

The next meeting of the group is scheduled for 19 February 1981, at the National Agricultural Centre. This will be an evening meeting, following the "Grain 81" demonstration; and the topic — "The Measurement of Moisture Content".

Book review

Applied Soil Physics

THIS book covers the basics of soil physics in a clear and readable way, which while not ignoring the mathematics of the subject, does not allow it to overwhelm the text.

Two-thirds of the book deal with soil water, covering the basic definitions and the importance of soil water potential, and brings these together to describe soil water flow. Soil/plant atmosphere and soil heat flow are covered in the remaining third.

There are several existing books covering this subject, but unlike many of these, the authors have made the useful addition of including many worked examples which very adequately illustrate the text and help the reader in understanding concepts. The authors consider this aspect important enough to include an index to all the worked examples.

Each chapter ends with a number of problems for each of which five possible answers are given. Unfortunately the reader has no check as to the correctness of his choice.

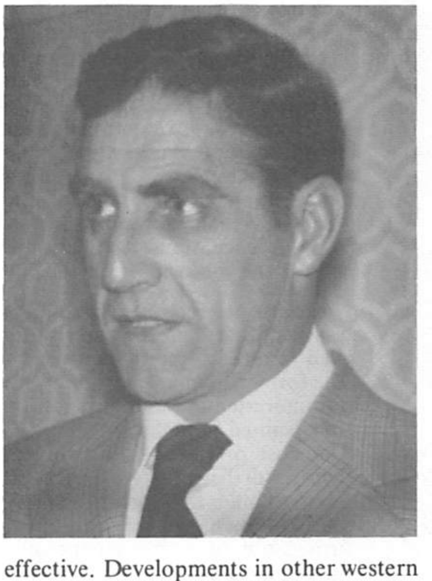
In 144 pages it is inevitable that many points will be omitted. Particularly missed is some discussion on swelling soils and on the aspects of applying the concepts to practical situations.

This book is clearly aimed at the student and is geared towards an introductory course in the subject.

Applied Soil Physics by R J Hanks and G L Ashcroft. (Advanced Series in Agricultural Sciences Vol 8). Published by Springer-Verlag, Berlin. Cloth DM39.50 (approx. £10.50). P B L-H

Low value intermediate technology machinery: should we export hardware or know-how?

A R Stokes



Summary

EXAMPLES are presented of the difficulties faced by a small UK company in pioneering the introduction of low-cost agricultural equipment for sale in emerging countries, mainly within the tropics. A selection of mainly animal-draught implements was designed, developed, tested overseas and sold in 70 countries. Initially, sub-contractors were used to manufacture the implements, but in 1974 the company commenced manufacture at its own works in Shropshire.

A resurgence of interest in horse-drawn implements in developed countries since the late 1970s has resulted in designs built for maximum efficiency.

Experience with a package deal scheme, to facilitate the production overseas of the company's designs is described, and preparations for the changing pattern of supplies of animal-draught equipment to Africa are outlined.

THE problems of designing suitable equipment to meet the needs of small farmers in developing countries is one which has exercised the minds of many individuals and organisations in the last two decades. Several items of equipment have been designed in the UK and some have been marketed commercially, but few have passed the acid test of: "Will the farmer put down his own money to buy it?".

The writer, having had first-hand experience of the problems of the peasant farmer in Africa, and having been frustrated in his attempts to have improved implements manufactured locally, resigned from Government service in Northern Nigeria in 1962 and a little later formed a design, development and sales company, specialising in implements for tropical agriculture.

Initially, implements were to be built by contractors, or by other companies under licence.

A number of animal draught items was designed, built in small numbers, and shipped to various parts of Africa, and several overseas trips were made to test the implements in their intended environment. Fortunately for the finances of the company, one of these trips resulted in an order for 700 examples of one implement and this immediately brought into focus the question of bulk supplies of wearing parts.

As production of horse-drawn tools had virtually ceased in the UK shortly after the 1939-45 war, there was no source of plough bodies, ridger bodies, suitable spring tines, hoe blades or points available from the specialist UK wearing-parts manufacturers. In cases where it was not possible to incorporate items from current equipment, new tooling had to be paid for and minimum quantities of at least 2000 had to be purchased.

Having tied up scarce capital and acquired considerable stocks of wearing parts, the need for further sales became urgent. One of the problems was how to bring the product to the attention of the peasant farmer. The usual commercial outlet in tropical countries then was the hardware department of a large import/export company, which dealt in thousands of different items and did not have the trained staff or the inclination to carry out field demonstrations and farmer training. An example of the implement was placed on the forecourt, and if farmers brought money to buy it, then by their standards, it was successful.

Being handled by the hardware department instead of the technical department meant that the product most favoured by the manager was the single-purpose plough or ridger, preferably with no detachable items which could be lost or pilfered, and bought at the lowest possible price so that a substantial mark-up could be achieved. Newspaper advertising or the distribution of glossy leaflets were of little value, as the majority of peasant farmers were illiterate.

The above factors militate against the commercial introduction of the more cost-effective multi-purpose implement, which tends to be recommended by research stations and expatriate experts, but which must be accompanied by a degree of farmer instruction, to be fully effective. Developments in other western countries, notably France, have shown a similar pattern, with designers concentrating on multi-purpose implements, to varying degrees of sophistication, while bulk exports tended to be of single-purpose ploughs.

In recent years, the emphasis has changed. As oil prices continue to increase, the oil-less countries of the developing world are becoming less capable of purchasing such equipment from their own resources. Bulk supplies, nowadays, are increasingly financed by outside resources, such as the EEC, voluntary aid agencies, and individual Governmental aid programmes. This means that the opportunities open to overseas commercial suppliers, selling to farmers through trade outlets, are very much less than they were. Such manufacturers, if they have no home market, are now largely at the mercy of their Governments regarding the placing of bulk orders. Thus the attitudes of the advisers to those Governments, as to whether they think it appropriate that this type of equipment should continue to be supplied from developed countries, may be crucial to their survival. One school of thought in this country is that such equipment should be manufactured in the country of need, and indeed this is already happening to some extent, with varying degrees of success.

There is no doubt that an entrepreneur

A R Stokes is managing director of Project Equipment Limited.

domiciled in such a country is in a strong position if he expressed interest in starting such a business. He can call on the resources of a number of national and international agencies who can provide experts to evaluate the feasibility of the project, design the project, and provide day-to-day supervision, with a resident adviser, in the early stages. In addition to this, funds are usually available in the form of loans or grants from the Government, and when production begins, barriers are often erected to keep out imports.

One country where this process was carried out entirely by a British-based commercial organisation, is Northern Nigeria where, in the late 1960's, a factory was set up to build the Emcot ridger, an implement which had been imported for many years from the UK. Designed originally to meet the requirements of the Empire Cotton Corporation, this ridger had become the universal implement throughout the former British territories in West Africa. When Nigerian production began in 1968, and supplies from the UK ceased, it was assumed that the Nigerian factory would supply the needs of the West African Commonwealth territories, and of the neighbouring ex-French countries.

With minor exceptions, this has not happened for the following reasons:

1. Nigerian production of Emcots was insufficient in the early years even to meet domestic demand.
2. The former French territories were not interested in buying ridgers — they wanted ploughs!
3. The cost of transporting ridgers from Northern Nigeria several hundred miles to the coast, then by sea to Ghana or the Gambia, turned out to be more expensive than shipping the same tool from the UK.
4. The allocation of export licences for Emcots ex-Nigeria, were subject to long delays.

Luckily, the writer, having been associated with the Emcot project, had foreseen the need for a standby ridger, and in 1968 had designed a new ridger/plough, using a ridging body similar to the Emcot. The frame, however, was fabricated from RHS tubing, and built in a jig, so eliminating the difficulties of bending the Emcot main beam accurately. Samples of the new ridger were sent to the Gambia and Ghana in time for the 1969 season, and a favourable Gambian report was issued. Slight modifications were requested, and were incorporated in the production implement, although they raised the manufacturing cost appreciably.

An initial order was placed to test farmer reaction, and as this was favourable, a larger order was placed for the 1973 season. The basic implements were completed by the contract date, but the manufacturer of the bought-out ridging bodies could not meet his delivery promise because of the problems caused by the miners strike at that time. Bodies promised at nine weeks from order were eventually supplied after 24 months had elapsed. Obviously, this caused tremendous difficulties to the Gambian Department of Agriculture, who declined to order further supplies.

A trial shipment was also sent to Ghana, and successfully sold, but a massive devaluation of the currency in that country closed the door on further imports on a commercial basis, although UK religious organisations have since financed ridger imports.

After the problems of the Gambia ridgers, two decisions were taken:

1. To avoid being let down again, provision would be made for in-house manufacture of as many wearing parts as possible, and this was achieved by fabricating press tools using a pair of genuine parts as the basis of the formers. This meant that tooling could be made cheaply and quickly and this IT method has since proved very satisfactory. Blanks are profile cut from high carbon steel sheet, heated by forge, then pressed to shape in a heavy duty flypress. Bolt holes are drilled, and the completed part is sent out for heat treatment.
2. A package deal scheme was devised to facilitate manufacture of the various designs in the country of need (Appendix I).

The structure of the package deal had been arrived at after consulting other companies as to the difficulties they had experienced in remitting royalties and/or profits from developing countries. The information obtained was not encouraging, so the final scheme required a once-and-for-all payment in advance, with no provision for subsequent royalties or commission payments.

Although no publicity had been given to the scheme, the word quickly got around, and to date 57 enquiries had been received, most of them from private individuals wanting to start their own enterprises. However, the requirement of payment in advance eliminated 90% of the applicants as the exchange control regulations in force in most Asian countries, where the majority of the enquiries originated, make it impossible to remit funds ahead of the receipt of hardware, and to import hardware requires a licence, which if obtainable at all, takes months or years to be granted.

Of the schemes that have reached fruition, only one has been straightforward — the others have required a number of devious means of circumventing financial restrictions, and for this reason, further details cannot be given.

There is no doubt that this scheme is effective in setting production going quickly, especially if all materials are supplied to manufacture a set of number of implements, (say 100) (see Package 3).

While this quantity is being assembled and introduced to farmers, further raw material supply sources can be investigated, orders placed, and initial reactions from early customers assessed, which assists in deciding future production quantities. Alternatively, if there is some doubt that a market exists at all, then the No 3 scheme is ideal, as a trial marketinggv exercise, in as much as the total cost is known ex-UK and if a local contractor is used to fabricate the implements from materials supplied, then his quotation is also a known figure, and no open-ended commitments need to be entered into with regard to buildings and machinery etc.

When first planned, it was envisaged that this scheme would be ideal for UN and Governmental aid programmes, charitable and missionary organisations and certain foundations. In theory, the attraction of paying out a modest, known sum of money, having none of the organisational headaches, and then being able to take the credit, should be ideal.

In fact, none of the above have shown the slightest interest — the purchasers have all been commercial organisations, entrepreneurs, and one University.

Conclusion

There is no doubt that the future will see an increase in the number of countries manufacturing their own animal draught implements, even though the design of those implements may not be indigenous. The package deal will have a role to play in this.

Supplies to those countries not making their own will be increasingly financed by aid funds from various sources, which means that the manufacturers of such equipment must be in a position to supply large numbers in a relatively short time. For this reason, licensed manufacture of some designs has been arranged with a medium-sized UK manufacturer having good production facilities and good overseas connections, while we will continue to supply small quantities for overseas markets and will build up the growing UK market.

There is no doubt that the complex problems associated with the provision of this type of equipment, ie the erratic ordering patterns, the lack of continuity in demand, the uncertainty among African decision-makers of what constitutes mechanisation in their countries, and the frequent changes in the policy of those governments due to political events, all contribute to making life very difficult for suppliers. The high failure rate of UK companies formed to supply such markets is evidence of this.

In the writer's opinion, a small company, with its lower overheads and ability to produce or modify a design virtually overnight, but with the back-up of a big company able to produce the occasional large order quickly, is the right formula for success in the inflationary 80s, and if the 20 years experience of this company can be made available to assist further the setting-up of local manufacturing units overseas, then the results could be mutually beneficial.

Appendix I

The package deal scheme provides technology transfer, a sample implement, samples of components, basic jigs and tools and if required, materials for an initial production run of implements.

The range of animal-drawn equipment has been designed expressly for use and production in emergent countries.

Our experience of marketing low-cost equipment to more than 70 developing countries, and the findings of other interested organisations working in this field indicated that a local production unit must be designed to cater for limited areas only. The reasons for this are the fact that ethnic and social structures, soil conditions, transport and communication difficulties vary so greatly that it is only possible to efficiently serve an area of approximately 50 miles radius from a distribution point.

There are advantages to the proprietor or manager of a small production unit as the establishment and running costs are very much less than those of a factory intended to serve a whole country. He is also in a better position to provide demonstrations, service, training and advice to local farmers without incurring the disproportionate travelling costs which country-wide coverage entails.

There is no need in the early stages to provide expensive sales literature etc. as communications by word of mouth would be the only effective method among many illiterate peoples. There is however no reason why an efficiently run scheme should not grow to become a basis for a country-wide agricultural engineering industry.

It is envisaged that this scheme would appeal not only to private entrepreneurs, but also to international, governmental and private aid agencies. The larger Mission Stations too would be ideally suited to operate such an enterprise, as many already have excellent but under-employed workshop facilities, often with expatriate engineers in charge of them.

Packages No 1, 2 and 3 would suit variations of this situation, whereas No. 4 is envisaged as a possible gift package by a charitable organisation, to a large co-operative for instance, as an investment in his people by a tribal head or chief, or perhaps part of a governmental or local authority rural development programme.

As the workshop facilities required to produce this range of tools are all general-purpose items, other work could be undertaken in a possible slack period.

Multi-purpose tool used for ploughing

Initially, supplies of wearing parts used on the implements could come from the UK possibly on a seasonal basis, but later on, if demand justifies it, the specialised plant required, ie heavy presses and heat treatment tanks, could be installed locally.

As an example of how this scheme works, Appendix II details the various 'packages' for the production of a simple animal drawn, multi-purpose tool. This can be used either as a mouldboard plough, or with a range of sweeps, tines or a rotary puddler for secondary cultivation or weeding.

Appendix II

Package No 1

For the larger establishments with a comprehensive workshop and a skilled engineer able to work from drawings.

1. Provision of one sample tool with all fittings and attachments for full field evaluation and demonstrations.
2. Provision of a full set of working drawings, materials schedule, machining procedures, assembly sequences etc.
3. Provision of a full set of all parts (unassembled) for jig-making and pattern purposes.
4. Provision of a full set of assembly jigs.

Delivery: 6 months from order.
Typical cost — about £5000.

Package No 2

For the new workshop with an engineer of moderate ability

As for No 1, but with the addition of one of each of all workshop machines required for the manufacture, excluding wearing parts, of the chosen implement, (requires only building and power source i.e. electricity or engine-driven shafting). Wearing parts to be supplied ex UK.

Delivery: 12-18 months.
Typical cost — about £18000.

Package No 3

As for No 1 and 2, but with the addition of raw materials to build 100 implements. Wearing parts to be supplied at extra cost.

Delivery: time schedule to be agreed.
Typical cost — about £22000.

Package No 4

As for No 1, 2 and 3, but with the addition of the specialised machinery necessary to produce all the wearing parts locally. Because of the escalating costs of the heavy machinery required, a quotation for this scheme would be subject to negotation regarding time scale and price.

Multi-purpose tool showing range of bolt-on attachments

Agricultural machinery manufacture in developing countries: the potential contribution to agricultural and industrial development

F M Inns

Summary

THE paper considers the development process involving the movement of labour from the agricultural to the non-agricultural sector. The increase in agricultural productivity to sustain this movement is quite modest in the early stages. The development process is best served by modest increases in production from many small-holder farms rather than attempted large increases from relatively few large-farm projects.

The equipment to be considered for broadly based productivity increases will include animal draught implements, small tractors and related machinery. Design must be well researched to meet agricultural needs, which are often ill-defined and insufficiently considered, and to make use of materials, processes and techniques which will encourage parallel broad-based industrial development.

Various infrastructural problems are considered together with desirable agricultural, industrial and commerical developments.

The development background

LOCAL manufacture of machinery inputs to agricultural production is a natural step in the development process. Structural transformation in a developing economy is marked by a transfer of human resources (labour and skills) from the agricultural (rural) sector to the non-agricultural (mainly urban) sector which includes workers in industry, services and government. Local manufacture of machinery represents a component of development within both agriculture and industry and should be compatible with development of both sectors.

The distribution of labour between agricultural and non-agricultural sectors is often used as an indicator of the stage of development within a country. In many developing countries the proportion of workers in the agricultural sector is greater than 80%. The rate of decrease with development is likely to be modest. Japan probably holds the record for fast and sustained development. Over the 80 years from 1880 to 1960 the agricultural population in Japan decreased from about 80% to 38% of the total population. The rate of decrease was approximately linear and averaged about 12½% per generation (20 years). Over the same period Britain averaged 3½% decrease per generation.

An optimistic view of the rate of transfer of labour in most developing countries might be 10% per generation. By the year 2050 the agricultural sector might decline from about 85% to 50% representing a reasonably advanced stage of development (Germany about 1880, Japan about 1930).

The average rate of increase of food production required from each family in the agricultural sector to sustain this development is very modest amounting to less than 1% each year. Large annual increases in productivity only became necessary at a later stage of growth as indicated in fig 1.

The required average increase in agricultural productivity can be met, at the extremes, by a large increase of productivity from a small number of workers or a small increase in productivity spread over the whole rural population. The former method is often used with the intention of building upon the impressive record of existing elite producers, typified in many developing countries by settlers or expatriate farmers. Such elite producers may be favoured by:

- superior technical and management ability as a result of education, experience and background
- possession of good land
- adequate climatic conditions
- access to capital
- well developed marketing arrangements
- effective support services such as for repair and manufacture of equipment, supply of spares, recording and accounting
- export potential and access to foreign exchange and investment.

In contrast the non-favoured rural producer lacks many, most or all of these facilities.

Many governments have found it expedient in the short term to encourage elite producers in preference to rural producers. Often this is done by setting up large parastatal or co-operative farming enterprises in the expectation that intensive management and investment will bring quick results. In many cases expected production has not materialised and even when successful the rural community itself has derived few direct benefits as far as improvements in its agricultural technology are concerned. Rather it has suffered from competition by the favoured producers

Many organisations are now seeking to support "grass roots" projects having a real impact on the rural community. Such projects aim at providing improvements to agricultural and food production technology to benefit large numbers of the rural community. Technical and administrative staff and aid organisations often have to reorientate their thinking to a philosophy and techniques which may be contrary to much of their training making if difficult for them to identify with the outlook and needs of the rural worker.

Parallel considerations apply in the industrial sector and have led to the concept of "appropriate technology" (or "intermediate technology"). It is impossible to define appropriate technology in absolute terms since the definition will very according to the viewpoint of the individual or organisation concerned. Thus capital — intensive technology might be

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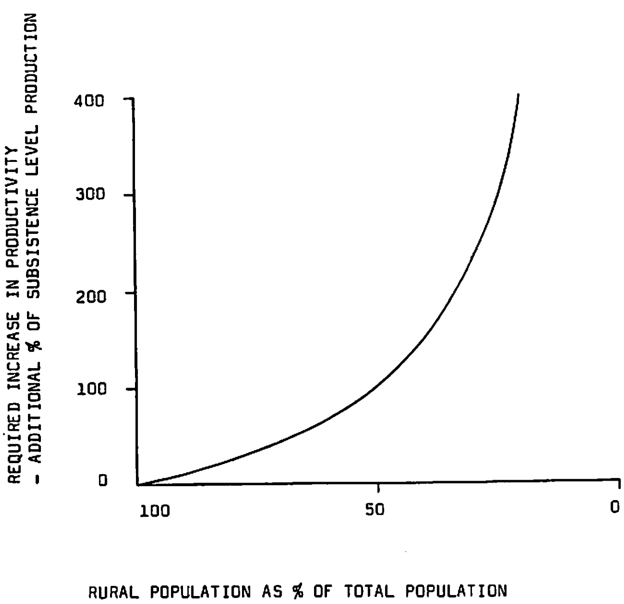


Fig 1 Average increase in productivity required from rural food production units (mostly families) to sustain development growth without importation of foodstuffs

appropriate to an entrepreneur wishing to maximise his profits but inappropriate to a group of workers who will lose their employment when labour-saving machines are introduced. Taking a national viewpoint appropriate technology might be suitably defined as that technology which makes minimal demands on scarce resources and spreads development throughout the work force and regions of the country.

Developing countries must use the following scarce resources to maximum effect:

- — foreign exchange
- — high level technical and commerical management staff
- — technically skilled operators
- — manufactured raw materials to sophisticated specifications
- — energy
- — transport.

Shortfalls in these resources are often circumvented through aid and development projects which supply the deficiencies from external sources, usually on a short-term basis. Better solutions would be to build up local resources to meet these deficiencies and/or initiate projects designed to operate effectively within the existing limitations. Manufacture of farm machinery is well able to contribute to development of an appropriate technology based on the definition and considerations mentioned above, provided that development is not strangled by competition from imported technology having an unjustifiably favoured status.

Machinery needs for the development of rural agriculture

The conditions in which the rural operator has to work are often the complete antithesis of those mentioned above for the favoured producer. It would be surprising if his machinery needs coincided. The following factors must be considered.

Marketing An over-riding factor which can completely stultify development is the flow of inputs and outputs for the agricultural production system. An inadequate marketing system for the farmer's crops makes it worthless for him to produce more, a fact which he recognises instinctively. In the early stages of development use of a machine must be justified by increased output of a saleable product. An effective marketing system is a priority need for agricultural development.

Power supplies Crop yield is strongly correlated with available power. This is shown in fig 2 (Giles, 1975). A power input of about 0.4 kW/ha is usual to enable a viable commercial yield, taken as about 2.5 t/ha, to be achieve. Higher levels of power input which are not accompanied by corresponding increases of yield are not likely to be economically viable.

There are only three feasible power sources to provide mechanical work inputs to field machinery, viz human labour, animal power and the internal combustion engine. Human labour (one family) can provide adequate power on only about one hectare of land. Together with a pair of draught oxen the power available should enable three to four hectares to be cultivated. The power of one tractor must be spread over a much greater area to obtain reasonable economic effectiveness — about 40 ha for a small (15 kW) tractor to 140 ha for a medium power (55 kW) tractor. Taking seven to eight hectare as a representative farm size the corresponding numbers of farms are about 5 for a small tractor and 20 for the medium tractor. Problems of organisation and management escalate enormously when equipment has to be used effectively on an increasing number of farms. In these circumstances a small tractor will provide the best opportunity to make use of existing modest management skills and provide widest opportunities for individual managers to develop and demonstrate superior abilities.

Management Timeliness is the essence of effective power utilisation. Increased power inputs must be managed efficiently to improve timeliness in:

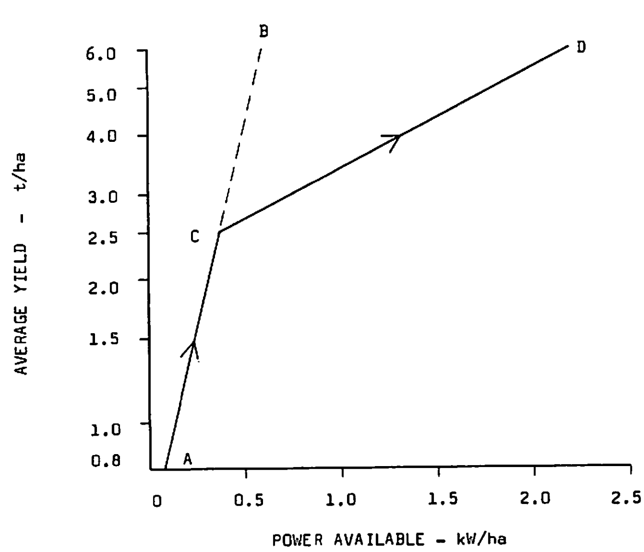
- — cultivation
- — planting
- — weeding
- — harvesting
- — transporting

Weeding is an operation which is particularly liable to be neglected, with disastrous results. One reason for this may be that machinery hire services and contractors are geared up to provide primary cultivation services which may be managed relatively easily compared to the organisation required to undertake a proper sequence of weeding operations on a large number of individual farms. The freedom for a farmer to plan and manage all operations on his own farm can only be achieved when he controls his own power and machinery units.

In many circumstances ownership of draught animals will enable the individual farmer to exercise and develop his own management skills. However, problems of animal health, traditions of

Fig 2 Relationship between average yield of major crops(1) and available power(2) for existing agricultural production.

(1) major crops = cereals, pulses, oil-seeds, sugar crops (raw sugar), potatoes, onions, tomatoes
(2) available power = human + animal + mechanical
(3) the trend is to move approximately along line AB (developing countries) or CD (developed countries) as shown by the arrows.



ownership, or land pressure, may inhibit the use of draught animals. Tractor use will then be necessary. The generally small size of rural farms dictates multi-farm use of these machines. Use of smaller rather than larger tractors is extremely desirable to ease management problems when used on a multiplicity of farms. Such machines are better suited to local design and manufacture.

Machinery needs The move towards comprehensive mechanisation of crop production systems should encourage review of machinery requirements. In the case of animal drawn equipment a toolbar with necessary attachments for cultivation, sowing, weeding and, where possible, harvesting is necessary for most systems aimed at achieving maximum productivity. Use of tined implements is also facilitated. The toolbar should have wheels with adequate load carrying capacity to permit fitting a cart body for transport of farming inputs and crops as well as for domestic use. Large capacity wheels will reduce rolling resistance on cultivated land and enable the operator to ride on the toolbar. The potential benefits of such an animal drawn toolbar should more than compensate for its relatively high cost.

Existing tractor-drawn machinery can often be faulted in the light of modern techniques and knowledge, particularly with regard to soil and moisture conservation and demand for high energy inputs. Implements such as mouldboard and disc ploughs have often been introduced and their use has spread to areas where other implements would be more suitable. This is particularly true where soil erosion is a hazard and where there is need to conserve moisture in areas of low or erratic rainfall. The local machinery manufacturer must take the opportunity to sit down and discuss cultivation machinery requirements with experts in agronomy and agricultural engineering.

Support services

Supply of spare parts is a notorious mechanisation problem in developing countries. Machinery importers attempt to relieve the disadvantage of long supply lines by applying sophisticated stock and inventory control systems. The local manufacturer has a potential advantage which he must pursue with vigour

It is widely accepted that mechanisation development requires comprehensive training for mechanics who will be concerned with machinery maintenance and repair. Training of operators it often neglected although it is every bit as essential. Local manufacture of machinery cannot prosper to its full extent if farmer training is neglected. The manufacturer must be prepared to accept responsibility for this training also if other facilities do not exist

Farmstead operations The effectiveness of post-harvest operations, particularly crop processing and storage, can greatly increase farm profitability. Electricity is the favoured power source where this is available. Alternatively hand labour or animal power can be used to operate threshers, winnowing and grading machines, grinders, oil presses and other equipment. Much of this machinery is well suited to local manufacture.

Irrigation Pumps and water control devices for irrigated farming are also suitable items for local manufacture, together with various water lifting devices, which can be human or animal powered.

Energy supplies Much effort has been put into developing energy converters for village use, particularly windmills and biogas generators. Watermills and water turbine coupled to electrical generators are also receiving attention. Such equipment will be suitable for local manufacture subject to its viability in the rural environment, which is a complex matter to assess.

Guidelines to local manufacture of agricultural machinery

Local production of farm machinery provides the opportunity to design machinery suited to the local farmers' needs and the infrastructure in which he has to operate. It will only be possible to take full advantage of this opportunity if the manufacturer is prepared to co-ordinate his activities with those of experienced specialists in machinery selection, operation and management, with marketing servicing and repair organisations and with training establishments.

Product specification Imported machinery is often not well chosen to meet the requirements for technical improvement in crop production systems to suit local needs, such as for soil and moisture conservation. The level of management required to use advanced and expensive mahcines is much underrated. Local manufacturers are in a good position to survey local requirements in conjunction with farmers and other experts in order to determine the most suitable machinery specifications to guide their design efforts. The product specification must be carefully formulated to define essential rather than ideal performance needs. It is unnecessarily costly to design to standards which are technically desirable in themselves but are not essential taking into account the overall operational environment.

Machine design The designer must put forward designs which make use of local materials and production skills as far as possible, whilst providing for steady evolution of materials and methods as industrial development proceeds. Imported machines have usually been designed in a different context and may be unsuitable for local production methods. It may then be necessary to import components, such as high grade castings and forgings, as high foreign exchange cost.

Local design must emphasise simplicity in achieving the essential performance specification. Components should be as simple to manufacture and as small in number as possible to ease the problem of supply of spares.

Spares and service Lack of spares is probably the most frustrating and economically damaging aspect of machinery use in developing countries compounded by their high cost when they do arrive. Bearing in mind the long supply lines involved there can only be limited scope for improving availability and reducing costs of imported spares even with the most sophisticated ordering and supply arrangements.

The supply of spares for machinery designed and produced locally in accordance with the procedures discussed above should be relatively easy to organise. Provided that locally available materials and production processes are used in their manufacture it would be possible to arrange for their production at a number of chosen centres in the country, or even as required in local repair shops.

Agricultural machinery manufacture as a component of industrial development

The rural farmer and his family need a number of machinery inputs which must be provided at low cost. These vary from farmstead machines such as threshers and winnowers which can be hand or pedal operated, through animal powered machinery to tractor operated equipment. These form a range of machinery of different degrees of complexity and requiring varying levels of skill for its construction and maintenance.

At farm and village level artisans will usually be available to contribute basic traditional skills, such as carpentry and blacksmithing, to local machinery production. Such skills are traditionally associated with the use of locally available materials. Less traditional skills, but still basic ones, are needed at high levels of production represented by small workshops. Fitters, welders and machinists can contribute in local workshops to construction of more advanced equipment such as carts, harrows, weeders and planters. Larger central workshops such as those manufacturing ploughs (and possibly tractors) need more specialist skills at an advanced level.

The range of skills and scales of enterprise represented in local machinery manufacture provide excellent opportunity for progressive development of both technical and managerial skills. This contrasts with much imported industrial development which uses advanced technology requiring a largely unskilled workforce with only a few highly skilled technicians and managers. Manufacture of locally designed machinery is essentially a broadly based industry.

In most developing countries agricultural machinery currently in use can be improved through a fundamental reappraisal of its purpose, function and deisgn. Engineers involved in this work will benefit by co-operating with other specialists and engaging in a thorough-going design activity which will develop their expertise and status. Reappraisal of machinery requirements along these lines might lead to the design and production of a tractor specifically suited to local agricultural needs, and generating national pride and prestige in consequence.

Local production of machinery, particularly tractors, will stimulate development of industries to supply raw materials, components and spare parts. Such contributing industries may be spread throughout the country to provide development which is broadly based in its products and geographical location. Service industries involved in distribution, maintenance repair and training should also respond to the need for development.

A local agricultural machinery manufacturing industry should demonstrate benefits to the nation's foreign exchange position by saving on import cost and possibly developing a regional export potential.

Undoubtedly local design and manufacture of machinery is beset by difficulties. In deciding to manufacture machinery locally, rather than import, one set of problems will be replaced by another. There is no reason to suppose that the new problems will be worse than the old ones, or take longer to solve. Certainly the benefits to be gained by overcoming them will be profound and lasting to the long-term benefit of the nation and its people.

Conclusions

1. Sound development of the rural sector may be encouraged best through modest increases in productivity from the largest possible numbers of small-farm producers rather then trying to achieve peak production from a small number of favoured producers.
2. As a first priority in achieving increased crop production every producer must have acess to an effective crop marketing system.
3. Crop production systems based on animal draught and small tractors as their power source provide opportunity to utilise, and encourage the development of, modest and scarce machinery management skills in rural areas.
4. Specification and design of tractors and machinery for local production must be based on local needs as determined by farmers, agronomists and agricultural, maintenance and production engineers. Machinery requirements may be guided by, but must not be determined by, historical usage or external experiences.
5. Assessment of machinery needs must take into account possible developments in cultural practices which might be facilitated by local manufacture of suitable machinery. One major objective of these developments should be timely completion of all operations particularly land preparation, sowing, weeding and harvesting.
6. Machinery and equipment for irrigation, crop processing and storage should be considered for local manufacture. Energy converters (windmills, water mills and turbines and biogas generators) should also be considered.
7. Machinery for local manufacture should be designed to make use of and develop available skills, materials and equipment and take account of infra-structural problems.
8. Local manufacture of machinery must be integrated with effective arrangements for distribution, operation and operational support. Training programmes to provide and develop necessary skills within the industrial, commercial and agricultural sectors are essential to overall success.

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Future priorities in developing agricultural machinery manufacturing capability in the developing countries

R D Bell

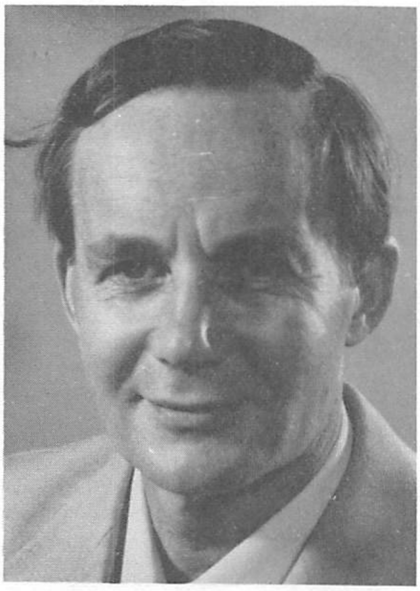
Summary

A HEALTHY agricultural machinery manufacturing industry can only exist in symbiosis with a healthy agricultural industry. Only that sector of farming which is above subsistence level provides any significant prospect for sales of agricultural machinery. Sales and use of machinery must be profitable for manufacturer, distributor and the farmer.

Finance is often a major problem, exacerbated by the seasonal demand for equipment and by the typically long delays in supply of materials and standard components required if the manufacturer is to respond to an active seasonal demand.

Some limited protection may be necessary against piracy of design but excessive protection is undesirable.

There may be need for official support by the provision of infrastructure, of training of staff, and establishment of standards for hardware and other common items.



IT must not be assumed that agricultural machinery manufacture in developing countries is, or will be, restricted to simple implements or machines, nor that high quality materials and processes will be unavailable.

Although developing countries may be characterised as having a low GNP, a high proportion of the population working in agriculture, and limited industrial manufacturing capacity, the countries differ markedly in the structure of agriculture and of their manufacturing industries. There are also wide differences in the education and skills of the available work force.

In many countries a significant sector of agriculture is in the hands of "business" farmers who produce cash crops (often for export). In other countries state farms or co-operatives play a major role. Even where legal limits on land holdings make individual ownership of large farms impossible, members of a family may group their holdings to operate as a large farm under a single manager. Thus not all the farms are small nor is appropriate equipment necessarily small.

In most developing countries labour is relatively cheap but in countries having oil or mineral wealth, or adjacent to rich countries, labour may be scarce and expensive.

From this brief introduction it can be seen that the farming conditions differ widely between different countries. Industrial capacity is just as diverse. Every country must therefore be considered separately. Generalised proposals can prove only a very poor guide to opportunities and to priorities.

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Manufacture for the home market

Most of the industrialised countries which export farm machinery had originally developed their industry on a firm home market basis. Now in the countries having little industry it is often suggested that the agricultural machinery industry might form the base on which to develop a general manufacturing industry. These suggestions have been based on the apparent simplicity of many agricultural implements and on the high transport costs resulting from their weight and bulk. Frequently the problems arising from the seasonal variations of demand, and of establishing a firm home market, have been underestimated. Some agencies have proposed that agricultural machinery should be produced by lalcom intensive methods in order to provide employment. The objective is laudable but for the industry to be healthy it must use the most efficient manufacturing methods. If the extra costs are incurred due to the use of labour intensive methods these must be met either by a subsidy or they must be passed on to the customer — and in fact constitute a tax on the farmer.

Enough attempts have been made to establish local industries either to supply a perceived 'need', or to replace imports for major priorities to become clear. These may be divided into:-

- Farmer requirements
- Dealer requirements
- Manufacturing requirements.

Farming requirements

(a) Agricultural production in the area must itself be profitable. An agricultural machinery industry dependent on a domestic market can only exist if farmers can obtain adequate yields and if they receive an adequate return for their crops.

(b) Agriculture must be dynamic. If agriculture is static in volume and in methods then the only market for agricultural machinery is in replacement of existing tools. Since in peasant cultivation most tools are simple and of low cost the prospect of developing a viable manufacturing industry is low.

(c) Other complementary inputs must be available: good seeds, fertilizer, water, fuel. Energy and machinery are now separate inputs but must be integral to the farming system. Timely availability of power may permit optimum use of fertilizer and

rainfall so that the potential of improved seeds may be realised. Often lack of farm power is *the* limiting input but the provision of power, by itself, will only realise a fraction of the farming potential, and other inputs must also increase if full production is to be realised.
(d) Markets must be capable of taking the farmers produce, and the farmer must have confidence in these markets if he is to invest capital for additional production.
(e) Credit. Farmers are frequently short of money both short term for crop production and longer term for equipment and stock purchase. Unless credit is available the farmer may be unable to purchase equipment even if convinced of its advantages.
(f) Extension training. Farmers need training and advice on the correct operation of their machinery in order that they may use it efficiently and profitably.
(g) Service facilities. The farmer must have confidence that if his machine breaks down at a critical season it can be speedily repaired. The higher the level of farming adopted, and the greater the inputs, the more is the risk of loss by the farmer. In many societies the peasant farmer is attuned more to risk aversion than to profit maximisation.

Dealers' requirements

Except where production volume is very small and located near to the point where the equipment is used, then the manufacturers will have to sell through dealers.

For dealers to have a real interest in continued sales of a product it is necessary:-
(a) For the dealer to make a satisfactory profit on each sale.
(b) For the work of each sale, and any subsequent service needs, not to be too onerous nor to interfere with other trading activities.
(c) For supplies to be available at seasonal optimum times, in order that turnover is fast and capital commitment is minimal.
(d) Credit for purchase of goods for sale may be essential if dealers are to carry stocks in readiness for the season.
(e) If service back-up is to be provided by the dealer than training of his staff will be necessary.
(f) Unless sales of farm machinery are only a part time occupation of the dealer he must have available a range of products which will provide sales throughout the year — or at least over a good part of the year.

Manufacturers' requirements

(a) First and foremost the manufacturer needs a product, or products, suited to the local conditions and for which a market exists or can be developed. Ideally the demand for the product(s) will be reasonably steady throughout the year.
(b) Material must be available of adequate quality and regularity of supply. If supplies are erratic so that large stocks must be carried, then the capital investment will be large and costs high.
(c) Foreign exchange must be available for import of materials and specialised components.
(d) Labour, especially skilled labour, must be available.
(e) Energy supplies must be reliable and of reasonable cost.
(f) Finance for investment and/or credit for production.
(g) Protection — Any manufacturer who invests in development needs some measure of protection against piracy — at least for a reasonable period. Where this protection is not inherent in the know-how of manufacture, then some legal protection may be desirable to protect developers from piracy of designs but excessive protection against imports of truly competitive products is undesirable and is likely to lead to stagnation of the industry.

The agricultural machinery industry can only thrive if it is profitable for manufacturer, dealer, and for the farmer. Reconciling the needs of each it can be seen that for the dealers and farmers it is relatively unimportant whether the equipment can be locally made or imported; the important factors are the availability of the equipment, its suitability to local conditions, price and credit availability, and the profitability of selling it or using it. Locally manufactured goods will only succeed if truly competitive with imported products on all counts.

Environment

Favourable conditions for establishment of an agricultural machinery manufacturing industry, and dealer organisation, are more likely to occur in irrigated areas having multiple (and perhaps staggered) cropping seasons than in rainfed areas having only one arable crop per year. In areas where rainfall is marginal and/or erratic, there may be substantial benefits from mechanised cultivation coupled with the use of improved seeds and fertiliser, but the risk may be too great for the peasant farmer to take. In such areas only the businessman farmer may be prepared to take the risk, or will be able to afford the substantial investment necessary to profit by extensive farming, and there may be little prospect of developing a significant market for machinery for small farmers. There may however be opportunity to develop a market for machines for entrepreneurs providing a contract service to small farmers.

Manufacturers

The potential manufacturers of agricultural machinery in the developing countries may be broadly classified:-
(a) Rural craftsmen currently manufacturing simple or traditional equipment. This equipment usually involves few moving parts. The craftsmen have few or no power tools and usually each machine is made separately without the aid of jigs. The manufacturer undertakes repair of the equipment as necessary. Sales are restricted to the immediate locality.
(b) Distributors of imported machinery who may graduate to assembly and partial manufacture of imported equipment. In the initial stages local inputs are usually limited to assembly and to mild steel fabrications. The original manufacturer may provide jigs to ensure dimensional reliability. Premises and equipment are superior to those available to the rural craftsman and sales may be over a wide area.
(c) Mechanical equipment manufacturers not previously concerned with agricultural machinery but prepared to manufacture agricultural equipment if it appears profitable. Although such companies may only have a limited range of power tools and lack access to supplies of special steels for soil engaging components, frequently they are very versatile and skilled in making maximum use of available resources. A not infrequent problem is that such manufacturers, when taking over a design, may not appreciate the importance of the design features and may, for manufacturing convenience, modify the machine in such a way as to reduce its effectiveness or reliability.
(d) Agricultural engineering companies whose sole business is manufacture of a range of machinery.

Problems in developing machinery manufacturing capacity

Seasonality

The demand for agricultural machinery is typically seasonal. Timely supply of original equipment and timely provision of spares in case of breakdown during the season are essential if sales are to be maintained. The users of cultivation equipment have usually to wait many months before they can realise its benefit, but the cash benefit of harvesting or threshing equipment may be more quickly realised. Provision of credit for sales of equipment may therefore be of longer duration and more serious for cultivation equipment than for harvesting machinery.

Supply of standard components

The time lag between placing orders and delivery of imported specialised components (eg bearings, belts, earth moving parts) may be many months so that a manufacturer may be unable to respond quickly to an upsurge of orders. He may also lack the capital for speculative investment in components for equipment for which he does not have firm orders. In many cases the smaller manufacturers, especially the rural craftsmen, lack the ability and the scale of operation to purchase specialised components from overseas.

For economical operation it is therefore necessary that there be effective stockists/importers of materials and specialised components. The evolution of such stockholders will be encouraged if there is a nationally agreed standard for material sizes and quality with a limited range of preferred sizes and grades, and similarly agreed standards for nuts, bolts and other hardware also with a limited range of preferred sizes. If no suitable stockists emerge in the private sector then in order to encourage the development of manufacture by rural craftsmen it may be necessary for Government to maintain some stocks as part of its service of extension to the rural sector. If Government does introduce such a service it should be self-financing and should not preclude private enterprise from entering this market.

Staff training and product quality

The International Rice Research Institute has been active in seeking to promote manufacture of agriculture machinery in many developing countries. Their experience shows that often small companies having the potential for manufacture have no one able to read drawings. Equipment which is 'custom' built may need 'custom' repair, and performance may be substandard. Provision of jigs for manufacture and provision of good models to copy may be effective for pilot production but if the company is to be dynamic and diversify to spread manufacturing load and risk then adequate training of workers and introduction of effective inspection methods is essential. Introduction of non-traditional materials such as plastics and aluminium may offer substantial advantages for bearings and new equipment.

Research

The effective application of research and development of agricultural machinery can only come from the commercial exploitation. There is need for the research organisations to work closely with industry for the transition from a technically successful development to a commercially successful venture. In adopting any new machine from a research organisation the manufacturer usually wishes to modify it to identify it as 'his' model suited to a local market but frequently the benefits of the modification do not justify the development costs involved. Sometimes however the modifications may be patented and provide a small measure of protection against plagiarism.

Government support

Government aid for local industry may be useful in the initial stage but it is essential for the development of a machinery manufacturing industry that it should be encouraged to be competitive rather than that it should be so protected that it fails, in the long run, to provide the equipment which will enable its customers, the farmers, to prosper. Thus too strong a Government insistence on total local control of manufacture and/or insistence on too high a local content in the manufacture will be counterproductive.

Not only must the industry be truly competitive against imports but it must also be competitive locally against alternative opportunities for manufacture. If production of agricultural machinery may be combined with production of, say, construction machinery, having different seasonal demands, then the manufacturer may be more competitive in both fields.

Government aid may be highly desirable in providing training for manufacturing staff, provision of a suitable infrastructure for the supply of materials and specialised components and for good communications. Onerous import duties which discriminate against import of essential components or materials are counterproductive. The greatest benefit which a Government can confer is to guarantee that the farmers will get an adequate return for their crops so that they may invest in machinery with confidence.

Manufacture for export

So far we have considered only manufacture for the home market — deliberately so since this is the sector with, by far, the largest potential for development. However, it is quite possible that manufacturers in some rapidly industrialising countries may find it profitable to manufacture, in quantity, agricultural machinery mainly for export; even of types of equipment not used in these countries. If this does occur it will almost certainly start by manufacture under contract for established countries in the industrialised countries, as has already happend with other products (cutlery, electronics, etc). Such developments will be most likely if costs of base materials and labour are lower than in industrialised countries, but will be least likely for machines incurring high transport costs to overseas markets.

To extend their exports beyond the manufacture of goods under licence, the developing countries will almost certainly need to establish effective equipment testing centres and standards institutes to ensure that the quality of their products match that of the industrialised countries. The move to establish such standards and test centres is gaining momentum and the possibility of manufacture of 'exotic' equipment mainly for export is likely.

Conclusions

For the majority of situations where production is intended to serve domestic markets the agricultural machinery manufacturing industry is dependent on, and must be integral with, the agricultural industry. Agricultural engineers must play an active role in agricutural development, training and extension.

Sales of equipment of subsistence farmers will always be minimal so that the machinery manufacturer must aim to supply those farms above subsistence level, and those entrepreneurs providing contract services. Governments may provide the infrastructure, training and some support services for industry, but the industry must itself be dynamic and competitive if it is to thrive.

There are as yet few situations where equipment is produced primarily for export from the developing country, and most developing countries lack the necessary test facilities and manufacturing standards to ensure a high quality in complex machinery.

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Agricultural machinery manufacture in developing countries

Edited summary of discussion

Mr B P Pothecary (Consultant), in opening the discussion, referred to the FAO integrated project on animal draught equipment in Upper Volta as an example of a co-ordinated approach to local manufacture in one of the poorest countries. In support of the design, test and progressive manufacture of implements and two wheeled carts attention had been given to the selection, feeding and training of animals, extension and the training of extension workers as well as credit to farmers.

The results were impressive and after five years a capacity of 25,000 units had been established comprising two centres for the manufacture of components and ten sub-centres for the final assembly, stocking and distribution of equipment. At all levels use was made of locally trained staff and artisans in the regions. Prices had been held constant by bulk purchase of basic materials and components with simple low cost manufacturing techniques. A built-in profit margin financed the extension service through seminars on animal draught techniques and practical training courses.

Although every attempt has been made to keep systems on the manufacturing, extension and training side as simple as possible, difficulties have been encountered in the progressive hand over of the going concern to a suitable local organisation. Some technical problems have also been encountered with meeting the varied needs of agriculture in Upper Volta as regards equipment. Each zone has its special requirements.

Mr R R Gladden (Independent adviser) asked how a farmer in a developing country would fare for support and advice during the first season of use of a new piece of equipment. Mr Frost indicated that this could be a time-consuming matter which was usually dealt with by extension workers, but it was essential that it be done.

Mr G F Cooper (Massey Ferguson Ltd, Canada) asked about the potential for utilising solar energy in equatorial countries. Mr Frost replied that the photo-voltaic cell had been proved technically between the latitudes of 30°N and 30°S. The price would drop in real terms and there was the possibility of manufacture in some of the more advanced developing countries in, perhaps, ten years time.

Mr A R Stokes (Project Equipment Ltd) asked the number of projects which had been financed by Intermediate Technology Industrial Services. Mr Frost pointed out that the function of ITIS was not to fund particular projects, but to offer technological options to people in developing countries.

Mr D Gee-Clough (NIAE) wished to know how many rice transplanters had been made. Mr Cooper had no positive information but would guess at several hundred since the development had been undertaken by the International Rice Research Institute. Mr Pothecary added that the machine was now being exported and that there was also a N Korean copy.

Mr Banbury (Inventor) asked of Mr Moore how an inventor could protect his inventions in view of the time problem in establishing patents. The speaker sympathised, since worldwide patents were prohibitively expensive, and were not recognised in certain countries. An inventor's best protection was a succession of good ideas.

Mr T C D Manby (NIAE) asked Mr Moore and the chairman to elaborate upon the effects on manufacturing companies of granting licences in overseas countries. Mr Fox answered that logically the developing country could in no way compensate the home manufacturer. Perhaps a partnership between a manufacturer and his licensee could evolve, particularly if the tax benefits suggested in his (chairman's) opening remarks were realised.

Mr Moore felt it was inevitable that there must be conflict with re-exports, but his own company had achieved a satisfactory exchange of products between Australia and Malaysia. He felt that inventiveness played a large part in a company's success.

Dr P A Cowell (NCAE) suggested that developing countries, with their high unemployment problem, must match increasing population with social development. This would undoubtedly include the increasing use of machinery, but care must be taken to find alternative and acceptable employment for those who were consequently displaced from the land.

Mr Moore observed that this problem had arisen in China, where erstwhile agricultural workers were finding employment in the increasingly mechanised food processing industries.

Mr D Knapman (British Agricultural Export Council) enquired as to the sufficiency of sources of non-government capital (eg banks) and the importance of being able to repatriate profits. Mr Moore felt that there would never be enough capital. It was to be hoped that repatriation would be allowed but indeed losses were often incurred. Some countries, e.g China, do even now allow repatriation of profits.

Mr P Fowles (Ford Motor Co) sought comment on the importance of involving governments in developing countries in the provision of feedback to manufacturers in developed countries. Mr Frost explained that ITDG, as a registered charity, did not negotiate between governments. Indeed sometimes governments appeared to inhibit a free interchange of information, perhaps for political reasons.

Mr J M Beeny (Halcrow-ULG Ltd) was concerned about the "pirating" of British ideas or indeed of ideas within the same country. For example, Thailand tractors could easily be copied within Thailand. Mr Cooper replied that there was little protection. In particular the communist world did not recognise patents or inventions and the manufacturer must simply aim for maximum advantage. The Chairman interjected that companies should reward their employees sufficiently to prevent them wishing to "start up on their own".

Mr D Gee-Clough (NIAE) expressed the view that the figure in Professor Inns' paper comparing production with power available was misleading in so far as other factors such as fertiliser and herbicide inputs could also have significant effects.

Mr P N Sillars (Geest Industrial Group Ltd) asked about the place of less conventional small tractors. Professor Inns suggested that models such as the "Good Earth" were likely to be the smallest viable units and that, in Africa, 2-wheeled models are unlikely to be the answer.

Mr B H Fowles expressed the anxiety that the speakers did not seem to have considered leisure a desirable objective for underdeveloped countries and that we should be encouraging better management to utilise the best possible equipment for the job which was available on world markets.

Mr D Knapman (British Agricultural Export Council) contrasted Professor Inns' paper with experiences in Latin America. Development in medium farms and equipment, as opposed to small, had achieved many of the objectives being aimed for. In reply Professor Inns agreed but emphasised that the basic situations were different. World wide, medium farmers can look after themselves.

Mr G Banbury (Inventor) asked Mr Stokes how the "packages" described in his paper could be funded. In reply Mr Stokes said that farmers will agitate for the package if they see a need. This involved government and exchange control which, whilst restricting numbers of orders, did guarantee payment in advance. Alternatively aid organisations could intervene.

Mr A Ellman (Commonwealth Secretariat) asked about the contribution to manufacture from the British Industry. He felt that the trend should be towards local manufacture for local conditions; a tough simple machine would match the requirements. Mr Moore agreed that standard British equipment was often not suitable and simplification was difficult and expensive. Appropriate copying was likely in the more developed countries. Mr Bell added that aid programmes are generally government-to-government or government-to-agency and consequently the manufacturer had to wait until he was asked before becoming involved.

Captain E N Griffith (Howard Machinery Ltd) cited the case of Egypt where an exploding population could be fed now only with American support. If we encouraged animal power rather than tractor power we would exacerbate the situation, the animals eating much needed food. Mr Stokes agreed that Egypt for many reasons was in this situation but stated that in much of Africa the animals were fed off the unutilised bush.

Mr Harold Poole (Harold Poole Group) emphasised that overseas manufacturing operations must be profitable if they were to attract finance and that unless inventors could present sound budgets they were unlikely to get the benefit of their inventions.

R H Marsden (COSIRA) written contribution) The speakers from both the platform and the floor have without exception stuck rigidly to the theme of the conference, namely the manufacture of agricultural implements in developing countries. The problems facing a project leader or manager charged with setting up a factory unit in these remote areas are formidable. The market for the product is specialised; it is spread out somewhat thinly, but over a restricted geographical area. The demand is seasonal and also dependent on the arrival of adequate rainfall, or similar criteria. There are bound to be shortages of capital and problems of methods and certainty of payments. Raw materials are anything but "off the shelf" and trained labour is probably non-existent or nearly so. Not a picture of glittering commercial promise, but rather a challenge for the wholly dedicated man of many parts.

I would like to suggest that a broader approach would go some way towards increasing the chances of establishing a viable factory unit. The aim should be to make a range of articles which are all similar from a manufacturing point of view. For example, in addition to the agricultural implements, the factory should offer such items as hinges, bolts, locks, hand-carts, animal drawn carts, motor vehicle trailers, cooking utensils and, perhaps most important of all, efficient iron wood-burning cooking stoves. Wood is the principal fuel in Africa and is in very short supply. A cut-weld-drill fabricating service would naturally lead on to numerous locally made windmills, water wheels and the like.

In short, it is pleaded that only by going some way towards meeting the broader needs of the community will sufficient momentum be generated to carry through the all important task of providing the farmers of the developing countries the implements they need.

Rural industrial development: another new dimension for agricultural engineering

V Austin

THE 1979 Winter Meeting of ASAE brought some new dimension to agricultural engineering beyond the traditional components of Power and Machinery; Soil and Water; Electric Power and Processing; Structures and Environment and Food Engineering.

This note poses the question of whether agricultural engineers could and should take more interest in, and play a bigger role in another new dimension: rural industrial development. It is clear that many traditional agricultural engineering activities such as crop processing and food engineering already make an important contribution, but is this enough?

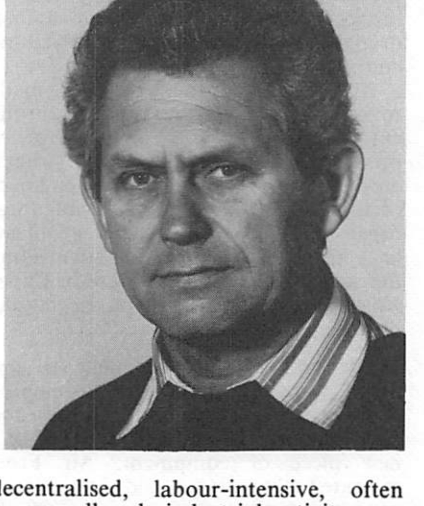
The human problems

The human problem in rural areas throughout the world has received increasing emphasis in the last decade. In the mid-1970's the World Bank[1] estimated that over six hundred million people in the world lived in absolute poverty, defined as an annual per capita income equivalent to US$50 or less, the majority of whom live in rural areas. In a recent report to the Secretary-General of the United Nations, entitled "North-South: A Programme for Survival"[2] new and equally horrifying statistics are quoted, such as 800 million people being destitute, and 17 million children dying below the age of five every year in developing countries.

Not only do the people in the rural areas of developing countries face major problems of employment to earn an adequate income for their basic needs of life, but the problem is becoming increasingly important in the developed countries. Although rural employment and incomes are usually associated in one form or another with agriculture, farming is only one rural activity although, of course, vital to the rural economy.

In developed countries the percentage of the rural population directly involved in farming may be in single figures, whilst in developing countries, farming is the major occupation, accounting for an estimated 70% to 80% of the rural labour force, as a primary source of employment and earnings[3]. For many of those employed in farming, the income may be insufficient and farming activities are only significant in the peak agricultural seasons.

In human terms there is an immense and growing need for the development of non-agricultural rural employment, both in the developed and developing countries; for those engaged in non-farming activities, and for farmers with inadequate incomes in the slack seasons and perhaps throughout the year. This need has been recognised by the OECD in a recent report, which considers that greater emphasis should be given to ". . . decentralised, labour-intensive, often very small-scale industrial activity . . . providing more income and employment to the poor — particularly the landless poor . . ." [4]



The technical and economic problems

Many economic and technical problems facing agricultural development are linked to non-agricultural employment. In many developing countries the problem is an excess of manual labour

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which may be unemployed or underemployed for much of the year, whilst in the minority of situations there may be scarcity of labour at the peak agricultural seasons. Three situations which have arisen in the author's experience in recent years are as follows:-

(a) In the northern part of Pakistan, in an area of scarce employment opportunities and low family incomes, women were employed by one farm owner to hand dig ground nuts (peanuts). This operation was economically and technically unattractive to the farm owner, and he was actively considering the purchase of a complete groundnut harvesting machine, which would make employment opportunities even scarcer. In the absence of alternative employment opportunities the answer would appear to be the selection of an appropriate technology between the labour-intensive and the capital-intensive technologies, such as a simple lifting implement and/or the development of additional rural employment opportunities.

(b) In the Southern part of Pakistan, the farmers growing cotton depend upon migrant workers to come at the cotton picking time. In normal seasons the workers always come, but in the year the author visited the cotton fields, the workers had refused to migrate, because a second and unseasonal rainfall had enabled them to remain on their own farms and to take a second crop. The answer to this problem would appear to be the development of employment opportunities in the workers' home area, to reduce or eliminate the need to migrate, and to allow the cotton farmers to mechanise the cotton harvesting operation.

(c) In some situations such as cocoa farms in West Africa, there is an immense need for manual labour at the peak harvesting season. Unless there is adequate income over the whole year, it can be expected that the labouring families will leave the cocoa growing areas, and create a labour shortage at critical times. The answer appears to be to generate alternative employment opportunities in the slack season to ensure the technical and economic viability of some important agricultural crops.

In other situations the problem is a shortage of skilled labour which is vital for the inputs to agriculture, such as servicing tractors and agricultural equipment, and essential for the outputs of agriculture, such as operating crop processing factories. The run-down of non-agricultural employment and income opportunities in both developed and developing countries can lead to a run-down of the rural infrastructure e.g. vehicle service centres, schools, bus services, etc., and an above average percentage of old people.

A new dimension

Although assistance is usually given by governments to the agricultural sector, the non-agricultural sector in general receives relatively little assistance. A new dimension to rural employment promotion is for governments to increase their aid and services to the non-agricultural, and particularly the rural industrial sector.

A national programme for rural industrial development should include:

(a) A national policy to assist the growth of rural industries.

(b) District planning at the local rather than national level.

(c) Planning integrated rural development and/or rural industrial development projects.

(d) Implementation of projects to co-ordinate national and field level services, eg training, marketing and financing services.

(e) An adequate national service to support rural industrial development at the field level.

(f) A field level service to assist individuals engaged in rural industrial activities.

The contribution of the agricultural engineer

Although the agricultural engineer could contribute to all aspects of a national programme for rural industrial development, his special education and experience are particularly relevant for the management of rural development projects and national and field level services:

(a) Project management for rural development and rural industrial development requires a sound knowledge and appreciation of both agricultural and industrial technology, and the fundamental skills of the economist and manager.

(b) National level services should include research and development in at least three main areas:
- (i) Marketing research and industrial product development.
- (ii) Technological R and D, which would include the choice of appropriate technology for rural industries.
- (iii) Training programme R and D to ensure that the programmes implemented at field level are well-designed and will contribute to national development objectives.

(c) Field level services will include some training programmes which depend heavily on agricultural engineering skills, such as crop processing and food engineering.

The new decade

It is apparent that, in this new decade, more professionals will be required to plan and implement rural industrial development. Many of these professionals could be recruited from within a widened profession of agricultural engineering. In order to ensure the maximum opportunity for our future agricultural engineers, it is essential that the traditional dimensions of agricultural engineering are expanded.

In summary, it can be seen that there is an international need for employment and income promotion within the rural sector, through rural industrial development, which is in addition to agricultural development opportunities.

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