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Fig. 1 - All-India area, production and yield of foodgrains (Source: Agricultural Statistics at a Glance, 1994. Min. of Agriculture, Government of India)

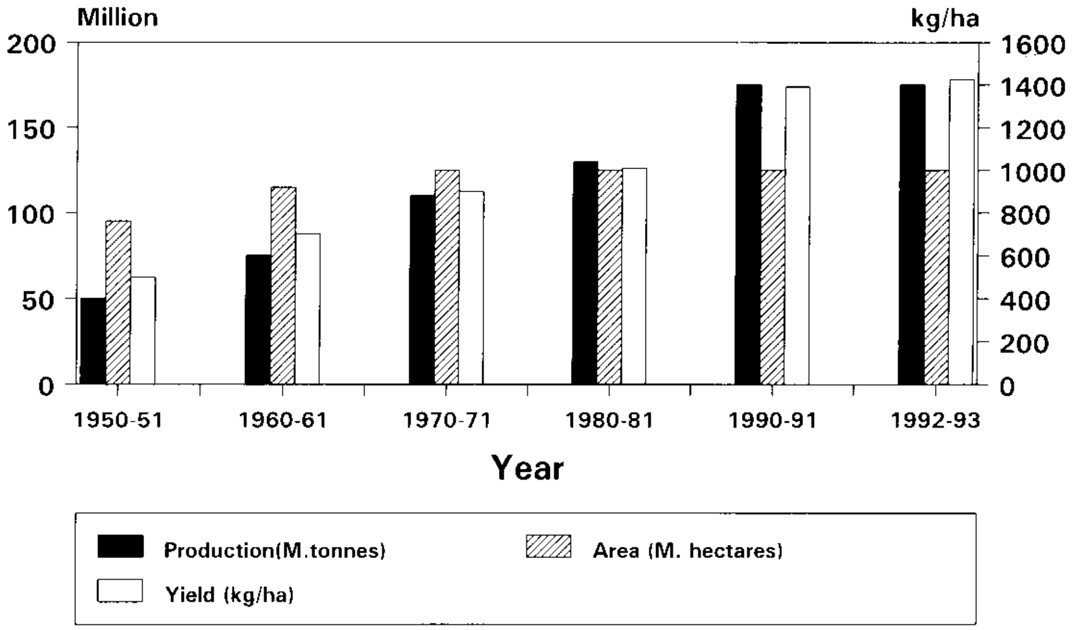


Fig. 2 - All-India estimates of foodgrains production (Source: Annual Report 1994-1995, Dept of Agriculture and Cooperation, Min. of Agriculture, Government of India)

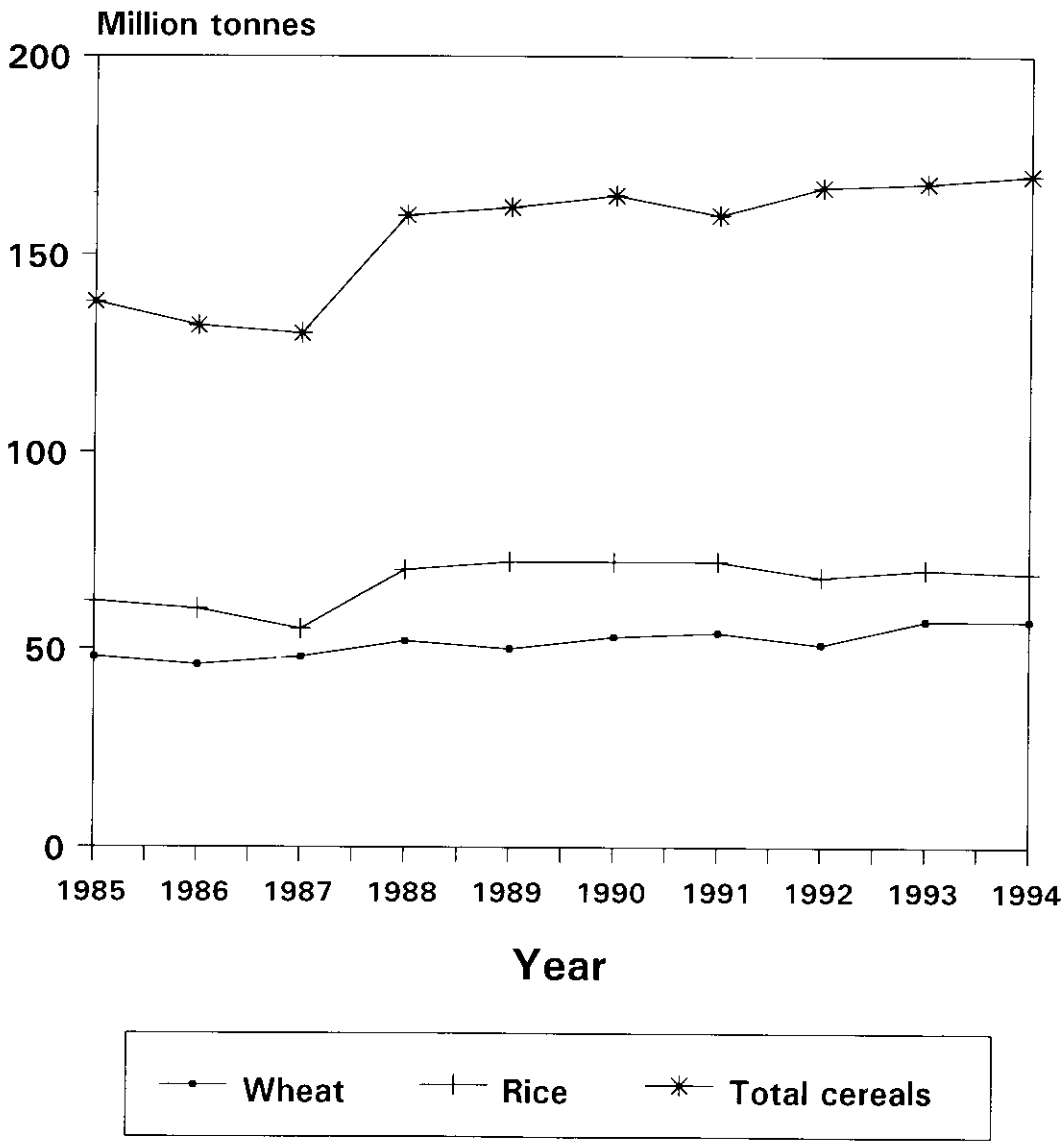


Fig. 3 - Area under cultivation and percent coverage under irrigation (Source: Agricultural Statistics at a Glance, 1994. Min. of Agriculture, Government of India)

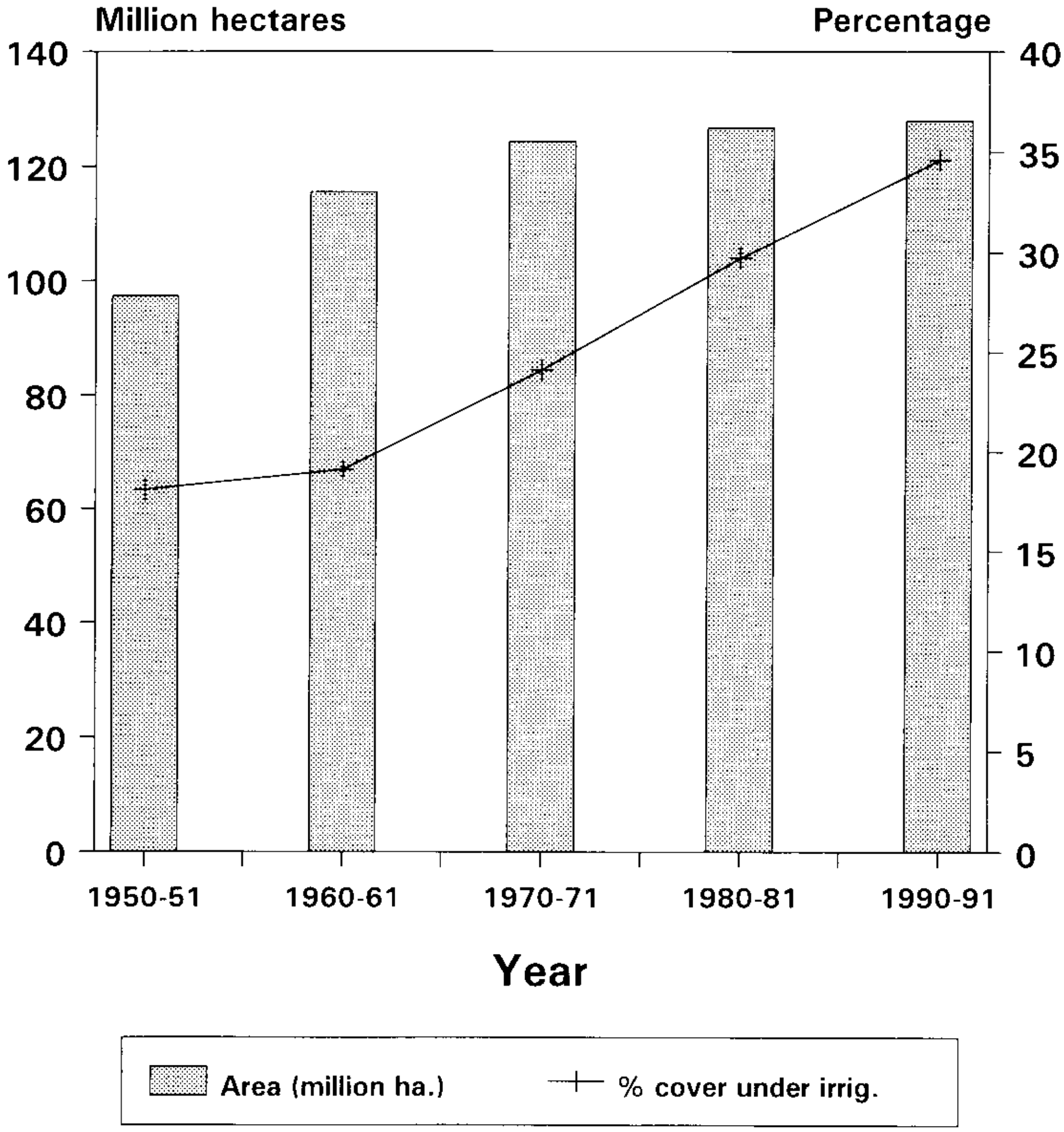


Fig. 4 - All-India consumption of fertilizers (Source: Agricultural Statistics at a Glance, 1994. Min. of Agriculture, Government of India)

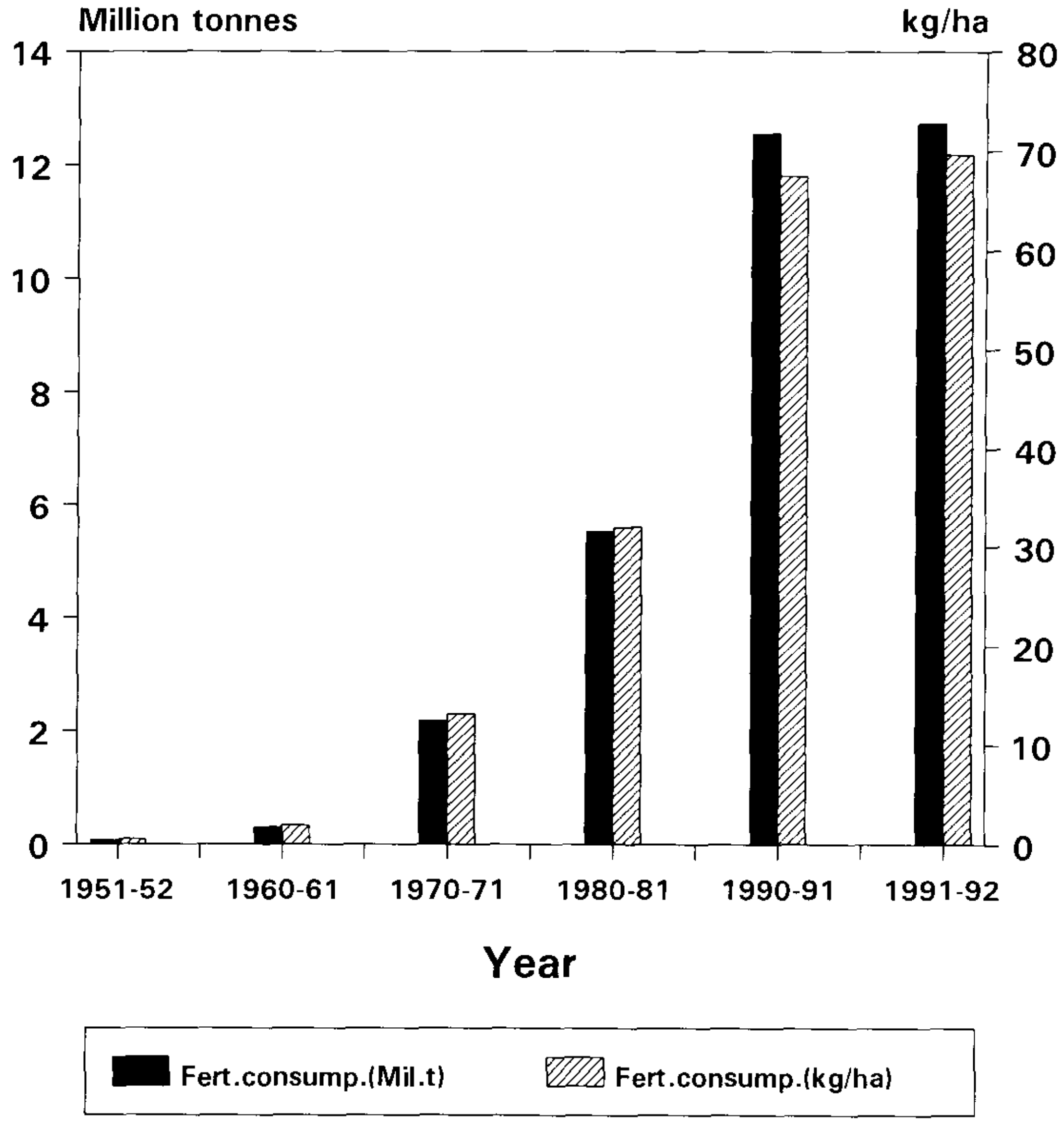


Fig. 5 - Sale of tractors and power tillers in India (Source: Tractor and Tiller Manufacturers)

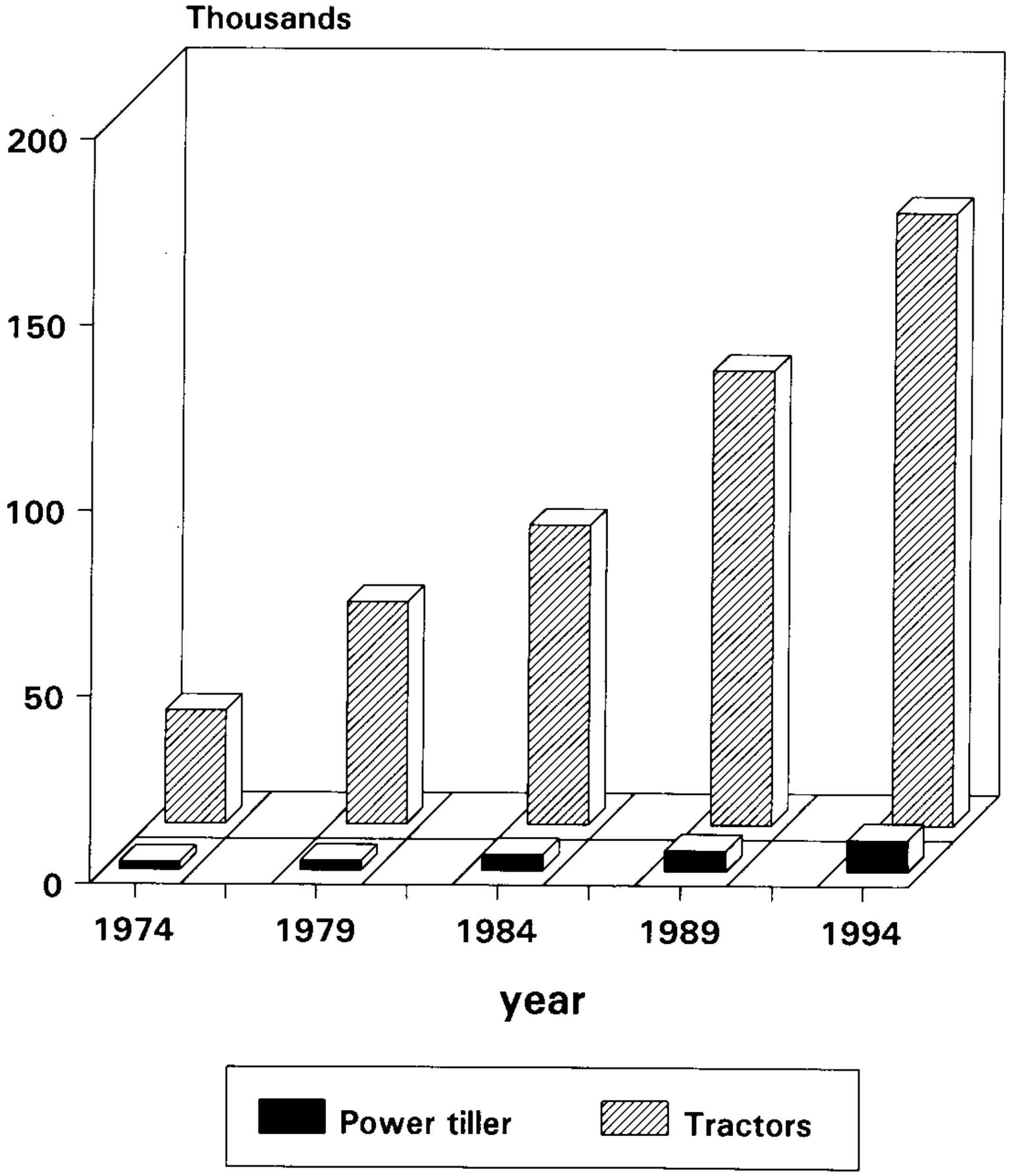


Fig. 6 - Number of operational holdings in 1991 (in '000 ha; Source: Annual Report 1994-1995, Dept. of Agriculture and Cooperation, Min. of Agriculture, Government of India)

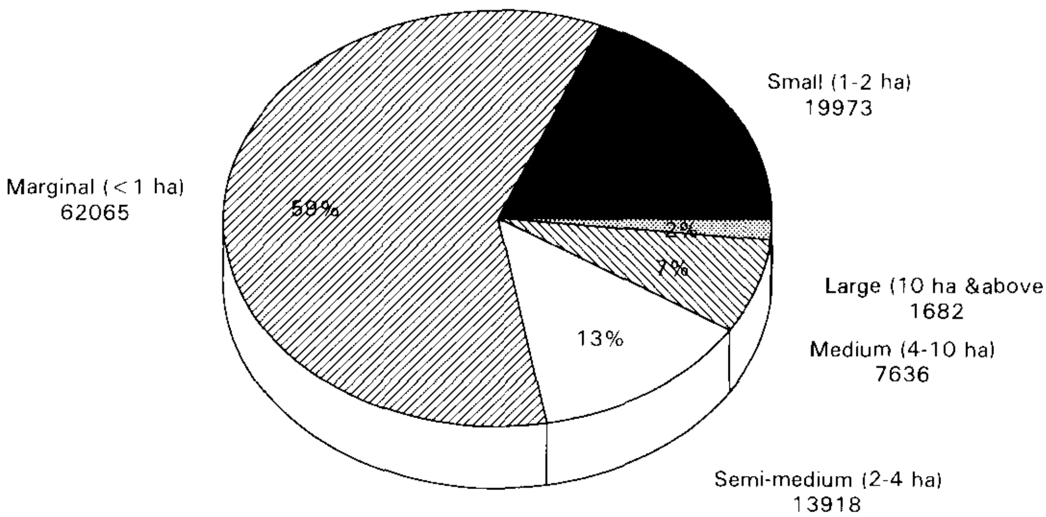
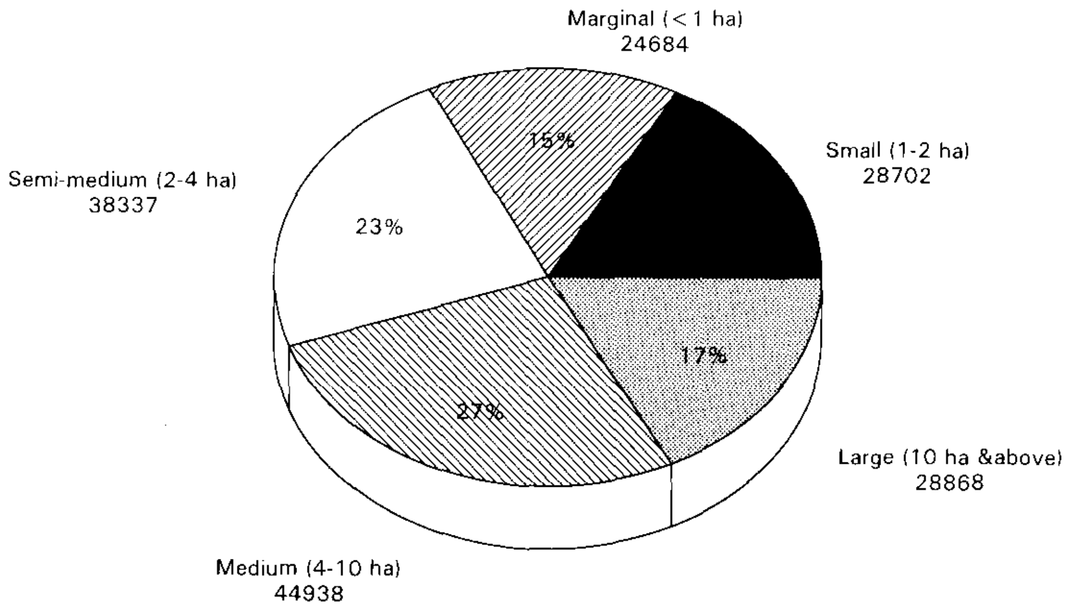


Fig. 7 - Area operated by major group in 1991 (in '000 ha; Source: Annual Report 1994-1995, Dept. of Agriculture and Cooperation, Min. of Agriculture, Government of India)



Appropriate technology levels for mechanisation - a case study for Latin America

by *Terry L. Wiles*

UK

1. Introduction

The mechanisation needs and levels of agricultural technology employed, vary considerably across Latin American. Examples can be found of highly sophisticated mechanised production methods in crops like sugar cane while alongside, or even integrated as part of an advanced cropping system, simple machines and techniques are employed.

As in much of the developing world, significant advances in farm mechanisation are largely imported from either Europe or USA. There are, however, notable exceptions where local industry has continued with machine development to suit local conditions as is the case with the sprayer manufacturer "Jacto" and several no-till planter manufacturers from Brazil.

It is my belief, that much needs to be done for Latin America to develop more appropriate farm machinery and production systems for the future to cater for:

- the increasing need for conservation farming, which is critical throughout the region;
- the need for increased food production to feed a rapidly growing young population;
- the rising cost of labour;
- pressure on availability of land.

It is often inappropriate to transfer machines directly from temperate countries into Latin American conditions as there are often special needs. A fresh and more enlightened approach to mechanization is required. The potential for increased production is high and the removal of trade barriers in recent years throughout the region, means that markets are accessible to international manufacturers.

2. Agricultural sprayers

Recent field studies in Latin America, which I am currently undertaking together with the engineering service of FAO (AGSE), have considered the machinery employed to apply pesticides, its design limitations, use patterns, efficiency and state of repair. Particular attention has been paid to the safety to the environment and to workers and we are seeking to determine how machines can improve the safety, efficiency and economics of pesticide use.

This class of farm machinery provides a very striking case study example of the needs and potential for improved designs and innovative thinking and is the example I should like to concentrate on today. My work in Latin America over the last 20 years has also involved the development of other mechanised tillage and harvesting solutions for sustainable production and I shall also refer to these.

Agricultural machinery and mechanisation is not the most popular topic in international development thinking today, however, agricultural spraying is a especially neglected area which merits serious attention.

When we mention "pesticide safety", spraying equipment is not the first issue to come to most people's minds. They think of registration, legislation, biological control, packaging, labelling, farmer safety training etc. All these are important, but when it comes to field practice, 99% of crops are protected against pests, diseases and weeds using chemicals or biological agents which are discharged into the environment through an agricultural sprayer often in a technically inefficient, wasteful and sometimes dangerous way.

Our FAO studies have covered a wide range of cropping systems from the small Andean potato farmer to the gigantic Brazilian soybean grower. From Colombian flowers to Brazilian citrus and Chilean fruit production.

In general, conventional spray technology throughout the region suffers from severe technical (drop deposition) and often economic (work rate and waste) limitations. Calibration is generally inadequate and there is often little control over the doses applied even on progressive farms.

In the past, spraying methods have not presented a major problem in the minds of the growers and the authorities, but with falling commodity prices and increased labour costs, the need to improve pesticide application is paramount on economic grounds alone, irrespective of the need to protect workers and to reduce environmental damage.

Let me take two "real life" examples from Colombia to illustrate what needs to be done and a potential solution which is being developed.

3. Coffee

Colombia is the second largest producer of coffee in the world after Brazil and the largest producer of quality coffee with 1.2 Mha of crop. Historically they have had no problems with pests and diseases and no need to spray until the arrival of coffee leaf rust (Hemileia vastatrix) in 1983 and berry borer (Hypothenemus hampei) in 1989.

Traditional control methods of mechanised tractor spraying cannot be used due to the very steep slopes and the dense planting. This limitation has led to the development of a novel solution based on a backpack, motorized, Controlled Droplet Application (CDA) sprayer with the following characteristics:

- droplets of a controlled size are produced using a spinning toothed disc and propelled into the crop canopy by a slow moving column of turbulent air;
- the machine is mounted on the operators back, can be adjusted to suit the row spacing and crop height and can oscillate horizontally or vertically to improve cover;
- it is capable of using standard pesticide formulations applied in 25-75 dm^3/ha of water;
- it is practical, robust and suitable for use by operators with limited technical ability;
- it is affordable to "technified" coffee growers;
- it has a high work rate (1-2 ha per man/day compared to 1 ha per 5 man days from the conventional system);
- the pesticide solution is sprayed behind and away from the operator.

This new equipment is being developed by Micron Sprayers Ltd. of Bromyard U.K. and is the result of a collaborative programme with the Colombian National Coffee Growers' Federation and the Overseas Development Administration of the British Government.

4. Flowers

Colombia is also one of the world's largest producers of flowers, mainly carnations and roses and is in many respects a technically advanced industry. The control of pests and diseases is vitally important but current systems have little scientific basis. They are inappropriate and are characterized by :

- excessive volumes of water, 2-4,000 dm^3/ha;
- excessive spraying pressures (up to 15 bar) applied through hand lances;
- high levels of pesticide;
- a danger of leaving high chemical residue levels.

Experiments in roses against mites using targeted droplets of 50-70 μm showed a potential to improve cover substantially and to reduce chemical rates by over 50% while giving near 100% control. To date these principles have not been developed into commercial machines or practices.

5. Orchard tree crops

In large-scale mechanised agriculture throughout Latin America, a major requirement is to develop efficient equipment and techniques to spray commercial orchard crops. Here we have a classic vicious circle. Existing high volume techniques were originally probably copied from USA where high volume spraying assisted by a high velocity airblast were, and I believe still are, commonplace. Agrochemical rates are calculated as percentage concentrations irrespective of the volumes applied and growers believe that the higher the volume and pressure, the better will be the control.

Experiments carried out at the University of Sao Paulo State (UNESP) Brazil, indicate that over 75% of the spray applied to citrus ends up on the ground. It is also evident that a further significant percentage is lost to drift, resulting in a most inefficient and often hazardous system which seems to be used extensively over 1 Mha of Brazilian citrus.

This is inappropriate mechanisation but who will break the mould ? Machinery manufacturers make what the farmer thinks he needs and will not tamper with registered agrochemical doses. Agrochemical companies no longer feel that they should develop spray machinery and techniques to maximise the efficacy of their products. Government authorities and grower associations have little expertise in this area and frequently the waste and abuse goes on unwittingly.

This situation is commonplace in tree crop spraying throughout the region. The methods used are a crude and inefficient means of applying often sophisticated formulations of chemical (or biological) products to control pests and represents a major challenge to the machinery industry.

6. The tillage saga

For many years I worked on tillage systems for arable farming across Latin America. Here is a striking example of the perpetuation of entrenched, inappropriate technology from USA and Europe.

In the tropics and sub-tropics and over much of the rest of Latin America, "Conservation Tillage" techniques are vitally important to protect the soils and ecosystems; much more so than in temperate climates. A fact which seems to escape many development planners and soil scientists.

Throughout Latin America, traditional methods of ploughing and clean cultivation are still widely practised and vigorously defended by the majority of scientists and field agronomists with all the classic "European" reasons why this represents good husbandry. This ignores the differences and fails to recognise the many advances in crop protection and weed control in the last two decades and the considerable advances in international knowledge of soil management under adverse conditions.

The machinery industry continues to sell to the farmer the tillage equipment he thinks he needs to buy. Who is to convince him otherwise ? Who will take the leadership role ?

One notable exception to this tillage picture is the widespread use of no-tillage in the soyabean/wheat areas of Southern Brazil and into Paraguay and the humid Pampas of Argentina. Here there are 2 Mha planted annually using no-tillage, where crop residues or purpose-planted mulch crops are left on the soil surface to prevent erosion and to conserve moisture. This system enables crops to be planted at the optimum time often with major energy and labour savings.

The system, however, has taken 20 years to gain acceptance. Adoption of new concepts in any agriculture is always slow, but can we afford to take so long ? Can we afford to let the industry persist with redundant machinery practices imported from elsewhere ? No-tillage has limited applicability in Europe but is absolutely vital to protect vast areas of soils throughout Latin America. There is work to be done on the design, development and promotion of machinery for conservation farming - tillage equipment, planters, sprayers, harvesters and traction equipment. Latin America is "fertile ground" for the development of these technologies and can lead the way.

7. What of the future ?

The above examples on crop spraying and tillage machinery are immediate issues of grave concern to those of us concerned with the development of world agriculture. There are, however, other challenges and major new market potentials besides these.

The mechanisation of horticultural crops in its entirety requires review and development over most of the region. The potato crop is fundamental to many areas and mechanization is neglected.

Due to the increasing cost of labour in Brazilian coffee over many years, local manufacturers have developed sophisticated mechanised coffee harvesters, which straddle the rows and dislodge the ripe fruit using rubber fingers. This has been a major investment over many years by private industry.

This technology, however, is inappropriate for the other coffee areas in Latin America where the slopes are prohibitively steep, farms often small and planting frequently dense and uneven. In Colombia a completely new and compelling situation has arisen because of the spread of the insect pest, berry borer. Previously there was no economic justification to harvest 100% of the production, however, because of the need to harvest all the berries to help control the pest, this means harvesting all the year round. Labour costs are rising sharply and a major challenge will be to design a portable system of mechanised harvesting for Colombian conditions.

This undoubtedly represents a formidable task which will take some years but is an example of the type of challenge which a modern machinery industry with modern technology, should be prepared to meet.

8. Is Latin America different ?

There is still considerable potential for increased crop production throughout the region both for the intensification of small-scale operations as well as the expansion of large-scale arable farming in areas like the Cerrados of Brazil.

It is important, however, that due care is exercised by those responsible for mechanisation, to take into account regional and local conditions which could demand machinery solutions different to those employed in Europe. We should consider extremes of climate - rainfall, temperature, humidity, topography, scales of operation, water use, pest pressures, pesticide use (and abuse), levels of infrastructure, operator educational levels, development trends and social conditions.

Only then can we obtain a realistic vision of the mechanisation needs and my experience, over the last 20 years, in the field indicates, time and again, that we need to apply the principles and experience from elsewhere in the world in a more innovative and objective manner.

There are of course examples of advanced and appropriate mechanisation systems in Latin America but over the majority of the area, we are looking at a gap of 20 years compared to Europe. This certainly does not mean that we can employ old and redundant technologies from Europe. The need is for an innovative but practical approach. We must bring knowledge and experience to develop more appropriate mechanisation to benefit the farmers of Latin America, to open new markets for farm machinery and not just expect to sell existing designs into these markets.

The mechanization principles must be right, the construction robust and the price affordable, but the latest electronic control systems and costly safety devices, which may be highly desirable or mandatory in Europe, are sometimes an unnecessary cost and complication, and even a burden for much of Latin America.

The need, the opportunity, and the knowledge exist but are those of us who can contribute towards the development of machinery for this exciting agriculture, ready to take up the challenge of Latin America ? I look forward to a lively debate on how this challenge might be met.

Technological levels needed in the various agricultural areas: study case East Europe

by *Pavel Kic*

Czech Republic

1. Introduction

Major political and very significant economic and social changes have been taking place in the countries of the East and Central Europe during the last five years. The legal basis for a market oriented economy has been created. Institutions of vital importance for the market economy were established. The role of market mechanisms and such economic terms as money, profits, demand, competition, capital and market have greatly increased.

Resulting from the reforms, the dominant role of the state in managing the economy as well as the role of state administration in creating economic processes significantly decreased. The role of the state budget in national income distribution, particularly in the field of production, investment, trade and consumption also decreased. The role and importance of market forces in creating prices, demand and supply grew significantly. The present systems have in this respect most of the features typical of a market economy. Unfortunately, the transformation had its downside. The most important involve economic recession, manifest as a decline in GDP, of industrial production and also of agricultural production and a fall in employment.

The present situation in the countries of East and Central Europe is not the same in all of them now, but we should always realise that their situations at the end of the 1980s was not the same. Their starting conditions and historical and traditional experience are rather different.

The agriculture of several countries, e.g. former Soviet Union, Hungary and Czechoslovakia was practically without small private farms and agricultural production was based on large-scale co-operative and state farms with an area of several thousand hectares of land. The opposite situation applied e.g. in Poland, where the majority of the land was in the ownership of small farmers, owning several hectares. The level of technological equipment and machinery; of technical infrastructure in rural areas; and of the food processing sector was also rather different. The result together with a different level of labour productivity, was a different quantity, quality and variety of assortment of food products between countries.

The production of different types of agricultural machinery in the countries of COMECON was distributed between different countries, some of which achieved near monopoly in the production of certain machines, while for other machines they became dependent on imports from other socialist countries.

The majority of the agricultural machinery was sold on the market of those countries by monopolistic trade organisations which provided marketing and, technical service and repairs within the guarantee period of the machines. Current repairs of the machines were provided by agricultural farms employing their own specialised repairmen in their own repair shops. Complete overhauls and other complicated repairs were done by specialised central repair plants, and some machine and tractor stations. The quality of production and services socialist countries varied, according to the technical level and standard of each country.

The transformation of agriculture to the new economic conditions has been equally different. Each country was, and is going in its own way towards a market economy according to its historical background, and previous level of agricultural production. Equally important is the general conception and programme of the government of each country during the transformation of the whole national economy. Some differences and national, specific problems of transformation are presented below, because developments in the farm-machinery-production sector depend on the over-all economic situation of the countries. Among the factors that affect demand for capital goods, such as farm machinery, are prices (inputs and outputs), farm income, debt (an indication of a farmer's ability to invest), interest rates, farm size, and age of the machinery stock.

As the former statistical system of COMECON has disintegrated and a new one is being created now, it is rather difficult to obtain up-to-date exact information from all the countries of East and Central Europe. Many previously recorded and evaluated statistical data are not followed up now. Nevertheless, the basic data of the national economy and agriculture are presented in the tables.

1.1 *Albania*

The agricultural sector has become the engine of Albania's recovery and subsequent growth. It is now the largest and strongest component of the domestic economy. It accounts for 55.8% of GDP, 65% of the population and 50% of the work force. Agriculture has also become a major component of trade, accounting for 50% of exports in 1993. It does not disguise the fact that agricultural production in Albania remains very low. A high proportion of farmers are subsistence oriented, yields are low, the market surplus is small. Developing a policy environment conducive to enhance agricultural production is thus essential.

Albania began to privatise the means of production very early on in the reform process and significant progress has been made towards this objective despite considerable difficulties. Nearly all land has been redistributed to private farmers and privatisation has been completed for public housing and most small business. The current emphasis is on completing the privatisation of medium and large scale public enterprises.

The land distribution has been an enormously complex political, legal, and administrative process. However, the distribution of agricultural land has been proceeding relatively rapidly in Albania. The creation of an orderly land market will now depend on first establishing an effective land registration system, and appropriate development controls and monitoring systems.

The result of the distribution is a very fragmented agricultural land with small holdings of average size ranging from 0.6 ha in mountainous areas to a high of 1.87 ha in the plains. The production growth and potential for increasing crop productivity will depend therefore on these emerging small-scale farmers. Those small and fragmented holdings are currently facing serious problems of accessibility for credit, crop and livestock management, and availability and marketing of inputs and outputs.

Most farmers reported renting tractors, ploughs, disks, harrows, and seeders. This rental service is prevalent in many areas and is becoming very important during the beginning of the cropping season and during harvest time. It is noticeable to find farmers principally in low land areas, who own or are willing to buy high power tractor and combine harvesters. They want to establish renting services; a few of them, are already generating capital and extra income by renting these assets.

1.2 *Bulgaria*

Concerning the macro-economy the estimates for 1994 have been revised several times. Inflation in 1994 accelerated. Food prices recorded the largest increase in the period January-November 1994, 125%; compared with a rise in non-food prices of 111%. The prices of services recorded the lowest increase of 57%. Data on unemployment differ substantially according to the method of estimation. The officially registered unemployment rate was 12.4% by the end of November 1994. According to the survey method the unemployment rate was 20.5%.

Privatisation did not take place on a large scale until 1994. The importance of farming activities outside the traditional socialised sector is growing. However it should be noted that there is no clear definition of what is classified as "private farming". The term refers to the different arrangements for farming outside the old collective and state farms, including the household plots. Household plots (gardens) are mixed in this group with individual farms and some partnerships or associations. According to the data from 1st July 1993 the private farms were distributed in accordance to the farm size as follows:

861,517 from 0.1 to 0.2 ha, 359,579 from 0.2 to 0.5 ha, 333,994 from 0.5 to 1.0 ha, 248,772 from 1.0 to 2.0 ha, 93,568 from 2.0 to 5.0 ha, 15,762 from 5.0 to 10.0 ha and 4,201 over 10.0 ha.

There is little other information about these “farms”. It could be assumed that the first three groups include gardens and household plots. This happens to be the same as the number of household plots reported pre-reform in 1989. The next three groups could be classified as family farms. The last group is likely to include partnership or associations, because few owners possess more than 10 ha. From this rough classification is clear that the core of what is referred to as the private sector post-reform is mainly what was also called private pre-reform, that is, the household plots.

During the first six months of 1994 agriculture and forestry contributed 7% to the GDP. In the period 1989-1993 the share of agriculture in employment rose from 18.1% to 22.5% and thus the importance of agriculture in total employment apparently increased. However, one should note it is much higher than the share of GDP. This means that labour productivity in agriculture is lower than in other sectors of the economy. It is perceived that agriculture is still overmanned and that incomes from agricultural activities are low. In the medium and long-term, low labour productivity will be a substantial problem for Bulgarian agriculture.

1.3 *Czech Republic*

The transfer to a market economy has meant considerable pressure on agriculture to adapt to the new economic conditions and market possibilities with regard to its volume, structure and efficiency. There has been a fundamental reduction in the numbers of the labour force; the production structure of agricultural concerns has been simplified; stocks of agricultural animals have been reduced (especially cattle), and there has been a fall in demand for material inputs with a consequent fall in agricultural market production and the supply of agricultural products. In addition, there has been a marked drop in investment with the current decline in basic resources and especially in reserve stock.

Important changes have been taking place including the renewal of legal property relations. This involved three processes: restitutions - on the basis of upheld claims agricultural property in state-owned estates has been returned, privatisation - of 971 state concerns and state limited companies intended for privatisation in the agricultural sector after subtraction of property designed for restitution, transformation - this entailed the transfer of the property of co-operatives into the private ownership of legal and natural entities.

Out of a total area of 4.28 Mha of agricultural land the newly established co-operative and commercial enterprises (Agricultural Co-operatives [ZD], Shareholding Companies [AS], Limited Companies [SRO] and other co-operatives [OD] are managing 74% of agricultural land and independent private farmers 23% of agricultural land. 97% of the agricultural land is now within the private sector. The remaining 3% of agricultural land is managed by other bodies - training estates, military estates with other special purposes. The processes mentioned have expressed themselves in a change in the macroeconomic position of agriculture. There has been a fall in its share of gross domestic product (in 1990 it was 6.5%, in 1994 only 4.5%, the labour force in 1990 was 9.2%, in 1994 only 5.1%).

During the process of privatisation and transformation the replacement of agricultural machinery has been limited, which has caused a higher rate of wear and depreciation of machines. The costs of repairs has been increased continuously (by 70-100%). At present, the rate of replacement of machinery is not sufficient, and the situation is improved only at farms with very good economic results. The survey of data about the most important agricultural machines is in the following **Table 1**.

A very similar situation applies for other machines for plant production. Similarly the machinery for animal production is going to be out of date. The technological level of many farms is rather low and it has become out of date. New technological equipment offering high labour productivity will be necessary.

1.4 *Hungary*

The macroeconomic situation shows both positive and negative signs at the beginning of 1995. Growth in GDP and expanding direct foreign investments on the positive side and a continued growth of the current account deficit and increasing foreign debt on the negative side. The unemployment rate was 12.3% at the end of 1993. In 1993 only 6.4% of GDP originated from agriculture. Statistics for the first nine months of 1994 show that 6.7% of persons employed were working in agriculture.

The most important sector in Hungary was and still is the co-operative (formerly collective) sector. State farms are to be transformed to companies, and the number of companies is increased by some former collective farms which transformed also to joint stock and limited liability companies. Therefore the company sector has an increasing share in the Hungarian agriculture. The number of companies (previously state farms) were expanded from 130 in 1989 to 1,117 in 1994. The average production land area has declined from 7,138 ha in 1989 to 1,976 ha in 1994.

Only a few empirical surveys are available on the structure of the transformation of co-operatives. Some up to date results show that there are more co-operatives now than a few years ago (1,245 in 1989 and 1,410 in 1994). The average area of co-operatives has been falling during that period from 4,179 ha in 1989 to 1,702 ha in 1994. The number of small-medium sized (in land) companies (from 100 to 500 ha) has increased most significantly, and the largest ones (over 4,000 ha) fallen in number. In the case of co-operatives the most significant increase in numbers was realised in groups below 1,000 ha.

Individual farms (part time and full time ones) are the third important sector. The number of full time farms is increasing but the number is still not very high, but they have an increasing share. The part time sector is declining significantly in number. Recent statistics provide much clearer information on the origin of the land in use by the individual farms. Of the 0.88 Mha total area in 1994 the greatest part was farmed by the owners (79.4%). Another 15.9% was leased and 4.7% of the land was “house spots”.

In 1994 the Agricultural Improvement Fund was a very popular support for small and medium sized farms. It provided investment subsidies and interest-free credit. A government decree has also provided support for buying agricultural machinery. The support provides a 70% reduction of a mid-term (over a year) credit taken for the machinery. The machines bought this way cannot be leased, but those clients who specialise in supplying services with machines (if this share exceeds three fourth of their sales) can be recipient of this program. Leasing of machines is also supported by this decree if the leasing period lasts at least 3 years. The support equals 12% of the leasing fee.

1.5 *Poland*

The budget deficit amounted to 3.2% in 1994. Public debt as a percentage of GDP declined from 86% in December 1993 to 70% in December 1994. This decline is due mostly to the reduction in external debt. The ratio of external debt to GDP declined from 63% in 1993 to 46% in 1994. The reduction in external debt results from agreements signed by the Polish government with public creditors (Paris Club) in 1991 and private banks (London Club) in 1994. The rate of inflation is still relatively high, about 32% in 1994. The rate of unemployment was 16.1% at the end of November 1994.

In 1989-90, at the beginning of the transformation in Poland, there were 2.1 million private farms cultivating 14.2 Mha, 1,720 co-operatives cultivating 0.7 Mha and 1,563 state farms cultivating 3.5 Mha. Only 30% of family farms reached adequate production potential, and had owners with adequate skills, to adapt to the new and difficult economic conditions. The remaining 70% of family farms provided their owners with an income (together with income from other sources) only slightly higher than that of families living on unemployment benefits.

In January 1992, the Agricultural Property Agency of the State Treasury (APA) was established in order to implement the ownership transformation in Polish agriculture. The APA has been obligated to take over all the property of liquidated state-owned farms and other agricultural real estate previously belonging to the State, as well as property from the National Land Fund. Assets taken over by APA include also distilleries, feed mills, plant and vegetable drying mills, slaughterhouses etc.

Changes in farm structure and size in Poland are slow. This is due to the high rate of unemployment which hampers any significant shift of labour from agriculture to other sectors. The average size of private farms in Poland is about 6.2 ha of arable land or about 7.4 ha if state-owned holdings are included. It is expected that demand for machines is likely to be differentiated. Introduction of more strict regulations on the imports of second-hand equipment from West European countries will lead e.g. to a rising demand for home made wheat and potato combine harvesters. Because of the need to improve labour productivity and product quality, the growth in demand for machines and equipment for animal production will be much higher than for other product groups.

Sales of tractors in 1994 is estimated at 10-12 thousand. Decreasing winding-up sales of tractors by former state-owned enterprises, and agricultural co-operatives; and limited imports will, however, affect the demand for new tractors. About 2,000 owners of tractors purchased during the period 1974-80 will begin exchanging them for new machines.

1.6 *Romania*

Agriculture represents a basic branch of the national economy, having significant social importance and implications. The contribution of agriculture and the food industry to GDP was about 24.3% in 1991. Besides its economic importance, agriculture plays an extremely important social role The agricultural sectors cover 27% of employment, and so ensure stability and the annual income of the rural population.

The privatisation process caused important changes in the agricultural ownership structure in Romania. After the dissolution of the agricultural production co-operatives during 1990-1991, the private sector started to develop. It owned at the end of 1992 over 70% of the agricultural land (10,398 thousand ha) and about 80% of the arable land (7,466 thousand ha). The main effect of the privatisation is the division and “crumbling” of land. Agricultural land belonging to about 4,000 Agricultural Production Co-operatives was divided and given to 5.1 million landowners, including more than 3 million peasant families. The average size of land ownership - in the case of individual private households - is less than 1.9 ha.

After 1989 the extent of mechanisation lessened because of the scrapping of a large number of tractors and other agricultural machinery which were long past their normal service period and were seriously affected by wear. During 1990-1991, 17% of the total number of tractors, 20% of cereal harvesting combines, 72% of maize harvesting ones and 66% of fodder harvesting combines were scrapped, due to their advanced wear. However, the main reasons for the low level of agricultural machinery are: land “crumbling” by privatisation, lack of fuel and dramatic increases in prices.

1.7 *Slovak Republic*

The share of agriculture in total GDP declined from 9.4% in 1989 to 6.7% in 1993. This decline was a consequence of the widening gap between prices of farm inputs and producers' prices. Agricultural employment was about 8.4 % in the same period. The average rate of unemployment for 1994 is 14.2%. From the total 146 state farms none was privatised in the 1st round of privatisation and 5 were privatised in the 2nd round by 1 January 1995. New trade corporations, based on the assets of co-operative farms are being founded to farm the land. The land market is still underdeveloped.

1.8 *Former USSR (FSU)*

The term "former Soviet Union (FSU)" used throughout this report refers to the group of individual countries of the former USSR. Because of limited space this article will mention only some of the principal problems of several of them. The governments of the FSU countries, to differing degrees, have pushed forward a number of reforms consistent with a transition to a market economy, such as price liberalisation, privatisation, decentralisation of State procurements, and subsidy cutbacks. These measures have had the effect of lowering import demand. However, at the same time, most FSU governments have attempted to maintain employment and arrest the downturn in production. Both have been at the expense of higher inflation.

Lower FSU imports during the last years resulted from the restructuring in the FSU economies and agriculture as those countries have undergone economic reform and have had to cope with substantial external debt. Grain use has declined considerably as livestock inventories in the countries of the FSU have fallen. Falling animal numbers are a result of price deregulation, which lead to a drop in real incomes and consumer demand for livestock products, and decreased agricultural support to the livestock sector, as the FSU governments eliminated much of the considerable producer and consumer subsidies for meat that existed before the reforms. Reduced grain waste and losses, including a sharp drop in feeding to animals, have also contributed to decreased grain utilisation. High external debt and large budget deficits have influenced the situation in agriculture of FSU.

Other important factors: such as the general economic situation; farm incomes, prices, interest rates, and the breakdown of ties with suppliers from other FSU countries have contributed to a reduced demand for farm machinery. Farm machinery prices have increased rapidly.

Machine breakdowns and lack of parts have always been a problem in Soviet agriculture. However, in the past, farms could overcome some of the problems by ordering more machines then needed, using some as reservoirs for spare parts. In the current climate this is not feasible. The machinery remaining on farms is becoming older, and shortages of spare parts are making fewer of them operable. One-third of Russia's agricultural machinery-building capacity has come to a halt. In an effort to increase demand for agricultural machinery, the Russian government has for example provided subsidies to help farmers purchase it.

The Russian government in June 1993 approved a federal development program for the agricultural machine-building industry. Government representatives state that the industry has not advanced much since the 1960's and is a technological laggard. Consequently, the farm sector is as badly equipped now as it was in 1960's, and it is estimated that about one-half of Russia's farm machinery is out-of-date. The program sets out priorities of farm needs and specifies the equipment that is needed by 1998. The program is budgeted of about 9 trillion rubles (U$ 9.6 billion at 1993 exchange rates) over the next 7 years. The government's share will be about 960 billion rubles (U$ 1 billion) for research and design work.

In addition to the financial woes facing the farm sector, which is dampening demand, the farm-machinery-production sector may not be producing the type of machines demanded. The present factories used to build farm machinery were designed to supply state farm and collective farms with an average size of over 5,000 ha. Reforms have generated a new class of private farmers. Since land reforms began, approximately 270,000 farms have been established in Russia, with an average farm size of 42 ha. Meeting the machinery demands for these farms will require the development of smaller machines.

2. Conclusion

Developments in the farm-machinery-production sector depend on overall economic situation in a country. Among the factors that affect demand for capital goods, such as farm machinery, are prices (inputs and outputs), farm incomes, debt (an indication of a farmer's ability to invest), interest rates, farm size and the age of the machinery stock.

A considerable decline in GDP and of industrial output occurred in all countries of East and Central Europe during the process of transformation to the market economy. As a consequence of the price liberalisation, the prices of industrial goods are several times higher. As approximately three-quarters of the costs in agriculture are inputs of industrial products (fertilisers, machinery, fuels, spare parts etc.) and hired services, the prices of agricultural products have also increased. These increases have been further magnified by the food processing companies adding to their mark-up to the retailer, and have resulted in very high food prices for the final consumer.

The considerable increase in the price of food has caused a decline in consumption. Although it has brought supply and demand into balance in the countries with formerly insufficient food production, in the countries with overproduction, or a well balanced supply and demand it has resulted in drastic declines.

As a consequence, many farms and agricultural companies are in a difficult economic situation, and besides other measures they have had to reduce their purchases of machinery. On the other hand the situation in some countries after the transformation of the economy has stabilised; and progressive agricultural companies and farms are planning the purchase of new machinery suitable for their size and needs.

The basic characteristics of agricultural machinery suitable for the countries of East and Central Europe are practically the same as those of machinery for other developed countries. High powered machinery constructed for farms with big areas of land will be used in many of them. E.g. the average area of land per agricultural enterprise after privatisation in Czech Republic is 1,135 ha, but there are also enterprises with an area about 4,000 ha. Specialised machinery with high labour productivity will be necessary for such farms. The number of contractors will grow, and they will also buy new big machines with high throughput and high labour productivity.

There also exists a sizeable group of enterprises (small family farms) with a small area of agricultural land. The need for small size mechanisation suitable for those farms will be higher now, especially in some countries of East and Central Europe. Farmers will prefer universal machinery equipped with some adapters for different jobs.

The changed political and economic conditions in Europe have also brought important changes for producers of agricultural machines in those countries. Many of them are fully aware that they have to produce machines of good quality and high utility, fulfilling strict criteria of energy consumption, long service life and operational reliability. In the same fashion, perspectives on the operational safety of machinery and the protection of our living environment are important.

Several new manufacturers of smaller and simple agricultural machines have grown up in some countries of East and Central Europe, where there has been a considerable fall in industrial production. Many small business organisations and dealers have recently entered the field.

A number of companies already co-operate in mutually advantageous programs with well-known foreign producers of agricultural machines. The goal should be to deepen such co-operation and to be involved in their commercial networks.

To summarise, producers of agricultural machinery and related enterprises should offer to all their customers - private farmholders; reorganised agricultural co-operatives and also traditional large-scale agricultural producers - all the range of equipment - tractors, special purpose trucks, installations for plant production as well as livestock farming - that meets their specific and often very different needs at a fair price for acceptable good quality.

References

[1] FAO Yearbooks 1988-1993
[2] Czech Statistical Yearbook 1993,1994
[3] Reports of Organisation for Economic Co-operation and Development
[4] Report: Basic Principles of the Agricultural Policy of the Government of the Czech Republic up to 1995 and for a further period
[5] Report: Former USSR (Economic Research Service US)

Table 1 - Data of agricultural machines in Czech Republic

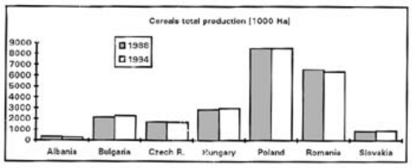
MACHINES	1986-90	1993
Tractors:		
- number	102,634	85,000
- number of replaced	4,916	600
- average age	9.6	12.0
Combine Harvesters:		
- number	14,615	13,400
- number of replaced	900	80
- average age	7.1	10.0

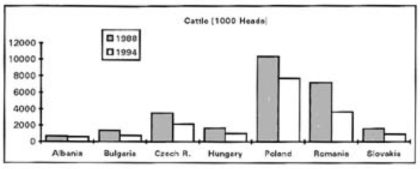
Table 2 - Basic data from some of East and Central European Countries

DATA	UNITS	COUNTRIES								
		ALBANIA	BULG.	CZECH REP.	HUNGARY	POLAND	ROM.	SLOVAK REP.	RUSSIAN FED.	UKRAINE
Total area (1993)	1000 ha	2,875	11,091	7,886	9,303	31,268	23,750	4,901	1,707,540	60,370
Arable land (1993)	1000 ha	577	4,063	3,173	4,748	14,305	9,341	1,483	129,500	33,334
Perm. past. (1993)	1000 ha	424	1,811	873	1,157	4,047	4,852	835	76,200	7,473
Forest (1993)	1000 ha	1,048	3,874	2,629	1,764	8,785	6,682	1,991	778,500 F	10,331
Total population (1994)	1000	3,414	8,856	10,295	10,266	38,544	22,733	5,333	147,370	51,465
Econ.active popul. (1994)	1000	1,659	4,389	4,800	5,212	19,824	11,692			
in agriculture (1994)	%	45.7	22.5*	5.1	9.5	18.2	17.1			
Cereals total production (1988) (1994)	1000 ha	350 266	2,117 2,283	1,677 1,654	2,838 2,958	8,439 8,481	6,532 6,329	838 868	- 54,304	- 12,053
Cereals yield (1988) (1994)	kg/ha	2,925 2,601	3,712 2,814	4,550 4,097	5,156 4,027	2,904 2,566	4,760 2,767	5,310 4,296	- 1,449	- 2,726
Cattle (1988) (1994)	1000 Heads	672 630 F	1,649 750	3,481 2,113*	1,664 1,002	10,322 7,696	7,120 F 3,597	1,594 916	- 48,900	- 21,607
Cows (1988) (1994)	1000 Heads	246 F 325 F	648 418	1,247 791	580 420 F	4,940* 3,866*	2,000 F 1,800 F	568 370	- 20,000	- -
Yield of milk (1988) (1994)	kg/yr	1,412 1,600	3,358 2,714	3,847 4,087	4,871 4,537	3,121 3,161	2,150 2,000	3,616 3,122	- 2,200	- -
Pigs (1988) (1994)	1000 Heads	214 86 F	4,034 2,071	4,686 4,071	8,216 5,002	19,605 19,466	15,224 9,262	2,698 2,179	- 28,600	- 15,298
Agric. tractors total (1989) (1993)		12,100* 9,049	53,210 47,410 F	103,753 78,000 F	50,388 39,000	1,152,644 1,155,600	151,700 146,790 F	37,438 33,000 F	- 1,200,000	- 425,437
harvester-threshers (1989) (1993)		1,770 765	7,865 7,690	15,057 11,800	10,762 8,500	77,489 84,000 F	44,799 42,686 F	6,442 6,000*	- 350,000	- 101,293

Notes: (F) FAO estimation
(*) non official data

Figures:


Cereals total production [1000 Ha]
1988
1994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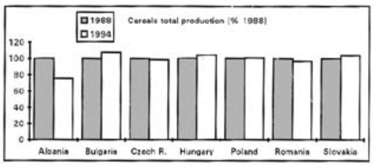
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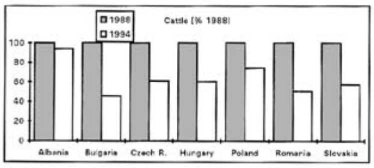
Cereals total production [% 1988]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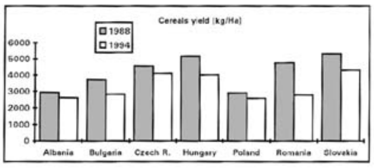
Cattle [% 1988]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1988
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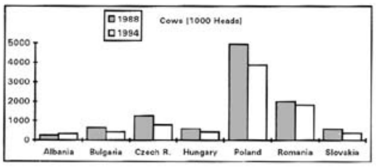
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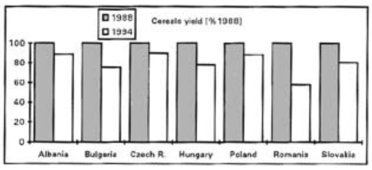
Cows [1000 Heads]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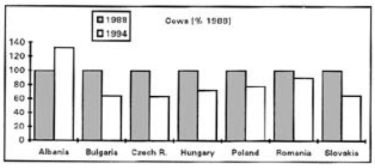
Cereals yield [% 1988]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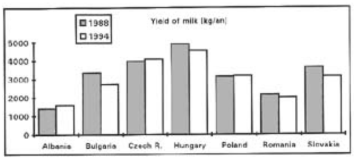
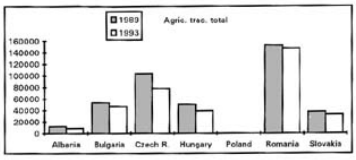
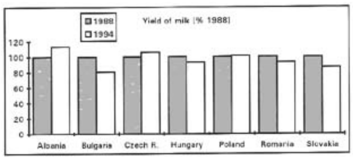
Cows [% 1988]


1988
1994
Yield of milk [kg/an]


1989
1993
Agric. trac. total


1988
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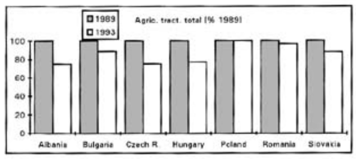
Yield of milk [% 1988]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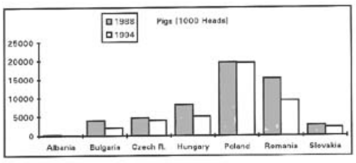
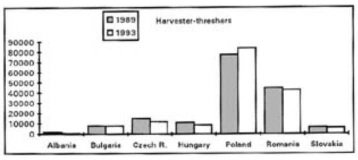
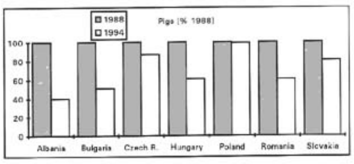

1988
1994
Pigs [1000 Heads]


1989
1993
Harvester-threshers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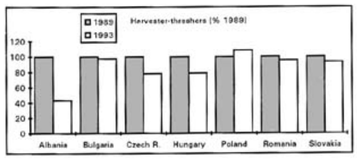
1989
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Harvester-threshers [% 1989]

24 - 2

A.M. EL HOSSARY

We experts who work in developing countries are perhaps overly fascinated by sophisticated machines. Although there's nothing wrong with that, the problem is that these manufacturers send their machines to developing countries, who are obliged to buy them under the terms of soft loans or grants offered by industrialized nations. I am preparing a study on twenty developing countries, and I've found that often these sophisticated machines work for 200 hours and then end up in the scrap yard. So, although I respect these machines, I am afraid they get a bad reputation. Not because of their sophistication but because, in many of these countries, after-sales service and spare parts are not available. For example, I found 25 pieces - 245 HP - that were stopped due to a fuse and nobody knew what it meant, because the people weren’t trained. We would like these manufacturers to take a different approach to the developing countries, and work together with us to find appropriate technologies.

Dr. Amir U. KHAN

USA

Often, manufacturers in the developed countries produce one model which they export all over the world, so whatever they develop for the home market also goes to the export market. I think that the automobile manufacturers have done a slightly better job in this respect. For example, Peugeot exports cars all over Africa, but they all have a certain type of engine and Peugeot won’t supply the very sophisticated cars sold in France, the USA and in other places. They adopt a sort of dual approach within their own possibilities, and supply simpler versions to the developing countries, but without really changing the basic design. Toyota does that all the time: in certain markets they will sell only certain types of engines to avoid creating problems. I think tractor manufacturers should learn something from this automobile experience, and can probably apply some of the techniques. They should start thinking along the lines of making a fairly sophisticated machine for the developed market, and then a simpler version with minimum changes for the developing countries. We aren't talking here about countries like India and China, with a domestic tractor industry, but about many other countries who don't have the possibility of producing their own tractors. When manufacturers in developed countries design for their own market they should consider marketing a simpler version of that machine in these developing countries. This problem concerns only manufacturers in developed countries, because manufacturers in developing countries are already aware of this and have chosen simpler machines for these reasons.

L. FISCHER

I feel that similar differentiation is also necessary in the North American and European markets. There is a demand for highly sophisticated products: some purchasers really use that level of sophistication, while others buy highly sophisticated products thinking of their resale value after three years or so. But there is also a need, in North America and Europe, for a low cost product. It must undoubtedly have high quality, but with lower specs. We've seen how manufacturers like Zetor or Belarus do have their market and, if they manage to provide quality, their market share will dramatically improve. We, too, have poor farmers in our regions who cannot afford to buy highly sophisticated products.

O. MARCHENKO

I would like to comment on that. We should first of all distinguish between the problems and objectives of developed, developing and in-between countries. The main problem in developed countries is overproduction, and they use highly sophisticated machines to cut costs and reduce environmental impact. And of course, this technology includes the use of sophisticated chemicals, biotechnology, and so on, all of which fall into one sphere of activity. What about developing countries? Their main goal is to increase food production, which is now also an objective in the former Soviet Union. In this context of producing more food, mechanization will be a little different. It seems to me we should first discuss developed countries, then consider the next presentation, and finally try to work out some comment approach.

A.G. RIJK

For developing countries it is a common problem, that of receiving equipment delivered as part of foreign projects, under concession loans or whatever. We have seen this in the past a lot, particularly in Africa, and we're all familiar with the pictures of scrap yards full of tractors that worked for 200 or 300 hours and, while virtually brand new, broke down simply because there wasn't the infrastructure to support that equipment. Before I joined the FAO Agricultural Engineering Service we had some eleven trust projects supplying tractors to African countries, and after a few years all the projects failed, and so did the tractors. The Agricultural Engineering Service has recently adopted a completely different approach, this time in Albania. There we are helping to set up a national network of equipment dealers, support infrastructure and so forth, and letting farmers choose what equipment they want to order from the donor country. In the beginning there was a resistance from all directions, from the donors and, of course, the manufacturers. But I explained to them that setting up a dealer network to support their equipment would, in the long run, be much better than making a quick buck and getting a bad reputation, and never being able to get back into that market. So they accepted that I handle the project, which has been running now for almost six months. Some of the dealers we were supporting are actually here, visiting the show to see all sorts of equipment. I hope that in the future these problems will diminish, and I think most donors now realize that it was a very bad way of handling the situation.

B. CHEZE

Dr. Schueller's excellent paper reminds me of a 1991 symposium in Chicago, on automated agriculture for the 21st century. It seems to me that, in contrast with the very futuristic ideas expressed at that seminar, you are getting back to a more realistic approach. In fact you didn't really mention anything about robotics, automation and the like. I wonder whether the US is now putting less emphasis on this robotics aspect. A second point, concerning Dr. Marchenko's mention of biotechnology, is that - putting apart the rather difficult ethical problems - biotechnology could have significant effects on equipment. We might even envisage that genetically self-protected seeds or plants would mean the end of spraying equipment and pesticides. How do you in the States see the evolution of biotechnology, and its effect on equipment? My final point concerns training. You discussed the evolution of the training of engineers, from mechanical to biological, etc. I would like to know if there is now also an effort to develop systems engineering as such in universities, because I think that's also part of the future for agriculture engineers.

Dr. John SCHUELLER

USA

My talk focused essentially on the technologies that we will be starting to see in the market place. There are keen research efforts on robotics - not the excitement there was once of thinking that robotics would solve all the world's problems - but we may soon achieve results that will solve some of them. I think the recent advances in computation and vision systems, in the hardware and software, have opened up the possibility of more use of robotics. The same thing happened in the manufacturing industry. After a lot of excitement we thought we'd been overly enthusiastic in thinking it could solve every problem, then we went through a phase of quiet disillusionment, and now we are finally seeing some results. Not a lot of robotics has been commercialized, but we may see more coming. With respect to biotechnology, we now have things like seeds protected against herbicides, but so far they haven't had a significant effect on the commercial market. I don't think sprayer manufacturers are afraid of being put out of business yet, because there always seems to be a new pest that none of the existing controls are able to get rid of it. And finally, on the subject of training of engineers, I would say that the US academic system moves slowly. Of course all students, engineering or otherwise, are very accustomed to using computers, but unfortunately that is mainly for word processing. There is some training in what we would consider systems engineering: responses, the study of system dynamics, and doing some simulations.

G. SINGH

My paper referred only to India but I think some of the lessons can be applied to other countries. Because of the very good support price for agricultural products in India, farmers have been able to invest in mechanization. I think it's a fact that farmers cannot invest until they get returns, and this has been the case: these good returns to farmers have produced a rapid increase in mechanization investment. Tractors sales are about 170,000 per annum now, pumps are at 700,000 and threshers are at about 300,000. All this despite the fact that - due to the population increase and our tradition of dividing land among the sons - the average holding size continues to decline. So because of the small size of fields and holdings, our main market will be for small tractors. Right now there is a need to increase the annual use of tractors in farming operations, and for this we need to develop high quality equipment. This is a problem because our small scale manufacturers of agricultural equipment don't have the research and development capabilities to invest in improving the quality of machinery. This matter has therefore been discussed and opened up to other sectors. In India the population is growing at the very high rate of 2.1% on a base of over 900 million people. So, in spite of a very comfortable food situation now, our food requirements will be rising so fast that we can hardly sit back and relax if we want to fully meet future demand. In this scenario of continuing improvements in production technology to increase yields, mechanization will play an ever more significant role in increasing food production.

K. TH. RENIUS

I think that, in the coming years, the Indian example of production of machinery for developing countries will be very interesting. I have some experience of this because we are helping an Indian vehicle company to start up a tractor business from nothing, and it's very interesting to see how this is developing. I agree that the requirements are simplified specifications, extremely low price and high durability, for some components higher durability than in Europe and in the US. This is not so easy to implement but there are possibilities if the right people work together.

H. GÖHLICH

Another topic that hasn't been mentioned yet, and that I don't think should be excluded completely, is energy: the energy supply for agricultural operations. I would like to ask John Schueller about this point. In US agriculture, are there any developments or perhaps even applications in the area of energy crops?

J. SCHUELLER

The main point is that in developed countries, due to the high use of fertilizers and so on, the energy consumption of producing grain crops and the like really makes it uneconomical to produce liquid fuels from agriculture. A more favourable situation can be found in some developing countries where - as Prof. Singh showed us - they use less fertilizers per unit of agricultural production. There has been a lot of research but it hasn't been very successful, I think, and there is certainly no commercialization at this time. There is a lot of effort on things like trying to burn soybean oils in diesel engines. But we will have to wait and see, I am not so optimistic about it. A question for Mr. Singh: I know India has very strong tractor manufacturing industry. When I visited the country several years ago you were only producing 700,000 a year, which is still a large number, but it seemed to me that for political reasons many government institutions catered more to "poor" farmers, with the emphasis on bullock type work, and were perhaps neglecting the need to support mechanization and safety. India has now overtaken the US as world leader in automobile accidents, and I suppose tractor accidents can't be far behind. As an example of a successfully developing country, do you find there is political resistance to providing agricultural engineering support for adoption of technology?

G. SINGH

This question is a very serious concern. Up until 1991, the government heavily emphasized animal-drawn equipment, and most research funding was along those lines. But then the liberalization policy removed all constraints and restrictions on industry, which led our industries to develop their export potential. As a result, our quality began to improve as companies produced not just for domestic markets, but also with an eye towards exporting overseas. As far as tractor safety is concerned, suffice to say that we don't even provide proper seats. Other than the spring under the seats there is nothing, and in many cases there is not even a spring under the seat. There is no cover or hood on the tractors as required. But we are now, for the first time, thinking of introducing some standards on roll-over bars, and human engineering aspects are now being incorporated into designs. There is no legislation but the Indian Bureau of Standards - I am chairman of that committee now - is introducing a number of standards that we will then incorporate into the testing procedure. Only those items that meet these standards, not only for the engine and accessories but also for the safety-related components that are part of the tractor, will pass. I think that with these processes we are moving in the right direction. India is definitely looking towards exports, especially to African countries where, as a matter of fact, Mahindra & Mahindra, has a reasonable market. I've recently read that all the Massey Ferguson goods produced in India by the Tafe Tractor and Farming Equipment company have found a market in the USA, and I'm sure they will now start entering many other countries. An encouraging possibility is that European or North American manufacturers might collaborate with the existing Indian tractor manufacturers. The Japanese, also, will be very much encouraged - like Kubota - to do this for the Indian market, to improve the quality of products in India as well as develop it for export purposes.

Dr. E.U. ODIGBOH

Nigeria

Africa's developing countries have in the past been strongly dependent on the developed countries for their agricultural mechanization hardware. But as time goes on the machines and equipment from these sources are becoming larger and larger, and progressively more and more sophisticated, to the point that they are literally unsuitable for operations in Nigeria and similar countries. Unfortunately, those who make the decisions - somebody mentioned political resistance, sometimes in fact I call it political ignorance - still choose this sophisticated equipment, resulting in the scrap yards mentioned earlier. I think that, if the developed countries are willing to help, they should take note of the statement made earlier about how some donations can actually obstruct progress. We believe that our success and our future will depend more on a development process similar to that of India. Perhaps the Club of Bologna could promote and assist agricultural mechanization in countries like Nigeria, along the lines of the Indian model. I think that for mechanization to be successful, a great deal of the hardware should be developed locally.

Dr. Yoshisuke KISHIDA

Japan

I have some questions. First, how can you assist farmers in developing know-how? In Japan I met several top farmers who all had agricultural know-how, which they had acquired through years of experience. But this type of farmer is becoming rare. Some rice farmers, for example, add fertilizers by observing the colour of the rice fields - they apply different amounts of fertilizer in different places. But in recent years it has become rare to see younger farmers performing this kind of operation. Perhaps we should transfer this know-how to artificial intelligence? This kind of thing has happened in other industries, for example steel manufacturing. But the problem now in steel manufacturing, after shifting the operators' know-how to the computer, is that after a while there is no further progress in production methods. How can we solve this problem?

J. SCHUELLER

That's a good point. First of all, to your skilled farmer I would say that the younger generation can undoubtedly learn those skills too. Obviously, the tools of technology should assist in rather than take over decision making, which ties in with our previous discussion about modelling. Those, too, are all aids for decision making. The idea is to process vast quantities of data and then let the humans, with their pattern-recognition abilities and so on, make the actual decisions. I completely agree that if the farmer can see the variations he is better off controlling the fertilization himself. But very often people cannot see them, or cannot measure their magnitude - they might see the variations but not the magnitude.

Mr. Terry L. WILES

UK

In my presentation I highlighted the vast agricultural diversity in Latin America, and the situation that has developed over the past few years. There is a tremendous diversity in farm size and cropping intensity, and even on quite sophisticated farms there are very high levels of hand labour. So, as far as mechanization is concerned, we range from highly sophisticated large scale machinery right down to hand tools. This creates a tremendous amount of opportunities but also great confusion in the minds of those trying to market equipment and those trying to formulate policies related to equipment. I chose pesticide application equipment as a case study to illustrate a few points and I think that - in terms of what the Club is about and what your interests are - this particular example can teach us some important lessons that don't just apply to pesticide application equipment, they apply to almost the whole range of farm machinery. Pesticide application equipment is a neglected area that deserves much more attention. In many of the Latin American institutes that we visited on the FAO study, spares were not considered agricultural implements so the faculties of agriculture wouldn't handle them, nor would the environmental department or the crop protection department, they just got left in the middle. Some manufacturers make equipment without a real understanding of the pesticides that go through that equipment and the damage they might inflict on the environment and on individuals. Therefore, what we're looking for in Latin America, and this also applies to much of the developing world, are appropriate designs. A complication we have now in Latin America is that formerly, tariff barriers meant that local manufacturers produced machinery for their local market, but now that tariff barriers have gone down, the market is open for imports. Latin Americans in general are very well informed - they're on the internet, they're tapping in to the sort of information John's been talking about, and there is a wide range of opinions about what sort of equipment is needed. They've got a competent national manufacturing industry in the major countries like Mexico, Brazil particularly, and Argentina. A lot of that equipment is being exported within Latin America, and the contribution from one country to another tends to produce equipment suitable for local agricultural needs. But everything is limited by education and awareness in the markets, amongst policy makers, and amongst professionals. Therefore, I would say that in Latin America there is a major need, a major opportunity and a major challenge. I would like the Club of Bologna, and the other organizations represented here, to think about how to assist in developing policies - how to help the government and the private sector formulate mechanization strategies appropriate to this rapidly developing agriculture.

Prof. Pavel KIC

Czech. Republic

In my presentation I discussed the agricultural situation in the Eastern and Central European countries. These countries have seen major changes in the political and economic situation over the past five years, and in some of these countries the process of transforming and privatizing agriculture is now complete. There are now some new, smaller private family farms, with an average area of about 20 hectares, but there are also many cooperative farms that were transformed and privatized, whose average area is about 1,000 hectares. So the problem faced by farm machinery producers is how to provide suitable mechanization to these diverse farms: ranging from small machines for family farms up to big machinery for large scale operations. The problem of most of our farmers and cooperatives is that they don't have sufficient capital to invest in buying these quite expensive machines. So the machinery should be of acceptable quality but at lower prices.

Dr. Gichuki MUCHIRI

Kenya

I agree with my colleague from Nigeria, however I put to you a pessimistic view of his concern. It seems to me that India developed by closing itself off from the outside world from the time of Nehru. They developed their technology based on their internal capacity, and they are very big. China has also been developing its economy by closing itself up and looking inward. I think we should give a very sincere objective response to my colleague from Nigeria. I don’t believe Western Europe will go out of its way to specifically develop Africa, because if that were the case it would have already happened by now. And we have a lot of debts to pay. What I would like to see from the Club of Bologna and from Western Europe is fair sharing of knowledge and technology resources, within a free market, in a new world where we believe that survival will come from all of us having enough to eat. So what I would like to ask the Club of Bologna is to have the good will to collaborate, which will help a lot because Africa has the capacity to develop like India, but we do need the good will.

A.U. KHAN

I would suggest that manufacturers in developed countries try to restrict their marketing of very sophisticated equipment, especially under the aid programs we've talked about. They should try, as far as possible, to sell fairly simple machines either produced by them or in collaboration with India, Turkey and other such countries.

H. GÖHLICH

I think that one important point is persuading farmers to accept machines described as having a lower standard or a developing standard.

Dr. Vincent BARON

France

I think low sophistication tractors or equipment does not mean low quality. There is a need for high quality and there is a need to assist the R&D and training institutions of developing countries, with equipment design methods and with the training of operators and technicians.

J. SCHUELLER

Having visited four of the about a dozen tractor manufacturers in India, I feel that the success of that industry is due to the local competition between those manufacturers.

Prof. Gary WELLS

USA

I think that the incentive to develop technological advances in agricultural machinery follows expectations of profit. The USDA projection of who is going to produce agricultural commodities in the future indicates that developing countries will be playing an ever increasing role.

Prof. Maohua WANG

P.R. China

I think that in the developing countries, when we adopt selected agricultural mechanization, we should consider yield increase technology first, cost-saving technology second, and thirdly we should look at technology to support construction of the agricultural industry - not just for crop production, but also to expand rising industries like animal husbandry and the processing industry in rural areas. I think it's important that the Club of Bologna encourage technical transfer from the developed world to developing countries. On the subject of quality: China - like India - has a large agricultural machinery industry with relatively low quality but very low prices. For example, in China now for transportation we have 3.7 million rural transporters, and they costs only 1,300 US dollars.

Dr. Henry JIMENEZ

Colombia

Considering that the agricultural sector is a basis for political and economic stability in every country, I think another recommendation could be to support education and research projects for developing countries, and the extension of programs for them.

Prof. Bill STOUT

USA

I don't think we can develop meaningful answers to such complex issues in a few minutes. My proposal is that the Club of Bologna develop a home page on the world wide web or a list-serve on e-mail, which most of the world can access quickly and easily, and then we can proceed to develop answers to these very difficult questions.

Dr. David J. WHITE

UK

I think developing countries should specify their own needs, because they know them best, and try to find manufacturers who are sympathetic to meeting those needs and, most importantly, who will help them set up home-based production on a regional scale, to meet the needs of individual regions.

T. WILES

I would like to endorse the previous speaker's comment. I don't think that the solution for Africa lies in wholesale transfer of the Indian experience. That is a good example which should be carefully studied, but its more important, for Africa, to set up R & D with an emphasis on development rather than research. We should revitalize education, involving the private sector throughout, right from the beginning, otherwise it will be an artificial exercise.

Dr. Massimo PARENTI

Italy

I fully support the proposal. I would just like to point out the importance of tractor specifications, because we must give the developing countries suitable products. And even more important - in my opinion - is developing the infrastructure for service, after-sales, training, etc. to support the agricultural machinery.

Eng. Uri M. PEIPER

Israel

The numbers involved are exceedingly tempting - one billion people in China, one billion people in India - the market is tremendously large. I have a friend who would like to sell one tractor for each Chinese, which would give him enough work for the rest of his life. Generalization is one of the problems that wasn’t tackled here: we tend to aim for a recipe that will answer all the questions, and this is very difficult. Some developed countries actually went through the same process several years ago. We should try to help developing countries avoid making the same mistakes we've made, by giving them technical advice, more extension service and technical assistance.

E.U. ODIGBOH

We specifically asked for profit-motivated local manufacture of agricultural machines in partnership with firms who are willing to assist, funded by international donor agencies to serve the African sub-region.

Dr. Hugo A. CETRANGOLO

Argentina

I think that in countries like Argentina, economic globalization and the decrease in cereal subsidies will mean that the technology level will have to increase during the coming years if we are to remain competitive on world markets.

Prof. Bassam A. SNOBAR

Jordan

The malfunction of tractors should be taken into consideration in the needs of developing countries, and they should not ignore the most important factor that is safety. Major manufacturers still supply us with extremely basic tractors that don’t have any safety features like roll bars and so on. I want to stress that no matter what you do to simplify your design or reduce its cost, two things have to be taken into consideration: quality and safety.

Y. KISHIDA

Our history shows that the most important element for promoting mechanization in developing countries is the private sector. Without developing private industry in a country it is very difficult to promote mechanization. How can be develop such an industry? Effort should be directed towards developing a suitable design that can provide profit for the manufacturer, profit for the dealers and distributors, and profit for the farmer. If we can design such a machine, industry will automatically develop it. But achieving this requires not only the work of research institutes, but also a major contribution from industry in the developed countries.

A.M. EL HOSSARY

A quick point about Eastern European countries: they need to promote investments in farm machinery multiform use to help farmers to regain the high yield they used to obtain before. The original mechanization-development networks must be technically supported by the industrialized countries and international institutions.

Mr. Bernard BONICELLI

France

For developing countries, the only solution is to employ good mechanization - sophisticated or not - to face up to the real problems of development. We think that special and adapted methods of engineering and design are necessary to define products that are valid - economically and technically - for the present and the future.

B. CHEZE

Let’s be optimistic and view Africa as a single-nation continent like India: nearly all the resources for development exist.

Prof. Laszlo LEHOCZKY

Hungary

The agricultural mechanization objectives should be determined by the local specialists in each country, without copying solutions from other countries, regardless of whether they are more sophisticated or developed. Therefore I would like to suggest that Mr. Stout keep this in mind when revising our yellow book.

O. MARCHENKO

I didn't speak about developing countries because in Russia we have even more problems than they do! I fully support the idea of individually-tailored approaches.

K. TH. RENIUS

In my opinion the number one condition is peace and political stability. And the second one is personal relations on a fair and friendly basis. Then everything else will follow.

G. SINGH

I just want to clarify one thing Dr. Muchiri said. India did not develop a tractor industry by itself. Almost all the makes were imported technology from some country outside. What they did was to indigenize that production over a period of time.

Prof. Jan PAWLAK

Poland

I would like to make some comments about Eastern and Central European countries. These countries are not homogeneous blocks, there are some common problems and there are some differences and I would like to point out both. The problem common to all countries in this region is that the prices of agricultural means of production and of agricultural products are rising rapidly. This leads to decreasing inputs and falling production levels; rising costs of means of production and rising production costs for the industries serving agriculture and farming. The difference is that in CIS countries, for instance, the increase in production is needed, while countries like Poland need more efficient production but don’t currently have a shortage of food. There are also different farm structures in the various countries, and different levels of equipment. Prof. Marchenko told us how in Russia there is shortage of appropriate agricultural equipment for private farms, which are on the increase there. The Polish situation is somewhat different because, although a recent census counted about 1,300,000 tractors, 48% of private farms in Poland still don't have their own tractor. So the problem is not solved. In conclusion, there is a need, as in the developing countries, for improved input efficiency in agriculture, in the machinery industry and in the other industries that supply means of production to agriculture. One final remark on Poland: Farm machinery prices tend to rise faster when there are monopoly producers than when there is internal or external competition. Market competition stimulates improved management, economy and organization of production.

A.G. RIJK

I just want to briefly react to Dr. Muchiri's statement that developing countries should probably follow the Indian example of closing up the market, which I don't think is really the case. If you look at India's development when it did close up the borders and had heavy government control, it didn't develop all that well. The Indian economy has started doing extremely well only in the past eight or nine years, and that is because it has opened up the borders and freed the market. Similarly with China: they haven't closed the borders at all. They welcome joint ventures, attract foreign investors, and have significantly curtailed the role of the government in recent years.

G. SINGH

Let me clarify the statement made by Dr. Muchiri which was to some extent explained by Dr. Rijk, from FAO. I said that all the tractor makes in India were originally imported. They were the result of collaboration, of a technology board. Even today all the new tractor makes are produced by joint ventures. Prof. Renius mentioned that new tractors are being developed together with automobile manufacturers and, similarly, the Claas combine from Germany is also establishing a joint venture in India. John Deere is also talking about establishing a factory and a joint venture. So these are not indigenous developments, they are partnerships - technology boards - that are then indigenized over a period of time. Also, although India was closed to imports and exports for a number of years, technology imports were never restricted. Products as such - for the market - might have been, but technology imports were not restricted. During the period when joint ventures were not encouraged, progress was definitely very slow. Only when the economy started opening up to joint ventures and partnerships did these developments take place.

A.U. KHAN

Obviously what G. Singh mentioned indicates to me that in the early stage India brought in technology from outside, and now there is a second stage where they are again doing the same thing to some extent. China initially brought in technology from outside and it seems to me that they have now acquired the capability to develop technology. In India now they have good production capabilities, labour costs are low and economically they can compete very well, but the weakness is the lack of capability to design new machines.

G. SINGH

The capability is there, but we are convinced that rather than reinventing the wheel it is sometimes cheaper and faster to buy already-available technology and develop as a joint venture. What we do is assess the technology, make minor modifications and then progress from there, rather than starting from scratch. We are now seeing significant R&D investments in industry. As a matter of fact, the Council for Scientific and Industrial Research in India has a mandate to raise its own money, and interestingly most of the funding for running this research establishment is coming from industry. This is really the same trend that you experienced in North America and Europe. So the capability is there, and on a number of fronts India is developing independently, but wherever it is possible and economical, to speed up the process, the joint venture route is still preferred. Dr. Khan raised the issue of tractor size in India. The developed world has seen a trend towards tremendous increase in size over the past 15 to 20 years, but in India the size of tractors is not increasing significantly. Tractors of 22 to 35 HP account for two-thirds of sales. We have some difficulty with tractors below 20 HP, but one of the most popular brands is only about 18 HP and its sales have been increasing rapidly over the last few years. In engineering circles, at the policy level, we try to discourage tractors size from exceeding 50 HP. First, because we have a large population base from which we can recruit and train drivers. Secondly, because we wish to avoid the serious compaction problems that you have experienced: we believe this compaction problem can only be minimized by keeping axle loads low, and on very large tractors - no matter what you do - it is difficult to keep the axle loads low. So it is preferable to limit tractor size, and we have tried to stop it at 50 HP.

M. WANG

In terms of agricultural mechanization, China also has a diversity of regional characteristics. Most tractors now are smaller than 15HP - we have 9.5 million small tractors of this type. After 15 years of working towards a market economy, only 7% of tractors are owned by individual farmers, so the scale in China is still very small. However, China's eastern and southern regions have been developing very rapidly, and I think they are now ready for more advanced technology. So a major objective is to considerably increase large-scale farming in this region. In the past, the eastern and southern parts of the country exported grain to North China, but now we should encourage greater use of agricultural machinery to increment grain output in the North. In central China, on the other hand, there is a shortage of water resources so the priority is to encourage water-saving technology. Therefore, to encourage agricultural mechanization we should develop water-saving technology as well as improved fertilization technology, because the efficiency of the use of chemical fertilizers is currently about 30%. Precision seedling technology must also be encouraged, because grain output has increased rapidly - by about 20% - due to the use of improved hybrid varieties. But these new advanced varieties are very expensive, so we must promote precision seeding for them. I think that in China the cost saving aspect is important, in terms of improving the farmer's income by adopting agricultural mechanization or low cost technology. It is also important to encourage the shift of labour force into other industries. In China we have a very strong agricultural machinery industry which I think is capable of producing anything, and the question is whether to accept a simplified design to keep the machinery very low cost. We have also encouraged some joint ventures, combining outside technology with our very low-cost labour force, which is a very good basis for the manufacturing industry. And I think that joint ventures should be encouraged to solve this problem in the country. The main problem is keeping machinery costs low, in line with the country's economic level.

O. MARCHENKO

I would like to ask Prof. Wang how they manage an agricultural system that has 300 million individual farmers and only about 9 million tractors, from 7.8 up to 20 HP? How is the use of tractors organized? Because that adds up to more than 30 farmers for each tractor.

M. WANG

As I said, we have 9.5 million tractors smaller than 15HP, but one third of these tractors are used for transport in rural areas, and only one third are for cultivation. Also, transportation is a very effective solution because first the farmers use their tractors for transportation, to earn some income, and then they use this money to buy other machines for cultivation. However, in East China, the use of these small tractors for transportation has greatly decreased. Instead, they now use three-wheel rural transporters which, as I mentioned earlier, are extremely low cost at about 1,300 US$. Economic growth will lead to more and more tractors being used for agricultural cultivation.

Y. KISHIDA

I would like to comment on Chinese mechanization. I first visited China in 1977 and at that time my impression was that they might take one hundred years to achieve full mechanization. Then 8 years afterwards - in 1985 - I visited China again and was extremely surprised. Their annual production of tractors, including two-wheeled tractors, had already reached 1.4 million. A major jump in just 8 years! I believe this may be the result of the new economic policies. Another reason, perhaps, is that when a farmer gets one tractor, he can make a profit through transportation, which is why farmers were so quickly able to buy their own tractors. I've also observed that China's Ministry for Machinery Industry is very well organized, and implements long term planning for the establishment of agricultural machinery industries. This means that, in China, almost 100% of every component is made in China, which is a very different situation from that of any other country. The result is that they now have very good component industries, so that virtually any type of machine can be made in China. Of course, they need to look overseas for new know-how and new designs, but the most important thing is that they have their own agricultural machinery industry to promote mechanization. This sets China apart from any other developing country.

A.U. KHAN

I think Mr. Kishida touched on a very interesting issue here. I have always been concerned about public sector research institutes dabbling in design, instead of leaving it to commercial companies whose role is important and who have already been successful. My feeling - going back to the comment about India - was that there were many public sector research institutions dabbling in machinery design, whereas the manufacturers seldom had a design component of their own. In my visits to China I've noticed that most design work was done by public sector research and design institutions. Some had links to manufacturers, but they essentially remained public sector activities. I wonder whether this approach - of public sector institutions attempting to solve farming design problems - has been successful. My feeling is that it hasn't been very successful: China, like India, is looking abroad for technology. I initially thought that China, because of the close ties between some institutions and manufacturers, had been more successful in producing effective commercial designs. But it's interesting to note how today both countries are seeking technology from outside, despite the fact that they both have the capability to fully produce what they need. We are doing exactly the same thing with tractors too.

The point is: you must encourage your manufacturers to develop their own technology and designs, otherwise you will not succeed. Public sector institutes cannot replace this all-important activity from private sector people. For developing countries, encouraging industry is an essential policy that holds the key to the future. Yet I see government officials and top-level policy makers thinking they can handle the job themselves, but this approach has proved a total failure.

G. SINGH

I think there are many similarities between the trends in the Indian and Chinese tractor industries. India's automotive parts industry is expanding very rapidly. India has become a major exporter of automotive parts to Europe and North America, and this is strengthening the industry. But I do agree that India, like China, has a need for advanced technology. This doesn't necessarily mean extremely complicated or sophisticated controls, but rather the technology for things like fuel efficient engines with lower weight. We are looking towards countries like Japan, Europe and North America for this type of collaboration with our industry. The aim is to save time. Industry has started to invest in R&D. Dr. Khan was correct in saying that, in the past, design was left to public sector, but now the public sector and industry are working in partnership, because they both need each other to survive. The public sector is no longer guaranteed the funding it used to receive. Accountability is now coming into things, and they are being asked to raise their own funds. The process the western world has gone through is starting. So, accountability is on its way, and there will be no free lunches any more.

K. TH. RENIUS

I would like to describe an example of the collaboration Prof. Singh mentioned: a 50% privately-owned company that produces special vehicles like small trucks, etc., with seven thousands employees. The chairman of the board had the idea of developing and producing tractors, starting from zero. He convinced his people, most of whom were against him at first, then he looked for assistance world-wide. The concept, about three and a half years ago, was to use the engines they were producing on license from Daimler Benz for the Mercedes 123 car line - the previous model. These were 2.4 litre car diesel engines, with pre-chamber, and the idea was to modify them for direct injection using the know-how of the Austrian Research Company AVAO. This is one of the most expensive research companies, but they recognized the need for this very costly assistance, without any help from FAO or any other government sources. They did this independently, and created this new engine - one of the first car engines converted to direct injection. The next problem was the transmission, and to save time - as Prof. Singh recommended - we examined all the transmissions in the world that could meet the Indian requirements. Out of hundreds of transmission principles, a transmission introduced in the late '60s was chosen, and the rights were acquired through a license at very low cost - less than 100 Deutschmarks. The next step was to make various modifications and adjustments to Indian conditions. For example, the brakes: drum brakes are not adequate for India, you need band brakes. And tooling was started two years ago. Now, the most serious problem was the control valve for the 3 point hitch because in India no company was able to deliver it at an adequate price. We worked hard to solve that problem and finally found a company in France that was still producing the special valves for this transmission, and which were transferred to India. This was all managed privately, and they are now just starting to produce this valve. Another deficiency was test specifications. There is no one example in world-wide tractor technology where any specification for testing is included, nothing available. So we did our best to help them build test facilities to test the design, and they were very good in applying finite element methods. At a very low cost they were able to model the tractor body, look for the weak points and make modifications. I am therefore very optimistic about project. Also, the shares in India went up very rapidly when it became known that this company was going into the tractor business, and they are coming out with series production at the end of next year. To conclude, I think this is a very interesting private idea, accomplished with no support from government, the World Bank or any other source, as far as I know.

G. MUCHIRI

I think that Prof. Renius has aptly expressed what I wanted to say, and has given a good example of what I had in mind. We can identify three basic requirements for Africa: R&D capacity, financing, and the market. We need the R & D capacity to produce a good design, because once we have a good design it will sell itself. In fact, there is local financing available for production and manufacturing - there are African manufacturers who are waiting for a good design. In my own Nigeria, too, there is a lot of idle manufacturing capacity and the market is there for a good design. So Africa has the market for a good design, and it has the financing for a good design that can sell. What we lack is the R & D capacity. So I'd like to make the following proposal to the Club of Bologna, because I think there is something we can do. I believe there are many people in America, Europe and Asia who have a lot of R & D experience and who have retired from their line of business, and are perhaps looking for an opportunity to make a contribution in a developing country. What they lack is a very small financing to locate them in the right place - to start a joint venture with a someone like Prof. Odigboh here - to form a company like the one we were just discussing and get into real private sector business. What is lacking is that seed money needed to live in a country for two or three years, go through the R & D process and come up with a good design. Perhaps the Club of Bologna could raise these small funds, as a contribution to a good cause, to help these committed individuals. Let me say, with a light touch, that the one thing Western Europe exported to Africa without any problems was the Christian religion, which was exported by very committed missionaries like Dr. Livingstone. What we now need are not bible missionaries but engineering missionaries, with the same degree of commitment. We aren't talking here about relationships between institutions or nations, but between individuals who can work together in a developing country. But they need seed money to do this.

A.M. EL HOSSARY

Fortunately, in the African continent there are some R & D institutions. In North and South Africa we have already thought of creating a sort of network for developing farm mechanization systems in the continent itself. I believe that we can do a lot for African agriculture by promoting such an idea: a network that encompasses small, medium-scale, and large-scale constructors as well as the R & D institutions, with the help of the other networks in Europe and Asia. In Asia, animal drawn equipment is flourishing and doing particularly well, and Africa also has possibilities for animal drawn equipment, because some countries cannot afford to buy petroleum. Sudan is one example: I was there to elaborate a project for animal drawn equipment for Sudan. I feel that there are institutions within the African continent that could join together, and we must find ways and means to do this. Perhaps the African banks, the African unities, could sponsor these initiatives, which should be conducted under the umbrella of an organization and financed by the private sector. This is one of the ideas we have to launch.

E.U. ODIGBOH

It's been said that one important condition is political stability, but that is really beyond the control of those involved in these topics. It's interesting to reflect on what Dr. Muchiri said about the missionaries. We aren't looking for hand-outs, what we want are willing partners to help us break out of the vicious circle of poverty - sponsors motivated by profit. A joint venture where you get as much as you put in, based on private relationships and partnership. It has been stated that we have the critical mass of technical manpower, and this can be developed further. But we have been talking about this for the past sixty years, since the '30s, and we still haven't succeeded. We believe that the successes achieved in India can be replicated in some of the African countries. The market is there, and market volume is perhaps just as high as in India and the Indian subregions. So what we would like is to see a farm in India being sponsored and assisted to go into partnership with a farm in Nigeria - I am not talking about government here - just a business venture that I believe will work. We need that assistance, because our governments in general have failed to provide it.

A.U. KHAN

In Egypt there are some manufacturers who went to India, supported by UNIDO, to visit agricultural machinery. There, one of these also saw many manufacturers who were building carts for garbage disposal and handling city garbage. He came back and went into that line of business, and now he is constantly in contact with this company and has worked very successfully, to the extent that he is now a regular producer; He has given up agricultural machinery and has now made a major business out of this garbage disposal at all levels - he still uses tractors for towing and he has these towing things which drop the container, come back and pick it up and all that. I think the point you raised is very important. We had a group of Thai manufacturers, small entrepreneurs, who came out to visit the Philippines. One of them went to Manila in his spare time and wanted to see somebody manufacturing cement flour parts and things of this sort. When I visited Thailand about six months later he had set up a little cement operation that eventually became a fairly big manufacturer of cement containers and the like. What I'm saying is that an entrepreneur has the mind to grasp things and to see market potential. When you send a person from a government, he is just interested in the trip and on looking casually on things. But when you send an entrepreneur he is looking at the possibility of transferring the technology very quickly, in the simplest, most direct manner. That's why I feel that large transfers of people at that level - entrepreneurs who have the decision making capabilities and the technical know-how, who have their own capabilities, their own resources and the will to expand their market - that would achieve technology transfer much more quickly than we can within these organizational structures, meetings and conferences.

Y. KISHIDA

I would like to add some comments on mechanization in the developing countries. We need to develop and create a strong private sector. The best way to achieve this is by having manufacturers in developed countries sending their engineers to developing countries for long periods of time. Perhaps these engineers can do a good job, and design better machinery than the professor does. Because for a design to be successful it must not only be functional, it must also be feasible to produce. Production engineering is extremely important, and manufacturing engineers have this kind of design ability. However, in many cases - in the projects to assist developing countries - governments send engineers from public institutions or from universities. These people can make functional designs, but sometimes they are very difficult to produce using the local materials. For many years I've been asking these industrial people to please send their engineers to the developing countries for enough time. One successful case was what Kubota did in Thailand: they sent an engineer over there for several years and he developed a simple reaper, and now they are producing many products and marketing them to developing countries. But in most cases the engineers in machinery companies are very busy. Machinery companies can be small, medium or large scale, but there are not so many tractor engine manufacturers, and almost all them are small or medium sized. So they have maybe just one design engineer, and for this kind of company it is very difficult to send the engineer to another country. Consequently, it is very difficult to find practical design engineers to send to developing countries. Governments and the public sector must address these problems, which are at the same time old and very new, and come up with solutions.

B. STOUT

I was going to say exactly the same thing, that many of the topics we've been discussing are old issues: The lack of infrastructure, the role of the public sector, the role of the private sector. This is my first Club of Bologna meeting so perhaps I don't understand the purpose of this meeting, of this club. But I would suggest that we need to focus on what this club can do about it and we need to map out an action programme. Perhaps a task force that would bring some industry and public representatives together. I may be wrong here, but I don't think there are many private manufacturing representatives around the table, yet it has been said over and over that the private sector holds the key to solving many of these problems. I hope we can come up with some recommendation for action by this Club and other groups and deal specifically with what we were talking about. Because I have been in discussions like this for thirty years, working for FAO, and many of the things we are saying are not much different today than they were thirty years ago, and we need action.

K. TH. RENIUS

The intention of the Club can be summed up in three principles: to understand issues, to bring people together, and to learn from case studies. The aim, in short, is to break down barriers and to have some material for political application.

SESSION 3

ROLE OF HIGH TECHS TO CONTRIBUTE TO THE MACHINE DESIGN AND OPERATIONS

Chairman: Mr. Yoshisuke KISHIDA, JAPAN

Complex machines engineering: description of the multi-disciplinary design of mechatronics systems for agriculture

by *F. Sevila, J.M. Roger, B. Bonicelli*

France

1. Mechatronics: a new age for Agricultural Machinery

New types of agricultural machinery are being developed under the influence of various social, economic and technical factors:

- the entrepreneurial style farmer is becoming the norm. As any other economical activities in the society, he tend to use the best of the available and affordable technology to run efficiently and securely his company;
- the performance of electronic components and of software development methods are constantly improving, while their prices continue to fall. The potential computing power that could equip a tractor has been steadily increasing during the last 20 years;
- industry and laboratories specialising in automation are now joining their efforts to agricultural machinery manufacturers. The latter are developing their skills and know-how in technologies that they were not using until recently;
- consequently, machines for agriculture include a growing proportion of automation and sensor technology for their executive and mobility functions, becoming complex mechatronics systems for which manufacturers have to apply new design methods.

2. Definition of an Agricultural Mechatronic System

Many agricultural machines are already partly automated, to perform repetitive tasks when set up by human operators. In industry, the term "mechatronics" is more widely applied to machines, operating with more or less human direct involvement on a wide variety of tasks and objects. They include the following components:

- on-line sensors;
- signal, data and information processing systems;
- electronically controlled actuators for more or less adaptive actions.

Whenever an agricultural machine has a complex sub-system that can be described in the above terms, it can be called an agricultural mechatronic system.

3. Complexity of Agricultural Mechatronic Systems

A mechatronic system is designed according to the task it is built for, to its environment, to its manufacturing possibilities, to the user and production conditions. These factors lead the designers of such systems for agriculture to specific constraints, which increase complexity when compared to those for factory use. Some of these specific constraints are described below (Sévila, 1993 for a more detailed approach).

3.1. *Detection in complex environment*

In the case of crops growing in open fields, a machine has to withstand bad weather, dust, and other adverse conditions. The ground can also present different aspects: for example slopes, irregular surfaces, and the canopy can vary significantly. In an industrial environment, machines are not usually beset by so many constraints and variabilities. Moreover the agricultural environment is partly unpredictable: which implies for instance that the machine needs sometime to be equipped with a redundant multisensor system in order to preserve its integrity as well as avoid any damage caused by malfunction.

Among the various sensors which have been put into practice for detection and control purposes by the most advanced projects, machine vision has gained a very privileged role: visual sensors tend to be the best suited type for observing the wide range of sizes, shapes and colours encountered in agriculture. Involving artificial intelligence concepts, these complex techniques can produce impressive results, when appropriately designed and tuned.

3.2 Modelling of biological objects

As for industrial applications, living objects to be handled or transformed by agricultural machines need to be modelled through descriptions using a limited and fixed list of geometrical and physical parameters. Mathematical models have been developed in order to simulate the behaviour or growth or shapes and structures of plants or animals. Most of the shapes and evolutions which are modelled in such models include random characteristics, due to the natural variety of living objects. The construction of such models implies a pluridisciplinary team of engineers, plant or animal scientists and informatics specialists.

3.3 Complex design for simple enough actuators

For each task, actuators (machine acting sub-systems) have to be provided and control through mostly electronic-based servo-systems. Because they have to follow specific constraints due to their agricultural use, they are seldom directly copied from the industrial types actuators. Constraints deal on one side with low selling cost possibilities, random shock and accidents, user experience+education, manufacturing+maintenance actual facilities, and on the other side, with characteristics of the agricultural tasks to be performed.

This leads to design constraints for actuators in agricultural mechatronic. The velocity needs are somewhat higher and precision needs lower than industrial applications. Due to the variability of objects dimensions and positions, the end-effectors have to be adaptive enough to provide the machine the necessary compliance.

The velocity constraints have a direct effect on the powering of such actuators. When increasing the dynamic efforts and torques which have to be generated, the powering systems to choose go from pneumatic, to electric and then hydraulic. The first ones are the easiest to design and implement, because of much wider use on industrial machines and automates. Electricity means ease of control and better precision, while hydraulics give more power and therefore better accelerations, at the expense of the variability of physical parameters (temperature, viscosity, compressibility). Design of hydraulic system control for agricultural mechatronic applications is one of the most complex engineering situation: it always implies a certain level of system modelisation in order for the control unit to predict the responses of such fluidic phenomena to any control order, in any situation of the actuator. Complex multi-technological system detailed representation, as BOND GRAPH, is very useful in such cases.

3.4. *Mechatronic vehicles*

The automated mobility functions (in-field data collections, advancement control assistance, etc.) require the use of perceptive systems composed of sensors and data processors. Compare to other applications there is a still modest, although rapidly increasing, state of the art. This is related to the locating difficulty in agricultural conditions: as well as in military conditions, the main problem which remains in agricultural mobile control is to know where the machine is actually located in an often poorly structured environment, with a wide variability of characteristics. Compare to the manufacturing industry ones, standard agricultural locating problems are more difficult to solve. The differences are based on:

- area of movement: agriculture 1 km^2/industry....0.01 km^2;
- nature of the ground: agriculture: hilly, muddy, uneven/industry: flat, regularly structured and on concrete;
- machine power: agriculture 100 HP/industry, 1 to 10 HP.

The first point implies for instance that current guiding systems like those for AGVS (Automatic Guided Vehicles Systems used in industry since the early 50's) are difficult to implement. The second implies trajectory error sources much bigger for agricultural ground, especially with slopes. The safety problem, and consequently the guidance quality, is much more crucial when the mobile machine is a very powerful one.

3.5 *Artificial intelligence implementations*

Implemented intelligence is at two levels for agricultural machines:

- an intelligent controller is needed for supervising the various functions which have to be run at the same time with a variety of constraints: it uses generally the state of the art in intelligent supervisors for machines;
- operators in the agricultural tasks have to be assisted, especially the non-expert ones, through simulation of among the most complex human behaviours, like perception and decision on biological processes and objects.

Simulations of human perceptions and decisions on complex objects and tasks have been necessary as soon as the very first automated system was developed. For real time and on-machine use, such simulations can not be as complex and powerful as those which may be found in other areas of artificial intelligence applications. On-board computers of agricultural automates can handle knowledge based software's of low level of complexity. This will change rapidly and on board simulation of human expertise will become more and more common. Nowadays tractors or combines have internal diagnostic software's giving the driver advises and warnings, using internally sensed information's. They will soon take more and more global machine operating decisions, taking into account sensors for external information's.

For these operating decision making, combination of the basic and previously learned know-how, with the sensors information's, is still an entire field of research activity for agricultural machines. Especially when those sensors are complex (e.g. image features extraction's), and have to be combined between themselves to obtain an appropriate data base for decision making. New techniques like sensors fusion, fuzzy logic, or artificial neural networks are often appropriate to modelise the complexity of human behaviours on natural objects and phenomena: they often allow easier real time on-board implementation when appropriate components are used.

4. Need for complex design process understanding

As shown in the previous chapter, agricultural mechatronic systems are continuously increasing in complexity, because they include knowledge's coming from more and more disciplines and crafts (not only mechanics, plant-animal sciences and economy, but also electricity, electronics, automation, informatics, artificial intelligence, optics, image processing, physics of sensors, etc.).

Designers have to face this complexity on various aspects:

- In running their own practice in the designing process:
    - how to manage the increasing multidisciplinarity of the designing teams?
    - how to simulate the machine functioning to identify designing problems?
- In the design of the machine control system itself;
- In the predictive design of the machine integration in the user system (technically, humanly, economically);
- In the maintenance of such complex systems at the farm level.

Similar complexity has been handled by heavy organisations, with important means, for expensive developments like in the design of planes, rockets, satellites, cars, etc.. The various expertise's needed in these hundred- to thousands-members teams of designers are combined using:

- appropriate work organisation : for instance, experts are gathered:
    - either in various mono-disciplinary groups, each one working as a group on its speciality part of the global machine;
    - or in various multi-disciplinary groups, each one completely designing a sub-system of the global machine in development;
- heavy computing systems for:
    - combined data management, all information's on the system being appropriately managed to help coherence between the various sub-developments;
    - multi-engineering assistance, each of the involved disciplines having its own CAD, computer aided design system, interfaced data on the system coming for other groups;
    - decision aids, especially for the managers of the groups, inter-groups and project, to run the overall development efficiently until the mechatronic system is designed and delivered.

Only part of these methods and tools can be afforded by the agricultural mechatronic industry, because of the following reasons:

- size of the designing teams, and time available for the design of a new system are much lower;
- flexibility to user needs fluctuations, and reactivity to market competition have to be much higher;
- design costs have to be much lower due to the price paid by the user for the machines, and to the size of the targeted market;
- knowledge's of biological and environmental disciplines are essential for the design of agricultural mechatronic systems, and they are difficult to involve, to handle and to modelise in such computerised organisations.

Without all these powerful design tools and methods to overcome complexity in the design of agricultural mechatronic systems, a solution for this industry is to partly rely on its teams know-how. This one has to be patiently built through the successes and failures of the various systems developments in one company history. It is of strategic importance for the research and development policy of these companies to develop a certain level of understanding of what is happening in a complex and multi-disciplinary design process, and what are the key aspects which have to be secured. The key aspects deal with:

- the most sensitive steps of the process where special care or checking have to be secured: prospective evaluation of risk, or organisation of the design management might depend on them;
- the appropriate profile of the specialists needed at the various steps of the design for the necessary tasks.

This information is essential to define policies for:

- recruiting specialists;
- buying CAD systems;
- building a sub-contractors network;
- starting new ventures on the market.

To look for, and to understand, such key aspects means to be able to describe and analyse, appropriately and comparatively, enough cases of agricultural mechatronic systems developments. Such descriptions should be made from the standpoints of the system itself, and of the team which has developed it. To do so, it is necessary to use knowledge and intellectual processes description tools, which are able to represent and describe these various aspects of such a design process.

From the construction of the original list of objectives for a new system, until the delivery of the developed system to the user, the design process description tools have:

- to completely and coherently describe the mechatronic system which is under development. Each specialist has his own view of the system with his own parameters and concepts to describe it, whether at a detailed level, or at a more or less global one : all these views have to be gathered in the system representation as soon as they are produced during its development;
- to represent the specialists professional attitudes on such complex systems: in particular the reasoning shortcuts that they are taking when solving together the problems described above. These shortcuts are generally based on non-rigorous reasonings related to the personal experience of each specialists of the design teams. It is important to qualify the type of reasoning which is applied at the main steps of the design by the various partners: it might have a major influence on the efficiency of the design process.

5. A Model for the Design Process

Non-rigorous methods of reasoning have been established through human intellectual behaviour observation. They are evidently associated in the every day practice of a designing team, because they unable to take the appropriate shortcuts to overcome the complexity of agricultural mechatronic system. These reasonings apply to the system, using its different parameters, descriptions, and views gathered in hierarchical models. To completely represent the design process implies to understand how these two sets of tools are interacting. To do so the frame of a general representation of the design of an agricultural mechatronic system has been built (see figure).

5.1 *Team knowledge base representation*

Before starting the process, a designing team is considered : it has an existing set of knowledge's and experiences on the design of similar systems. This knowledge can be globally structured using the same composition hierarchical model as shown in figure. All the possible disciplines and crafts which are potentially needed, available in the team or not, are included. All the experiences of the design actors can be classified with it.

5.2 *Agricultural mechatronic system representation*

As shown in figure, any new system to be designed will be also described with the same hierarchical formalism all along the process:

- from the very beginning: the initial set of objectives and constraints for the systems are expressed with it;
- until the end of it: a system delivered to the customer include virtually all the concepts, reasonings, methods and trials which have been used to develop it.

As mentioned in 5.1, an history of a design can be structured with a pile of the successive hierarchical matrix's, each of them representing the system at a particular step in the process, with only the active elements of this step being activated on it.

5.3 *Reasonings representation*

Actions between 2 successive steps, i.e. 2 successive matrix's, are made through the various reasonings of the design actors to solve the problems at this step. These reasonings are made in the disciplines and crafts which are active on these 2 matrix's. The various types of reasonings described in 5.2 can be applied, but actors are usually using the shortest ones, generally non rigorous. The information on the type of reasonings between two steps is part of the future historical knowledge model of the mechatronic system.

5.4 *Total design process representation*

At each step of the design (**Fig.1**), results from the reasoning actions allow:

- to jump to the next step of the design, with a new matrix representation of the system itself;
- to complete or modify the team knowledge base, due to the experience gain by the team actors who are active during this step.

6. Conclusion

The on-going development of mechatronics systems for agriculture has allowed to point two main problems:

- these systems tend to be more complex than the one developed for other applications: detection, modelisation, actuators, mobility, and information processing tend to bring more design problems, because of the natural and biological tasks and environments;
- to manage this complexity, the agricultural mechatronic industry cannot use all the powerful engineering tools and methods that other mechatronic manufacturers are more and more using.

The only solution for this industry is to develop specific know-how's in its design teams which will allow their actors to make experienced shortcuts in their complex design reasonings.

Building such teams and securing their actions imply a certain understanding of the functioning of a complex design process. Tools to describe such a process have been identified. They should allow:

- to describe a system under development from the very beginning of the design to its delivery to the customer;

- to identify which type of reasonings and knowledge's are applied when going from step to step in the design process;
- to represent the design team knowledge base, and its evolution during the on-going design;
- to build an history of the design of the system.

These various representations have lead to the frame of a proposed coherent model of the total design process. When further developed, this frame should help:

- to clarify weakness and strengths in any design team;
- to help the management of design projects;
- to determine the necessary know-how's to be gathered including:
    - profiles of the team members;
    - engineering or decision making assistance which can be sub-contracted or bought through CAD packages.

It is a general result of this first analysis that the professionals who are best suited to build rapid reasoning ability, made of shortcuts for the design of complex systems, have a multi-disciplinary type of profile. Among them, agricultural engineers should be in a good position to help the agricultural mechatronic industry solving its complex design problems.

Consequently, the tools proposed in this report should also help to build the curricula of the future agricultural engineers this industry will need.

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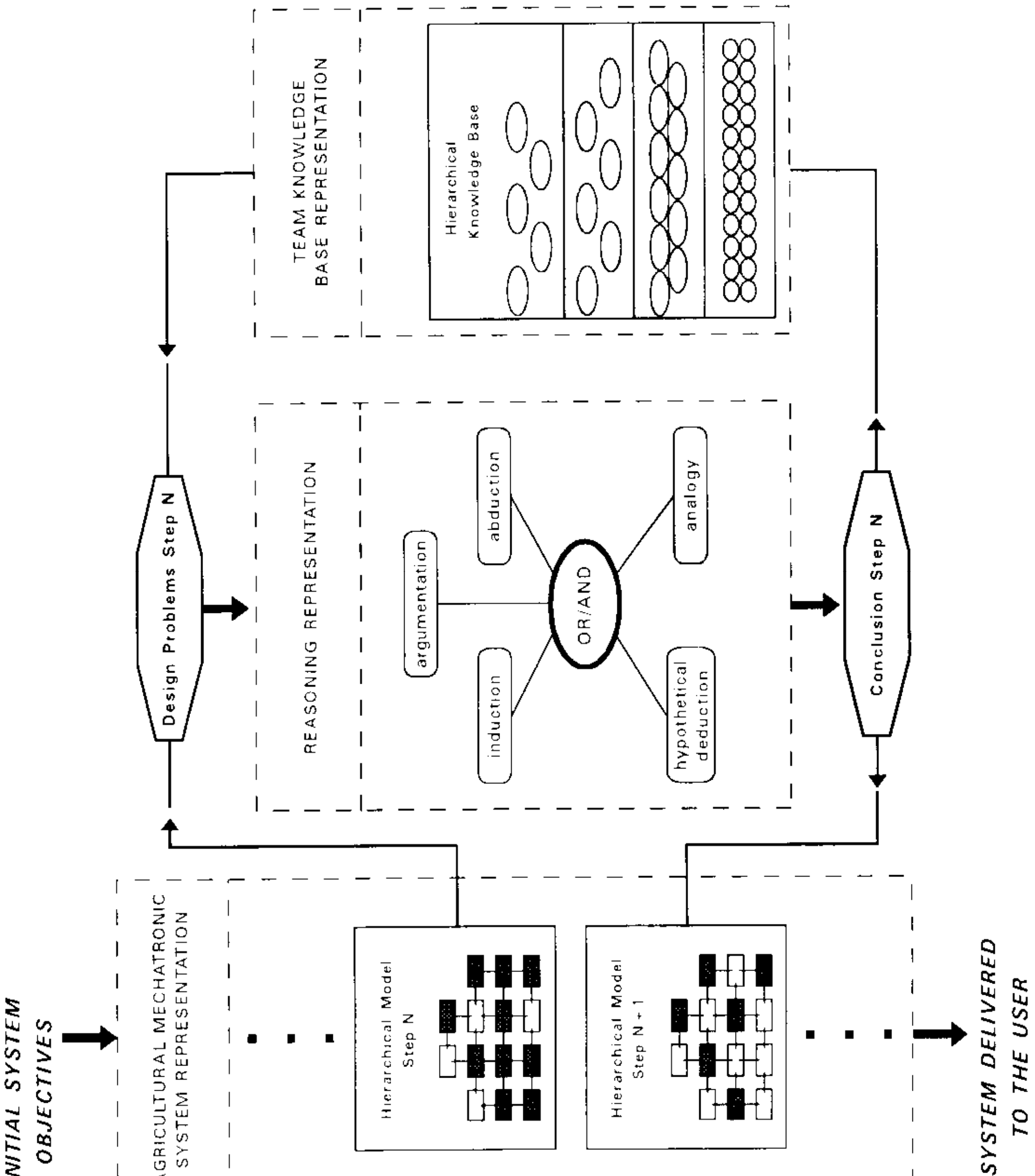
Fig. 1 - Total design system representation



J. SCHUELLER

When we look at high technology we say “It’s very complex and it’s very costly and it’s only for the most sophisticated applications”. But that may not be the case. Prof. Göhlich told me this morning that in Germany they sell GPS receivers, probably not the most accurate ones, but at a cost of 500 DM. The same ones are sold in the USA for only 300 US dollars. A lot of this technology is not that expensive, the most expensive part is engineering it into the system. So what has just been said here is very important. Some of the companies that develop software for tractor engines in particular, as well as other engines, do not hire electronic engineers because the electronic engineers do not understand the application. I think this is an important area for agricultural and related engineers because they understand the application. But we have to realign our educational systems so that the graduates of our various programs are able to do this. While we may not be seeing these very advanced applications in tractors for the developing world, let’s not sell the developing world short. Let’s give them the ability to develop to their full potential.

L. FISCHER

I share your opinion but I would like to add that we do not have the core competencies even in our ag-engineering environment. I think a solution is to look for joint ventures or to buy into those high tech engineering groups which are sometimes very small, very efficient, and make use of that. The trends and techniques are changing faster than these bureaucratic engineering groups and large ag-industry companies can follow.

V. BARON

With regard to complex machine engineering, I just would like to add that it looks like exceedingly complex and high-tech technology, but in fact I understand that some teams are working on applying these technologies in developing countries. It’s more a kind of philosophy integrating a complex approach to equipment design than high-tech technology. I think that Mr. Bonicelli could reinforce this idea, because mechatronics seems to be high-tech, very sophisticated technology, but it’s more a design philosophy incorporating different kinds of knowledge.

H. GÖHLICH

When considering the future education of highly qualified engineers, in our case at the Berlin university, we examined two possibilities: Should we educate mechatronic engineers in the general view of mechatronics resulting in a concrete relation to the application, or should we add a part of mechatronic knowledge to the education of our design engineers? We decided that it was definitely necessary to add a mechatronics component to the education of engineers - meaning electronics in general, a combination of electronic and mechanical work, and mechanical design. A mechatronic engineer alone will have very basic knowledge and will not be able to follow up the development of the new design in the mechanical machine area and similar cases. So, the conclusion is that we can’t separate mechatronics and design, we have to integrate it into design: the future design engineer must have at least a qualified part of knowledge in mechatronics.

K. TH. RENIUS

I agree with Prof. Göhlich, and it may be of interest that at Munich University of Technology we have had, for the past eight or nine years, a separate faculty for information technology and the government was very happy. We now have another faculty with high tech people and so on, but the results were not satisfactory, so both our mechanical and electrical engineering faculties decided some years ago to incorporate within the faculty an institute of information technology for engineering. This concept has been very successful, and now we see that when our young engineers leave university they bring new information technology ideas into companies - even into major, reputable companies - and proceed to develop new systems there. In our experience, this is the right way to go, and I feel you agree. So we would recommend not to make the same mistake again, because this is a very expensive mistake. They buy the biggest computers and spend a lot of money that can be used in other places better.

B. CHEZE

I would have liked Mr. Bonicelli to show us some slides on the applications, because I know that Cemagref has worked on the practice as well as the theory. Perhaps he could tell us something about how he has implemented this sort of application on different machines that are practical realities. Another point is: what about the maintenance of such systems?

B. BONICELLI

We've developed many applications in Cemagref, but my contribution is to develop the methods actually discussed in Cemagref and in Cirad, because the knowledge is in the laboratory and you need good methods to have good product concepts. For example, maintenance is completely integrated into the design from the very start of the project, so there that the machine won't give any problems in the future. If you have a good design in terms of cost and maintenance, you have a good product overall. So for us there are two kinds of applications. One is robotics in agriculture - although these are really automatic machines and not robots. The other application is in forestry, which is a good domain because the price of machines is high, making it very easy to have sophisticated techniques to control these machines. I think that in agriculture the problem is the price of the machines, because it's difficult to implement high technology in very low cost machines. So in this case we try to develop new sensors and very simple systems to achieve low prices, but this is very difficult. In the automotive industry, sensors have an extremely low price, but you need a large-scale industry to develop such sensors.

Dr. Uri M. PEIPER

I think that what seems high tech today will probably become very low tech tomorrow. I think that high technology doesn't just encompass computers and electronics. There is also ample scope for new technologies in materials. The new materials developed for military or space technology may be usefully adapted to agricultural equipment, allowing us - in this era of peace - to finally benefit from the vast amounts of money invested in this negative field of human activity. One other point concerns the use of graphic simulation techniques, which can speed up the design phase of all kinds of machinery. My example will be on a robot which we have developed and I'll talk on that later.

Prof. Pierre ABEELS

Belgium

I am a supporter of implementing equipment with devices that assist human performance, but a major deficiency is the lack of biological data. What, for example, is good soil preparation? There's no definition. It's just been a subjective assessment up to now. How do you determine the value of a crop from the beginning - and not just at the time of harvesting? This is a major obstacle to the application our engineering principles - a major lack from the biological side.

There should be greater integration of engineering and biological knowledge, and I think the main problem lies in the knowledge of mathematics. I think the Club of Bologna should not only promote work involving electronic and materials engineers, but should also involve ag-engineers who really understand agriculture, crop development and genetic development, and who can simplify our devices, our sensors and perhaps the control of the machines.

L. FISCHER

I think it is very important that institutes, universities, and also advanced engineering groups and manufacturing companies think about what may happen ten years into the future. This is very important. But getting back to today's problems: all the manufacturers now supply electronic devices and information systems, and we are confronted with serious problems. Sometimes what you use on one component is not usable on a competitor's product. The supplier can't cope with the quality, and we ourselves can't cope with the quality. It sounds great when we advertise products to our customers and try to convince them that this will improve the hours, costs and so on. But then we end up having down times, and worrying more about how fast we can supply spare parts than about adding electronic devices. I think here there is a gap between the expectations and the day-to-day realities. Of course we must have a vision of the future, but we also have to get the reality under control.

E.U. ODIGBOH

In the tropical world we have serious problems maintaining even mundane items, like computer disks. These things don't last very long under our conditions of high relative humidity, high temperature and high dust cover: we've sometimes lost the information stored on diskettes in a month. Because we, in these developing countries, do not have the capability to address the problem, I ask that the developers of these devices - on which we spend a lot of money - take into consideration our environmental and climatic problems. We definitely get less value for money due to our climatic conditions.

D. J. WHITE

As editor of the well known journal "Advertising", I see many research papers that involve the use of very expensive, highly sophisticated equipment to perform experiments for improving our ability to control machines and processes in the future. Looking at these projects, I often wonder how many of them will actually come to fruition. It's very easy to become cynical, and I was therefore rather glad when Bernard Cheze asked for some practical examples. I think that looking back over the years there are both successes and failures to report. For example, research on automatic identification of animals began all of 25 years ago, and what have we achieved a quarter of a century down the road? Some things, like the attempt to detect - on line, while milking - the onset of oestrus, have not been successful. But on the other hand we now have fully automatic systems which are being tested by researchers, and the current stage of development is their integration into the agricultural system. I think that's one example of something that's on the verge of success. I believe the most exciting new development is the one I already mentioned: location-specific agriculture, in which sprays and fertilizers are applied as required in specific locations of the field. I myself have been monitoring very sophisticated EC project, known as computer integrated agriculture, that includes this as part of the work, and I have been very impressed by what I have seen. But we do not yet have the agronomic models that will really tell us how to make use of this information, no do we have the sensors. Unless we can actually make some very sophisticated measurements, on the move, of soil conditions, it is unlikely we will be able to exploit these systems to their full capacity. So one of the warnings I would give is that our mechatronic experiences and abilities may well be ahead of our capabilities in sensor technology and also perhaps in the algorithms and programmes to actually use and integrate that information.

Prof. Malcolm MACKAY

Australia

We should keep in mind that when we start these projects we're not always aware of their full potential: projects often produce significant spin-off advantages that were not foreseen at the beginning. One example is a project we are currently finalizing to the commercialization stage: machine vision guidance of tractors in row crop. That started off as an attempt to control soil compaction - traffic control. The problem was that, when making multiple passes down a field, compaction became wider with the variation of each pass because the tractor couldn't be kept on line. So it started from an energy saving compaction point of view but we quickly realized that the if we could control the tractor very accurately then we could set the tools closer to the rows. In Australia we have found that by being able to control tractors we can obtain a reduction of one spraying and one stripping operation. This means very significant economic advantages for the farmer, and very significant environmental benefits. One of the greatest advantages, that we didn't really perceive at the time, was the human interface: the reduction of fatigue in driver operations, etc. Drivers often work fourteen to fifteen hours, under very difficult, concentrated conditions to try to maintain accurate driving. So the workplace health and safety aspects are very significant. In this case, what started out as high tech mechatronic device for controlling tractor compaction and traffic ended up providing very significant economic environmental and workplace safety advantages. I think that sometimes we don't see all the possible end results and can be discouraged from continuing along those lines. In this example, the product is likely to sell in the marketplace for straightforward economic reasons - the ability to reduce operations, thus paying off the product in one season. We should keep in mind that all the applications and advantages of certain systems are not immediately obvious from the start. We shouldn't be put off by thinking that it might be irrelevant in the market place that time.

K. TH. RENIUS

I would like to come back to the comments made by Mr. Fischer and Mr. White. I think it is really difficult for industry to develop this new information technology. The expenses of this new component - as it may be defined - in a tractor combine or self-propelled machine is about 10% of the total cost, which approaches the cost of the engine. This is increasing and I think it will not be stopped, it will go ahead, it's a reality that these information systems are coming up more and more. Given this trend, and the difficulties - of reliability and risk and so on - I think the solution is cooperation, research and education. I have an example of a company that has been using a radar sensor for many years, and for many years had applied an incorrect definition for zero slip. Nobody could explain what zero slip was, and nobody even perceived this as a problem. There are many other examples concerning issues like standardization. I repeat: cooperation, research, education must be done in this field.

Eng. Aad A. JONGEBREUR

The Netherlands

I want to go back to John Schueller's remark that mechatronic systems are too expensive to market. As an institute, we've been working on automatic milking systems for about ten years, and have also acquired some knowledge of the market. I think that if a company offered a reliable system for complete automatic milking - even if it was more expensive than the standard equipment - they could successfully market it to farmers today. However, no such system is currently available. I believe that development of mechatronic systems will take a lot of time, especially in terms of reliability and durability of the software controlling the system, which is a major point that today gives dairy farmers a lot of trouble. So I would reiterate what has been said about reliability and durability also in terms of this example. Another important issue for the future is the implementation of mechatronic systems in the farm. This has not yet been solved and will demand plenty of attention in the future. I do believe that eventually, mechatronic systems will come, but it will take time to develop them to the level where a farmer can work reliably with them.

M. RUIZ

Spain

If we look at the parts of mechatronic systems discussed by the keynote speaker: we have on line sensors, signal data, information processing systems and electronic control. The first part - which also relates to what Mr. White said - is that the development of sensors poses a major challenge for agricultural engineers. This is a field where biology and agriculture meet physics and mathematics, and there lies the gap that we have for developing all these systems for any area. I am certain that if we train our students in physics and mathematics, combined with a strong biological training, they will be able to develop sensors. The development of sensors progresses at the same pace as the development of knowledge of the biological systems.

K. TH. RENIUS

Just to add some comments on the sensors and the actuators regarding machinery. You focused on the applications of machinery. But looking at the actual machinery, we have to realize that the next generation of diesel engines will be electronically controlled, the next generation of transmissions, will be electronically controlled and many of them will be infinitely variable. The present generation of hydraulics is already infinitely controlled by load sensing systems. We will have a bus system for tractor-implement communication. This is almost standardized. Looking into machinery, I would say we already have a good technical level to introduce good systems. I see more problems in applications, in agriculture.

Y. KISHIDA

I would like to make some comments. Recently in Japan our Ministry of Agriculture started a new research and development project for the next decade of mechanization. One of the major considerations in that project was how to make a system that better utilizes the farmer’s know-how. The farmer has a good computer - in his brain - and that means that means we don’t want to realize full automation of agriculture, instead we want to achieve a better combination of the farmer’s ability and mechatronic systems. This is one of the important considerations for the new research.

Eng. Mikio KINOSHITA

Japan

From my own experience in developing this kind of devices, I am really pessimistic about fully automated machines like the ones used in factories. We have tried to make such machines, and have put resources into these projects for a long time but, as Mrs. Ruiz said, it is hard to obtain good sensors and actuators and it is also very difficult to make machines perform like the human brain.

Appendix

The Current State of Mechanization in Russian Agriculture

by: *O.S.Marchenko*, *L.P.Kormanovsky*, *V.M.Krjazkov*,

RUSSIAN FEDERATION

1. Economic reforms and their influence on agricultural production

The decrease in agricultural production in the last few years is directly associated with the current state of the crisis-ridden Agro-Industrial Complex.

It is enough to say that the basic production funds in Agriculture put out of action for the period of 1991-1995 exceeded the ones brought into use by 5 times. The agricultural producers were forced to reduce: the arable area by 6-7% of total Agricultural Used Area (AUA); the application of fertilizers by 4-5 times and the area under pest, diseases and weeds control by more than 50%. In consequence of this the decline of main crops and forage production as well as the reduction of animal herds and their productivity took place.

As a result, by 1994 the Gross Agricultural Output (GAO) dropped down by one quarter in comparison with 1990. 60% it is the output of animal production **(Fig.1).**

2. Depression of agricultural machinery production

The catastrophic reduction of agricultural machinery deliveries exerted a crucial influence on the decrease of agricultural production. For instance, by 1994 the production and deliveries of tractors, grain harvesters, forage harvesters and ploughs dropped down by 7-8 times, drills, fertilizer applicators, plant protection machines, milking equipment and others-by 30-70 times in comparison with 1990 **(Fig.2).** In addition, by 1994 the machinery fleet of Russian agriculture decreased by 1,2-1,5 times with respect to even 1986 **(Fig.3).**

Besides, from the data reported by the Russian State Committee on Statistics (Goscomstat) it has been known that the part of agricultural machinery fleet which kept in good working conditions comes to only 74% of the total machinery fleet registered.

Because of a large disparity in prices (the prices index for agricultural products is now lower than the price indices for machinery by 3-5 and for diesel fuel by 10-12 times, respectively) the agricultural producers have practically no possibilities to buy up-to-date machinery. The low solvency of agricultural producers and the very low cost of labour in Russian agriculture along with high prices for fuel and machinery are not favourable for the domestic production, the import **(Fig.4)** and for the development of mechanization in Russian agriculture too.

Such a state of machinery fleet along with deterioration of technology and timeliness of agricultural activities cause fuel overconsumption by 10-12% and yield losses by more than 30%.

There is no doubt that if the machinery deliveries remain at the 1994 level the machinery fleet would be cut down by 2,5-3 times in next 4 or 5 years.

3. Efficiency of multistructural agriculture on the way to market economy

The reorganization of agricultural enterprises and the creation of private farms without necessary support did not give positive results. The comparison of activity of the agricultural enterprises which have retained their original status as collective or state farms as well as ones which have retained their original phisical dimensions but reorganized as joint stock companies including lease, family and cooperative farms as well as large agrocombinats, the private farms and the individuals involved in agricultural production (small plots, gardens, collective gardens) is given in **Table 1** and **Fig.5**.

The dramatic situation it might be well pointed out as follows:

- agricultural enterprises impacts on the GAO decrease to a great extent.Having in use about 90% of AUA these enterprises produced only 62% of GAO in 1994.The individuals farmers produced about 36% of GAO having in use only 5% of AUA. The private farms at the same used area (5%) produced the balance of 2% of GAO;
- the efficiency of land use for the period of 1990-1994 was reduced by all the agricultural producers. The average output per hectare dropped down from 700 US$ in 1990 to 578 US$ in 1994. The reorganized enterprises had output 460 US$/ha on average in 1994 when the existing collective and state farms, 390 US$/ha and the private farms 215 US$/ha. The efficiency of land use by the individuals exceeded 7-12 times the average output but also significantly dropped down from 8,566 US$/ha to 3,874 US$/ha for the same period of time;
- the higher efficiency of the reorganized enterprises can be explained by the use to a great extent of the lease farming and by introducing market relationships between all the partners involved in the production process which are still kept in the frame of reorganized enterprises;
- the low efficiency of the private farms can be determined by the lack of necessary engineering-technical maintenance and technological systems, unsufficient credit and poor governmental finance support. At present, a private farmer has about 0.5 tractor, 1.88-agricultural machines, 0.26-truck, 0.04-grain harvester on average **(Fig.6).** With finance shortages it is practically impossible to use the profitable integration of production and processing on-farm and realization of processed products by private farmers;
- the provision of the population with additional land and the growing of food shortage forced individual activity in food production. Having very small plots of land (0.04-0.15 ha per family) and applying mostly manual operation they added to GAO up to 20-22% (average for the period of 1976-1986), then 24 % in 1990 and of about 36 % in 1994.

4. The scientific-technical policy in mechanization of Russian agriculture

The main orientations of the economic-technical policy in agricultural engineering in consequence of the situation should be:

- in the first place all the measures of the governmental support of agricultural commodity producers should be continued. This refers to the subsidy for material and machinery and also the allocation of state resources for leasing for purchase of new equipment. Side by side with the allocation of means from the federal budget it is necessary to find additional financing sources both in the centre and on places for replenishment of the leasing fund, using local budget, personal resources, credits on favourable terms of home and foreign investors and other possibilities;

- the mission of specialists is to give the farmers recommendations on how to use the leasing form, what machinery should be primarily purchased and how to organize its use to justify its cost as soon as possible. Analysing the first experience it is important to elaborate the ways of leasing operations realization,particularly in identification of mediators who could not only draw up the documents but also carry out the presale preparation of machines,fulfil adjustment,provide guarantee and post guarantee repair and service of the leasing machinery;
- taking into consideration high prices of the machinery the scientists should define less expensive machinery maintenance systems, including new methods of diagnostics, modern adjustments, optimum loading and also concentrate on quick development of cheaper and accessible ways of recovery of the worn parts, units and base components, new technologies of repair with minimum disassembling and disturbance of fit and run-up of conjugated parts;
- the strategic problem for agricultural machinery building industry is to increase the quality of new machines which is much behind of imported ones. That is why some Regional administrations supported by local finance-industrial groups help their agricultural producers to buy more expensive but durable and more efficient foreign equipment;
- the market of machinery maintenance systems should be created and developed, providing Agro-Industrial Complex with resources close to agricultural producers, including cooperatives, machine-tractor stations, private firms in order to create competitive conditions and promote of service quality increasing and the reduction of costs;
- for the Russian agriculture is very important to decrease significantly the cost of agricultural products because the specific energy and labour expenses per ton of agricultural product are several times higher than in developed countries;
- the next key orientation of technical policy is to develop sets of technologies and new generation of machinery which should be effective at federal and regional levels. All of these will help the producer of any regions to identify costs and profit in order to choose the proper version of technology and machines;
- new generation of machinery should be multifunctional, combined, adapted to climate, soil, plants and animals. For this the experience of foreign science and industry has necessary to be used more widely;
- under the conditions of poor technical equipment all the positive forms and accumulated experience of effective utilization of machinery should be revised. First of all, it is necessary to use the experience of mechanized groups and harvest-transport complexes for grain, forage harvesting and for fulfilment of other power consuming works. Concentration of harvesting and transport machinery, its proper maintenance allow to decrease standing idles, to increase significantly output and quality of works, to improve organization of mechanizators work and to rise the efficiency of machinery utilization by 2-3 times;
- The organization of Machine-Technological Stations (MTS) which can be used by any of agricultural producers should be decisive part of this process. The form of organization and activity may be various. The main idea is to concentrate highly productive machinery, to stimulate all the executors and due to modern technology, to obtain maximum crop productivity. We are available of good experience of purchase and utilization of high productive foreign machinery on the basis of contracts through MTS. Thus MTS can become the leader of newest machinery utilization and new technology experience in agricultural production.

Table 1 - Efficiency of multistructural agriculture (1990-1994)

Forms of Farming	1990	1992	1994
Agricultural enterprises (total):			
AUA, %	98	93	83*
GAO, %	76	66	62
including:			
– Reorganized enterprises:			
AUA, %	3	34	49
GAO, %	NA	24	39
– Existing enterprises:			
AUA, %	95	59	34
GAO, %	76	42	23
Population (Individ. plots, gardens):			
AUA, %	2	4	5
GAO, %	24	33	36
Private Farms:			
AUA, %	0.05	3	5
GAO, %	NA	1	2

Note: (*) 7% of AUA was put out of use

Fig. 1

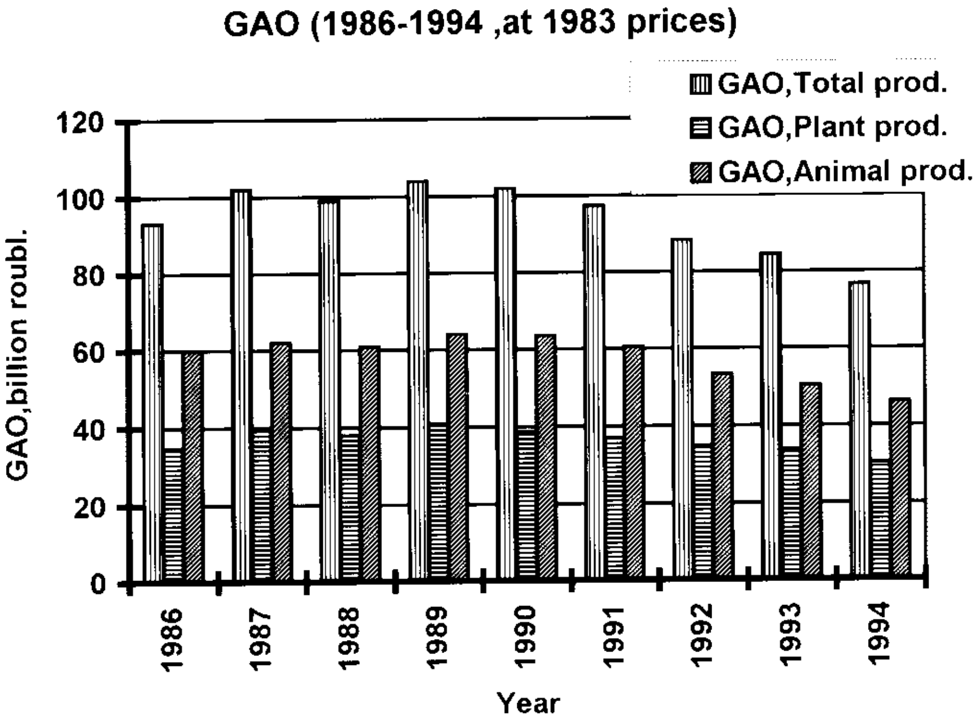


Fig. 2

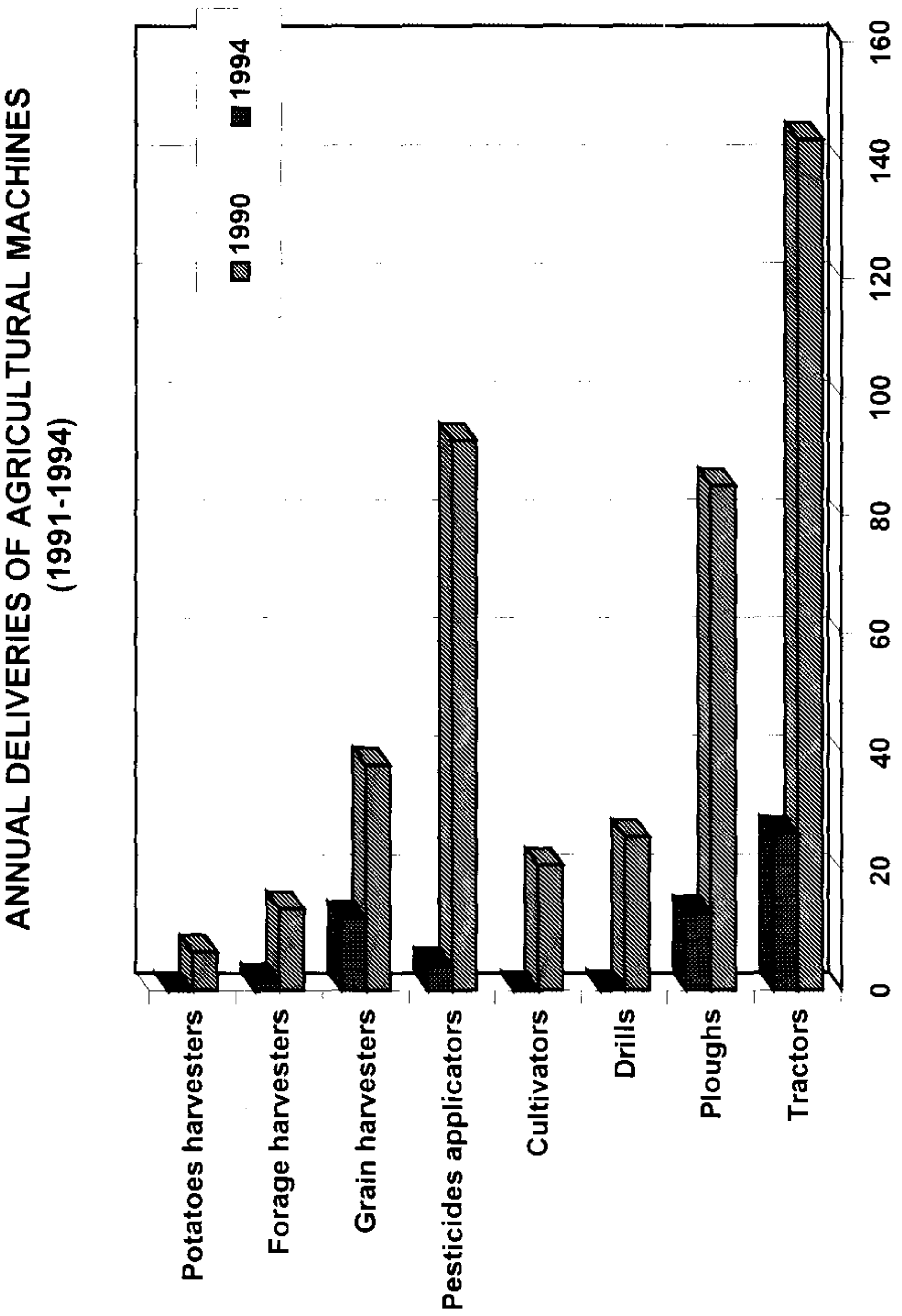

ANNUAL DELIVERIES OF AGRICULTURAL MACHINES
(1991-1994)
1990
1994
Potatoes harvesters
Forage harvesters
Grain harvesters
Pesticides applicators
Cultivators
Drills
Ploughs
Tractors
0
20
40
60
80
100
120
140
160
Thous. units

Fig. 3

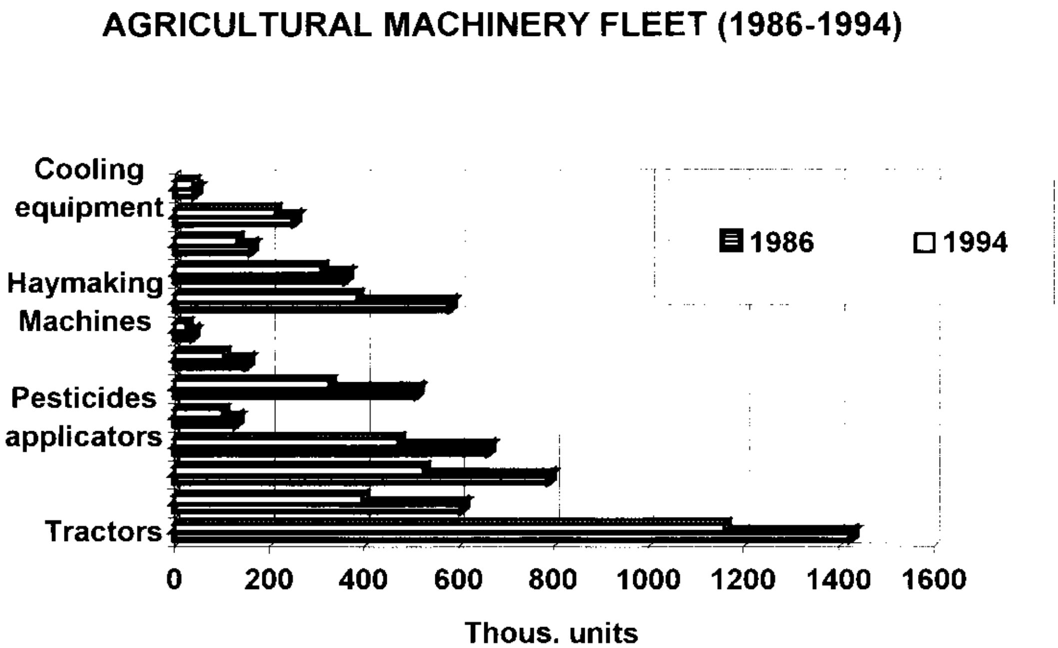
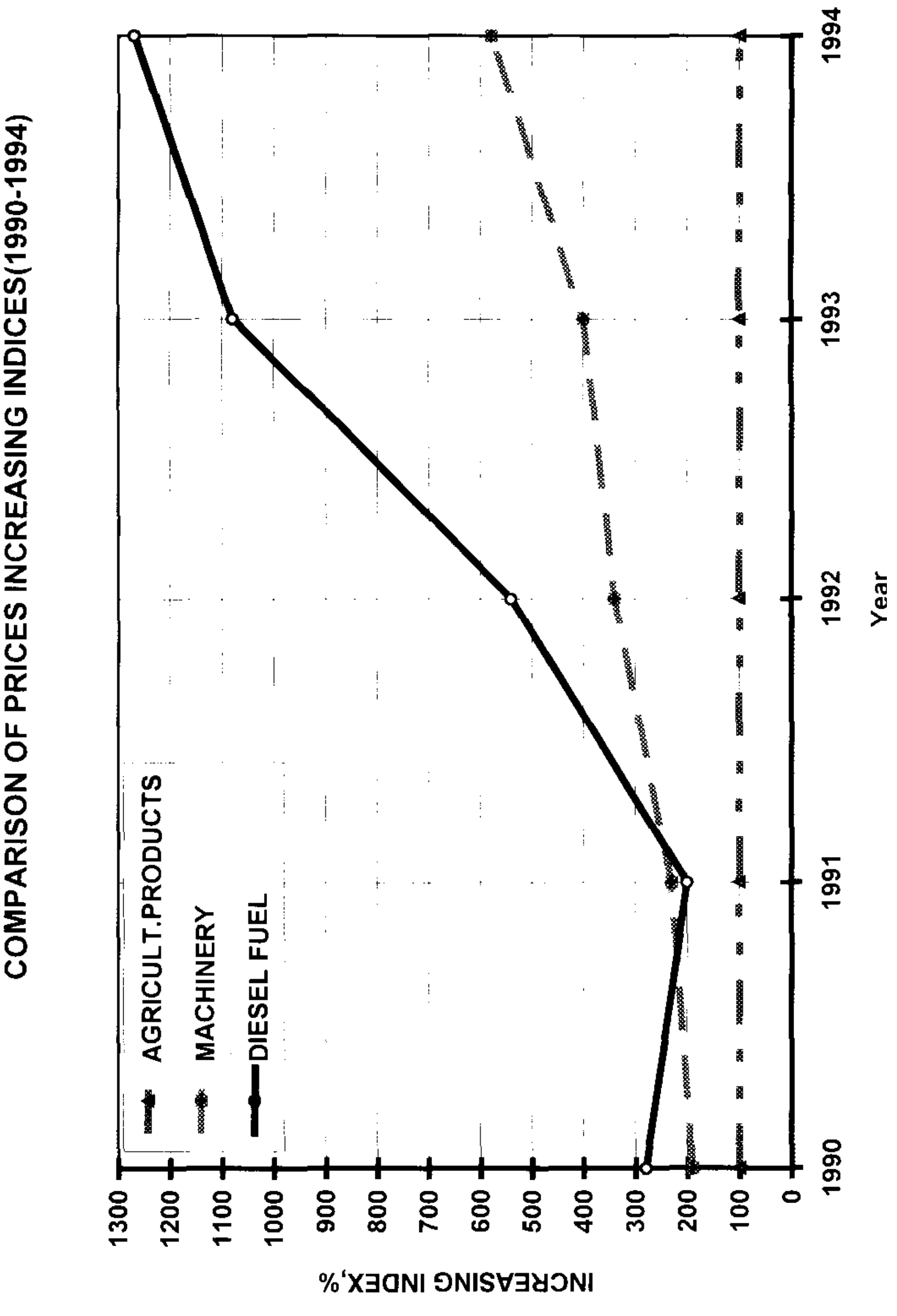

AGRICULTURAL MACHINERY FLEET (1986-1994)
Cooling equipment
Haymaking Machines
Pesticides applicators
Tractors
1986
1994
0
200
400
600
800
1000
1200
1400
1600
Thous. units

Fig. 4



COMPARISON OF PRICES INCREASING INDICES(1990-1994)
AGRICULT.PRODUCTS
MACHINERY
DIESEL FUEL
INCREASING INDEX,%
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
1990
1991
1992
1993
1994
Year

Fig. 5

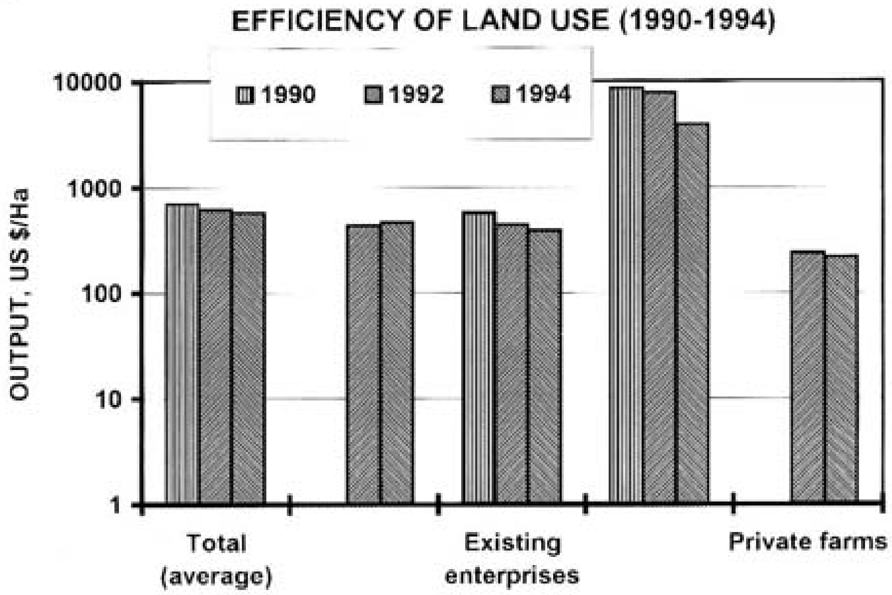
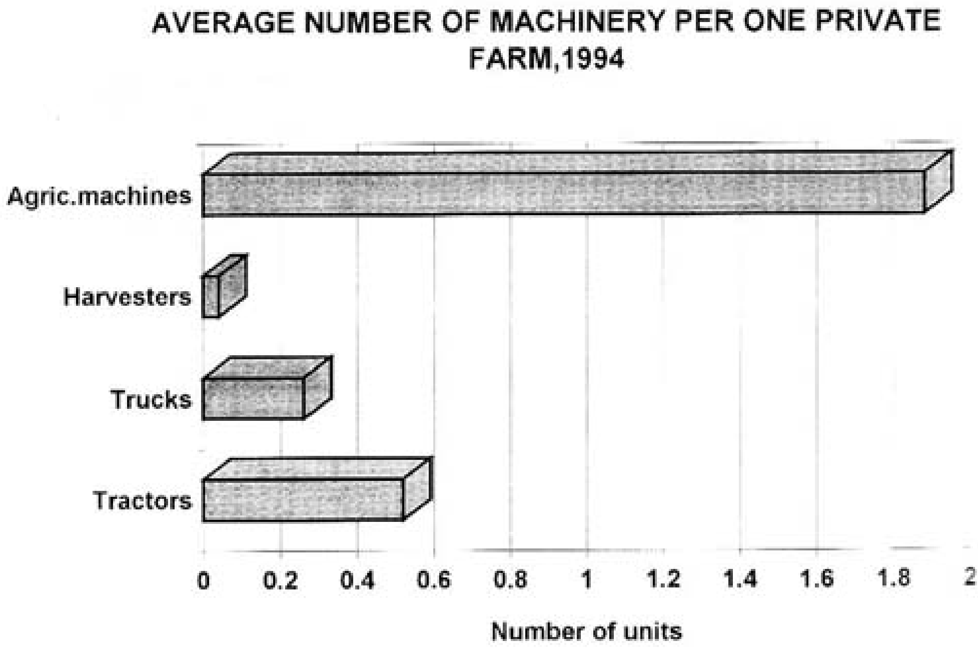

EFFICIENCY OF LAND USE (1990-1994)
1990
1992
1994
10000
1000
100
10
1
OUTPUT, US $/Ha
Total
(average)
Existing
enterprises
Private farms

Fig. 6


AVERAGE NUMBER OF MACHINERY PER ONE PRIVATE FARM,1994
Agric.machines
Harvesters
Trucks
Tractors
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Number of units

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