Trends in Agricultural Mechanization in Brazil – an Overview

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Introduction

Brazil has a territory of roughly 8.5 Mkm^2, representing 20.8% of the American Continent as well as 47.0% of Latin America. Over 41% are flat lands, 58.5% are altiplans, and less than 0.5% are mountains. Brazilian climate is predominantly tropical, being partially equatorial, semi- arid and subtropical in some regions. The annual average temperature is 22 ℃ and rain precipitation is 1,300 mm. The total Brazilian population is about 165 million inhabitants, with an average population density of 19 inhabitants per km^2. Approximately 76% and 45 % of the country population live in urban and in the Southern region, respectively.

The economic activities have grown in the last 10 years. In 1980 gross GNP represented US$173,153 millions and increased 3.5 times throughout the period, reaching 1998 with US$775,700 millions, representing different sectors of the economy distributed as follows: agriculture 6.84%, industries 38.43%, and services 54.80%. This trend points out a small increase on the industrial business and a large decrease in the agricultural activities (ALVES et al., 1999). Nowadays the Brazilian economy contributes around 60% of the total South America gross domestic product which represents around US$1,316.6 millions (IPEA, 2000).

The size of the country as well as the uneven distribution of land with agricultural potential in some regions make the concentration of large farms in frontier lands where there are problems regarding the agricultural products storage and distribution for different markets. This paper presents a prospective overview of the agricultural mechanization in Brazil.

Today's Agricultural Production Profile

The Brazilian agricultural production is spread over available arable land which is divided in 5 major geographical regions. The Southeastern region produces mainly coffee beans and sugarcane. Dairy production is also important, representing around 50% of the total Brazilian production. The region's main characteristic is the intensive industrial processing of the agricultural production partly using labor employment at farm level. The Northern region is located mostly in the Amazon rain forest. Agricultural production is mainly subsistence level, even though there are changes in some areas where beef cattle has been introduced as well as soybean, corn and bean crops. With dry and hot climate, Northeast Brazil has been developing tropical fruits crops in areas where irrigation is available such as melon, grape, pineapple and cashew. This area is known for intensive agriculture. In some sub-regions, irrigated corn and soybean have been grown with success. With large cultivated area, the States of Pernambuco and Alagoas have a significant sugarcane production.

Many regions in Brazil are in the process of development and expansion of agricultural lands, but one of the great concerns of government is the agricultural use for the 127 million ha of the arable lands in the so-called "*cerrados*"*(savannas)*. These lands extend over part of Center-West, Northern, Northeastern and Southeastern regions of Brazil, which relate to one of the fewest available lands in the world for increasing food production. The

current annual agricultural production of *cerrados* corresponds to 25% of the Brazilian production, which can be considered very important for the economy.

The cost of equipment allied to the unstable economy problems in the country and the cut in agricultural subsidies, made it very difficult for farmers to invest in purchasing new equipment. On the other hand, the process of elimination of small farming units due to the lack of economical power for purchasing new technology is proportional to the industrial and urban expansion. The urban employment is a factor that may regulate this. However, the whole process is not properly managed by governmental policies leading to high unemployment rates and the consequent crisis and social conflicts.

In other areas where crops like sugarcane dominates, the small farm units are already gone or rented. Without capital for investment in updated machinery, it is nearly impossible for small farmers to remain in business, and this has already caused a major process in land ownership concentration. In crops such as coffee, mechanization has not been yet the interfering factor in the change in land distribution. However, the harvesting technology for both coffee and sugarcane production is in large expansion process. This means that a large number of labor force employed in the fields will soon be out of work, adding to the already large rate of urban unemployment. In addition, due to environmental enforcement laws the burning of sugarcane prior to harvest has been restricted and, the only option is replacing the human labor force by machine harvesters.

Agricultural machinery in Brazil is mainly owned by either the farmers or cooperatives so that the contractors do not have an important role in the agricultural business as in other countries.

Interactions of Agricultural Production and Brazilian Economy

According to IBGE (1998) total Brazilian production of grains reached 82.5 million tons in 1999, increasing 9.83% compared to the 1998 production. The Southeast, South and Center West regions which contributed 90% of the total, presented an increase of 7.18 %, while the regions North and Northeast, reflecting 10% of national production, increased around 44%. Fig. 1 summarizes the total Brazilian grain production in 1999, by each geographic region. Fig. 2 shows the evolution on crop production through the late years.

The South and Southeast regions represent over 50% of the crop production of the country. It is in those regions that agriculture is more mechanized. In the beginning of the 90s in the whole country, there were 6 million of rural enterprises of 380 million ha, where 60 million farms have approximately 750,000 tractors or about 80 ha per each tractor (Alves et al, 1999). Among the rural business in both South and Southeast regions, there have been immigrant entrepreneurs that carried out an important segment of the small scale agricultural business. However, the pressure today is more towards eliminating the small agricultural business which lies compressed, at least in some transition areas, between the *modern* and *old fashion* agricultural trends.

According to Mantovani et al. (2000), in 1990 Brazil exported 3,744 million dollars of sugar, 10,996 million dollars of raw coffee and around 1,644 million dollars of soybeans. Even though fluctuations on the external market involving the orange prices influences the national production, this is the sector that developed most in the past years. In 1990 the exports of orange juice was of 6,180 million dollars. On the other hand, Brazil imported some of the fertilizers used in agricultural production. During the last five years the percentage of production *versus* consumption increased, representing a deficit of 5.1% of nitrogen, 3.2% of phosphate and 8.8% of potassium which was supplied by imports.

Over all, the Brazilian labor force in agriculture is very significant representing 60%, while animal traction is 31% and mechanized agriculture is only 14%. Southern and Southeastern of Brazil detains

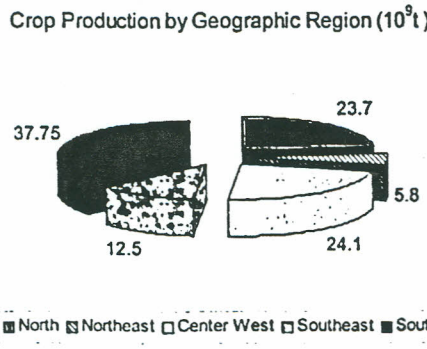

Fig. 1 Brazilian crop production in each geographic region (IBGE, 1998).

Fig. 2 Brazilian crop production evolution, 1980 to 1999 (adapted from SBEA, 2000).

around 28% of the mechanized land. Table 1 shows the percent evolution of the country land with agricultural potential, indicating the growth in the agricultural production indexes relating to the intensive use of mechanization, proportional to the labor force migration from rural areas between 1970 and 1995 (Manitova et al., 2000).

Several investments were made in order to increase the use of tractors in Brazil. However, the lack of real agricultural governmental subsidies made it very difficult for the small farmer to invest in infrastructure. The size of the country as well as the uneven distribution of land with agricultural potential in some regions made the concentration of large farms in frontier lands where there are concentrated problems of storage and distribution for the market.

The implement industry was also affected by the same crisis that merged with the tractor market. Lately this industry has been involved in a direction change through no-tillage planters production, and that is strongly pushing the prices up mainly for industry that has a good no-tillage planter to offer the market. A well designed implement has been associated with air seed meters and that has been possible by joint ventures with foreign companies that provide such technology.

From 1970 to 1975, the mechanization level of Brazil, ha/wheel tractors, improved 57%, and 35% from 1975 to 1980 (Table 2). The data also show a non-growth period from 1980 to 1990, and a 17% decrease up to now, with a mechanization level of 116 ha/wheel tractors, in 1998. Comparing these number it can be seen that even though improving the existing problems the country index are far away from the developed countries' results that have as Brazil, large production areas.

Trends in Precision Farming

The conflict between the *old* and *modern* techniques is evident in some farming activities. A small farmer with up to 50 ha corn and dry beans farming, just feasible in a mechanized system, hardly survives in an economy that is in transition to the so called *developed world.* A crop like soybean is not competitive without mechanization, at least for harvesting operation. Few projects have been tried to adjust low scale mechanization system for small producers without success.

The timing for plowing in the Brazilian savanna area (*cerrados)* is short for the conventional system. In order to plant in this large area within the right schedule, the conventional system does not apply efficiently, leading to losses in quality and soil management. This difficulty related to a lack of horsepower resulted in the preferential use of no-tillage technology by the farmers during the short rain period. In the last three years, more than 3 million ha of lands were added to this no-tillage crop production system.

A proper infrastructure construction is needed in order to use the existing agricultural potential in the *cerrados* and attend production demand. The increase in cotton production at Mato Grosso State (located within the limits of Longitude 50-58° W and Latitude 15.5 – 16° S) with the development of a resistant variety to insect infestation is an example. In this region, several projects have been worked introducing new technological alternatives to the farmers for a good qualitative and quantitative agricultural production response. It is also observed that some farmers struggle to reduce the grain production management and processing costs, for competing in the global market.

The country's dimension demands a criteriously technological evaluation for each country region as well as the distinct agricultural production systems adopting for a proper mechanization system, in order to attend the soils and cultural needs in an economic way.

The Brazilian agricultural systems have a great application potential in precision farming technologies, mainly in the center-west region, where most of the 50 combines with yield monitor are currently at work. An improvement has been observed in the last 10 years on agricultural project applications involving the use of machinery equipped with sensors, remote sensing, image processing (surface, aircraft and satellite). More recently, the precision farming technology is allowing the organization and maintenance of spatial and temporary crop production systems databases, which is important for the development of techniques seeking the rational use of natural resources and agricultural inputs, with consequent reduction of agricultural production systems costs and environmental impacts, assuring a sustainable exploration. This new technology is

Table 1. Evolution of Land with Agricultural Potential in Use

Year	1970	1980	1990	1995
Land witmtial (%)	197.84	220.95	240.80	245.20

Adapted from FAO, 1995.

Table 2. Farm Mechanization Level in Brazil, 1960-1998

Year	Cultivated area (1000 ha)	Wheel tractors (units)	Mechanization level ha/wheel tractors
1960	25,671.7	62,684	410
1970	34,811.1	97,160	359
1980	47,640.6	480,340	99
1990	47,666.4	515,815	92
1998	53,500.0	542,143	116

Adapted from Manitova et al., 2000.

being used as a tool to minimize losses and to reduce the production systems vulnerability. The traditional systems management with inefficient treatment of variability factors that affect crop production (fertility, soil moisture, plant disease control, etc.) uses the average concept for extensive areas.

Precision farming can be an economical strategy and ecologically more efficient, as it treats specific sites, and Brazilian agriculture can benefit from precision farming to produce more food for the internal market and to export with competitive prices compared to developed countries. The agricultural technological modification happening in the world each time more competitive, especially in food production, demands an adoption of these new technologies.

In spite of the precision farming being a new theme in Brazil, progresses have been obtained mainly in the machines and implements development that allow specific site management. The most advanced resources of the electronics and information technology, as GPS and GIS, remote sensing, control and data acquisition systems, sensors, among others, are being introduced in the field. Thus, it will be possible for the optimization of agricultural inputs, based in precision farming, for an economical return and environmental benefits. The variability quantification allows identifying the productive potential areas, which can be worth larger investment in inputs for maximizing production. Regarding the areas with low production potential, productivity improvement can or cannot be considered, depending on economical feasibility. The data analysis allows natural resources and agricultural inputs optimization and variable rate inputs maps generation that takes into account spatial and temporal field variability.

The Brazilian agriculture actual scenery can lead to a decreasing productivity, since technicians works with base in field considerations that can differ with the physical, chemistry and biological reality of different soils. For instance, the application of fertilizer levels based on the whole areas uniformity in farming fields that presents a great spatial variability (average treatment), can lead to unbalance those plots that are already fertile and not to benefit others presenting nutrient lacking. This kind of decision can compromise possible strategies of soil management addressed to the high productivity indexes. A methodological approach capable to work these differences in an automated way to allow adjustment in the fertilizer levels recommendations still needs to be investigated. In addition, the characterization and modeling of the crop production systems spatial variability and the evaluation of the technical feasibility of the agricultural inputs located application concepts can promote the associated use of more advanced technologies. The acquiring, organizing and use of database for management support decisions will allow for global diagnoses, involving all the decisive factors in the productive chain.

Trends in Irrigated Agriculture

Irrigated agriculture in Brazil is an important aspect, being responsible for 1.4 and 2.8 million direct and indirect jobs, respectively. The potential for irrigated agriculture is estimated in 49 million ha, of which 33 million ha are low flat lands (flood irrigation schemes) and 16 million ha are upper lands (Christofidis, 1999). According to the National Plan for Irrigation and Drainage, by the end of 2000, an expansion of about 500,000 ha is expected. In the last 50 years (1950 to 2000) the irrigated area has expanded from 60,000 ha to 2.87 million ha, of which about 0.96 million ha (33 %) are the low flat lands in the South, mostly used for flood irrigation. Presently, the total irrigated area represents about 6 % of the total national area planted, most of it is private, with only 4.2 % of public irrigation districts, comprising about 120,000 ha. Santos (1998) points out that the irrigated area in Brazil is contributes to 16 % of the total agricultural production and for 35 % of this production value, representing one of the most cost-effective ways to generate employment.

Brazil has a great potential to yield irrigated grain crops, such as soybean, corn and bean, in terms of quantity and quality. The country's Northeast region has developed tropical fruits crops, since the dry and hot climate is favorable, mainly in areas where irrigation is available. Fruits such as melon, grape, pineapple and cashew are economically important in this region. Also, irrigated corn and soybean has been grown with success.

Mechanization of different irrigation schemes occurred in Brazil mainly due to increase of farm labor costs, together with the shortage of labor for different farm practices and operations. This labor scarcity on irrigated farms has accelerated the trend toward mechanized irrigation systems, such as traveling gun sprinklers, side-roll sprinklers, center-pivot sprinklers, and some of the localized schemes (trickle or drip and micro-sprinkler systems). The surface irrigation scheme is the most used in Brazil, with about 1.7 million ha (59 %) which is concentrated at the North and South regions. On the other hand, in other regions the sprinkler scheme predominates in approximately 1,005 million ha (35 %). The lowest area is used with the localized irrigation schemes with about 176,000 ha (6 %), which is expanding, mainly at the Northeast and Southeast regions (Christofidis, op.cit.).

Conclusions

The level of research and technology development for different regions in order to reach the national demand for a convenient degree of mechanize agriculture was met through in the late years. There is an installed chain of trained professionals able to respond to an emerging demand for agricultural products in both research and educational systems. Apparently, despite all these the problems and limitations Brazil has developed an infrastructure capable of supporting the agricultural expansion to supply the internal and export market demand.

The trends lead to the development of the new agricultural frontier; in the Cerrados area, in terms of expansion of land with agricultural potential, and the use of precision farming in large cultivated land in order to reduce production costs.

Brazilian agricultural expansion potential is large and mechanization plays an important role for supporting the production systems. There is a need to decrease the gap between private enterprise, which provides equipment and modern technology for farmers, and the agronomic sectors which generate proper technology for extension.

Precision farming can be an efficient tool for Brazilian agriculture and can help farmers manage spatial variability, as well as to support food production for the internal market and to export with competitive prices compared to developed countries.

Brazilian irrigated agriculture has great potential in terms of food production and employment generation. Most mechanization of different irrigation schemes occurred due to increase of farm labor costs, together with the shortage of labor for different farm practices and operations.

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