Technological Developments in the Sustainable Plantation of Forests in Brazil

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Brazil is a huge country, with a friendly people and amazing natural resources. The economy is very active: the country has a strong position in the international market, mainly in products from the mining and agribusiness segments, such as iron ore, sugar, alcohol, soybean, coffee, meat (poultry & beef), leather & shoes, and pulp and paper.

Thanks to the fast growth rate of the plantation forests, the wood coming from these man-made forests are unbeatable, one of the least expensive in the world. This means that all wooden products may take advantage of this benefit. The forestry-based industry is responsible for about 4% of the Brazilian GDP, and pulp and paper shares close to 40% of this slice. The other important players in the forest business are: wood panels, saw-timber, furniture, veneers and plywood, etc.

There are no doubts that a great percentage of this success is due to the wood grown in plantations. Eucalyptus and pines are the leading raw materials for several of these products, but acacia, mimosa, araucaria and teak are also gaining importance. Eucalyptus and pines are able to grow in almost all country regions, from North to South. The today's forest technologies enable the foresters to grow trees in most of the country. The annual growth rates are difficult to be beaten: eucalyptus grow from 35 to 55 m^3/ha.year and pines from 25 to 35. However, the success of the forest industry is not only based on the fact that the wood may be produced at low cost. Today, thanks to the accumulated knowledge in this segment, it is possible to engineer the quality of the wood according to the end-uses. This means uniform and high quality wood, excellent raw materials to the users and to the final customers. This miracle is a combination of huge efforts in genetic breeding, and appropriate silviculture, harvesting and industrial operations.

The history of the plantation forests in Brazil is recent. Roughly one century ago, the eucalyptus were first planted following an agricultural model. The first eucalyptus plantations had the mission to fuel the locomotives of the railways, as fuel-wood, and to supply wood to other railways utilization (poles, fences, sleepers, etc). In a second moment, the impressive growth rates of the eucalyptus plantations were noticed by the pulp & paper and steel industry. This wood shortly became the main source of fibers to the Brazilian pulp & paper industry, and to the manufacture of charcoal to feed the country steel industry.

Although important, it is a mistake to imagine that the Eucalyptus and Pinus are successful in Brazil just because the low wood cost. The knowledge developed by the industry in partnership with universities and research institutes has enabled the development of high quality products to the end-users. The eucalyptus, for example, are being able to provide fibers with different properties to support several niches in the pulp and paper manufacturing. According to the wood characteristics, they may bring specific advantages to the tissue, filter, and printing & writing paper industry.

Pines are winning softwoods, supplying wood to the panel and furniture industry. The Brazilian pulp and paper industry pays more attention to the Eucalyptus, but pines long fibers also play important role in the Brazilian packaging paper industry.

The world technology to manufacture paper in large scale, using more and more Eucalyptus fibers in the furnish, is relatively recent. The early stages of this industry happened in the mid 50's, but the acceleration period was during the 70's and 80's. However, just now in the 2000's, the Eucalyptus fibers have gained the status of preferred hardwood fiber to the papermaker. For sure, Eucalyptus fibers have gained world recognition as the most important short fiber pulp to the paper industry. Eucalyptus is the dominant hardwood to the manufacture of paper, representing over 50% of the bleached hardwood kraft pulp traded in the pulp markets. Other Latin America (Uruguay, Chile, Argentina, Colombia) and Asian countries (Thailand, Indonesia, Philippines, Malaysia, India, China) are also growing Eucalyptus forests for the pulp industry. This is not a privilege of few regions. Eucalyptus species also grow well in many other tropical and sub-tropical countries or regions: Spain, Portugal, South Africa, Morocco, Mexico, France, Italy, etc.

The Brazilian Eucalyptus fibers are being marketed in all continents, specially in Europe, Asia and North America. This competitive position is based on several key factors:

- Highly efficient and sustainable forestry;
- Low wood cost;
- Homogenous quality of the fibrous raw material;
- State-of-the-art pulp and paper mills;
- Highly qualified human resources;
- Excellent quality management (ISO 9000, 14000 18000, SA, etc)
- Environmental sustainability;
- Social responsibility;
- Intense R&D;
- Continuous growth of the pulp and paper segment, by new capacities addition every single year;
- Continuous modernization of the existing mill facilities, adopting world-class technologies;
- Competitive management;
- Competition in the most strict markets in the world.

There are no doubts that this important industry in Brazil has the forestry as one of its main foundations. We know that other factors are being also vital, but the pillar to guarantee financial health and business sustainability to this industry is being the forestry based on plantations. From now onwards, it is my purpose in this article, to discuss the development of the "Eucalyptus Forestry in Brazil", discussing the steps of this winning activity. Just reminding: forests are growing well in Brazil not only because privileged weather and soil conditions: there are many other factors involved, being the most important the development of a high quality forestry technology.

The development of the forestry technology followed several steps along the first century of Eucalyptus plantations in Brazil. In order to simplify the explanation, let me divide then according to the most relevant technical and fundamentals issues. Let me do this in stages, given a name to each of these stages, depending on the relevant feature that took place.

Features of the First Stage (1904 – 1960): "*Early steps and the admiration for the just born silvicultural techniques"*

- Intense introduction of Eucalyptus species from Australia (more than 150 species were randomly introduced);
- Search of the most appropriate species and provenance's;
- Development of silvicultural techniques for seedling production, soil preparation and planting;
- Unexpected intense hybridization among the species leading to poor quality seeds;
- Plantations based on seedlings originated from seeds;
- Eucalyptus forest management by coppicing (2 to 3 rotations);
- Average growth rates still low: about 15 - 20 m^3/ha.year.

Features of the Second Stage (1970's ⇒...): *"Seeding the road"*

- Reintroduction of successful species and provenance's from Australia and Indonesia;
- Search for tropical species to allow the growth of forests in other regions in Brazil. The species adapted to South of Brazil proved to be sensitive to diseases in the Northern and Central warm and humid regions of the country;
- High efforts on traditional tree breeding (sexual propagation): massive selection of superior individuals, development of collecting seed areas, implantation of tree orchards for better quality seed production;
- Intense preparation of soil;
- Management mostly by coppicing (2 – 3 rotations in the same plantation);
- Average growth rates improved to about 25 - 30 m^3/ha.year.

Features of the Third Stage (1975 – 1985): *"The Quest for the Vegetative Propagation"*

- Search for the most appropriate vegetative propagation technique (tissue culture, grafting, cuttings);
- Utilization of the man-made hybridization technique as a tool to provide more resistant and more productive individuals to be vegetatively propagated;
- Cloning development.

Features of the Fourth Stage (1985's ⇒...): *"Upgrading cloning technology"*

- Development of the most appropriate clones according to climate, soil, topography, nutrition, pests and diseases resistance, wood quality, etc;
- Development of nurseries to allow the production of millions of seedlings by cloning;
- Cloning as the dominant process for tree multiplication;
- Average growth rates improved to about 40 m^3/ha.year.

Features of the Fifth Stage (1990's ⇒...): *"Genetics cannot have all responsibility"*

- Intense development of silviculture and operational techniques from planting to harvesting:
    - minimum soil preparation,

    - retention of water in the soil,
    - roads planning,
    - weed combat/ control,
    - ants and termites control,
    - biological control of pests and diseases,
    - fertilization,
    - irrigation.
- Better understanding of the plantation forest ecosystem;
- Intense substitution of the old Eucalyptus coppiced managed forests by new and more productive forests (cloned and with better genetic basis);
- Average growth rates improved to about 40 - 45 m^3/ha.year.

Features of the Sixth Stage (1995's ⇒...): *"In search of sustainability"*

- Previous planning of the area to be planted (agroecological zoning);
- Minimum soil preparation;
- Disposal of mill residues in the soil as fertilizers (biomass boiler ashes);
- Minimum impact of agrochemicals (insecticides and herbicides);
- Intense adoption of biological control of pests and diseases;
- Fertilization based on soil and trees nutritional balances;
- Development of highly efficient clones (minimum consumption of mineral nutrients per unit of produced wood);
- Watershed management;
- Mosaic plantation design;
- Development of conservation measures to guarantee the growth of high percentage of the areas with native trees in the mosaic design;
- Intense mechanization in all operational activities;
- Forest certifications (FSC, IS0 14001, CERFLOR);
- Minimum impact harvesting, leaving forest residues covering, nourishing and protecting the soil;
- Social benefits for workers.

Features of the Seventh Stage (2000's ⇒...): *"Dividing the cake"*

- Inclusion of rural farmers in the plantation model;
- Share of the highly sophisticated forest technology with partners;
- Promotion of the plantation of forests by improving the price paid to the wood in the market.

Features of the Eight Stage (2005's ⇒...): *"Opening the doors"*

- Intense participation of third parties in the production of forests;
- Better dialogue and communication to the interested parties;
- Agroforestry initiatives;
- Better planning and implementation of strategic and operational plans;
- Environmental impact assessment as a tool for planning operations;

- Better understanding of plantation impacts and mitigation;
- Acceptance of plantations as a viable and environmentally sound measure to provide wood to society.

Features of the Ninth Stage (2000's ⇒...): *"The wood quality and the tailor-making concept"*

This stage is concomitant to the 7th and 8th. It includes new ways in the tree breeding, aiming more efficient and more customer oriented trees. The main characteristics are:

- Search of clones that may be able to produce more pulp per unit of volume or weight (minimum wood specific consumption), with improved pulping conditions;
- Search of clones very efficient on utilizing natural resources (water and minerals);
- Search of clones producing wood fibers oriented to end users (tissue, printing & writing papers);
- Engineering of the form and architecture of the trees to guarantee maximum aerial growth;
- Improvements in the photosynthetic efficiency, to guarantee better utilization of the natural resources and maximum growth;
- Studies for developing the appropriate spacing to these highly productive clones;
- Improvements in the survival of the seedling/trees along the forest rotation. The aim is to harvest a number of trees similar to the number of planted seedlings.
- Search of very flexible clones with ability to grow in different conditions, but consistent in producing high quality wood.

Features of the Tenth Stage (2005's ⇒...): *"Genomics is arriving"*

Today, the Eucalyptus genome has already been mapped. The goal now is to identify the relationship between the genes and the expression of the phenotypic characteristics (wood density, tree form, resistance to some disease, lignin content, pulp yield, etc). With this tool at the hands, a tree individual can be selected at the embryo stage. This means that the speed of selection and development will be dramatically improved from now onwards.

Genetically modified organisms are also being investigated by some companies, in partnership with universities. There are rigid protocols and legislation to be followed.

Conclusion:

As it may be noticed, from the early days until now, the technology has moved and changed dramatically. In the beginning, the developments were 100% oriented to forest productivity (volumes) and operational issues. In a second moment, starting this move in the 1990's, the environmental issues gained importance. Now-a-days, the dominant investigations are related to the forest sustainability, including the economical, environmental and social aspects of the sustainable development. At the same time, sophisticated researches are being develop on silviculture, mechanization and genetics/genomics.

Are we in the end of this road? Are the today's growth rates the maximum we may achieve? Are the today's operation sustainable?

Surely, there are new developments to come. We are just starting this process, and there are many other issues to come. What we know is that this road is being paved with knowledge,

enthusiasm and good will. The next steps are to include more and more the participation of other interested parties, trying to develop a process that may be economically viable, environmentally correct, and with social justice. Nothing different than requested in the Sustainable Development Policies.