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GROWTH AND YIELD OF FOREST PLANTATIONS: ANALYSIS OF THE CURRENT STATE OF GLOBAL TRENDS

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ABSTRACT

Tree growth is variable because it depends on the genetic heritage of individuals, their environment, the stage of development and the action of man. The objective of this study is to present an updated and comprehensive review of the state of the art on growth and yield of forest plantations, which identifies the research conducted and aspects that remain unknown. The planted forest area worldwide increased considerably between 1990 and 2015 from 167.5 to 277.9 M ha; in 2012, worldwide, 46.3% of industrial roundwood came from forest plantations. In recent years there has been increased interest in understanding the effects of the environment on wood properties; the productivity of forest plantations is a function of supply, harvest and resource use efficiency; several different traits can be modified through genetic improvement, such as more vigorous growth, resistance to pests or diseases, or product quality. It is essential to know the biology of the species to be established in plantations and the agro-ecological characteristics of the area to be planted, in addition to defining the destination objectives of the production. Research should provide a more complete understanding of the physiological processes, the efficiency of the use of resources that control the development of wood, and the genetic improvement.

Keywords: environmental and economic benefits, wood, global warming mitigation, allometric models, productivity, forestry.

INTRODUCTION

Tree growth is a complex biological activity in which different factors intervene such as the activity of the buds (primary development or increase in length of the axes) and of the cambium (secondary development or increase in thickness of the axes) (Pretzsch, 2009). This evolution of trees is variable, as it depends on the genetic information of the individual, on the stage of development (physiological age of the tissues), and on the environmental conditions of their surroundings including the action of man through the modification of the environment as a response to certain activities such as cutting or pruning (Picard *et al.*, 2012).

Within the stand, a tree tends to be differentiated from the set. This distinction allows dissociating the different factors that intervene in tree growth: fertility of the place, competition between trees, and sociological classification. The fertility of the place in its broad sense entails the capacity of the soil to sustain the trees with nutrients and water, as well as the general climate of the zone including the photoperiod, temperature and precipitation, the intensity of frosts or droughts, etc. The competition between trees within the stand is measured with different indexes of density. Lastly, the sociological class of each individual defines its capacity to mobilize resources in its nearby surroundings (Picard *et al.*, 2012). Understanding how these factors affect the growth of trees is fundamental to know how the structure and the spatial and temporal composition vary.

The growth can be measured at different levels based on the structure of the woodland through dendrometric variables such as diameter, basal area, height, volume and biomass (Salas *et al.*, 2016). There is a global tendency to establish plantations to satisfy the demand for wood, and in addition, the plantations are cultivated to provide environmental, social and economic benefits (West, 2014). Plantations are forests established by humans that are generally in a regular space. Although most of them are of a single species for higher yield and productivity, there are plantations where species are mixed for product diversification. An objective of cultivating forests of higher production in limited areas is the production of prime material for the forestry industry. Therefore, it is important to consider silviculture of the plantations, the use of trees to achieve the objectives established (West, 2014).

Forest plantations are more productive than forests from the point of view of volume of wood, and if they are managed well, they could decrease the pressure on natural forests. However, they cannot provide all the services that the forests offer, especially when they are mono-specific plantations constituted by coetaneous masses of species that are managed intensively (Cordero, 2011).

Natural forests and forest plantations provide multiple benefits directly or indirectly (De Groot and Van der Meer, 2010). The direct benefits include goods such as wood, fiber, foods, fodder, ornamental and medicinal resources, and opportunities for recreation. Indirect services include the conservation of soil and water, as habitat of pollinating species and wildlife (Campos *et al.*, 2005), connectivity of landscape mosaics for biodiversity conservation (Kanninen, 2010), and they carry out a key role in global warming mitigation through carbon capture (Paquette and Messier, 2010). The forest plantations designed to provide multiple ecosystem services can reduce the pressure on natural forests, and even recover certain ecological services.

According to the aforementioned, the objective of this document is to present an updated and integral review of the state of the art on cultivation and yield of forest plantations, with which to identify the studies carried as well as the aspects that are still left to understand.

MATERIALS AND METHODS

The information from this study is mainly from secondary data review (derived from databases), and complemented with an extensive review of bibliographic material to back up the information gathered on growth and yield of forest plantations (FAO, 2012;

Jürgensen *et al*., 2014; West, 2014; Payn *et al*., 2015); silviculture and wood quality (Briggs, 2010; Muñoz *et al*., 2010; Watt *et al*., 2011; Gagné *et al*., 2012; Park *et al*., 2012; Campoe *et al*., 2014); nutrient management (Richards *et al*., 2010; Khouri *et al*., 2010; Faustino *et al*., 2011; Murillo *et al*., 2014; Balám *et al*., 2015; Oliva *et al*., 2016; Tchichelle *et al*., 2017); and genetic improvement (Bradbury *et al*., 2010; Han *et al*., 2011; Raymond, 2011; Apiolaza, 2012; Aparicio, 2012; Vargas *et al*., 2012; Mora *et al*., 2013; Ávila-Arias *et al*., 2015a; Ávila-Arias *et al*., 2015b).

RESULTS AND DISCUSSION

Forest plantations

The Food and Agriculture Organization of the United Nations (FAO) defines forest plantations as forests composed predominantly of trees established through planting and/or sowing, in which it is expected that planted/sown trees constitute more than 50% of the standing material in maturity (FAO, 2012). For its part, the National Forest Commission (*Comisión Nacional Forestal*, CONAFOR) specifies that a commercial forest plantation is the establishment and management of forest species in lands of agriculture and livestock use or plots that have lost their natural forest vegetation (CONAFOR, 2017).

Since 1980, FAO has gathered data about forest zones through Forest Resource Evaluations (*Evaluaciones de los Recursos Forestales*, ERF), for two main categories of forest: natural forests and forest plantations (Evans, 2009).

The forest plantation surface planted globally increased considerably between 1990 and 2015, going from 167.5 to 277.9 M ha. The World Wildlife Fund (WWF) and the International Institute for Applied Systems Analysis (IIASA) have suggested that a rate of increase of 2.4% is necessary to satisfy the future demand and to supply wood and fiber to compensate the impacts of deforestation (WWF and IIASA, 2012). Meanwhile, the annual rates of surface sown were higher in the periods of 1990-2000 (2%) and in 2000-2005 (2.7%); they were 1.9% 2005-2010 and 1.2% for 2010-2015. Based on this, Payn *et al*. (2015) mention that there are factors because of which this decrease takes place, among them management practices and climate change trends which stand out. Out of the 277.9 M ha of forest plantations, 56% are located in the temperate region, 15% in the northern zone, 20% tropical, and 9% in tropical and subtropical regions. The region of greatest increase in surface is temperate (93.4-154.4 M ha) followed by tropical, northern and subtropical regions. Eastern Asia and Europe have the largest area of plantation, followed by North and South America and Southeastern Asia (Payn *et al*., 2015).

Forest plantations represent a role in the compensation of pressure and negative impacts on natural resources; the decrease in natural forest surface is compensated by the increase in planted forest surface, although the objectives are different. They increased from 4.1 to 7% of the total forest surface during the period of 1990-2015, or from 1.29 to 2.14%

of the total land surface. Between 18 and 19% of the surfaces planted include introduced species, that is, non-native (*Eucalyptus*, *Pinus patula*, *Tectona grandis*). Figure 1 shows the surface of plantations with introduced species in different regions (Payn *et al*., 2015); they stand out for their large surface planted with introduced species from South America, Oceania, and East and South Africa, which average 76%.

Trends at the global level

Of the global surface with forest plantations with introduced species, 85% are distributed in Asia, America, the Caribbean, and the center, east and south of Africa. Figure 2 shows that China has the most extensive area of forest plantations in the world, with a surface of 91.8 Mha, followed by the United States with 26.4 Mha, Russia with 19.8 Mha and Canada with 15.8 Mha for the period 2010-2015.

China showed the greatest increase in surface, followed by Canada, USA and Russia. The next level of increase in surface was presented by India, Sweden, Brazil and Finland in the period 2010-2015 (Figure 3).

In general, the highest rate of planted areas was in the period 2000-2005 with 2.7%, and it decreased to 1.9% by 2005-2010. The decrease in the plantation rate was common in most of the countries with only three of the 20 producing countries of roundwood (Chile, Sudan and Ukraine) during the period 2010-2015 (Payn *et al*., 2015).

Yield of forest plantations

The different species established in forest plantations worldwide that show higher levels of productivity, less rotation time, larger estimated surface, and the main producing

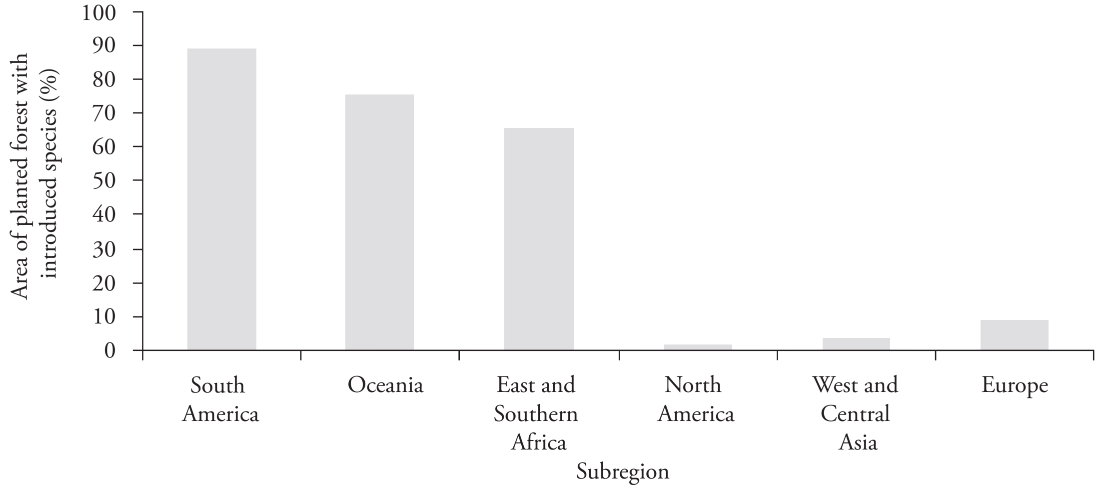

Figure 1. Surface of plantations with introduced species in different regions of the world (Payn *et al*., 2015).

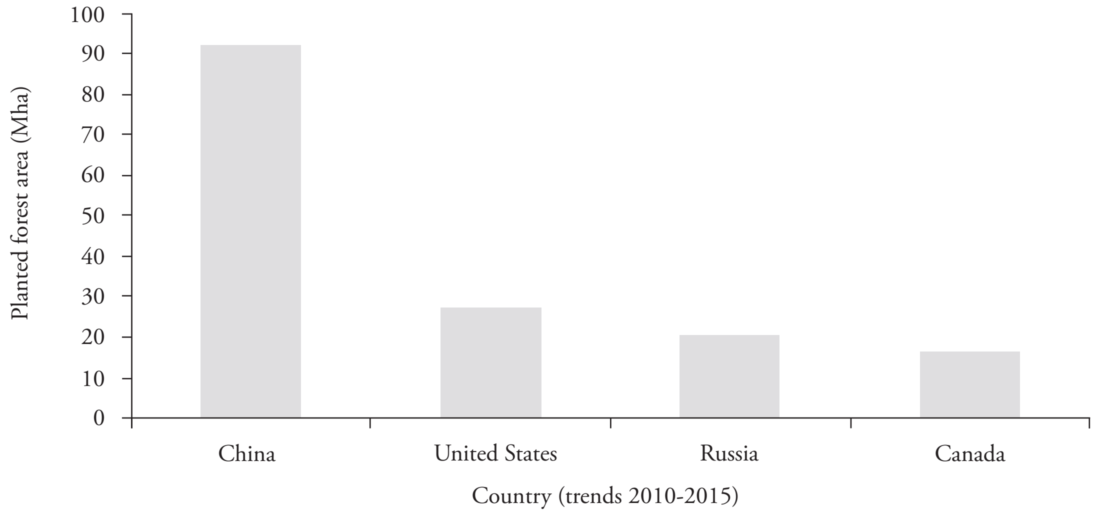

Figure 2. Surface with forest plantations (Payn *et al.*, 2015).

countries, are summarized in Table 1. The forest plantations of fast growth are defined in general terms as those that have average growth rates that range from ≤10 to ≤40 m^3/ha/year, with shorter rotations from ≤6 years to around 35 or 40 years.

Trends of wood production (roundwood supply)

The supply of industrial roundwood is the main production variable. Worldwide, in the year 2012, 46.3% of the roundwood (m^3/roll) originated from forest plantations (Table 2), of which 65% was from tropical and subtropical plantations, 45% from temperate

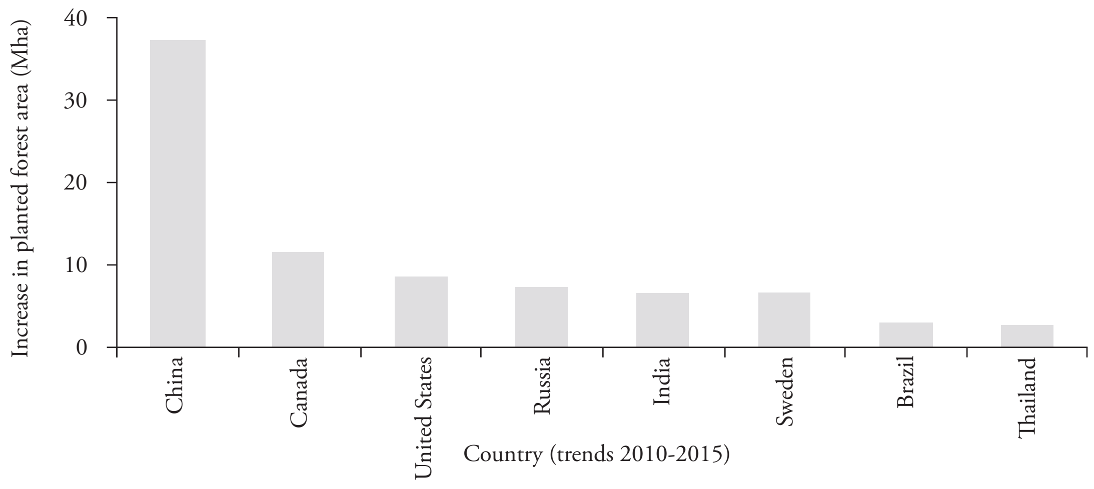

Figure 3. Increase in the surface of forest plantations (Payn *et al.*, 2015).

Table 1. High yield, short-rotation plantation forestry*.

Species	MAI* (m^3/ha/yr)	Time to reach maturity (years)	Estimated extent fast-wood plantations only (1000 ha)	Main countries (In decreasing order of impartance)
Eucalyptus grandis W. Hill ex Maiden, and various eucalypt hybrids	15-40	5-15	±3,700	Brazil, South Africa, Uruguay, India Congo, Zimbabwe
Other tropical *Eucalyptus* spp	10-20	5-10	±1,550	China, India, Thailand, Vietnam, Madagascar, Myanmar
Temperate eucalyptus	5-18	10-15	±1,900	Chile, Portugal, north-west Spain, Argentina, Uruguay, South Africa, Australia
Tropical acacias	15-30	7-10	±1,400	Indonesia, China, Malaysia, Vietnam, Philippines, Thailand
Pinus	8-35	10-18	±300	Venezuela, Argentina, Chile, New Zealand, Swaziland
Gmelina arborea Roxb	12-35	12-20	±100	Costa Rica, Malaysia, Solomon Islands
Paraserianthes falcataria (L.) I.C.Nielsen	15-35	12-20	±200	Indonesia, Malaysia, Philippines
Poplars	11-30	7-15	±900	China, India, USA,central and western Europe, Turkey
Extensive plantations (Native species) Conventional regeneration of conifers after thinning	2-6			Canada
Intensive silviculture	2-7			Scandinavia
Natural Forests Extensively managed	1-3			North America, Europe, China, Russia
Certified Forests	<1			World

*MAI= Mean Annual Increment.
Source: prepared with information obtained from Park *et al.* (2012).

plantations, and only 14% from the northern zone (Jürgensen *et al.*, 2014). The lower values for northern and temperate zones could be because the forest plantations in these areas are young to produce wood. However, given the large areas of forest plantations, especially in the temperate zone (25.78% of the total forest surface), there is potential for a higher production in the future from these. The increase in surface planted in the regions should cause an important increase in wood production over the next decades. This indicates that in the future wood will come further from forest plantations (Payn *et al.*, 2015).

Roundwood production from forest plantations in the year 2012 was approximately just over 770,200 M m^3, in South America 193 M m^3, Asia 165,300 M m^3, and North and Central America 171,700 M m^3. The Caribbean and northern Africa produced considerably less, between 300 and 400 M m^3. The regions of Oceania, Africa and Asia are home to countries with highly developed intensive forest plantations using exotic species of fast growth (Payn *et al.*, 2015).

Table 2. Planted forest roundwood production by región and climate domain.

	Total forest area 2015 (Mha)	Planted forest area 2015 (Mha)	Annualised % change in planted forest area 1990-2015	Planted forest industrial roundwood 2012 (1000 m^3)	Planted forest % for total industrial roundwood
World	3,999.1	277.9	2.0	770,200	46.3
Tropical	1,770.1	56.8	2.5	255,300	63.7
Subtropical	320.0	24.7	1.2	69,600	64.7
Temperate	1,031.0	154.4	2.0	410,100	45.2
Boreal	877.3	41.9	2.0	35,200	13.9
South America	842.0	15.0	2.5	193,000	89.8
Oceania	173.5	4.3	1.9	47,500	84.0
East and Southern Africa	274.8	4.6	1.2	20,700	64.7
Caribbean	7.1	0.7	2.4	300	24.7
East Asia	257.0	91.8	2.2	78,700	46.9
Central America	86.2	0.4	0.6	1600	18.0
West and Central Africa	313.0	3.2	3.2	5100	14.1
Southern and SE Asia	292.8	29.9	3.4	82,700	52.0
North Africa	36.2	8.4	0.9	400	15.7
Europe	1,015.4	70.4	1.3	166,200	33.4
West and Central Asia	43.5	6.7	2.1	3900	19.1
North America	657.1	42.1	2.5	170,100	36.0

Source: prepared with information obtained from Jürgensen *et al.* (2014).

In 2012, countries like China, the United States, Russia, Canada, Switzerland, India, Japan, Brazil, Finland, Sudan, Germany, Indonesia, Ukraine, Thailand, Vietnam, Turkey, Chile, Spain, New Zealand and Australia produced overall 87% of the global industrial production of roundwood from forest plantations, with a total of 675 M m^3, which reflects the opportunities of large increases in production in countries such as China, where the surface is high and the production is presently relatively low because many of the plantations are still young (Payn *et al.*, 2015).

The global need for wood production has led to planting of species selected on the basis of their capacity for adaptation to local conditions and their fast growth (Dodet and Collet, 2012). To evaluate the growth rates, the owner of a plantation will need some way of measuring and showing the results of the evaluation (West, 2014).

The estimation of production in silviculture includes the stand volume, and the biomass that dies and/or is removed by clearing. These production data, as they come up in the production models or the growth models based on dendrometry do not include fallen litter (leaves, branches, bark) or root recycling. Instead, in the models based on eco-physiology or balance of carbon and mineral elements in the stands, the production includes this renovation of the organs (Picard *et al.*, 2012).

A measurement of the productive capacity that has been used is known as site index, which is defined as the dominant height (which is the average height of the tallest trees in a stand) at a specific age (Yuancai and Parresol, 2001). The studies carried out in various types of forests have shown that this measurement is closely correlated with biomass production. The height of the dominant trees (H_0) constitutes the main motor of most of the growth models with dendrometric bases (García, 2011).

A second measurement is the mean annual increase (MAI) of wood from the stand observed in a site (West, 2014). The growth and production models allow predicting the development of trees or forest masses for foresters and forest managers (Diéguez-Aranda *et al*., 2009). Through information about the growth, the age of the optimal rotation for harvest is estimated and the decision is made about when and how intensively to apply forestry treatments such as clearing and pruning (De Groot and Van der Meer, 2010).

The mathematical models of forest growth based on processes are those that involve physiological processes that happen in plants and how these are affected by the environmental conditions in which plants are growing (West, 2014), which include:

1. The way in which the leaves are arranged in the canopy to intercept sunlight.
2. The chemical efficiency of their photosynthetic system.
3. The way in which their metabolic processes are affected by air temperature.
4. Their capacity to keep their stomata open as water availability in the soil decreases.
5. The size and distribution of their fine roots in the soil and their efficiency in water and nutrient uptake.

Silviculture and wood quality

As the markets have become increasingly preoccupied with the quality of the wood supplied by the plantations, the interest over effects on the properties of wood from the environment where plantations are cultivated has increased (Briggs, 2010); these include factors about the site, such as soil fertility and climate, as well as the effects of silviculture practices that are applied to promote the growth of plantations. Special attention has been placed on the effects on the basic density and hardness of wood, since the latter is mainly correlated with the density (Watt *et al*., 2010).

The environmental conditions that accelerate the growth of the tree shaft, whether due to the characteristics of the site or to silviculture practices, often lead to the production of wood with reduced hardness according to Watt *et al*. (2011); however, the effect does not always happen and the clearing does not have any consequence on the hardness of wood as exposed by Gagné *et al*. (2012) on plantations of *Picea glauca,* where this forestry practice did not have effects on the hardness of the wood.

The acceleration of the growth rate of the shaft diameter often also leads to a reduction of the basic density of the wood as indicated by Park *et al*. (2012) in a clonal plantation of *Picea glauca*. Although not always, as pointed out by Muñoz *et al*. (2010); in plantations of *Eucalyptus nitens*, they found that eight years after clearing, it did not have a significant effect. Based on this, West (2014) indicates that there is scarce evidence that silviculture treatments on their own lead to effects on the wood properties.

On the other hand, intensive silviculture, for example managing fertilization or weed control in comparison to traditional silviculture, reduces environmental stress during the first years of the plantation, which gives rise to a significant increase in growth and the capacity for adaptation and survival of the trees, as is the case of *Eucalyptus* (Villalba *et al*., 2010; Campoe *et al*., 2014).

Management of nutrients

The productivity of forest plantations is in function of the supply, capture and efficiency in the use of resources (Richards *et al*., 2010); according to the aforementioned, Fisher and Binkley (2000) point out that in order to maintain forest productivity it is essential to conserve soil nutrients, which depend on the positive balance between inputs and outputs of these nutrients in the system. West (2014) mentions that the first years of growth of a plantation are particularly crucial for the supply of nutrients, and any scarcity that happens in the supply of nutrients can be compensated by fertilization. However, fertilization is expensive and should only be used if the resulting increase in production can be justified economically; in addition, it is important that it is the correct type and that it is applied in the adequate stage and amount, to compensate for the needs of growing trees. The need for fertilization supplied to conserve the nutritional balance in tree growth in forest plantations is indisputable, as shown by Khouri *et al*. (2010). Faustino *et al*. (2011) show that the prepared application of P and N on stony soil can have negative effects on the growth of *Pinus taeda* established in plantations that are fundamentally product of the depressive action of N; in plantations of *Tectona grandis*, Balám *et al*. (2015) determined that the high application of K can affect the absorption of other nutrients.

A setback in the development which involves fertilizing with urea in the establishment can be avoided with genetic improvement, factor that provides the use of this silviculture practice to recover or maintain the endowment of N in the sites that are subject to repeated cycles of planting and harvesting (Faustino *et al*., 2012). For their part, Calixto *et al*. (2015) manifest the potential of fertilization as a method to control the impact of *Hypsipyla grandella* in plantations of *Cedrela odorata*. The leaf concentration of nutrients allows relating the variables of growth with the nutrition in plantations; in addition, Murillo *et al.* (2014) mention that the leaf nutrients vary with age, leaf concentrations of Ca, Mg, Mn, Fe and Al show an increasing trend with age, while those of N, K and Zn tend to decrease.

Correndo and García (2012) consider that leaf analysis is very useful to relate the soil with the nutritional status of the woodland; this leaf analysis can give direct information about the nutritional status of a forest mass and indirect information about the soil nutrient content; as shown by Fraga *et al*. (2012), with the use of functions to model the concentrations and macro and micro nutrients in needles of *Pinus pinaster* established in plantations as a function of age, where a good rate between the site index and the concentration of nutrients stands out. In plantations of *Tectona grandis*, Salcedo *et al*. (2014) determined that the leaf content of K does not limit the growth, the higher concentrations of N, P and K are seen in young leaves and it stands out that among the soil variables, the content of clay presents a positive correlation with the development of the diameter, where the soils with highest proportion of clay and organic matter (OM) show the greatest cation exchange capacity (CEC), which favors growth.

Fernández *et al*. (2010) indicate that the increments in productivity represent a high potential of nutrient export which increases the importance of applying techniques such as maintaining harvest residues; for their part, Martiarena *et al*. (2011) calculated the effect of the intensity of clearing on the conservation and stability of N, K, Ca and Mg in different strata of a plantation of *Pinus taeda* with remnant densities of 711, 364 and 122 trees/ha, and they found that the N, K, Ca and Mg content in the system decreased to the extent that the intensity of clearing increased, and the nutrient export from the shaft and the complete tree showed the same proportion; they concluded that the remnant nutrient index (RNI) shows the convenience of applying a harvest of shafts and conserving the residues of the harvest. In plantations of *Pinus patula*, Oliva *et al*. (2016) report a slight reduction of pH (4.50) compared to areas without pines (4.83), and an increase of organic matter; regarding K, the areas with pine exhibited lower amounts (109.50 ppm) than the areas without pine (135.73 ppm), and the same happens with the P content. The low availability of phosphorus in Andosol soils and the excess of active aluminun limits the development and the production of forest plantations (Álvarez *et al*., 2013).

Regarding the concentration of nutrients available in the superior layer of the soil, Lutter *et al*. (2015) concluded that the concentrations of available N and P had maintained the same level, contrary case to K and pH_{KCl} which decreased significantly during the 13 years that passed between the two monitoring events in a plantation of *Betula pendula*, which is why the horizon A of old agricultural soils provides sufficient nutrients to ensure a high productivity of trees. For their part, Tchichelle *et al*. (2017) mention that the establishment of plantations of eucalyptus in poor sandy soils leads to a high loss of nutrients, including the N after wood harvesting; they conclude that eucalyptus trees benefit from the increase in availability of N in the soil of stands with mixed species.

Genetic improvement

Several different traits can be modified through genetic improvement, such as a more vigorous growth, resistance to pests or diseases, of product quality (wood in trees). Most of the main programs of forest plantations worldwide have an associated improvement program. Among others, the quantitative traits include the tree growth rate, density of shaft wood, or resistance to the attack of some pests and diseases (West, 2014). In improvement programs, something to always take into account is that environmental effects will modify the degree to which an individual tree shows any trait, and this is why the interactions genotype × environment have been examined in the properties of survival, growth and form in plantations of *Acacia melanoxylon* (Bradbury *et al.*, 2010; Bradbury *et al.*, 2011). Regarding plantations of *Pinus radiata*, the interactions genotype × environment were examined in the tree's growth rate, shape of the shaft, shape of the branch, and basic wood density (Raymond, 2011; Apiolaza, 2012); and other characteristics about clonal plantations of *Populus* (Senisterra *et al.*, 2011); 80% of the clonal trees of *Eucalyptus grandis* showed good straightness of the shaft, while the seed material in only 21% of the trees presented good straightness of the shaft (Aparicio, 2012).

With clone-environment interaction models (Bayesian analysis of genetic growth parameters) on a clonal plantation of *Eucalyptus globulus*, Mora *et al.* (2013) determined values of iheritability under contrasting environmental conditions (H_2= 0.41, 0.36 and 0.39 for height, diameter and basal area). On the clones of two origins of *Gmelina arborea* planted in flat sites, the dasometric variables evaluated did not show significant differences as pointed out by Ávila-Arias *et al.* (2015a), Ávila-Arias *et al.* (2015b). For their part, Vargas *et al.* (2012) suggested a high potential of improvement at the family level in growth and productivity of plantations of *Acacia mangium*. Morales *et al.* (2013) used 84 families of half-siblings of *Pinus patula*, to evaluate the increase in volume and adaptability to different altitudes; they found significant differences in growth and determined that the best reponse was presented in sites of lower altitude. Phenotypical plasticity was observed in 13 families of half-siblings of *Pinus pseudostrobus*, in which some families were competent to modify attributes in the production and the distribution of biomass in response to the levels of competence formed through plantation densities, and different strategies of growth were identified in the families evaluated between each category of competence (Cambrón *et al.*, 2013).

The genetic profit achieved in plantations of *Eucalyptus* cultivated in rotations of 10 years for wood production for pulp; the increase in wood volume of the standing shaft had an average of 8% at 5 years of age, seeds from one and two generations of an improvement program were used; the profits were higher in sites with higher productivity than in the less productive, according to Du Tiot *et al.* (2010). Two generations of reproduction of hybrid poplars (*Populus tremula* × *Populus tremuloides*) increased by 25%the shaft wood production in a rotation period of 25 years; the hybrids between many species of *Populus* have been used in North America and Europe because of their high growth rates (Tullus *et al.*, 2012). Assays of progeny of *Acacia mangium* compared to the genetic profit expected recorded average inheritability values (40% and 50%); based on this, Pavlotzky and Murillo

(2012) concluded that if the two best individuals were selected within the best twelve families, a genetic profit of 40.85% in commercial volumen/ha will be obtained, at a rate of 22.9 m^3/ha/year. Studies in plantations of *Populus* included genetic engineering so that the hormonal metabolism modified affects the growth rate and the wood characteristics (Han *et al*., 2011); genetic engineering is included in plantations of *Eucalyptus globulus* for the tolerance to high salinity of the soil (Matsunaga *et al*., 2012).

CONCLUSIONS

Although the studies on growth and yield of commercial forest plantations are an important activity for research at the global level, most of these activities are limited to certain regions, types of plantations and species. It is necessary to carry out more research to cover regions, types of plantations, particular growth forms and tree classes of low representation.

The studies on growth and yield of commercial forest plantations are focalized on a few species; however, there is broad diversity of species, both native and exotic, with high potential of wood exploitation, about which research should be directed to generate this knowledge, which can be considered as an option both for owners, managers and investors. It is essential for studies to provide a thorough comprehension of the biology and physiology processes, the efficiency of resource use that control wood development, and of the genetic improvement of species of interes to be established in plantations, as well as the agroecological characteristics of the area to be planted, and to define the objectives regarding the destination of the production, for it to be directed towards sustainability. In addition, the trends in climate change should be taken into account.

Conflict of interest: the authors declare that they do not have any conflict of interest.

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