Conceitos e Conhecimentos de Métodos e Técnicas de Pesquisa Científica em Engenharia Florestal

Cristina Aledi Felsemburgh
(Organizadora)

Atena
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Atena Editora
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APRESENTAÇÃO

É com enorme contentamento que apresentamos o e-book "Conceitos e Conhecimentos de Métodos e Técnicas de Pesquisa Científica em Engenharia Florestal" que foi elaborado para a divulgação de resultados e avanços relacionados às Ciências Florestais. O e-book está disposto em 1 volume subdividido em 17 capítulos. Os capítulos estão organizados de acordo com a abordagem por assuntos relacionados nas diversas áreas da Engenharia Florestal. Em uma primeira parte, os capítulos estão de forma a atender a área de silvicultura voltada para as técnicas silviculturais para produção, tecnologias para produção de sementes e mudas, melhoramento florestal e proteção florestal. Em uma segunda parte, os trabalhos estão estruturados de forma a abordar a área de ecologia e dinâmica florestal. Em uma terceira parte, os trabalhos estão voltados para a tecnologia de produtos florestais mais especificamente relacionados às propriedades físicas, químicas e mecânicas da madeira. Em uma quarta parte, com um trabalho sobre gestão ambiental, abordando a importância dos recursos hídricos. E finalizando, a quinta parte com um trabalho sobre sensoriamento remoto. Desta forma, o e-book "Conceitos e Conhecimentos de Métodos e Técnicas de Pesquisa Científica em Engenharia Florestal" apresenta resultados relevantes realizados por diversos professores e acadêmicos que serão apresentados neste de forma didática. Agradecemos o empenho e dedicação de todos os autores das diferentes instituições de ensino, pesquisa e extensão, por partilharem ao público os resultados dos trabalhos desenvolvidos por seus grupos de pesquisa. Esperamos que os trabalhos aqui apresentados possam inspirar outros estudos voltados às Ciências Florestais.

Cristina Aledi Felsemburgh

SUMÁRIO

CAPÍTULO 10

INFILTRATION CAPACITY MODELLING UNDER FORESTS IN THE BASIN OF THE SAN CRISTOBAL RIVER, BOGOTÁ

Data de aceite: 04/01/2021

Carlos Francisco García Olmos
Universidad Distrital Francisco José de Caldas
Bogotá D.C., Colombia

Diana Constanza García Rincón
University of Sao Paulo
Sao Paulo, Brazil

ABSTRACT: It studied the infiltration capacity under mature forests of *Cupressus lusitanica, Eucalyptus globulus* and natural forest in the basin of the San Cristobal River, southeast of the Bogotá city. The characterization of the forests was made and identified in each three representative trees; around which were measured infiltration capacity. With the curves of the infiltration capacity obtained according to Horton, Philip, Kostiakow and modified Kostiakow, models using MATLAB, class nonlinear model fit. The most representative model was Horton. *Cupressus lusitanica* forest presents the curves with the highest values of the infiltration capacity in the soils, and then the saturation of *Eucalyptus globulus*; both by its more robust and deep root systems. Found differences were found to be statistically significant. These results allow to know the benefits of these mature forests in regulating flows.
KEYWORDS: Natural forests, *lusitanica Cupressus, Eucalyptus globulus*, Horton, infiltration.

RESUMEN: Se modelizó la capacidad de infiltración bajo bosques maduros de *Cupressus lusitanica, Eucalyptus globulus* y bosque natural en la cuenca del río San Cristóbal al sureste de la ciudad de Bogotá. Primero se hizo la caracterización de los bosques y se identificó en cada uno tres árboles representativos. Con centro en cada árbol representativo se trazaron líneas radiales cada 120 grados sobre las cuales realizaron mediciones de capacidad de infiltración a los 3, 6 y 9 metros de distancia a partir de cada uno de ellos. Con las curvas de la capacidad de infiltración obtenidas se hallaron los modelos según Horton, Philip, Kostiakow y Kostiakow modificado, utilizando MATLAB, clase nonlinear model fit. El modelo más representativo fue el de Horton. Se pudo establecer que el bosque de *Cupresssus lusitanica* presenta las curvas con los mayores valores de la capacidad de infiltración y las mayores tasas de la capacidad de infiltración a suelo saturado, y luego el de *Eucalyptus globulus*; ambos por sus sistemas radiculares más robustos y profundos. Las diferencias halladas resultaron ser estadísticamente significativas. Estos resultados permiten conocer las bondades de estos bosques maduros en la regulación de caudales.
PALABRAS CLAVE: Bosque natural, *Cupressus lusitánica Mill, Eucalyptus globulus Labill*, Horton, infiltration.

INTRODUCTION

It studied the behavior of the infiltration capacity of a natural forest, and mature plantations of cypress (*Cupressus lusitanica* Mill) and eucalyptus (*Eucalyptus globules* Labill), and analyzed the differences between them, result that allows to make a better choice of species that should be planted to obtain a higher water potential in the watershed.

The modeling of the infiltration capacity it can to know how these forest species have their infiltration processes in search for a better regulation of flows in watersheds.

Factors affecting the capacity of infiltration are related to species planted, the type of soil, the content of organic matter, slope and their configuration, the transfer of water in soil, its storage capacity, characteristics of the permeable medium and the flow of water through the soil profile. (Philip, 1957); (Terlien, 1998); (Lal and Shukla, 2004).

The tree characteristics that affect the ability of soil infiltration include their age, layout, density, management, root development and its aerial structure.

Root systems forming cracks in the soil or contribute to enlarge the pores and the treetops cushioning the impact of rain drops. In general, protected by forest areas have higher rates of infiltration capacity than those who are not. In addition, the organic layer that can be found on the ground in areas with good cover, protects the soil from the impact of water drops rain, and contributes to higher infiltration capacity.

In Kenya, Brazil and Niger there are examples that good management and care of the Earth prevents or reduces the scarcity of water, and is achieved by increasing the infiltration of rain water on the floor, being retained for the use of the plants or to recharge the groundwater**.** (Shaxson & Barben, 2005).

Vegetation exerts control over the components of interception, runoff, evapotranspiration and infiltration, increasing the capacity regulation of rain water that reaches the soil. (Cortés *et al.*, 2014). Capacity of infiltration have been made different mathematical models, which according to Mishra *et al.,* (1999), are classified in theorists such as Green-Ampt, Philip, Mein and Larson; semi empirical as Horton, Holtan, Overton, Singh-Yu and Grigorjev-Iritz and empirical as the SCS-CN, Kostiakov, Huggins-Monke, modified Kostiakov (Smith) and Collis-George.

The formulated models are derived from specific tests, regardless of the presence of the forest. According to Bruijnzeel (1997), plantation and its management have an influence on the hydrological characteristics, among which is the infiltration, which affects the water yield, runoff and sediments that occur in those soils.

Manzano Agugliaro & Zapata (2008), in the study of the influence of six tree species on soil water infiltration concluded that the infiltration must be corrected when there is presence of trees, and that infiltration decreases as the trees are more distanced. This work established a given density of trees to obtain greater soil infiltration.

Landini *et al* (2007) confirm the importance that infiltration in the conservation of groundwater. The infiltrated water can be much of fall rain and is very important to be able to quantify.

This research was designed to the characterization of tree species in the basin of the river San Cristobal, infiltration processes modeling and analysis, where was a contribution to their hydrological knowledge, for the conditions in which they are, allowing you to know what kind of forest favored greater infiltration capacity, to make a better water regulation applicable in similar watersheds.

The results obtained provide a knowledge in the hydrological process simulation lluvia-escorrentia, to improve regulation and water balance of watershed.

MATERIALS AND METHODS

Area of study

Located to the South East of the Bogotá city, on the eastern cordillera of the Colombian Andes, in the forest reserve of the basin of the river San Cristobal, between the 2900 and the 3200 meters above sea level, the village of San Cristobal. Figure 1.

The mean annual precipitation is 1220 mm. (Deliriumpluviometric-pluviographic station at the 3,000 meters, 1933-2013 period), with an average temperature of 13.3 °C (Vitelma weather station, at 2800 meters, 1981-2013 period). (Empresa de Acueducto y Alcantarillado de Bogotá "EAAB", 2014).

According to the rainfall regime, the way how are temperatures, relative humidity and winds, the weather in the area has two dry periods, which are: from December to March and in September; and two wet: from April to August and October to November. (García, 2007).

Figure 1. Location of the basin of the river San Cristobal in the town that bears his name, in the city of Bogotá, D.C. source: www.esetunjuelito.gov.co

In the basin were identified *C. lusitanica* forested experimental areas, *E. globulus*and natural forest. (Figure 2).

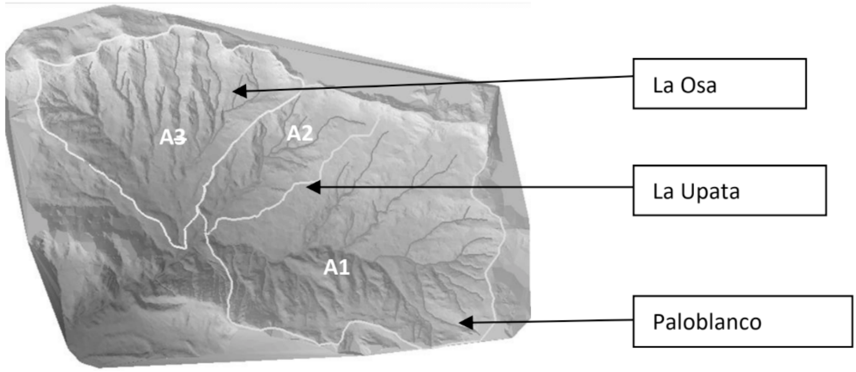

Figure 2. Basin of the river San Cristobal, watersheds, and the experimental areas located: (*C. lusitanica*) A1, A2 (*E. globulus*) and A3 (Natural forest).

In the forest of *C. lusitanica*, much of the area is free of undergrowth, but in Exchange there is an important organic layer on the ground, with abundant supply of needles, own a very mature, planted forest without any design or management later but is in good condition.

The forest coverage of *E. globulus* is very populated with chusque (*Chusquea* sp.) It is a planted forest as old as that of *C. lusitanica*.

Natural forest, has the greatest variety of species compared to the others. Between the chusque and other species, are few clearances. There the reference tree is the encenillo (*Weinmannia tomentosa*). (Table 1).

The study area is of sandstone and clay with varied States of compaction. The geological formations belong to the upper Cretaceous age. These are the Guadalupe formation with hard sandstones and limestones, the Guaduas formation siltstones and claystones, the Chub formation with sandstone and Quaternary formation which is of fluvio-glacial and alluvial accumulations. (Van der Hammen & Gonzalez, 1963).

The relative density of the soil under the plant cover is low, with values of 0.3 to 0.7 and porosity of 60 to 75% with a volume of empty of 55 to 65%.

According to the identified characteristics of soils in the experimental areas, were classified taxonomically, in accordance with the United States Department of Agriculture - USDA, in the order of the Inseptisoles, of recent volcanic origin, with little defined characteristics. They are soils of low temperatures that can develop in humid climates, with low rates of organic decomposition, have accumulations of amorphous clays and an acid ph. (De Las Salas & García, 2000).

Watershed	Species of Reference	h (m)	DAP (m)	D Cup (m)	Density (No. / ha.)	Main species understory
Palo Blanco	*Cupressus lusitanica*	25-32	0.92	2.5	1166	*Chusquea*sp,
The Osa	*Weinmannia tomentosa*	12-17	0.08-0.27	6.0	2672	*Chusquea*sp, *Myrcianthesleucoxyla (large Myrtle), Myrsine sp.(hayuelo), Alnusacuminata (Alder)*
The Upata	*Eucalyptus globules*	20-30	0.70	3.0	1000	Chusquea sp

Table. 1. An overview of the reference species

Were it obtained in-situ nine cylindrical samples taken to 0.60 meters deep, in the central area of each forest, one at each site where**;** infiltration capacity test was performed samples were examined to evaluate the texture**,** identifying these as sandy soils and sandy frank, with permeability from 25 to 50 mm/h.

Design Experimental implemented for each type of forest

Each forest type had an experimental area of one hectare, where three representative trees is selected. Around each representative tree radial lines were plotted every 120 degrees, and on them were the sites of the trials of infiltration capacity, to distances of 3, 6 and 9 meters. Two replications by trial, for 18 trials by representative tree done at each site. Replications were verification purposes. (Figure 3).

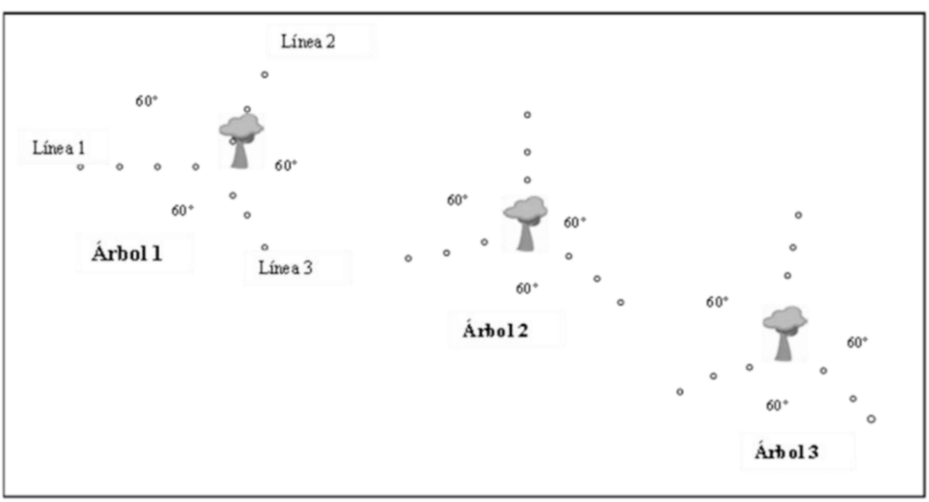

Figure 3. Disposal of trials according to experimental design, in every forest.

Eexperimentation

Experimentation was done by conducting trials of infiltration capacity around the representative trees in each forest type, for a total of 162 tests, according to design of Figure 3.

Infiltration capacity

The degree of initial soil humidity for each trial was established with the TDR-100 moisture meter. Trials were made by concentric metal rings 28 cm in diameter, kneeling on the ground to a depth of 10 centimeters, in the mineral soil, prior retired from the organic layer.

Infiltration capacity models in three types of forests

Preprocessing: calculation of soil infiltration capacity for each time interval: were digitized data that correspond to the level of water in millimeters and the time in minutes. The calculation of soil infiltration capacity was based on the definition of differentiation:

$$Infiltration\ \ capacity[{}^{mm}/_{min}] = \frac{|Water\ layer(t_{i+1}) - Water\ layer(t_i)|}{t_{i+1} - t_i} \qquad (1)$$

Processing: Calculation of parameters of different models using non-linear regression. The treatment of the data was performed with MATLAB R2012b (Moler, 2012).

In the setting of parameters of the models in the study used the same method of non-linear regression. This setting was optimized by the least squares technique, which is the tool that is used in MATLAB called the nonlinearmodel.fit class.

The initial value assigned to the parameters was empirical, based on the shape of the curve obtained and the equation which is intended to represent.

The models used were: Horton, Philip, Kostiakov and modified Kostiakov, whose mathematical expressions are presented in Table 2.

Model	Equation
Horton	$f(t) = f_c + (f_o - f_c)e^{-kt}$
Philip	$f(t) = st^{-0.5} + C$
Kostiakov	$f(t) = abt^{b-1}$
Kostiakov Modificado	$f(t) = f_c + \alpha t^{-\beta}$

Table 2. Equations for the infiltration capacity

Where:

t = time passed since the surface soil saturation, in minutes

k = constant of decay

f (t) = permeation rate at time t, mm/h

f_0= initial infiltration rate (t = 0), mm/h

f_c= minimum infiltration rate (asymptotic), mm/h

s = sortividad in Philip, obtained by regression model.

C = transmissivity in Philip, obtained by regression model.

a, b = parameters of Kostiakov model, obtained by regression.

A, β = modified Kostiakov model parameters, obtained by regression.

The modelling was done taking into account the criteria of initial moisture content of the soil, which were defined as high (60-80%), medium (40 to 60%) and low (20-40%) and the distance to trees representative, that they were 3, 6 and 9 meters.

Behavior of the infiltration capacity in three types of forests

It is determined based on the obtained modeling, first associated with general level including all trials of each species, and then for the trials around each representative tree in particular, and then taking into account the distances to the representative tree and subsequently according to the degree of moisture in soil.

Analysis of the infiltration capacity in three types of forests

Using calibration curves obtained from the behavior of the infiltration capacity for each species and taking into account the degree of moisture in soil and the distances to the representative trees. The results are compared with other studies.

Analysis of variance of the infiltration capacity under saturation in three types of forests

In order to determine whether the differences in the capacity of infiltration under three types of forests are significant, variance analyses were made based on infiltration under the condition of saturation of the soil, which is the final rate of infiltration, of each of the experiments made capacity.

Discussed the statistical validity through analysis of variance of each forest with the design of blocks at random for each of the forests, which allowed to determine the behavior to the inside of each one of them and then that those results met this led to an analysis of variance of data completely at random.

RESULTS AND DISCUSSION

For the modelling done, a good overall fit was obtained at Horton model according to the indicator R^2, for natural forest, but not for other coverages. But grouping the tests based on the degree of initial soil moisture were found trends which are defined for all forests in study, especially when the initial soil moisture content is high (60-80%), with $R^2$of at least 60%, and with the other contents of initial humidity of the soil (low and medium) the degree of adjustment was 15% lower. (Table 3).

Soil moisture	Species	R^2	Model
	E. globulus	0.4257	Kostiakov mod.
Initial low moisture	*C. lusitanica*	0.5308	Horton
	Natural forest	0.7179	Horton
	E. globulus	0.4880	Horton
Initial average moisture	*C. lusitanica*	0.5496	Horton
	Natural forest	0.8140	Horton
	E. globulus	0.9328	Horton
Initial high humidity	*C. lusitanica*	0.6036	Horton
	Natural forest	0.9440	Horton

Table 3. Assessment of R^2 of some capacity modelling of Infiltration, according to the soil moisture range.

The considered models were those of Horton, Philip, Kostiakov and modified Kostiakov, the behavior of the infiltration capacity presented a better degree of adjustment with the formulation of Horton (R^2> 60%), under sandy soils sandy, accompanied by the plant cover in the study; the other models were not sufficiently representative.

The results were compared with those obtained by Guevara & Marquez (2010), who evaluated nine models in three sectors of a farming community, Basin of Chirgua River, Venezuela, under organic silt soils, sand loam and clay loam, using infiltration meters. They found that the Horton model was satisfactory for the entire series of data, the model of Kostiakov modification best estimated from the 400 mm/h and high moisture content model of Philip, who was the only one with an R^2 had a good fit greater than 70%.

Although in the former case it is not same soils and coverage, if the wide applicability of the Horton model, but also other models which were considered in the present study also had an acceptable level of approximation.

Ateca *et al* (2007), studied the movement of the water in the profile of a Haplustol under conditions of natural forest and monoculture of soy, and found that the Horton equation best described that of Philip the process of infiltration of water in the soil, corroborating the applicability of this model in the process of infiltration under forest.

Navar & Synnott (2000), determined the effect of the use of the soil at the rate of infiltration of vertisols in Northeast Mexico. They used double infiltration meters of constant load, in trials from July to November 1985 on the agricultural property of the Universidad Autónoma de Nuevo León - UANL on agricultural lands, grasslands, scrub and forest plantations. Data were adjusted using the models of Green and Ampt, modified Kostiakov, Horton and Philip, finding that the modified Kostiakov model was the best fit. When compared with the modeling done in the present study with modified Kostiakov, this was one of the best fit, which shows that in forestry and agricultural applications is representative, by adjusting its coefficients.

Shown the model curves of the infiltration capacity according to the considered initial soil moisture ranges, in Figures 4a, 4b and 4 c.

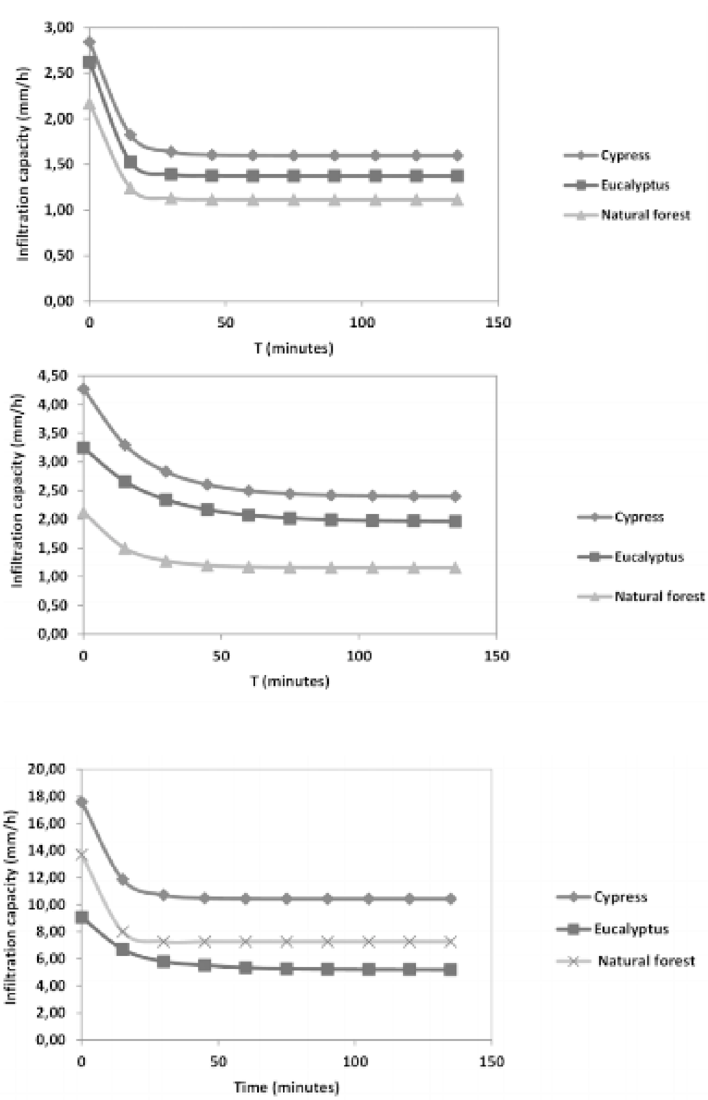

Figure 4. Curves of the infiltration capacity, modelled for initial soil moisture: (a). 60 to 80%. (b). 40 to 60%. (c). 20 to 40%.

Ranges that were experimentally infiltration capabilities for forests study are presented in Table 4. Shows that differences in the capacity of infiltration of the species in the study are minimized higher initial moisture content of soil, being lower for initial soil moisture of 60 to 80%.

Species	ω_i (20-40%)		ω_i (40-60%)		ω_i (60-80%)	
Cypress	660.0	1,050.0	168.0	258.0	102.0	174.0
Natural forest	450.0	810.0	78.0	126.0	72.0	126.0
Eucalyptus	360.0	540.0	138.0	198.0	90.0	162.0

Table 4.Ranges ofinfiltrationcapacity (mm/h), for intervals of initial soil moisture ω_i (%), Basin of San Cristobal River, Bogotá, D.C.

According to Figure 4 and Table 4 the infiltration capacity for contents of initial soil moisture (40 to 60%) and (60-80%) is greater for *C. lusitanica* and then *E. globulus* by the influence of their root systems on the structure of the soil, which are more robust and become a trainer agent of the same, when it comes to forests that have been there for many years.

Another analysis that was made was the compare to a same species variations in the values of the capacity of infiltration, according to the initial soil moisture contents considered content of initial soil moisture (20 to 40%) shows that the natural forest presents greater sensitivity on the behavior of the infiltration capacity by changes in the value of the initial soil moisture of the ground in front of content medium and high soil moisture, with which the differences are slim. This fact can be explained by the influence that it has varied and abundant vegetation that is superficial, which favors the process of infiltration under this low soil moisture condition.

Is assessed the degree of development of root systems by linking them with the column shafts and height of trees, where the *C. lusitanica*, turns out to be the larger species, with a diameter at the height of the chest-DAP in the order of 0.92 meters, heights of 25 to 32 meters and diameters of the order of 2.5 Cup meters, but the density of the forest of 1166 trees per hectare. This result is consistent with that obtained by Manzano Agugliaro & Zapata (2008), who determined that higher values of infiltration are presented to greater height and diameter of trees.

The general trend for a second place in terms of the infiltration capacity, turned out to be of the *E. globulus*, which has trees with a diameters of up to 0.70 m, heights of 20 to 30 meters, diameter of Cup of the order of 5 meters, but with very few branches and leaves and a density of 1000 trees per hectare. While it has an understory rich in chusques, with a density of 100%, this did not influence both in the process of infiltration capacity. However should highlight that differences in infiltration capacity between the covers of Cypress, eucalyptus and natural forest are diminished to high contents of humidity (60-80%), since these effects of root systems were reduced in that State of moisture.

Comparatively the curves to content medium and low soil moisture are marked by differences increasingly older in the behavior of the infiltration capacity, and to a moisture content of 20 to 40%, the differences become up to 100% between cypress and eucalyptus, indicating that they will lead to greater infiltration facilities in the forest of *C. lusitanica*.

In terms of the infiltration capacity with respect to the distance to the representative trees, a definite trend not found due to the fact that these forests are not due to a design, or have had management, being planted randomly. Trials at distances of 3, 6 and 9 meters, finding that these differences were minimal for Cypress were. However for the natural forest the infiltration capacity to 3 meters of distance to the representative tree was slightly greater than the one presented to the 6 and 9 meters, among which there was no variation in the infiltration capacity.

Other studies that addressed the infiltration under the forest, as the one made by Manzano Agugliaro & Zapata (2008), could define that the infiltration capacity is greater as the distance to the tree is minor, where the trees if obeyed a plantation ordered according to a design.

The capacity of infiltration under a forest cover has a different behavior to the bare soil, by altering that induces the forest. Bruijnzeel, (1997); Manzano Agugliaro & Zapata (2008). This can be verified by comparing the rates of the infiltration capacity obtained in trials to bare soil with values of 25 to 50 mm/h, in contrast with those obtained under forests, which were of the order of 120 to 1080 mm/h. This difference is explained in addition, because the forest through many years of staying in those soils has induced modifications as forming agent.

Rates of infiltration under natural forest capacity have been measured by different authors, where Oyarzún *et al* (2011), worked in the Cordillera de la Costa in the South of Chile, obtaining values of 323.3 to 1083.3 mm/h for the month of March and 20.2 to 133.6 mm/h for June, which were higher than in a plantation of *E. globulus,* infiltration rates ranging from 3.3 to 42.7 mm/h in august and 1.7 11.7 mm/h, in April.

The above results in natural forest are approaching those obtained in this study, Table 4, where rates of the infiltration capacity of 450 to 810 mm/h, and 72 to 126 mm/h to soil moisture of 60 to 80% were obtained for contents of moisture of 20 to 40%. However, for *E. globulus* the values found in the basin of the San Cristobal River are much higher (from 90 to 540 mm/h), because that is very developed mature forests, while Chile was a young plantation.

According to the Anova statistical analysis based on saturation average rates for each of the blocks designed around each of the three trees representative, in each of the forests, applying the analysis of blocks at random, was found for all forests that there were no significant differences between the blocks of each forest, neither nor were there significant differences regarding distances to representative trees. Tables 5, 6, 7 y 8. Consequently, to make the analysis of all the data completely at random were found significant differences in rates of infiltration capacity saturation between three types of forests, confirming that the differences identified by the modelling of greater adjustment are confirmed as representative. This analysis was a validation process, where it was an approximation to the normality of the residuals, which does not affect the results, (Mongomery, 2004).

Source of variation	Sum of squares	Degrees of freedom	Medium square	F- ratio	Fo	p -value
Blocks	9779,85	2	4889,9	4,30		
Treatments	3395,85	8	424,5	0,37	Fo=2.09	<0,01
Error	18198,81	16	1137,4			
Total	31374,52	26				

Table 5. Analysis of variance of the data, design blocks at random, according to the rate of saturation, for *Cupressus lusitanica.*

Source of variation	Sum of squares	Degrees of freedom	Medium square	F- ratio	Fo	p -value
Blocks	835,85	2	417,9	0,66		
Treatments	5930,96	8	741,4	1,17	Fo=2.09	<0,01
Error	10137,48	16	633,6			
Total	16904,30	26				

Table 6. Analysis of variance of the data, design blocks at random, according to the rate of saturation, for *Eucalyptus globulus.*

Source of variation	Sum of squares	Degrees of freedom	Medium square	F- ratio	Fo	p -value
Blocks	45,31	2	22,7	0,20		
Treatments	1417,49	8	177,2	1,54	Fo=2.09	<0,01
Error	1844,59	16	115,3			
Total	3307,39	26				

Table 7. Analysis of variance of the data, design blocks at random, according to the rate of saturation, for natural forest.

Source of variation	Sum of squares	Degrees of freedom	Medium square	F- ratio	Fo	p -value
Treatments	10192	2	5096	7,24	Fo=2.37	<0,01
Error	54908	78	704			
Total	65100	80	814			

Table 8.Analysis of variance of the data, design completely at random, according to the rate of saturation, for *Eucalyptus globulus*, *Cupressus lusitanica* and natural forest.

CONCLUSIONS

The behavior of the capacity of infiltration under mature forests *of E. globulus, C. lusitanica* and natural forest in the basin of the San Cristobal River was modelled adequately according to Horton reaching an average level of approximation of the 60%, according to the indicator R^2, in comparison with those of Philip, Kostiakov and modified Kostiakov.

The previous result was obtained when it pooled trials with a same soil moisture range, proving to be the point of comparison allowing to identify defined trends.

The modelling according to soil moisture content, the behavior of the infiltration capacity present higher values for cypress forest, and in second place for the eucalyptus and then by natural forest, because this process of deep water ingress was favored by sturdy root systems, and towards the inside of the soil. This result because is mature forests, but it cannot say that introduced species are ideal substitute for natural forest, which presents great differences to a plantation in its early stages.

There are significant differences in the behavior of the infiltration capacity under three types of forests in study, which were identified in the modelling, which were checked by analysis of variance.

Not identified a definite trend of capacity of infiltration with respect to the distance to trees representative, in reason that these forests do not obey any design, as if it has been the case with other investigations where if trends have been defined. ManzanoAgugliaro& Zapata (2008).

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