INFLUENCE OF TILLAGE ON SOME SOIL CHEMICAL PROPERTIES AND EUCALYPTUS GRANDIS GROWTH

Pérez Bidegain, Mario(1); Resquín, Fernando(2); Rachid, Cecilia(2)

1 - Departamento de Suelos y Aguas, Facultad de Agronomía, UdelaR. 2
- Instituto Nacional de Investigación Agropecuaria.

Abstract

Afforestation has increased rapidly in Uruguay since the Congress in1989 passed a law that promotes commercial forestation. This has raised public questions about the long term effects of forestation on soil quality and tillage requirements. The objective of this work was to evaluate the effect of tillage intensity on some soil chemical properties and wood production. The experiment was carried out in a Mollic Hapludalf , and planted with *Eucalyptus grandis* in 1992. A randomized complete block design with three replicates was established. Tillage treatments included: pit-planting (PP), intensive tillage of the whole surface (IT), reduced tillage (RT) that corresponds to 1/3 of the surface, and unplanted soil (US). Soil organic carbon (SOC), pH(H20), pH(KCl), and exchangeable Al was measured in the planting row from 0-2.5, 2-5, 5-10, and 10-15 cm depth after remove all soil surface litter, 8 and 19 years after plantation. Diameter breath height (DBH), tree height (Ht), and wood volume (WV) was determined. Soil pH (H_20) was higher in PP than the mean between IT and RT 8 years after plantation; however soil pH (H20) was higher in US than the mean of all tillage systems from 10-25 cm depth. Tillage systems did not affect soil pH (H_20) 19 year after plantation. Soil pH (KCl) was higher in PP than IT and RT mean from 0-0.025, 0-025-0.05, and 0.10-0.15 m depth 8 years after plantation. Pit planting had more SOC from 0-2.5 than the other tillage systems in both evaluations. DBH, Ht, and WV were not affected by tillage systems. This research indicates that tillage systems effects on soil pH detected 8 years after plantation tends to disappear when the plantation was 19 years-old. Pit-planting had more SOC than intensive tillage systems while maintaining the same wood production than more intensive tillage systems.

Key words: Eucalyptus grandis; pit planting; soil organic carbon; tillage; growth

Introduction

Afforestation has increased rapidly in Uruguay since the Congress in1989 passed a law that promotes commercial forestation. This has raised public questions about the long term effects of forestation on soil quality and tillage requirements. The effect of tillage intensity on Eucalyptus wood production has been studied internationally (*1, 2, 3, y 4*), and locally (*5,6*) for different authors. Additionally, the effect of land use change from native pastures or agriculture to forestation on soil chemical properties is being intensively studied (*7*). However, the long term effect of tillage intensity site preparation on soil chemical properties has not been addressed.

The objective of this study was to quantify the long term effect of different soil tillage intensities on some soil chemical properties and wood production in a soil planted with *Eucalyptus grandis.*

Materials and Methods

The experimental site was located at La Magnolia Experiment Unit (National Agricultural Research Institute of Uruguay), Tacuarembó, Uruguay. The soil corresponded to a fine, mixed, active, thermic Mollic Hapludalf, and some physical and chemical soil properties are shown in Table 1..

A randomized complete block design with three replicates was established, and three tillage treatments were applied. The soil remaining as natural pasture was added as a fourth treatment. Tillage treatments included: pit-planting (PP), intensive tillage of the whole surface (IT), reduced tillage (RT) that corresponds to 1/3 of the surface, and unplanted soil (US). *Eucalyptus grandis* was planted in 1992 with 1100 plants/ha. Each experimental unit comprised 48 trees consisting of 8 rows of 6 plants each one.

Soil organic carbon (SOC), soil pH, and exchangeable aluminum (EAl) was determined in a composite soil sample taken from the plantation row 9 and 19 years after plantation Soil sampling corresponded to 0-0.025, 0.025-0.05, 0.05-0.10, and 0.10-0.15 m depths.

Table 1 Physical and chemical soil properties in the experimental site

Depth (m)	pH (H_2O)	pH (KCl)	SOC	Sand	Silt	Clay
					% weight	
0-0.2	5.1	4.0	0.82	83	9	8
0.2-0.4	5.1	4.0	0.70	83	7	9
0.4-0.6	5.1	4.0	0.57	81	8	10

Trees growth parameters were measured in 26 central trees (6 central rows of 4 plants each). Diameter breath height (DBH), tree height (Ht), trees survival (S) and wood volume (WV) was determined 19 years after plantation. Wood volume 19 years after plantation was calculated according to equation 1. Fourteen trees were felled for all the experiment (2 by 7clases diameter each). The trees selected were those had the DBH average within each class. In each tree the diameter was measured with and without bark at 0.15, 0.7, 1.3, 2.3, 3.3 m. height and then every two meters until diameter of 0.06 m with bark. With these values we adjusted equation 1 for the total tree volume (V_{Total}). . The equations used, based on (*8*); was as follows:

$$V_{total} = 0{,}41674+0{,}00007186\ (DBH)^2Ht-0{,}00186\ \ (DBH)^2 \quad \text{Eq. (1)}$$

Wood volume was estimated as the product of volume per tree and tree survival.

Results

Table 2 shows soil pH (H_2O) and pH (KCl) for all tillage systems 8 years after plantation. Soil pH (H_2O) was higher in PP than the mean between IT and RT from 0 -0.025 m($P<0.007$) and 0.10-0.15 m($P<0.06$) depth, respectively. US had higher soil pH (H_2O) than the overall tillage mean ($P<0.01$) from 0.10-0.15 m depth. Soil pH (KCl) was lower in US than the overall tillage mean ($P<0.005$), while PP had higher soil pH (KCl) than the mean between IT and RT from 0-0.025 depth ($P<0.008$). PP had higher soil pH (KCl) than the mean between IT and RT from 0.025-0.05($P<0.002$) and 0,05-0.10 m depth($P<0.02$), respectively. From 0.05-0.1m depth, US had higher soil pH (KCl) than the overall tillage mean ($P<0.05$). Nineteen years after plantation (Table 3) soil pH by depth was not different among tillage systems.

Table 2 Soil pH by tillage system and depth 8 years after plantation

	Tillage system							
	PP	RT	IT	US	PP	RT	IT	US
Depth (m)	pH (H_2O)				pH (KCl)			
0-0.025	5.5	5.08	4.9	4.9	4.9	4.3	4.1	4.0
0.025-0.05	5.0	4.7	4.8	4.6	4.2	3.8	3.8	3.8
0.05-0.10	4.7	4.5	4.5	4.7	3.8	3.7	3.7	3.9
0.10-0.15	4.6	4.4	4.4	4.7	3.9	3.7	3.6	3.9

PP=pit plantation, RT=reduced tillage, IT=intensive tillage, and US=unplanted soil

Table 3 Soil pH by tillage system and depth 19 years after plantation

	Tillage system							
	PP	RT	IT	US	PP	RT	IT	US
Depth (m)	pH (H_2O)				pH (KCl)			
0-0.025	4.8	5.0	4.7	4.8	4.03	4.3	4.1	3.9
0.025-0.05	4.5	4.5	4.6	4.3	3.8	3.8	3.7	3.7
0.05-0.10	4.3	4.8	4.3	4.4	3.7	3.7	3.7	3.7
0.10-0.15	4.3	4.3	4.2	4.3	3.7	3.6	3.7	3.7

PP=pit plantation, RT=reduced tillage, IT=intensive tillage, and US=unplanted soil

Table 4 shows SOC by tillage system and depth 8 and 19 years after plantation. SOC was higher in PP than the mean between RT and IT *($P<0.002$)* from 0.025-0.05 m depth 9 years after plantation. Nineteen years after plantation SOC in PP was higher than the mean between RT and IT from 0-0.025(*$P<0.05$*) and 0.10-0.15 m (*$P<0.03$*) depth, respectively.

Table 4 Soil organic carbon by tillage system and depth 8 and 19 years after plantation

	Tillage system							
	PP	RT	IT	US	PP	RT	IT	US
Depth (m)	8 years-old				19 years-old			
0-0.025	2.0.	1.9	1.7	1.9	2.3	1.7	1.7	1.9
0.025-0.05	1.7	1.3	1.3	1.7	1.3	1.0	0.98	1.3
0.05-0.10	0.98	1.0	0.9	1.0	1.0	0.8	0.8	1.0
0.10-0.15	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.8

PP=pit plantation, RT=reduced tillage, IT=intensive tillage, and US=unplanted soil

Table 5 shows EAI by tillage system and depth 8 and 19 years after plantation. EAI was lower in PP than the mean between RT and IT from 0-0.025 *($P<0.05$)* and 0.025-0.05 mm depth *($P<0.05$),* respectively 8 years after plantation. Nineteen years after plantation EAI in US was higher than the overall mean tillage from 0-0.025 and 0.05-0.10 m depth. PP had higher EAI than the mean between RT and IT *($P<0.009$)* from 0.05-0.10 m depth.

Table 5 Exchangeable aluminum (meq/100g) by tillage system and depth 8 and 19 years after plantation

	Tillage system							
	PP	RT	IT	US	PP	RT	IT	US
Depth (m)	8 years-old				19 years-old			
0-0.025	0.05	0.11	0.26	0.26	0.2	0.09	0.12	1.2
0.025-0.05	0.2	0.6	0.6	0.5	0.7	0.5	0.9	1.02
0.05-0.10	0.7	1.0	1.1	0.8	1.9	1.5	1.4	1.7
0.10-0.15	1.1	1.1	1.2	1.1	1.9	1.5	1.6	1.5

PP=pit plantation, RT=reduced tillage, IT=intensive tillage, and US=unplanted soil

Nineteen years after plantation DBH was 0.33, 0.294, and 0.316 m for PP, IT, and RT, respectively. Tree height was 32.2, 33.1, and 32.2 for PP, IT, and RT, respectively. Wood volume production per ha reached 603, 661, and 706 for PP, IT, and RT, respectively. Neither DBH and Ht, nor VW were different among tillage systems.

Discussion and conclusions

Tillage intensity effects on soil pH detected on an 8 years old *Eucalyptus grandis* forest were not detected on an 19 years old forest. The fact that soil pH did not differ among tillage system is attributed to cations leakage, mainly calcium, from the discomposed tree residues on soil surface (Hernandez, 2010)
Wood production was analyzed (*9*) 9 years after plantation and tillage system did not affect forest productivity .Our work indicates that it is possible to obtain an adequate wood production 19 years after plantation with reduce, or minimum tillage. It is important to recognized that the experiment was established in 1992 when scientific knowledge about herbicide and fertilization management on forest plantations were not the same as nowadays.

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