EVALUATION OF DIFFERENT TILLAGE INTENSITIES ON EUCALYPTUS GRANDIS ON A TYPIC HAPLUDULT OF URUGUAY

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Abstract

Planting and harvesting time are the most critical moments in terms of soil erosion risk in commercial forest plantations. Soil tillage systems that reduce soil removal while maintaining wood productivity are necessary. The objective of this research was to evaluate the effect of different site preparation methods on *Eucalyptus grandis* wood productivity 10 years after plantation. The experimental site was located on a Typic Hapludult in the department of Rivera, Uruguay. A randomized complete block design with three replicates was established. Treatments included: furrower on the plantation row, and mechanical weed control (disk-harrow) in the inter-row area (T1); idem to T1 but substituting inter-row mechanical control by herbicide control (glyphosate) (T2); pit-planting (T3); rotavator on the plantation row and inter-row weed control idem to T1 (T4); and T5 idem to T4 but herbicide control in the inter-row area. Tree height (Ht) and diameter breath height (DBH) was measured 5 times after thinning in the experimental period (21, 38, 58, 98 and 120 months after plantation) and DBH and wood production(WP) data were analyzed with repeated measures in time, where the subject was the plot and the autocorrelation structure selected was antedependence (ANTE(1)). Significant differences in DBH were not founded between treatments any time. However, WP was higher on T1 than T2, T3 and T4 measured to 120 months, while T3 had the lowest WP comparing with T1 and T5. The utilization of herbicide control increased DBH in initial stages, while mechanical control in the inter-row area increased WP in harvest time. WP was not affected by row preparation (furrower vs rotavator) at any time, while lower production were obtained with T3 associated to a fewer number of trees after thinning. A reduction on tillage intensity did not produce a reduction on DBH, however WP decreased due to a reduction on tree population at harvest time. The causes of a different plant population dynamics by tillage system after thinning remains unclear.

Key words: Site preparation, Eucalyptus, Repeated measures.

Introduction

Planting and harvesting time are the most critical moments in terms of soil erosion risk in commercial forest plantations (*1*). Long term effect of site preparation tillage system on wood production is scarse in our country (*2*), and most of the published information is focused on early tree wood production (*3*). Soil tillage systems that reduce soil removal while maintaining long term wood productivity are necessary. The objective of this research was to evaluate the effect of different site preparation methods on *Eucalyptus grandis* wood productivity 10 years after plantation.

Materials and methods

The experiment was located in a forest farm in the department of Rivera, north of Uruguay. The soil at the experimental site was a Typic Hapludult, and Table 1 shows some soil physical and chemical properties at the experimental site.

Table 1 Soil physical and chemical properties at the experimental site

Depth (m)	pH (H_2O)	pH (KCl)	O.M.	Clay	Silt	Sand
			%		% weight	
0-0.30	4,6	3,9	1,37	0.04	0.12	0.84
0.30-0.55	4,4	3,9	1,07	0.08	0.10	0.82
0.55-0.73	4,8	4,0	1,08	0.05	0.15	0.80
0.73 +	4,6	3,8	0,69	0.32	0.12	0.57

A randomized complete block design with three replicates was established, and five tillage treatments were applied.

Treatments were: furrower on the plantation row and mechanical weed control (disk-harrow) in the inter-row area (T1); furrower on the plantation row and herbicide control (glyphosate) in the inter-row area (T2); pit planting and herbicide control in the inter-row area (T3); rotovator on the plantation row and herbicide control (glyphosate) in the inter-row area(T4); and rotovator on the plantation row and mechanical weed control (disk-harrow) in the inter-row area (T5).

Each experimental unit comprised a rectangular plots of 5 rows with 8 plants each row. In row plant spacing was 2 m and 4 m between rows (1250 plants/ha^{-1}). *Eucalyptus grandis* was planted on September 2001. The experiment was thinned 18 months after plantation but this operation did not generate different numbers of trees among treatments .

Height (Ht) and diameter breath height (DBH) of all trees in the experimental plots were measured five times in the experimental period (20, 38, 58, 87 y 120 months after plantation).

The other response variable used was wood production (WP) per plot, calculated from the following equation:

$$WP\ (m^3/ha^{-1}) = DBH_{ijk} * H_{jk} * 0.45 * N_{jk} * 31.25$$

Where:

DBH_{ijk} = Diameter Breath Height of the i-th tree in the j-th plot in the k-th time

H_{jk} = Average height in the j-th plot in the k-th time

N_{jk} = Number of trees in the j-th plot in the k-th time

DBH and wood production was analyzed by repeated measures analysis of variance with the MIXED procedure of SAS with the plot as the repeated measurement. The statistical model was:

$$\Psi_{\iota\varphi\kappa} = \mu + \tau_{\iota} + \beta_{\varphi} + \delta_{\iota\varphi} + \gamma_{\kappa} + \tau\gamma_{(\iota\kappa)} + \varepsilon_{\iota\varphi\kappa}$$

Where Y_{ijk} is the dependent variable (DBH or WP), μ is the overall mean, τ_i the tillage effect (i=1-5), β_j the block effect (j=1-3), δ_{ij} the whole plot random error, γ_k the measurement time effect (k=1-5), $\tau\gamma_{(ik)}$ the interaction tillage-measurement time and ε_{ijk} is the experimental error.

The first-order antedependence covariance structure (ANTE(1)) was used for DBH variable according AIC and BIC criterion, being in this structure type the covariance between two time points a function of the product of variances at both points and the product of the correlations at the distances up to the one chosen. While for wood production, autoregressive heterogeneous covariance structure (ARH(1)) was selected assuming different variances by measurement time.

The treatment means were compared through orthogonal contrasts, analyzing only the first measurement time (after thinning) and the last time (harvest). The four contrasts analyzed were: pit planting vs. any tillage on the plantation row, furrower vs. rotovator on the plantation row, herbicide weed control vs. mechanical control in the inter-row area with furrower on the plantation row and herbicide weed control vs. mechanical control in the inter-row area with rotovator on the plantation row.

Results and discussion

DBH was not affected by tillage treatments at any time (*P>0.05*), however the adjusted means by measurements times were significantly different due to the time elapsed between measurements (Table 2).

Table 2. Diameter breath height by measurement time on *Eucalyptus grandis*

Treatment	Measurement time (months after plantation)				
	21	38	58	98	120
T1	2.42 [a]	4.18 [a]	18.36 [a]	24.48 [a]	28.28 [a]
T2	2.75 [a]	4.63 [a]	19.36 [a]	24.66 [a]	27.91 [a]
T3	2.67 [a]	4.59 [a]	19.52 [a]	25.06 [a]	28.86 [a]
T4	2.76 [a]	4.52 [a]	18.6 [a]	23.53 [a]	26.14 [a]
T5	2.46 [a]	4.14 [a]	18.21 [a]	25.32 [a]	29.13 [a]
	2.61	4.41	18.81	24.61	28.07

DBH was not affected by tillage treatment (Table 3) on the plantation row area after thinning (21 months after plantation) and at harvest time (120 months after plantation). However, DBH was affected by inter-row tillage , being the herbicide control better than mechanical control after thinning independently of the row tillage used. Possibly differences in DBH between chemical and mechanical controls in inter-row area are associated with the remaining trees in each treatment plot, being higher the competition among trees in plots with mechanical control than with chemical control (Fig. 1). At harvest time (120 months after plantation) differences between treatments were not significant.

Table 3. Contrasts for DBH 21 and 120 months after *Eucalyptus grandis* plantation.

	Estimate	
Contrast	Post-thinning	Harvest
Pit planting(+) vs Tillage (-)	0.067	0.998
Furrower(+) vs Rotovator(-)	-0.059	0.923
Herbicide(+) vs Mechanical Control(-) in Rotovator	0.300 *	-2.982
Mechanical(+) vs Herbicide Control(-) in furrower	-0.327 *	

*Significant differences (*P≤0.05*)

The average number of trees by treatment in the experimental period is presented in figure 1. The number of trees in T1 was significantly higher than treatments T2, T3 and T4. T3 had the lowest number of trees comparing with any tillage treatment due to a high tree losses, being the reason of this fact an open question.

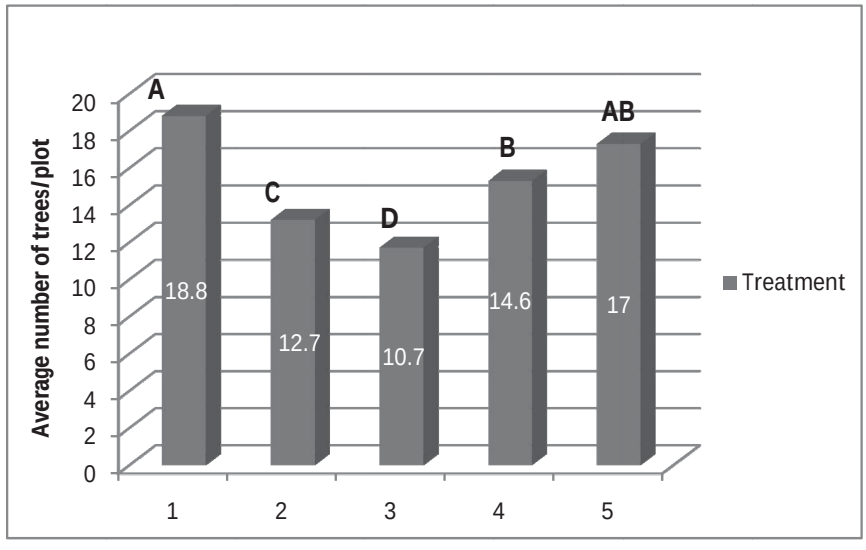

Figure 1. Average number of trees by treatment in the experimental period

Wood production 21, 38 and 58 months after planting did not reveal any significant differences between treatments (Table 4). However, 98 months after plantation T1, T4 and T5 had higher productions than T2 and T3. In harvest time T1 was significantly higher in wood production comparing with T2, T3 and T4.

Table 4. Wood production by measurement time ($m^3 ha^{-1}$)

	Time (months after plantation)				
Treatment	**21**	**38**	**58**	**98**	**120**
T1	0.94[a]	5.52 [a]	129.77 [a]	336.48 [a]	583.2 [a]
T2	1.04 [a]	4.53 [a]	92.82 [a]	230.01 [bc]	374.08 [bc]
T3	0.79 [a]	4.33 [a]	92.77 [a]	218.57 [c]	338.1 [c]
T4	1.12 [a]	6.42 [a]	108.69 [a]	253.12 [abc]	391.1 [bc]
T5	0.98 [a]	4.09 [a]	103.96 [a]	330.35 [a]	553.49 [ab]

Wood production was not different among treatments 21 months after plantation, mainly due to the size of the trees that in initial stages is too small to generate differences in WP (Table 5). However, at harvest time WP in T3 was lower than the mean of the remaining tillage systems, being this explained by the significant lower remaining number of trees that determines directly the levels of production at harvest time time.

Neither rotovator nor furrower affected WP (Table 5). At harvest time mechanical operation in the inter-row area had higher WP than herbicide control.

Table 5. Contrasts for wood production (m^3/ha^{-1}) at 21 (post-thinning) and 120 months after plantation (harvest).

	Estimate	
Contrast	**Post-thinning**	**Harvest**
Pit planting(+) vs Tillage (-)	-0.227	-137.36 *
Furrower(+) vs Rotovator(-)	-0.107	12.67
Herbicide(+) vs Mechanical Control(-) in Rotovator	0.142	-162.39 *
Mechanical(+) vs Herbicide Control(-) in furrower	-0.108	209.12 *

*Significant differences (*P≤0.05*)

Conclusions

Our results indicates that tillage systems did not affected DBH after thinning and at harvest time, however wood production was affected because the number of trees was different among tillage systems. The reason behind a different tree population dynamics among tillage systems remains unclear.

References

(*1*) Denis Lepiane, V. y Garcia Préchac, F. 1997. Estimación del factor C de la Ecuación Universal de Pérdida de Suelos en la instalación de montes de rendimiento de Eucaliptos. Agrociencia 1(1): 30-37.

(*2*) Resquin, F.; Rachid, C.; Perez Bidegain, M. 2010. Serie Actividades de Difusión Nro 616. Efecto del laboreo y fertilización sobre las propiedades físicas del suelo y la productividad de E. grandis. En "Jornada técnica forestal en zona norte". INIA Tacuarembó, pp. 42-55

(*3*) Garcia Préchac, F.; Pérez Bidegain, M.; Christie, S. y Santini, P. 2001. Efecto de la Intensidad de Laboreo en el Crecimiento Áereo y Radicular de Eucalyptus dunnii y sobre algunas Propiedades Físicas y Químicas del Suelo. Agrociencia 5(1): 1-9.