ESCUELA POLITÉCNICA SUPERIOR
DEPARTMENT OF CROP PRODUCTION
DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL RESEARCH

EFFECTS OF WOOD ASH APPLICATION ON NUTRITIONAL STATUS, TREE GROWTH AND BIOMASS PRODUCTION IN A YOUNG *Pseudotsuga menziesii* PLANTATION

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Precipitación: 1200- 1800 mm
Temperatura: 11-14 ºC

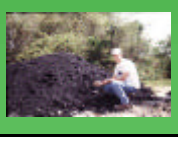




1: In the forest industries tree bark (and waste wood) is burnt as a mean to produce energy and to reduce residues

Wood ash production in N. Spain : 70.000 t / year

Finland: 100.000 t / y
Sweden: 150.000 t / y



Most of wood ash is disposed in landfills

2. Wood ash shows interesting properties to improve the forest acid soils

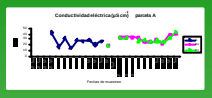
Variable	Mean	Range
pH	11,0	9,0 – 13,0
Macronutrients	g kg^{-1}	
Ca	42,6	25,0 - 99,7
K	18,0	10,9 - 30,2
Mg	12,1	5,7 - 20,2
P	4,8	2,6 - 7,6
N	2,4	0,96 - 5,56
Micronutrients	mg kg^{-1}	
Mn	2378,7	1215,0 - 6173,0
Cu	59,7	18,8 - 172,1
Zn	310,0	170,4 - 745,3

3. As consequence of the strong acidity of the soils, in Northern Spain many plantations show important deficiencies in P, Mg and Ca

Could we improve the nutritional status of forest plantation through the application of wood ash???

Activities of the programme (1)

1. Evaluation of losses of nutrients by erosion and leaching after application of wood ash



2. Application of wood ash during establishment of new plantations

Activities of the programme (2)

3. Application of wood ash in young forest plantations

Castanea x coudercii *Pinus radiata* *Pseudotsuga menziesii*

EXPERIMENTAL DESIGN

CONTROL
10.000 kg/ha cenizas
20.000 kg/ha cenizas

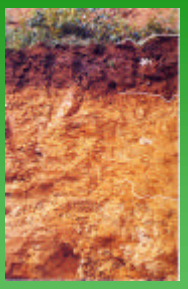
PISTA

Soil and soil solution composition

Forest nutrition

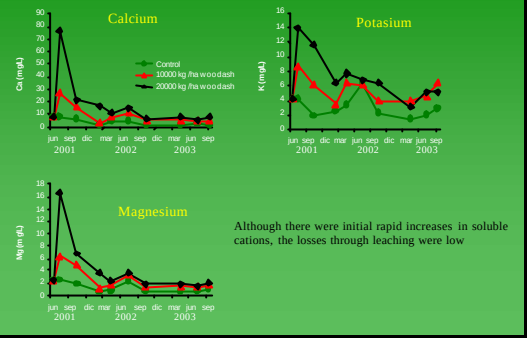
Tree growth

Humic umbrisol



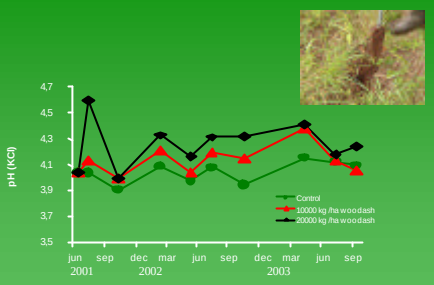
- Developed on schist
- O. M. = 15. %
- C/N = 17
- pH = 4.7
- Extr. P = 14 mg kg^{-1}

Soil solution chemistry (1)

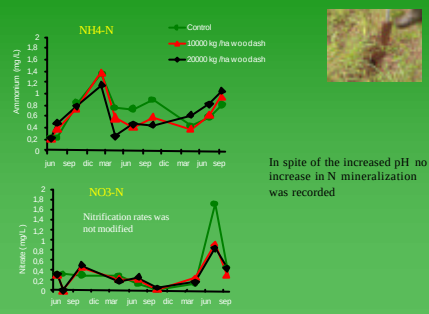


Although there were initial rapid increases in soluble cations, the losses through leaching were low

Soil pH



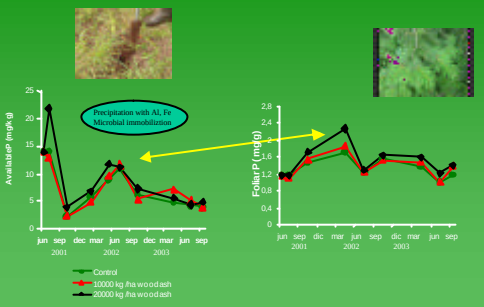
Mineral N in soil solution



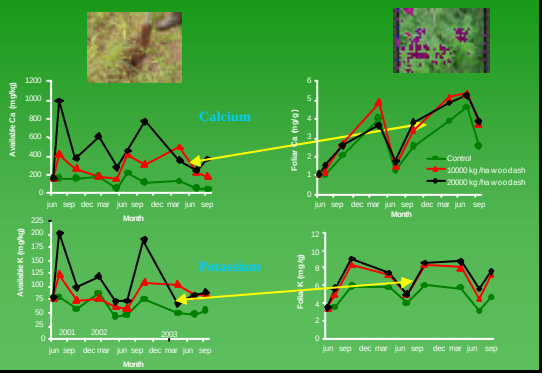
Nitrification rates was not modified

In spite of the increased pH no increase in N mineralization was recorded

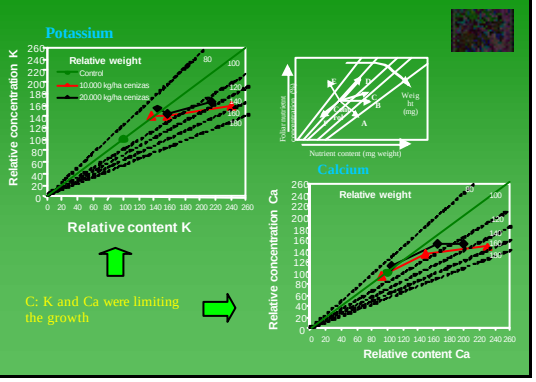
Phosphorus



Calcium and Potassium



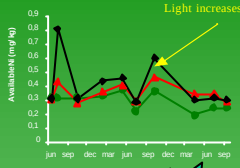
Foliar nutrient (Vector Analyses)

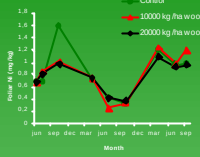


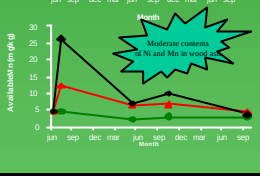
C: K and Ca were limiting the growth

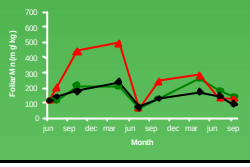
Heavy metals

Light increases in Ni

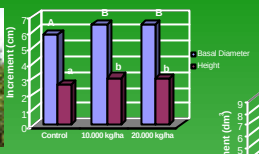


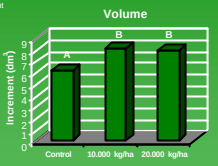


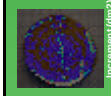


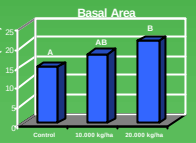


Tree growth and production









BIOMASS MEASUREMENTS

8 trees per plot

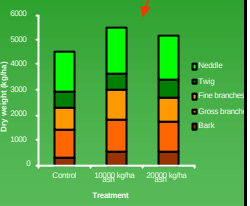
BIOMASS DISTRIBUTION IN kg / ha

Fracción	ECUACIÓN	R^2_{aj}
Árbola	$W_t = 7{,}34 \cdot d^{2{,}11}$	0.8456
Ramillo	$W_r = 1184 \cdot d^{2} \cdot h$	0.6999
Rama fina	$W_{rf} = 1666 \cdot e^{-0{,}88d}$	0.7722
Rama gruesa	$W_{rg} = 3{,}83 \cdot d^{2{,}14} \cdot h^{-1{,}12}$	0.7363
Raíz	$W_r = 19{,}29 \cdot d^{2{,}20} \cdot h^{-0{,}68}$	0.8439
Biomasa total	$W_t = W_r + W_r + W_{rf} + W_{rg} + W_r$	0.9113

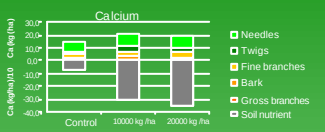
BIOMASS PRODUCTION

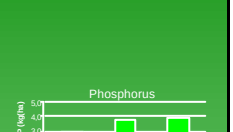
Control **10.000 kg ha^{-1} ash**

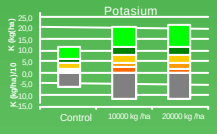
The ratio branches / total biomass was reduced

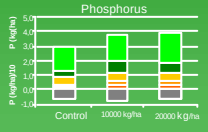


Nutrient distribution: tree / soil



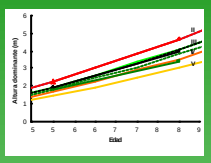






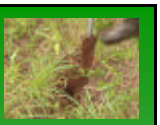
Conclusions

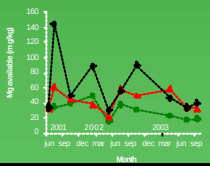
- The application of wood ash can improve the nutritional status and growth of forest plantations growing on acid soils
- Although this is a safe practice, wood ash should be analysed in regular basis to avoid possible environmental damages

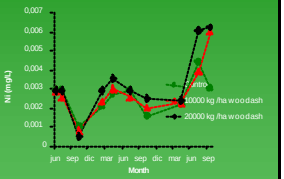


M factor

Soil solid fraction



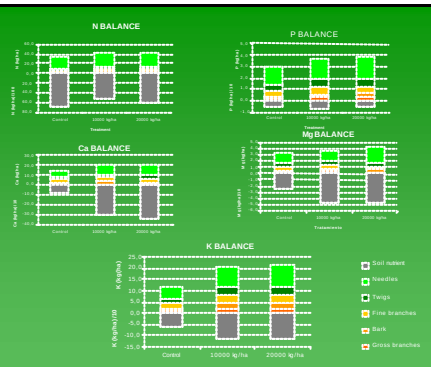




Soil solid fraction (P)

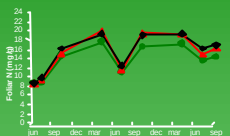
- No increases in extractable P
  - Low solubility
  - Precipitation in Al and Fe compounds

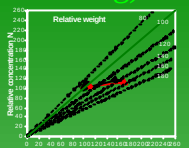
P en disoluvción



Foliar nutrients (K, Ca and Mg)

Foliar N

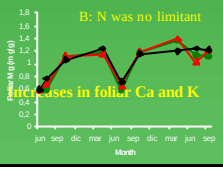




Light increases in Foliar N were found

B: N was no limitant

Little raises in foliar Ca and K



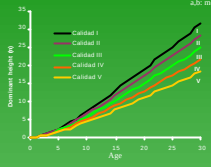
RESULTS: Growth and Yield

$$LnH_a = a - 1.2296 \left(\frac{1}{t^{0.8889}}\right)$$

Ho: Dominant height

t: age (years)

a,b: model parameters

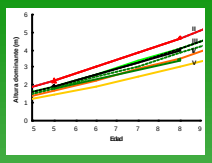


Coeficiente multiplicador del crecimiento

$$m = \frac{F^{-1}(C_2) - F^{-1}(C_1)}{t_2 - t_1}$$

donde: t2=60y t1=5 fueron las edades en las que se realizaron las observaciones, F-1(C2) devolvió el valor de edad a la que correspondió una observación de altura C2, si se considera que H0=F(t) son las ecuaciones generales de evolución de la altura dominante o área basimétrica empleadas y F-1(C1) devolvió el valor de edad a la que correspondió una observación C1, en este caso, F-1(C1) =5.

RESULTS: Growth and Yield



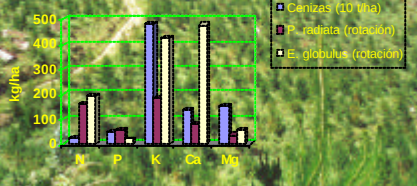
Coefiente multipliador

2.- Por otro lado, analisisde covarianza . Crecimiento significativamente mayor con las dosis de cenizas

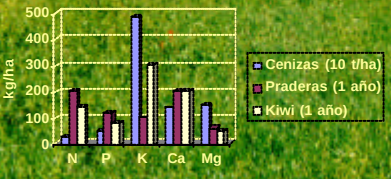
	Valor *m*
N foliar	0,690*
S foliar	0,021
P foliar	0,382
Ca foliar	0,796*
Mg foliar	0,674*
K foliar	0,792*

TREATMENT	*SI*	*m*	Incremento porcentual de la velocidad de crecimiento respecto al control
Control	13,83	0,818 (0,15)	-
10.000 kg ha⁻¹ wood ash	17,05	1,011 (0,10)	23,6 %
20.000 kg ha⁻¹ wood ash	14,76	0,971 (0,09)	18,7 %

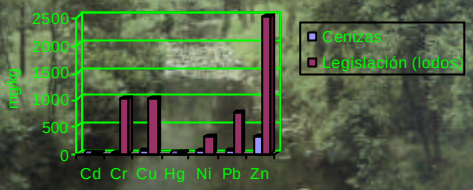
1. Composición de las cenizas. Aporte de nutrientes en sistemas forestales.



1. Composición de las cenizas. Aporte de nutrientes en cultivos.



Wood ash composition
Heavy metal concentration



Tree Growth

Grafica normal de barras

Control ? 6 m^3 ha^{-1}
10.000 kg ha^{-1} Ash ? 8 m^3 ha^{-1} → + 30% volume

DIAGNOSTICO POR ANALITICA FOLIAR

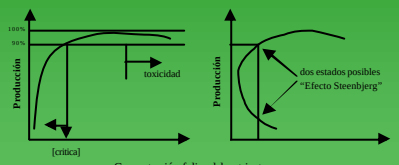
NIVELES CRITICOS

Concentraciones que aseguran un desarrollo optimo de las plantascuando no hay otro factor limitante

Inconvenientes "Desarrollo optimo" y "Ningún otro factor limitante".

Definiciones arbitrarias y subjetivas

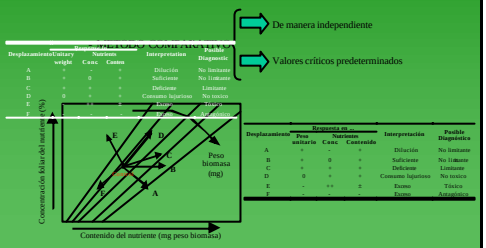
1.- INTRODUCCIÓN
2.- OBJETIVOS
3.- MATERIAL Y MÉTODOS
4.- RESULTADOS Y DISCUSIÓN
5.- CONCLUSIONES



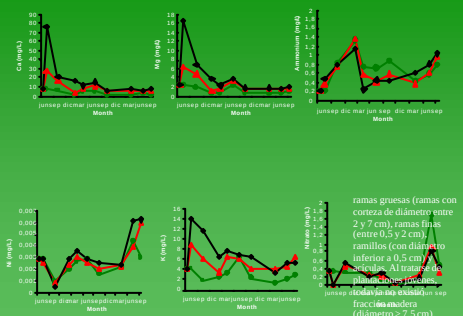
DIAGNOSTICO POR ANALITICA FOLIAR

ANALISIS DE VECTORES

Formato grafico que compara la concentración de nutrientes, su contenido y algún parámetro relacionado con el crecimiento de la planta.



RESULTS: Soil solution Analyses



ramas gruesas (ramas con corteza de diámetro entre 2 y 7 cm), ramas finas (entre 0,5 y 2 cm), ramillos (con diámetro inferior a 0,5 cm) y acículas. Al tratarse de plantas obtenidas jóvenes, todavía no existía fracción madera (diámetro > 7,5 cm).