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SAND CULTURE USED FOR FIVE DIFFERENT CONIFER SPECIES TO COMPARE THEIR NUTRIENT REQUIREMENTS.

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Abstract

Seedlings of five different conifer species (*Cedrus deodara, Cupressocyparis leylandii, Cupressus glabra, Pinus pinea* and *Thuja occidentalis*), interesting as ornamental plants or as reforestation plants, were grown during a vegetative period in plastic containers filled with siliceous sand and irrigated with a nutrient solution which had been previously optimized for *Cupressus glabra* (reference species in this assay).

The aim of this was to obtain data on nutrient levels for the four species not previously assayed and on plant nutrient requirements which could allow changing nutrient solution composition to fit the requirements of each species .

Results showed significant differences between total annual nutrient uptake levels and also in the annual time nutrient uptake distribution. Foliar and sap analysis showed differences in nutrient contents for different species. These results may be of interest to later fertilizer assays and mineral nutrition diagnosis for the four species tested.

1. Introduction

Cadahía & Eymar (1989) proved the efficiency of fertigation as a way to improve the growth of conifers in commercial nurseries. Later, Hassan (1992) fitted NO_3^-/NH_{4+}, K/(Ca+Mg) and Fe/Mn ratios to the requirements of *Cupressus glabra* (ornamental conifer) by means of hydroponic (sand) culture. Based on his results, and after carrying out several experiments growing *Cupressus glabra* in similar conditions to those in nurseries, Eymar (1993) provided some guidelines for the correct use of fertigation in conifer nurseries.

Soon, several Madrid conifer growers, who could not keep up with the increasing demand, showed interest in these results and began to install fertigation systems and ask for similar research on several other conifer species.

Thus, a new sand culture experiment, including four species not previously assayed but interesting as ornamental or reforestation plants, was designed and carried out with the aim of obtaining data on nutrient levels and some on plant nutrient requirements for these species. Results, if showing significant differences between species, could be used to change nutrient solution composition to fit each species requirements.

2. Materials, Methods, Experiments

In 1993, a sand culture of the following five species was carried out:

1) *Cupressus glabra* (Sudworth) Little (E1)
2) *Cedrus deodara* (Roxb.) Loudon (E2)
3) *Cupressocyparis leylandii* (Leighton Green) (E3)
4) *Pinus pinea* L. (E4)
5) *Thuja occidentalis* L. (E5).

Plastic containers were used, filled with 40 kg of siliceous gravel which was washed

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in acid and had a diameter of 2 to 4 mm. Five one-year-old plants of the same species were planted in each container on April 20th 1993. Each species was repeated three times in a randomized block design.

The nutrient solution used for all plants is shown in Table 1 and it is the one fitted by Hassan (1992), Cadahía et al. (1995) and Perero (1994) for *Cupressus glabra*. According to Eymar (1993), the 50% dilute solution was applied until September 15th to avoid too high nutrient concentrations after the summer because of the higher water requirements of plants in this season.

The nutrient solution was kept in 200 L tanks from which it was pumped to the containers. Drainage solutions were recirculated. Plants were watered fourteen times every day for 30 minutes.

Nutrient concentration, solution volume, EC and pH were controlled every 21 days to keep composition constant and to quantify nutrient uptakes by plants.

Environmental conditions in the glasshouse where the assay was carried out (average minimum - maximum values per day per growing period), were as follows:

* Temperature: 15,5°C - 27,8°C
* Atmospheric moisture contents: 38% - 62%
* Lighting: 53,1 μmol s^{-1} m^{-2} - 515 μmol s^{-1} m^{-2}

Plant height was the buffer index taken into account because this was the one growers used to decide if plants had grown enough to be sold or not.

Plant nutrition was controlled by means of leaf, root and sap analysis. Leaves were taken from the youngest, fully developed branches as described by González et al. (1988). All the roots were analysed as in Hassan (1992) and Eymar (1993). Sap was extracted from the previously frozen conducting tissue of the collected leaves and was analysed.

Leaf, root and sap analyses were carried out twice during the cycle (September 27th, November 22nd).

Phosphorus content was determined by colorimetry, Ca, Mg, Fe and Mn by atomic absorption, K by flame emission and N by Kjeldahl digestion and colorimetry.

Data from this assay were treated by analysis of variance, and differences between means were calculated by the least significant difference (L.S.D.) at p = 0,05.

3. Results

3.1. Buffer index: plant height.

Figure 1 shows plant height increases during the growing period. One can see how the five species studied are fitted to three different growing patterns:

A) *Cupressus glabra*, *Cupressocyparis leylandii* and *Thuja occidentalis* show a sigmoidal pattern with the highest height increase between July and September.

B) *Cedrus deodara* shows a pattern quite linear with a flex point in July, followed by slightly faster plant growth.

C) *Pinus pinea* is the only of the five species which shows the highest growth rate between May and July. After July, growth rate decreases till November when plant height seems to be about to become steady.

As there are significant differences between initial heights of the species, absolute values cannot be considered for comparisons but a relative growth rate referred to these initial values can be. Thus, there are no significant differences between *Cupressus glabra* and *Cupressocyparis leylandii* which are the species which show the highest rate of height increase (59,5% and 58,4% respectively). Following them, *Pinus pinea* shows

a height increase of 38,1% and *Thuja occidentalis* increases its height by 25,6% along the cultivation. The lowest height increase appears for *Cedrus deodara* with only a 17,8% increase during the growing period.

3.2. Nutrient uptakes.

Although the trend, already observed by Hassan (1992), to concentrate the highest nutrient uptakes at the end of the growing period can be observed in the five species, data also show seasonal differences between them.

As a summary of nutrient uptake differences between species, in figures 2 and 3, annual macronutrient uptakes and annual micronutrient uptakes respectively are plotted for the five species tested.

The most outstanding data in these charts are the following:

* *Cupressus glabra* shows the lowest Mg uptake.
* *Cedrus deodara* has the smallest values for N, P, Ca and Fe uptakes but, together with *Thuja occidentalis*, has the highest values for Mn.
* In the data of *Cupressocyparis leylandii*, the highest amounts of P, K (together with *Thuja occidentalis*) and Fe taken up appear.
* *Pinus pinea* shows the highest amounts of Mg and the lowest of Mn taken up.

3.3. Nutrient content.

Foliar contents of all studied nutrients together with sap K, Ca and Mg contents and with K content of roots are significantly higher in November than in September because, according to González et al. (1988), conifers tend to accumulate photosynthates in autumn to be used in summer when trees have the highest growth rate and, besides, high amounts of K are required for stem hardening.

Significant differences appear in foliar N (fig. 4; $L.S.D._{sp} = 0,10$). E4 (*Pinus pinea*) and E5 (*Thuja occidentalis*) have the highest content. In the roots (fig. 4; $L.S.D._{sp} = 0,09$), E1 (*Cupressus glabra*) has the lowest N content.

With regard to P (figs.5 and 11), no significant differences appear in leaves ($L.S.D._{sp} = 0,02$) in spite of the high contents showed by E4 (*Pinus pinea*) in the roots ($L.S.D._{sp} = 0,02$) and sap ($L.S.D._{sp} = 171$).

E1 and E3 (*Cupressocyparis leylandii*) show similar high K contents in leaves (fig. 6, $L.S.D._{sp} = 0,08$). In the roots (fig. 6, $L.S.D._{sp} = 0,09$) and sap (fig. 12, $L.S.D._{sp} = 724$), E2 (*Cedrus deodara*) shows the lowest K content. E3 has a significantly higher K content in sap than the rest of the species.

E5 (*Thuja occidentalis*), a species which is used to living in calcareous soils, has the highest Ca contents in leaves and sap while E4 (*Pinus pinea*), a species well adapted to acid soils, has the lowest. E2 (*Cedrus deodara*) shows high Ca contents in the whole plant with the highest value for roots.

Significant differences between species in Mg levels only appear for leaves (fig.8, $L.S.D._{sp} = 0,01$) and sap (fig. 14, $L.S.D._{sp} = 80$). The highest contents are found for E2 in leaves and for E4 in sap.

High iron levels appear for E2 and E5 in leaves but there are no differences in root contents. With respect to roots, the high levels previously found by Hassan (1992) and Eymar (1993) again appear for the five species studied.

Finally, E2 and E5 have the highest Mn levels for roots in spite of E2 showing the lowest foliar values. E4 and E5 have high Mn levels in leaves.

3.4. Nutrient ratios.

N/K ratio is plotted in figure 15 and shows its highest values for E2 (*Cedrus deodara*) in roots, but E5 (*Thuja occidentalis*) is the species with a higher ratio in leaves.

Similar trends are shown (figures 16 and 17) for K/(Ca+Mg) in leaves and sap with E1 (*Cupressus glabra*) having the highest values and E2, together with E5, the lowest. In roots, only the low ratio for E2 stands out.

Finally, for Fe/Mn (figure 18), E2 has the highest ratio in leaves, significantly different from the rest of the species but, in spite of this, this species has the lowest Fe/Mn ratio in roots.

4. Discussion

Cupressus glabra (E1) and *Cupressocyparis leylandii* (E3) have similar growth patterns and only a few differences in nutrient contents and nutrient ratios in the plant. Thus, no problems in *Cupressocyparis leylandii* nutrition are expected to appear when using the same nutrient solution fitted to *Cupressus glabra*.

Cedrus deodara (E2) shows the lowest growth rate and seems to be the species whose nutrition was the worst of this assay. Its low N uptake level, together with its low N levels in leaves and roots can partly explain the low vegetative growth observed for this species. Thus, to improve the nutrition for E2, higher N doses and/or different NO_3^- /NH_4^+ ratios in the nutrient solution must be tested. Low K contents, together with a very low K/(Ca+Mg) ratio which is partly due to high levels of Ca and Mg, show that it is necessary to fit cationic ratios for this species, probably raising K levels since Ca and Mg uptake levels are low enough to allow more decreases. Finally, a fitting of the Fe/Mn ratio is also needed, probably by means of decreasing Fe proportion in the nutrient solution.

Data for *Pinus pinea* (E4) show high nitrogen contents which make it necessary to raise the K concentration in the nutrient solution, particularly at the end of the cycle, to avoid problems with the hardening of stems. With respect to phosphorus, the high levels in root and sap which do not correspond with a significantly high level in leaves, suggest the possibility of decreasing P levels in the nutrient solution without plant damage.

Finally, with respect to *Thuja occidentalis* (E5), K raising is necessary due to the high N and Ca contents.

5. References

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Table 1.- Nutrient solution used in the sand culture assay.

Macronutrients (meq/L)					
	NH_4^+	Ca^{2+}	K^+	Mg^{2+}	
NO_3^-	1.66	0.38	---	---	
$H_2PO_4^-$	---	---	0.50	---	E.C. = 0.52 dS/m
SO_4^{2-}	---	0.82	0.50	0.60	pH = 6.4
Micronutrients					
Fe: 5.0 mg/L		Zn: 0.05 mg/L			
Mn: 1.5 mg/L		B: 0.5 mg/L			
Cu: 0.02 mg/L		Mo: 0.01 mg/L			

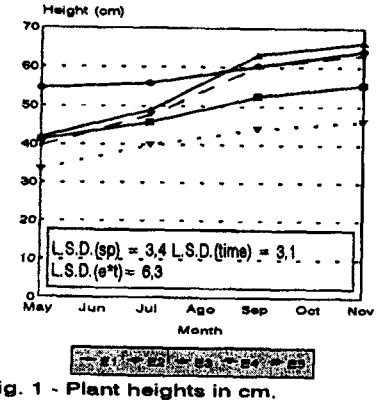

Fig. 1 - Plant heights in cm.

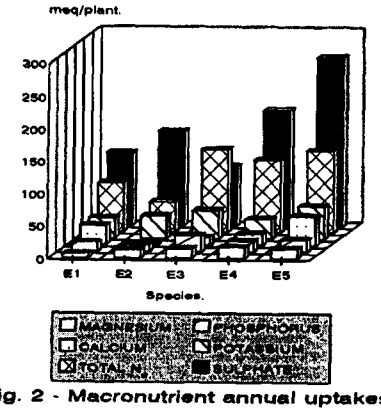

Fig. 2 - Macronutrient annual uptakes.

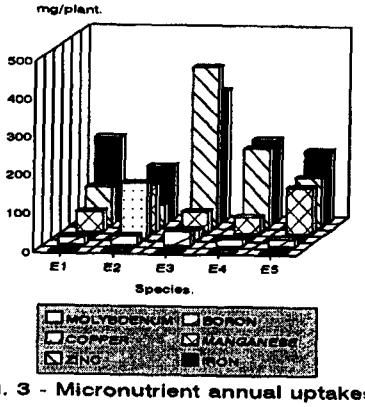

Fig. 3 - Micronutrient annual uptakes.

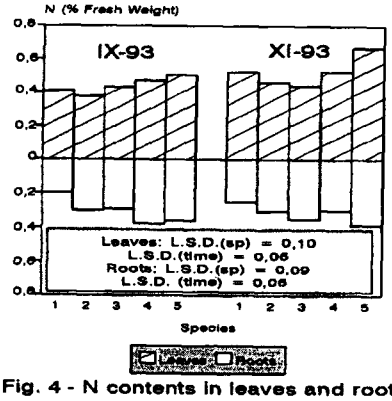

Fig. 4 - N contents in leaves and roots.

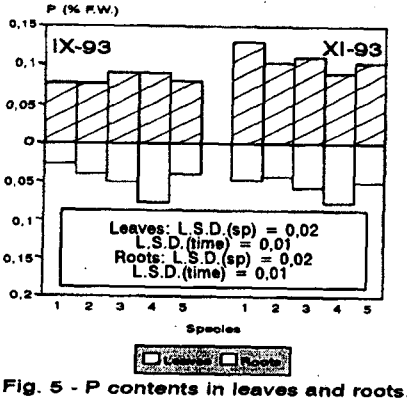

Fig. 5 - P contents in leaves and roots.

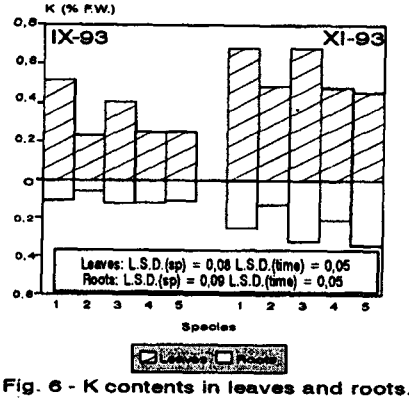

Fig. 6 - K contents in leaves and roots.

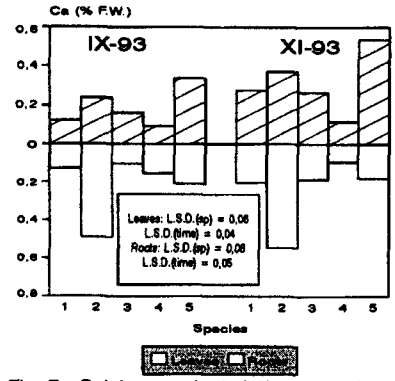

Fig. 7 - Calcium contents in leaves and roots.

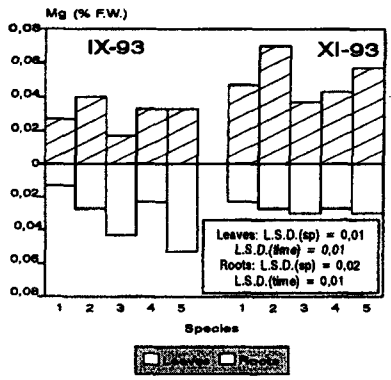

Fig. 8 - Mg contents in leaves and roots.

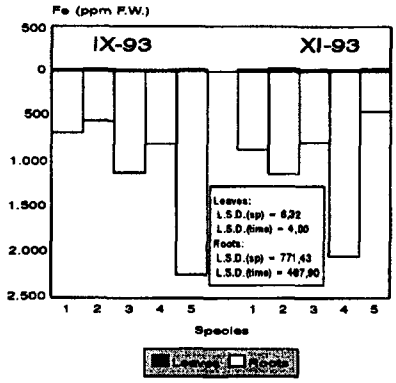

Fig. 9 - Fe contents in leaves and roots.

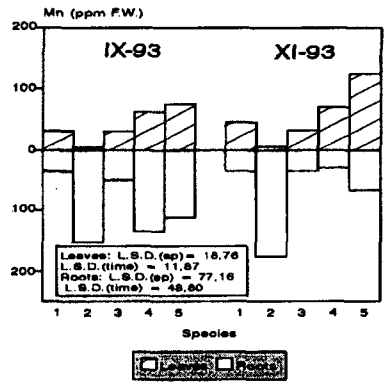

Fig. 10 - Mn contents in roots and leaves.

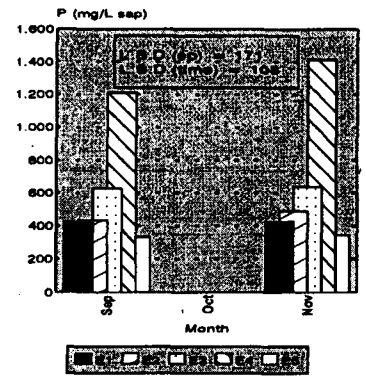

Fig. 11 - P content in sap.

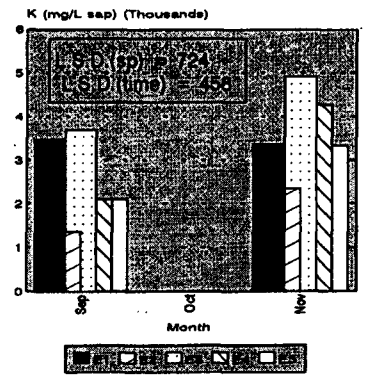

Fig. 12 - K content in sap.

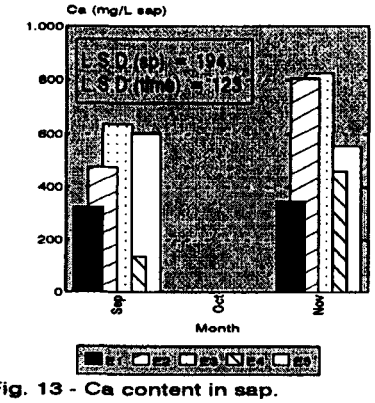

Fig. 13 - Ca content in sap.

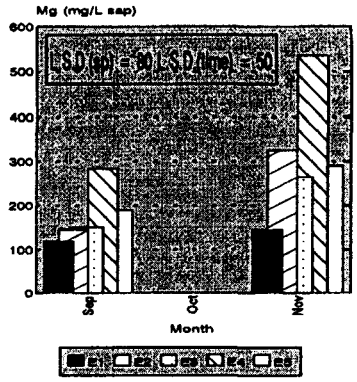

Fig. 14 - Mg content in sap.

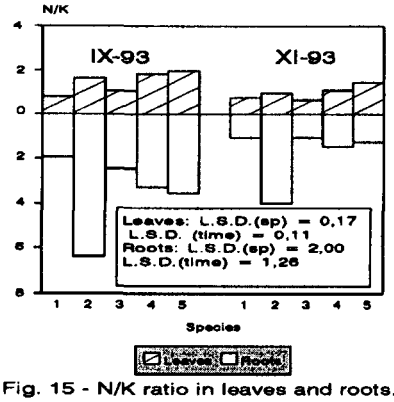

Fig. 15 - N/K ratio in leaves and roots.

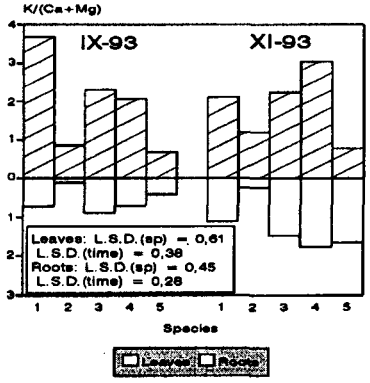

Fig. 16 - K/(Ca+Mg) ratio in leaves and roots.

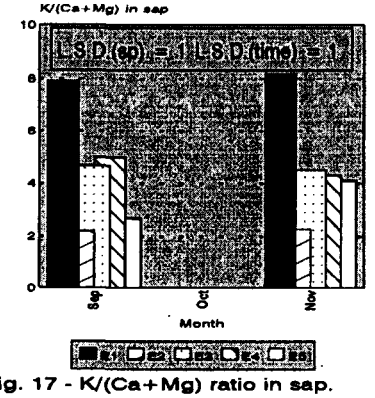

Fig. 17 - K/(Ca+Mg) ratio in sap.

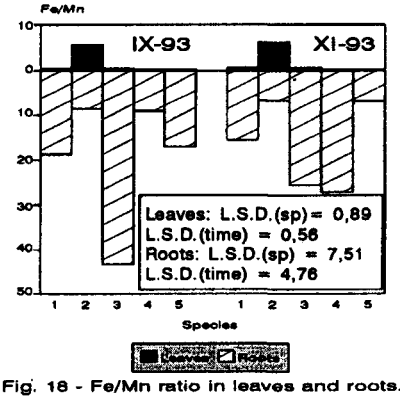

Fig. 18 - Fe/Mn ratio in leaves and roots.