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REFERENCE VALUES FOR INTERPRETING FOLIAR ANALYSIS OF *PINUS PINEA* L.

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OBJECTIVE

❖ **To establish the reference values for the interpretation of needle analysis of stone pine for the winter rest period**

MATERIAL and METHODS

Location:

- In 2017, stone pine stands were selected and 34 Permanent Observation Plots (POP) were installed in the Region of Provenience V of Portugal (Fig. 1)
- At each POP, 10 stone pine trees were marked in order to evaluate cone yields and to take needle samples

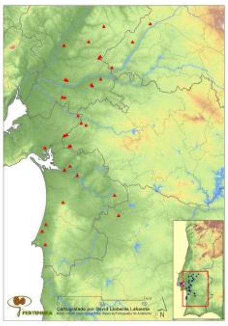

Fig. 1 - Distribution of Permanent Observation Plots

Stone pine stands characteristics:

- Soils - Arenossols, Podzols and Cambissols (WRB, 2015)
- Dryland - 100%
- Not grafted - 74 %; grafted - 26 %
- Pure - 65 %; the others are mixed with cork oak trees
- Age - 9 to 100 years
- Prevailing density (53 %) - 50 to 100 trees/ha

Experimental data:

- The data was obtained from 2017/18 to 2019/20
- Cone yields per tree were evaluated annually (Fig. 2)
- During the winter rest period (December to February) sprigs located at the base of the upper half of the crown, exposed to full light, were collected (Fig. 3); fully expanded needles from the middle third of the lateral shoots were stripped to form one sample per tree (Fig. 4); later they were analysed for macro and micronutrients

Fig. 2 - Pine cone weighing

Fig. 3 – Sampled sprig

Fig. 4 - Needle sample

Analytical methods:

- The needle samples were washed with distilled water, dried at 65 ± 5 °C and ground to a particle size of 1 ± 0.1 mm
- N concentration was determined in an Elemental Analyser by dynamic flash combustion based method
- P, K, Ca, Mg, Na, Fe, Mn, Zn, Cu and B concentrations were determined by inductively coupled plasma optical emission spectrometry (ICP-OES) in the solution obtained by the uptake in HCl of dry ashes 500 °C
- The results refer to dry material at 100-105 °C

Statistical analysis:

- Descriptive statistical methods

A) Two subpopulations were considered: reference (REF) and low yield (LY) populations, based on the upper quartile value (yield ≥ 6,4 kg/tree)

B) The needle concentration values of these subpopulations were compared using the difference between means (Student's t-test) and the ratio between variances (F-test)

C) The reference values for foliar diagnosis were established using the mean values of mineral concentrations ± standard deviation ($\bar{x}$ ± s), considering the reference subpopulation

RESULTS

Except for N, Ca and Zn, the means and/or variances of the other nutrients in the two subpopulations are significantly different ($p \leq 0.05$), separating the two groups of data (Table 1).

Table 1 - Comparison between the needle concentration values and pine cone yield of the reference subpopulation (REF) and the low-yield subpopulation (LY)

Nutrient	Sub-population	Mean	s (±)	Difference between means[1]	Variance ratio
N (g kg^{-1})	REF	9.2	1.77	0.21 NS	1,14 NS
	LY	9.4	1.65		
P (g kg^{-1})	REF	0.93	0.204	0.031 *	1.02 NS
	LY	0.90	0.207		
K (g kg^{-1})	REF	5.4	1.31	0.04 NS	1.24 *
	LY	5.4	1.45		
Ca (g kg^{-1})	REF	2.2	0.83	0.09 NS	1.01 NS
	LY	2.1	0.83		
Mg (g kg^{-1})	REF	1.7	0.39	0.02 NS	1.81 ***
	LY	1.7	0.52		
Fe (mg kg^{-1})	REF	39	13.9	0.8 NS	1.27 *
	LY	40	15.6		
Mn (mg kg^{-1})	REF	125	106.3	17.0 *	1.35 **
	LY	108	123.3		
Zn (mg kg^{-1})	REF	17	5.3	0.6 NS	1.14 NS
	LY	17	5.0		
Cu (mg kg^{-1})	REF	3.0	1.3	0,15 NS	1.64 ***
	LY	3.2	1.0		
B (mg kg^{-1})[2]	REF	17	10.7	1,6 *	2.01 ***
	LY	15	7.6		
Pine cone yield (kg tree^{-1})	REF	19.2	19.28	5,596 ***	129,14 ***
	LY	1.4	1.70		

Reference subpopulation: n= 274; low-yield subpopulation: n= 816; s - standard deviation; [1] in absolute value; [2] values > 5; NS - $p > 0.05$; * - $p \leq 0.05$; ** - $p \leq 0.01$; *** - $p \leq 0.001$

The reference values established for the interpretation of needle analysis of stone pine are presented in Tables 2 and 3.

Table 2 - Reference values for needle analysis interpretation of stone pine for the winter rest period (g kg^{-1} dry weight) - Macronutrients

Nitrogen (N)	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)
[7.5, 11]	[0.73, 1.1]	[4.1, 6.7]	[1.4, 3.0]	[1.3, 2.1]

Table 3 - Reference values for needle analysis interpretation of stone pine for the winter rest period (mg kg^{-1} dry weight) - Micronutrients

Iron (Fe)	Manganese (Mn)	Zinc (Zn)	Copper (Cu)	Boron (B)
[25, 53]	[19, 231]	[12, 23]	[1.7, 4.3]	[6.2*, 28]

*provisional value

CONCLUSIONS

❖ **The reference values contribute to prescribe suitable fertilizer recommendations to stone pine's need.**

❖ **However, they should be refined by increasing the number of observations conducted in a broader range of stone pine stands over an extended period.**

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